kwimage Documentation

Release 0.9.6

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The Kitware Image Module (kwimage) contains functions to accomplish lower-level image operations via a high level API.

CHAPTER

ONE

FUNCTION USEFULNESS

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1.1 kwimage package

1.1.1 Subpackages

kwimage.algo package

Submodules

kwimage.algo.algo_nms module

Generic Non-Maximum Suppression API with efficient backend implementations

kwimage.algo.algo_nms.**daq_spatial_nms**(*ltrb*, *scores*, *diameter*, *thresh*, *max_depth=6*, *stop_size=2048*, *recsize=2048*, *impl='auto'*, *device_id=None*)

Divide and conquor speedup non-max-supression algorithm for when bboxes have a known max size

Parameters

- **ltrb** (*ndarray*) – boxes in (tlx, tly, brx, bry) format
- **scores** (*ndarray*) – scores of each box
- **diameter** (*int | Tuple[int, int]*) – Distance from split point to consider rectification. If specified as an integer, then number is used for both height and width. If specified as a tuple, then dims are assumed to be in [height, width] format.
- **thresh** (*float*) – iou threshold. Boxes are removed if they overlap greater than this threshold. 0 is the most strict, resulting in the fewest boxes, and 1 is the most permissive resulting in the most.
- **max_depth** (*int*) – maximum number of times we can divide and conquor
- **stop_size** (*int*) – number of boxes that triggers full NMS computation
- **recsize** (*int*) – number of boxes that triggers full NMS recombination
- **impl** (*str*) – algorithm to use

LookInfo:

Didn't read yet but it seems similar http://www.cyberneum.de/fileadmin/user_upload/files/publications/CVPR2010-Lampert_{[}0{]}.pdf

https://www.researchgate.net/publication/220929789_Efficient_Non-Maximum_Suppression

This seems very similar https://projet.liris.cnrs.fr/m2disco/pub/Congres/2006-ICPR/DATA/C03_0406.PDF

Example

```
>>> import kwimage
>>> # Make a bunch of boxes with the same width and height
>>> #boxes = kwimage.Boxes.random(230397, scale=1000, format='cxywh')
>>> boxes = kwimage.Boxes.random(237, scale=1000, format='cxywh')
>>> boxes.data.T[2] = 10
>>> boxes.data.T[3] = 10
>>> #
>>> ltrb = boxes.to_ltrb().data.astype(np.float32)
>>> scores = np.arange(0, len(ltrb)).astype(np.float32)
>>> #
>>> n_megabytes = (ltrb.size * ltrb.dtype.itemsize) / (2 ** 20)
>>> print('n_megabytes = {!r}'.format(n_megabytes))
>>> #
>>> thresh = iou_thresh = 0.01
>>> impl = 'auto'
>>> max_depth = 20
>>> diameter = 10
>>> stop_size = 2000
>>> recsize = 500
>>> #
```

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```
>>> import ubelt as ub
>>> #
>>> with ub.Timer(label='daq'):
>>>     keep1 = daq_spatial_nms(ltrb, scores,
>>>         diameter=diameter, thresh=thresh, max_depth=max_depth,
>>>         stop_size=stop_size, recsize=recsize, impl=impl)
>>> #
>>> with ub.Timer(label='full'):
>>>     keep2 = non_max_supression(ltrb, scores,
>>>         thresh=thresh, impl=impl)
>>> #
>>> # Due to the greedy nature of the algorithm, there will be slight
>>> # differences in results, but they will be mostly similar.
>>> similarity = len(set(keep1) & set(keep2)) / len(set(keep1) | set(keep2))
>>> print('similarity = {!r}'.format(similarity))
```

kwimage.algo.algo_nms.**available_nms_impls**()

List available values for the *impl* kwarg of *non_max_supression*

CommandLine

```
xdoctest -m kwimage.algo.algo_nms available_nms_impls
```

Example

```
>>> impls = available_nms_impls()
>>> assert 'numpy' in impls
>>> print('impls = {!r}'.format(impls))
```

kwimage.algo.algo_nms.**non_max_supression**(*ltrb*, *scores*, *thresh*, *bias=0.0*, *classes=None*, *impl='auto'*, *device_id=None*)

Non-Maximum Suppression - remove redundant bounding boxes

Parameters

- **ltrb** (*ndarray[Any, Float32]*) – Float32 array of shape Nx4 representing boxes in ltrb format
- **scores** (*ndarray[Any, Float32]*) – Float32 array of shape N representing scores for each box
- **thresh** (*float*) – iou threshold. Boxes are removed if they overlap greater than this threshold (i.e. Boxes are removed if iou > threshold). Thresh = 0 is the most strict, resulting in the fewest boxes, and 1 is the most permissive resulting in the most.
- **bias** (*float*) – bias for iou computation either 0 or 1
- **classes** (*ndarray[Shape[''], Int64] | None**) – integer classes. If specified NMS is done on a perclass basis.
- **impl** (*str*) – implementation can be “auto”, “python”, “cython_cpu”, “gpu”, “torch”, or “torchvision”.
- **device_id** (*int*) – used if impl is gpu, device id to work on. If not specified *torch.cuda.current_device()* is used.

Note: Using impl='cython_gpu' may result in an CUDA memory error that is not exposed to the python processes. In other words your program will hard crash if impl='cython_gpu', and you feed it too many bounding boxes. Ideally this will be fixed in the future.

References

https://github.com/facebookresearch/Detectron/blob/master/detectron/utils/cython_nms.pyx https://www.pyimagesearch.com/2015/02/16/faster-non-maximum-suppression-python/ https://github.com/bharatsingh430/soft-nms/blob/master/lib/nms/cpu_nms.pyx <- TODO

CommandLine

```
xdoctest -m ~/code/kwimage/kwimage/algo/algo_nms.py non_max_supression
```

Example

```
>>> from kwimage.algo.algo_nms import *
>>> from kwimage.algo.algo_nms import _impls
>>> ltrb = np.array([
>>>     [0, 0, 100, 100],
>>>     [100, 100, 10, 10],
>>>     [10, 10, 100, 100],
>>>     [50, 50, 100, 100],
>>> ], dtype=np.float32)
>>> scores = np.array([.1, .5, .9, .1])
>>> keep = non_max_supression(ltrb, scores, thresh=0.5, impl='numpy')
>>> print('keep = {!r}'.format(keep))
>>> assert keep == [2, 1, 3]
>>> thresh = 0.0
>>> non_max_supression(ltrb, scores, thresh, impl='numpy')
>>> if 'numpy' in available_nms_impls():
>>>     keep = non_max_supression(ltrb, scores, thresh, impl='numpy')
>>>     assert list(keep) == [2, 1]
>>> if 'cython_cpu' in available_nms_impls():
>>>     keep = non_max_supression(ltrb, scores, thresh, impl='cython_cpu')
>>>     assert list(keep) == [2, 1]
>>> if 'cython_gpu' in available_nms_impls():
>>>     keep = non_max_supression(ltrb, scores, thresh, impl='cython_gpu')
>>>     assert list(keep) == [2, 1]
>>> if 'torch' in available_nms_impls():
>>>     keep = non_max_supression(ltrb, scores, thresh, impl='torch')
>>>     assert set(keep.tolist()) == {2, 1}
>>> if 'torchvision' in available_nms_impls():
>>>     keep = non_max_supression(ltrb, scores, thresh, impl='torchvision')  # note␣
↪torchvision has no bias
>>>     assert list(keep) == [2]
>>> thresh = 1.0
>>> if 'numpy' in available_nms_impls():
```

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```
>>>     keep = non_max_supression(ltrb, scores, thresh, impl='numpy')
>>>     assert list(keep) == [2, 1, 3, 0]
>>> if 'cython_cpu' in available_nms_impls():
>>>     keep = non_max_supression(ltrb, scores, thresh, impl='cython_cpu')
>>>     assert list(keep) == [2, 1, 3, 0]
>>> if 'cython_gpu' in available_nms_impls():
>>>     keep = non_max_supression(ltrb, scores, thresh, impl='cython_gpu')
>>>     assert list(keep) == [2, 1, 3, 0]
>>> if 'torch' in available_nms_impls():
>>>     keep = non_max_supression(ltrb, scores, thresh, impl='torch')
>>>     assert set(keep.tolist()) == {2, 1, 3, 0}
>>> if 'torchvision' in available_nms_impls():
>>>     keep = non_max_supression(ltrb, scores, thresh, impl='torchvision')  # note␣
↪torchvision has no bias
>>>     assert set(kwarray.ArrayAPI.tolist(keep)) == {2, 1, 3, 0}
```

Example

```
>>> import ubelt as ub
>>> ltrb = np.array([
>>>     [0, 0, 100, 100],
>>>     [100, 100, 10, 10],
>>>     [10, 10, 100, 100],
>>>     [50, 50, 100, 100],
>>>     [100, 100, 150, 101],
>>>     [120, 100, 180, 101],
>>>     [150, 100, 200, 101],
>>> ], dtype=np.float32)
>>> scores = np.linspace(0, 1, len(ltrb))
>>> thresh = .2
>>> solutions = {}
>>> if not _impls._funcs:
>>>     _impls._lazy_init()
>>> for impl in _impls._funcs:
>>>     keep = non_max_supression(ltrb, scores, thresh, impl=impl)
>>>     solutions[impl] = sorted(keep)
>>> assert 'numpy' in solutions
>>> print('solutions = {}'.format(ub.repr2(solutions, nl=1)))
>>> assert ub.allsame(solutions.values())
```

CommandLine

```
xdoctest -m ~/code/kwimage/kwimage/algo/algo_nms.py non_max_supression
```

Example

```
>>> import ubelt as ub
>>> # Check that zero-area boxes are ok
>>> ltrb = np.array([
>>>     [0, 0, 0, 0],
>>>     [0, 0, 0, 0],
>>>     [10, 10, 10, 10],
>>> ], dtype=np.float32)
>>> scores = np.array([1, 2, 3], dtype=np.float32)
>>> thresh = .2
>>> solutions = {}
>>> if not _impls._funcs:
>>>     _impls._lazy_init()
>>> for impl in _impls._funcs:
>>>     keep = non_max_supression(ltrb, scores, thresh, impl=impl)
>>>     solutions[impl] = sorted(keep)
>>> assert 'numpy' in solutions
>>> print('solutions = {}'.format(ub.repr2(solutions, nl=1)))
>>> assert ub.allsame(solutions.values())
```

Module contents

mkinit ~/code/kwimage/kwimage/algo/__init__.py -w –relative

kwimage.algo.**available_nms_impls**()

List available values for the *impl* kwarg of *non_max_supression*

CommandLine

```
xdoctest -m kwimage.algo.algo_nms available_nms_impls
```

Example

```
>>> impls = available_nms_impls()
>>> assert 'numpy' in impls
>>> print('impls = {!r}'.format(impls))
```

kwimage.algo.**daq_spatial_nms**(*ltrb*, *scores*, *diameter*, *thresh*, *max_depth=6*, *stop_size=2048*, *recsize=2048*, *impl='auto'*, *device_id=None*)

Divide and conquor speedup non-max-supression algorithm for when bboxes have a known max size

Parameters

- **ltrb** (*ndarray*) – boxes in (tlx, tly, brx, bry) format

- **scores** (*ndarray*) – scores of each box
- **diameter** (*int | Tuple[int, int]*) – Distance from split point to consider rectification. If specified as an integer, then number is used for both height and width. If specified as a tuple, then dims are assumed to be in [height, width] format.
- **thresh** (*float*) – iou threshold. Boxes are removed if they overlap greater than this threshold. 0 is the most strict, resulting in the fewest boxes, and 1 is the most permissive resulting in the most.
- **max_depth** (*int*) – maximum number of times we can divide and conquor
- **stop_size** (*int*) – number of boxes that triggers full NMS computation
- **recsize** (*int*) – number of boxes that triggers full NMS recombination
- **impl** (*str*) – algorithm to use

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Example

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>>> boxes = kwimage.Boxes.random(237, scale=1000, format='cxywh')
>>> boxes.data.T[2] = 10
>>> boxes.data.T[3] = 10
>>> #
>>> ltrb = boxes.to_ltrb().data.astype(np.float32)
>>> scores = np.arange(0, len(ltrb)).astype(np.float32)
>>> #
>>> n_megabytes = (ltrb.size * ltrb.dtype.itemsize) / (2 ** 20)
>>> print('n_megabytes = {!r}'.format(n_megabytes))
>>> #
>>> thresh = iou_thresh = 0.01
>>> impl = 'auto'
>>> max_depth = 20
>>> diameter = 10
>>> stop_size = 2000
>>> recsize = 500
>>> #
>>> import ubelt as ub
>>> #
>>> with ub.Timer(label='daq'):
>>>     keep1 = daq_spatial_nms(ltrb, scores,
>>>         diameter=diameter, thresh=thresh, max_depth=max_depth,
>>>         stop_size=stop_size, recsize=recsize, impl=impl)
>>> #
```

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```
>>> with ub.Timer(label='full'):
>>>     keep2 = non_max_supression(ltrb, scores,
>>>         thresh=thresh, impl=impl)
>>> #
>>> # Due to the greedy nature of the algorithm, there will be slight
>>> # differences in results, but they will be mostly similar.
>>> similarity = len(set(keep1) & set(keep2)) / len(set(keep1) | set(keep2))
>>> print('similarity = {!r}'.format(similarity))
```

kwimage.algo.**non_max_supression**(*ltrb*, *scores*, *thresh*, *bias=0.0*, *classes=None*, *impl='auto'*, *device_id=None*)

Non-Maximum Suppression - remove redundant bounding boxes

Parameters

- **ltrb** (*ndarray[Any, Float32]*) – Float32 array of shape Nx4 representing boxes in ltrb format
- **scores** (*ndarray[Any, Float32]*) – Float32 array of shape N representing scores for each box
- **thresh** (*float*) – iou threshold. Boxes are removed if they overlap greater than this threshold (i.e. Boxes are removed if iou > threshold). Thresh = 0 is the most strict, resulting in the fewest boxes, and 1 is the most permissive resulting in the most.
- **bias** (*float*) – bias for iou computation either 0 or 1
- **classes** (*ndarray[Shape[''], Int64] | None**) – integer classes. If specified NMS is done on a perclass basis.
- **impl** (*str*) – implementation can be “auto”, “python”, “cython_cpu”, “gpu”, “torch”, or “torchvision”.
- **device_id** (*int*) – used if impl is gpu, device id to work on. If not specified *torch.cuda.current_device()* is used.

Note: Using impl=’cython_gpu’ may result in an CUDA memory error that is not exposed to the python processes. In other words your program will hard crash if impl=’cython_gpu’, and you feed it too many bounding boxes. Ideally this will be fixed in the future.

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CommandLine

```
xdoctest -m ~/code/kwimage/kwimage/algo/algo_nms.py non_max_supression
```

Example

```
>>> from kwimage.algo.algo_nms import *
>>> from kwimage.algo.algo_nms import _impls
>>> ltrb = np.array([
>>>     [0, 0, 100, 100],
>>>     [100, 100, 10, 10],
>>>     [10, 10, 100, 100],
>>>     [50, 50, 100, 100],
>>> ], dtype=np.float32)
>>> scores = np.array([.1, .5, .9, .1])
>>> keep = non_max_supression(ltrb, scores, thresh=0.5, impl='numpy')
>>> print('keep = {!r}'.format(keep))
>>> assert keep == [2, 1, 3]
>>> thresh = 0.0
>>> non_max_supression(ltrb, scores, thresh, impl='numpy')
>>> if 'numpy' in available_nms_impls():
>>>     keep = non_max_supression(ltrb, scores, thresh, impl='numpy')
>>>     assert list(keep) == [2, 1]
>>> if 'cython_cpu' in available_nms_impls():
>>>     keep = non_max_supression(ltrb, scores, thresh, impl='cython_cpu')
>>>     assert list(keep) == [2, 1]
>>> if 'cython_gpu' in available_nms_impls():
>>>     keep = non_max_supression(ltrb, scores, thresh, impl='cython_gpu')
>>>     assert list(keep) == [2, 1]
>>> if 'torch' in available_nms_impls():
>>>     keep = non_max_supression(ltrb, scores, thresh, impl='torch')
>>>     assert set(keep.tolist()) == {2, 1}
>>> if 'torchvision' in available_nms_impls():
>>>     keep = non_max_supression(ltrb, scores, thresh, impl='torchvision')  # note␣
↪torchvision has no bias
>>>     assert list(keep) == [2]
>>> thresh = 1.0
>>> if 'numpy' in available_nms_impls():
>>>     keep = non_max_supression(ltrb, scores, thresh, impl='numpy')
>>>     assert list(keep) == [2, 1, 3, 0]
>>> if 'cython_cpu' in available_nms_impls():
>>>     keep = non_max_supression(ltrb, scores, thresh, impl='cython_cpu')
>>>     assert list(keep) == [2, 1, 3, 0]
>>> if 'cython_gpu' in available_nms_impls():
>>>     keep = non_max_supression(ltrb, scores, thresh, impl='cython_gpu')
```

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```
>>>     assert list(keep) == [2, 1, 3, 0]
>>> if 'torch' in available_nms_impls():
>>>     keep = non_max_supression(ltrb, scores, thresh, impl='torch')
>>>     assert set(keep.tolist()) == {2, 1, 3, 0}
>>> if 'torchvision' in available_nms_impls():
>>>     keep = non_max_supression(ltrb, scores, thresh, impl='torchvision')  # note␣
↪torchvision has no bias
>>>     assert set(kwarray.ArrayAPI.tolist(keep)) == {2, 1, 3, 0}
```

Example

```
>>> import ubelt as ub
>>> ltrb = np.array([
>>>     [0, 0, 100, 100],
>>>     [100, 100, 10, 10],
>>>     [10, 10, 100, 100],
>>>     [50, 50, 100, 100],
>>>     [100, 100, 150, 101],
>>>     [120, 100, 180, 101],
>>>     [150, 100, 200, 101],
>>> ], dtype=np.float32)
>>> scores = np.linspace(0, 1, len(ltrb))
>>> thresh = .2
>>> solutions = {}
>>> if not _impls._funcs:
>>>     _impls._lazy_init()
>>> for impl in _impls._funcs:
>>>     keep = non_max_supression(ltrb, scores, thresh, impl=impl)
>>>     solutions[impl] = sorted(keep)
>>> assert 'numpy' in solutions
>>> print('solutions = {}'.format(ub.repr2(solutions, nl=1)))
>>> assert ub.allsame(solutions.values())
```

CommandLine

```
xdoctest -m ~/code/kwimage/kwimage/algo/algo_nms.py non_max_supression
```

Example

```
>>> import ubelt as ub
>>> # Check that zero-area boxes are ok
>>> ltrb = np.array([
>>>     [0, 0, 0, 0],
>>>     [0, 0, 0, 0],
>>>     [10, 10, 10, 10],
>>> ], dtype=np.float32)
>>> scores = np.array([1, 2, 3], dtype=np.float32)
```

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```
>>> thresh = .2
>>> solutions = {}
>>> if not _impls._funcs:
>>>     _impls._lazy_init()
>>> for impl in _impls._funcs:
>>>     keep = non_max_supression(ltrb, scores, thresh, impl=impl)
>>>     solutions[impl] = sorted(keep)
>>> assert 'numpy' in solutions
>>> print('solutions = {}'.format(ub.repr2(solutions, nl=1)))
>>> assert ub.allsame(solutions.values())
```

kwimage.structs package

Submodules

kwimage.structs.boxes module

Vectorized Bounding Boxes

kwimage.Boxes is a tool for efficiently transporting a set of bounding boxes within python as well as methods for operating on bounding boxes. It is a VERY thin wrapper around a pure numpy/torch array/tensor representation, and thus it is very fast.

Raw bounding boxes come in lots of different formats. There are lots of ways to parameterize two points! Because of this THE USER MUST ALWAYS BE EXPLICIT ABOUT THE BOX FORMAT.

There are 3 main bounding box formats:

xywh: top left xy-coordinates and width height offsets cxywh: center xy-coordinates and width height offsets ltrb: top left and bottom right xy coordinates

Here is some example usage

Example

```
>>> import kwimage
>>> data = np.array([[ 0,  0, 10, 10],
>>>                  [ 5,  5, 50, 50],
>>>                  [10,  0, 20, 10],
>>>                  [20,  0, 30, 10]])
>>> # Note that the format of raw data is ambiguous, so you must specify
>>> boxes = kwimage.Boxes(data, 'ltrb')
>>> print('boxes = {!r}'.format(boxes))
boxes = <Boxes(ltrb,
    array([[ 0,  0, 10, 10],
           [ 5,  5, 50, 50],
           [10,  0, 20, 10],
           [20,  0, 30, 10]]))>
```

```
>>> # Now you can operate on those boxes easily
>>> print(boxes.translate((10, 10)))
<Boxes(ltrb,
```

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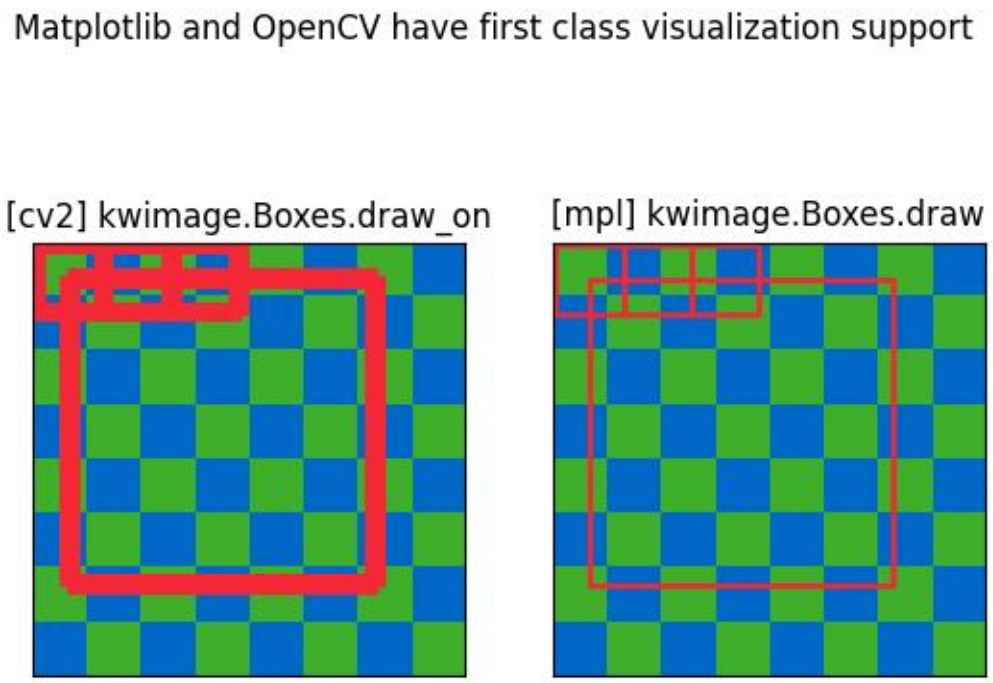
```
    array([[10., 10., 20., 20.],
           [15., 15., 60., 60.],
           [20., 10., 30., 20.],
           [30., 10., 40., 20.]]))>
>>> print(boxes.to_cxywh())
<Boxes(cxywh,
    array([[ 5. ,  5. , 10. , 10. ],
           [27.5, 27.5, 45. , 45. ],
           [15. ,  5. , 10. , 10. ],
           [25. ,  5. , 10. , 10. ]]))>
>>> print(ub.repr2(boxes.ious(boxes), precision=2, with_dtype=False))
np.array([[1.  , 0.01, 0.  , 0.  ],
          [0.01, 1.  , 0.02, 0.02],
          [0.  , 0.02, 1.  , 0.  ],
          [0.  , 0.02, 0.  , 1.  ]])
>>> # OpenCV and Matplotlib have first class visualization support
>>> # xdoc: +REQUIRES(--show)
>>> # xdoc: +REQUIRES(module:kwplot)
>>> import kwplot
>>> plt = kwplot.autoplt()
>>> # opencv "draw_on" method
>>> background = kwimage.checkerboard(dsize=(64, 64), dtype=np.uint8, on_value='kw_green
↪', off_value='kw_blue')
>>> canvas = background.copy()
>>> boxes.draw_on(canvas, color='kw_red')
>>> kwplot.imshow(canvas, fnum=1, pnum=(1, 2, 1), doclf=1, title='[cv2] kwimage.Boxes.
↪draw_on')
>>> # matplotlib "draw_on" method
>>> kwplot.imshow(background, fnum=1, pnum=(1, 2, 2), title='[mpl] kwimage.Boxes.draw')
>>> boxes.draw(color='kw_red')
>>> plt.gcf().suptitle('Matplotlib and OpenCV have first class visualization support')
>>> kwplot.show_if_requested()
```



class kwimage.structs.boxes.**Boxes**(*data*, *format=None*, *check=True*)

Bases: _BoxConversionMixins, _BoxPropertyMixins, _BoxTransformMixins, _BoxDrawMixins, NiceRepr

Converts boxes between different formats as long as the last dimension contains 4 coordinates and the format is specified.

This is a convinience class, and should not not store the data for very long. The general idiom should be create class, convert data, and then get the raw data and let the class be garbage collected. This will help ensure that your code is portable and understandable if this class is not available.

Example

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> import kwimage
>>> import numpy as np
>>> # Given an array / tensor that represents one or more boxes
>>> data = np.array([[ 0,  0, 10, 10],
>>>                  [ 5,  5, 50, 50],
>>>                  [20,  0, 30, 10]])
>>> # The kwimage.Boxes data structure is a thin fast wrapper
>>> # that provides methods for operating on the boxes.
>>> # It requires that the user explicitly provide a code that denotes
```

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```
>>> # the format of the boxes (i.e. what each column represents)
>>> boxes = kwimage.Boxes(data, 'ltrb')
>>> # This means that there is no ambiguity about box format
>>> # The representation string of the Boxes object demonstrates this
>>> print('boxes = {!r}'.format(boxes))
boxes = <Boxes(ltrb,
    array([[ 0,  0, 10, 10],
           [ 5,  5, 50, 50],
           [20,  0, 30, 10]]))>
>>> # if you pass this data around. You can convert to other formats
>>> # For docs on available format codes see :class:`BoxFormat`.
>>> # In this example we will convert (left, top, right, bottom)
>>> # to (left-x, top-y, width, height).
>>> boxes.toformat('xywh')
<Boxes(xywh,
    array([[ 0,  0, 10, 10],
           [ 5,  5, 45, 45],
           [20,  0, 10, 10]]))>
>>> # In addition to format conversion there are other operations
>>> # We can quickly (using a C-backend) find IoUs
>>> ious = boxes.ious(boxes)
>>> print('{}'.format(ub.repr2(ious, nl=1, precision=2, with_dtype=False)))
np.array([[1.  , 0.01, 0.  ],
          [0.01, 1.  , 0.02],
          [0.  , 0.02, 1.  ]])
>>> # We can ask for the area of each box
>>> print('boxes.area = {}'.format(ub.repr2(boxes.area, nl=0, with_dtype=False)))
boxes.area = np.array([[ 100],[2025],[ 100]])
>>> # We can ask for the center of each box
>>> print('boxes.center = {}'.format(ub.repr2(boxes.center, nl=1, with_
↪dtype=False)))
boxes.center = (
    np.array([[ 5. ],[27.5],[25. ]]),
    np.array([[ 5. ],[27.5],[ 5. ]]),
)
>>> # We can translate / scale the boxes
>>> boxes.translate((10, 10)).scale(100)
<Boxes(ltrb,
    array([[1000., 1000., 2000., 2000.],
           [1500., 1500., 6000., 6000.],
           [3000., 1000., 4000., 2000.]]))>
>>> # We can clip the bounding boxes
>>> boxes.translate((10, 10)).scale(100).clip(1200, 1200, 1700, 1800)
<Boxes(ltrb,
    array([[1200., 1200., 1700., 1800.],
           [1500., 1500., 1700., 1800.],
           [1700., 1200., 1700., 1800.]]))>
>>> # We can perform arbitrary warping of the boxes
>>> # (note that if the transform is not axis aligned, the axis aligned
>>> #  bounding box of the transform result will be returned)
>>> transform = np.array([[-0.83907153,  0.54402111,  0. ],
>>>                       [-0.54402111, -0.83907153,  0. ],
```

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```
>>>                       [ 0.        ,  0.        ,  1. ]])
>>> boxes.warp(transform)
<Boxes(ltrb,
    array([[ -8.3907153 , -13.8309264 ,   5.4402111 ,   0.        ],
           [-39.23347095, -69.154632  ,  23.00569785,  -6.9154632 ],
           [-25.1721459 , -24.7113486 , -11.3412195 , -10.8804222 ]]))>
>>> # Note, that we can transform the box to a Polygon for more
>>> # accurate warping.
>>> transform = np.array([[-0.83907153,  0.54402111,  0. ],
>>>                       [-0.54402111, -0.83907153,  0. ],
>>>                       [ 0.        ,  0.        ,  1. ]])
>>> warped_polys = boxes.to_polygons().warp(transform)
>>> print(ub.repr2(warped_polys.data, sv=1))
[
    <Polygon({
        'exterior': <Coords(data=
                        array([[  0.       ,   0.       ],
                               [  5.4402111,  -8.3907153],
                               [ -2.9505042, -13.8309264],
                               [ -8.3907153,  -5.4402111],
                               [  0.       ,   0.       ]]))>,
        'interiors': [],
    })>,
    <Polygon({
        'exterior': <Coords(data=
                        array([[ -1.4752521 ,  -6.9154632 ],
                               [ 23.00569785, -44.67368205],
                               [-14.752521  , -69.154632  ],
                               [-39.23347095, -31.39641315],
                               [ -1.4752521 ,  -6.9154632 ]]))>,
        'interiors': [],
    })>,
    <Polygon({
        'exterior': <Coords(data=
                        array([[-16.7814306, -10.8804222],
                               [-11.3412195, -19.2711375],
                               [-19.7319348, -24.7113486],
                               [-25.1721459, -16.3206333],
                               [-16.7814306, -10.8804222]]))>,
        'interiors': [],
    })>,
]
>>> # The kwimage.Boxes data structure is also convertable to
>>> # several alternative data structures, like shapely, coco, and imgaug.
>>> print(ub.repr2(boxes.to_shapely(), sv=1))
[
    POLYGON ((0 0, 0 10, 10 10, 10 0, 0 0)),
    POLYGON ((5 5, 5 50, 50 50, 50 5, 5 5)),
    POLYGON ((20 0, 20 10, 30 10, 30 0, 20 0)),
]
>>> # xdoctest: +REQUIRES(module:imgaug)
>>> print(ub.repr2(boxes[0:1].to_imgaug(shape=(100, 100)), sv=1))
```

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```
BoundingBoxesOnImage([BoundingBox(x1=0.0000, y1=0.0000, x2=10.0000, y2=10.0000,␣
↪label=None)], shape=(100, 100))
>>> # xdoctest: -REQUIRES(module:imgaug)
>>> print(ub.repr2(list(boxes.to_coco()), sv=1))
[
    [0, 0, 10, 10],
    [5, 5, 45, 45],
    [20, 0, 10, 10],
]
>>> # Finally, when you are done with your boxes object, you can
>>> # unwrap the raw data by using the ``.data`` attribute
>>> # all operations are done on this data, which gives the
>>> # kwiamge.Boxes data structure almost no overhead when
>>> # inserted into existing code.
>>> print('boxes.data =\n{}'.format(ub.repr2(boxes.data, nl=1)))
boxes.data =
np.array([[ 0,  0, 10, 10],
          [ 5,  5, 50, 50],
          [20,  0, 30, 10]], dtype=np.int64)
>>> # xdoctest: +REQUIRES(module:torch)
>>> # This data structure was designed for use with both torch
>>> # and numpy, the underlying data can be either an array or tensor.
>>> boxes.tensor()
<Boxes(ltrb,
    tensor([[ 0,  0, 10, 10],
            [ 5,  5, 50, 50],
            [20,  0, 30, 10]]))>
>>> boxes.numpy()
<Boxes(ltrb,
    array([[ 0,  0, 10, 10],
           [ 5,  5, 50, 50],
           [20,  0, 30, 10]]))>
```

Example

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> from kwimage.structs.boxes import *  # NOQA
>>> # Demo of conversion methods
>>> import kwimage
>>> kwimage.Boxes([[25, 30, 15, 10]], 'xywh')
<Boxes(xywh, array([[25, 30, 15, 10]]))>
>>> kwimage.Boxes([[25, 30, 15, 10]], 'xywh').to_xywh()
<Boxes(xywh, array([[25, 30, 15, 10]]))>
>>> kwimage.Boxes([[25, 30, 15, 10]], 'xywh').to_cxywh()
<Boxes(cxywh, array([[32.5, 35. , 15. , 10. ]]))>
>>> kwimage.Boxes([[25, 30, 15, 10]], 'xywh').to_ltrb()
<Boxes(ltrb, array([[25, 30, 40, 40]]))>
>>> kwimage.Boxes([[25, 30, 15, 10]], 'xywh').scale(2).to_ltrb()
<Boxes(ltrb, array([[50., 60., 80., 80.]]))>
>>> # xdoctest: +REQUIRES(module:torch)
```

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```
>>> kwimage.Boxes(torch.FloatTensor([[25, 30, 15, 20]]), 'xywh').scale(.1).to_ltrb()
<Boxes(ltrb, tensor([[ 2.5000,  3.0000,  4.0000,  5.0000]]))>
```

Note: In the following examples we show cases where *Boxes* can hold a single 1-dimensional box array. This is a holdover from an older codebase, and some functions may assume that the input is at least 2-D. Thus when representing a single bounding box it is best practice to view it as a list of 1 box. While many function will work in the 1-D case, not all functions have been tested and thus we cannot gaurentee correctness.

Example

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> Boxes([25, 30, 15, 10], 'xywh')
<Boxes(xywh, array([25, 30, 15, 10]))>
>>> Boxes([25, 30, 15, 10], 'xywh').to_xywh()
<Boxes(xywh, array([25, 30, 15, 10]))>
>>> Boxes([25, 30, 15, 10], 'xywh').to_cxywh()
<Boxes(cxywh, array([32.5, 35. , 15. , 10. ]))>
>>> Boxes([25, 30, 15, 10], 'xywh').to_ltrb()
<Boxes(ltrb, array([25, 30, 40, 40]))>
>>> Boxes([25, 30, 15, 10], 'xywh').scale(2).to_ltrb()
<Boxes(ltrb, array([50., 60., 80., 80.]))>
>>> # xdoctest: +REQUIRES(module:torch)
>>> Boxes(torch.FloatTensor([[25, 30, 15, 20]]), 'xywh').scale(.1).to_ltrb()
<Boxes(ltrb, tensor([[ 2.5000,  3.0000,  4.0000,  5.0000]]))>
```

Example

```
>>> datas = [
>>>     [1, 2, 3, 4],
>>>     [[1, 2, 3, 4], [4, 5, 6, 7]],
>>>     [[[1, 2, 3, 4], [4, 5, 6, 7]]],
>>> ]
>>> formats = BoxFormat.cannonical
>>> for format1 in formats:
>>>     for data in datas:
>>>         self = box1 = Boxes(data, format1)
>>>         for format2 in formats:
>>>             box2 = box1.toformat(format2)
>>>             back = box2.toformat(format1)
>>>             assert box1 == back
```

classmethod random(*num=1*, *scale=1.0*, *format='xywh'*, *anchors=None*, *anchor_std=0.16666666666666666*, *tensor=False*, *rng=None*)

Makes random boxes; typically for testing purposes

Parameters

- **num** (*int*) – number of boxes to generate

- **scale** (*float | Tuple[float, float]*) – size of imgdims
- **format** (*str*) – format of boxes to be created (e.g. ltrb, xywh)
- **anchors** (*ndarray*) – normalized width / heights of anchor boxes to perterb and randomly place. (must be in range 0-1)
- **anchor_std** (*float*) – magnitude of noise applied to anchor shapes
- **tensor** (*bool*) – if True, returns boxes in tensor format
- **rng** (*None | int | RandomState*) – initial random seed

Returns
random boxes

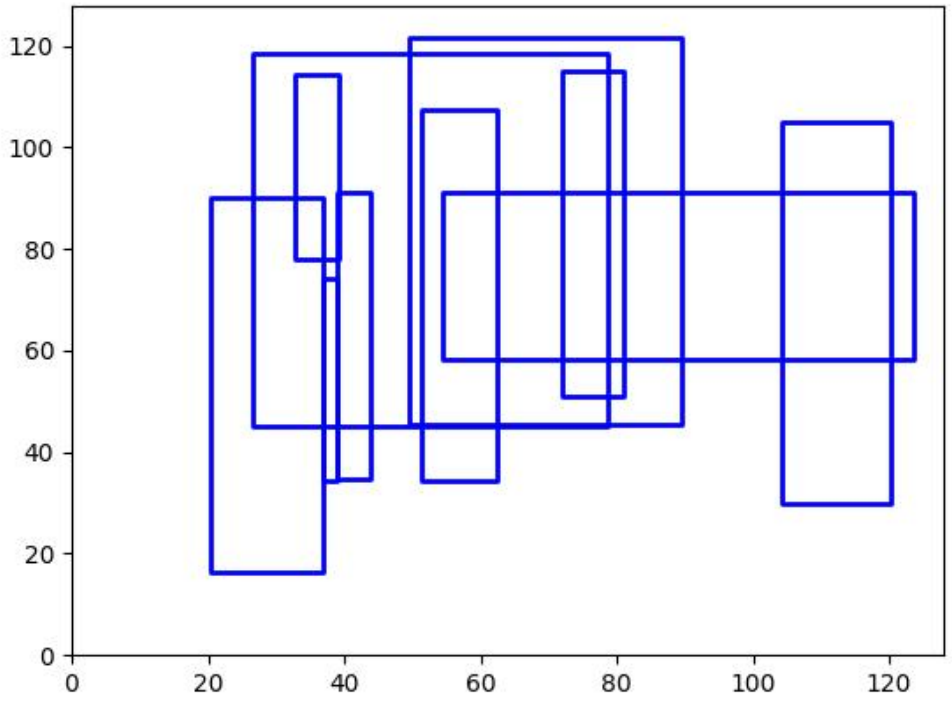
Return type
Boxes

Example

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> Boxes.random(3, rng=0, scale=100)
<Boxes(xywh,
    array([[54, 54,  6, 17],
           [42, 64,  1, 25],
           [79, 38, 17, 14]]))>
>>> # xdoctest: +REQUIRES(module:torch)
>>> Boxes.random(3, rng=0, scale=100).tensor()
<Boxes(xywh,
    tensor([[ 54,  54,   6,  17],
            [ 42,  64,   1,  25],
            [ 79,  38,  17,  14]]))>
>>> anchors = np.array([[.5, .5], [.3, .3]])
>>> Boxes.random(3, rng=0, scale=100, anchors=anchors)
<Boxes(xywh,
    array([[ 2, 13, 51, 51],
           [32, 51, 32, 36],
           [36, 28, 23, 26]]))>
```

Example

```
>>> # Boxes position/shape within 0-1 space should be uniform.
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> fig = kwplot.figure(fnum=1, doclf=True)
>>> fig.gca().set_xlim(0, 128)
>>> fig.gca().set_ylim(0, 128)
>>> import kwimage
>>> kwimage.Boxes.random(num=10).scale(128).draw()
```



`copy`()

Returns
a copy of these boxes

Return type
Boxes

`classmethod concatenate`(*boxes*, *axis=0*)

Concatenates multiple boxes together

Parameters

- **boxes** (*Sequence[Boxes]*) – list of boxes to concatenate
- **axis** (*int*) – axis to stack on. Defaults to 0.

Returns
stacked boxes

Return type
Boxes

Example

```
>>> boxes = [Boxes.random(3) for _ in range(3)]
>>> new = Boxes.concatenate(boxes)
>>> assert len(new) == 9
>>> assert np.all(new.data[3:6] == boxes[1].data)
```

Example

```
>>> boxes = [Boxes.random(3) for _ in range(3)]
>>> boxes[0].data = boxes[0].data[0]
>>> boxes[1].data = boxes[0].data[0:0]
>>> new = Boxes.concatenate(boxes)
>>> assert len(new) == 4
>>> # xdoctest: +REQUIRES(module:torch)
>>> new = Boxes.concatenate([b.tensor() for b in boxes])
>>> assert len(new) == 4
```

compress(*flags*, *axis=0*, *inplace=False*)

Filters boxes based on a boolean criterion

Parameters

- **flags** (*ArrayLike*) – true for items to be kept. Extended type: ArrayLike[bool]
- **axis** (*int*) – you usually want this to be 0
- **inplace** (*bool*) – if True, modifies this object

Returns
the boxes corresponding to where flags were true

Return type
Boxes

Example

```
>>> self = Boxes([[25, 30, 15, 10]], 'ltrb')
>>> self.compress([True])
<Boxes(ltrb, array([[25, 30, 15, 10]]))>
>>> self.compress([False])
<Boxes(ltrb, array([], shape=(0, 4), dtype=int64))>
```

take(*idxs*, *axis=0*, *inplace=False*)

Takes a subset of items at specific indices

Parameters

- **indices** (*ArrayLike*) – Indexes of items to take. Extended type ArrayLike[int].
- **axis** (*int*) – you usually want this to be 0
- **inplace** (*bool*) – if True, modifies this object

Returns
the boxes corresponding to the specified indices

Return type
Boxes

Example

```
>>> self = Boxes([[25, 30, 15, 10]], 'ltrb')
>>> self.take([0])
<Boxes(ltrb, array([[25, 30, 15, 10]]))>
>>> self.take([])
<Boxes(ltrb, array([], shape=(0, 4), dtype=int64))>
```

`is_tensor`()

is the backend fueled by torch?

Returns
True if the Boxes are torch tensors

Return type
bool

`is_numpy`()

is the backend fueled by numpy?

Returns
True if the Boxes are numpy arrays

Return type
bool

`property device`

If the backend is torch returns the data device, otherwise None

`astype`(*dtype*)

Changes the type of the internal array used to represent the boxes

---

Note: this operation is not inplace

Returns
the boxes with the chosen type

Return type
Boxes

Example

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> # xdoctest: +REQUIRES(module:torch)
>>> Boxes.random(3, 100, rng=0).tensor().astype('int32')
<Boxes(xywh,
    tensor([[54, 54,  6, 17],
            [42, 64,  1, 25],
            [79, 38, 17, 14]], dtype=torch.int32))>
>>> Boxes.random(3, 100, rng=0).numpy().astype('int32')
```

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```
<Boxes(xywh,
    array([[54, 54,  6, 17],
           [42, 64,  1, 25],
           [79, 38, 17, 14]], dtype=int32))>
>>> Boxes.random(3, 100, rng=0).tensor().astype('float32')
>>> Boxes.random(3, 100, rng=0).numpy().astype('float32')
```

round(*inplace=False*)

Rounds data coordinates to the nearest integer.

This operation is applied directly to the box coordinates, so its output will depend on the format the boxes are stored in.

Parameters
inplace (*bool*) – if True, modifies this object. Defaults to False.

Returns
the boxes with rounded coordinates

Return type
Boxes

SeeAlso:
Boxes.quantize()

Example

```
>>> import kwimage
>>> self = kwimage.Boxes.random(3, rng=0).scale(10)
>>> new = self.round()
>>> print('self = {!r}'.format(self))
>>> print('new = {!r}'.format(new))
self = <Boxes(xywh,
    array([[5.48813522, 5.44883192, 0.53949833, 1.70306146],
           [4.23654795, 6.4589411 , 0.13932407, 2.45878875],
           [7.91725039, 3.83441508, 1.71937704, 1.45453393]]))>
new = <Boxes(xywh,
    array([[5., 5., 1., 2.],
           [4., 6., 0., 2.],
           [8., 4., 2., 1.]]))>
```

quantize(*inplace=False*, *dtype=<class 'numpy.int32'>*)

Converts the box to integer coordinates.

This operation takes the floor of the left side and the ceil of the right side. Thus the area of the box will never decreases. But this will often increase the width / height of the box by a pixel.

Parameters

- **inplace** (*bool*) – if True, modifies this object
- **dtype** (*type*) – type to cast as

Returns
the boxes with quantized coordinates

Return type
Boxes

SeeAlso:
Boxes.round() Boxes.resize() if you need to ensure the size does not change

Example

```
>>> import kwimage
>>> self = kwimage.Boxes.random(3, rng=0).scale(10)
>>> new = self.quantize()
>>> print('self = {!r}'.format(self))
>>> print('new = {!r}'.format(new))
self = <Boxes(xywh,
    array([[5.48813522, 5.44883192, 0.53949833, 1.70306146],
           [4.23654795, 6.4589411 , 0.13932407, 2.45878875],
           [7.91725039, 3.83441508, 1.71937704, 1.45453393]]))>
new = <Boxes(xywh,
    array([[5, 5, 2, 3],
           [4, 6, 1, 3],
           [7, 3, 3, 3]], dtype=int32))>
```

Example

```
>>> import kwimage
>>> # Be careful if it is important to preserve the width/height
>>> self = kwimage.Boxes([[0, 0, 10, 10]], 'xywh')
>>> aff = kwimage.Affine.coerce(offset=(0.5, 0.0))
>>> warped = self.warp(aff)
>>> new = warped.quantize(dtype=int)
>>> print('self   = {!r}'.format(self))
>>> print('warped = {!r}'.format(warped))
>>> print('new    = {!r}'.format(new))
self   = <Boxes(xywh, array([[ 0,  0, 10, 10]]))>
warped = <Boxes(xywh, array([[ 0.5,  0. , 10. , 10. ]]))>
new    = <Boxes(xywh, array([[ 0,  0, 11, 10]]))>
```

Example

```
>>> import kwimage
>>> self = kwimage.Boxes.random(3, rng=0)
>>> orig = self.copy()
>>> self.quantize(inplace=True)
>>> assert np.any(self.data != orig.data)
```

numpy()

Converts tensors to numpy. Does not change memory if possible.

Returns
the boxes with a numpy backend

Return type
Boxes

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> self = Boxes.random(3).tensor()
>>> newself = self.numpy()
>>> self.data[0, 0] = 0
>>> assert newself.data[0, 0] == 0
>>> self.data[0, 0] = 1
>>> assert self.data[0, 0] == 1
```

tensor(*device=NoParam*)

Converts numpy to tensors. Does not change memory if possible.

Parameters
device (*int | None | torch.device*) – The torch device to put the backend tensors on

Returns
the boxes with a torch backend

Return type
Boxes

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> self = Boxes.random(3)
>>> # xdoctest: +REQUIRES(module:torch)
>>> newself = self.tensor()
>>> self.data[0, 0] = 0
>>> assert newself.data[0, 0] == 0
>>> self.data[0, 0] = 1
>>> assert self.data[0, 0] == 1
```

ious(*other*, *bias=0*, *impl='auto'*, *mode=None*)

Intersection over union.

Compute IOUs (intersection area over union area) between these boxes and another set of boxes. This is a symmetric measure of similarity between boxes.

Todo:

- **[ ] Add pairwise flag to toggle between one-vs-one and all-vs-all**
  computation. I.E. Add option for componentwise calculation.

Parameters

- **other** (*Boxes*) – boxes to compare IoUs against
- **bias** (*int*) – either 0 or 1, does TL=BR have area of 0 or 1? Defaults to 0.

- **impl** (*str*) – code to specify implementation used to ious. Can be either torch, py, c, or auto. Efficiency and the exact result will vary by implementation, but they will always be close. Some implementations only accept certain data types (e.g. impl='c', only accepts float32 numpy arrays). See ~/code/kwimage/dev/bench_bbox.py for benchmark details. On my system the torch impl was fastest (when the data was on the GPU). Defaults to 'auto'
- **mode** (*str*) – depricated, use impl

Returns
the ious

Return type
ndarray

SeeAlso:
iooas - for a measure of coverage between boxes

Examples

```
>>> import kwimage
>>> self = kwimage.Boxes(np.array([[ 0,  0, 10, 10],
>>>                                [10,  0, 20, 10],
>>>                                [20,  0, 30, 10]]), 'ltrb')
>>> other = kwimage.Boxes(np.array([6, 2, 20, 10]), 'ltrb')
>>> overlaps = self.ious(other, bias=1).round(2)
>>> assert np.all(np.isclose(overlaps, [0.21, 0.63, 0.04])), repr(overlaps)
```

Examples

```
>>> import kwimage
>>> boxes1 = kwimage.Boxes(np.array([[ 0,  0, 10, 10],
>>>                                  [10,  0, 20, 10],
>>>                                  [20,  0, 30, 10]]), 'ltrb')
>>> other = kwimage.Boxes(np.array([[6, 2, 20, 10],
>>>                                 [100, 200, 300, 300]]), 'ltrb')
>>> overlaps = boxes1.ious(other)
>>> print('{}'.format(ub.repr2(overlaps, precision=2, nl=1)))
np.array([[0.18, 0.  ],
          [0.61, 0.  ],
          [0.  , 0.  ]]...)
```

Examples

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> Boxes(np.empty(0), 'xywh').ious(Boxes(np.empty(4), 'xywh')).shape
(0,)
>>> #Boxes(np.empty(4), 'xywh').ious(Boxes(np.empty(0), 'xywh')).shape
>>> Boxes(np.empty((0, 4)), 'xywh').ious(Boxes(np.empty((0, 4)), 'xywh')).shape
(0, 0)
>>> Boxes(np.empty((1, 4)), 'xywh').ious(Boxes(np.empty((0, 4)), 'xywh')).shape
(1, 0)
```

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```
>>> Boxes(np.empty((0, 4)), 'xywh').ious(Boxes(np.empty((1, 4)), 'xywh')).shape
(0, 1)
```

Examples

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> formats = BoxFormat.cannonical
>>> istensors = [False, True]
>>> results = {}
>>> for format in formats:
>>>     for tensor in istensors:
>>>         boxes1 = Boxes.random(5, scale=10.0, rng=0, format=format,␣
↪tensor=tensor)
>>>         boxes2 = Boxes.random(7, scale=10.0, rng=1, format=format,␣
↪tensor=tensor)
>>>         ious = boxes1.ious(boxes2)
>>>         results[(format, tensor)] = ious
>>> results = {k: v.numpy() if torch.is_tensor(v) else v for k, v in results.
↪items() }
>>> results = {k: v.tolist() for k, v in results.items()}
>>> print(ub.repr2(results, sk=True, precision=3, nl=2))
>>> from functools import partial
>>> assert ub.allsame(results.values(), partial(np.allclose, atol=1e-07))
```

iooas(*other*, *bias=0*)

Intersection over other area.

This is an asymetric measure of coverage. How much of the "other" boxes are covered by these boxes. It is the area of intersection between each pair of boxes and the area of the "other" boxes.

SeeAlso:
ious - for a measure of similarity between boxes

Parameters

- **other** (*Boxes*) – boxes to compare IoOA against
- **bias** (*int*) – either 0 or 1, does TL=BR have area of 0 or 1? Defaults to 0.

Returns
the iooas

Return type
ndarray

Examples

```
>>> self = Boxes(np.array([[ 0,  0, 10, 10],
>>>                        [10,  0, 20, 10],
>>>                        [20,  0, 30, 10]]), 'ltrb')
>>> other = Boxes(np.array([[6, 2, 20, 10], [0, 0, 0, 3]]), 'xywh')
>>> coverage = self.iooas(other, bias=0).round(2)
>>> print('coverage = {!r}'.format(coverage))
```

isect_area(*other*, *bias=0*)

Intersection part of intersection over union computation

Parameters

- **other** (*Boxes*) – boxes to compare IoOA against
- **bias** (*int*) – either 0 or 1, does TL=BR have area of 0 or 1? Defaults to 0.

Returns
the iooas

Return type
ndarray

Examples

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> self = Boxes.random(5, scale=10.0, rng=0, format='ltrb')
>>> other = Boxes.random(3, scale=10.0, rng=1, format='ltrb')
>>> isect = self.isect_area(other, bias=0)
>>> ious_v1 = isect / ((self.area + other.area.T) - isect)
>>> ious_v2 = self.ious(other, bias=0)
>>> assert np.allclose(ious_v1, ious_v2)
```

intersection(*other*)

Componentwise intersection between two sets of Boxes

intersections of boxes are always boxes, so this works

Parameters
other (*Boxes*) – boxes to intersect with this object. (must be of same length)

Returns
the intersection geometry

Return type
Boxes

Examples

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> from kwimage.structs.boxes import *  # NOQA
>>> self = Boxes.random(5, rng=0).scale(10.)
>>> other = self.translate(1)
>>> new = self.intersection(other)
>>> new_area = np.nan_to_num(new.area).ravel()
>>> alt_area = np.diag(self.isect_area(other))
>>> close = np.isclose(new_area, alt_area)
>>> assert np.all(close)
```

union_hull(*other*)

Componentwise hull union between two sets of Boxes

NOTE: convert to polygon to do a real union.

Parameters
other (*Boxes*) – boxes to union with this object. (must be of same length)

Returns
unioned boxes

Return type
Boxes

Examples

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> from kwimage.structs.boxes import *  # NOQA
>>> self = Boxes.random(5, rng=0).scale(10.)
>>> other = self.translate(1)
>>> new = self.union_hull(other)
>>> new_area = np.nan_to_num(new.area).ravel()
```

bounding_box()

Returns the box that bounds all of the contained boxes

Returns
a single box

Return type
Boxes

Examples

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> from kwimage.structs.boxes import *  # NOQA
>>> self = Boxes.random(5, rng=0).scale(10.)
>>> other = self.translate(1)
>>> new = self.union_hull(other)
>>> new_area = np.nan_to_num(new.area).ravel()
```

contains(*other*)

Determine of points are completely contained by these boxes

Parameters
other (*kwimage.Points*) – points to test for containment. TODO: support generic data types

Returns

flags - N x M boolean matrix indicating which box
contains which points, where N is the number of boxes and M is the number of points.

Return type
ArrayLike

Examples

```
>>> import kwimage
>>> self = kwimage.Boxes.random(10).scale(10).round()
>>> other = kwimage.Points.random(10).scale(10).round()
>>> flags = self.contains(other)
>>> flags = self.contains(self.xy_center)
>>> assert np.all(np.diag(flags))
```

view(**shape*)

Passthrough method to view or reshape

Parameters
***shape** (*Tuple[int, ...]*) – new shape

Returns
data with a different view

Return type
Boxes

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> self = Boxes.random(6, scale=10.0, rng=0, format='xywh').tensor()
>>> assert list(self.view(3, 2, 4).data.shape) == [3, 2, 4]
>>> self = Boxes.random(6, scale=10.0, rng=0, format='ltrb').tensor()
>>> assert list(self.view(3, 2, 4).data.shape) == [3, 2, 4]
```

kwimage.structs.coords module

Coordinates the fundamental "point" datatype. They do not contain metadata, only geometry. See the *Points* data type for a structure that maintains metadata on top of coordinate data.

class kwimage.structs.coords.**Coords**(*data=None*, *meta=None*)

Bases: Spatial, NiceRepr

A data structure to store n-dimensional coordinate geometry.

Currently it is up to the user to maintain what coordinate system this geometry belongs to.

Note: This class was designed to hold coordinates in r/c format, but in general this class is anostic to dimension ordering as long as you are consistent. However, there are two places where this matters: (1) drawing and (2) gdal/imgaug-warping. In these places we will assume x/y for legacy reasons. This may change in the future.

The term axes with resepct to `Coords` always refers to the final numpy axis. In other words the final numpy-axis represents ALL of the coordinate-axes.

CommandLine

```
xdoctest -m kwimage.structs.coords Coords
```

Example

```
>>> from kwimage.structs.coords import *  # NOQA
>>> import kwarray
>>> rng = kwarray.ensure_rng(0)
>>> self = Coords.random(num=4, dim=3, rng=rng)
>>> print('self = {}'.format(self))
self = <Coords(data=
    array([[0.5488135 , 0.71518937, 0.60276338],
           [0.54488318, 0.4236548 , 0.64589411],
           [0.43758721, 0.891773  , 0.96366276],
           [0.38344152, 0.79172504, 0.52889492]]))>
>>> matrix = rng.rand(4, 4)
>>> self.warp(matrix)
<Coords(data=
    array([[0.71037426, 1.25229659, 1.39498435],
           [0.60799503, 1.26483447, 1.42073131],
           [0.72106004, 1.39057144, 1.38757508],
           [0.68384299, 1.23914654, 1.29258196]]))>
>>> self.translate(3, inplace=True)
<Coords(data=
    array([[3.5488135 , 3.71518937, 3.60276338],
           [3.54488318, 3.4236548 , 3.64589411],
           [3.43758721, 3.891773  , 3.96366276],
           [3.38344152, 3.79172504, 3.52889492]]))>
>>> self.translate(3, inplace=True)
<Coords(data=
    array([[6.5488135 , 6.71518937, 6.60276338],
           [6.54488318, 6.4236548 , 6.64589411],
           [6.43758721, 6.891773  , 6.96366276],
           [6.38344152, 6.79172504, 6.52889492]]))>
>>> self.scale(2)
<Coords(data=
    array([[13.09762701, 13.43037873, 13.20552675],
           [13.08976637, 12.8473096 , 13.29178823],
           [12.87517442, 13.783546  , 13.92732552],
           [12.76688304, 13.58345008, 13.05778984]]))>
>>> # xdoctest: +REQUIRES(module:torch)
```

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```
>>> self.tensor()
>>> self.tensor().tensor().numpy().numpy()
>>> self.numpy()
>>> #self.draw_on()
```

property dtype

property dim

property shape

copy()

classmethod random(*num=1*, *dim=2*, *rng=None*, *meta=None*)

Makes random coordinates; typically for testing purposes

is_numpy()

is_tensor()

compress(*flags*, *axis=0*, *inplace=False*)

Filters items based on a boolean criterion

Parameters

- **flags** (*ArrayLike*) – true for items to be kept. Extended type: ArrayLike[bool].
- **axis** (*int*) – you usually want this to be 0
- **inplace** (*bool*) – if True, modifies this object

Returns

filtered coords

Return type

Coords

Example

```
>>> import kwimage
>>> self = kwimage.Coords.random(10, rng=0)
>>> self.compress([True] * len(self))
>>> self.compress([False] * len(self))
<Coords(data=array([], shape=(0, 2), dtype=float64))>
>>> # xdoctest: +REQUIRES(module:torch)
>>> self = self.tensor()
>>> self.compress([True] * len(self))
>>> self.compress([False] * len(self))
```

take(*indices*, *axis=0*, *inplace=False*)

Takes a subset of items at specific indices

Parameters

- **indices** (*ArrayLike*) – indexes of items to take. Extended type ArrayLike[int].
- **axis** (*int*) – you usually want this to be 0

- **inplace** (*bool*) – if True, modifies this object

Returns
filtered coords

Return type
Coords

Example

```
>>> import kwimage
>>> self = kwimage.Coords(np.array([[25, 30, 15, 10]]))
>>> self.take([0])
<Coords(data=array([[25, 30, 15, 10]]))>
>>> self.take([])
<Coords(data=array([], shape=(0, 4), dtype=int64))>
```

astype(*dtype*, *inplace=False*)

Changes the data type

Parameters

- **dtype** – new type
- **inplace** (*bool*) – if True, modifies this object

Returns
modified coordinates

Return type
Coords

round(*decimals=0*, *inplace=False*)

Rounds data to the specified decimal place

Parameters

- **inplace** (*bool*) – if True, modifies this object
- **decimals** (*int*) – number of decimal places to round to

Returns
modified coordinates

Return type
Coords

Example

```
>>> import kwimage
>>> self = kwimage.Coords.random(3).scale(10)
>>> self.round()
```

view(**shape*)

Passthrough method to view or reshape

Parameters
***shape** – new shape of the data

Returns
modified coordinates

Return type
Coords

Example

```
>>> self = Coords.random(6, dim=4).numpy()
>>> assert list(self.view(3, 2, 4).data.shape) == [3, 2, 4]
>>> # xdoctest: +REQUIRES(module:torch)
>>> self = Coords.random(6, dim=4).tensor()
>>> assert list(self.view(3, 2, 4).data.shape) == [3, 2, 4]
```

classmethod concatenate(*coords*, *axis=0*)

Concatenates lists of coordinates together

Parameters

- **coords** (*Sequence[Coords]*) – list of coords to concatenate
- **axis** (*int*) – axis to stack on. Defaults to 0.

Returns
stacked coords

Return type
Coords

CommandLine

```
xdoctest -m kwimage.structs.coords Coords.concatenate
```

Example

```
>>> coords = [Coords.random(3) for _ in range(3)]
>>> new = Coords.concatenate(coords)
>>> assert len(new) == 9
>>> assert np.all(new.data[3:6] == coords[1].data)
```

property device

If the backend is torch returns the data device, otherwise None

tensor(*device=NoParam*)

Converts numpy to tensors. Does not change memory if possible.

Returns
modified coordinates

Return type
Coords

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> self = Coords.random(3).numpy()
>>> newself = self.tensor()
>>> self.data[0, 0] = 0
>>> assert newself.data[0, 0] == 0
>>> self.data[0, 0] = 1
>>> assert self.data[0, 0] == 1
```

numpy()

Converts tensors to numpy. Does not change memory if possible.

Returns
modified coordinates

Return type
Coords

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> self = Coords.random(3).tensor()
>>> newself = self.numpy()
>>> self.data[0, 0] = 0
>>> assert newself.data[0, 0] == 0
>>> self.data[0, 0] = 1
>>> assert self.data[0, 0] == 1
```

reorder_axes(*new_order*, *inplace=False*)

Change the ordering of the coordinate axes.

Parameters

- **new_order** (*Tuple[int]*) – `new_order[i]` should specify which axes in the original coordinates should be mapped to the `i-th` position in the returned axes.
- **inplace** (*bool*) – if True, modifies data inplace

Returns
modified coordinates

Return type
Coords

Note: This is the ordering of the "columns" in final numpy axis, not the numpy axes themselves.

Example

```
>>> from kwimage.structs.coords import *  # NOQA
>>> self = Coords(data=np.array([
>>>     [7, 11],
>>>     [13, 17],
>>>     [21, 23],
>>> ]))
>>> new = self.reorder_axes((1, 0))
>>> print('new = {!r}'.format(new))
new = <Coords(data=
    array([[11,  7],
           [17, 13],
           [23, 21]]))>
```

Example

```
>>> from kwimage.structs.coords import *  # NOQA
>>> self = Coords.random(10, rng=0)
>>> new = self.reorder_axes((1, 0))
>>> # Remapping using 1, 0 reverses the axes
>>> assert np.all(new.data[:, 0] == self.data[:, 1])
>>> assert np.all(new.data[:, 1] == self.data[:, 0])
>>> # Remapping using 0, 1 does nothing
>>> eye = self.reorder_axes((0, 1))
>>> assert np.all(eye.data == self.data)
>>> # Remapping using 0, 0, destroys the 1-th column
>>> bad = self.reorder_axes((0, 0))
>>> assert np.all(bad.data[:, 0] == self.data[:, 0])
>>> assert np.all(bad.data[:, 1] == self.data[:, 0])
```

warp(*transform*, *input_dims=None*, *output_dims=None*, *inplace=False*)

Generalized coordinate transform.

Parameters

- **transform** (*GeometricTransform | ArrayLike | Augmenter | Callable*) – scikit-image tranform, a 3x3 transformation matrix, an imgaug Augmenter, or generic callable which transforms an NxD ndarray.
- **input_dims** (*Tuple*) – shape of the image these objects correspond to (only needed / used when transform is an imgaug augmenter)
- **output_dims** (*Tuple*) – unused in non-raster structures, only exists for compatibility.
- **inplace** (*bool*) – if True, modifies data inplace

Returns

modified coordinates

Return type

Coords

Note: Let D = self.dims

transformation matrices can be either:

- (D + 1) x (D + 1) # for homog
- D x D # for scale / rotate
- D x (D + 1) # for affine

Example

```
>>> from kwimage.structs.coords import *  # NOQA
>>> self = Coords.random(10, rng=0)
>>> transform = skimage.transform.AffineTransform(scale=(2, 2))
>>> new = self.warp(transform)
>>> assert np.all(new.data == self.scale(2).data)
```

Doctest

```
>>> self = Coords.random(10, rng=0)
>>> assert np.all(self.warp(np.eye(3)).data == self.data)
>>> assert np.all(self.warp(np.eye(2)).data == self.data)
```

Doctest

```
>>> # xdoctest: +REQUIRES(module:osgeo)
>>> from osgeo import osr
>>> wgs84_crs = osr.SpatialReference()
>>> wgs84_crs.ImportFromEPSG(4326)
>>> dst_crs = osr.SpatialReference()
>>> dst_crs.ImportFromEPSG(2927)
>>> transform = osr.CoordinateTransformation(wgs84_crs, dst_crs)
>>> self = Coords.random(10, rng=0)
>>> new = self.warp(transform)
>>> assert np.all(new.data != self.data)
```

```
>>> # Alternative using generic func
>>> def _gdal_coord_tranform(pts):
...     return np.array([transform.TransformPoint(x, y, 0)[0:2]
...                      for x, y in pts])
>>> alt = self.warp(_gdal_coord_tranform)
>>> assert np.all(alt.data != self.data)
>>> assert np.all(alt.data == new.data)
```

Doctest

```
>>> # can use a generic function
>>> def func(xy):
...     return np.zeros_like(xy)
>>> self = Coords.random(10, rng=0)
>>> assert np.all(self.warp(func).data == 0)
```

to_imgaug(*input_dims*)

Translate to an imgaug object

Returns
imgaug data structure

Return type
imgaug.KeypointsOnImage

Example

```
>>> # xdoctest: +REQUIRES(module:imgaug)
>>> import kwimage
>>> import numpy as np
>>> self = kwimage.Coords.random(10)
>>> input_dims = (10, 10)
>>> kpoi = self.to_imgaug(input_dims)
>>> new = kwimage.Coords.from_imgaug(kpoi)
>>> assert np.allclose(new.data, self.data)
```

classmethod from_imgaug(*kpoi*)

scale(*factor*, *about=None*, *output_dims=None*, *inplace=False*)

Scale coordinates by a factor

Parameters

- **factor** (*float | Tuple[float, float]*) – scale factor as either a scalar or per-dimension tuple.
- **about** (*Tuple | None*) – if unspecified scales about the origin (0, 0), otherwise the rotation is about this point.
- **output_dims** (*Tuple*) – unused in non-raster spatial structures
- **inplace** (*bool*) – if True, modifies data inplace

Returns
modified coordinates

Return type
Coords

Example

```
>>> from kwimage.structs.coords import *  # NOQA
>>> self = Coords.random(10, rng=0)
>>> new = self.scale(10)
>>> assert new.data.max() <= 10
```

```
>>> self = Coords.random(10, rng=0)
>>> self.data = (self.data * 10).astype(int)
>>> new = self.scale(10)
>>> assert new.data.dtype.kind == 'i'
>>> new = self.scale(10.0)
>>> assert new.data.dtype.kind == 'f'
```

translate(*offset*, *output_dims=None*, *inplace=False*)

Shift the coordinates

Parameters

- **offset** (*float | Tuple[float, float]*) – transation offset as either a scalar or a per-dimension tuple.
- **output_dims** (*Tuple*) – unused in non-raster spatial structures
- **inplace** (*bool*) – if True, modifies data inplace

Returns

modified coordinates

Return type

Coords

Example

```
>>> from kwimage.structs.coords import *  # NOQA
>>> self = Coords.random(10, dim=3, rng=0)
>>> new = self.translate(10)
>>> assert new.data.min() >= 10
>>> assert new.data.max() <= 11
>>> Coords.random(3, dim=3, rng=0)
>>> Coords.random(3, dim=3, rng=0).translate((1, 2, 3))
```

rotate(*theta*, *about=None*, *output_dims=None*, *inplace=False*)

Rotate the coordinates about a point.

Parameters

- **theta** (*float*) – rotation angle in radians
- **about** (*Tuple | None*) – if unspecified rotates about the origin (0, 0), otherwise the rotation is about this point.
- **output_dims** (*Tuple*) – unused in non-raster spatial structures
- **inplace** (*bool*) – if True, modifies data inplace

Returns

modified coordinates

Return type
Coords

Todo:

- [ ] Generalized ND Rotations?

References

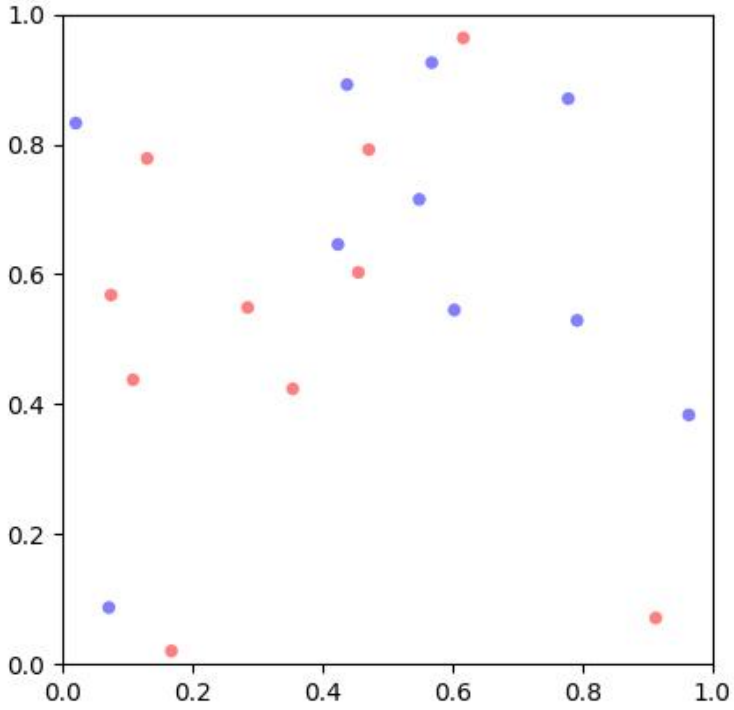
https://math.stackexchange.com/questions/197772/gen-rot-matrix

Example

```
>>> from kwimage.structs.coords import *  # NOQA
>>> self = Coords.random(10, dim=2, rng=0)
>>> theta = np.pi / 2
>>> new = self.rotate(theta)
```

```
>>> # Test rotate agrees with warp
>>> sin_ = np.sin(theta)
>>> cos_ = np.cos(theta)
>>> rot_ = np.array([[cos_, -sin_], [sin_,  cos_]])
>>> new2 = self.warp(rot_)
>>> assert np.allclose(new.data, new2.data)
```

```
>>> #
>>> # Rotate about a custom point
>>> theta = np.pi / 2
>>> new3 = self.rotate(theta, about=(0.5, 0.5))
>>> #
>>> # Rotate about the center of mass
>>> about = self.data.mean(axis=0)
>>> new4 = self.rotate(theta, about=about)
>>> # xdoc: +REQUIRES(--show)
>>> # xdoc: +REQUIRES(module:kwplot)
>>> import kwplot
>>> kwplot.figure(fnum=1, doclf=True)
>>> plt = kwplot.autoplt()
>>> self.draw(radius=0.01, color='blue', alpha=.5, coord_axes=[1, 0], setlim=
↪'grow')
>>> plt.gca().set_aspect('equal')
>>> new3.draw(radius=0.01, color='red', alpha=.5, coord_axes=[1, 0], setlim=
↪'grow')
```



fill(*image*, *value*, *coord_axes=None*, *interp='bilinear'*)

Sets sub-coordinate locations in a grid to a particular value

Parameters

coord_axes (*Tuple*) – specify which image axes each coordinate dim corresponds to. For 2D images, if you are storing r/c data, set to [0,1], if you are storing x/y data, set to [1,0].

Returns

image with coordinates rasterized on it

Return type

ndarray

soft_fill(*image*, *coord_axes=None*, *radius=5*)

Used for drawing keypoint truth in heatmaps

Parameters

coord_axes (*Tuple*) – specify which image axes each coordinate dim corresponds to. For 2D images, if you are storing r/c data, set to [0,1], if you are storing x/y data, set to [1,0].

In other words the i-th entry in coord_axes specifies which row-major spatial dimension the i-th column of a coordinate corresponds to. The index is the coordinate dimension and the value is the axes dimension.

Returns

image with coordinates rasterized on it

Return type

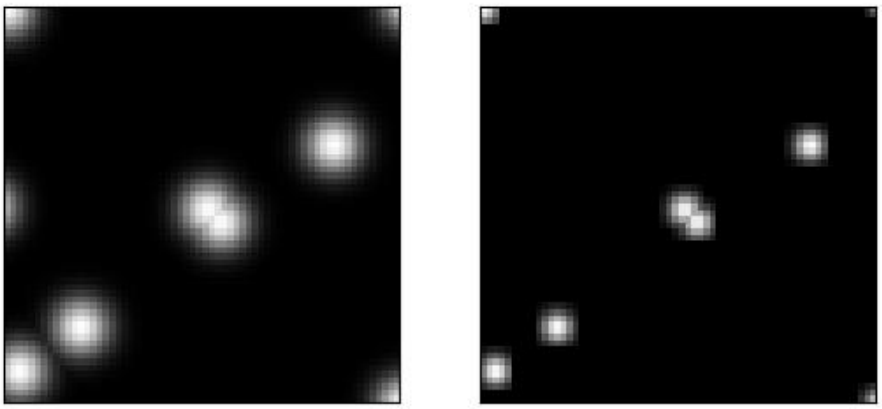
ndarray

References

https://stackoverflow.com/questions/54726703/generating-keypoint-heatmaps-in-tensorflow

Example

```
>>> from kwimage.structs.coords import *  # NOQA
>>> s = 64
>>> self = Coords.random(10, meta={'shape': (s, s)}).scale(s)
>>> # Put points on edges to to verify "edge cases"
>>> self.data[1] = [0, 0]       # top left
>>> self.data[2] = [s, s]       # bottom right
>>> self.data[3] = [0, s + 10]  # bottom left
>>> self.data[4] = [-3, s // 2] # middle left
>>> self.data[5] = [s + 1, -1]  # top right
>>> # Put points in the middle to verify overlap blending
>>> self.data[6] = [32.5, 32.5] # middle
>>> self.data[7] = [34.5, 34.5] # middle
>>> fill_value = 1
>>> coord_axes = [1, 0]
>>> radius = 10
>>> image1 = np.zeros((s, s))
>>> self.soft_fill(image1, coord_axes=coord_axes, radius=radius)
>>> radius = 3.0
>>> image2 = np.zeros((s, s))
>>> self.soft_fill(image2, coord_axes=coord_axes, radius=radius)
>>> # xdoc: +REQUIRES(--show)
>>> # xdoc: +REQUIRES(module:kwplot)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(image1, pnum=(1, 2, 1))
>>> kwplot.imshow(image2, pnum=(1, 2, 2))
```



draw_on(*image=None*, *fill_value=1*, *coord_axes=[1, 0]*, *interp='bilinear'*)

Note: unlike other methods, the defaults assume x/y internal data

Parameters

coord_axes (*Tuple*) – specify which image axes each coordinate dim corresponds to. For 2D images, if you are storing r/c data, set to [0,1], if you are storing x/y data, set to [1,0].

In other words the i-th entry in coord_axes specifies which row-major spatial dimension the i-th column of a coordinate corresponds to. The index is the coordinate dimension and the value is the axes dimension.

Returns

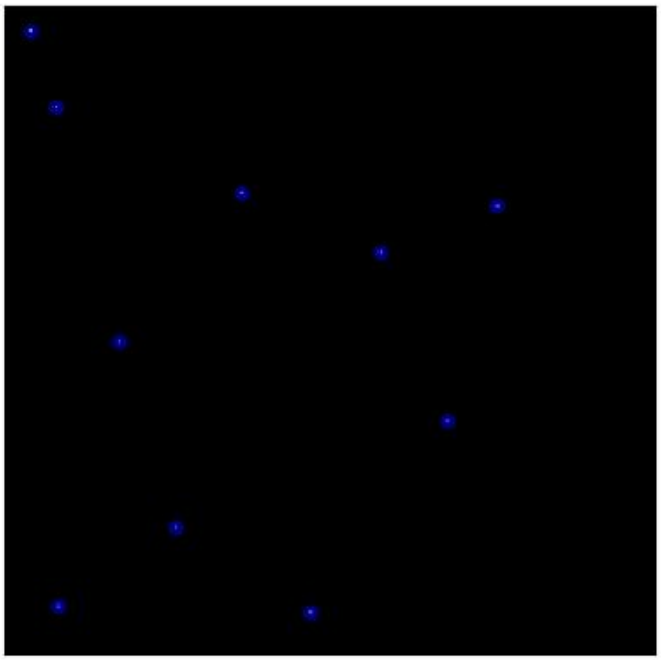
image with coordinates drawn on it

Return type

ndarray

Example

```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> from kwimage.structs.coords import *  # NOQA
>>> s = 256
>>> self = Coords.random(10, meta={'shape': (s, s)}).scale(s)
>>> self.data[0] = [10, 10]
>>> self.data[1] = [20, 40]
>>> image = np.zeros((s, s))
>>> fill_value = 1
>>> image = self.draw_on(image, fill_value, coord_axes=[1, 0], interp='bilinear
↪')
>>> # image = self.draw_on(image, fill_value, coord_axes=[0, 1], interp='nearest
↪')
>>> # image = self.draw_on(image, fill_value, coord_axes=[1, 0], interp='bilinear
↪')
>>> # image = self.draw_on(image, fill_value, coord_axes=[1, 0], interp='nearest
↪')
>>> # xdoc: +REQUIRES(--show)
>>> # xdoc: +REQUIRES(module:kwplot)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.figure(fnum=1, doclf=True)
>>> kwplot.imshow(image)
>>> self.draw(radius=3, alpha=.5, coord_axes=[1, 0])
```



draw(*color='blue'*, *ax=None*, *alpha=None*, *coord_axes=[1, 0]*, *radius=1*, *setlim=False*)

Draw these coordinates via matplotlib

Note: unlike other methods, the defaults assume x/y internal data

Parameters

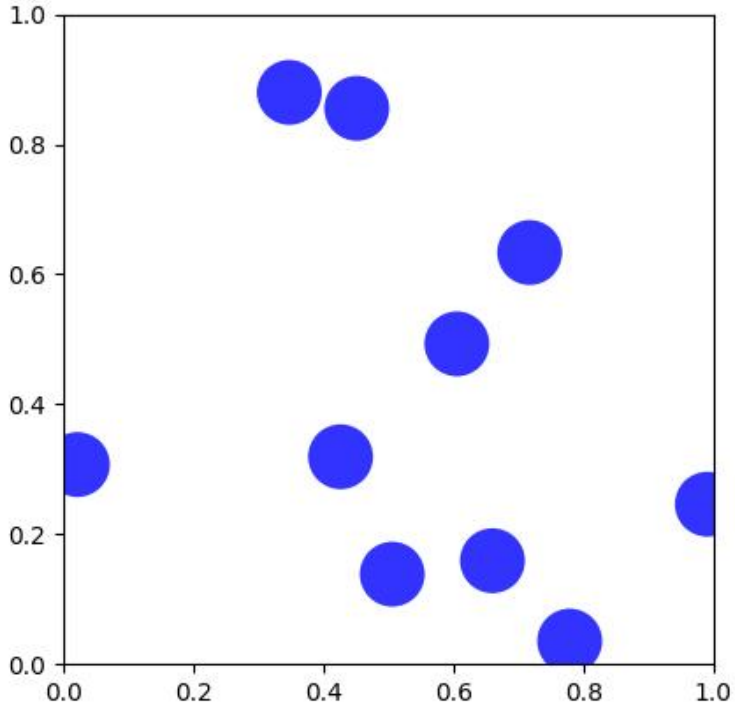
- **setlim** (*bool*) – if True ensures the limits of the axes contains the polygon
- **coord_axes** (*Tuple*) – specify which image axes each coordinate dim corresponds to. For 2D images, if you are storing r/c data, set to [0,1], if you are storing x/y data, set to [1,0].

Returns
drawn matplotlib objects

Return type
List[mpl.collections.PatchCollection]

Example

```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> from kwimage.structs.coords import *  # NOQA
>>> self = Coords.random(10)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> plt = kwplot.autoplt()
>>> self.draw(radius=0.05, alpha=0.8)
>>> plt.gca().set_xlim(0, 1)
>>> plt.gca().set_ylim(0, 1)
>>> plt.gca().set_aspect('equal')
```



kwimage.structs.detections module

Structure for efficient access and modification of bounding boxes with associated scores and class labels. Builds on top of the *kwimage.Boxes* structure.

Also can optionally incorporate *kwimage.PolygonList* for segmentation masks and *kwimage.PointsList* for keypoints.

If you want to visualize boxes and scores you can do this:

```
>>> # Given data
>>> data = np.random.rand(10, 4) * 224
>>> scores = np.random.rand(10,)
>>> class_idxs = np.random.randint(0, 3, size=10)
>>> classes = ['class1', 'class2', 'class3']
>>> #
>>> # Wrap your data with a Detections object
>>> import kwimage
>>> dets = kwimage.Detections(
>>>     boxes=kwimage.Boxes(data, format='xywh'),
>>>     scores=scores,
>>>     class_idxs=class_idxs,
>>>     classes=classes,
>>> )
>>> dets.draw()
>>> import matplotlib.pyplot as plt
```

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```
>>> plt.gca().set_xlim(0, 224)
>>> plt.gca().set_ylim(0, 224)
```

class kwimage.structs.detections.**Detections**(*data=None*, *meta=None*, *datakeys=None*, *metakeys=None*, *checks=True*, ***kwargs*)

Bases: NiceRepr, _DetAlgoMixin, _DetDrawMixin

Container for holding and manipulating multiple detections.

Variables

- **data** (*Dict*) – dictionary containing corresponding lists. The length of each list is the number of detections. This contains the bounding boxes, confidence scores, and class indices. Details of the most common keys and types are as follows:

  boxes (kwimage.Boxes[ArrayLike]): multiple bounding boxes scores (ArrayLike): associated scores class_idxs (ArrayLike): associated class indices segmentations (ArrayLike): segmentations masks for each box, members can be `Mask` or `MultiPolygon`. keypoints (ArrayLike): keypoints for each box. Members should be `Points`.

  Additional custom keys may be specified as long as (a) the values are array-like and the first axis corresponds to the standard data values and (b) are custom keys are listed in the *datakeys* kwargs when constructing the Detections.

- **meta** (*Dict*) – This contains contextual information about the detections. This includes the class names, which can be indexed into via the class indexes.

Example

```
>>> import kwimage
>>> dets = kwimage.Detections(
>>>     # there are expected keys that do not need registration
>>>     boxes=kwimage.Boxes.random(3),
>>>     class_idxs=[0, 1, 1],
>>>     classes=['a', 'b'],
>>>     # custom data attrs must align with boxes
>>>     myattr1=np.random.rand(3),
>>>     myattr2=np.random.rand(3, 2, 8),
>>>     # there are no restrictions on metadata
>>>     mymeta='a custom metadata string',
>>>     # Note that any key not in kwimage.Detections.__datakeys__ or
>>>     # kwimage.Detections.__metakeys__ must be registered at the
>>>     # time of construction.
>>>     datakeys=['myattr1', 'myattr2'],
>>>     metakeys=['mymeta'],
>>>     checks=True,
>>> )
>>> print('dets = {}'.format(dets))
dets = <Detections(3)>
```

copy()

Returns a deep copy of this Detections object

classmethod coerce(*data=None*, ***kwargs*)

The "try-anything to get what I want" constructor

Parameters

- **data**
- ****kwargs** – currently boxes and cnames

Example

```
>>> from kwimage.structs.detections import *  # NOQA
>>> import kwimage
>>> kwargs = dict(
>>>     boxes=kwimage.Boxes.random(4),
>>>     cnames=['a', 'b', 'c', 'c'],
>>> )
>>> data = {}
>>> self = kwimage.Detections.coerce(data, **kwargs)
```

classmethod from_coco_annots(*anns*, *cats=None*, *classes=None*, *kp_classes=None*, *shape=None*, *dset=None*)

Create a Detections object from a list of coco-like annotations.

Parameters

- **anns** (*List[Dict]*) – list of coco-like annotation objects
- **dset** (*kwcoco.CocoDataset*) – if specified, cats, classes, and kp_classes can are ignored.
- **cats** (*List[Dict]*) – coco-format category information. Used only if *dset* is not specified.
- **classes** (*kwcoco.CategoryTree*) – category tree with coco class info. Used only if *dset* is not specified.
- **kp_classes** (*kwcoco.CategoryTree*) – keypoint category tree with coco keypoint class info. Used only if *dset* is not specified.
- **shape** (*tuple*) – shape of parent image

Returns

a detections object

Return type

Detections

Example

```
>>> from kwimage.structs.detections import *  # NOQA
>>> # xdoctest: +REQUIRES(--module:ndsampler)
>>> anns = [{
>>>     'id': 0,
>>>     'image_id': 1,
>>>     'category_id': 2,
>>>     'bbox': [2, 3, 10, 10],
>>>     'keypoints': [4.5, 4.5, 2],
>>>     'segmentation': {
```

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```
>>>         'counts': '_11a04M2O0O20N101N3L_5',
>>>         'size': [20, 20],
>>>     },
>>> }]
>>> dataset = {
>>>     'images': [],
>>>     'annotations': [],
>>>     'categories': [
>>>         {'id': 0, 'name': 'background'},
>>>         {'id': 2, 'name': 'class1', 'keypoints': ['spot']}
>>>     ]
>>> }
>>> #import ndsampler
>>> #dset = ndsampler.CocoDataset(dataset)
>>> cats = dataset['categories']
>>> dets = Detections.from_coco_annots(anns, cats)
```

Example

```
>>> # xdoctest: +REQUIRES(--module:ndsampler)
>>> # Test case with no category information
>>> from kwimage.structs.detections import *  # NOQA
>>> anns = [{
>>>     'id': 0,
>>>     'image_id': 1,
>>>     'category_id': None,
>>>     'bbox': [2, 3, 10, 10],
>>>     'prob': [.1, .9],
>>> }]
>>> cats = [
>>>     {'id': 0, 'name': 'background'},
>>>     {'id': 2, 'name': 'class1'}
>>> ]
>>> dets = Detections.from_coco_annots(anns, cats)
```

Example

```
>>> import kwimage
>>> # xdoctest: +REQUIRES(--module:ndsampler)
>>> import ndsampler
>>> sampler = ndsampler.CocoSampler.demo('photos')
>>> iminfo, anns = sampler.load_image_with_annots(1)
>>> shape = iminfo['imdata'].shape[0:2]
>>> kp_classes = sampler.dset.keypoint_categories()
>>> dets = kwimage.Detections.from_coco_annots(
>>>     anns, sampler.dset.dataset['categories'], sampler.catgraph,
>>>     kp_classes, shape=shape)
```

to_coco(*cname_to_cat=None*, *style='orig'*, *image_id=None*, *dset=None*)

Converts this set of detections into coco-like annotation dictionaries.

Note: Not all aspects of the MS-COCO format can be accurately represented, so some liberties are taken. The MS-COCO standard defines that annotations should specifiy a category_id field, but in some cases this information is not available so we will populate a 'category_name' field if possible and in the worst case fall back to 'category_index'.

Additionally, detections may contain additional information beyond the MS-COCO standard, and this information (e.g. weight, prob, score) is added as forign fields.

Parameters

- **cname_to_cat** – currently ignored.
- **style** (*str*) – either 'orig' (for the original coco format) or 'new' for the more general kwcoco-style coco format. Defaults to 'orig'
- **image_id** (*int*) – if specified, populates the image_id field of each image.
- **dset** (*kwcoco.CocoDataset | None*) – if specified, attempts to populate the category_id field to be compatible with this coco dataset.

Yields

dict – coco-like annotation structures

Example

```
>>> # xdoctest: +REQUIRES(module:ndsampler)
>>> from kwimage.structs.detections import *
>>> self = Detections.demo()[0]
>>> cname_to_cat = None
>>> list(self.to_coco())
```

property boxes

property class_idxs

property scores

typically only populated for predicted detections

property probs

typically only populated for predicted detections

property weights

typically only populated for groundtruth detections

property classes

num_boxes()

warp(*transform*, *input_dims=None*, *output_dims=None*, *inplace=False*)

Spatially warp the detections.

Parameters

- **transform** (*kwimage.Affine | ndarray | Callable | Any*) – Something coercable to a transform. Usually a kwimage.Affine object
- **input_dims** (*Tuple[int, int]*) – shape of the expected input canvas

- **output_dims** (*Tuple[int, int]*) – shape of the expected output canvas
- **inplace** (*bool*) – if true operate inplace

Returns
the warped detections object

Return type
Detections

Example

```
>>> import skimage
>>> transform = skimage.transform.AffineTransform(scale=(2, 3), translation=(4,␣
↪5))
>>> self = Detections.random(2)
>>> new = self.warp(transform)
>>> assert new.boxes == self.boxes.warp(transform)
>>> assert new != self
```

scale(*factor*, *output_dims=None*, *inplace=False*)

Spatially scale the detections.

Example

```
>>> import skimage
>>> transform = skimage.transform.AffineTransform(scale=(2, 3), translation=(4,␣
↪5))
>>> self = Detections.random(2)
>>> new = self.warp(transform)
>>> assert new.boxes == self.boxes.warp(transform)
>>> assert new != self
```

translate(*offset*, *output_dims=None*, *inplace=False*)

Spatially translate the detections.

Example

```
>>> import skimage
>>> self = Detections.random(2)
>>> new = self.translate(10)
```

classmethod concatenate(*dets*)

Parameters
boxes (*Sequence[Detections]*) – list of detections to concatenate

Returns
stacked detections

Return type
Detections

Example

```
>>> self = Detections.random(2)
>>> other = Detections.random(3)
>>> dets = [self, other]
>>> new = Detections.concatenate(dets)
>>> assert new.num_boxes() == 5
```

```
>>> self = Detections.random(2, segmentations=True)
>>> other = Detections.random(3, segmentations=True)
>>> dets = [self, other]
>>> new = Detections.concatenate(dets)
>>> assert new.num_boxes() == 5
```

argsort(*reverse=True*)

Sorts detection indices by descending (or ascending) scores

Returns
sorted indices torch.Tensor: sorted indices if using torch backends

Return type
ndarray[Shape['*'], Integer]

sort(*reverse=True*)

Sorts detections by descending (or ascending) scores

Returns
sorted copy of self

Return type
kwimage.structs.Detections

compress(*flags*, *axis=0*)

Returns a subset where corresponding locations are True.

Parameters
flags (*ndarray[Any, Bool] | torch.Tensor*) – mask marking selected items

Returns
subset of self

Return type
kwimage.structs.Detections

CommandLine

```
xdoctest -m kwimage.structs.detections Detections.compress
```

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> import kwimage
>>> dets = kwimage.Detections.random(keypoints='dense')
>>> flags = np.random.rand(len(dets)) > 0.5
>>> subset = dets.compress(flags)
>>> assert len(subset) == flags.sum()
>>> subset = dets.tensor().compress(flags)
>>> assert len(subset) == flags.sum()
```

take(*indices*, *axis=0*)

Returns a subset specified by indices

Parameters
indices (*ndarray[Any, Integer]*) – indices to select

Returns
subset of self

Return type
kwimage.structs.Detections

Example

```
>>> import kwimage
>>> dets = kwimage.Detections(boxes=kwimage.Boxes.random(10))
>>> subset = dets.take([2, 3, 5, 7])
>>> assert len(subset) == 4
>>> # xdoctest: +REQUIRES(module:torch)
>>> subset = dets.tensor().take([2, 3, 5, 7])
>>> assert len(subset) == 4
```

property device

If the backend is torch returns the data device, otherwise None

is_tensor()

is the backend fueled by torch?

is_numpy()

is the backend fueled by numpy?

numpy()

Converts tensors to numpy. Does not change memory if possible.

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> self = Detections.random(3).tensor()
>>> newself = self.numpy()
>>> self.scores[0] = 0
>>> assert newself.scores[0] == 0
>>> self.scores[0] = 1
>>> assert self.scores[0] == 1
>>> self.numpy().numpy()
```

property dtype

tensor(*device=NoParam*)

Converts numpy to tensors. Does not change memory if possible.

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> from kwimage.structs.detections import *
>>> self = Detections.random(3)
>>> newself = self.tensor()
>>> self.scores[0] = 0
>>> assert newself.scores[0] == 0
>>> self.scores[0] = 1
>>> assert self.scores[0] == 1
>>> self.tensor().tensor()
```

classmethod demo()

classmethod random(*num=10*, *scale=1.0*, *classes=3*, *keypoints=False*, *segmentations=False*, *tensor=False*, *rng=None*)

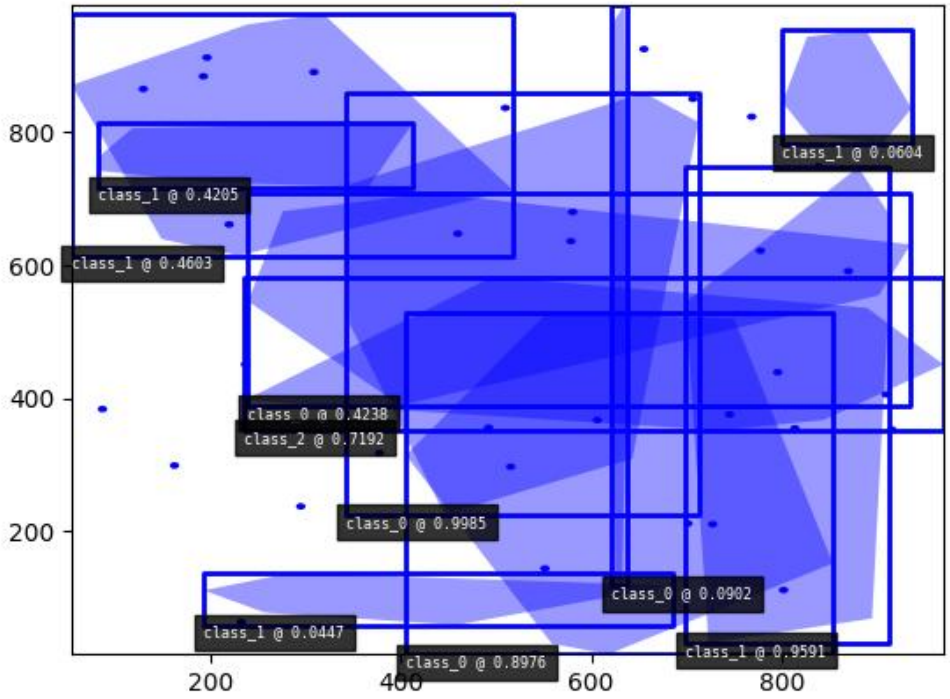
Creates dummy data, suitable for use in tests and benchmarks

Parameters

- **num** (*int*) – number of boxes
- **scale** (*float | tuple*) – bounding image size. Defaults to 1.0
- **classes** (*int | Sequence*) – list of class labels or number of classes
- **keypoints** (*bool*) – if True include random keypoints for each box. Defaults to False.
- **segmentations** (*bool*) – if True include random segmentations for each box. Defaults to False.
- **tensor** (*bool*) – determines backend. DEPRECATED. Call `.tensor()` on resulting object instead.
- **rng** (*np.random.RandomState*) – random state

Example

```
>>> import kwimage
>>> dets = kwimage.Detections.random(keypoints='jagged')
>>> dets.data['keypoints'].data[0].data
>>> dets.data['keypoints'].meta
>>> dets = kwimage.Detections.random(keypoints='dense')
>>> dets = kwimage.Detections.random(keypoints='dense', segmentations=True).
↪scale(1000)
>>> # xdoctest:+REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> dets.draw(setlim=True)
```



Example

```
>>> import kwimage
>>> dets = kwimage.Detections.random(
>>>     keypoints='jagged', segmentations=True, rng=0).scale(1000)
>>> print('dets = {}'.format(dets))
dets = <Detections(10)>
>>> dets.data['boxes'].quantize(inplace=True)
>>> print('dets.data = {}'.format(ub.repr2(
>>>     dets.data, nl=1, with_dtype=False, strvals=True)))
```

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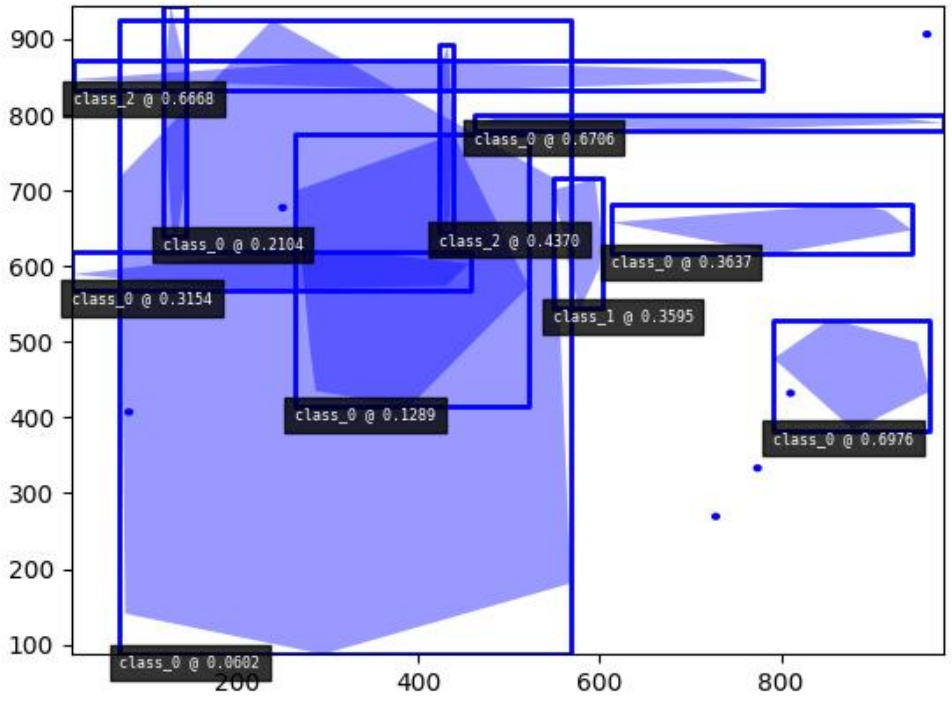
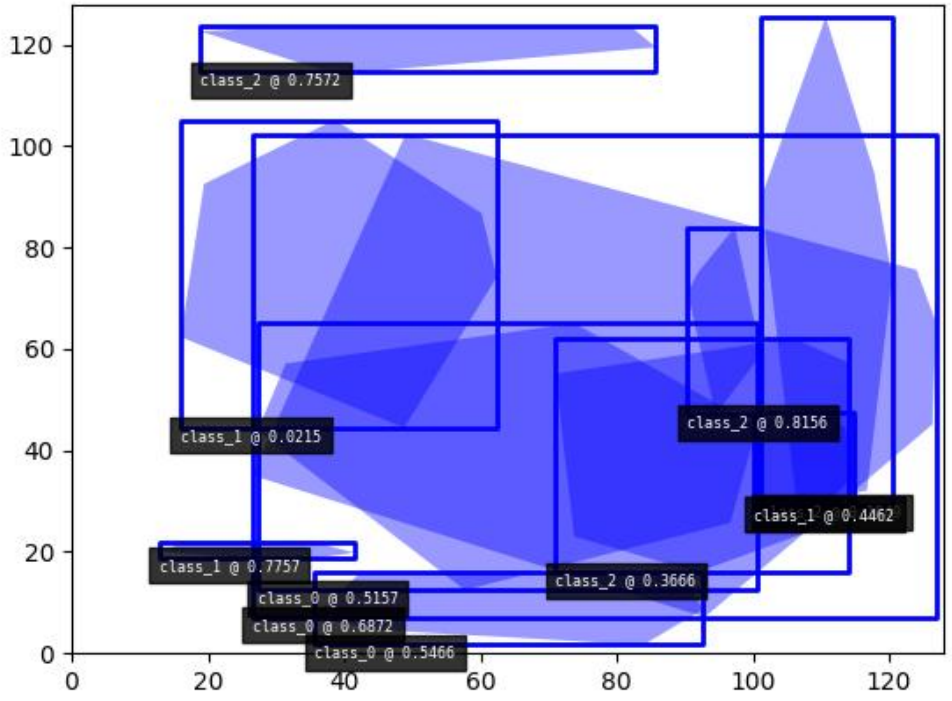
```
dets.data = {
    'boxes': <Boxes(xywh,
                 array([[548, 544,  55, 172],
                        [423, 645,  15, 247],
                        [791, 383, 173, 146],
                        [ 71,  87, 498, 839],
                        [ 20, 832, 759,  39],
                        [461, 780, 518,  20],
                        [118, 639,  26, 306],
                        [264, 414, 258, 361],
                        [ 18, 568, 439,  50],
                        [612, 616, 332,  66]], dtype=int32))>,
    'class_idxs': [1, 2, 0, 0, 2, 0, 0, 0, 0, 0],
    'keypoints': <PointsList(n=10)>,
    'scores': [0.3595079 , 0.43703195, 0.6976312 , 0.06022547, 0.66676672, 0.
↪67063787,0.21038256, 0.1289263 , 0.31542835, 0.36371077],
    'segmentations': <SegmentationList(n=10)>,
}
>>> # xdoctest:+REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> dets.draw(setlim=True)
```



Example

```
>>> # Boxes position/shape within 0-1 space should be uniform.
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> fig = kwplot.figure(fnum=1, doclf=True)
>>> fig.gca().set_xlim(0, 128)
>>> fig.gca().set_ylim(0, 128)
>>> import kwimage
>>> kwimage.Detections.random(num=10, segmentations=True).scale(128).draw()
```



kwimage.structs.heatmap module

Todo:

- [ ] Remove doctest dependency on ndsampler?
- **[ ] Remove the datakeys that tries to define what heatmap should represent**
  (e.g. class_probs, keypoints, etc...) and instead just focus on a data structure that stores a [C, H, W] or [H, W] tensor?

CommandLine

```
xdoctest -m ~/code/kwimage/kwimage/structs/heatmap.py __doc__
```

Example

```
>>> # xdoctest: +REQUIRES(module:ndsampler)
>>> # xdoctest: +REQUIRES(--mask)
>>> from kwimage.structs.heatmap import *  # NOQA
>>> import kwimage
>>> import ndsampler
>>> sampler = ndsampler.CocoSampler.demo('shapes')
>>> iminfo, anns = sampler.load_image_with_annots(1)
>>> image = iminfo['imdata']
>>> input_dims = image.shape[0:2]
>>> kp_classes = sampler.dset.keypoint_categories()
>>> dets = kwimage.Detections.from_coco_annots(
>>>     anns, sampler.dset.dataset['categories'],
>>>     sampler.catgraph, kp_classes, shape=input_dims)
>>> bg_size = [100, 100]
>>> heatmap = dets.rasterize(bg_size, input_dims, soften=2)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.figure(fnum=1, doclf=True)
>>> kwplot.imshow(image)
>>> heatmap.draw(invert=True, kpts=[0, 1, 2, 3, 4])
```

Example

```
>>> # xdoctest: +REQUIRES(module:ndsampler)
>>> # xdoctest: +REQUIRES(--mask)
>>> from kwimage.structs.heatmap import *  # NOQA
>>> from kwimage.structs.detections import _dets_to_fcmaps
>>> import kwimage
>>> import ndsampler
>>> sampler = ndsampler.CocoSampler.demo('shapes')
>>> iminfo, anns = sampler.load_image_with_annots(1)
>>> image = iminfo['imdata']
>>> input_dims = image.shape[0:2]
>>> kp_classes = sampler.dset.keypoint_categories()
>>> dets = kwimage.Detections.from_coco_annots(
>>>     anns, sampler.dset.dataset['categories'],
>>>     sampler.catgraph, kp_classes, shape=input_dims)
>>> bg_size = [100, 100]
>>> bg_idxs = sampler.catgraph.index('background')
>>> fcn_target = _dets_to_fcmaps(dets, bg_size, input_dims, bg_idxs)
>>> fcn_target.keys()
>>> print('fcn_target: ' + ub.repr2(ub.map_vals(lambda x: x.shape, fcn_target), nl=1))
>>> # xdoctest: +REQUIRES(--show)
```

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```
>>> import kwplot
>>> kwplot.autompl()
>>> size_mask = fcn_target['size']
>>> dxdy_mask = fcn_target['dxdy']
>>> cidx_mask = fcn_target['cidx']
>>> kpts_mask = fcn_target['kpts']
>>> def _vizmask(dxdy_mask):
>>>     dx, dy = dxdy_mask
>>>     mag = np.sqrt(dx ** 2 + dy ** 2)
>>>     mag /= (mag.max() + 1e-9)
>>>     mask = (cidx_mask != 0).astype(np.float32)
>>>     angle = np.arctan2(dy, dx)
>>>     orimask = kwplot.make_orimask(angle, mask, alpha=mag)
>>>     vecmask = kwplot.make_vector_field(
>>>         dx, dy, stride=4, scale=0.1, thickness=1, tipLength=.2,
>>>         line_type=16)
>>>     return [vecmask, orimask]
>>> vecmask, orimask = _vizmask(dxdy_mask)
>>> raster = kwimage.overlay_alpha_layers(
>>>     [vecmask, orimask, image], keepalpha=False)
>>> raster = dets.draw_on((raster * 255).astype(np.uint8),
>>>                       labels=True, alpha=None)
>>> kwplot.imshow(raster)
>>> kwplot.show_if_requested()
```

class kwimage.structs.heatmap.**Heatmap**(*data=None*, *meta=None*, ***kwargs*)

Bases: Spatial, _HeatmapDrawMixin, _HeatmapWarpMixin, _HeatmapAlgoMixin

Keeps track of a downscaled heatmap and how to transform it to overlay the original input image. Heatmaps generally are used to estimate class probabilites at each pixel. This data struction additionally contains logic to augment pixel with offset (dydx) and scale (diamter) information.

Variables

- **data** (*Dict[str, ArrayLike]*) – dictionary containing spatially aligned heatmap data. Valid keys are as follows.

  class_probs (ArrayLike[C, H, W] | ArrayLike[C, D, H, W]):
  A probability map for each class. C is the number of classes.

  offset (ArrayLike[2, H, W] | ArrayLike[3, D, H, W], optional):
  object center position offset in y,x / t,y,x coordinates

  diamter (ArrayLike[2, H, W] | ArrayLike[3, D, H, W], optional):
  object bounding box sizes in h,w / d,h,w coordinates

  keypoints (ArrayLike[2, K, H, W] | ArrayLike[3, K, D, H, W], optional):
  y/x offsets for K different keypoint classes

- **meta** (*Dict[str, object]*) – dictionary containing miscellanious metadata about the heatmap data. Valid keys are as follows.

  img_dims (Tuple[H, W] | Tuple[D, H, W]):
  original image dimension

  tf_data_to_image (skimage.transform._geometric.GeometricTransform):
  transformation matrix (typically similarity or affine) that projects the given, heatmap onto

the image dimensions such that the image and heatmap are spatially aligned.

classes (List[str] | ndsampler.CategoryTree):
information about which index in `data['class_probs']` corresponds to which semantic class.

- **dims** (*Tuple*) – dimensions of the heatmap (See `image_dims`) for the original image dimensions.
- ****kwargs** – any key that is accepted by the *data* or *meta* dictionaries can be specified as a keyword argument to this class and it will be properly placed in the appropriate internal dictionary.

CommandLine

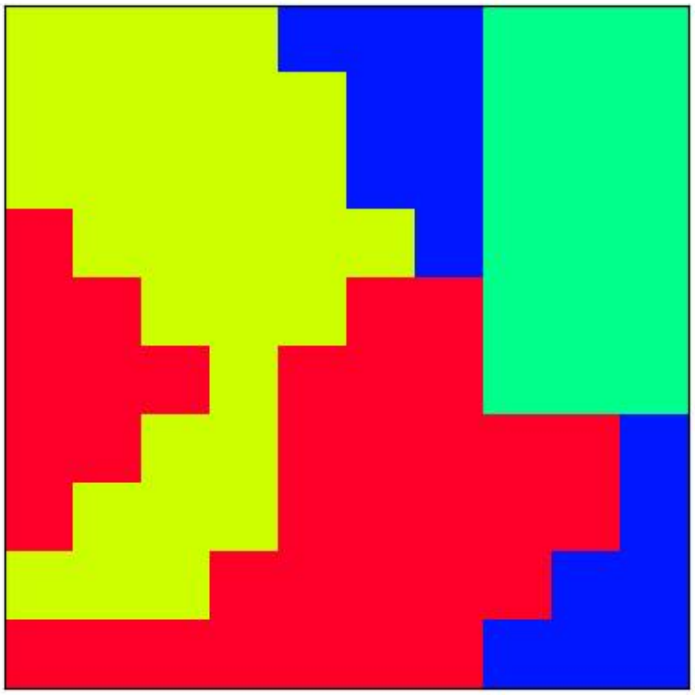
```
xdoctest -m ~/code/kwimage/kwimage/structs/heatmap.py Heatmap --show
```

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> from kwimage.structs.heatmap import *  # NOQA
>>> import kwimage
>>> class_probs = kwimage.grab_test_image(dsize=(32, 32), space='gray')[None, ...,␣
↪0] / 255.0
>>> img_dims = (220, 220)
>>> tf_data_to_img = skimage.transform.AffineTransform(translation=(-18, -18),␣
↪scale=(8, 8))
>>> self = Heatmap(class_probs=class_probs, img_dims=img_dims,
>>>                tf_data_to_img=tf_data_to_img)
>>> aligned = self.upscale()
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(aligned[0])
>>> kwplot.show_if_requested()
```

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> import kwimage
>>> self = Heatmap.random()
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> self.draw()
```



property shape

property bounds

property dims

space-time dimensions of this heatmap

is_numpy()

is_tensor()

classmethod random(*dims=(10, 10)*, *classes=3*, *diameter=True*, *offset=True*, *keypoints=False*, *img_dims=None*, *dets=None*, *nblips=10*, *noise=0.0*, *smooth_k=3*, *rng=None*, *ensure_background=True*)

Creates dummy data, suitable for use in tests and benchmarks

Parameters

- **dims** (*Tuple[int, int]*) – dimensions of the heatmap
- **classes** (*int | List[str] | kwcoco.CategoryTree*) – foreground classes
- **diameter** (*bool*) – if True, include a "diameter" heatmap
- **offset** (*bool*) – if True, include an "offset" heatmap
- **keypoints** (*bool*)
- **smooth_k** (*int*) – kernel size for gaussian blur to smooth out the heatmaps.

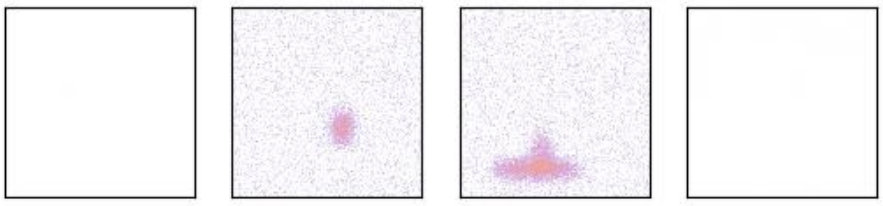
- **img_dims** (*Tuple*) – dimensions of an upscaled image the heatmap corresponds to. (This should be removed and simply handled with a transform

  in the future).

Returns
Heatmap

Example

```
>>> from kwimage.structs.heatmap import *  # NOQA
>>> self = Heatmap.random((128, 128), img_dims=(200, 200),
>>>     classes=3, nblips=10, rng=0, noise=0.1)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(self.colorize(0, imgspace=0), fnum=1, pnum=(1, 4, 1), doclf=1)
>>> kwplot.imshow(self.colorize(1, imgspace=0), fnum=1, pnum=(1, 4, 2))
>>> kwplot.imshow(self.colorize(2, imgspace=0), fnum=1, pnum=(1, 4, 3))
>>> kwplot.imshow(self.colorize(3, imgspace=0), fnum=1, pnum=(1, 4, 4))
```



Example

```
>>> # xdoctest: +REQUIRES(module:ndsampler)
>>> import kwimage
>>> self = kwimage.Heatmap.random(dims=(50, 200), dets='coco',
>>>                               keypoints=True)
>>> image = np.zeros(self.img_dims)
>>> # xdoctest: +REQUIRES(module:kwplot)
>>> toshow = self.draw_on(image, 1, vecs=True, kpts=0, with_alpha=0.85)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.figure(fnum=1, doclf=True)
>>> kwplot.imshow(toshow)
```

property class_probs

property offset

property diameter

property img_dims

property tf_data_to_img

property classes

numpy()

Converts underlying data to numpy arrays

tensor(*device=NoParam*)

Converts underlying data to torch tensors

kwimage.structs.heatmap.**smooth_prob**(*prob*, *k=3*, *inplace=False*, *eps=1e-09*)

Smooths the probability map, but preserves the magnitude of the peaks.

Note: even if inplace is true, we still need to make a copy of the input array, however, we do ensure that it is cleaned up before we leave the function scope.

sigma=0.8 @ k=3, sigma=1.1 @ k=5, sigma=1.4 @ k=7

---

kwimage.structs.mask module

Data structure for Binary Masks

Structure for efficient encoding of per-annotation segmentation masks Based on efficient cython/C code in the cocoapi [CocoStuffPyx] [CocoStuffC] [CocoStuffH] [CocoStuffPy].

References

Goals:

The goal of this file is to create a datastructure that lets the developer seemlessly convert between: (1) raw binary uint8 masks (2) memory-efficient compressed run-length-encodings of binary segmentation masks. (3) convex polygons (4) convex hull polygons (5) bounding box

It is not there yet, and the API is subject to change in order to better accomplish these goals.

Note: IN THIS FILE ONLY: size corresponds to a h/w tuple to be compatible with the coco semantics. Everywhere else in this repo, size uses opencv semantics which are w/h.

---

class kwimage.structs.mask.**Mask**(*data=None*, *format=None*)

Bases: NiceRepr, _MaskConversionMixin, _MaskConstructorMixin, _MaskTransformMixin, _MaskDrawMixin

Manages a single segmentation mask and can convert to and from multiple formats including:

- bytes_rle - byte encoded run length encoding
- array_rle - raw run length encoding
- c_mask - c-style binary mask
- f_mask - fortran-style binary mask

Example

```
>>> # xdoc: +REQUIRES(--mask)
>>> # a ms-coco style compressed bytes rle segmentation
>>> segmentation = {'size': [5, 9], 'counts': ';?1B10O30O4'}
>>> mask = Mask(segmentation, 'bytes_rle')
>>> # convert to binary numpy representation
>>> binary_mask = mask.to_c_mask().data
>>> print(ub.repr2(binary_mask.tolist(), nl=1, nobr=1))
[0, 0, 0, 1, 1, 1, 1, 1, 0],
[0, 0, 1, 1, 1, 0, 0, 0, 0],
[0, 0, 1, 1, 1, 1, 1, 1, 0],
[0, 0, 1, 1, 1, 0, 1, 1, 0],
[0, 0, 1, 1, 1, 0, 1, 1, 0],
```

property dtype

classmethod random(*rng=None*, *shape=(32, 32)*)

Create a random binary mask object

Parameters

- **rng** (*int | RandomState | None*) – the random seed
- **shape** (*Tuple[int, int]*) – the height / width of the returned mask

Returns

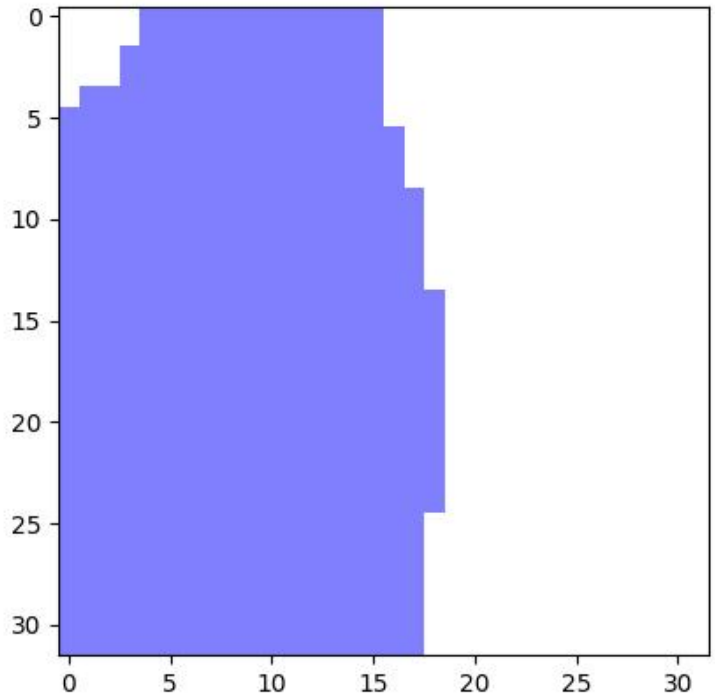
the random mask

Return type

Mask

Example

```
>>> import kwimage
>>> mask = kwimage.Mask.random()
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> mask.draw()
>>> kwplot.show_if_requested()
```



classmethod demo()

Demo mask with holes and disjoint shapes

Returns
the demo mask

Return type
Mask

classmethod from_text(*text*, *zero_chr='.'*, *shape=None*, *has_border=False*)

Construct a mask from a text art representation

Parameters

- **text** (*str*) – the text representing a mask
- **zero_chr** (*str*) – the character that represents a zero
- **shape** (*None | Tuple[int, int]*) – if specified force a specific height / width, otherwise the character extent determines this.

- **has_border** (*bool*) – if True, assume the characters at the edge are representing a border and remove them.

Example

```
>>> import kwimage
>>> import ubelt as ub
>>> text = ub.indent(ub.codeblock(
>>>     '''
>>>     ooo
>>>     ooo
>>>     ooooo
>>>         o
>>>     '''))
>>> mask = kwimage.Mask.from_text(text, zero_chr=' ')
>>> print(mask.data)
[[0 0 0 0 1 1 1 0 0]
 [0 0 0 0 1 1 1 0 0]
 [0 0 0 0 1 1 1 1 1]
 [0 0 0 0 0 0 0 0 1]]
```

Example

```
>>> import kwimage
>>> import ubelt as ub
>>> text = ub.codeblock(
>>>     '''
>>>     +------------+
>>>     |            |
>>>     |    ooo     |
>>>     |    ooo     |
>>>     |    ooooo   |
>>>     |        o   |
>>>     |            |
>>>     +------------+
>>>     ''')
>>> mask = kwimage.Mask.from_text(text, has_border=True, zero_chr=' ')
>>> print(mask.data)
[[0 0 0 0 0 0 0 0 0 0 0 0]
 [0 0 0 0 1 1 1 0 0 0 0 0]
 [0 0 0 0 1 1 1 0 0 0 0 0]
 [0 0 0 0 1 1 1 1 1 0 0 0]
 [0 0 0 0 0 0 0 0 1 0 0 0]
 [0 0 0 0 0 0 0 0 0 0 0 0]]
```

copy()

Performs a deep copy of the mask data

Returns

the copied mask

Return type
Mask

Example

```
>>> self = Mask.random(shape=(8, 8), rng=0)
>>> other = self.copy()
>>> assert other.data is not self.data
```

union(**others*)

This can be used as a staticmethod or an instancemethod

Parameters
***others** – multiple input masks to union

Returns
the unioned mask

Return type
Mask

Example

```
>>> # xdoc: +REQUIRES(--mask)
>>> from kwimage.structs.mask import *  # NOQA
>>> masks = [Mask.random(shape=(8, 8), rng=i) for i in range(2)]
>>> mask = Mask.union(*masks)
>>> print(mask.area)
>>> masks = [m.to_c_mask() for m in masks]
>>> mask = Mask.union(*masks)
>>> print(mask.area)
```

```
>>> masks = [m.to_bytes_rle() for m in masks]
>>> mask = Mask.union(*masks)
>>> print(mask.area)
```

intersection(**others*)

This can be used as a staticmethod or an instancemethod

Parameters
***others** – multiple input masks to intersect

Returns
the intersection of the masks

Return type
Mask

Example

```
>>> n = 3
>>> masks = [Mask.random(shape=(8, 8), rng=i) for i in range(n)]
>>> items = masks
>>> mask = Mask.intersection(*masks)
>>> areas = [item.area for item in items]
>>> print('areas = {!r}'.format(areas))
>>> print(mask.area)
>>> print(Mask.intersection(*masks).area / Mask.union(*masks).area)
```

property shape

property area

Returns the number of non-zero pixels

Returns
the number of non-zero pixels

Return type
int

Example

```
>>> self = Mask.demo()
>>> self.area
150
```

get_patch()

Extract the patch with non-zero data

Example

```
>>> # xdoc: +REQUIRES(--mask)
>>> from kwimage.structs.mask import *  # NOQA
>>> self = Mask.random(shape=(8, 8), rng=0)
>>> self.get_patch()
```

get_xywh()

Gets the bounding xywh box coordinates of this mask

Returns

x, y, w, h: Note we dont use a Boxes object because
a general singular version does not yet exist.

Return type
ndarray

Example

```
>>> # xdoc: +REQUIRES(--mask)
>>> self = Mask.random(shape=(8, 8), rng=0)
>>> self.get_xywh().tolist()
>>> self = Mask.random(rng=0).translate((10, 10))
>>> self.get_xywh().tolist()
```

Example

```
>>> # test empty case
>>> import kwimage
>>> self = kwimage.Mask(np.empty((0, 0), dtype=np.uint8), format='c_mask')
>>> assert self.get_xywh().tolist() == [0, 0, 0, 0]
```

bounding_box()

Returns an axis-aligned bounding box for this mask

Returns
kwimage.Boxes

get_polygon()

DEPRECATED: USE to_multi_polygon

Returns a list of (x,y)-coordinate lists. The length of the list is equal to the number of disjoint regions in the mask.

Returns

polygon around each connected component of the
mask. Each ndarray is an Nx2 array of xy points.

Return type
List[ndarray]

Note: The returned polygon may not surround points that are only one pixel thick.

Example

```
>>> # xdoc: +REQUIRES(--mask)
>>> from kwimage.structs.mask import *  # NOQA
>>> self = Mask.random(shape=(8, 8), rng=0)
>>> polygons = self.get_polygon()
>>> print('polygons = ' + ub.repr2(polygons))
>>> polygons = self.get_polygon()
>>> self = self.to_bytes_rle()
>>> other = Mask.from_polygons(polygons, self.shape)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> image = np.ones(self.shape)
```

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```
>>> image = self.draw_on(image, color='blue')
>>> image = other.draw_on(image, color='red')
>>> kwplot.imshow(image)
```

to_mask(*dims=None*)

Converts to a mask object (which does nothing because this already is mask object!)

Returns
kwimage.Mask

to_boxes()

Returns the bounding box of the mask.

Returns
kwimage.Boxes

to_multi_polygon(*pixels_are='points'*)

Returns a MultiPolygon object fit around this raster including disjoint pieces and holes.

Parameters
pixel_are (*str*) – Can either be "points" or "areas".

If pixels are "points", the we treat each pixel (i, j) as a single infinitely small point at (i, j). As such, some polygons may have zero area.

If pixels are "areas", then each pixel (i, j) represents a square with coordinates ([i - 0.5, j - 0.5], [i + 0.5, j - 0.5], [i + 0.5, j + 0.5], and [i - 0.5, j + 0.5]). Must have rasterio installed to use this method.

Returns
vectorized representation

Return type
kwimage.MultiPolygon

Note: The OpenCV (and thus this function) coordinate system places coordinates at the center of pixels, and the polygon is traced tightly around these coordinates. A single pixel is not considered to have any width, so polygon edges will directly trace through the centers of pixels, and in the case where an object is only 1 pixel thick, this will produce a polygon that is not a valid shapely polygon.

Todo:

- [x] add a flag where polygons consider pixels to have width and the resulting polygon is traced around the pixel edges, not the pixel centers.
- [ ] Polygons and Masks should keep track of what "pixels_are"

Example

```
>>> # xdoc: +REQUIRES(--mask)
>>> from kwimage.structs.mask import *  # NOQA
>>> self = Mask.demo()
>>> self = self.scale(5)
>>> multi_poly = self.to_multi_polygon()
>>> # xdoc: +REQUIRES(module:kwplot)
>>> # xdoc: +REQUIRES(--show)
>>> self.draw(color='red')
>>> multi_poly.scale(1.1).draw(color='blue')
```

```
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> image = np.ones(self.shape)
>>> image = self.draw_on(image, color='blue')
>>> #image = other.draw_on(image, color='red')
>>> kwplot.imshow(image)
>>> multi_poly.draw()
```

Example

```
>>> # Test empty cases
>>> import kwimage
>>> mask0 = kwimage.Mask(np.zeros((0, 0), dtype=np.uint8), format='c_mask')
>>> mask1 = kwimage.Mask(np.zeros((1, 1), dtype=np.uint8), format='c_mask')
>>> mask2 = kwimage.Mask(np.zeros((2, 2), dtype=np.uint8), format='c_mask')
>>> mask3 = kwimage.Mask(np.zeros((3, 3), dtype=np.uint8), format='c_mask')
>>> pixels_are = 'points'
>>> poly0 = mask0.to_multi_polygon(pixels_are=pixels_are)
>>> poly1 = mask1.to_multi_polygon(pixels_are=pixels_are)
>>> poly2 = mask2.to_multi_polygon(pixels_are=pixels_are)
>>> poly3 = mask3.to_multi_polygon(pixels_are=pixels_are)
>>> assert len(poly0) == 0
>>> assert len(poly1) == 0
>>> assert len(poly2) == 0
>>> assert len(poly3) == 0
>>> # xdoctest: +REQUIRES(module:rasterio)
>>> pixels_are = 'areas'
>>> poly0 = mask0.to_multi_polygon(pixels_are=pixels_are)
>>> poly1 = mask1.to_multi_polygon(pixels_are=pixels_are)
>>> poly2 = mask2.to_multi_polygon(pixels_are=pixels_are)
>>> poly3 = mask3.to_multi_polygon(pixels_are=pixels_are)
>>> assert len(poly0) == 0
>>> assert len(poly1) == 0
>>> assert len(poly2) == 0
>>> assert len(poly3) == 0
```

Example

```
>>> # Test full ones cases
>>> import kwimage
>>> mask1 = kwimage.Mask(np.ones((1, 1), dtype=np.uint8), format='c_mask')
>>> mask2 = kwimage.Mask(np.ones((2, 2), dtype=np.uint8), format='c_mask')
>>> mask3 = kwimage.Mask(np.ones((3, 3), dtype=np.uint8), format='c_mask')
>>> pixels_are = 'points'
>>> poly1 = mask1.to_multi_polygon(pixels_are=pixels_are)
>>> poly2 = mask2.to_multi_polygon(pixels_are=pixels_are)
>>> poly3 = mask3.to_multi_polygon(pixels_are=pixels_are)
>>> assert np.all(poly1.to_mask(mask1.shape).data == 1)
>>> assert np.all(poly2.to_mask(mask2.shape).data == 1)
>>> assert np.all(poly3.to_mask(mask3.shape).data == 1)
>>> # xdoctest: +REQUIRES(module:rasterio)
>>> pixels_are = 'areas'
>>> poly1 = mask1.to_multi_polygon(pixels_are=pixels_are)
>>> poly2 = mask2.to_multi_polygon(pixels_are=pixels_are)
>>> poly3 = mask3.to_multi_polygon(pixels_are=pixels_are)
>>> assert np.all(poly1.to_mask(mask1.shape).data == 1)
>>> assert np.all(poly2.to_mask(mask2.shape).data == 1)
>>> assert np.all(poly3.to_mask(mask3.shape).data == 1)
```

Example

```
>>> # Corner case, only two pixels are on
>>> import kwimage
>>> self = kwimage.Mask(np.zeros((768, 768), dtype=np.uint8), format='c_mask')
>>> x_coords = np.array([621, 752])
>>> y_coords = np.array([366, 292])
>>> self.data[y_coords, x_coords] = 1
>>> poly = self.to_multi_polygon()
```

Example

```
>>> # xdoctest: +REQUIRES(module:rasterio)
>>> import kwimage
>>> dims = (10, 10)
>>> data = np.zeros(dims, dtype=np.uint8)
>>> data[0, 3:5] = 1
>>> data[9, 1:3] = 1
>>> data[3:5, 0:2] = 1
>>> data[1, 1] = 1
>>> # 1 pixel L shape
>>> data[3, 5] = 1
>>> data[4, 5] = 1
>>> data[4, 6] = 1
>>> data[1, 5] = 1
>>> data[2, 6] = 1
>>> data[3, 7] = 1
```

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```
>>> data[6, 1] = 1
>>> data[7, 1] = 1
>>> data[7, 2] = 1
>>> data[6:10, 5] = 1
>>> data[6:10, 8] = 1
>>> data[9, 5:9] = 1
>>> data[6, 5:9] = 1
>>> #data = kwimage.imresize(data, scale=2.0, interpolation='nearest')
>>> self = kwimage.Mask.coerce(data)
>>> #self = self.translate((0, 0), output_dims=(10, 9))
>>> self = self.translate((0, 1), output_dims=(11, 11))
>>> dims = self.shape[0:2]
>>> multi_poly1 = self.to_multi_polygon(pixels_are='points')
>>> multi_poly2 = self.to_multi_polygon(pixels_are='areas')
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> pretty_data = kwplot.make_heatmask(self.data/1.0, cmap='magma')[..., 0:3]
>>> def _pixel_grid_lines(self, ax):
>>>     h, w = self.data.shape[0:2]
>>>     ybasis = np.arange(0, h) + 0.5
>>>     xbasis = np.arange(0, w) + 0.5
>>>     xmin = 0 - 0.5
>>>     xmax = w - 0.5
>>>     ymin = 0 - 0.5
>>>     ymax = h - 0.5
>>>     ax.hlines(y=ybasis, xmin=xmin, xmax=xmax, color="gainsboro")
>>>     ax.vlines(x=xbasis, ymin=ymin, ymax=ymax, color="gainsboro")
>>> def _setup_grid(self, pnum):
>>>     ax = kwplot.imshow(pretty_data, show_ticks=True, pnum=pnum)[1]
>>>     # The gray ticks show the center of the pixels
>>>     ax.grid(color='dimgray', linewidth=0.5)
>>>     ax.set_xticks(np.arange(self.data.shape[1]))
>>>     ax.set_yticks(np.arange(self.data.shape[0]))
>>>     # Also draw black lines around the edges of the pixels
>>>     _pixel_grid_lines(self, ax=ax)
>>>     return ax
>>> # Overlay the extracted polygons
>>> ax = _setup_grid(self, pnum=(2, 3, 1))
>>> ax.set_title('input binary mask data')
>>> ax = _setup_grid(self, pnum=(2, 3, 2))
>>> multi_poly1.draw(linewidth=5, alpha=0.5, radius=0.2, ax=ax, fill=False,␣
↪vertex=0.2)
>>> ax.set_title('opencv "point" polygons')
>>> ax = _setup_grid(self, pnum=(2, 3, 3))
>>> multi_poly2.draw(linewidth=5, alpha=0.5, radius=0.2, color='limegreen',␣
↪ax=ax, fill=False, vertex=0.2)
>>> ax.set_title('raterio "area" polygons')
>>> ax.figure.suptitle(ub.codeblock(
>>>     '''
>>>     Gray lines are coordinates and pass through pixel centers (integer␣
↪coords)
```

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```
>>>     White lines trace pixel boundaries (fractional coords)
>>>     '''))
>>> raster1 = multi_poly1.to_mask(dims, pixels_are='points')
>>> raster2 = multi_poly2.to_mask(dims, pixels_are='areas')
>>> kwplot.imshow(raster1.draw_on(), pnum=(2, 3, 5), title='rasterized')
>>> kwplot.imshow(raster2.draw_on(), pnum=(2, 3, 6), title='rasterized')
```

get_convex_hull()

Returns a list of xy points around the convex hull of this mask

---

Note: The returned polygon may not surround points that are only one pixel thick.

Example

```
>>> # xdoc: +REQUIRES(--mask)
>>> self = Mask.random(shape=(8, 8), rng=0)
>>> polygons = self.get_convex_hull()
>>> print('polygons = ' + ub.repr2(polygons))
>>> other = Mask.from_polygons(polygons, self.shape)
```

iou(*other*)

The area of intersection over the area of union

Todo:

- [ ] Write plural Masks version of this class, which should be able to perform this operation more efficiently.

CommandLine

```
xdoctest -m kwimage.structs.mask Mask.iou
```

Example

```
>>> # xdoc: +REQUIRES(--mask)
>>> self = Mask.demo()
>>> other = self.translate(1)
>>> iou = self.iou(other)
>>> print('iou = {:.4f}'.format(iou))
iou = 0.0830
>>> iou2 = self.intersection(other).area / self.union(other).area
>>> print('iou2 = {:.4f}'.format(iou2))
```

classmethod coerce(*data*, *dims=None*)

Attempts to auto-inspect the format of the data and conver to Mask

Parameters

- **data** (*Any*) – the data to coerce
- **dims** (*Tuple*) – required for certain formats like polygons height / width of the source image

Returns
the constructed mask object

Return type
Mask

Example

```
>>> # xdoc: +REQUIRES(--mask)
>>> segmentation = {'size': [5, 9], 'counts': ';?1B10030O4'}
>>> polygon = [
>>>     [np.array([[3, 0],[2, 1],[2, 4],[4, 4],[4, 3],[7, 0]])],
>>>     [np.array([[2, 1],[2, 2],[4, 2],[4, 1]])],
>>> ]
>>> dims = (9, 5)
>>> mask = (np.random.rand(32, 32) > .5).astype(np.uint8)
>>> Mask.coerce(polygon, dims).to_bytes_rle()
>>> Mask.coerce(segmentation).to_bytes_rle()
>>> Mask.coerce(mask).to_bytes_rle()
```

`to_coco`(*style='orig'*)

Convert the Mask to a COCO json representation based on the current format.

A COCO mask is formatted as a run-length-encoding (RLE), of which there are two variants: (1) a array RLE, which is slightly more readable and extensible, and (2) a bytes RLE, which is slightly more concise. The returned format will depend on the current format of the Mask object. If it is in "bytes_rle" format, it will be returned in that format, otherwise it will be converted to the "array_rle" format and returned as such.

Parameters
style (*str*) – Does nothing for this particular method, exists for API compatibility and if alternate encoding styles are implemented in the future.

Returns

either a bytes-rle or array-rle encoding, depending
on the current mask format. The keys in this dictionary are as follows:

counts (List[int] | str): the array or bytes rle encoding

size (Tuple[int]): the height and width of the encoded mask
see note.

shape (Tuple[int]): only present in array-rle mode. This
is also the height/width of the underlying encoded array. This exists for semantic consistency with other kwimage conventions, and is not part of the original coco spec.

order (str): only present in array-rle mode.
Either C or F, indicating if counts is aranged in row-major or column-major order. For COCO-compatibility this is always returned in F (column-major) order.

binary (bool): only present in array-rle mode.
For COCO-compatibility this is always returned as False, indicating the mask only contains binary 0 or 1 values.

Return type
dict

Note: The output dictionary will contain a key named "size", this is the only location in kwimage where "size" refers to a tuple in (height/width) order, in order to be backwards compatible with the original coco spec. In all other locations in kwimage a "size" will refer to a (width/height) ordered tuple.

SeeAlso:

func
kwimage.im_runlen.encode_run_length - backend function that does array-style run length encoding.

Example

```
>>> # xdoc: +REQUIRES(--mask)
>>> from kwimage.structs.mask import *  # NOQA
>>> self = Mask.demo()
>>> coco_data1 = self.toformat('array_rle').to_coco()
>>> coco_data2 = self.toformat('bytes_rle').to_coco()
>>> print('coco_data1 = {}'.format(ub.repr2(coco_data1, nl=1)))
>>> print('coco_data2 = {}'.format(ub.repr2(coco_data2, nl=1)))
coco_data1 = {
    'binary': True,
    'counts': [47, 5, 3, 1, 14, ... 1, 4, 19, 141],
    'order': 'F',
    'shape': (23, 32),
    'size': (23, 32),
}
coco_data2 = {
    'counts': '_153L;4EL...ON3060L0N060L0Nb0Y4',
    'size': [23, 32],
}
```

class kwimage.structs.mask.**MaskList**(*data*, *meta=None*)

Bases: ObjectList

Store and manipulate multiple masks, usually within the same image

to_polygon_list()

Converts all mask objects to multi-polygon objects

Returns
kwimage.PolygonList

to_segmentation_list()

Converts all items to segmentation objects

Returns
kwimage.SegmentationList

to_mask_list()

returns this object

Returns
kwimage.MaskList

kwimage.structs.points module

Data structures to represent and manipulate 2D Points

class kwimage.structs.points.**Points**(*data=None*, *meta=None*, *datakeys=None*, *metakeys=None*, ***kwargs*)

Bases: Spatial, _PointsWarpMixin

Stores multiple keypoints for a single object.

This stores both the geometry and the class metadata if available

Example

```
>>> from kwimage.structs.points import *  # NOQA
>>> xy = np.random.rand(10, 2)
>>> pts = Points(xy=xy)
>>> print('pts = {!r}'.format(pts))
```

property shape

property xy

classmethod random(*num=1*, *classes=None*, *rng=None*)

Makes random points; typically for testing purposes

Example

```
>>> import kwimage
>>> self = kwimage.Points.random(classes=[1, 2, 3])
>>> self.data
>>> print('self.data = {!r}'.format(self.data))
```

is_numpy()

is_tensor()

tensor(*device=NoParam*)

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> from kwimage.structs.points import *  # NOQA
>>> self = Points.random(10)
>>> self.tensor()
```

round(*inplace=False*)

Rounds data to the nearest integer

Parameters
inplace (*bool*) – if True, modifies this object

Example

```
>>> import kwimage
>>> self = kwimage.Points.random(3).scale(10)
>>> self.round()
```

numpy()

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> from kwimage.structs.points import *  # NOQA
>>> self = Points.random(10)
>>> self.tensor().numpy().tensor().numpy()
```

draw_on(*image=None*, *color='white'*, *radius=None*, *copy=False*)

Parameters

- **image** (*ndarray*) – image to draw points on.
- **color** (*str | Any | List[Any]*) – one color for all boxes or a list of colors for each box Can be any type accepted by kwimage.Color.coerce. Extended types: str | ColorLike | List[ColorLike]
- **radius** (*None | int*) – if an integer, an circle is drawn at each xy point with this radius. if None, attempts to fill a single point with subpixel accuracy, which generally means 4 pixels will be given some weight. Note: color can only be a single value for all points in this case.
- **copy** (*bool*) – if True, force a copy of the image, otherwise try to draw inplace (may not work depending on dtype).

CommandLine

```
xdoctest -m ~/code/kwimage/kwimage/structs/points.py Points.draw_on --show
```

Example

```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> from kwimage.structs.points import *  # NOQA
>>> s = 128
>>> image = np.zeros((s, s))
>>> self = Points.random(10).scale(s)
>>> image = self.draw_on(image)
>>> # xdoc: +REQUIRES(--show)
```

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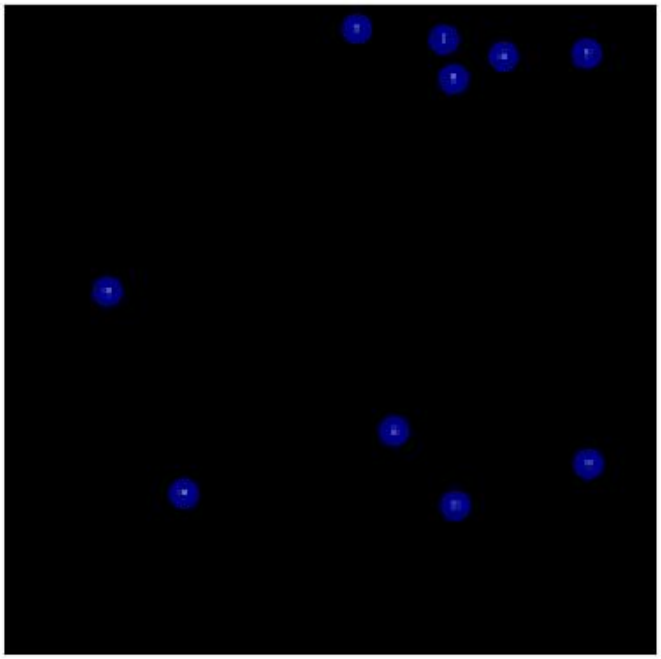
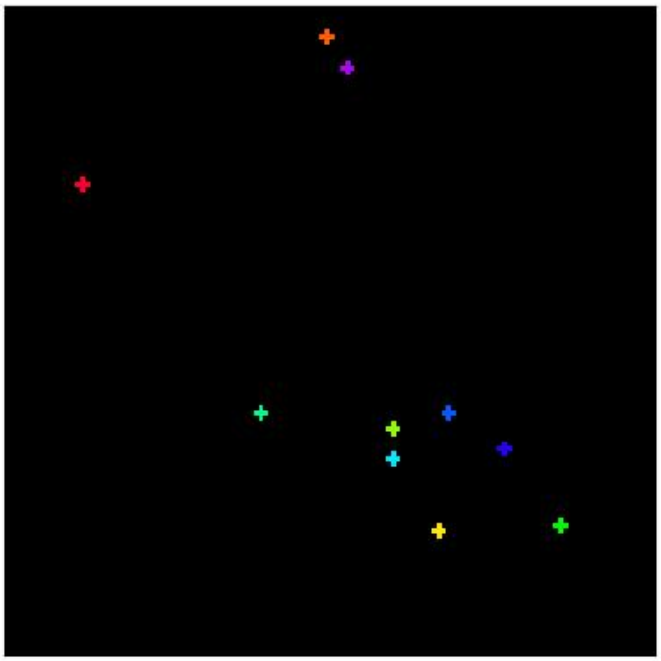
```
>>> import kwplot
>>> kwplot.figure(fnum=1, doclf=True)
>>> kwplot.autompl()
>>> kwplot.imshow(image)
>>> self.draw(radius=3, alpha=.5)
>>> kwplot.show_if_requested()
```



Example

```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> from kwimage.structs.points import *  # NOQA
>>> s = 128
>>> image = np.zeros((s, s))
>>> self = Points.random(10).scale(s)
>>> image = self.draw_on(image, radius=3, color='distinct')
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.figure(fnum=1, doclf=True)
>>> kwplot.autompl()
>>> kwplot.imshow(image)
>>> #self.draw(radius=3, alpha=.5, color='classes')
>>> kwplot.show_if_requested()
```



Example

```
>>> import kwimage
>>> s = 32
>>> self = kwimage.Points.random(10).scale(s)
>>> color = 'kitware_green'
>>> # Test drawing on all channel + dtype combinations
>>> im3 = np.zeros((s, s, 3), dtype=np.float32)
>>> im_chans = {
>>>     'im3': im3,
>>>     'im1': kwimage.convert_colorspace(im3, 'rgb', 'gray'),
>>>     'im4': kwimage.convert_colorspace(im3, 'rgb', 'rgba'),
>>> }
>>> inputs = {}
>>> for k, im in im_chans.items():
>>>     inputs[k + '_01'] = (kwimage.ensure_float01(im.copy()), {'radius': None}
↪)
>>>     inputs[k + '_255'] = (kwimage.ensure_uint255(im.copy()), {'radius':␣
↪None})
>>> outputs = {}
>>> for k, v in inputs.items():
>>>     im, kw = v
>>>     outputs[k] = self.draw_on(im, color=color, **kw)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
```

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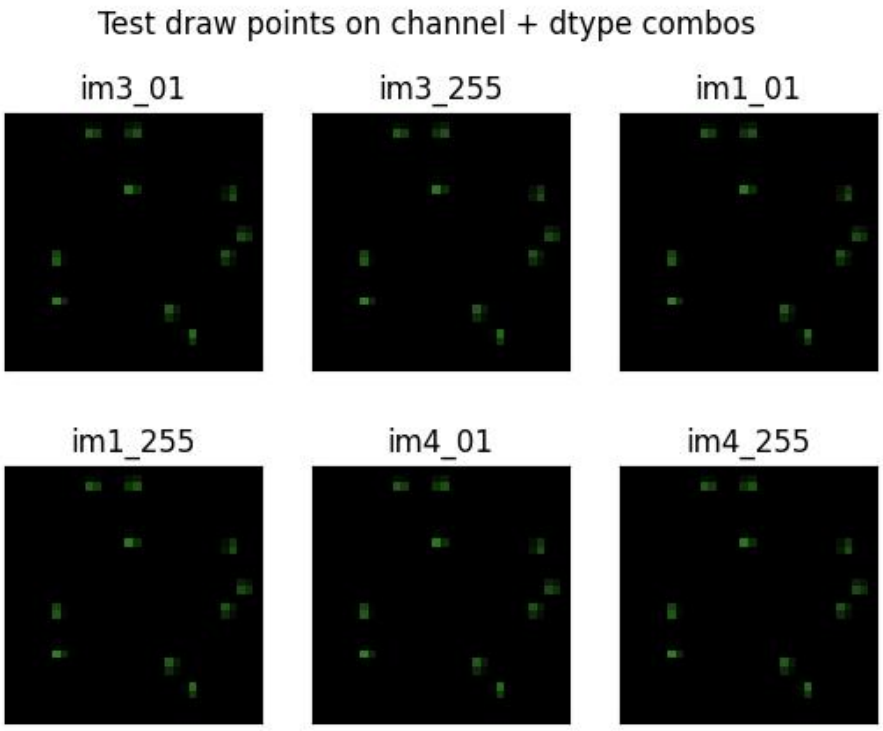
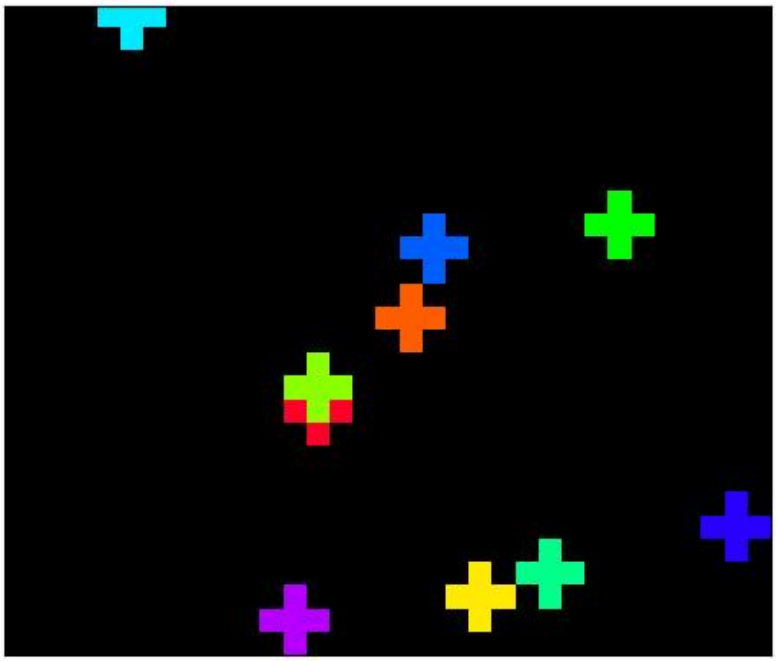
```
>>> kwplot.figure(fnum=2, doclf=True)
>>> plt = kwplot.autoplt()
>>> pnum_ = kwplot.PlotNums(nRows=2, nSubplots=len(inputs))
>>> for k in inputs.keys():
>>>     kwplot.imshow(outputs[k], fnum=2, pnum=pnum_(), title=k)
>>> plt.gcf().suptitle('Test draw points on channel + dtype combos')
>>> kwplot.show_if_requested()
```



Example

```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> from kwimage.structs.points import *  # NOQA
>>> self = Points.random(10).scale(32)
>>> image = self.draw_on(radius=3, color='distinct')
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(image)
>>> kwplot.show_if_requested()
```



Example

```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> # Test cases where single and multiple colors are given
>>> # with radius=None and radius=scalar
>>> from kwimage.structs.points import *  # NOQA
>>> import kwimage
>>> self = kwimage.Points.random(10).scale(32)
>>> image1 = self.draw_on(radius=2, color='blue')
>>> image2 = self.draw_on(radius=None, color='blue')
>>> image3 = self.draw_on(radius=2, color='distinct')
>>> image4 = self.draw_on(radius=None, color='distinct')
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> canvas = kwimage.stack_images_grid(
>>>     [image1, image2, image3, image4],
>>>     pad=3, bg_value=(1, 1, 1))
>>> kwplot.autompl()
>>> kwplot.imshow(canvas)
>>> kwplot.show_if_requested()
```

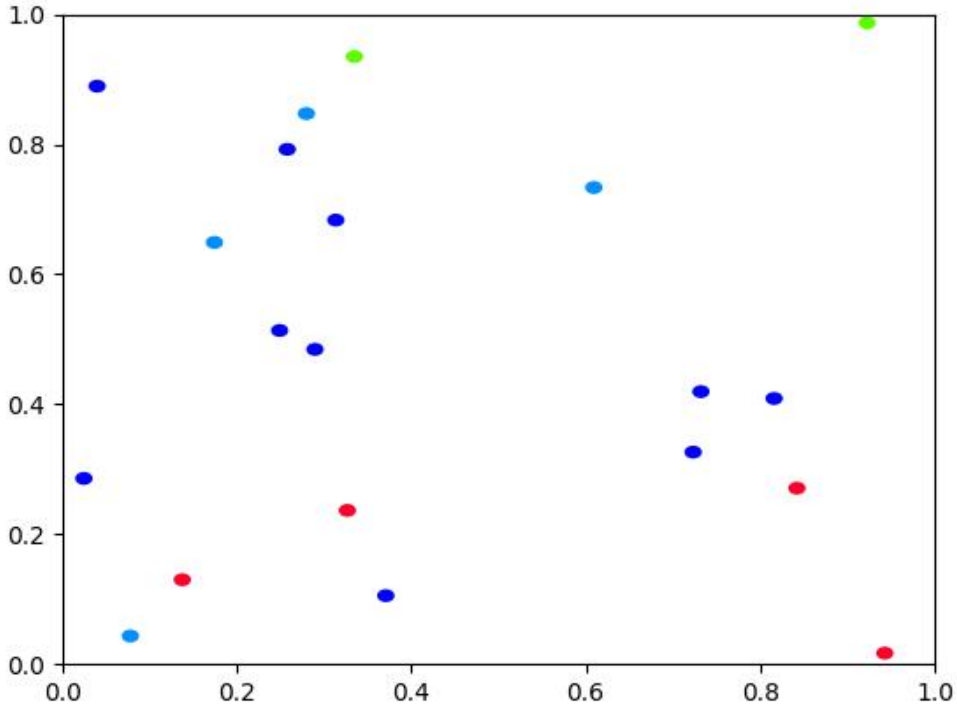
draw(*color='blue'*, *ax=None*, *alpha=None*, *radius=1*, ***kwargs*)

TODO: can use kwplot.draw_points

Example

```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> from kwimage.structs.points import *  # NOQA
>>> pts = Points.random(10)
>>> # xdoc: +REQUIRES(--show)
>>> pts.draw(radius=0.01)
```

```
>>> from kwimage.structs.points import *  # NOQA
>>> self = Points.random(10, classes=['a', 'b', 'c'])
>>> self.draw(radius=0.01, color='classes')
```



compress(*flags*, *axis=0*, *inplace=False*)

Filters items based on a boolean criterion

Example

```
>>> from kwimage.structs.points import *  # NOQA
>>> self = Points.random(4)
>>> flags = [1, 0, 1, 1]
>>> other = self.compress(flags)
>>> assert len(self) == 4
>>> assert len(other) == 3
```

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> other = self.tensor().compress(flags)
>>> assert len(other) == 3
```

take(*indices*, *axis=0*, *inplace=False*)

Takes a subset of items at specific indices

Example

```
>>> from kwimage.structs.points import *  # NOQA
>>> self = Points.random(4)
>>> indices = [1, 3]
>>> other = self.take(indices)
>>> assert len(self) == 4
>>> assert len(other) == 2
```

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> other = self.tensor().take(indices)
>>> assert len(other) == 2
```

classmethod concatenate(*points*, *axis=0*)

to_coco(*style='orig'*)

Converts to an mscoco-like representation

Note: items that are usually id-references to other objects may need to be rectified.

Parameters

style (*str*) – either orig, new, new-id, or new-name

Returns

mscoco-like representation

Return type

Dict

Example

```
>>> from kwimage.structs.points import *  # NOQA
>>> self = Points.random(4, classes=['a', 'b'])
>>> orig = self._to_coco(style='orig')
>>> print('orig = {!r}'.format(orig))
>>> new_name = self._to_coco(style='new-name')
>>> print('new_name = {}'.format(ub.repr2(new_name, nl=-1)))
>>> # xdoctest: +REQUIRES(module:kwcoco)
>>> import kwcoco
>>> self.meta['classes'] = kwcoco.CategoryTree.coerce(self.meta['classes'])
>>> new_id = self._to_coco(style='new-id')
>>> print('new_id = {}'.format(ub.repr2(new_id, nl=-1)))
```

classmethod coerce(*data*)

Attempt to coerce data into a Points object

classmethod from_coco(*coco_kpts*, *class_idxs=None*, *classes=None*, *warn=False*)

Parameters

- **coco_kpts** (*list | dict*) – either the original list keypoint encoding or the new dict keypoint encoding.

- **class_idxs** (*list*) – only needed if using old style
- **classes** (*list | kwcoco.CategoryTree*) – list of all keypoint category names
- **warn** (*bool*) – if True raise warnings

Example

```
>>> ##
>>> classes = ['mouth', 'left-hand', 'right-hand']
>>> coco_kpts = [
>>>     {'xy': (0, 0), 'visible': 2, 'keypoint_category': 'left-hand'},
>>>     {'xy': (1, 2), 'visible': 2, 'keypoint_category': 'mouth'},
>>> ]
>>> Points.from_coco(coco_kpts, classes=classes)
>>> # Test without classes
>>> Points.from_coco(coco_kpts)
>>> # Test without any category info
>>> coco_kpts2 = [ub.dict_diff(d, {'keypoint_category'}) for d in coco_kpts]
>>> Points.from_coco(coco_kpts2)
>>> # Test without category instead of keypoint_category
>>> coco_kpts3 = [ub.map_keys(lambda x: x.replace('keypoint_', ''), d) for d in␣
↪coco_kpts]
>>> Points.from_coco(coco_kpts3)
>>> #
>>> # Old style
>>> coco_kpts = [0, 0, 2, 0, 1, 2]
>>> Points.from_coco(coco_kpts)
>>> # Fail case
>>> coco_kpts4 = [{'xy': [4686.5, 1341.5], 'category': 'dot'}]
>>> Points.from_coco(coco_kpts4, classes=[])
```

Example

```
>>> # xdoctest: +REQUIRES(module:kwcoco)
>>> import kwcoco
>>> classes = kwcoco.CategoryTree.from_coco([
>>>     {'name': 'mouth', 'id': 2}, {'name': 'left-hand', 'id': 3}, {'name':
↪'right-hand', 'id': 5}
>>> ])
>>> coco_kpts = [
>>>     {'xy': (0, 0), 'visible': 2, 'keypoint_category_id': 5},
>>>     {'xy': (1, 2), 'visible': 2, 'keypoint_category_id': 2},
>>> ]
>>> pts = Points.from_coco(coco_kpts, classes=classes)
>>> assert pts.data['class_idxs'].tolist() == [2, 0]
```

class kwimage.structs.points.**PointsList**(*data*, *meta=None*)

Bases: ObjectList

Stores a list of Points, each item usually corresponds to a different object.

Note: # TODO: when the data is homogenous we can use a more efficient # representation, otherwise we have to use heterogenous storage.

kwimage.structs.polygon module

Todo:

- [ ] Make function mask -> polygon list
- [ ] Make function multipolygon -> polygon list
- [ ] Make function PolygonList -> Boxes
- [ ] Make function SegmentationList -> Boxes

class kwimage.structs.polygon.**Polygon**(*data=None*, *meta=None*, *datakeys=None*, *metakeys=None*, ***kwargs*)

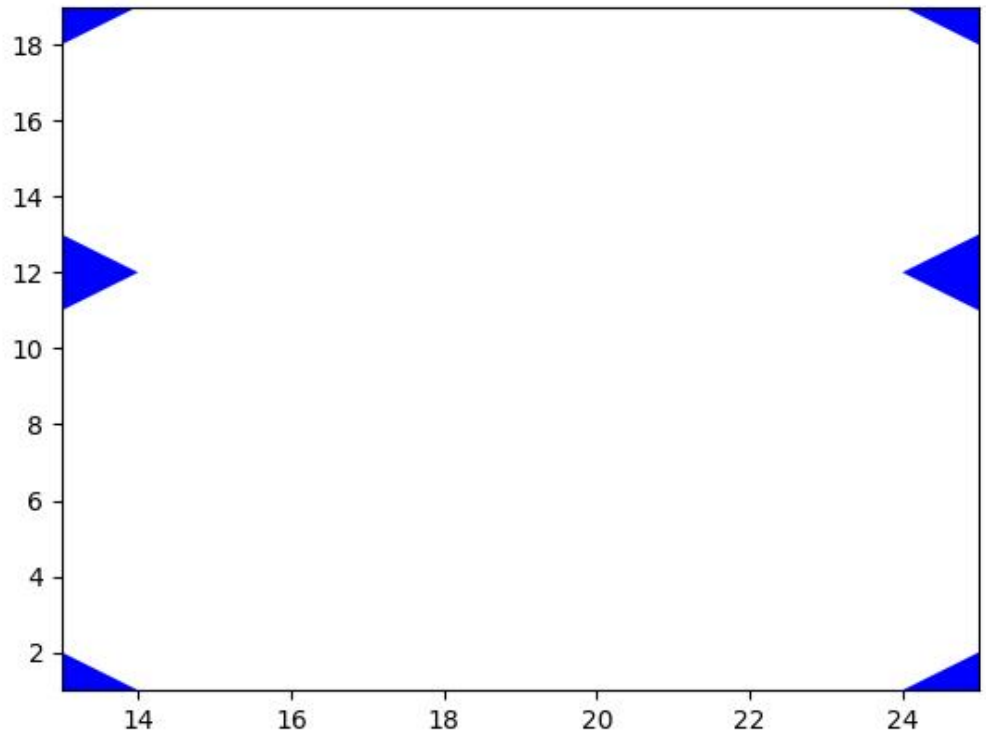
Bases: Spatial, _PolyArrayBackend, _PolyWarpMixin, NiceRepr

Represents a single polygon as set of exterior boundary points and a list of internal polygons representing holes.

By convention exterior boundaries should be counterclockwise and interior holes should be clockwise.

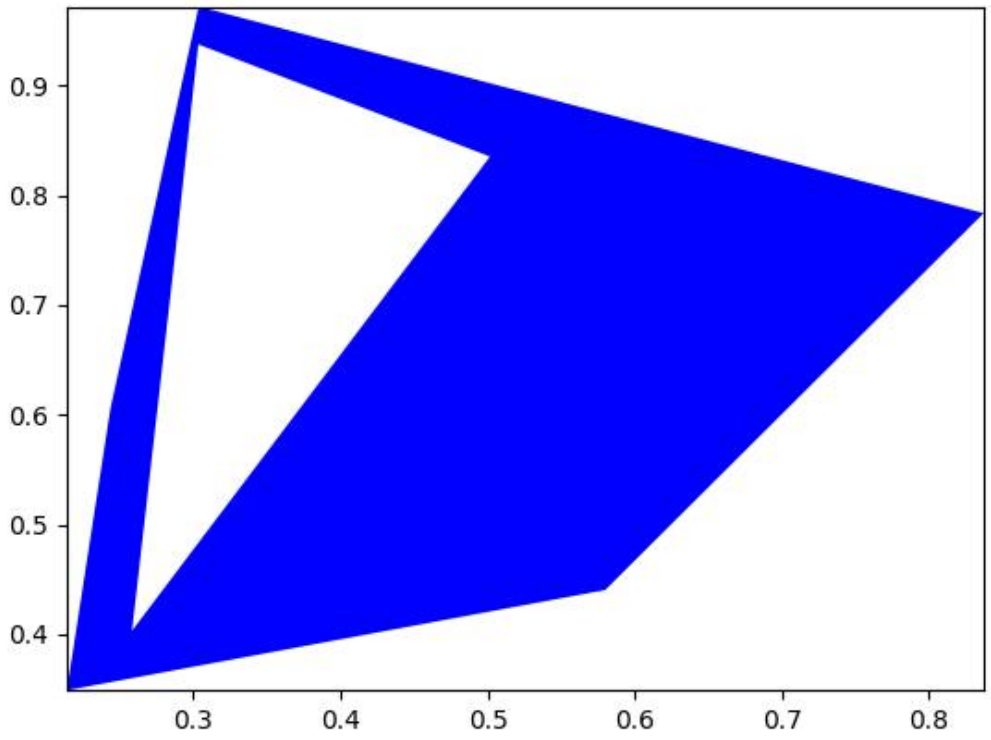
Example

```
>>> import kwimage
>>> data = {
>>>     'exterior': np.array([[13,  1], [13, 19], [25, 19], [25,  1]]),
>>>     'interiors': [
>>>         np.array([[13, 13], [14, 12], [24, 12], [25, 13], [25, 18],
>>>                   [24, 19], [14, 19], [13, 18]]),
>>>         np.array([[13,  2], [14,  1], [24,  1], [25, 2], [25, 11],
>>>                   [24, 12], [14, 12], [13, 11]])]
>>> }
>>> self = kwimage.Polygon(**data)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> self.draw(setlim=True)
```



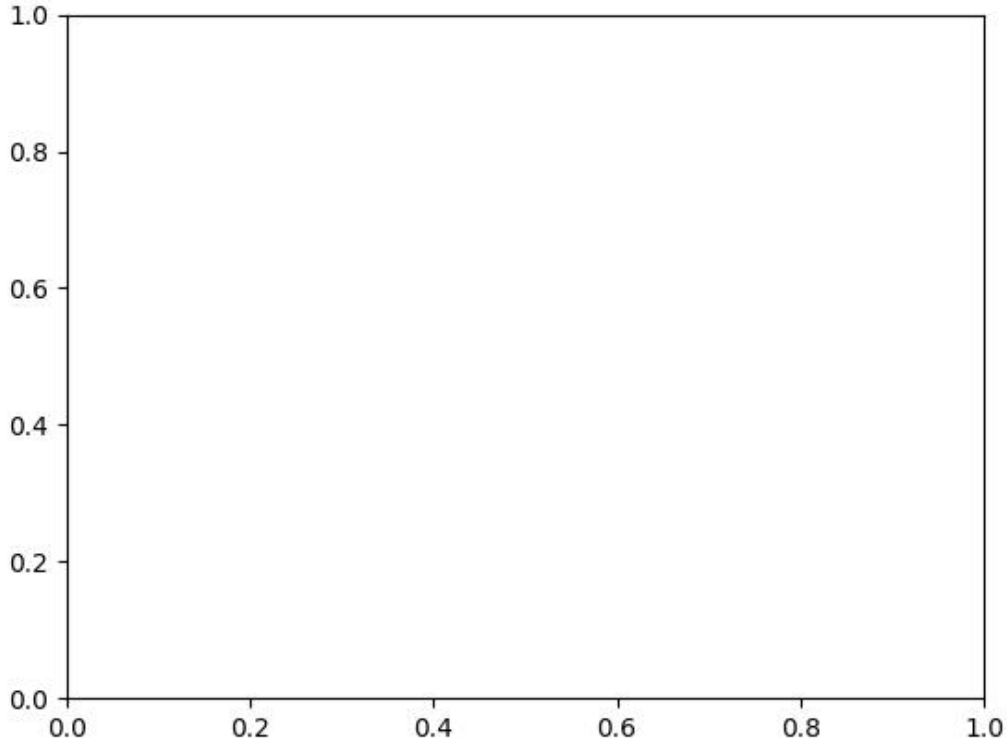
Example

```
>>> import kwimage
>>> self = kwimage.Polygon.random(
>>>     n=5, n_holes=1, convex=False, rng=0)
>>> print('self = {}'.format(self))
self = <Polygon({
    'exterior': <Coords(data=
                    array([[0.30371392, 0.97195856],
                           [0.24372304, 0.60568445],
                           [0.21408694, 0.34884262],
                           [0.5799477 , 0.44020379],
                           [0.83720288, 0.78367234]]))>,
    'interiors': [<Coords(data=
                     array([[0.50164209, 0.83520279],
                            [0.25835064, 0.40313428],
                            [0.28778562, 0.74758761],
                            [0.30341266, 0.93748088]]))>],
})>
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> self.draw(setlim=True)
```



Example

```
>>> # Test empty polygon
>>> import kwimage
>>> data = {
>>>     'exterior': np.array([]),
>>>     'interiors': [],}
>>> self = kwimage.Polygon(**data)
>>> geos = self.to_geojson()
>>> kwimage.Polygon.from_geojson(geos)
>>> geom = self.to_shapely()
>>> kwimage.Polygon.from_shapely(geom)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> self.draw(setlim=True)
```



property exterior

Returns: kwimage.Coords

property interiors

Returns: List[kwimage.Coords]

classmethod circle(*xy*, *r*, *resolution=64*)

Create a circular or elliptical polygon.

Might rename to ellipse later?

Parameters

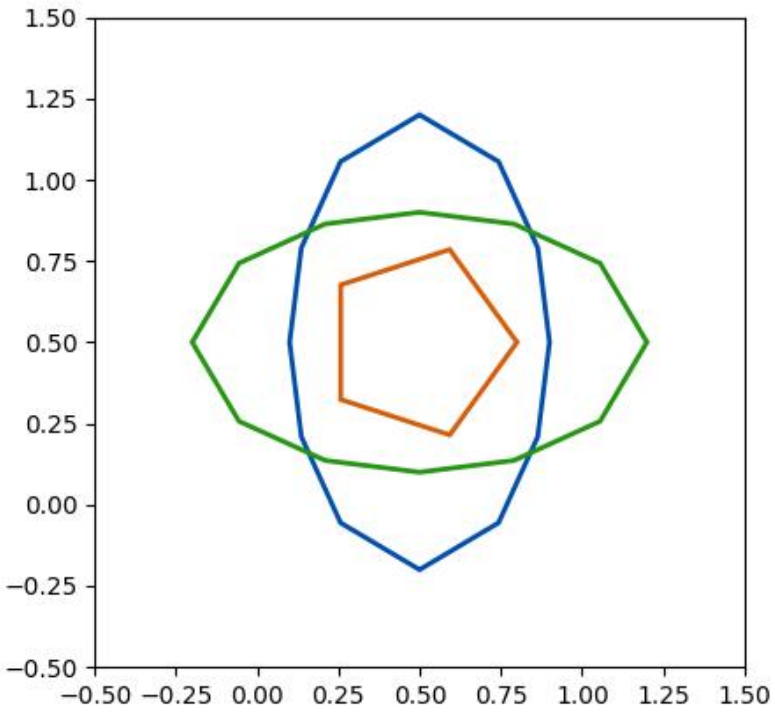
- **xy** (*Iterable[Number]*) – x and y center coordinate
- **r** (*Number | Tuple[Number, Number]*) – circular radius or major and minor elliptical radius
- **resolution** (*int*) – number of sides

Returns

Polygon

Example

```
>>> import kwimage
>>> xy = (0.5, 0.5)
>>> r = .3
>>> # Demo with circle
>>> circle = kwimage.Polygon.circle(xy, r, resolution=6)
>>> # Demo with ellipse
>>> xy = (0.5, 0.5)
>>> r = (.4, .7)
>>> ellipse1 = kwimage.Polygon.circle(xy, r, resolution=12)
>>> ellipse2 = kwimage.Polygon.circle(xy, (.7, .4), resolution=12)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> plt = kwplot.autoplt()
>>> kwplot.figure(fnum=1, doclf=True)
>>> circle.draw(setlim=True, border=1, fill=0, color='kitware_orange')
>>> ellipse1.draw(setlim=True, border=1, fill=0, color='kitware_blue')
>>> ellipse2.draw(setlim=True, border=1, fill=0, color='kitware_green')
>>> plt.gca().set_xlim(-0.5, 1.5)
>>> plt.gca().set_ylim(-0.5, 1.5)
>>> plt.gca().set_aspect('equal')
```



classmethod random(*n=6*, *n_holes=0*, *convex=True*, *tight=False*, *rng=None*)

Parameters

- **n** (*int*) – number of points in the polygon (must be 3 or more)
- **n_holes** (*int*) – number of holes
- **tight** (*bool*) – fits the minimum and maximum points between 0 and 1
- **convex** (*bool*) – force resulting polygon will be convex (may remove exterior points)

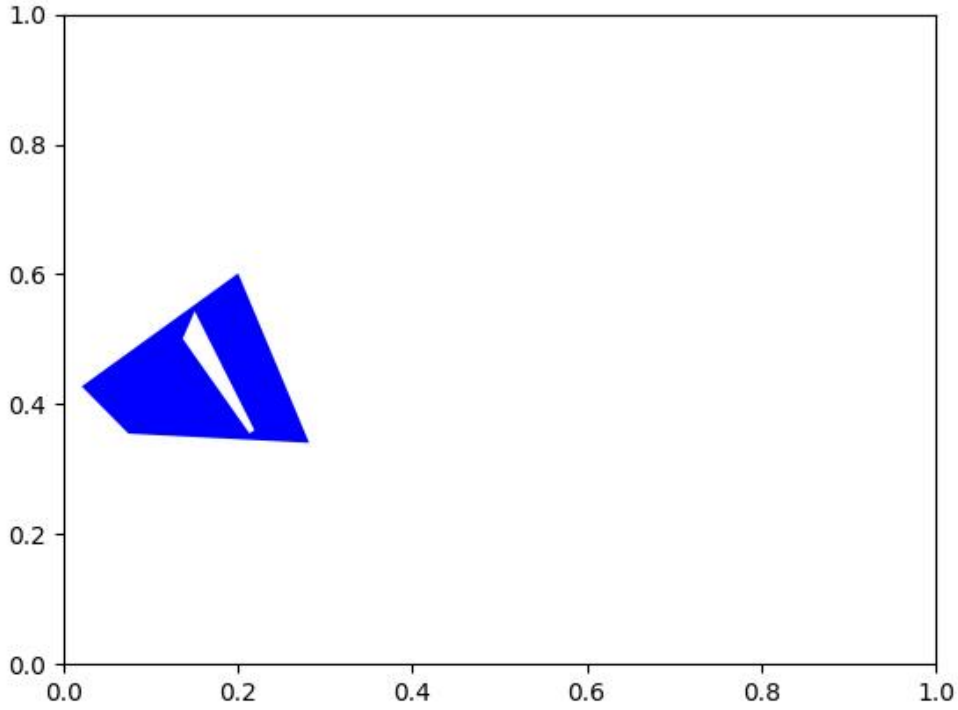
Returns
Polygon

CommandLine

```
xdoctest -m kwimage.structs.polygon Polygon.random
```

Example

```
>>> rng = None
>>> n = 4
>>> n_holes = 1
>>> cls = Polygon
>>> self = Polygon.random(n=n, rng=rng, n_holes=n_holes, convex=1)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.figure(fnum=1, doclf=True)
>>> self.draw()
```



References

https://gis.stackexchange.com/questions/207731/random-multipolygon https://stackoverflow.com/questions/8997099/random-polygon https://stackoverflow.com/questions/27548363/from-voronoi-tessellation-to-shapely-polygons https://stackoverflow.com/questions/8997099/algorithm-to-generate-random-2d-polygon

`to_mask`(*dims=None*, *pixels_are='points'*)

Convert this polygon to a mask

Todo:

- [ ] currently not efficient

Parameters

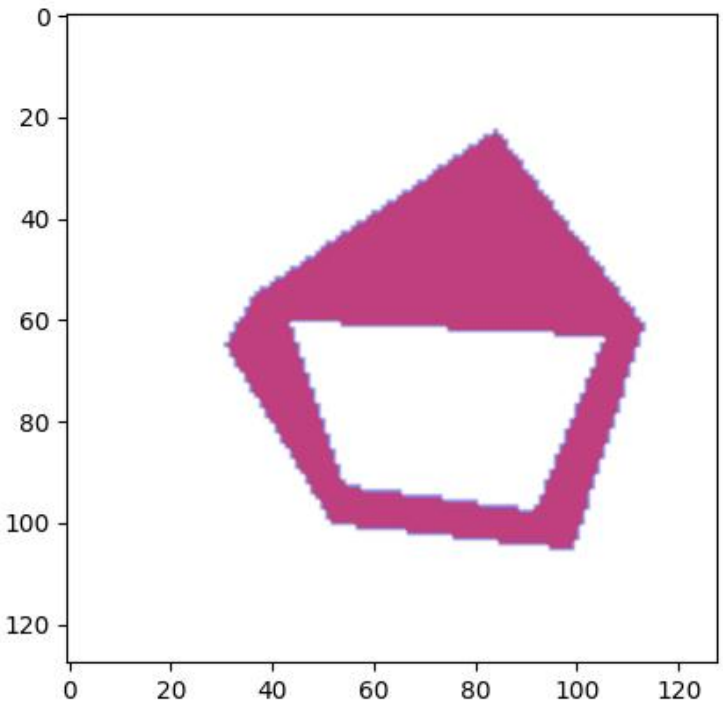
- **dims** (*Tuple*) – height and width of the output mask
- **pixels_are** (*str*) – either “points” or “areas”

Returns

kwimage.Mask

Example

```
>>> from kwimage.structs.polygon import *  # NOQA
>>> self = Polygon.random(n_holes=1).scale(128)
>>> mask = self.to_mask((128, 128))
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.figure(fnum=1, doclf=True)
>>> mask.draw(color='blue')
>>> mask.to_multi_polygon().draw(color='red', alpha=.5)
```



to_relative_mask(*return_offset=False*)

Returns a translated mask such the mask dimensions are minimal.

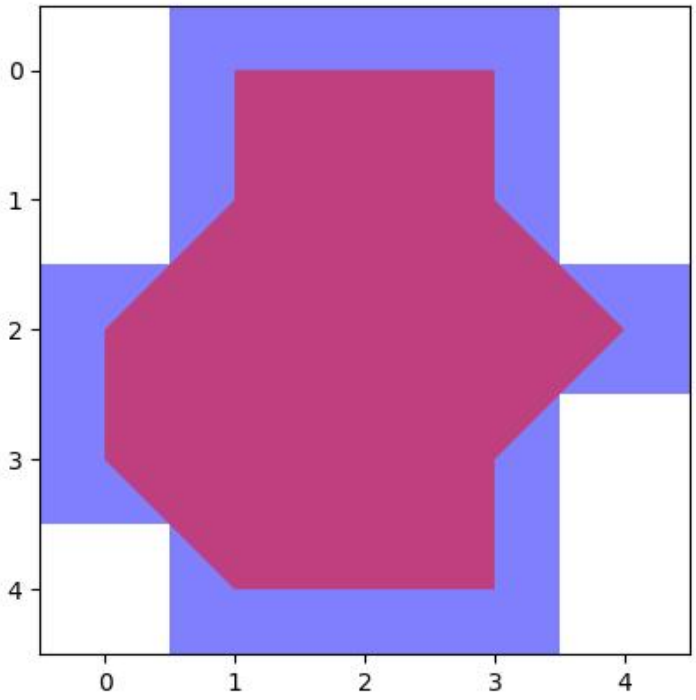
In other words, we move the polygon all the way to the top-left and return a mask just big enough to fit the polygon.

Returns

kwimage.Mask

Example

```
>>> from kwimage.structs.polygon import *  # NOQA
>>> self = Polygon.random().scale(8).translate(100, 100)
>>> mask = self.to_relative_mask()
>>> assert mask.shape <= (8, 8)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.figure(fnum=1, doclf=True)
>>> mask.draw(color='blue')
>>> mask.to_multi_polygon().draw(color='red', alpha=.5)
```



classmethod coerce(*data*)

Routes the input to the proper constructor

Try to autodetermine format of input polygon and coerce it into a kwimage.Polygon.

Parameters

data (*object*) – some type of data that can be interpreted as a polygon.

Returns

kwimage.Polygon

Example

```
>>> import kwimage
>>> self = kwimage.Polygon.random()
>>> kwimage.Polygon.coerce(self)
>>> kwimage.Polygon.coerce(self.exterior)
>>> kwimage.Polygon.coerce(self.exterior.data)
>>> kwimage.Polygon.coerce(self.data)
>>> kwimage.Polygon.coerce(self.to_geojson())
>>> kwimage.Polygon.coerce('POLYGON ((0.11 0.61, 0.07 0.588, 0.015 0.50, 0.11 0.
↪61))')
```

classmethod from_shapely(*geom*)

Convert a shapely polygon to a kwimage.Polygon

Parameters
geom (*shapely.geometry.polygon.Polygon*) – a shapely polygon

Returns
kwimage.Polygon

classmethod from_wkt(*data*)

Convert a WKT string to a kwimage.Polygon

Parameters
data (*str*) – a WKT polygon string

Returns
kwimage.Polygon

Example

```
>>> import kwimage
>>> data = 'POLYGON ((0.11 0.61, 0.07 0.588, 0.015 0.50, 0.11 0.61))'
>>> self = kwimage.Polygon.from_wkt(data)
>>> assert len(self.exterior) == 4
```

classmethod from_geojson(*data_geojson*)

Convert a geojson polygon to a kwimage.Polygon

Parameters
data_geojson (*dict*) – geojson data

Returns
Polygon

References

https://geojson.org/geojson-spec.html

Example

```
>>> from kwimage.structs.polygon import *  # NOQA
>>> self = Polygon.random(n_holes=2)
>>> data_geojson = self.to_geojson()
>>> new = Polygon.from_geojson(data_geojson)
```

to_shapely()

Returns
shapely.geometry.polygon.Polygon

Example

```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> # xdoc: +REQUIRES(module:shapely)
>>> from kwimage.structs.polygon import *  # NOQA
>>> self = Polygon.random(n_holes=1)
>>> self = self.scale(100)
>>> geom = self.to_shapely()
>>> print('geom = {!r}'.format(geom))
```

property area

Computes are via shapley conversion

Returns
float

to_geojson()

Converts polygon to a geojson structure

Returns
Dict[str, object]

Example

```
>>> import kwimage
>>> self = kwimage.Polygon.random()
>>> print(self.to_geojson())
```

to_wkt()

Convert a kwimage.Polygon to WKT string

Returns
str

Example

```
>>> import kwimage
>>> self = kwimage.Polygon.random()
>>> print(self.to_wkt())
```

classmethod from_coco(*data*, *dims=None*)

Accepts either new-style or old-style coco polygons

Parameters

- **data** (*List[Number] | Dict*) – A new or old-style coco polygon
- **dims** (*None | Tuple[int, ...]*) – the shape dimensions of the canvas. Unused. Exists for compatibility with masks.

Returns
Polygon

to_coco(*style='orig'*)

Parameters
style (*str*) – can be “orig” or “new”

Returns
coco-style polygons

Return type
List | Dict

to_multi_polygon()

Returns
MultiPolygon

to_boxes()

Deprecated: lossy conversion use ‘bounding_box’ instead

Returns
kwimage.Boxes

property centroid

Returns: Tuple[Number, Number]

bounding_box()

Returns an axis-aligned bounding box for the segmentation

Returns
kwimage.Boxes

bounding_box_polygon()

Returns an axis-aligned bounding polygon for the segmentation.

Note: This Polygon will be a Box, not a convex hull! Use shapely for convex hulls.

Returns
kwimage.Polygon

copy()

Returns
a copy

Return type
Polygon

clip(*x_min*, *y_min*, *x_max*, *y_max*, *inplace=False*)

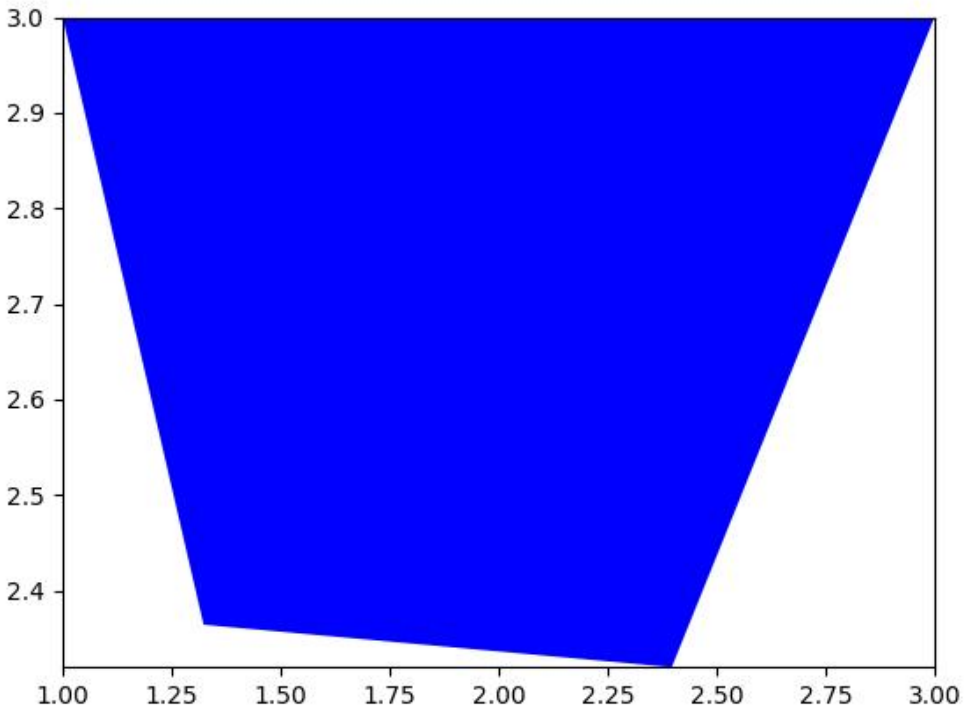
Clip polygon to specified boundaries.

Returns
clipped polygon

Return type
Polygon

Example

```
>>> from kwimage.structs.polygon import *
>>> self = Polygon.random().scale(10).translate(-1)
>>> self2 = self.clip(1, 1, 3, 3)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> self2.draw(setlim=True)
```



fill(*image*, *value=1*, *pixels_are='points'*)

Inplace fill in an image based on this polyon.

Parameters

- **image** (*ndarray*) – image to draw on
- **value** (*int | Tuple[int]*) – value fill in with. Defaults to 1.
- **pixels_are** (*str*) – either points or areas

Returns
the image that has been modified in place

Return type
ndarray

Example

```
>>> # xdoctest: +REQUIRES(module:rasterio)
>>> import kwimage
>>> mask = kwimage.Mask.random()
>>> self = mask.to_multi_polygon(pixels_are='areas').data[0]
>>> image = np.zeros_like(mask.data)
>>> self.fill(image, pixels_are='areas')
```

Example

```
>>> # Test case where there are multiple channels
>>> import kwimage
>>> mask = kwimage.Mask.random(shape=(4, 4), rng=0)
>>> self = mask.to_multi_polygon()
>>> image = np.zeros(mask.shape[0:2] + (2,))
>>> fill_v1 = self.fill(image.copy(), value=1)
>>> fill_v2 = self.fill(image.copy(), value=(1, 2))
>>> assert np.all((fill_v1 > 0) == (fill_v2 > 0))
```

draw_on(*image*, *color='blue'*, *fill=True*, *border=False*, *alpha=1.0*, *edgecolor=None*, *facecolor=None*, *copy=False*)

Rasterizes a polygon on an image. See *draw* for a vectorized matplotlib version.

Parameters

- **image** (*ndarray*) – image to raster polygon on.
- **color** (*str | tuple*) – data coercable to a color
- **fill** (*bool*) – draw the center mass of the polygon. Note: this will be deprecated. Use facecolor instead.
- **border** (*bool*) – draw the border of the polygon Note: this will be deprecated. Use edgecolor instead.
- **alpha** (*float*) – polygon transparency (setting alpha < 1 makes this function much slower). Defaults to 1.0
- **copy** (*bool*) – if False only copies if necessary

- **edgecolor** (*str | tuple*) – color for the border
- **facecolor** (*str | tuple*) – color for the fill

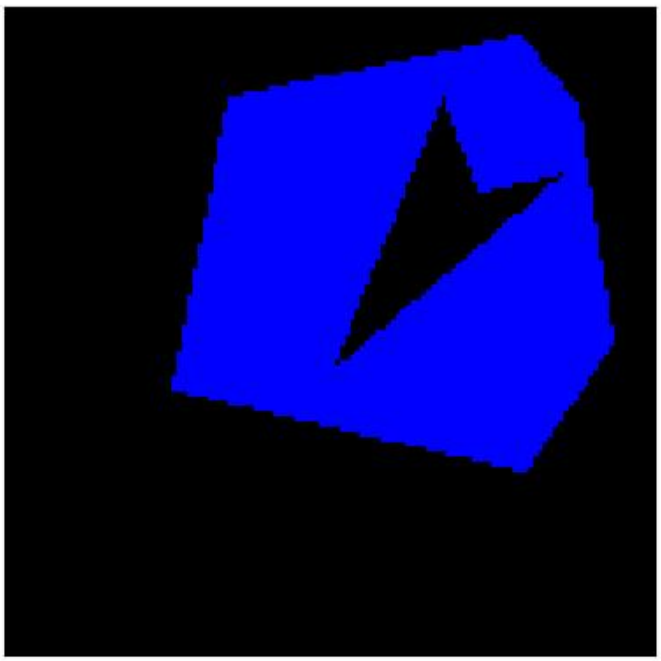
Returns
np.ndarray

Note: This function will only be inplace if alpha=1.0 and the input has 3 or 4 channels. Otherwise the output canvas is coerced so colors can be drawn on it. In the case where alpha < 1.0,

---

Example

```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> from kwimage.structs.polygon import *  # NOQA
>>> self = Polygon.random(n_holes=1).scale(128)
>>> image_in = np.zeros((128, 128), dtype=np.float32)
>>> image_out = self.draw_on(image_in)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(image_out, fnum=1)
```



Example

```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> # Demo drawing on a RGBA canvas
>>> # If you initialize an zero rgba canvas, the alpha values are
>>> # filled correctly.
>>> from kwimage.structs.polygon import *  # NOQA
>>> s = 16
>>> self = Polygon.random(n_holes=1, rng=32).scale(s)
>>> image_in = np.zeros((s, s, 4), dtype=np.float32)
>>> image_out = self.draw_on(image_in, color='black')
>>> assert np.all(image_out[..., 0:3] == 0)
>>> assert not np.all(image_out[..., 3] == 1)
>>> assert not np.all(image_out[..., 3] == 0)
```

Example

```
>>> import kwimage
>>> color = 'blue'
>>> self = kwimage.Polygon.random(n_holes=1).scale(128)
>>> image = np.zeros((128, 128), dtype=np.float32)
>>> # Test drawing on all channel + dtype combinations
>>> im3 = np.random.rand(128, 128, 3)
>>> im_chans = {
>>>     'im3': im3,
>>>     'im1': kwimage.convert_colorspace(im3, 'rgb', 'gray'),
>>>     #'im0': im3[..., 0],
>>>     'im4': kwimage.convert_colorspace(im3, 'rgb', 'rgba'),
>>> }
>>> inputs = {}
>>> for k, im in im_chans.items():
>>>     inputs[k + '_f01'] = (kwimage.ensure_float01(im.copy()), {'alpha': None}
↪)
>>>     inputs[k + '_u255'] = (kwimage.ensure_uint255(im.copy()), {'alpha':␣
↪None})
>>>     inputs[k + '_f01_a'] = (kwimage.ensure_float01(im.copy()), {'alpha': 0.
↪5})
>>>     inputs[k + '_u255_a'] = (kwimage.ensure_uint255(im.copy()), {'alpha': 0.
↪5})
>>> # Check cases when image is/isnot written inplace Construct images
>>> # with different dtypes / channels and run a draw_on with different
>>> # keyword args.  For each combination, demo if that results in an
>>> # implace operation or not.
>>> rows = []
>>> outputs = {}
>>> for k, v in inputs.items():
>>>     im, kw = v
>>>     outputs[k] = self.draw_on(im, color=color, **kw)
>>>     inplace = outputs[k] is im
>>>     rows.append({'key': k, 'inplace': inplace})
>>> # xdoc: +REQUIRES(module:pandas)
```

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```
>>> import pandas as pd
>>> df = pd.DataFrame(rows).sort_values('inplace')
>>> print(df.to_string())
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.figure(fnum=2, doclf=True)
>>> kwplot.autompl()
>>> pnum_ = kwplot.PlotNums(nCols=2, nRows=len(inputs))
>>> for k in inputs.keys():
>>>     kwplot.imshow(inputs[k][0], fnum=2, pnum=pnum_(), title=k)
>>>     kwplot.imshow(outputs[k], fnum=2, pnum=pnum_(), title=k)
>>> kwplot.show_if_requested()
```

Example

```
>>> # Test empty polygon draw
>>> from kwimage.structs.polygon import *  # NOQA
>>> self = Polygon.from_coco([])
>>> image_in = np.zeros((128, 128), dtype=np.float32)
>>> image_out = self.draw_on(image_in)
```

Example

```
>>> # Test stupid large polygon draw
>>> from kwimage.structs.polygon import *  # NOQA
>>> from kwimage.structs.polygon import _generic
>>> import kwimage
>>> self = kwimage.Polygon.random().scale(2e11)
>>> image = np.zeros((128, 128), dtype=np.float32)
>>> image_out = self.draw_on(image)
```

draw(*color='blue'*, *ax=None*, *alpha=1.0*, *radius=1*, *setlim=False*, *border=None*, *linewidth=None*, *edgecolor=None*, *facecolor=None*, *fill=True*, *vertex=False*, *vertexcolor=None*)

Draws polygon in a matplotlib axes. See *draw_on* for in-memory image modification.

Parameters

- **setlim** (*bool*) – if True ensures the limits of the axes contains the polygon
- **color** (*str | Tuple*) – coercable color. Default color if specific colors are not given.
- **alpha** (*float*) – fill transparency
- **fill** (*bool*) – if True fill the polygon with facecolor, otherwise just draw the border if linewidth > 0
- **setlim** (*bool*) – if True, modify the x and y limits of the matplotlib axes such that the polygon is can be seen.
- **border** (*bool*) – if True, draws an edge border on the polygon. DEPRECATED. Use linewidth instead.
- **linewidth** (*bool*) – width of the border

- **edgecolor** (*None | Any*) – if None, uses the value of `color`. Otherwise the color of the border when linewidth > 0. Extended types Coercable[kwimage.Color].
- **facecolor** (*None | Any*) – if None, uses the value of `color`. Otherwise, color of the border when fill=True. Extended types Coercable[kwimage.Color].
- **vertex** (*float*) – if non-zero, draws vertexes on the polygon with this radius.
- **vertexcolor** (*Any*) – color of vertexes Extended types Coercable[kwimage.Color].

Returns
None for am empty polygon

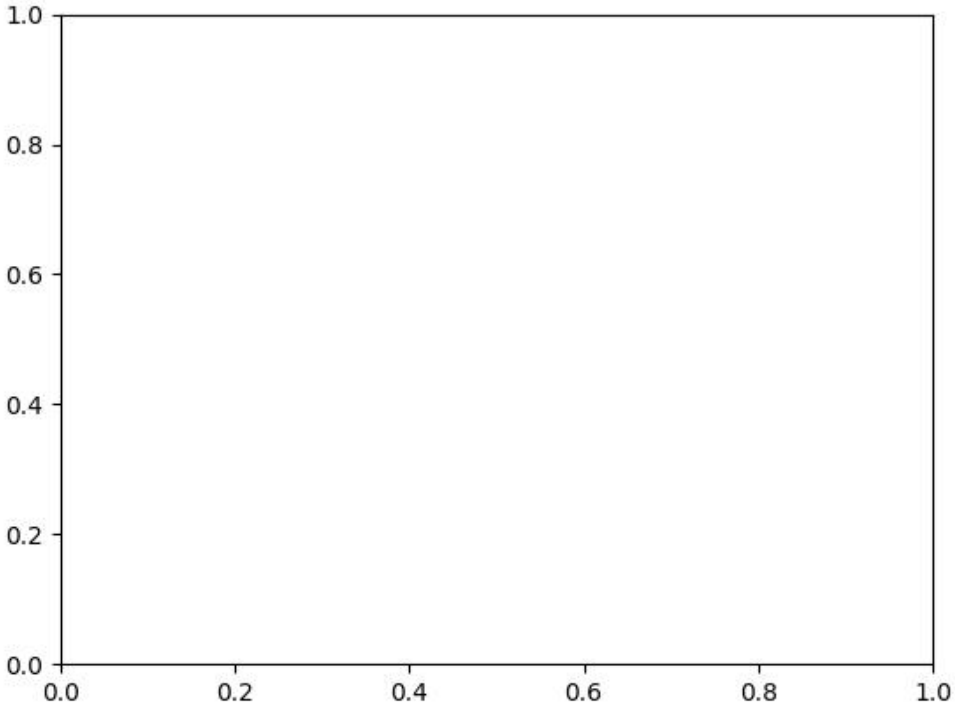
Return type
matplotlib.patches.PathPatch | None

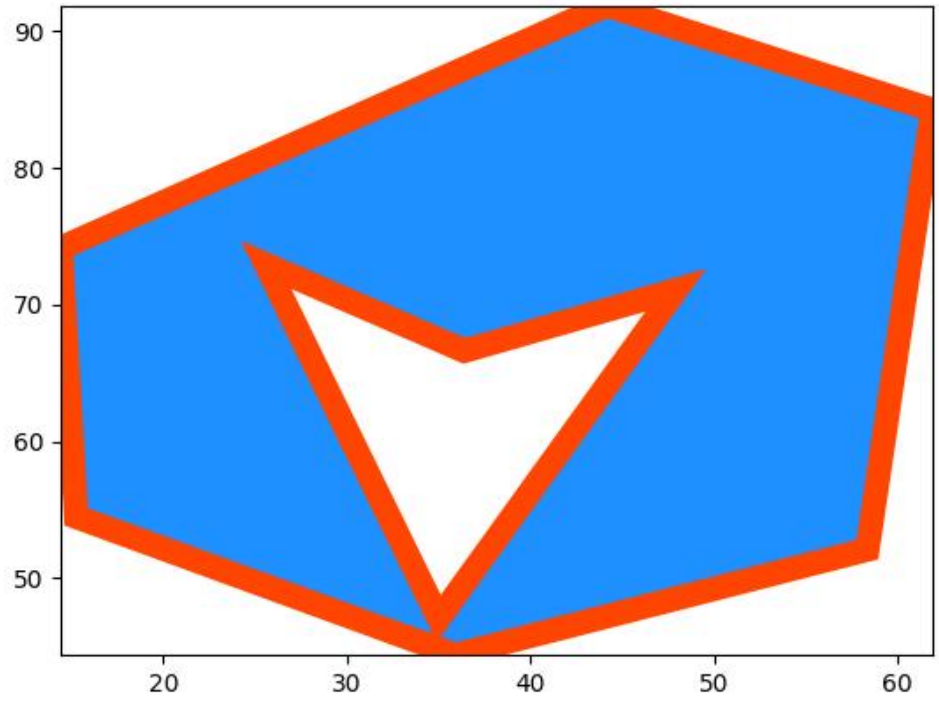
Todo:

- [ ] Rework arguments in favor of matplotlib standards

Example

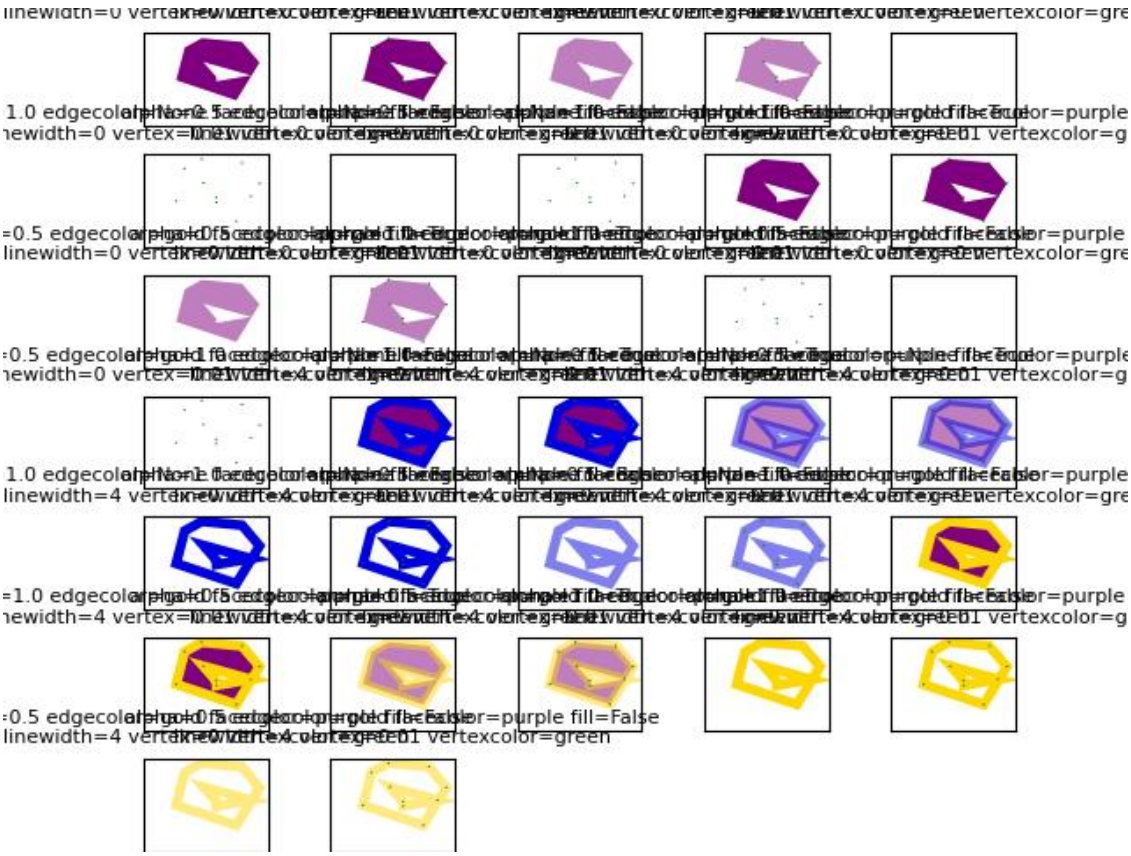
```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> from kwimage.structs.polygon import *  # NOQA
>>> self = Polygon.random(n_holes=1)
>>> self = self.scale(100)
>>> # xdoc: +REQUIRES(--show)
>>> kwargs = dict(edgecolor='orangered', facecolor='dodgerblue', linewidth=10)
>>> self.draw(**kwargs)
>>> import kwplot
>>> kwplot.autompl()
>>> from matplotlib import pyplot as plt
>>> kwplot.figure(fnum=2)
>>> self.draw(setlim=True, **kwargs)
```


1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0


90
80
70
60
50
20
30
40
50
60

Example

```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> # xdoc: +REQUIRES(--show)
>>> from kwimage.structs.polygon import *  # NOQA
>>> self = Polygon.random(n_holes=1, rng=33202)
>>> import textwrap
>>> # Test over a range of parameters
>>> basis = {
>>>     'linewidth': [0, 4],
>>>     'edgecolor': [None, 'gold'],
>>>     'facecolor': ['purple'],
>>>     'fill': [True, False],
>>>     'alpha': [1.0, 0.5],
>>>     'vertex': [0, 0.01],
>>>     'vertexcolor': ['green'],
>>> }
>>> grid = list(ub.named_product(basis))
>>> import kwplot
>>> kwplot.autompl()
>>> pnum_ = kwplot.PlotNums(nSubplots=len(grid))
>>> for kwargs in grid:
>>>     fig = kwplot.figure(fnum=1, pnum=pnum_())
>>>     ax = fig.gca()
>>>     self.draw(ax=ax, **kwargs)
>>>     title = ub.repr2(kwargs, compact=True)
>>>     title = '\n'.join(textwrap.wrap(
>>>         title.replace(',', ' '), break_long_words=False,
>>>         width=60))
>>>     ax.set_title(title, fontdict={'fontsize': 8})
>>>     ax.grid(False)
>>>     ax.set_xticks([])
>>>     ax.set_yticks([])
>>> fig.subplots_adjust(wspace=0.5, hspace=0.3, bottom=0.001, top=0.97)
>>> kwplot.show_if_requested()
```



class kwimage.structs.polygon.**MultiPolygon**(*data*, *meta=None*)

Bases: ObjectList

Data structure for storing multiple polygons (typically related to the same underlying but potentitally disjoing object)

Variables

data (*List[Polygon]*) –

property **area**

Computes are via shapley conversion

Returns

float

classmethod **random**(*n=3*, *n_holes=0*, *rng=None*, *tight=False*)

Create a random MultiPolygon

Returns

MultiPolygon

fill(*image*, *value=1*, *pixels_are='points'*)

Inplace fill in an image based on this multi-polyon.

Parameters

- **image** (*ndarray*) – image to draw on (inplace)
- **value** (*int | Tuple[int, ...]*) – value fill in with. Defaults to 1.0

Returns

the image that has been modified in place

Return type
ndarray

`to_multi_polygon`()

Returns
MultiPolygon

`to_boxes`()

Deprecated: lossy conversion use 'bounding_box' instead

Returns
kwimage.Boxes

`bounding_box`()

Return the bounding box of the multi polygon

Returns

a Boxes object with one box that encloses all
polygons

Return type
kwimage.Boxes

Example

```
>>> from kwimage.structs.polygon import *  # NOQA
>>> self = MultiPolygon.random(rng=0, n=10)
>>> boxes = self.to_boxes()
>>> sub_boxes = [d.to_boxes() for d in self.data]
>>> areas1 = np.array([s.intersection(boxes).area[0] for s in sub_boxes])
>>> areas2 = np.array([s.area[0] for s in sub_boxes])
>>> assert np.allclose(areas1, areas2)
```

`to_mask`(*dims=None*, *pixels_are='points'*)

Returns a mask object indication regions occupied by this multipolygon

Returns
kwimage.Mask

Example

```
>>> from kwimage.structs.polygon import *  # NOQA
>>> s = 100
>>> self = MultiPolygon.random(rng=0).scale(s)
>>> dims = (s, s)
>>> mask = self.to_mask(dims)
>>> # xdoc: +REQUIRES(--show)
>>> # xdoc: +REQUIRES(module:kwplot)
>>> import kwplot
>>> plt = kwplot.autoplt()
>>> kwplot.figure(fnum=1, doclf=True)
>>> ax = plt.gca()
>>> ax.set_xlim(0, s)
```

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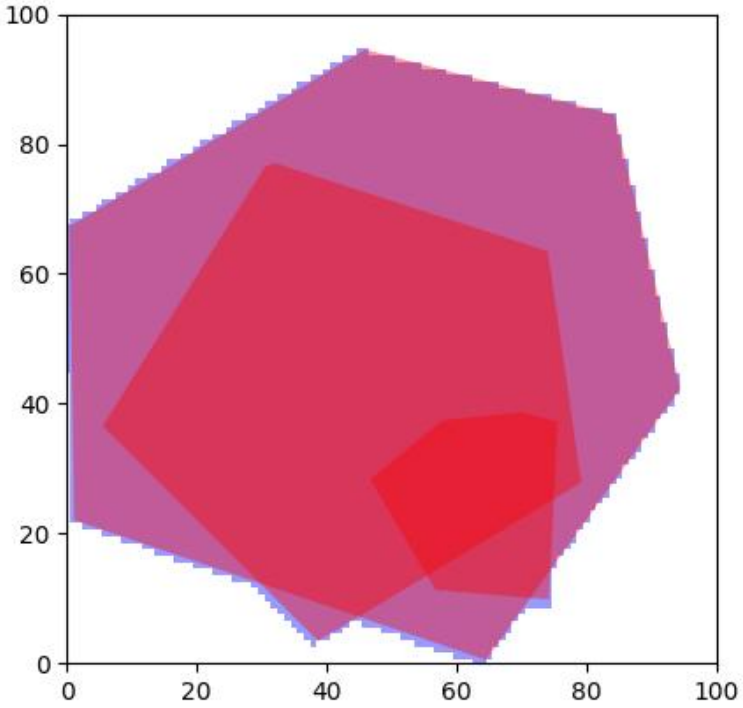
```
>>> ax.set_ylim(0, s)
>>> self.draw(color='red', alpha=.4)
>>> mask.draw(color='blue', alpha=.4)
```



to_relative_mask(*return_offset=False*)

Returns a translated mask such the mask dimensions are minimal.

In other words, we move the polygon all the way to the top-left and return a mask just big enough to fit the polygon.

Returns

kwimage.Mask

classmethod coerce(*data*, *dims=None*)

Attempts to construct a MultiPolygon instance from the input data

See Segmentation.coerce

Returns

None | MultiPolygon

Example

```
>>> import kwimage
>>> dims = (32, 32)
>>> kw_poly = kwimage.Polygon.random().scale(dims)
>>> kw_multi_poly = kwimage.MultiPolygon.random().scale(dims)
>>> forms = [kw_poly, kw_multi_poly]
>>> forms.append(kw_poly.to_shapely())
>>> forms.append(kw_poly.to_mask((32, 32)))
>>> forms.append(kw_poly.to_geojson())
>>> forms.append(kw_poly.to_coco(style='orig'))
>>> forms.append(kw_poly.to_coco(style='new'))
>>> forms.append(kw_multi_poly.to_shapely())
>>> forms.append(kw_multi_poly.to_mask((32, 32)))
>>> forms.append(kw_multi_poly.to_geojson())
>>> forms.append(kw_multi_poly.to_coco(style='orig'))
>>> forms.append(kw_multi_poly.to_coco(style='new'))
>>> for data in forms:
>>>     result = kwimage.MultiPolygon.coerce(data, dims=dims)
>>>     assert isinstance(result, kwimage.MultiPolygon)
```

to_shapely()

Returns
shapely.geometry.MultiPolygon

Example

```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> # xdoc: +REQUIRES(module:shapely)
>>> from kwimage.structs.polygon import *  # NOQA
>>> self = MultiPolygon.random(rng=0)
>>> geom = self.to_shapely()
>>> print('geom = {!r}'.format(geom))
```

classmethod from_shapely(*geom*)

Convert a shapely polygon or multipolygon to a kwimage.MultiPolygon

Parameters
geom (*shapely.geometry.MultiPolygon | shapely.geometry.Polygon*)

Returns
MultiPolygon

Example

```
>>> import kwimage
>>> sh_poly = kwimage.Polygon.random().to_shapely()
>>> sh_multi_poly = kwimage.MultiPolygon.random().to_shapely()
>>> kwimage.MultiPolygon.from_shapely(sh_poly)
>>> kwimage.MultiPolygon.from_shapely(sh_multi_poly)
```

classmethod from_geojson(*data_geojson*)

Convert a geojson polygon or multipolygon to a kwimage.MultiPolygon

Parameters
data_geojson (*Dict*) – geojson data

Returns
MultiPolygon

Example

```
>>> import kwimage
>>> orig = kwimage.MultiPolygon.random()
>>> data_geojson = orig.to_geojson()
>>> self = kwimage.MultiPolygon.from_geojson(data_geojson)
```

to_geojson()

Converts polygon to a geojson structure

Returns
Dict

classmethod from_coco(*data*, *dims=None*)

Accepts either new-style or old-style coco multi-polygons

Parameters

- **data** (*List[List[Number] | Dict]*) – a new or old style coco multi polygon
- **dims** (*None | Tuple[int, ...]*) – the shape dimensions of the canvas. Unused. Exists for compatibility with masks.

Returns
MultiPolygon

to_coco(*style='orig'*)

Parameters
style (*str*) – can be “orig” or “new”

Example

```
>>> from kwimage.structs.polygon import *  # NOQA
>>> self = MultiPolygon.random(1, rng=0)
>>> self.to_coco()
```

swap_axes(*inplace=False*)

Swap x and y axis

Parameters
inplace (*bool*)

Returns
MultiPolygon

draw_on(*image*, ***kwargs*)

class kwimage.structs.polygon.**PolygonList**(*data*, *meta=None*)

Bases: ObjectList

Stores and allows manipluation of multiple polygons, usually within the same image.

to_mask_list(*dims=None*, *pixels_are='points'*)

Converts all items to masks

Returns
kwimage.MaskList

to_polygon_list()

Returns
PolygonList

to_segmentation_list()

Converts all items to segmentation objects

Returns
kwimage.SegmentationList

swap_axes(*inplace=False*)

Returns
PolygonList

to_geojson(*as_collection=False*)

Converts a list of polygons/multipolygons to a geojson structure

Parameters
as_collection (*bool*) – if True, wraps the polygon geojson items in a geojson feature collection, otherwise just return a list of items.

Returns
items or geojson data

Return type
List[Dict] | Dict

Example

```
>>> import kwimage
>>> data = [kwimage.Polygon.random(),
>>>         kwimage.Polygon.random(n_holes=1),
>>>         kwimage.MultiPolygon.random(n_holes=1),
>>>         kwimage.MultiPolygon.random()]
>>> self = kwimage.PolygonList(data)
>>> geojson = self.to_geojson(as_collection=True)
>>> items = self.to_geojson(as_collection=False)
>>> print('geojson = {}'.format(ub.repr2(geojson, nl=-2, precision=1)))
>>> print('items = {}'.format(ub.repr2(items, nl=-2, precision=1)))
```

fill(*image*, *value=1*, *pixels_are='points'*)

Inplace fill in an image based on these polygons

Parameters

- **image** (*ndarray*) – image to draw on (inplace)
- **value** (*int | Tuple[int, ...]*) – value fill in with

Returns

the image that has been modified in place

Return type

ndarray

draw_on(**args*, ***kw*)

kwimage.structs.segmentation module

Generic segmentation object that can use either a Mask or (Multi)Polygon backend.

class kwimage.structs.segmentation.**Segmentation**(*data*, *format=None*)

Bases: _WrapperObject

Either holds a MultiPolygon, Polygon, or Mask

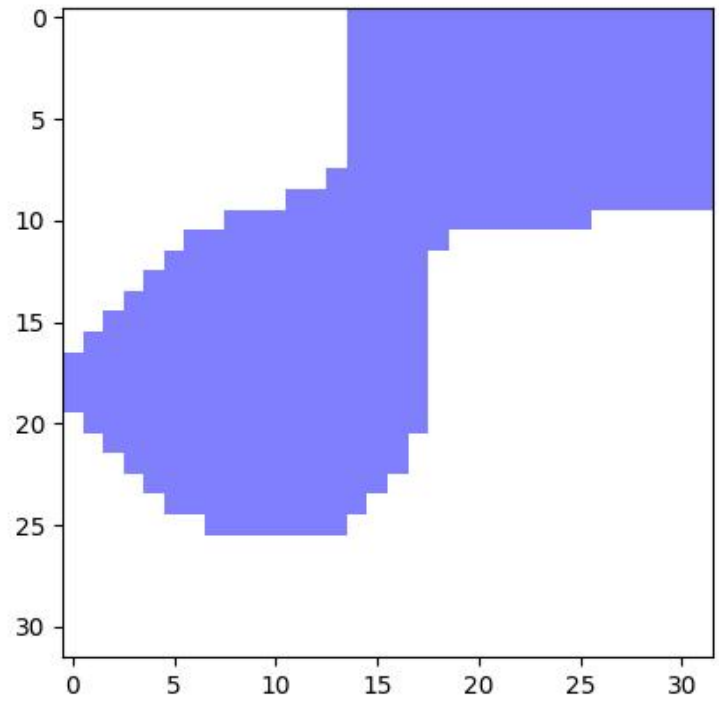
Parameters

- **data** (*object*) – the underlying object
- **format** (*str*) – either 'mask', 'polygon', or 'multipolygon'

classmethod random(*rng=None*)

Example

```
>>> self = Segmentation.random()
>>> print('self = {!r}'.format(self))
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.figure(fnum=1, doclf=True)
>>> self.draw()
>>> kwplot.show_if_requested()
```



to_multi_polygon()

to_mask(*dims=None*, *pixels_are='points'*)

property meta

classmethod coerce(*data*, *dims=None*)

class kwimage.structs.segmentation.**SegmentationList**(*data*, *meta=None*)

Bases: ObjectList

Store and manipulate multiple segmentations (masks or polygons), usually within the same image

to_polygon_list()

Converts all mask objects to multi-polygon objects

to_mask_list(*dims=None*, *pixels_are='points'*)

Converts all mask objects to multi-polygon objects

to_segmentation_list()

classmethod coerce(*data*)

Interpret data as a list of Segmentations

Module contents

mkinit ~/code/kwimage/kwimage/structs/__init__.py -w –relative –nomod

A common thread in many kwimage.structs / kwannot objects is that they attempt to store multiple data elements using a single data structure when possible e.g. the classes are Boxes, Points, Detections, Coords, and not Box, Detection, Coord. The exceptions are Polygon, Heatmap, and Mask, where it made more sense to have one object-per item because each individual item is a reasonably sized chuck of data.

Another commonality is that objects have only two main attributes: .data and .meta. These allow the underlying representation of the object to vary as needed.

Currently Boxes and Mask do not have a .meta attribute. They instead have a .format attribute which is a text-code indicating the underlying layout of the data.

The *data* and *meta* instance attributes in the Points, Detections, and Heatmaps classes are dictionaries. These classes also have a *__datakeys__* and *__metakeys__* class attribute, which are lists of strings. These lists specify which keys are expected in each dictionary. For instance, *Points.__datakeys__ = ['xy', 'class_idxs', 'visible']* and *Points.__metakeys__ = ['classes']*. All objects in the data dictionary are expected to be aligned, whereas the meta dictionary is for auxillay data. For example in Points, the xy position data['xy'][i] is expected to have the class index data['class_idxs'][i]. By convention, a class index indexes into the list of category names stored in *meta['classes']*.

The Heatmap.data behaves slighly different than Points. Its *data* dictionary stores different per-pixel attributes like class probability scores, or offset vectors. The *meta* dictionary stores data like the originaly image dimensions (heatmaps are usually downsampled wrt the image that they correspond to) and the transformation matrices would warp the "data" space back onto the original image space.

Note that the developer can add any extra data or meta keys that they like, but they should keep in mind that all items in *data* should be aligned, whereas *meta* can contain arbitrary information.

class kwimage.structs.**Boxes**(*data*, *format=None*, *check=True*)

Bases: _BoxConversionMixins, _BoxPropertyMixins, _BoxTransformMixins, _BoxDrawMixins, NiceRepr

Converts boxes between different formats as long as the last dimension contains 4 coordinates and the format is specified.

This is a convinience class, and should not not store the data for very long. The general idiom should be create class, convert data, and then get the raw data and let the class be garbage collected. This will help ensure that your code is portable and understandable if this class is not available.

Example

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> import kwimage
>>> import numpy as np
>>> # Given an array / tensor that represents one or more boxes
>>> data = np.array([[ 0,  0, 10, 10],
>>>                  [ 5,  5, 50, 50],
>>>                  [20,  0, 30, 10]])
>>> # The kwimage.Boxes data structure is a thin fast wrapper
>>> # that provides methods for operating on the boxes.
>>> # It requires that the user explicitly provide a code that denotes
>>> # the format of the boxes (i.e. what each column represents)
>>> boxes = kwimage.Boxes(data, 'ltrb')
>>> # This means that there is no ambiguity about box format
```

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```
>>> # The representation string of the Boxes object demonstrates this
>>> print('boxes = {!r}'.format(boxes))
boxes = <Boxes(ltrb,
    array([[ 0,  0, 10, 10],
           [ 5,  5, 50, 50],
           [20,  0, 30, 10]]))>
>>> # if you pass this data around. You can convert to other formats
>>> # For docs on available format codes see :class:`BoxFormat`.
>>> # In this example we will convert (left, top, right, bottom)
>>> # to (left-x, top-y, width, height).
>>> boxes.toformat('xywh')
<Boxes(xywh,
    array([[ 0,  0, 10, 10],
           [ 5,  5, 45, 45],
           [20,  0, 10, 10]]))>
>>> # In addition to format conversion there are other operations
>>> # We can quickly (using a C-backend) find IoUs
>>> ious = boxes.ious(boxes)
>>> print('{}'.format(ub.repr2(ious, nl=1, precision=2, with_dtype=False)))
np.array([[1.  , 0.01, 0.  ],
          [0.01, 1.  , 0.02],
          [0.  , 0.02, 1.  ]])
>>> # We can ask for the area of each box
>>> print('boxes.area = {}'.format(ub.repr2(boxes.area, nl=0, with_dtype=False)))
boxes.area = np.array([[ 100],[2025],[ 100]])
>>> # We can ask for the center of each box
>>> print('boxes.center = {}'.format(ub.repr2(boxes.center, nl=1, with_
↪dtype=False)))
boxes.center = (
    np.array([[ 5. ],[27.5],[25. ]]),
    np.array([[ 5. ],[27.5],[ 5. ]]),
)
>>> # We can translate / scale the boxes
>>> boxes.translate((10, 10)).scale(100)
<Boxes(ltrb,
    array([[1000., 1000., 2000., 2000.],
           [1500., 1500., 6000., 6000.],
           [3000., 1000., 4000., 2000.]]))>
>>> # We can clip the bounding boxes
>>> boxes.translate((10, 10)).scale(100).clip(1200, 1200, 1700, 1800)
<Boxes(ltrb,
    array([[1200., 1200., 1700., 1800.],
           [1500., 1500., 1700., 1800.],
           [1700., 1200., 1700., 1800.]]))>
>>> # We can perform arbitrary warping of the boxes
>>> # (note that if the transform is not axis aligned, the axis aligned
>>> #  bounding box of the transform result will be returned)
>>> transform = np.array([[-0.83907153,  0.54402111,  0. ],
>>>                       [-0.54402111, -0.83907153,  0. ],
>>>                       [ 0.        ,  0.        ,  1. ]])
>>> boxes.warp(transform)
<Boxes(ltrb,
```

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```
    array([[ -8.3907153 , -13.8309264 ,   5.4402111 ,   0.        ],
           [-39.23347095, -69.154632  ,  23.00569785,  -6.9154632 ],
           [-25.1721459 , -24.7113486 , -11.3412195 , -10.8804222 ]]))>
>>> # Note, that we can transform the box to a Polygon for more
>>> # accurate warping.
>>> transform = np.array([[-0.83907153,  0.54402111,  0. ],
>>>                       [-0.54402111, -0.83907153,  0. ],
>>>                       [ 0.        ,  0.        ,  1. ]])
>>> warped_polys = boxes.to_polygons().warp(transform)
>>> print(ub.repr2(warped_polys.data, sv=1))
[
    <Polygon({
        'exterior': <Coords(data=
                        array([[  0.       ,   0.       ],
                               [  5.4402111,  -8.3907153],
                               [ -2.9505042, -13.8309264],
                               [ -8.3907153,  -5.4402111],
                               [  0.       ,   0.       ]]))>,
        'interiors': [],
    })>,
    <Polygon({
        'exterior': <Coords(data=
                        array([[ -1.4752521 ,  -6.9154632 ],
                               [ 23.00569785, -44.67368205],
                               [-14.752521  , -69.154632  ],
                               [-39.23347095, -31.39641315],
                               [ -1.4752521 ,  -6.9154632 ]]))>,
        'interiors': [],
    })>,
    <Polygon({
        'exterior': <Coords(data=
                        array([[-16.7814306, -10.8804222],
                               [-11.3412195, -19.2711375],
                               [-19.7319348, -24.7113486],
                               [-25.1721459, -16.3206333],
                               [-16.7814306, -10.8804222]]))>,
        'interiors': [],
    })>,
]
>>> # The kwimage.Boxes data structure is also convertable to
>>> # several alternative data structures, like shapely, coco, and imgaug.
>>> print(ub.repr2(boxes.to_shapely(), sv=1))
[
    POLYGON ((0 0, 0 10, 10 10, 10 0, 0 0)),
    POLYGON ((5 5, 5 50, 50 50, 50 5, 5 5)),
    POLYGON ((20 0, 20 10, 30 10, 30 0, 20 0)),
]
>>> # xdoctest: +REQUIRES(module:imgaug)
>>> print(ub.repr2(boxes[0:1].to_imgaug(shape=(100, 100)), sv=1))
BoundingBoxesOnImage([BoundingBox(x1=0.0000, y1=0.0000, x2=10.0000, y2=10.0000,␣
↪label=None)], shape=(100, 100))
>>> # xdoctest: -REQUIRES(module:imgaug)
```

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```
>>> print(ub.repr2(list(boxes.to_coco()), sv=1))
[
    [0, 0, 10, 10],
    [5, 5, 45, 45],
    [20, 0, 10, 10],
]
>>> # Finally, when you are done with your boxes object, you can
>>> # unwrap the raw data by using the ``.data`` attribute
>>> # all operations are done on this data, which gives the
>>> # kwiamge.Boxes data structure almost no overhead when
>>> # inserted into existing code.
>>> print('boxes.data =\n{}'.format(ub.repr2(boxes.data, nl=1)))
boxes.data =
np.array([[ 0,  0, 10, 10],
          [ 5,  5, 50, 50],
          [20,  0, 30, 10]], dtype=np.int64)
>>> # xdoctest: +REQUIRES(module:torch)
>>> # This data structure was designed for use with both torch
>>> # and numpy, the underlying data can be either an array or tensor.
>>> boxes.tensor()
<Boxes(ltrb,
    tensor([[ 0,  0, 10, 10],
            [ 5,  5, 50, 50],
            [20,  0, 30, 10]]))>
>>> boxes.numpy()
<Boxes(ltrb,
    array([[ 0,  0, 10, 10],
           [ 5,  5, 50, 50],
           [20,  0, 30, 10]]))>
```

Example

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> from kwimage.structs.boxes import *  # NOQA
>>> # Demo of conversion methods
>>> import kwimage
>>> kwimage.Boxes([[25, 30, 15, 10]], 'xywh')
<Boxes(xywh, array([[25, 30, 15, 10]]))>
>>> kwimage.Boxes([[25, 30, 15, 10]], 'xywh').to_xywh()
<Boxes(xywh, array([[25, 30, 15, 10]]))>
>>> kwimage.Boxes([[25, 30, 15, 10]], 'xywh').to_cxywh()
<Boxes(cxywh, array([[32.5, 35. , 15. , 10. ]]))>
>>> kwimage.Boxes([[25, 30, 15, 10]], 'xywh').to_ltrb()
<Boxes(ltrb, array([[25, 30, 40, 40]]))>
>>> kwimage.Boxes([[25, 30, 15, 10]], 'xywh').scale(2).to_ltrb()
<Boxes(ltrb, array([[50., 60., 80., 80.]]))>
>>> # xdoctest: +REQUIRES(module:torch)
>>> kwimage.Boxes(torch.FloatTensor([[25, 30, 15, 20]]), 'xywh').scale(.1).to_ltrb()
<Boxes(ltrb, tensor([[ 2.5000,  3.0000,  4.0000,  5.0000]]))>
```

Note: In the following examples we show cases where *Boxes* can hold a single 1-dimensional box array. This is a holdover from an older codebase, and some functions may assume that the input is at least 2-D. Thus when representing a single bounding box it is best practice to view it as a list of 1 box. While many function will work in the 1-D case, not all functions have been tested and thus we cannot gaurentee correctness.

Example

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> Boxes([25, 30, 15, 10], 'xywh')
<Boxes(xywh, array([25, 30, 15, 10]))>
>>> Boxes([25, 30, 15, 10], 'xywh').to_xywh()
<Boxes(xywh, array([25, 30, 15, 10]))>
>>> Boxes([25, 30, 15, 10], 'xywh').to_cxywh()
<Boxes(cxywh, array([32.5, 35. , 15. , 10. ]))>
>>> Boxes([25, 30, 15, 10], 'xywh').to_ltrb()
<Boxes(ltrb, array([25, 30, 40, 40]))>
>>> Boxes([25, 30, 15, 10], 'xywh').scale(2).to_ltrb()
<Boxes(ltrb, array([50., 60., 80., 80.]))>
>>> # xdoctest: +REQUIRES(module:torch)
>>> Boxes(torch.FloatTensor([[25, 30, 15, 20]]), 'xywh').scale(.1).to_ltrb()
<Boxes(ltrb, tensor([[ 2.5000,  3.0000,  4.0000,  5.0000]]))>
```

Example

```
>>> datas = [
>>>     [1, 2, 3, 4],
>>>     [[1, 2, 3, 4], [4, 5, 6, 7]],
>>>     [[[1, 2, 3, 4], [4, 5, 6, 7]]],
>>> ]
>>> formats = BoxFormat.cannonical
>>> for format1 in formats:
>>>     for data in datas:
>>>         self = box1 = Boxes(data, format1)
>>>         for format2 in formats:
>>>             box2 = box1.toformat(format2)
>>>             back = box2.toformat(format1)
>>>             assert box1 == back
```

classmethod random(*num=1*, *scale=1.0*, *format='xywh'*, *anchors=None*, *anchor_std=0.16666666666666666*, *tensor=False*, *rng=None*)

Makes random boxes; typically for testing purposes

Parameters

- **num** (*int*) – number of boxes to generate
- **scale** (*float | Tuple[float, float]*) – size of imgdims
- **format** (*str*) – format of boxes to be created (e.g. ltrb, xywh)
- **anchors** (*ndarray*) – normalized width / heights of anchor boxes to perterb and randomly place. (must be in range 0-1)

- **anchor_std** (*float*) – magnitude of noise applied to anchor shapes
- **tensor** (*bool*) – if True, returns boxes in tensor format
- **rng** (*None | int | RandomState*) – initial random seed

Returns
random boxes

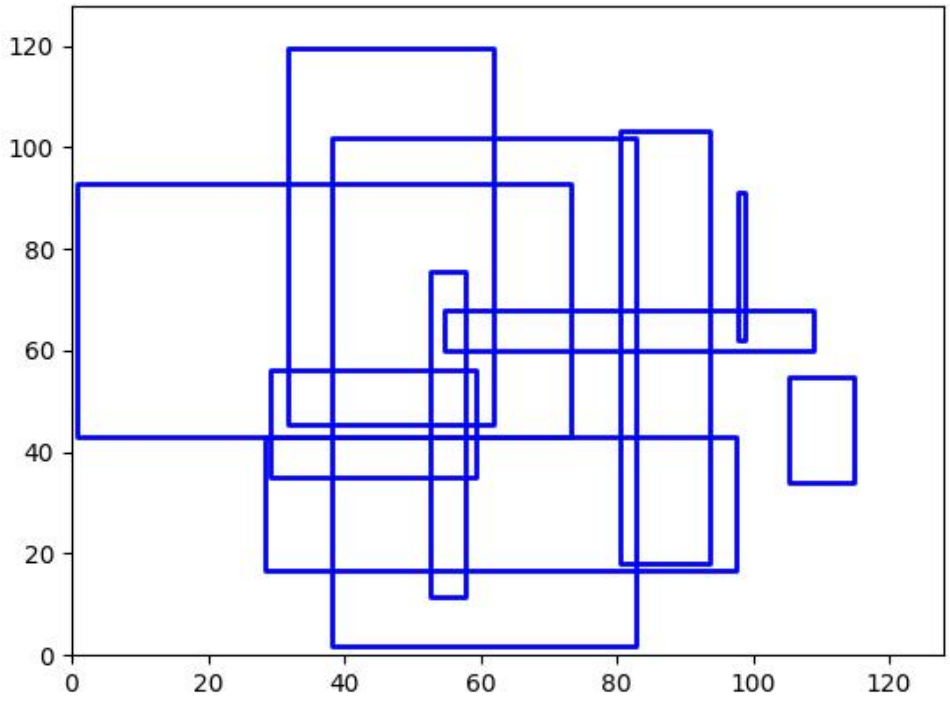
Return type
Boxes

Example

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> Boxes.random(3, rng=0, scale=100)
<Boxes(xywh,
    array([[54, 54,  6, 17],
           [42, 64,  1, 25],
           [79, 38, 17, 14]]))>
>>> # xdoctest: +REQUIRES(module:torch)
>>> Boxes.random(3, rng=0, scale=100).tensor()
<Boxes(xywh,
    tensor([[ 54,  54,   6,  17],
            [ 42,  64,   1,  25],
            [ 79,  38,  17,  14]]))>
>>> anchors = np.array([[.5, .5], [.3, .3]])
>>> Boxes.random(3, rng=0, scale=100, anchors=anchors)
<Boxes(xywh,
    array([[ 2, 13, 51, 51],
           [32, 51, 32, 36],
           [36, 28, 23, 26]]))>
```

Example

```
>>> # Boxes position/shape within 0-1 space should be uniform.
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> fig = kwplot.figure(fnum=1, doclf=True)
>>> fig.gca().set_xlim(0, 128)
>>> fig.gca().set_ylim(0, 128)
>>> import kwimage
>>> kwimage.Boxes.random(num=10).scale(128).draw()
```



copy()

Returns
a copy of these boxes

Return type
Boxes

classmethod concatenate(*boxes*, *axis=0*)

Concatenates multiple boxes together

Parameters

- **boxes** (*Sequence[Boxes]*) – list of boxes to concatenate
- **axis** (*int*) – axis to stack on. Defaults to 0.

Returns
stacked boxes

Return type
Boxes

Example

```
>>> boxes = [Boxes.random(3) for _ in range(3)]
>>> new = Boxes.concatenate(boxes)
>>> assert len(new) == 9
>>> assert np.all(new.data[3:6] == boxes[1].data)
```

Example

```
>>> boxes = [Boxes.random(3) for _ in range(3)]
>>> boxes[0].data = boxes[0].data[0]
>>> boxes[1].data = boxes[0].data[0:0]
>>> new = Boxes.concatenate(boxes)
>>> assert len(new) == 4
>>> # xdoctest: +REQUIRES(module:torch)
>>> new = Boxes.concatenate([b.tensor() for b in boxes])
>>> assert len(new) == 4
```

compress(*flags*, *axis=0*, *inplace=False*)

Filters boxes based on a boolean criterion

Parameters

- **flags** (*ArrayLike*) – true for items to be kept. Extended type: ArrayLike[bool]
- **axis** (*int*) – you usually want this to be 0
- **inplace** (*bool*) – if True, modifies this object

Returns
the boxes corresponding to where flags were true

Return type
Boxes

Example

```
>>> self = Boxes([[25, 30, 15, 10]], 'ltrb')
>>> self.compress([True])
<Boxes(ltrb, array([[25, 30, 15, 10]]))>
>>> self.compress([False])
<Boxes(ltrb, array([], shape=(0, 4), dtype=int64))>
```

take(*idxs*, *axis=0*, *inplace=False*)

Takes a subset of items at specific indices

Parameters

- **indices** (*ArrayLike*) – Indexes of items to take. Extended type ArrayLike[int].
- **axis** (*int*) – you usually want this to be 0
- **inplace** (*bool*) – if True, modifies this object

Returns
the boxes corresponding to the specified indices

Return type
Boxes

Example

```
>>> self = Boxes([[25, 30, 15, 10]], 'ltrb')
>>> self.take([0])
<Boxes(ltrb, array([[25, 30, 15, 10]]))>
>>> self.take([])
<Boxes(ltrb, array([], shape=(0, 4), dtype=int64))>
```

`is_tensor`()

is the backend fueled by torch?

Returns
True if the Boxes are torch tensors

Return type
bool

`is_numpy`()

is the backend fueled by numpy?

Returns
True if the Boxes are numpy arrays

Return type
bool

`property device`

If the backend is torch returns the data device, otherwise None

`astype`(*dtype*)

Changes the type of the internal array used to represent the boxes

---

Note: this operation is not inplace

Returns
the boxes with the chosen type

Return type
Boxes

Example

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> # xdoctest: +REQUIRES(module:torch)
>>> Boxes.random(3, 100, rng=0).tensor().astype('int32')
<Boxes(xywh,
    tensor([[54, 54,  6, 17],
            [42, 64,  1, 25],
            [79, 38, 17, 14]], dtype=torch.int32))>
>>> Boxes.random(3, 100, rng=0).numpy().astype('int32')
```

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```
<Boxes(xywh,
    array([[54, 54,  6, 17],
           [42, 64,  1, 25],
           [79, 38, 17, 14]], dtype=int32))>
>>> Boxes.random(3, 100, rng=0).tensor().astype('float32')
>>> Boxes.random(3, 100, rng=0).numpy().astype('float32')
```

round(*inplace=False*)

Rounds data coordinates to the nearest integer.

This operation is applied directly to the box coordinates, so its output will depend on the format the boxes are stored in.

Parameters
inplace (*bool*) – if True, modifies this object. Defaults to False.

Returns
the boxes with rounded coordinates

Return type
Boxes

SeeAlso:
Boxes.quantize()

Example

```
>>> import kwimage
>>> self = kwimage.Boxes.random(3, rng=0).scale(10)
>>> new = self.round()
>>> print('self = {!r}'.format(self))
>>> print('new = {!r}'.format(new))
self = <Boxes(xywh,
    array([[5.48813522, 5.44883192, 0.53949833, 1.70306146],
           [4.23654795, 6.4589411 , 0.13932407, 2.45878875],
           [7.91725039, 3.83441508, 1.71937704, 1.45453393]]))>
new = <Boxes(xywh,
    array([[5., 5., 1., 2.],
           [4., 6., 0., 2.],
           [8., 4., 2., 1.]]))>
```

quantize(*inplace=False*, *dtype=<class 'numpy.int32'>*)

Converts the box to integer coordinates.

This operation takes the floor of the left side and the ceil of the right side. Thus the area of the box will never decreases. But this will often increase the width / height of the box by a pixel.

Parameters

- **inplace** (*bool*) – if True, modifies this object
- **dtype** (*type*) – type to cast as

Returns
the boxes with quantized coordinates

Return type
Boxes

SeeAlso:
Boxes.round() Boxes.resize() if you need to ensure the size does not change

Example

```
>>> import kwimage
>>> self = kwimage.Boxes.random(3, rng=0).scale(10)
>>> new = self.quantize()
>>> print('self = {!r}'.format(self))
>>> print('new = {!r}'.format(new))
self = <Boxes(xywh,
    array([[5.48813522, 5.44883192, 0.53949833, 1.70306146],
           [4.23654795, 6.4589411 , 0.13932407, 2.45878875],
           [7.91725039, 3.83441508, 1.71937704, 1.45453393]]))>
new = <Boxes(xywh,
    array([[5, 5, 2, 3],
           [4, 6, 1, 3],
           [7, 3, 3, 3]], dtype=int32))>
```

Example

```
>>> import kwimage
>>> # Be careful if it is important to preserve the width/height
>>> self = kwimage.Boxes([[0, 0, 10, 10]], 'xywh')
>>> aff = kwimage.Affine.coerce(offset=(0.5, 0.0))
>>> warped = self.warp(aff)
>>> new = warped.quantize(dtype=int)
>>> print('self   = {!r}'.format(self))
>>> print('warped = {!r}'.format(warped))
>>> print('new    = {!r}'.format(new))
self   = <Boxes(xywh, array([[ 0,  0, 10, 10]]))>
warped = <Boxes(xywh, array([[ 0.5,  0. , 10. , 10. ]]))>
new    = <Boxes(xywh, array([[ 0,  0, 11, 10]]))>
```

Example

```
>>> import kwimage
>>> self = kwimage.Boxes.random(3, rng=0)
>>> orig = self.copy()
>>> self.quantize(inplace=True)
>>> assert np.any(self.data != orig.data)
```

numpy()

Converts tensors to numpy. Does not change memory if possible.

Returns
the boxes with a numpy backend

Return type
Boxes

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> self = Boxes.random(3).tensor()
>>> newself = self.numpy()
>>> self.data[0, 0] = 0
>>> assert newself.data[0, 0] == 0
>>> self.data[0, 0] = 1
>>> assert self.data[0, 0] == 1
```

tensor(*device=NoParam*)

Converts numpy to tensors. Does not change memory if possible.

Parameters
device (*int | None | torch.device*) – The torch device to put the backend tensors on

Returns
the boxes with a torch backend

Return type
Boxes

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> self = Boxes.random(3)
>>> # xdoctest: +REQUIRES(module:torch)
>>> newself = self.tensor()
>>> self.data[0, 0] = 0
>>> assert newself.data[0, 0] == 0
>>> self.data[0, 0] = 1
>>> assert self.data[0, 0] == 1
```

ious(*other*, *bias=0*, *impl='auto'*, *mode=None*)

Intersection over union.

Compute IOUs (intersection area over union area) between these boxes and another set of boxes. This is a symmetric measure of similarity between boxes.

Todo:

- **[ ] Add pairwise flag to toggle between one-vs-one and all-vs-all**
  computation. I.E. Add option for componentwise calculation.

Parameters

- **other** (*Boxes*) – boxes to compare IoUs against
- **bias** (*int*) – either 0 or 1, does TL=BR have area of 0 or 1? Defaults to 0.

- **impl** (*str*) – code to specify implementation used to ious. Can be either torch, py, c, or auto. Efficiency and the exact result will vary by implementation, but they will always be close. Some implementations only accept certain data types (e.g. impl='c', only accepts float32 numpy arrays). See ~/code/kwimage/dev/bench_bbox.py for benchmark details. On my system the torch impl was fastest (when the data was on the GPU). Defaults to 'auto'
- **mode** (*str*) – depricated, use impl

Returns
the ious

Return type
ndarray

SeeAlso:
iooas - for a measure of coverage between boxes

Examples

```
>>> import kwimage
>>> self = kwimage.Boxes(np.array([[ 0,  0, 10, 10],
>>>                                [10,  0, 20, 10],
>>>                                [20,  0, 30, 10]]), 'ltrb')
>>> other = kwimage.Boxes(np.array([6, 2, 20, 10]), 'ltrb')
>>> overlaps = self.ious(other, bias=1).round(2)
>>> assert np.all(np.isclose(overlaps, [0.21, 0.63, 0.04])), repr(overlaps)
```

Examples

```
>>> import kwimage
>>> boxes1 = kwimage.Boxes(np.array([[ 0,  0, 10, 10],
>>>                                  [10,  0, 20, 10],
>>>                                  [20,  0, 30, 10]]), 'ltrb')
>>> other = kwimage.Boxes(np.array([[6, 2, 20, 10],
>>>                                 [100, 200, 300, 300]]), 'ltrb')
>>> overlaps = boxes1.ious(other)
>>> print('{}'.format(ub.repr2(overlaps, precision=2, nl=1)))
np.array([[0.18, 0.  ],
          [0.61, 0.  ],
          [0.  , 0.  ]]...)
```

Examples

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> Boxes(np.empty(0), 'xywh').ious(Boxes(np.empty(4), 'xywh')).shape
(0,)
>>> #Boxes(np.empty(4), 'xywh').ious(Boxes(np.empty(0), 'xywh')).shape
>>> Boxes(np.empty((0, 4)), 'xywh').ious(Boxes(np.empty((0, 4)), 'xywh')).shape
(0, 0)
>>> Boxes(np.empty((1, 4)), 'xywh').ious(Boxes(np.empty((0, 4)), 'xywh')).shape
(1, 0)
```

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```
>>> Boxes(np.empty((0, 4)), 'xywh').ious(Boxes(np.empty((1, 4)), 'xywh')).shape
(0, 1)
```

Examples

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> formats = BoxFormat.cannonical
>>> istensors = [False, True]
>>> results = {}
>>> for format in formats:
>>>     for tensor in istensors:
>>>         boxes1 = Boxes.random(5, scale=10.0, rng=0, format=format,␣
↪tensor=tensor)
>>>         boxes2 = Boxes.random(7, scale=10.0, rng=1, format=format,␣
↪tensor=tensor)
>>>         ious = boxes1.ious(boxes2)
>>>         results[(format, tensor)] = ious
>>> results = {k: v.numpy() if torch.is_tensor(v) else v for k, v in results.
↪items() }
>>> results = {k: v.tolist() for k, v in results.items()}
>>> print(ub.repr2(results, sk=True, precision=3, nl=2))
>>> from functools import partial
>>> assert ub.allsame(results.values(), partial(np.allclose, atol=1e-07))
```

iooas(*other*, *bias=0*)

Intersection over other area.

This is an asymetric measure of coverage. How much of the "other" boxes are covered by these boxes. It is the area of intersection between each pair of boxes and the area of the "other" boxes.

SeeAlso:
ious - for a measure of similarity between boxes

Parameters

- **other** (*Boxes*) – boxes to compare IoOA against
- **bias** (*int*) – either 0 or 1, does TL=BR have area of 0 or 1? Defaults to 0.

Returns
the iooas

Return type
ndarray

Examples

```
>>> self = Boxes(np.array([[ 0,  0, 10, 10],
>>>                        [10,  0, 20, 10],
>>>                        [20,  0, 30, 10]]), 'ltrb')
>>> other = Boxes(np.array([[6, 2, 20, 10], [0, 0, 0, 3]]), 'xywh')
>>> coverage = self.iooas(other, bias=0).round(2)
>>> print('coverage = {!r}'.format(coverage))
```

isect_area(*other*, *bias=0*)

Intersection part of intersection over union computation

Parameters

- **other** (*Boxes*) – boxes to compare IoOA against
- **bias** (*int*) – either 0 or 1, does TL=BR have area of 0 or 1? Defaults to 0.

Returns
the iooas

Return type
ndarray

Examples

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> self = Boxes.random(5, scale=10.0, rng=0, format='ltrb')
>>> other = Boxes.random(3, scale=10.0, rng=1, format='ltrb')
>>> isect = self.isect_area(other, bias=0)
>>> ious_v1 = isect / ((self.area + other.area.T) - isect)
>>> ious_v2 = self.ious(other, bias=0)
>>> assert np.allclose(ious_v1, ious_v2)
```

intersection(*other*)

Componentwise intersection between two sets of Boxes

intersections of boxes are always boxes, so this works

Parameters
other (*Boxes*) – boxes to intersect with this object. (must be of same length)

Returns
the intersection geometry

Return type
Boxes

Examples

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> from kwimage.structs.boxes import *  # NOQA
>>> self = Boxes.random(5, rng=0).scale(10.)
>>> other = self.translate(1)
>>> new = self.intersection(other)
>>> new_area = np.nan_to_num(new.area).ravel()
>>> alt_area = np.diag(self.isect_area(other))
>>> close = np.isclose(new_area, alt_area)
>>> assert np.all(close)
```

union_hull(*other*)

Componentwise hull union between two sets of Boxes

NOTE: convert to polygon to do a real union.

Parameters
other (*Boxes*) – boxes to union with this object. (must be of same length)

Returns
unioned boxes

Return type
Boxes

Examples

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> from kwimage.structs.boxes import *  # NOQA
>>> self = Boxes.random(5, rng=0).scale(10.)
>>> other = self.translate(1)
>>> new = self.union_hull(other)
>>> new_area = np.nan_to_num(new.area).ravel()
```

bounding_box()

Returns the box that bounds all of the contained boxes

Returns
a single box

Return type
Boxes

Examples

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> from kwimage.structs.boxes import *  # NOQA
>>> self = Boxes.random(5, rng=0).scale(10.)
>>> other = self.translate(1)
>>> new = self.union_hull(other)
>>> new_area = np.nan_to_num(new.area).ravel()
```

contains(*other*)

Determine of points are completely contained by these boxes

Parameters
other (*kwimage.Points*) – points to test for containment. TODO: support generic data types

Returns

flags - N x M boolean matrix indicating which box
contains which points, where N is the number of boxes and M is the number of points.

Return type
ArrayLike

Examples

```
>>> import kwimage
>>> self = kwimage.Boxes.random(10).scale(10).round()
>>> other = kwimage.Points.random(10).scale(10).round()
>>> flags = self.contains(other)
>>> flags = self.contains(self.xy_center)
>>> assert np.all(np.diag(flags))
```

view(**shape*)

Passthrough method to view or reshape

Parameters
***shape** (*Tuple[int, ...]*) – new shape

Returns
data with a different view

Return type
Boxes

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> self = Boxes.random(6, scale=10.0, rng=0, format='xywh').tensor()
>>> assert list(self.view(3, 2, 4).data.shape) == [3, 2, 4]
>>> self = Boxes.random(6, scale=10.0, rng=0, format='ltrb').tensor()
>>> assert list(self.view(3, 2, 4).data.shape) == [3, 2, 4]
```

class kwimage.structs.**Coords**(*data=None*, *meta=None*)

Bases: Spatial, NiceRepr

A data structure to store n-dimensional coordinate geometry.

Currently it is up to the user to maintain what coordinate system this geometry belongs to.

Note: This class was designed to hold coordinates in r/c format, but in general this class is anostic to dimension ordering as long as you are consistent. However, there are two places where this matters: (1) drawing and (2) gdal/imgaug-warping. In these places we will assume x/y for legacy reasons. This may change in the future.

The term axes with resepct to `Coords` always refers to the final numpy axis. In other words the final numpy-axis represents ALL of the coordinate-axes.

CommandLine

```
xdoctest -m kwimage.structs.coords Coords
```

Example

```
>>> from kwimage.structs.coords import *  # NOQA
>>> import kwarray
>>> rng = kwarray.ensure_rng(0)
>>> self = Coords.random(num=4, dim=3, rng=rng)
>>> print('self = {}'.format(self))
self = <Coords(data=
    array([[0.5488135 , 0.71518937, 0.60276338],
           [0.54488318, 0.4236548 , 0.64589411],
           [0.43758721, 0.891773  , 0.96366276],
           [0.38344152, 0.79172504, 0.52889492]]))>
>>> matrix = rng.rand(4, 4)
>>> self.warp(matrix)
<Coords(data=
    array([[0.71037426, 1.25229659, 1.39498435],
           [0.60799503, 1.26483447, 1.42073131],
           [0.72106004, 1.39057144, 1.38757508],
           [0.68384299, 1.23914654, 1.29258196]]))>
>>> self.translate(3, inplace=True)
<Coords(data=
    array([[3.5488135 , 3.71518937, 3.60276338],
           [3.54488318, 3.4236548 , 3.64589411],
           [3.43758721, 3.891773  , 3.96366276],
           [3.38344152, 3.79172504, 3.52889492]]))>
>>> self.translate(3, inplace=True)
<Coords(data=
    array([[6.5488135 , 6.71518937, 6.60276338],
           [6.54488318, 6.4236548 , 6.64589411],
           [6.43758721, 6.891773  , 6.96366276],
           [6.38344152, 6.79172504, 6.52889492]]))>
>>> self.scale(2)
<Coords(data=
    array([[13.09762701, 13.43037873, 13.20552675],
           [13.08976637, 12.8473096 , 13.29178823],
           [12.87517442, 13.783546  , 13.92732552],
           [12.76688304, 13.58345008, 13.05778984]]))>
>>> # xdoctest: +REQUIRES(module:torch)
>>> self.tensor()
>>> self.tensor().tensor().numpy().numpy()
>>> self.numpy()
>>> #self.draw_on()
```

property dtype

property dim

property shape

copy()

classmethod random(*num=1*, *dim=2*, *rng=None*, *meta=None*)

Makes random coordinates; typically for testing purposes

is_numpy()

is_tensor()

compress(*flags*, *axis=0*, *inplace=False*)

Filters items based on a boolean criterion

Parameters

- **flags** (*ArrayLike*) – true for items to be kept. Extended type: ArrayLike[bool].
- **axis** (*int*) – you usually want this to be 0
- **inplace** (*bool*) – if True, modifies this object

Returns

filtered coords

Return type

Coords

Example

```
>>> import kwimage
>>> self = kwimage.Coords.random(10, rng=0)
>>> self.compress([True] * len(self))
>>> self.compress([False] * len(self))
<Coords(data=array([], shape=(0, 2), dtype=float64))>
>>> # xdoctest: +REQUIRES(module:torch)
>>> self = self.tensor()
>>> self.compress([True] * len(self))
>>> self.compress([False] * len(self))
```

take(*indices*, *axis=0*, *inplace=False*)

Takes a subset of items at specific indices

Parameters

- **indices** (*ArrayLike*) – indexes of items to take. Extended type ArrayLike[int].
- **axis** (*int*) – you usually want this to be 0
- **inplace** (*bool*) – if True, modifies this object

Returns

filtered coords

Return type

Coords

Example

```
>>> import kwimage
>>> self = kwimage.Coords(np.array([[25, 30, 15, 10]]))
>>> self.take([0])
<Coords(data=array([[25, 30, 15, 10]]))>
>>> self.take([])
<Coords(data=array([], shape=(0, 4), dtype=int64))>
```

astype(*dtype*, *inplace=False*)

Changes the data type

Parameters

- **dtype** – new type
- **inplace** (*bool*) – if True, modifies this object

Returns
modified coordinates

Return type
Coords

round(*decimals=0*, *inplace=False*)

Rounds data to the specified decimal place

Parameters

- **inplace** (*bool*) – if True, modifies this object
- **decimals** (*int*) – number of decimal places to round to

Returns
modified coordinates

Return type
Coords

Example

```
>>> import kwimage
>>> self = kwimage.Coords.random(3).scale(10)
>>> self.round()
```

view(**shape*)

Passthrough method to view or reshape

Parameters
***shape** – new shape of the data

Returns
modified coordinates

Return type
Coords

Example

```
>>> self = Coords.random(6, dim=4).numpy()
>>> assert list(self.view(3, 2, 4).data.shape) == [3, 2, 4]
>>> # xdoctest: +REQUIRES(module:torch)
>>> self = Coords.random(6, dim=4).tensor()
>>> assert list(self.view(3, 2, 4).data.shape) == [3, 2, 4]
```

classmethod concatenate(*coords*, *axis=0*)

Concatenates lists of coordinates together

Parameters

- **coords** (*Sequence[Coords]*) – list of coords to concatenate
- **axis** (*int*) – axis to stack on. Defaults to 0.

Returns
stacked coords

Return type
Coords

CommandLine

```
xdoctest -m kwimage.structs.coords Coords.concatenate
```

Example

```
>>> coords = [Coords.random(3) for _ in range(3)]
>>> new = Coords.concatenate(coords)
>>> assert len(new) == 9
>>> assert np.all(new.data[3:6] == coords[1].data)
```

property device

If the backend is torch returns the data device, otherwise None

tensor(*device=NoParam*)

Converts numpy to tensors. Does not change memory if possible.

Returns
modified coordinates

Return type
Coords

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> self = Coords.random(3).numpy()
>>> newself = self.tensor()
>>> self.data[0, 0] = 0
>>> assert newself.data[0, 0] == 0
>>> self.data[0, 0] = 1
>>> assert self.data[0, 0] == 1
```

numpy()

Converts tensors to numpy. Does not change memory if possible.

Returns
modified coordinates

Return type
Coords

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> self = Coords.random(3).tensor()
>>> newself = self.numpy()
>>> self.data[0, 0] = 0
>>> assert newself.data[0, 0] == 0
>>> self.data[0, 0] = 1
>>> assert self.data[0, 0] == 1
```

reorder_axes(*new_order*, *inplace=False*)

Change the ordering of the coordinate axes.

Parameters

- **new_order** (*Tuple[int]*) – `new_order[i]` should specify which axes in the original coordinates should be mapped to the `i-th` position in the returned axes.
- **inplace** (*bool*) – if True, modifies data inplace

Returns
modified coordinates

Return type
Coords

Note: This is the ordering of the "columns" in final numpy axis, not the numpy axes themselves.

Example

```
>>> from kwimage.structs.coords import *  # NOQA
>>> self = Coords(data=np.array([
>>>     [7, 11],
>>>     [13, 17],
>>>     [21, 23],
>>> ]))
>>> new = self.reorder_axes((1, 0))
>>> print('new = {!r}'.format(new))
new = <Coords(data=
    array([[11,  7],
           [17, 13],
           [23, 21]]))>
```

Example

```
>>> from kwimage.structs.coords import *  # NOQA
>>> self = Coords.random(10, rng=0)
>>> new = self.reorder_axes((1, 0))
>>> # Remapping using 1, 0 reverses the axes
>>> assert np.all(new.data[:, 0] == self.data[:, 1])
>>> assert np.all(new.data[:, 1] == self.data[:, 0])
>>> # Remapping using 0, 1 does nothing
>>> eye = self.reorder_axes((0, 1))
>>> assert np.all(eye.data == self.data)
>>> # Remapping using 0, 0, destroys the 1-th column
>>> bad = self.reorder_axes((0, 0))
>>> assert np.all(bad.data[:, 0] == self.data[:, 0])
>>> assert np.all(bad.data[:, 1] == self.data[:, 0])
```

warp(*transform*, *input_dims=None*, *output_dims=None*, *inplace=False*)

Generalized coordinate transform.

Parameters

- **transform** (*GeometricTransform | ArrayLike | Augmenter | Callable*) – scikit-image tranform, a 3x3 transformation matrix, an imgaug Augmenter, or generic callable which transforms an NxD ndarray.
- **input_dims** (*Tuple*) – shape of the image these objects correspond to (only needed / used when transform is an imgaug augmenter)
- **output_dims** (*Tuple*) – unused in non-raster structures, only exists for compatibility.
- **inplace** (*bool*) – if True, modifies data inplace

Returns

modified coordinates

Return type

Coords

Note: Let D = self.dims

transformation matrices can be either:

- (D + 1) x (D + 1) # for homog
- D x D # for scale / rotate
- D x (D + 1) # for affine

Example

```
>>> from kwimage.structs.coords import *  # NOQA
>>> self = Coords.random(10, rng=0)
>>> transform = skimage.transform.AffineTransform(scale=(2, 2))
>>> new = self.warp(transform)
>>> assert np.all(new.data == self.scale(2).data)
```

Doctest

```
>>> self = Coords.random(10, rng=0)
>>> assert np.all(self.warp(np.eye(3)).data == self.data)
>>> assert np.all(self.warp(np.eye(2)).data == self.data)
```

Doctest

```
>>> # xdoctest: +REQUIRES(module:osgeo)
>>> from osgeo import osr
>>> wgs84_crs = osr.SpatialReference()
>>> wgs84_crs.ImportFromEPSG(4326)
>>> dst_crs = osr.SpatialReference()
>>> dst_crs.ImportFromEPSG(2927)
>>> transform = osr.CoordinateTransformation(wgs84_crs, dst_crs)
>>> self = Coords.random(10, rng=0)
>>> new = self.warp(transform)
>>> assert np.all(new.data != self.data)
```

```
>>> # Alternative using generic func
>>> def _gdal_coord_tranform(pts):
...     return np.array([transform.TransformPoint(x, y, 0)[0:2]
...                      for x, y in pts])
>>> alt = self.warp(_gdal_coord_tranform)
>>> assert np.all(alt.data != self.data)
>>> assert np.all(alt.data == new.data)
```

Doctest

```
>>> # can use a generic function
>>> def func(xy):
...     return np.zeros_like(xy)
>>> self = Coords.random(10, rng=0)
>>> assert np.all(self.warp(func).data == 0)
```

to_imgaug(*input_dims*)

Translate to an imgaug object

Returns
imgaug data structure

Return type
imgaug.KeypointsOnImage

Example

```
>>> # xdoctest: +REQUIRES(module:imgaug)
>>> import kwimage
>>> import numpy as np
>>> self = kwimage.Coords.random(10)
>>> input_dims = (10, 10)
>>> kpoi = self.to_imgaug(input_dims)
>>> new = kwimage.Coords.from_imgaug(kpoi)
>>> assert np.allclose(new.data, self.data)
```

classmethod from_imgaug(*kpoi*)

scale(*factor*, *about=None*, *output_dims=None*, *inplace=False*)

Scale coordinates by a factor

Parameters

- **factor** (*float | Tuple[float, float]*) – scale factor as either a scalar or per-dimension tuple.
- **about** (*Tuple | None*) – if unspecified scales about the origin (0, 0), otherwise the rotation is about this point.
- **output_dims** (*Tuple*) – unused in non-raster spatial structures
- **inplace** (*bool*) – if True, modifies data inplace

Returns
modified coordinates

Return type
Coords

Example

```
>>> from kwimage.structs.coords import *  # NOQA
>>> self = Coords.random(10, rng=0)
>>> new = self.scale(10)
>>> assert new.data.max() <= 10
```

```
>>> self = Coords.random(10, rng=0)
>>> self.data = (self.data * 10).astype(int)
>>> new = self.scale(10)
>>> assert new.data.dtype.kind == 'i'
>>> new = self.scale(10.0)
>>> assert new.data.dtype.kind == 'f'
```

translate(*offset*, *output_dims=None*, *inplace=False*)

Shift the coordinates

Parameters

- **offset** (*float | Tuple[float, float]*) – transation offset as either a scalar or a per-dimension tuple.
- **output_dims** (*Tuple*) – unused in non-raster spatial structures
- **inplace** (*bool*) – if True, modifies data inplace

Returns

modified coordinates

Return type

Coords

Example

```
>>> from kwimage.structs.coords import *  # NOQA
>>> self = Coords.random(10, dim=3, rng=0)
>>> new = self.translate(10)
>>> assert new.data.min() >= 10
>>> assert new.data.max() <= 11
>>> Coords.random(3, dim=3, rng=0)
>>> Coords.random(3, dim=3, rng=0).translate((1, 2, 3))
```

rotate(*theta*, *about=None*, *output_dims=None*, *inplace=False*)

Rotate the coordinates about a point.

Parameters

- **theta** (*float*) – rotation angle in radians
- **about** (*Tuple | None*) – if unspecified rotates about the origin (0, 0), otherwise the rotation is about this point.
- **output_dims** (*Tuple*) – unused in non-raster spatial structures
- **inplace** (*bool*) – if True, modifies data inplace

Returns

modified coordinates

Return type
Coords

Todo:

- [ ] Generalized ND Rotations?

References

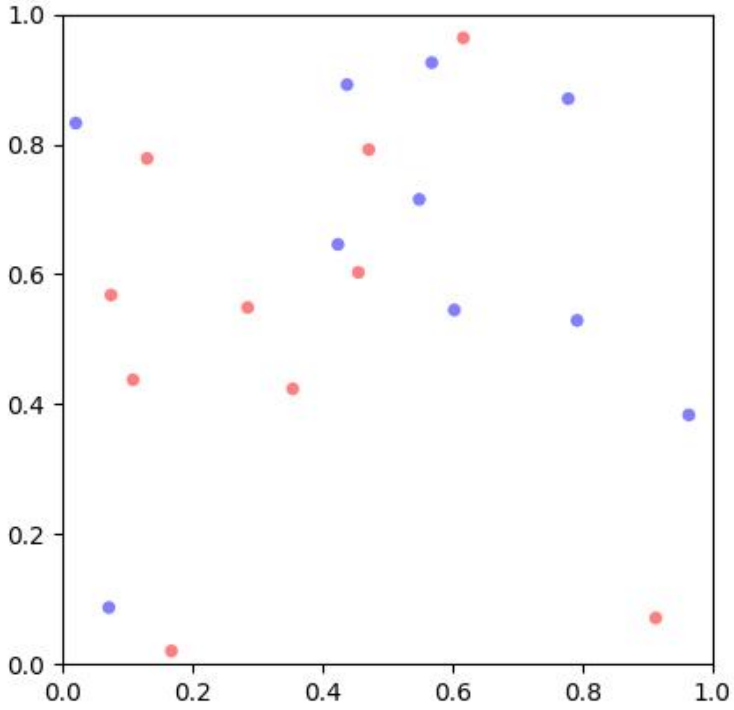
https://math.stackexchange.com/questions/197772/gen-rot-matrix

Example

```
>>> from kwimage.structs.coords import *  # NOQA
>>> self = Coords.random(10, dim=2, rng=0)
>>> theta = np.pi / 2
>>> new = self.rotate(theta)
```

```
>>> # Test rotate agrees with warp
>>> sin_ = np.sin(theta)
>>> cos_ = np.cos(theta)
>>> rot_ = np.array([[cos_, -sin_], [sin_,  cos_]])
>>> new2 = self.warp(rot_)
>>> assert np.allclose(new.data, new2.data)
```

```
>>> #
>>> # Rotate about a custom point
>>> theta = np.pi / 2
>>> new3 = self.rotate(theta, about=(0.5, 0.5))
>>> #
>>> # Rotate about the center of mass
>>> about = self.data.mean(axis=0)
>>> new4 = self.rotate(theta, about=about)
>>> # xdoc: +REQUIRES(--show)
>>> # xdoc: +REQUIRES(module:kwplot)
>>> import kwplot
>>> kwplot.figure(fnum=1, doclf=True)
>>> plt = kwplot.autoplt()
>>> self.draw(radius=0.01, color='blue', alpha=.5, coord_axes=[1, 0], setlim=
↪'grow')
>>> plt.gca().set_aspect('equal')
>>> new3.draw(radius=0.01, color='red', alpha=.5, coord_axes=[1, 0], setlim=
↪'grow')
```



fill(*image*, *value*, *coord_axes=None*, *interp='bilinear'*)

Sets sub-coordinate locations in a grid to a particular value

Parameters

coord_axes (*Tuple*) – specify which image axes each coordinate dim corresponds to. For 2D images, if you are storing r/c data, set to [0,1], if you are storing x/y data, set to [1,0].

Returns

image with coordinates rasterized on it

Return type

ndarray

soft_fill(*image*, *coord_axes=None*, *radius=5*)

Used for drawing keypoint truth in heatmaps

Parameters

coord_axes (*Tuple*) – specify which image axes each coordinate dim corresponds to. For 2D images, if you are storing r/c data, set to [0,1], if you are storing x/y data, set to [1,0].

In other words the i-th entry in coord_axes specifies which row-major spatial dimension the i-th column of a coordinate corresponds to. The index is the coordinate dimension and the value is the axes dimension.

Returns

image with coordinates rasterized on it

Return type

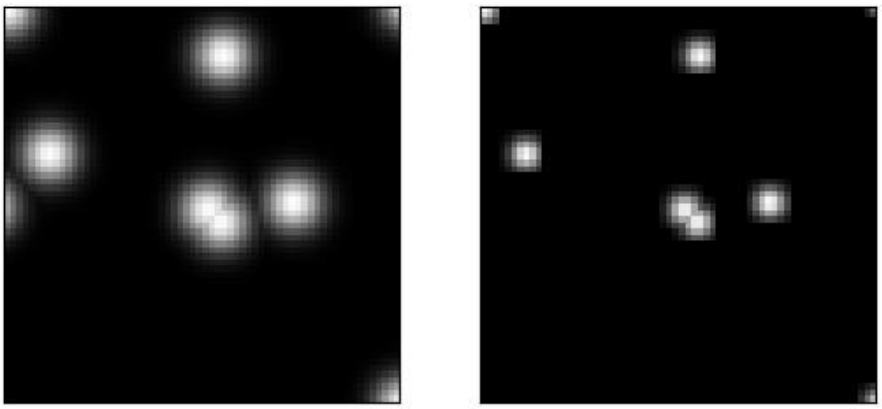
ndarray

References

https://stackoverflow.com/questions/54726703/generating-keypoint-heatmaps-in-tensorflow

Example

```
>>> from kwimage.structs.coords import *  # NOQA
>>> s = 64
>>> self = Coords.random(10, meta={'shape': (s, s)}).scale(s)
>>> # Put points on edges to to verify "edge cases"
>>> self.data[1] = [0, 0]       # top left
>>> self.data[2] = [s, s]       # bottom right
>>> self.data[3] = [0, s + 10]  # bottom left
>>> self.data[4] = [-3, s // 2] # middle left
>>> self.data[5] = [s + 1, -1]  # top right
>>> # Put points in the middle to verify overlap blending
>>> self.data[6] = [32.5, 32.5] # middle
>>> self.data[7] = [34.5, 34.5] # middle
>>> fill_value = 1
>>> coord_axes = [1, 0]
>>> radius = 10
>>> image1 = np.zeros((s, s))
>>> self.soft_fill(image1, coord_axes=coord_axes, radius=radius)
>>> radius = 3.0
>>> image2 = np.zeros((s, s))
>>> self.soft_fill(image2, coord_axes=coord_axes, radius=radius)
>>> # xdoc: +REQUIRES(--show)
>>> # xdoc: +REQUIRES(module:kwplot)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(image1, pnum=(1, 2, 1))
>>> kwplot.imshow(image2, pnum=(1, 2, 2))
```



draw_on(*image=None*, *fill_value=1*, *coord_axes=[1, 0]*, *interp='bilinear'*)

Note: unlike other methods, the defaults assume x/y internal data

Parameters

coord_axes (*Tuple*) – specify which image axes each coordinate dim corresponds to. For 2D images, if you are storing r/c data, set to [0,1], if you are storing x/y data, set to [1,0].

In other words the i-th entry in coord_axes specifies which row-major spatial dimension the i-th column of a coordinate corresponds to. The index is the coordinate dimension and the value is the axes dimension.

Returns

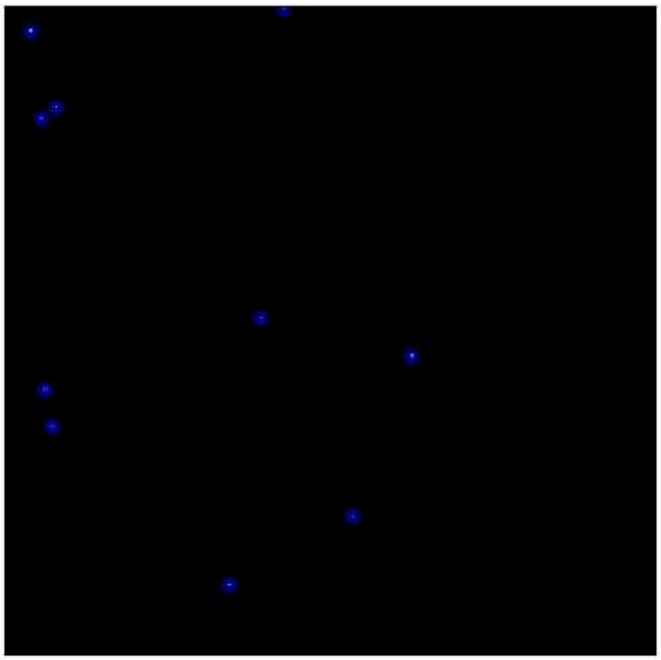
image with coordinates drawn on it

Return type

ndarray

Example

```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> from kwimage.structs.coords import *  # NOQA
>>> s = 256
>>> self = Coords.random(10, meta={'shape': (s, s)}).scale(s)
>>> self.data[0] = [10, 10]
>>> self.data[1] = [20, 40]
>>> image = np.zeros((s, s))
>>> fill_value = 1
>>> image = self.draw_on(image, fill_value, coord_axes=[1, 0], interp='bilinear
↪')
>>> # image = self.draw_on(image, fill_value, coord_axes=[0, 1], interp='nearest
↪')
>>> # image = self.draw_on(image, fill_value, coord_axes=[1, 0], interp='bilinear
↪')
>>> # image = self.draw_on(image, fill_value, coord_axes=[1, 0], interp='nearest
↪')
>>> # xdoc: +REQUIRES(--show)
>>> # xdoc: +REQUIRES(module:kwplot)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.figure(fnum=1, doclf=True)
>>> kwplot.imshow(image)
>>> self.draw(radius=3, alpha=.5, coord_axes=[1, 0])
```



draw(*color='blue'*, *ax=None*, *alpha=None*, *coord_axes=[1, 0]*, *radius=1*, *setlim=False*)

Draw these coordinates via matplotlib

Note: unlike other methods, the defaults assume x/y internal data

Parameters

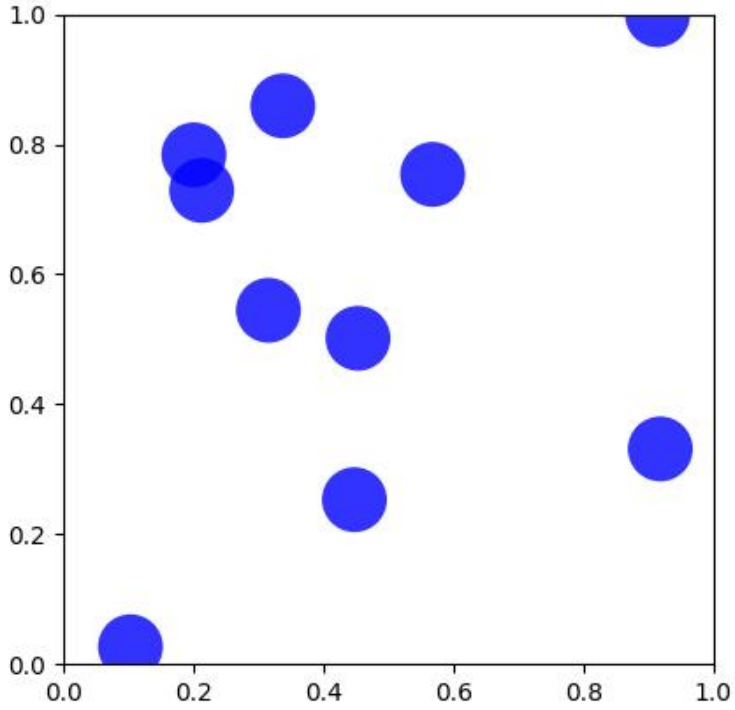
- **setlim** (*bool*) – if True ensures the limits of the axes contains the polygon
- **coord_axes** (*Tuple*) – specify which image axes each coordinate dim corresponds to. For 2D images, if you are storing r/c data, set to [0,1], if you are storing x/y data, set to [1,0].

Returns
drawn matplotlib objects

Return type
List[mpl.collections.PatchCollection]

Example

```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> from kwimage.structs.coords import *  # NOQA
>>> self = Coords.random(10)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> plt = kwplot.autoplt()
>>> self.draw(radius=0.05, alpha=0.8)
>>> plt.gca().set_xlim(0, 1)
>>> plt.gca().set_ylim(0, 1)
>>> plt.gca().set_aspect('equal')
```



class kwimage.structs.**Detections**(*data=None*, *meta=None*, *datakeys=None*, *metakeys=None*, *checks=True*, ***kwargs*)

Bases: NiceRepr, _DetAlgoMixin, _DetDrawMixin

Container for holding and manipulating multiple detections.

Variables

- **data** (*Dict*) – dictionary containing corresponding lists. The length of each list is the number of detections. This contains the bounding boxes, confidence scores, and class indices. Details of the most common keys and types are as follows:

  boxes (kwimage.Boxes[ArrayLike]): multiple bounding boxes scores (ArrayLike): associated scores class_idxs (ArrayLike): associated class indices segmentations (ArrayLike): segmentations masks for each box, members can be *Mask* or *MultiPolygon*. keypoints (ArrayLike): keypoints for each box. Members should be *Points*.

  Additional custom keys may be specified as long as (a) the values are array-like and the first axis corresponds to the standard data values and (b) are custom keys are listed in the *datakeys* kwargs when constructing the Detections.

- **meta** (*Dict*) – This contains contextual information about the detections. This includes the class names, which can be indexed into via the class indexes.

Example

```
>>> import kwimage
>>> dets = kwimage.Detections(
>>>     # there are expected keys that do not need registration
>>>     boxes=kwimage.Boxes.random(3),
>>>     class_idxs=[0, 1, 1],
>>>     classes=['a', 'b'],
>>>     # custom data attrs must align with boxes
>>>     myattr1=np.random.rand(3),
>>>     myattr2=np.random.rand(3, 2, 8),
>>>     # there are no restrictions on metadata
>>>     mymeta='a custom metadata string',
>>>     # Note that any key not in kwimage.Detections.__datakeys__ or
>>>     # kwimage.Detections.__metakeys__ must be registered at the
>>>     # time of construction.
>>>     datakeys=['myattr1', 'myattr2'],
>>>     metakeys=['mymeta'],
>>>     checks=True,
>>> )
>>> print('dets = {}'.format(dets))
dets = <Detections(3)>
```

copy()

Returns a deep copy of this Detections object

classmethod coerce(*data=None*, ***kwargs*)

The "try-anything to get what I want" constructor

Parameters

- **data**
- ****kwargs** – currently boxes and cnames

Example

```
>>> from kwimage.structs.detections import *  # NOQA
>>> import kwimage
>>> kwargs = dict(
>>>     boxes=kwimage.Boxes.random(4),
>>>     cnames=['a', 'b', 'c', 'c'],
>>> )
>>> data = {}
>>> self = kwimage.Detections.coerce(data, **kwargs)
```

classmethod from_coco_annots(*anns*, *cats=None*, *classes=None*, *kp_classes=None*, *shape=None*, *dset=None*)

Create a Detections object from a list of coco-like annotations.

Parameters

- **anns** (*List[Dict]*) – list of coco-like annotation objects
- **dset** (*kwcoco.CocoDataset*) – if specified, cats, classes, and kp_classes can are ignored.

- **cats** (*List[Dict]*) – coco-format category information. Used only if *dset* is not specified.
- **classes** (*kwcoco.CategoryTree*) – category tree with coco class info. Used only if *dset* is not specified.
- **kp_classes** (*kwcoco.CategoryTree*) – keypoint category tree with coco keypoint class info. Used only if *dset* is not specified.
- **shape** (*tuple*) – shape of parent image

Returns
a detections object

Return type
Detections

Example

```
>>> from kwimage.structs.detections import *  # NOQA
>>> # xdoctest: +REQUIRES(--module:ndsampler)
>>> anns = [{
>>>     'id': 0,
>>>     'image_id': 1,
>>>     'category_id': 2,
>>>     'bbox': [2, 3, 10, 10],
>>>     'keypoints': [4.5, 4.5, 2],
>>>     'segmentation': {
>>>         'counts': '_11a04M2O0O20N101N3L_5',
>>>         'size': [20, 20],
>>>     },
>>> }]
>>> dataset = {
>>>     'images': [],
>>>     'annotations': [],
>>>     'categories': [
>>>         {'id': 0, 'name': 'background'},
>>>         {'id': 2, 'name': 'class1', 'keypoints': ['spot']}
>>>     ]
>>> }
>>> #import ndsampler
>>> #dset = ndsampler.CocoDataset(dataset)
>>> cats = dataset['categories']
>>> dets = Detections.from_coco_annots(anns, cats)
```

Example

```
>>> # xdoctest: +REQUIRES(--module:ndsampler)
>>> # Test case with no category information
>>> from kwimage.structs.detections import *  # NOQA
>>> anns = [{
>>>     'id': 0,
>>>     'image_id': 1,
>>>     'category_id': None,
```

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```
>>>     'bbox': [2, 3, 10, 10],
>>>     'prob': [.1, .9],
>>> }]
>>> cats = [
>>>     {'id': 0, 'name': 'background'},
>>>     {'id': 2, 'name': 'class1'}
>>> ]
>>> dets = Detections.from_coco_annots(anns, cats)
```

Example

```
>>> import kwimage
>>> # xdoctest: +REQUIRES(--module:ndsampler)
>>> import ndsampler
>>> sampler = ndsampler.CocoSampler.demo('photos')
>>> iminfo, anns = sampler.load_image_with_annots(1)
>>> shape = iminfo['imdata'].shape[0:2]
>>> kp_classes = sampler.dset.keypoint_categories()
>>> dets = kwimage.Detections.from_coco_annots(
>>>     anns, sampler.dset.dataset['categories'], sampler.catgraph,
>>>     kp_classes, shape=shape)
```

to_coco(*cname_to_cat=None*, *style='orig'*, *image_id=None*, *dset=None*)

Converts this set of detections into coco-like annotation dictionaries.

Note: Not all aspects of the MS-COCO format can be accurately represented, so some liberties are taken. The MS-COCO standard defines that annotations should specifiy a category_id field, but in some cases this information is not available so we will populate a 'category_name' field if possible and in the worst case fall back to 'category_index'.

Additionally, detections may contain additional information beyond the MS-COCO standard, and this information (e.g. weight, prob, score) is added as forign fields.

Parameters

- **cname_to_cat** – currently ignored.
- **style** (*str*) – either 'orig' (for the original coco format) or 'new' for the more general kwcoco-style coco format. Defaults to 'orig'
- **image_id** (*int*) – if specified, populates the image_id field of each image.
- **dset** (*kwcoco.CocoDataset | None*) – if specified, attempts to populate the category_id field to be compatible with this coco dataset.

Yields

dict – coco-like annotation structures

Example

```
>>> # xdoctest: +REQUIRES(module:ndsampler)
>>> from kwimage.structs.detections import *
>>> self = Detections.demo()[0]
>>> cname_to_cat = None
>>> list(self.to_coco())
```

property boxes

property class_idxs

property scores

typically only populated for predicted detections

property probs

typically only populated for predicted detections

property weights

typically only populated for groundtruth detections

property classes

num_boxes()

warp(*transform*, *input_dims=None*, *output_dims=None*, *inplace=False*)

Spatially warp the detections.

Parameters

- **transform** (*kwimage.Affine | ndarray | Callable | Any*) – Something coercable to a transform. Usually a kwimage.Affine object
- **input_dims** (*Tuple[int, int]*) – shape of the expected input canvas
- **output_dims** (*Tuple[int, int]*) – shape of the expected output canvas
- **inplace** (*bool*) – if true operate inplace

Returns

the warped detections object

Return type

Detections

Example

```
>>> import skimage
>>> transform = skimage.transform.AffineTransform(scale=(2, 3), translation=(4,␣
↪5))
>>> self = Detections.random(2)
>>> new = self.warp(transform)
>>> assert new.boxes == self.boxes.warp(transform)
>>> assert new != self
```

scale(*factor*, *output_dims=None*, *inplace=False*)

Spatially scale the detections.

Example

```
>>> import skimage
>>> transform = skimage.transform.AffineTransform(scale=(2, 3), translation=(4,␣
↪5))
>>> self = Detections.random(2)
>>> new = self.warp(transform)
>>> assert new.boxes == self.boxes.warp(transform)
>>> assert new != self
```

translate(*offset*, *output_dims=None*, *inplace=False*)

Spatially translate the detections.

Example

```
>>> import skimage
>>> self = Detections.random(2)
>>> new = self.translate(10)
```

classmethod concatenate(*dets*)

Parameters
boxes (*Sequence[Detections]*) – list of detections to concatenate

Returns
stacked detections

Return type
Detections

Example

```
>>> self = Detections.random(2)
>>> other = Detections.random(3)
>>> dets = [self, other]
>>> new = Detections.concatenate(dets)
>>> assert new.num_boxes() == 5
```

```
>>> self = Detections.random(2, segmentations=True)
>>> other = Detections.random(3, segmentations=True)
>>> dets = [self, other]
>>> new = Detections.concatenate(dets)
>>> assert new.num_boxes() == 5
```

argsort(*reverse=True*)

Sorts detection indices by descending (or ascending) scores

Returns
sorted indices torch.Tensor: sorted indices if using torch backends

Return type
ndarray[Shape[‘*’], Integer]

sort(*reverse=True*)

Sorts detections by descending (or ascending) scores

Returns
sorted copy of self

Return type
kwimage.structs.Detections

compress(*flags*, *axis=0*)

Returns a subset where corresponding locations are True.

Parameters
flags (*ndarray[Any, Bool] | torch.Tensor*) – mask marking selected items

Returns
subset of self

Return type
kwimage.structs.Detections

CommandLine

```
xdoctest -m kwimage.structs.detections Detections.compress
```

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> import kwimage
>>> dets = kwimage.Detections.random(keypoints='dense')
>>> flags = np.random.rand(len(dets)) > 0.5
>>> subset = dets.compress(flags)
>>> assert len(subset) == flags.sum()
>>> subset = dets.tensor().compress(flags)
>>> assert len(subset) == flags.sum()
```

take(*indices*, *axis=0*)

Returns a subset specified by indices

Parameters
indices (*ndarray[Any, Integer]*) – indices to select

Returns
subset of self

Return type
kwimage.structs.Detections

Example

```
>>> import kwimage
>>> dets = kwimage.Detections(boxes=kwimage.Boxes.random(10))
>>> subset = dets.take([2, 3, 5, 7])
>>> assert len(subset) == 4
>>> # xdoctest: +REQUIRES(module:torch)
>>> subset = dets.tensor().take([2, 3, 5, 7])
>>> assert len(subset) == 4
```

property device

If the backend is torch returns the data device, otherwise None

is_tensor()

is the backend fueled by torch?

is_numpy()

is the backend fueled by numpy?

numpy()

Converts tensors to numpy. Does not change memory if possible.

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> self = Detections.random(3).tensor()
>>> newself = self.numpy()
>>> self.scores[0] = 0
>>> assert newself.scores[0] == 0
>>> self.scores[0] = 1
>>> assert self.scores[0] == 1
>>> self.numpy().numpy()
```

property dtype

tensor(*device=NoParam*)

Converts numpy to tensors. Does not change memory if possible.

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> from kwimage.structs.detections import *
>>> self = Detections.random(3)
>>> newself = self.tensor()
>>> self.scores[0] = 0
>>> assert newself.scores[0] == 0
>>> self.scores[0] = 1
>>> assert self.scores[0] == 1
>>> self.tensor().tensor()
```

classmethod demo()

classmethod random(*num=10*, *scale=1.0*, *classes=3*, *keypoints=False*, *segmentations=False*, *tensor=False*, *rng=None*)

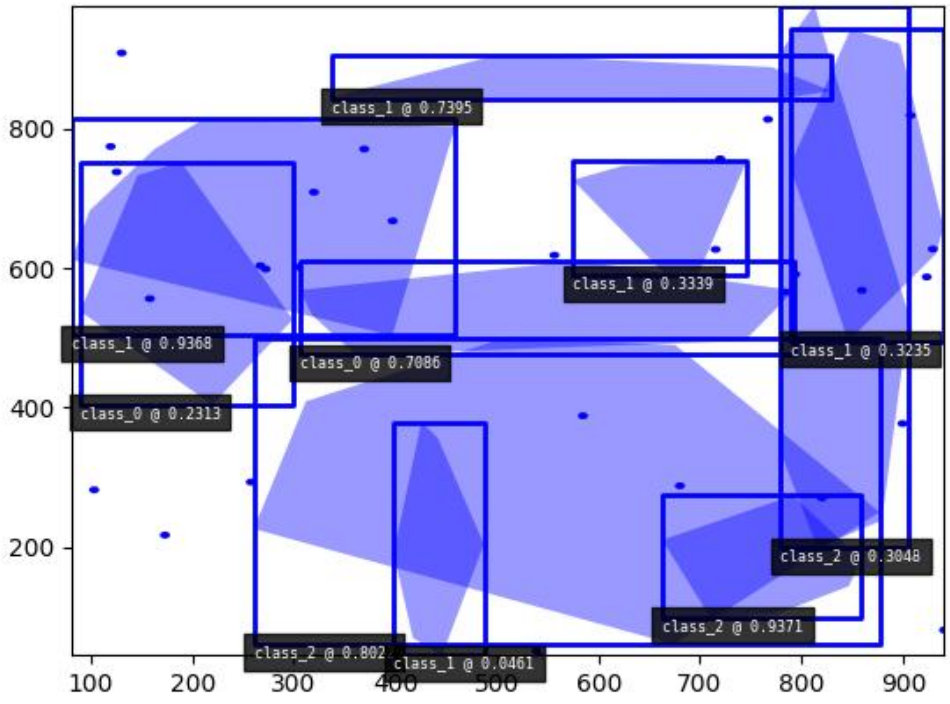
Creates dummy data, suitable for use in tests and benchmarks

Parameters

- **num** (*int*) – number of boxes
- **scale** (*float | tuple*) – bounding image size. Defaults to 1.0
- **classes** (*int | Sequence*) – list of class labels or number of classes
- **keypoints** (*bool*) – if True include random keypoints for each box. Defaults to False.
- **segmentations** (*bool*) – if True include random segmentations for each box. Defaults to False.
- **tensor** (*bool*) – determines backend. DEPRECATED. Call `.tensor()` on resulting object instead.
- **rng** (*np.random.RandomState*) – random state

Example

```
>>> import kwimage
>>> dets = kwimage.Detections.random(keypoints='jagged')
>>> dets.data['keypoints'].data[0].data
>>> dets.data['keypoints'].meta
>>> dets = kwimage.Detections.random(keypoints='dense')
>>> dets = kwimage.Detections.random(keypoints='dense', segmentations=True).
↪scale(1000)
>>> # xdoctest:+REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> dets.draw(setlim=True)
```



Example

```
>>> import kwimage
>>> dets = kwimage.Detections.random(
>>>     keypoints='jagged', segmentations=True, rng=0).scale(1000)
>>> print('dets = {}'.format(dets))
dets = <Detections(10)>
>>> dets.data['boxes'].quantize(inplace=True)
>>> print('dets.data = {}'.format(ub.repr2(
>>>     dets.data, nl=1, with_dtype=False, strvals=True)))
dets.data = {
    'boxes': <Boxes(xywh,
                  array([[548, 544,  55, 172],
                         [423, 645,  15, 247],
                         [791, 383, 173, 146],
                         [ 71,  87, 498, 839],
                         [ 20, 832, 759,  39],
                         [461, 780, 518,  20],
                         [118, 639,  26, 306],
                         [264, 414, 258, 361],
                         [ 18, 568, 439,  50],
                         [612, 616, 332,  66]], dtype=int32))>,
    'class_idxs': [1, 2, 0, 0, 2, 0, 0, 0, 0, 0],
    'keypoints': <PointsList(n=10)>,
    'scores': [0.3595079 , 0.43703195, 0.6976312 , 0.06022547, 0.66676672, 0.
```

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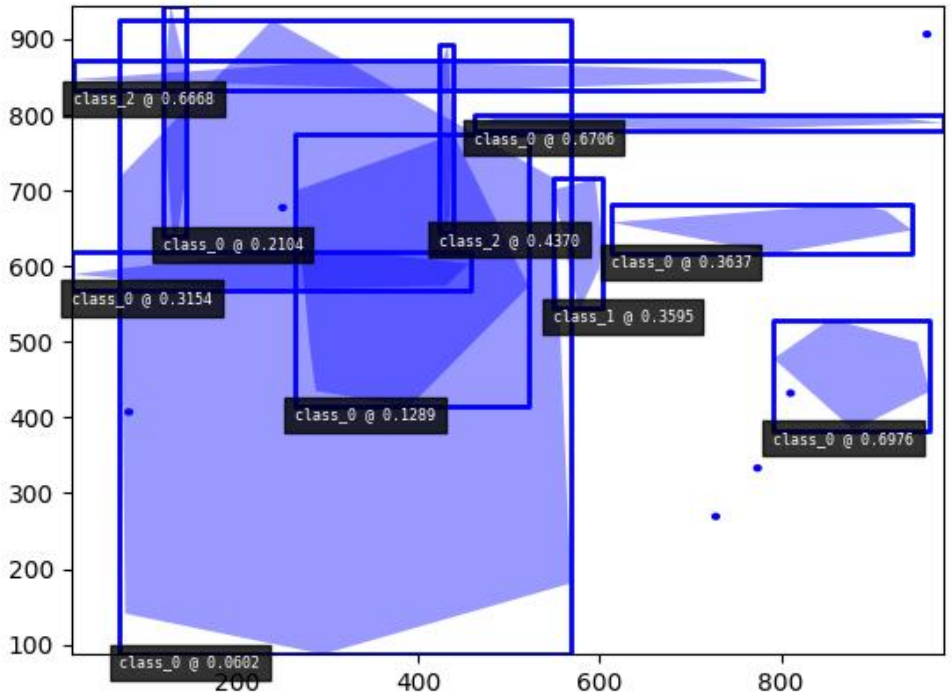
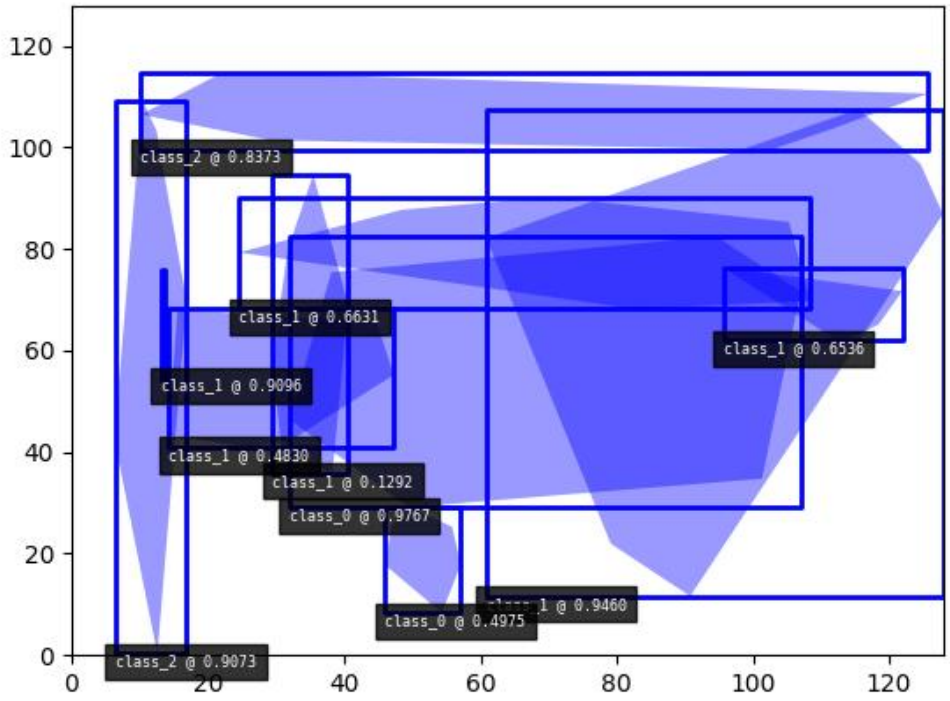
```
↪67063787,0.21038256, 0.1289263 , 0.31542835, 0.36371077],
    'segmentations': <SegmentationList(n=10)>,
}
>>> # xdoctest:+REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> dets.draw(setlim=True)
```



Example

```
>>> # Boxes position/shape within 0-1 space should be uniform.
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> fig = kwplot.figure(fnum=1, doclf=True)
>>> fig.gca().set_xlim(0, 128)
>>> fig.gca().set_ylim(0, 128)
>>> import kwimage
>>> kwimage.Detections.random(num=10, segmentations=True).scale(128).draw()
```



class kwimage.structs.**Heatmap**(*data=None*, *meta=None*, ***kwargs*)

Bases: Spatial, _HeatmapDrawMixin, _HeatmapWarpMixin, _HeatmapAlgoMixin

Keeps track of a downscaled heatmap and how to transform it to overlay the original input image. Heatmaps generally are used to estimate class probabilites at each pixel. This data struction additionally contains logic to augment pixel with offset (dydx) and scale (diamter) information.

Variables

- **data** (*Dict[str, ArrayLike]*) – dictionary containing spatially aligned heatmap data. Valid keys are as follows.

  class_probs (ArrayLike[C, H, W] | ArrayLike[C, D, H, W]):
  A probability map for each class. C is the number of classes.

  offset (ArrayLike[2, H, W] | ArrayLike[3, D, H, W], optional):
  object center position offset in y,x / t,y,x coordinates

  diamter (ArrayLike[2, H, W] | ArrayLike[3, D, H, W], optional):
  object bounding box sizes in h,w / d,h,w coordinates

  keypoints (ArrayLike[2, K, H, W] | ArrayLike[3, K, D, H, W], optional):
  y/x offsets for K different keypoint classes

- **meta** (*Dict[str, object]*) – dictionary containing miscellanious metadata about the heatmap data. Valid keys are as follows.

  img_dims (Tuple[H, W] | Tuple[D, H, W]):
  original image dimension

  tf_data_to_image (skimage.transform._geometric.GeometricTransform):
  transformation matrix (typically similarity or affine) that projects the given, heatmap onto

the image dimensions such that the image and heatmap are spatially aligned.

classes (List[str] | ndsampler.CategoryTree):
information about which index in `data['class_probs']` corresponds to which semantic class.

- **dims** (*Tuple*) – dimensions of the heatmap (See `image_dims`) for the original image dimensions.
- ****kwargs** – any key that is accepted by the *data* or *meta* dictionaries can be specified as a keyword argument to this class and it will be properly placed in the appropriate internal dictionary.

CommandLine

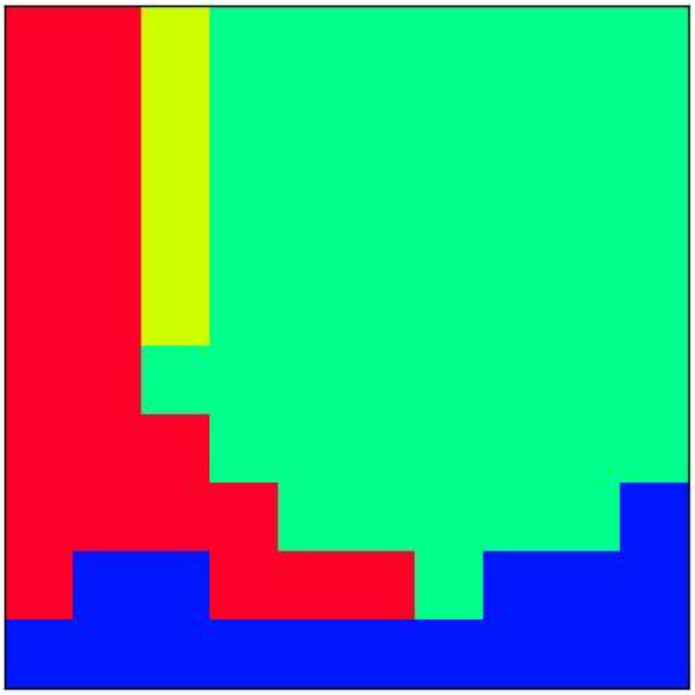
```
xdoctest -m ~/code/kwimage/kwimage/structs/heatmap.py Heatmap --show
```

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> from kwimage.structs.heatmap import *  # NOQA
>>> import kwimage
>>> class_probs = kwimage.grab_test_image(dsize=(32, 32), space='gray')[None, ...,␣
↪0] / 255.0
>>> img_dims = (220, 220)
>>> tf_data_to_img = skimage.transform.AffineTransform(translation=(-18, -18),␣
↪scale=(8, 8))
>>> self = Heatmap(class_probs=class_probs, img_dims=img_dims,
>>>                tf_data_to_img=tf_data_to_img)
>>> aligned = self.upscale()
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(aligned[0])
>>> kwplot.show_if_requested()
```

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> import kwimage
>>> self = Heatmap.random()
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> self.draw()
```



property shape

property bounds

property dims

space-time dimensions of this heatmap

is_numpy()

is_tensor()

classmethod random(*dims=(10, 10)*, *classes=3*, *diameter=True*, *offset=True*, *keypoints=False*, *img_dims=None*, *dets=None*, *nblips=10*, *noise=0.0*, *smooth_k=3*, *rng=None*, *ensure_background=True*)

Creates dummy data, suitable for use in tests and benchmarks

Parameters

- **dims** (*Tuple[int, int]*) – dimensions of the heatmap
- **classes** (*int | List[str] | kwcoco.CategoryTree*) – foreground classes
- **diameter** (*bool*) – if True, include a "diameter" heatmap
- **offset** (*bool*) – if True, include an "offset" heatmap
- **keypoints** (*bool*)
- **smooth_k** (*int*) – kernel size for gaussian blur to smooth out the heatmaps.

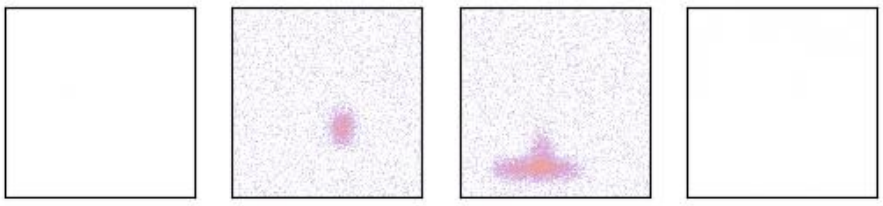
- **img_dims** (*Tuple*) – dimensions of an upscaled image the heatmap corresponds to. (This should be removed and simply handled with a transform

  in the future).

Returns
Heatmap

Example

```
>>> from kwimage.structs.heatmap import *  # NOQA
>>> self = Heatmap.random((128, 128), img_dims=(200, 200),
>>>     classes=3, nblips=10, rng=0, noise=0.1)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(self.colorize(0, imgspace=0), fnum=1, pnum=(1, 4, 1), doclf=1)
>>> kwplot.imshow(self.colorize(1, imgspace=0), fnum=1, pnum=(1, 4, 2))
>>> kwplot.imshow(self.colorize(2, imgspace=0), fnum=1, pnum=(1, 4, 3))
>>> kwplot.imshow(self.colorize(3, imgspace=0), fnum=1, pnum=(1, 4, 4))
```



Example

```
>>> # xdoctest: +REQUIRES(module:ndsampler)
>>> import kwimage
>>> self = kwimage.Heatmap.random(dims=(50, 200), dets='coco',
>>>                               keypoints=True)
>>> image = np.zeros(self.img_dims)
>>> # xdoctest: +REQUIRES(module:kwplot)
>>> toshow = self.draw_on(image, 1, vecs=True, kpts=0, with_alpha=0.85)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.figure(fnum=1, doclf=True)
>>> kwplot.imshow(toshow)
```

property class_probs

property offset

property diameter

property img_dims

property tf_data_to_img

property classes

numpy()

Converts underlying data to numpy arrays

tensor(*device=NoParam*)

Converts underlying data to torch tensors

class kwimage.structs.**Mask**(*data=None*, *format=None*)

Bases: NiceRepr, _MaskConversionMixin, _MaskConstructorMixin, _MaskTransformMixin, _MaskDrawMixin

Manages a single segmentation mask and can convert to and from multiple formats including:

- bytes_rle - byte encoded run length encoding
- array_rle - raw run length encoding
- c_mask - c-style binary mask
- f_mask - fortran-style binary mask

Example

```
>>> # xdoc: +REQUIRES(--mask)
>>> # a ms-coco style compressed bytes rle segmentation
>>> segmentation = {'size': [5, 9], 'counts': ';?1B10O30O4'}
>>> mask = Mask(segmentation, 'bytes_rle')
>>> # convert to binary numpy representation
>>> binary_mask = mask.to_c_mask().data
>>> print(ub.repr2(binary_mask.tolist(), nl=1, nobr=1))
```

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```
[0, 0, 0, 1, 1, 1, 1, 1, 0],
[0, 0, 1, 1, 1, 0, 0, 0, 0],
[0, 0, 1, 1, 1, 1, 1, 1, 0],
[0, 0, 1, 1, 1, 0, 1, 1, 0],
[0, 0, 1, 1, 1, 0, 1, 1, 0],
```

property dtype

classmethod random(*rng=None*, *shape=(32, 32)*)

Create a random binary mask object

Parameters

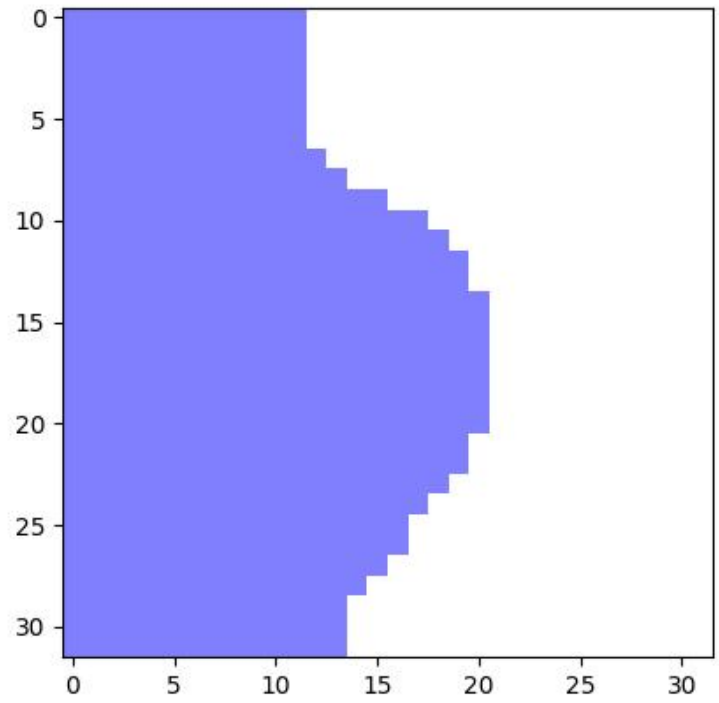
- **rng** (*int | RandomState | None*) – the random seed
- **shape** (*Tuple[int, int]*) – the height / width of the returned mask

Returns
the random mask

Return type
Mask

Example

```
>>> import kwimage
>>> mask = kwimage.Mask.random()
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> mask.draw()
>>> kwplot.show_if_requested()
```



classmethod demo()

Demo mask with holes and disjoint shapes

Returns
the demo mask

Return type
Mask

classmethod from_text(*text*, *zero_chr='.'*, *shape=None*, *has_border=False*)

Construct a mask from a text art representation

Parameters

- **text** (*str*) – the text representing a mask
- **zero_chr** (*str*) – the character that represents a zero
- **shape** (*None | Tuple[int, int]*) – if specified force a specific height / width, otherwise the character extent determines this.
- **has_border** (*bool*) – if True, assume the characters at the edge are representing a border and remove them.

Example

```
>>> import kwimage
>>> import ubelt as ub
>>> text = ub.indent(ub.codeblock(
>>>     '''
>>>     ooo
>>>     ooo
>>>     ooooo
>>>         o
>>>     '''))
>>> mask = kwimage.Mask.from_text(text, zero_chr=' ')
>>> print(mask.data)
[[0 0 0 0 1 1 1 0 0]
 [0 0 0 0 1 1 1 0 0]
 [0 0 0 0 1 1 1 1 1]
 [0 0 0 0 0 0 0 0 1]]
```

Example

```
>>> import kwimage
>>> import ubelt as ub
>>> text = ub.codeblock(
>>>     '''
>>>     +------------+
>>>     |            |
>>>     |    ooo     |
>>>     |    ooo     |
>>>     |    ooooo   |
>>>     |        o   |
>>>     |            |
>>>     +------------+
>>>     ''')
>>> mask = kwimage.Mask.from_text(text, has_border=True, zero_chr=' ')
>>> print(mask.data)
[[0 0 0 0 0 0 0 0 0 0 0 0]
 [0 0 0 0 1 1 1 0 0 0 0 0]
 [0 0 0 0 1 1 1 0 0 0 0 0]
 [0 0 0 0 1 1 1 1 1 0 0 0]
 [0 0 0 0 0 0 0 0 1 0 0 0]
 [0 0 0 0 0 0 0 0 0 0 0 0]]
```

copy()

Performs a deep copy of the mask data

Returns
the copied mask

Return type
Mask

Example

```
>>> self = Mask.random(shape=(8, 8), rng=0)
>>> other = self.copy()
>>> assert other.data is not self.data
```

union(**others*)

This can be used as a staticmethod or an instancemethod

Parameters
***others** – multiple input masks to union

Returns
the unioned mask

Return type
Mask

Example

```
>>> # xdoc: +REQUIRES(--mask)
>>> from kwimage.structs.mask import *  # NOQA
>>> masks = [Mask.random(shape=(8, 8), rng=i) for i in range(2)]
>>> mask = Mask.union(*masks)
>>> print(mask.area)
>>> masks = [m.to_c_mask() for m in masks]
>>> mask = Mask.union(*masks)
>>> print(mask.area)
```

```
>>> masks = [m.to_bytes_rle() for m in masks]
>>> mask = Mask.union(*masks)
>>> print(mask.area)
```

intersection(**others*)

This can be used as a staticmethod or an instancemethod

Parameters
***others** – multiple input masks to intersect

Returns
the intersection of the masks

Return type
Mask

Example

```
>>> n = 3
>>> masks = [Mask.random(shape=(8, 8), rng=i) for i in range(n)]
>>> items = masks
>>> mask = Mask.intersection(*masks)
>>> areas = [item.area for item in items]
>>> print('areas = {!r}'.format(areas))
>>> print(mask.area)
>>> print(Mask.intersection(*masks).area / Mask.union(*masks).area)
```

property shape

property area

Returns the number of non-zero pixels

Returns
the number of non-zero pixels

Return type
int

Example

```
>>> self = Mask.demo()
>>> self.area
150
```

get_patch()

Extract the patch with non-zero data

Example

```
>>> # xdoc: +REQUIRES(--mask)
>>> from kwimage.structs.mask import *  # NOQA
>>> self = Mask.random(shape=(8, 8), rng=0)
>>> self.get_patch()
```

get_xywh()

Gets the bounding xywh box coordinates of this mask

Returns

x, y, w, h: Note we dont use a Boxes object because
a general singular version does not yet exist.

Return type
ndarray

Example

```
>>> # xdoc: +REQUIRES(--mask)
>>> self = Mask.random(shape=(8, 8), rng=0)
>>> self.get_xywh().tolist()
>>> self = Mask.random(rng=0).translate((10, 10))
>>> self.get_xywh().tolist()
```

Example

```
>>> # test empty case
>>> import kwimage
>>> self = kwimage.Mask(np.empty((0, 0), dtype=np.uint8), format='c_mask')
>>> assert self.get_xywh().tolist() == [0, 0, 0, 0]
```

bounding_box()

Returns an axis-aligned bounding box for this mask

Returns
kwimage.Boxes

get_polygon()

DEPRECATED: USE to_multi_polygon

Returns a list of (x,y)-coordinate lists. The length of the list is equal to the number of disjoint regions in the mask.

Returns

polygon around each connected component of the
mask. Each ndarray is an Nx2 array of xy points.

Return type
List[ndarray]

Note: The returned polygon may not surround points that are only one pixel thick.

Example

```
>>> # xdoc: +REQUIRES(--mask)
>>> from kwimage.structs.mask import *  # NOQA
>>> self = Mask.random(shape=(8, 8), rng=0)
>>> polygons = self.get_polygon()
>>> print('polygons = ' + ub.repr2(polygons))
>>> polygons = self.get_polygon()
>>> self = self.to_bytes_rle()
>>> other = Mask.from_polygons(polygons, self.shape)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> image = np.ones(self.shape)
```

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```
>>> image = self.draw_on(image, color='blue')
>>> image = other.draw_on(image, color='red')
>>> kwplot.imshow(image)
```

to_mask(*dims=None*)

Converts to a mask object (which does nothing because this already is mask object!)

Returns
kwimage.Mask

to_boxes()

Returns the bounding box of the mask.

Returns
kwimage.Boxes

to_multi_polygon(*pixels_are='points'*)

Returns a MultiPolygon object fit around this raster including disjoint pieces and holes.

Parameters
pixel_are (*str*) – Can either be “points” or “areas”.

If pixels are “points”, the we treat each pixel (i, j) as a single infinitely small point at (i, j). As such, some polygons may have zero area.

If pixels are “areas”, then each pixel (i, j) represents a square with coordinates ([i - 0.5, j - 0.5], [i + 0.5, j - 0.5], [i + 0.5, j + 0.5], and [i - 0.5, j + 0.5]). Must have rasterio installed to use this method.

Returns
vectorized representation

Return type
kwimage.MultiPolygon

Note: The OpenCV (and thus this function) coordinate system places coordinates at the center of pixels, and the polygon is traced tightly around these coordinates. A single pixel is not considered to have any width, so polygon edges will directly trace through the centers of pixels, and in the case where an object is only 1 pixel thick, this will produce a polygon that is not a valid shapely polygon.

Todo:

- [x] add a flag where polygons consider pixels to have width and the resulting polygon is traced around the pixel edges, not the pixel centers.
- [ ] Polygons and Masks should keep track of what “pixels_are”

Example

```
>>> # xdoc: +REQUIRES(--mask)
>>> from kwimage.structs.mask import *  # NOQA
>>> self = Mask.demo()
>>> self = self.scale(5)
>>> multi_poly = self.to_multi_polygon()
>>> # xdoc: +REQUIRES(module:kwplot)
>>> # xdoc: +REQUIRES(--show)
>>> self.draw(color='red')
>>> multi_poly.scale(1.1).draw(color='blue')
```

```
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> image = np.ones(self.shape)
>>> image = self.draw_on(image, color='blue')
>>> #image = other.draw_on(image, color='red')
>>> kwplot.imshow(image)
>>> multi_poly.draw()
```

Example

```
>>> # Test empty cases
>>> import kwimage
>>> mask0 = kwimage.Mask(np.zeros((0, 0), dtype=np.uint8), format='c_mask')
>>> mask1 = kwimage.Mask(np.zeros((1, 1), dtype=np.uint8), format='c_mask')
>>> mask2 = kwimage.Mask(np.zeros((2, 2), dtype=np.uint8), format='c_mask')
>>> mask3 = kwimage.Mask(np.zeros((3, 3), dtype=np.uint8), format='c_mask')
>>> pixels_are = 'points'
>>> poly0 = mask0.to_multi_polygon(pixels_are=pixels_are)
>>> poly1 = mask1.to_multi_polygon(pixels_are=pixels_are)
>>> poly2 = mask2.to_multi_polygon(pixels_are=pixels_are)
>>> poly3 = mask3.to_multi_polygon(pixels_are=pixels_are)
>>> assert len(poly0) == 0
>>> assert len(poly1) == 0
>>> assert len(poly2) == 0
>>> assert len(poly3) == 0
>>> # xdoctest: +REQUIRES(module:rasterio)
>>> pixels_are = 'areas'
>>> poly0 = mask0.to_multi_polygon(pixels_are=pixels_are)
>>> poly1 = mask1.to_multi_polygon(pixels_are=pixels_are)
>>> poly2 = mask2.to_multi_polygon(pixels_are=pixels_are)
>>> poly3 = mask3.to_multi_polygon(pixels_are=pixels_are)
>>> assert len(poly0) == 0
>>> assert len(poly1) == 0
>>> assert len(poly2) == 0
>>> assert len(poly3) == 0
```

Example

```
>>> # Test full ones cases
>>> import kwimage
>>> mask1 = kwimage.Mask(np.ones((1, 1), dtype=np.uint8), format='c_mask')
>>> mask2 = kwimage.Mask(np.ones((2, 2), dtype=np.uint8), format='c_mask')
>>> mask3 = kwimage.Mask(np.ones((3, 3), dtype=np.uint8), format='c_mask')
>>> pixels_are = 'points'
>>> poly1 = mask1.to_multi_polygon(pixels_are=pixels_are)
>>> poly2 = mask2.to_multi_polygon(pixels_are=pixels_are)
>>> poly3 = mask3.to_multi_polygon(pixels_are=pixels_are)
>>> assert np.all(poly1.to_mask(mask1.shape).data == 1)
>>> assert np.all(poly2.to_mask(mask2.shape).data == 1)
>>> assert np.all(poly3.to_mask(mask3.shape).data == 1)
>>> # xdoctest: +REQUIRES(module:rasterio)
>>> pixels_are = 'areas'
>>> poly1 = mask1.to_multi_polygon(pixels_are=pixels_are)
>>> poly2 = mask2.to_multi_polygon(pixels_are=pixels_are)
>>> poly3 = mask3.to_multi_polygon(pixels_are=pixels_are)
>>> assert np.all(poly1.to_mask(mask1.shape).data == 1)
>>> assert np.all(poly2.to_mask(mask2.shape).data == 1)
>>> assert np.all(poly3.to_mask(mask3.shape).data == 1)
```

Example

```
>>> # Corner case, only two pixels are on
>>> import kwimage
>>> self = kwimage.Mask(np.zeros((768, 768), dtype=np.uint8), format='c_mask')
>>> x_coords = np.array([621, 752])
>>> y_coords = np.array([366, 292])
>>> self.data[y_coords, x_coords] = 1
>>> poly = self.to_multi_polygon()
```

Example

```
>>> # xdoctest: +REQUIRES(module:rasterio)
>>> import kwimage
>>> dims = (10, 10)
>>> data = np.zeros(dims, dtype=np.uint8)
>>> data[0, 3:5] = 1
>>> data[9, 1:3] = 1
>>> data[3:5, 0:2] = 1
>>> data[1, 1] = 1
>>> # 1 pixel L shape
>>> data[3, 5] = 1
>>> data[4, 5] = 1
>>> data[4, 6] = 1
>>> data[1, 5] = 1
>>> data[2, 6] = 1
>>> data[3, 7] = 1
```

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```
>>> data[6, 1] = 1
>>> data[7, 1] = 1
>>> data[7, 2] = 1
>>> data[6:10, 5] = 1
>>> data[6:10, 8] = 1
>>> data[9, 5:9] = 1
>>> data[6, 5:9] = 1
>>> #data = kwimage.imresize(data, scale=2.0, interpolation='nearest')
>>> self = kwimage.Mask.coerce(data)
>>> #self = self.translate((0, 0), output_dims=(10, 9))
>>> self = self.translate((0, 1), output_dims=(11, 11))
>>> dims = self.shape[0:2]
>>> multi_poly1 = self.to_multi_polygon(pixels_are='points')
>>> multi_poly2 = self.to_multi_polygon(pixels_are='areas')
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> pretty_data = kwplot.make_heatmask(self.data/1.0, cmap='magma')[..., 0:3]
>>> def _pixel_grid_lines(self, ax):
>>>     h, w = self.data.shape[0:2]
>>>     ybasis = np.arange(0, h) + 0.5
>>>     xbasis = np.arange(0, w) + 0.5
>>>     xmin = 0 - 0.5
>>>     xmax = w - 0.5
>>>     ymin = 0 - 0.5
>>>     ymax = h - 0.5
>>>     ax.hlines(y=ybasis, xmin=xmin, xmax=xmax, color="gainsboro")
>>>     ax.vlines(x=xbasis, ymin=ymin, ymax=ymax, color="gainsboro")
>>> def _setup_grid(self, pnum):
>>>     ax = kwplot.imshow(pretty_data, show_ticks=True, pnum=pnum)[1]
>>>     # The gray ticks show the center of the pixels
>>>     ax.grid(color='dimgray', linewidth=0.5)
>>>     ax.set_xticks(np.arange(self.data.shape[1]))
>>>     ax.set_yticks(np.arange(self.data.shape[0]))
>>>     # Also draw black lines around the edges of the pixels
>>>     _pixel_grid_lines(self, ax=ax)
>>>     return ax
>>> # Overlay the extracted polygons
>>> ax = _setup_grid(self, pnum=(2, 3, 1))
>>> ax.set_title('input binary mask data')
>>> ax = _setup_grid(self, pnum=(2, 3, 2))
>>> multi_poly1.draw(linewidth=5, alpha=0.5, radius=0.2, ax=ax, fill=False,␣
↪vertex=0.2)
>>> ax.set_title('opencv "point" polygons')
>>> ax = _setup_grid(self, pnum=(2, 3, 3))
>>> multi_poly2.draw(linewidth=5, alpha=0.5, radius=0.2, color='limegreen',␣
↪ax=ax, fill=False, vertex=0.2)
>>> ax.set_title('raterio "area" polygons')
>>> ax.figure.suptitle(ub.codeblock(
>>>     '''
>>>     Gray lines are coordinates and pass through pixel centers (integer␣
↪coords)
```

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```
>>>     White lines trace pixel boundaries (fractional coords)
>>>     '''))
>>> raster1 = multi_poly1.to_mask(dims, pixels_are='points')
>>> raster2 = multi_poly2.to_mask(dims, pixels_are='areas')
>>> kwplot.imshow(raster1.draw_on(), pnum=(2, 3, 5), title='rasterized')
>>> kwplot.imshow(raster2.draw_on(), pnum=(2, 3, 6), title='rasterized')
```

get_convex_hull()

Returns a list of xy points around the convex hull of this mask

---

Note: The returned polygon may not surround points that are only one pixel thick.

Example

```
>>> # xdoc: +REQUIRES(--mask)
>>> self = Mask.random(shape=(8, 8), rng=0)
>>> polygons = self.get_convex_hull()
>>> print('polygons = ' + ub.repr2(polygons))
>>> other = Mask.from_polygons(polygons, self.shape)
```

iou(*other*)

The area of intersection over the area of union

Todo:

- [ ] Write plural Masks version of this class, which should be able to perform this operation more efficiently.

CommandLine

```
xdoctest -m kwimage.structs.mask Mask.iou
```

Example

```
>>> # xdoc: +REQUIRES(--mask)
>>> self = Mask.demo()
>>> other = self.translate(1)
>>> iou = self.iou(other)
>>> print('iou = {:.4f}'.format(iou))
iou = 0.0830
>>> iou2 = self.intersection(other).area / self.union(other).area
>>> print('iou2 = {:.4f}'.format(iou2))
```

classmethod coerce(*data*, *dims=None*)

Attempts to auto-inspect the format of the data and conver to Mask

Parameters

- **data** (*Any*) – the data to coerce
- **dims** (*Tuple*) – required for certain formats like polygons height / width of the source image

Returns
the constructed mask object

Return type
Mask

Example

```
>>> # xdoc: +REQUIRES(--mask)
>>> segmentation = {'size': [5, 9], 'counts': ';?1B10030O4'}
>>> polygon = [
>>>     [np.array([[3, 0],[2, 1],[2, 4],[4, 4],[4, 3],[7, 0]])],
>>>     [np.array([[2, 1],[2, 2],[4, 2],[4, 1]])],
>>> ]
>>> dims = (9, 5)
>>> mask = (np.random.rand(32, 32) > .5).astype(np.uint8)
>>> Mask.coerce(polygon, dims).to_bytes_rle()
>>> Mask.coerce(segmentation).to_bytes_rle()
>>> Mask.coerce(mask).to_bytes_rle()
```

`to_coco`(*style='orig'*)

Convert the Mask to a COCO json representation based on the current format.

A COCO mask is formatted as a run-length-encoding (RLE), of which there are two variants: (1) a array RLE, which is slightly more readable and extensible, and (2) a bytes RLE, which is slightly more concise. The returned format will depend on the current format of the Mask object. If it is in "bytes_rle" format, it will be returned in that format, otherwise it will be converted to the "array_rle" format and returned as such.

Parameters
style (*str*) – Does nothing for this particular method, exists for API compatibility and if alternate encoding styles are implemented in the future.

Returns

either a bytes-rle or array-rle encoding, depending
on the current mask format. The keys in this dictionary are as follows:

counts (List[int] | str): the array or bytes rle encoding

size (Tuple[int]): the height and width of the encoded mask
see note.

shape (Tuple[int]): only present in array-rle mode. This
is also the height/width of the underlying encoded array. This exists for semantic consistency with other kwimage conventions, and is not part of the original coco spec.

order (str): only present in array-rle mode.
Either C or F, indicating if counts is aranged in row-major or column-major order. For COCO-compatibility this is always returned in F (column-major) order.

binary (bool): only present in array-rle mode.
For COCO-compatibility this is always returned as False, indicating the mask only contains binary 0 or 1 values.

Return type
dict

Note: The output dictionary will contain a key named "size", this is the only location in kwimage where "size" refers to a tuple in (height/width) order, in order to be backwards compatible with the original coco spec. In all other locations in kwimage a "size" will refer to a (width/height) ordered tuple.

SeeAlso:

func
kwimage.im_runlen.encode_run_length - backend function that does array-style run length encoding.

Example

```
>>> # xdoc: +REQUIRES(--mask)
>>> from kwimage.structs.mask import *  # NOQA
>>> self = Mask.demo()
>>> coco_data1 = self.toformat('array_rle').to_coco()
>>> coco_data2 = self.toformat('bytes_rle').to_coco()
>>> print('coco_data1 = {}'.format(ub.repr2(coco_data1, nl=1)))
>>> print('coco_data2 = {}'.format(ub.repr2(coco_data2, nl=1)))
coco_data1 = {
    'binary': True,
    'counts': [47, 5, 3, 1, 14, ... 1, 4, 19, 141],
    'order': 'F',
    'shape': (23, 32),
    'size': (23, 32),
}
coco_data2 = {
    'counts': '_153L;4EL...ON3060L0N060L0Nb0Y4',
    'size': [23, 32],
}
```

class kwimage.structs.**MaskList**(*data*, *meta=None*)

Bases: ObjectList

Store and manipulate multiple masks, usually within the same image

to_polygon_list()

Converts all mask objects to multi-polygon objects

Returns
kwimage.PolygonList

to_segmentation_list()

Converts all items to segmentation objects

Returns
kwimage.SegmentationList

to_mask_list()

returns this object

Returns
kwimage.MaskList

class kwimage.structs.**MultiPolygon**(*data*, *meta=None*)

Bases: ObjectList

Data structure for storing multiple polygons (typically related to the same underlying but potentitally disjoing object)

Variables
data (*List[Polygon]*) –

property **area**

Computes are via shapley conversion

Returns
float

classmethod **random**(*n=3*, *n_holes=0*, *rng=None*, *tight=False*)

Create a random MultiPolygon

Returns
MultiPolygon

fill(*image*, *value=1*, *pixels_are='points'*)

Inplace fill in an image based on this multi-polyon.

Parameters

- **image** (*ndarray*) – image to draw on (inplace)
- **value** (*int | Tuple[int, ...]*) – value fill in with. Defaults to 1.0

Returns
the image that has been modified in place

Return type
ndarray

to_multi_polygon()

Returns
MultiPolygon

to_boxes()

Deprecated: lossy conversion use 'bounding_box' instead

Returns
kwimage.Boxes

bounding_box()

Return the bounding box of the multi polygon

Returns

a Boxes object with one box that encloses all
polygons

Return type
kwimage.Boxes

Example

```
>>> from kwimage.structs.polygon import *  # NOQA
>>> self = MultiPolygon.random(rng=0, n=10)
>>> boxes = self.to_boxes()
>>> sub_boxes = [d.to_boxes() for d in self.data]
>>> areas1 = np.array([s.intersection(boxes).area[0] for s in sub_boxes])
>>> areas2 = np.array([s.area[0] for s in sub_boxes])
>>> assert np.allclose(areas1, areas2)
```

to_mask(*dims=None*, *pixels_are='points'*)

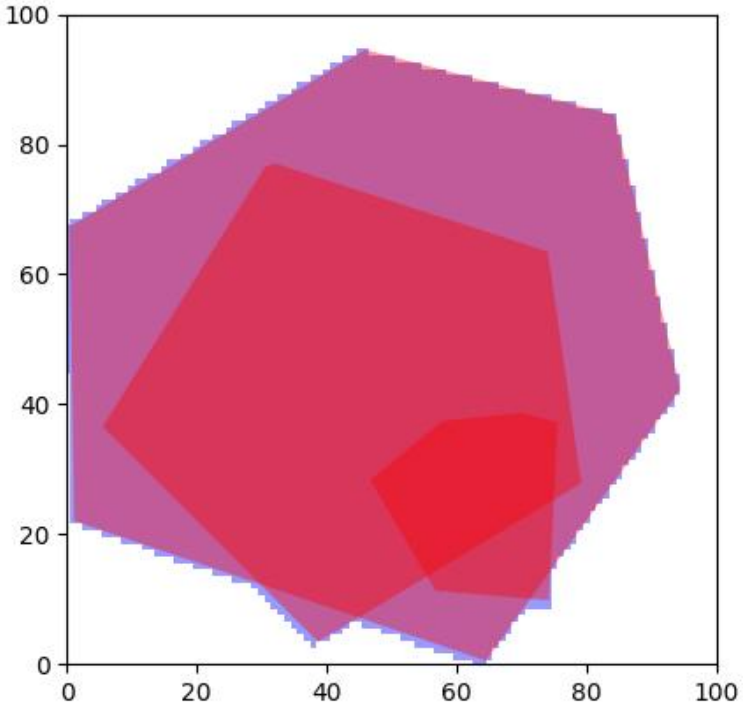
Returns a mask object indication regions occupied by this multipolygon

Returns

kwimage.Mask

Example

```
>>> from kwimage.structs.polygon import *  # NOQA
>>> s = 100
>>> self = MultiPolygon.random(rng=0).scale(s)
>>> dims = (s, s)
>>> mask = self.to_mask(dims)
>>> # xdoc: +REQUIRES(--show)
>>> # xdoc: +REQUIRES(module:kwplot)
>>> import kwplot
>>> plt = kwplot.autoplt()
>>> kwplot.figure(fnum=1, doclf=True)
>>> ax = plt.gca()
>>> ax.set_xlim(0, s)
>>> ax.set_ylim(0, s)
>>> self.draw(color='red', alpha=.4)
>>> mask.draw(color='blue', alpha=.4)
```



to_relative_mask(*return_offset=False*)

Returns a translated mask such the mask dimensions are minimal.

In other words, we move the polygon all the way to the top-left and return a mask just big enough to fit the polygon.

Returns
kwimage.Mask

classmethod coerce(*data*, *dims=None*)

Attempts to construct a MultiPolygon instance from the input data

See Segmentation.coerce

Returns
None | MultiPolygon

Example

```
>>> import kwimage
>>> dims = (32, 32)
>>> kw_poly = kwimage.Polygon.random().scale(dims)
>>> kw_multi_poly = kwimage.MultiPolygon.random().scale(dims)
>>> forms = [kw_poly, kw_multi_poly]
>>> forms.append(kw_poly.to_shapely())
>>> forms.append(kw_poly.to_mask((32, 32)))
>>> forms.append(kw_poly.to_geojson())
```

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```
>>> forms.append(kw_poly.to_coco(style='orig'))
>>> forms.append(kw_poly.to_coco(style='new'))
>>> forms.append(kw_multi_poly.to_shapely())
>>> forms.append(kw_multi_poly.to_mask((32, 32)))
>>> forms.append(kw_multi_poly.to_geojson())
>>> forms.append(kw_multi_poly.to_coco(style='orig'))
>>> forms.append(kw_multi_poly.to_coco(style='new'))
>>> for data in forms:
>>>     result = kwimage.MultiPolygon.coerce(data, dims=dims)
>>>     assert isinstance(result, kwimage.MultiPolygon)
```

to_shapely()

Returns
shapely.geometry.MultiPolygon

Example

```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> # xdoc: +REQUIRES(module:shapely)
>>> from kwimage.structs.polygon import *  # NOQA
>>> self = MultiPolygon.random(rng=0)
>>> geom = self.to_shapely()
>>> print('geom = {!r}'.format(geom))
```

classmethod from_shapely(*geom*)

Convert a shapely polygon or multipolygon to a kwimage.MultiPolygon

Parameters
geom (*shapely.geometry.MultiPolygon | shapely.geometry.Polygon*)

Returns
MultiPolygon

Example

```
>>> import kwimage
>>> sh_poly = kwimage.Polygon.random().to_shapely()
>>> sh_multi_poly = kwimage.MultiPolygon.random().to_shapely()
>>> kwimage.MultiPolygon.from_shapely(sh_poly)
>>> kwimage.MultiPolygon.from_shapely(sh_multi_poly)
```

classmethod from_geojson(*data_geojson*)

Convert a geojson polygon or multipolygon to a kwimage.MultiPolygon

Parameters
data_geojson (*Dict*) – geojson data

Returns
MultiPolygon

Example

```
>>> import kwimage
>>> orig = kwimage.MultiPolygon.random()
>>> data_geojson = orig.to_geojson()
>>> self = kwimage.MultiPolygon.from_geojson(data_geojson)
```

to_geojson()

Converts polygon to a geojson structure

Returns
Dict

classmethod from_coco(*data*, *dims=None*)

Accepts either new-style or old-style coco multi-polygons

Parameters

- **data** (*List[List[Number] | Dict]*) – a new or old style coco multi polygon
- **dims** (*None | Tuple[int, ...]*) – the shape dimensions of the canvas. Unused. Exists for compatibility with masks.

Returns
MultiPolygon

to_coco(*style='orig'*)

Parameters
style (*str*) – can be “orig” or “new”

Example

```
>>> from kwimage.structs.polygon import *  # NOQA
>>> self = MultiPolygon.random(1, rng=0)
>>> self.to_coco()
```

swap_axes(*inplace=False*)

Swap x and y axis

Parameters
inplace (*bool*)

Returns
MultiPolygon

draw_on(*image*, ***kwargs*)

class kwimage.structs.**Points**(*data=None*, *meta=None*, *datakeys=None*, *metakeys=None*, ***kwargs*)

Bases: Spatial, _PointsWarpMixin

Stores multiple keypoints for a single object.

This stores both the geometry and the class metadata if available

Example

```
>>> from kwimage.structs.points import *  # NOQA
>>> xy = np.random.rand(10, 2)
>>> pts = Points(xy=xy)
>>> print('pts = {!r}'.format(pts))
```

property shape

property xy

classmethod random(*num=1*, *classes=None*, *rng=None*)

Makes random points; typically for testing purposes

Example

```
>>> import kwimage
>>> self = kwimage.Points.random(classes=[1, 2, 3])
>>> self.data
>>> print('self.data = {!r}'.format(self.data))
```

is_numpy()

is_tensor()

tensor(*device=NoParam*)

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> from kwimage.structs.points import *  # NOQA
>>> self = Points.random(10)
>>> self.tensor()
```

round(*inplace=False*)

Rounds data to the nearest integer

Parameters
inplace (*bool*) – if True, modifies this object

Example

```
>>> import kwimage
>>> self = kwimage.Points.random(3).scale(10)
>>> self.round()
```

numpy()

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> from kwimage.structs.points import *  # NOQA
>>> self = Points.random(10)
>>> self.tensor().numpy().tensor().numpy()
```

draw_on(*image=None*, *color='white'*, *radius=None*, *copy=False*)

Parameters

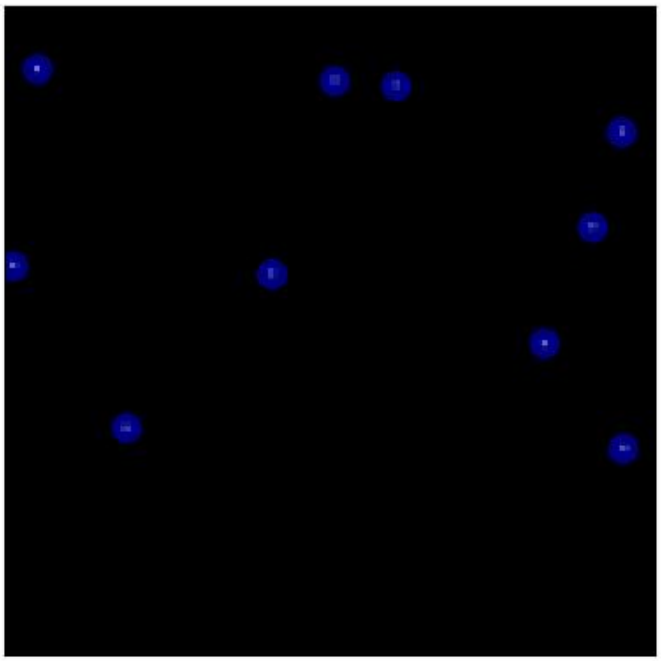
- **image** (*ndarray*) – image to draw points on.
- **color** (*str | Any | List[Any]*) – one color for all boxes or a list of colors for each box Can be any type accepted by kwimage.Color.coerce. Extended types: str | ColorLike | List[ColorLike]
- **radius** (*None | int*) – if an integer, an circle is drawn at each xy point with this radius. if None, attempts to fill a single point with subpixel accuracy, which generally means 4 pixels will be given some weight. Note: color can only be a single value for all points in this case.
- **copy** (*bool*) – if True, force a copy of the image, otherwise try to draw inplace (may not work depending on dtype).

CommandLine

```
xdoctest -m ~/code/kwimage/kwimage/structs/points.py Points.draw_on --show
```

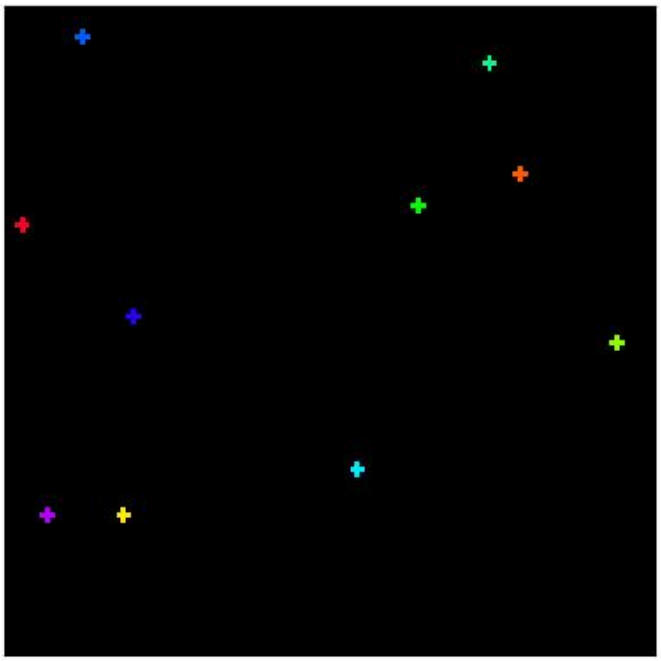
Example

```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> from kwimage.structs.points import *  # NOQA
>>> s = 128
>>> image = np.zeros((s, s))
>>> self = Points.random(10).scale(s)
>>> image = self.draw_on(image)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.figure(fnum=1, doclf=True)
>>> kwplot.autompl()
>>> kwplot.imshow(image)
>>> self.draw(radius=3, alpha=.5)
>>> kwplot.show_if_requested()
```



Example

```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> from kwimage.structs.points import *  # NOQA
>>> s = 128
>>> image = np.zeros((s, s))
>>> self = Points.random(10).scale(s)
>>> image = self.draw_on(image, radius=3, color='distinct')
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.figure(fnum=1, doclf=True)
>>> kwplot.autompl()
>>> kwplot.imshow(image)
>>> #self.draw(radius=3, alpha=.5, color='classes')
>>> kwplot.show_if_requested()
```



Example

```
>>> import kwimage
>>> s = 32
>>> self = kwimage.Points.random(10).scale(s)
>>> color = 'kitware_green'
>>> # Test drawing on all channel + dtype combinations
>>> im3 = np.zeros((s, s, 3), dtype=np.float32)
>>> im_chans = {
>>>     'im3': im3,
>>>     'im1': kwimage.convert_colorspace(im3, 'rgb', 'gray'),
>>>     'im4': kwimage.convert_colorspace(im3, 'rgb', 'rgba'),
>>> }
>>> inputs = {}
>>> for k, im in im_chans.items():
>>>     inputs[k + '_01'] = (kwimage.ensure_float01(im.copy()), {'radius': None}
↪)
>>>     inputs[k + '_255'] = (kwimage.ensure_uint255(im.copy()), {'radius':␣
↪None})
>>> outputs = {}
>>> for k, v in inputs.items():
>>>     im, kw = v
>>>     outputs[k] = self.draw_on(im, color=color, **kw)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
```

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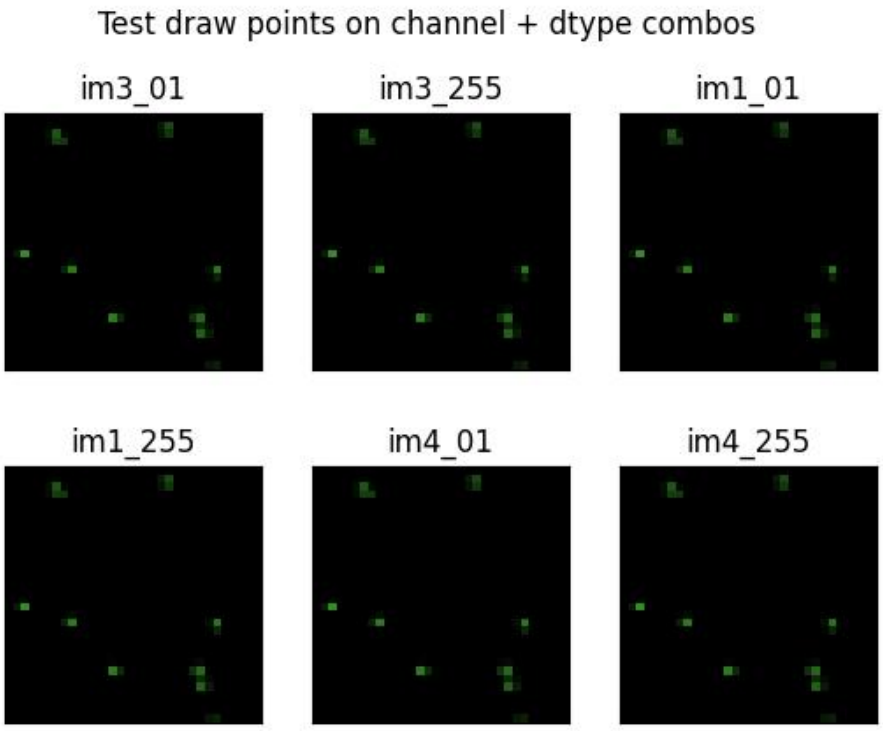
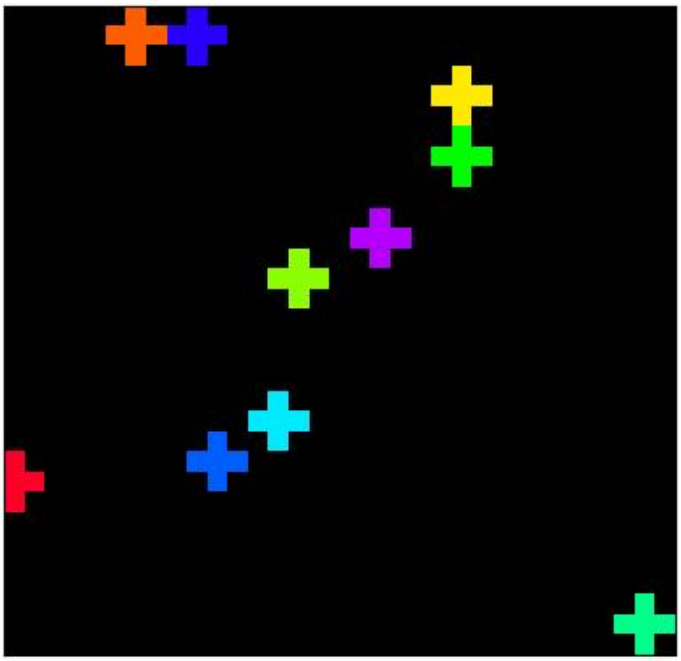
```
>>> kwplot.figure(fnum=2, doclf=True)
>>> plt = kwplot.autoplt()
>>> pnum_ = kwplot.PlotNums(nRows=2, nSubplots=len(inputs))
>>> for k in inputs.keys():
>>>     kwplot.imshow(outputs[k], fnum=2, pnum=pnum_(), title=k)
>>> plt.gcf().suptitle('Test draw points on channel + dtype combos')
>>> kwplot.show_if_requested()
```



Example

```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> from kwimage.structs.points import *  # NOQA
>>> self = Points.random(10).scale(32)
>>> image = self.draw_on(radius=3, color='distinct')
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(image)
>>> kwplot.show_if_requested()
```



Example

```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> # Test cases where single and multiple colors are given
>>> # with radius=None and radius=scalar
>>> from kwimage.structs.points import *  # NOQA
>>> import kwimage
>>> self = kwimage.Points.random(10).scale(32)
>>> image1 = self.draw_on(radius=2, color='blue')
>>> image2 = self.draw_on(radius=None, color='blue')
>>> image3 = self.draw_on(radius=2, color='distinct')
>>> image4 = self.draw_on(radius=None, color='distinct')
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> canvas = kwimage.stack_images_grid(
>>>     [image1, image2, image3, image4],
>>>     pad=3, bg_value=(1, 1, 1))
>>> kwplot.autompl()
>>> kwplot.imshow(canvas)
>>> kwplot.show_if_requested()
```

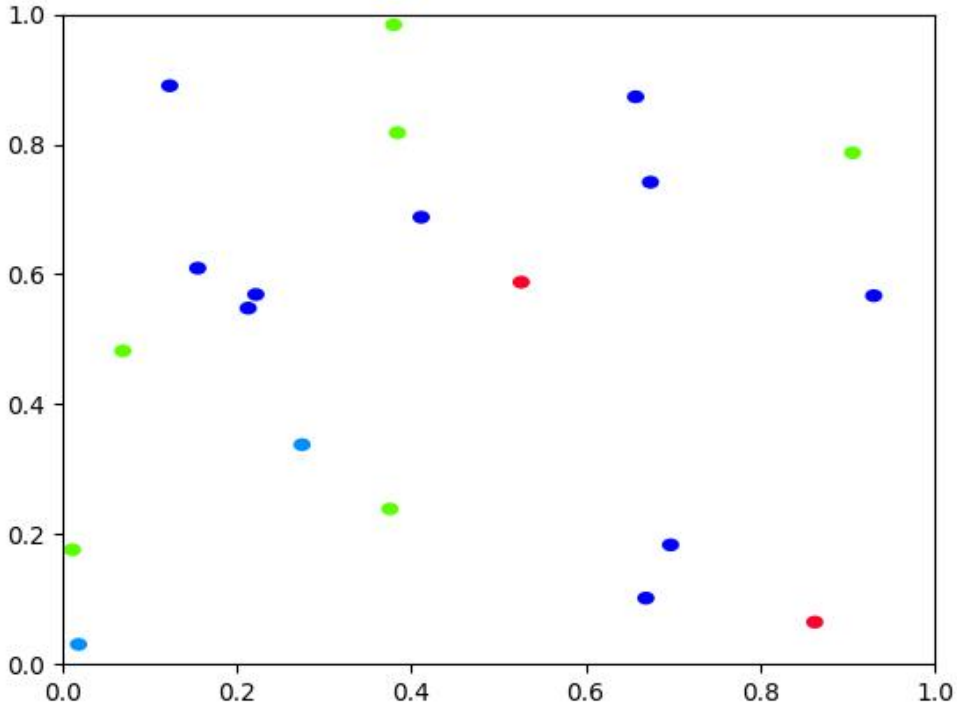
draw(*color='blue'*, *ax=None*, *alpha=None*, *radius=1*, ***kwargs*)

TODO: can use kwplot.draw_points

Example

```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> from kwimage.structs.points import *  # NOQA
>>> pts = Points.random(10)
>>> # xdoc: +REQUIRES(--show)
>>> pts.draw(radius=0.01)
```

```
>>> from kwimage.structs.points import *  # NOQA
>>> self = Points.random(10, classes=['a', 'b', 'c'])
>>> self.draw(radius=0.01, color='classes')
```



compress(*flags*, *axis=0*, *inplace=False*)

Filters items based on a boolean criterion

Example

```
>>> from kwimage.structs.points import *  # NOQA
>>> self = Points.random(4)
>>> flags = [1, 0, 1, 1]
>>> other = self.compress(flags)
>>> assert len(self) == 4
>>> assert len(other) == 3
```

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> other = self.tensor().compress(flags)
>>> assert len(other) == 3
```

take(*indices*, *axis=0*, *inplace=False*)

Takes a subset of items at specific indices

Example

```
>>> from kwimage.structs.points import *  # NOQA
>>> self = Points.random(4)
>>> indices = [1, 3]
>>> other = self.take(indices)
>>> assert len(self) == 4
>>> assert len(other) == 2
```

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> other = self.tensor().take(indices)
>>> assert len(other) == 2
```

classmethod concatenate(*points*, *axis=0*)

to_coco(*style='orig'*)

Converts to an mscoco-like representation

Note: items that are usually id-references to other objects may need to be rectified.

Parameters

style (*str*) – either orig, new, new-id, or new-name

Returns

mscoco-like representation

Return type

Dict

Example

```
>>> from kwimage.structs.points import *  # NOQA
>>> self = Points.random(4, classes=['a', 'b'])
>>> orig = self._to_coco(style='orig')
>>> print('orig = {!r}'.format(orig))
>>> new_name = self._to_coco(style='new-name')
>>> print('new_name = {}'.format(ub.repr2(new_name, nl=-1)))
>>> # xdoctest: +REQUIRES(module:kwcoco)
>>> import kwcoco
>>> self.meta['classes'] = kwcoco.CategoryTree.coerce(self.meta['classes'])
>>> new_id = self._to_coco(style='new-id')
>>> print('new_id = {}'.format(ub.repr2(new_id, nl=-1)))
```

classmethod coerce(*data*)

Attempt to coerce data into a Points object

classmethod from_coco(*coco_kpts*, *class_idxs=None*, *classes=None*, *warn=False*)

Parameters

- **coco_kpts** (*list | dict*) – either the original list keypoint encoding or the new dict keypoint encoding.

- **class_idxs** (*list*) – only needed if using old style
- **classes** (*list | kwcoco.CategoryTree*) – list of all keypoint category names
- **warn** (*bool*) – if True raise warnings

Example

```
>>> ##
>>> classes = ['mouth', 'left-hand', 'right-hand']
>>> coco_kpts = [
>>>     {'xy': (0, 0), 'visible': 2, 'keypoint_category': 'left-hand'},
>>>     {'xy': (1, 2), 'visible': 2, 'keypoint_category': 'mouth'},
>>> ]
>>> Points.from_coco(coco_kpts, classes=classes)
>>> # Test without classes
>>> Points.from_coco(coco_kpts)
>>> # Test without any category info
>>> coco_kpts2 = [ub.dict_diff(d, {'keypoint_category'}) for d in coco_kpts]
>>> Points.from_coco(coco_kpts2)
>>> # Test without category instead of keypoint_category
>>> coco_kpts3 = [ub.map_keys(lambda x: x.replace('keypoint_', ''), d) for d in␣
↪coco_kpts]
>>> Points.from_coco(coco_kpts3)
>>> #
>>> # Old style
>>> coco_kpts = [0, 0, 2, 0, 1, 2]
>>> Points.from_coco(coco_kpts)
>>> # Fail case
>>> coco_kpts4 = [{'xy': [4686.5, 1341.5], 'category': 'dot'}]
>>> Points.from_coco(coco_kpts4, classes=[])
```

Example

```
>>> # xdoctest: +REQUIRES(module:kwcoco)
>>> import kwcoco
>>> classes = kwcoco.CategoryTree.from_coco([
>>>     {'name': 'mouth', 'id': 2}, {'name': 'left-hand', 'id': 3}, {'name':
↪'right-hand', 'id': 5}
>>> ])
>>> coco_kpts = [
>>>     {'xy': (0, 0), 'visible': 2, 'keypoint_category_id': 5},
>>>     {'xy': (1, 2), 'visible': 2, 'keypoint_category_id': 2},
>>> ]
>>> pts = Points.from_coco(coco_kpts, classes=classes)
>>> assert pts.data['class_idxs'].tolist() == [2, 0]
```

class kwimage.structs.**PointsList**(*data*, *meta=None*)

Bases: ObjectList

Stores a list of Points, each item usually corresponds to a different object.

Note: # TODO: when the data is homogenous we can use a more efficient # representation, otherwise we have to use heterogenous storage.

class kwimage.structs.**Polygon**(*data=None*, *meta=None*, *datakeys=None*, *metakeys=None*, ***kwargs*)

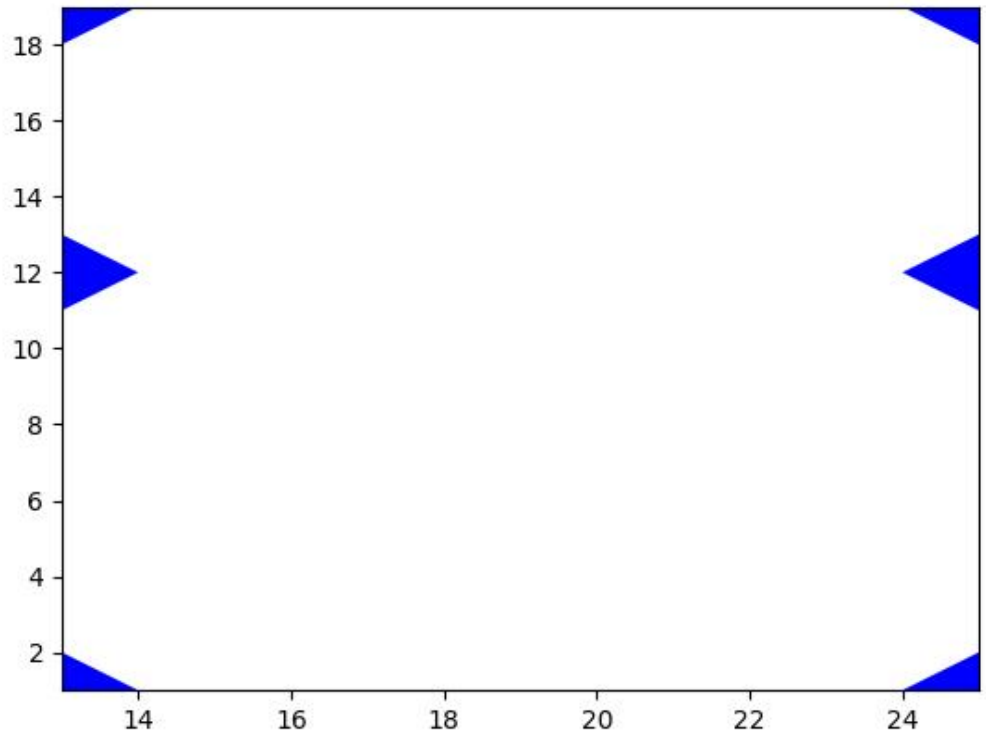
Bases: Spatial, _PolyArrayBackend, _PolyWarpMixin, NiceRepr

Represents a single polygon as set of exterior boundary points and a list of internal polygons representing holes.

By convention exterior boundaries should be counterclockwise and interior holes should be clockwise.

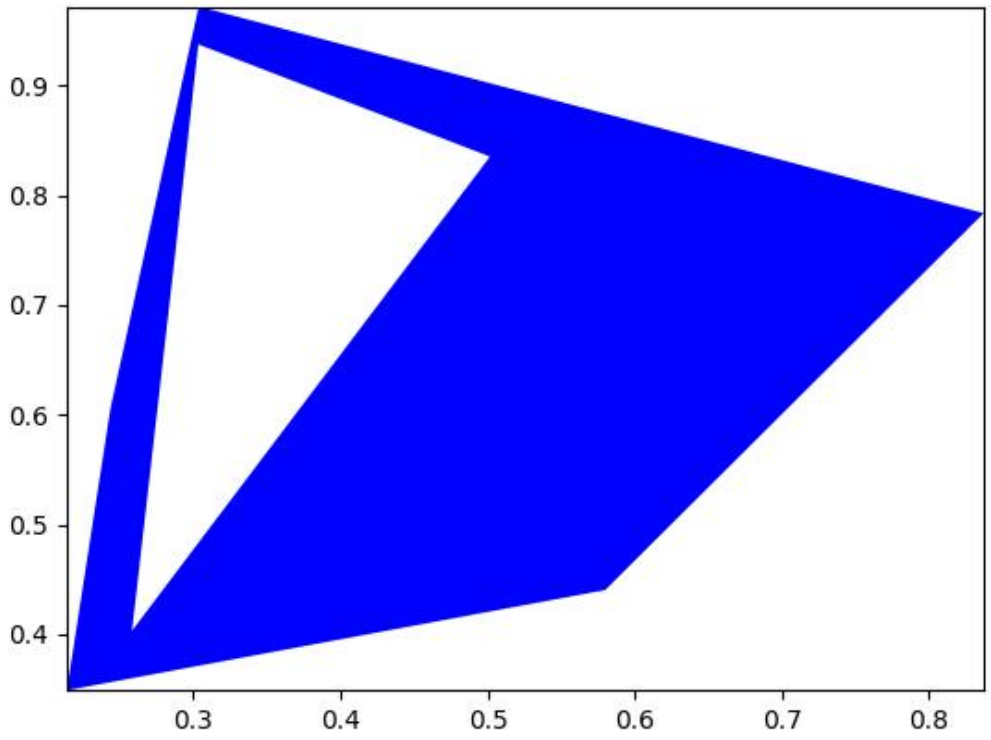
Example

```
>>> import kwimage
>>> data = {
>>>     'exterior': np.array([[13,  1], [13, 19], [25, 19], [25,  1]]),
>>>     'interiors': [
>>>         np.array([[13, 13], [14, 12], [24, 12], [25, 13], [25, 18],
>>>                   [24, 19], [14, 19], [13, 18]]),
>>>         np.array([[13,  2], [14,  1], [24,  1], [25, 2], [25, 11],
>>>                   [24, 12], [14, 12], [13, 11]])]
>>> }
>>> self = kwimage.Polygon(**data)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> self.draw(setlim=True)
```



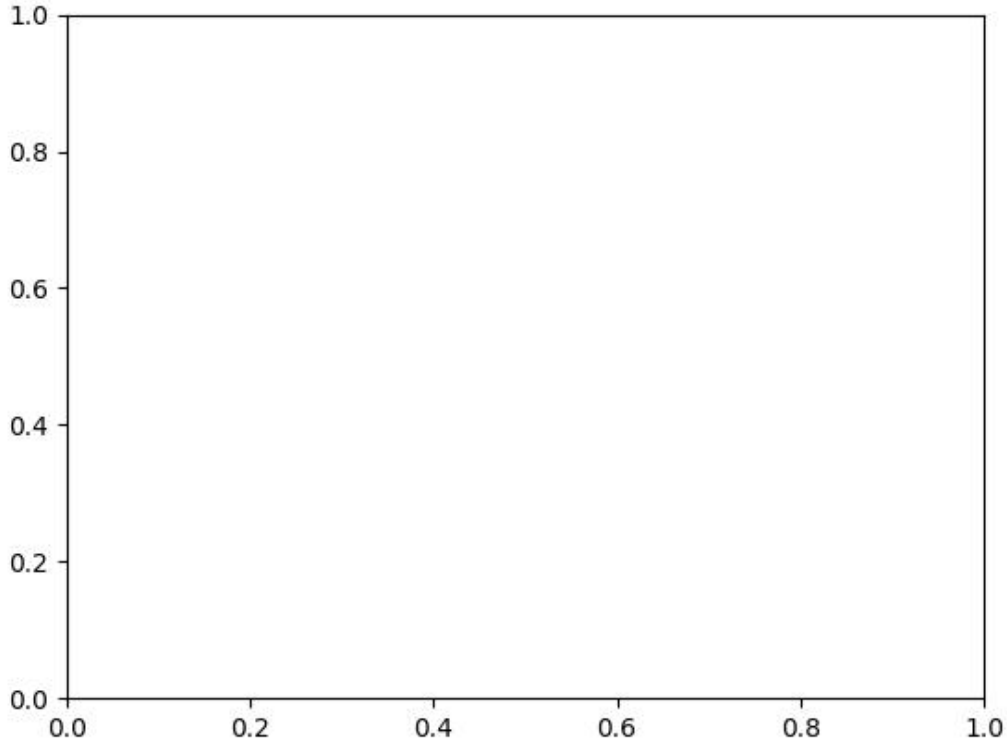
Example

```
>>> import kwimage
>>> self = kwimage.Polygon.random(
>>>     n=5, n_holes=1, convex=False, rng=0)
>>> print('self = {}'.format(self))
self = <Polygon({
    'exterior': <Coords(data=
                    array([[0.30371392, 0.97195856],
                           [0.24372304, 0.60568445],
                           [0.21408694, 0.34884262],
                           [0.5799477 , 0.44020379],
                           [0.83720288, 0.78367234]]))>,
    'interiors': [<Coords(data=
                     array([[0.50164209, 0.83520279],
                            [0.25835064, 0.40313428],
                            [0.28778562, 0.74758761],
                            [0.30341266, 0.93748088]]))>],
})>
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> self.draw(setlim=True)
```



Example

```
>>> # Test empty polygon
>>> import kwimage
>>> data = {
>>>     'exterior': np.array([]),
>>>     'interiors': [],}
>>> self = kwimage.Polygon(**data)
>>> geos = self.to_geojson()
>>> kwimage.Polygon.from_geojson(geos)
>>> geom = self.to_shapely()
>>> kwimage.Polygon.from_shapely(geom)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> self.draw(setlim=True)
```



property exterior

Returns: kwimage.Coords

property interiors

Returns: List[kwimage.Coords]

classmethod circle(*xy*, *r*, *resolution=64*)

Create a circular or elliptical polygon.

Might rename to ellipse later?

Parameters

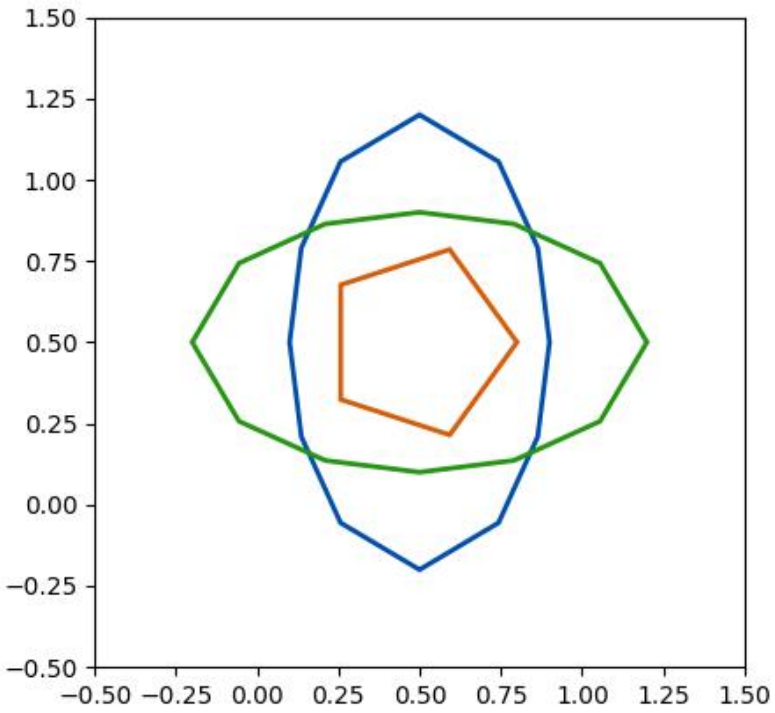
- **xy** (*Iterable[Number]*) – x and y center coordinate
- **r** (*Number | Tuple[Number, Number]*) – circular radius or major and minor elliptical radius
- **resolution** (*int*) – number of sides

Returns

Polygon

Example

```
>>> import kwimage
>>> xy = (0.5, 0.5)
>>> r = .3
>>> # Demo with circle
>>> circle = kwimage.Polygon.circle(xy, r, resolution=6)
>>> # Demo with ellipse
>>> xy = (0.5, 0.5)
>>> r = (.4, .7)
>>> ellipse1 = kwimage.Polygon.circle(xy, r, resolution=12)
>>> ellipse2 = kwimage.Polygon.circle(xy, (.7, .4), resolution=12)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> plt = kwplot.autoplt()
>>> kwplot.figure(fnum=1, doclf=True)
>>> circle.draw(setlim=True, border=1, fill=0, color='kitware_orange')
>>> ellipse1.draw(setlim=True, border=1, fill=0, color='kitware_blue')
>>> ellipse2.draw(setlim=True, border=1, fill=0, color='kitware_green')
>>> plt.gca().set_xlim(-0.5, 1.5)
>>> plt.gca().set_ylim(-0.5, 1.5)
>>> plt.gca().set_aspect('equal')
```



classmethod random(*n=6*, *n_holes=0*, *convex=True*, *tight=False*, *rng=None*)

Parameters

- **n** (*int*) – number of points in the polygon (must be 3 or more)
- **n_holes** (*int*) – number of holes
- **tight** (*bool*) – fits the minimum and maximum points between 0 and 1
- **convex** (*bool*) – force resulting polygon will be convex (may remove exterior points)

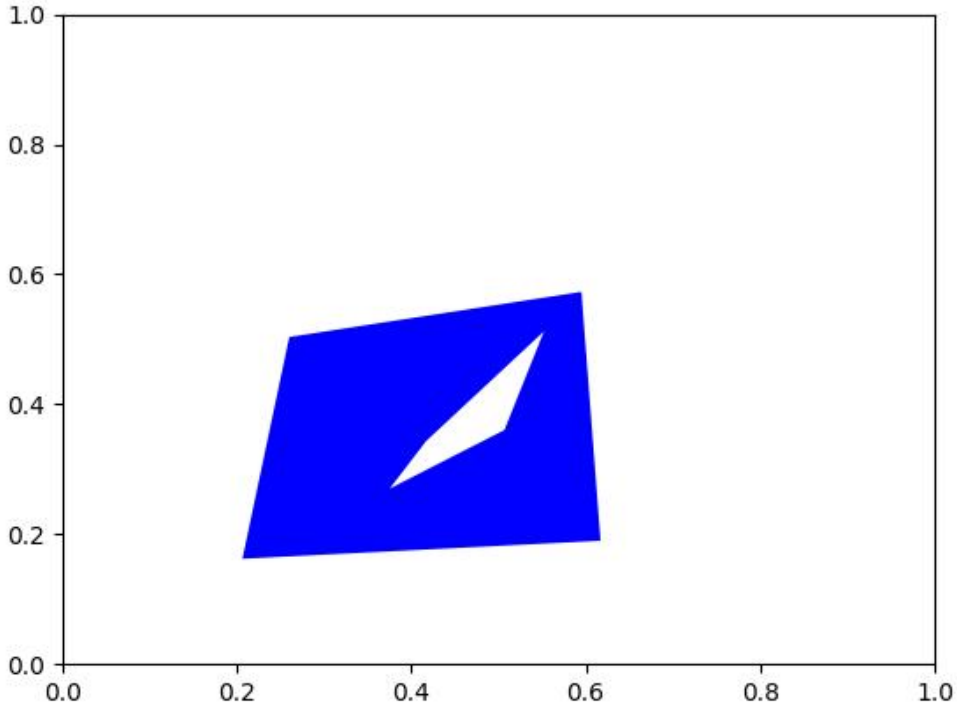
Returns
Polygon

CommandLine

```
xdoctest -m kwimage.structs.polygon Polygon.random
```

Example

```
>>> rng = None
>>> n = 4
>>> n_holes = 1
>>> cls = Polygon
>>> self = Polygon.random(n=n, rng=rng, n_holes=n_holes, convex=1)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.figure(fnum=1, doclf=True)
>>> self.draw()
```



References

https://gis.stackexchange.com/questions/207731/random-multipolygon https://stackoverflow.com/questions/8997099/random-polygon https://stackoverflow.com/questions/27548363/from-voronoi-tessellation-to-shapely-polygons https://stackoverflow.com/questions/8997099/algorithm-to-generate-random-2d-polygon

`to_mask`(*dims=None*, *pixels_are='points'*)

Convert this polygon to a mask

Todo:

- [ ] currently not efficient

Parameters

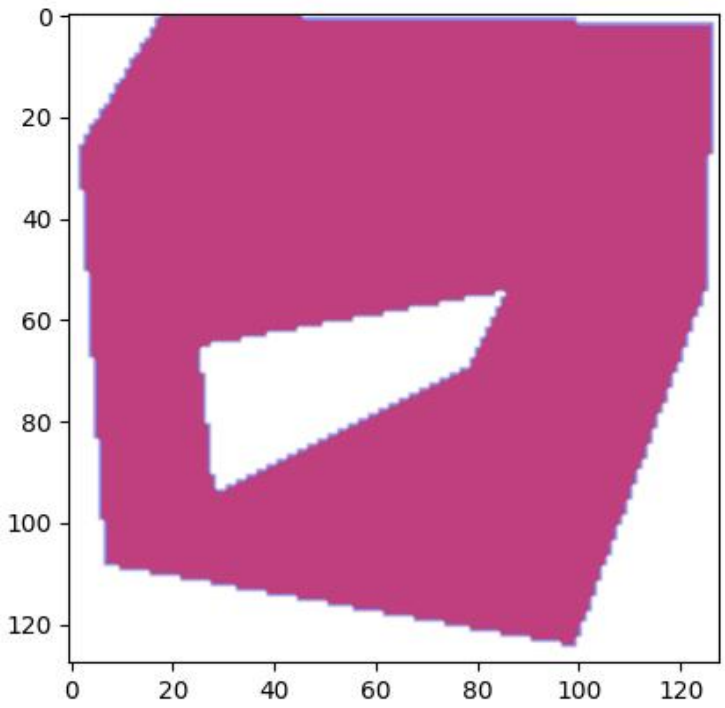
- **dims** (*Tuple*) – height and width of the output mask
- **pixels_are** (*str*) – either “points” or “areas”

Returns

kwimage.Mask

Example

```
>>> from kwimage.structs.polygon import *  # NOQA
>>> self = Polygon.random(n_holes=1).scale(128)
>>> mask = self.to_mask((128, 128))
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.figure(fnum=1, doclf=True)
>>> mask.draw(color='blue')
>>> mask.to_multi_polygon().draw(color='red', alpha=.5)
```



to_relative_mask(*return_offset=False*)

Returns a translated mask such the mask dimensions are minimal.

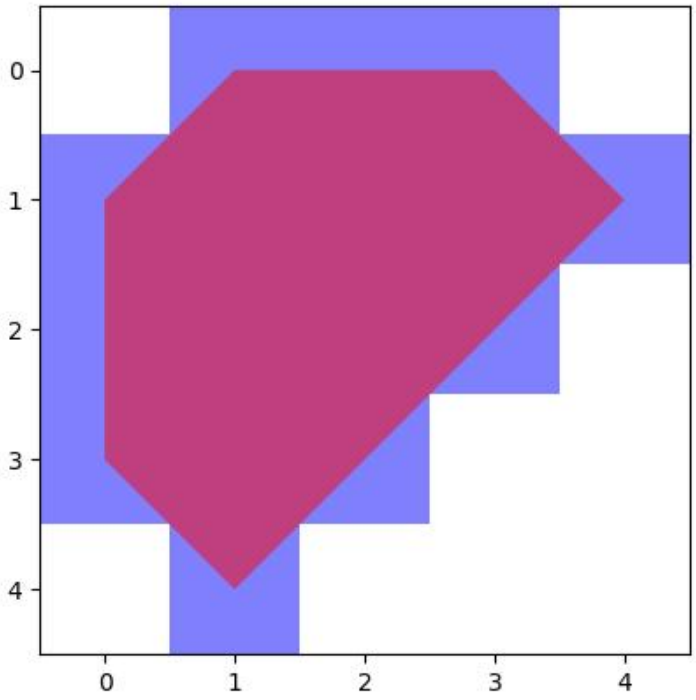
In other words, we move the polygon all the way to the top-left and return a mask just big enough to fit the polygon.

Returns

kwimage.Mask

Example

```
>>> from kwimage.structs.polygon import *  # NOQA
>>> self = Polygon.random().scale(8).translate(100, 100)
>>> mask = self.to_relative_mask()
>>> assert mask.shape <= (8, 8)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.figure(fnum=1, doclf=True)
>>> mask.draw(color='blue')
>>> mask.to_multi_polygon().draw(color='red', alpha=.5)
```



classmethod coerce(*data*)

Routes the input to the proper constructor

Try to autodetermine format of input polygon and coerce it into a kwimage.Polygon.

Parameters

data (*object*) – some type of data that can be interpreted as a polygon.

Returns

kwimage.Polygon

Example

```
>>> import kwimage
>>> self = kwimage.Polygon.random()
>>> kwimage.Polygon.coerce(self)
>>> kwimage.Polygon.coerce(self.exterior)
>>> kwimage.Polygon.coerce(self.exterior.data)
>>> kwimage.Polygon.coerce(self.data)
>>> kwimage.Polygon.coerce(self.to_geojson())
>>> kwimage.Polygon.coerce('POLYGON ((0.11 0.61, 0.07 0.588, 0.015 0.50, 0.11 0.
↪61))')
```

classmethod from_shapely(*geom*)

Convert a shapely polygon to a kwimage.Polygon

Parameters
geom (*shapely.geometry.polygon.Polygon*) – a shapely polygon

Returns
kwimage.Polygon

classmethod from_wkt(*data*)

Convert a WKT string to a kwimage.Polygon

Parameters
data (*str*) – a WKT polygon string

Returns
kwimage.Polygon

Example

```
>>> import kwimage
>>> data = 'POLYGON ((0.11 0.61, 0.07 0.588, 0.015 0.50, 0.11 0.61))'
>>> self = kwimage.Polygon.from_wkt(data)
>>> assert len(self.exterior) == 4
```

classmethod from_geojson(*data_geojson*)

Convert a geojson polygon to a kwimage.Polygon

Parameters
data_geojson (*dict*) – geojson data

Returns
Polygon

References

https://geojson.org/geojson-spec.html

Example

```
>>> from kwimage.structs.polygon import *  # NOQA
>>> self = Polygon.random(n_holes=2)
>>> data_geojson = self.to_geojson()
>>> new = Polygon.from_geojson(data_geojson)
```

to_shapely()

Returns
shapely.geometry.polygon.Polygon

Example

```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> # xdoc: +REQUIRES(module:shapely)
>>> from kwimage.structs.polygon import *  # NOQA
>>> self = Polygon.random(n_holes=1)
>>> self = self.scale(100)
>>> geom = self.to_shapely()
>>> print('geom = {!r}'.format(geom))
```

property area

Computes are via shapley conversion

Returns
float

to_geojson()

Converts polygon to a geojson structure

Returns
Dict[str, object]

Example

```
>>> import kwimage
>>> self = kwimage.Polygon.random()
>>> print(self.to_geojson())
```

to_wkt()

Convert a kwimage.Polygon to WKT string

Returns
str

Example

```
>>> import kwimage
>>> self = kwimage.Polygon.random()
>>> print(self.to_wkt())
```

classmethod from_coco(*data*, *dims=None*)

Accepts either new-style or old-style coco polygons

Parameters

- **data** (*List[Number] | Dict*) – A new or old-style coco polygon
- **dims** (*None | Tuple[int, ...]*) – the shape dimensions of the canvas. Unused. Exists for compatibility with masks.

Returns
Polygon

to_coco(*style='orig'*)

Parameters
style (*str*) – can be “orig” or “new”

Returns
coco-style polygons

Return type
List | Dict

to_multi_polygon()

Returns
MultiPolygon

to_boxes()

Deprecated: lossy conversion use ‘bounding_box’ instead

Returns
kwimage.Boxes

property centroid

Returns: Tuple[Number, Number]

bounding_box()

Returns an axis-aligned bounding box for the segmentation

Returns
kwimage.Boxes

bounding_box_polygon()

Returns an axis-aligned bounding polygon for the segmentation.

Note: This Polygon will be a Box, not a convex hull! Use shapely for convex hulls.

Returns
kwimage.Polygon

copy()

Returns
a copy

Return type
Polygon

clip(*x_min*, *y_min*, *x_max*, *y_max*, *inplace=False*)

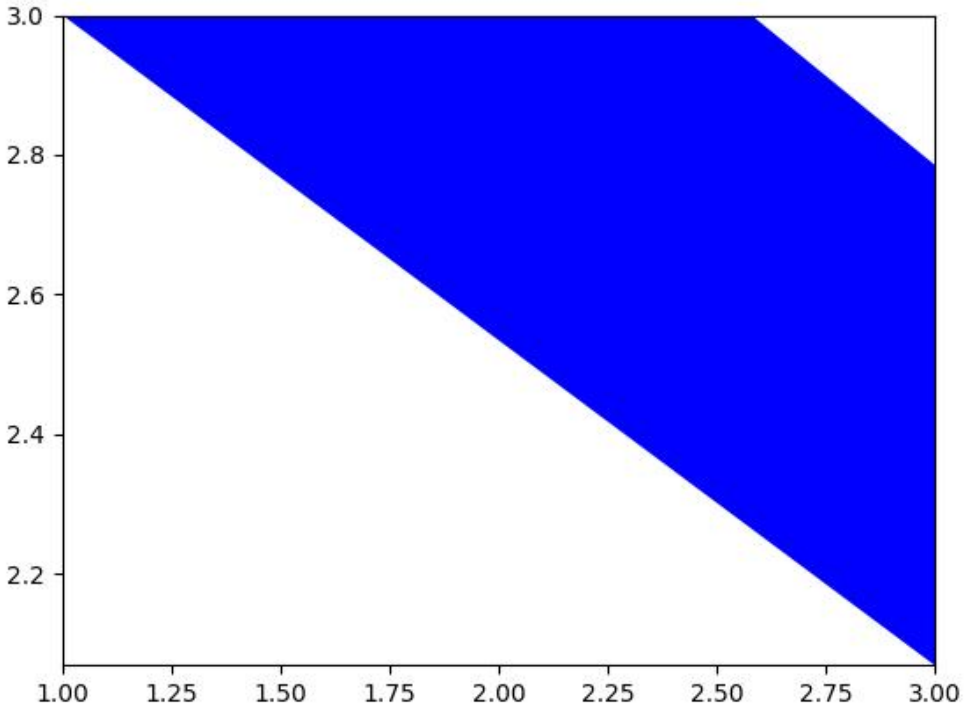
Clip polygon to specified boundaries.

Returns
clipped polygon

Return type
Polygon

Example

```
>>> from kwimage.structs.polygon import *
>>> self = Polygon.random().scale(10).translate(-1)
>>> self2 = self.clip(1, 1, 3, 3)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> self2.draw(setlim=True)
```



fill(*image*, *value=1*, *pixels_are='points'*)

Inplace fill in an image based on this polyon.

Parameters

- **image** (*ndarray*) – image to draw on
- **value** (*int | Tuple[int]*) – value fill in with. Defaults to 1.
- **pixels_are** (*str*) – either points or areas

Returns
the image that has been modified in place

Return type
ndarray

Example

```
>>> # xdoctest: +REQUIRES(module:rasterio)
>>> import kwimage
>>> mask = kwimage.Mask.random()
>>> self = mask.to_multi_polygon(pixels_are='areas').data[0]
>>> image = np.zeros_like(mask.data)
>>> self.fill(image, pixels_are='areas')
```

Example

```
>>> # Test case where there are multiple channels
>>> import kwimage
>>> mask = kwimage.Mask.random(shape=(4, 4), rng=0)
>>> self = mask.to_multi_polygon()
>>> image = np.zeros(mask.shape[0:2] + (2,))
>>> fill_v1 = self.fill(image.copy(), value=1)
>>> fill_v2 = self.fill(image.copy(), value=(1, 2))
>>> assert np.all((fill_v1 > 0) == (fill_v2 > 0))
```

draw_on(*image*, *color='blue'*, *fill=True*, *border=False*, *alpha=1.0*, *edgecolor=None*, *facecolor=None*, *copy=False*)

Rasterizes a polygon on an image. See *draw* for a vectorized matplotlib version.

Parameters

- **image** (*ndarray*) – image to raster polygon on.
- **color** (*str | tuple*) – data coercable to a color
- **fill** (*bool*) – draw the center mass of the polygon. Note: this will be deprecated. Use facecolor instead.
- **border** (*bool*) – draw the border of the polygon Note: this will be deprecated. Use edgecolor instead.
- **alpha** (*float*) – polygon transparency (setting alpha < 1 makes this function much slower). Defaults to 1.0
- **copy** (*bool*) – if False only copies if necessary

- **edgecolor** (*str | tuple*) – color for the border
- **facecolor** (*str | tuple*) – color for the fill

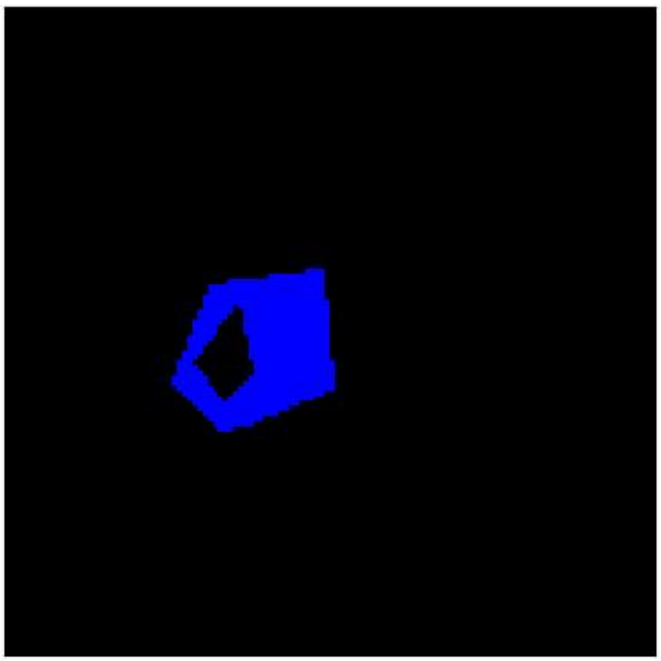
Returns
np.ndarray

Note: This function will only be inplace if alpha=1.0 and the input has 3 or 4 channels. Otherwise the output canvas is coerced so colors can be drawn on it. In the case where alpha < 1.0,

---

Example

```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> from kwimage.structs.polygon import *  # NOQA
>>> self = Polygon.random(n_holes=1).scale(128)
>>> image_in = np.zeros((128, 128), dtype=np.float32)
>>> image_out = self.draw_on(image_in)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(image_out, fnum=1)
```



Example

```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> # Demo drawing on a RGBA canvas
>>> # If you initialize an zero rgba canvas, the alpha values are
>>> # filled correctly.
>>> from kwimage.structs.polygon import *  # NOQA
>>> s = 16
>>> self = Polygon.random(n_holes=1, rng=32).scale(s)
>>> image_in = np.zeros((s, s, 4), dtype=np.float32)
>>> image_out = self.draw_on(image_in, color='black')
>>> assert np.all(image_out[..., 0:3] == 0)
>>> assert not np.all(image_out[..., 3] == 1)
>>> assert not np.all(image_out[..., 3] == 0)
```

Example

```
>>> import kwimage
>>> color = 'blue'
>>> self = kwimage.Polygon.random(n_holes=1).scale(128)
>>> image = np.zeros((128, 128), dtype=np.float32)
>>> # Test drawing on all channel + dtype combinations
>>> im3 = np.random.rand(128, 128, 3)
>>> im_chans = {
>>>     'im3': im3,
>>>     'im1': kwimage.convert_colorspace(im3, 'rgb', 'gray'),
>>>     #'im0': im3[..., 0],
>>>     'im4': kwimage.convert_colorspace(im3, 'rgb', 'rgba'),
>>> }
>>> inputs = {}
>>> for k, im in im_chans.items():
>>>     inputs[k + '_f01'] = (kwimage.ensure_float01(im.copy()), {'alpha': None}
↪)
>>>     inputs[k + '_u255'] = (kwimage.ensure_uint255(im.copy()), {'alpha':␣
↪None})
>>>     inputs[k + '_f01_a'] = (kwimage.ensure_float01(im.copy()), {'alpha': 0.
↪5})
>>>     inputs[k + '_u255_a'] = (kwimage.ensure_uint255(im.copy()), {'alpha': 0.
↪5})
>>> # Check cases when image is/isnot written inplace Construct images
>>> # with different dtypes / channels and run a draw_on with different
>>> # keyword args.  For each combination, demo if that results in an
>>> # implace operation or not.
>>> rows = []
>>> outputs = {}
>>> for k, v in inputs.items():
>>>     im, kw = v
>>>     outputs[k] = self.draw_on(im, color=color, **kw)
>>>     inplace = outputs[k] is im
>>>     rows.append({'key': k, 'inplace': inplace})
>>> # xdoc: +REQUIRES(module:pandas)
```

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```
>>> import pandas as pd
>>> df = pd.DataFrame(rows).sort_values('inplace')
>>> print(df.to_string())
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.figure(fnum=2, doclf=True)
>>> kwplot.autompl()
>>> pnum_ = kwplot.PlotNums(nCols=2, nRows=len(inputs))
>>> for k in inputs.keys():
>>>     kwplot.imshow(inputs[k][0], fnum=2, pnum=pnum_(), title=k)
>>>     kwplot.imshow(outputs[k], fnum=2, pnum=pnum_(), title=k)
>>> kwplot.show_if_requested()
```

Example

```
>>> # Test empty polygon draw
>>> from kwimage.structs.polygon import *  # NOQA
>>> self = Polygon.from_coco([])
>>> image_in = np.zeros((128, 128), dtype=np.float32)
>>> image_out = self.draw_on(image_in)
```

Example

```
>>> # Test stupid large polygon draw
>>> from kwimage.structs.polygon import *  # NOQA
>>> from kwimage.structs.polygon import _generic
>>> import kwimage
>>> self = kwimage.Polygon.random().scale(2e11)
>>> image = np.zeros((128, 128), dtype=np.float32)
>>> image_out = self.draw_on(image)
```

draw(*color='blue'*, *ax=None*, *alpha=1.0*, *radius=1*, *setlim=False*, *border=None*, *linewidth=None*, *edgecolor=None*, *facecolor=None*, *fill=True*, *vertex=False*, *vertexcolor=None*)

Draws polygon in a matplotlib axes. See *draw_on* for in-memory image modification.

Parameters

- **setlim** (*bool*) – if True ensures the limits of the axes contains the polygon
- **color** (*str | Tuple*) – coercable color. Default color if specific colors are not given.
- **alpha** (*float*) – fill transparency
- **fill** (*bool*) – if True fill the polygon with facecolor, otherwise just draw the border if linewidth > 0
- **setlim** (*bool*) – if True, modify the x and y limits of the matplotlib axes such that the polygon is can be seen.
- **border** (*bool*) – if True, draws an edge border on the polygon. DEPRECATED. Use linewidth instead.
- **linewidth** (*bool*) – width of the border

- **edgecolor** (*None | Any*) – if None, uses the value of `color`. Otherwise the color of the border when linewidth > 0. Extended types Coercable[kwimage.Color].
- **facecolor** (*None | Any*) – if None, uses the value of `color`. Otherwise, color of the border when fill=True. Extended types Coercable[kwimage.Color].
- **vertex** (*float*) – if non-zero, draws vertexes on the polygon with this radius.
- **vertexcolor** (*Any*) – color of vertexes Extended types Coercable[kwimage.Color].

Returns
None for am empty polygon

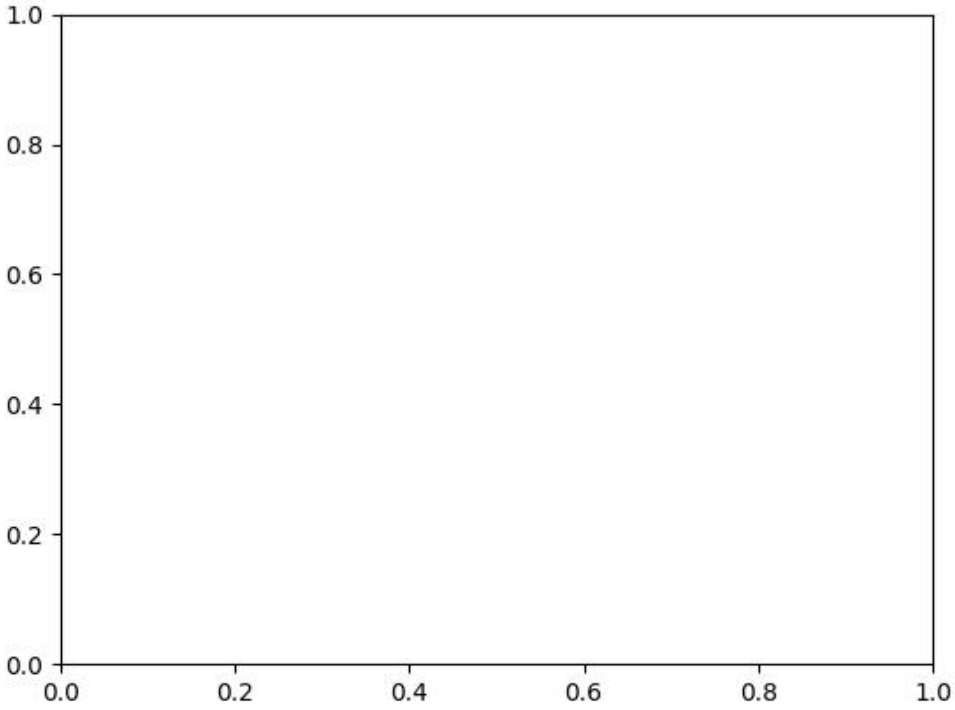
Return type
matplotlib.patches.PathPatch | None

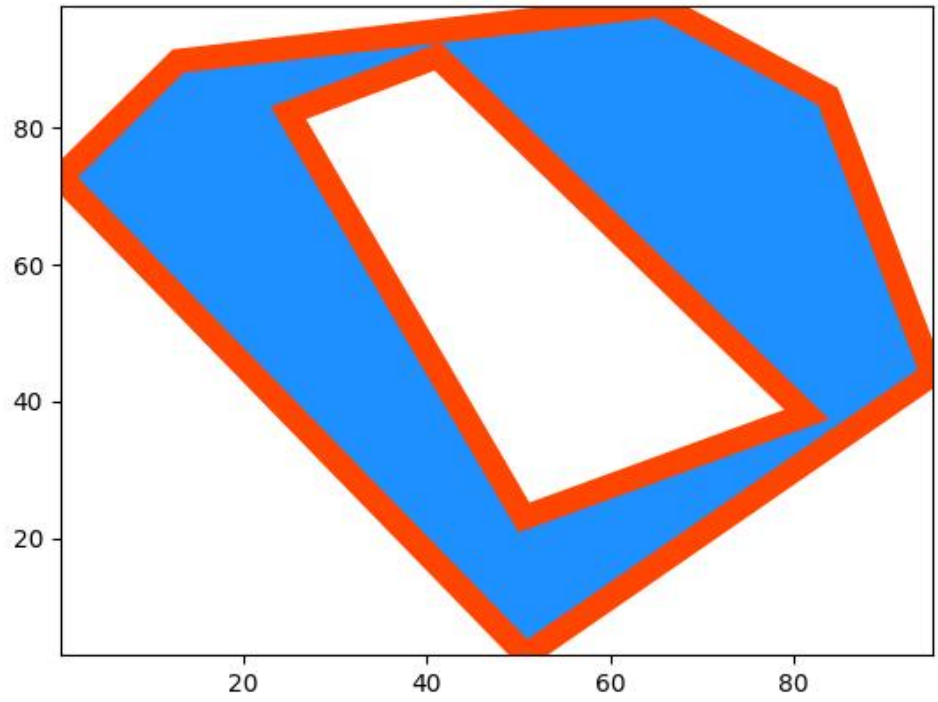
Todo:

- [ ] Rework arguments in favor of matplotlib standards

Example

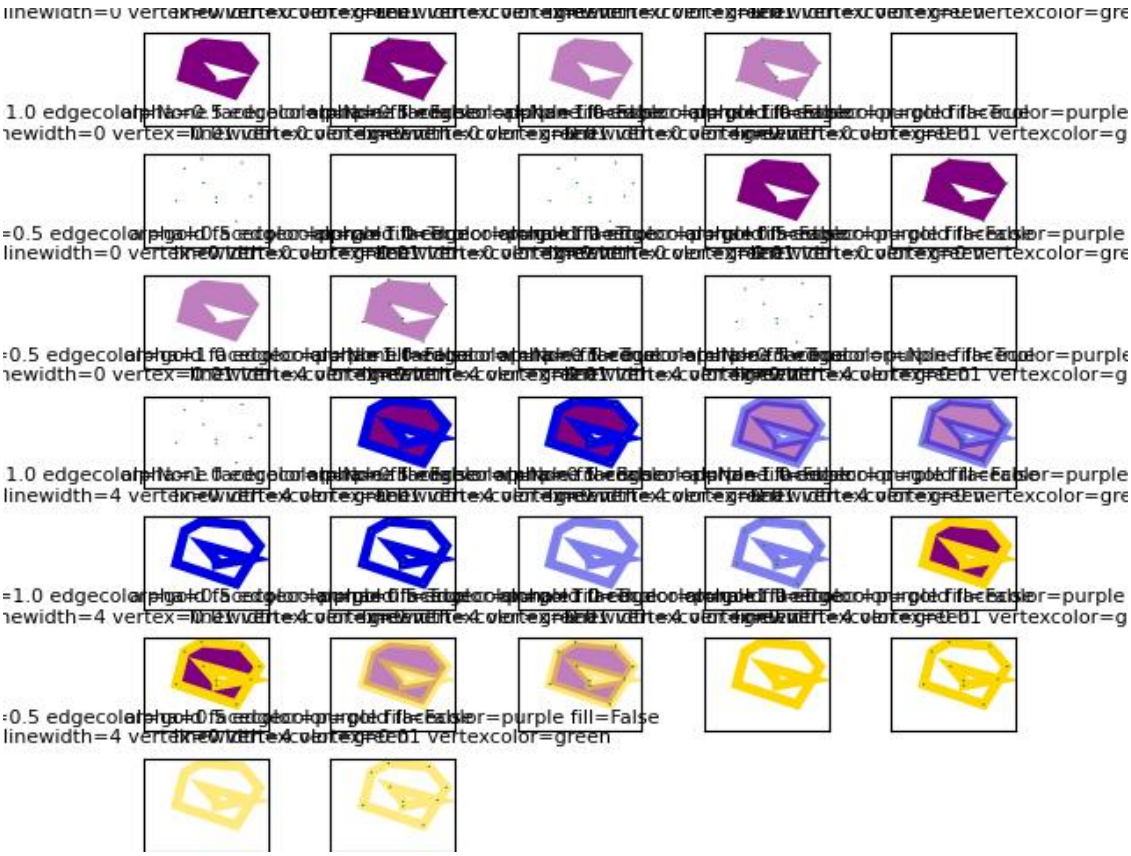
```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> from kwimage.structs.polygon import *  # NOQA
>>> self = Polygon.random(n_holes=1)
>>> self = self.scale(100)
>>> # xdoc: +REQUIRES(--show)
>>> kwargs = dict(edgecolor='orangered', facecolor='dodgerblue', linewidth=10)
>>> self.draw(**kwargs)
>>> import kwplot
>>> kwplot.autompl()
>>> from matplotlib import pyplot as plt
>>> kwplot.figure(fnum=2)
>>> self.draw(setlim=True, **kwargs)
```


1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0


80
60
40
20
20
40
60
80

Example

```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> # xdoc: +REQUIRES(--show)
>>> from kwimage.structs.polygon import *  # NOQA
>>> self = Polygon.random(n_holes=1, rng=33202)
>>> import textwrap
>>> # Test over a range of parameters
>>> basis = {
>>>     'linewidth': [0, 4],
>>>     'edgecolor': [None, 'gold'],
>>>     'facecolor': ['purple'],
>>>     'fill': [True, False],
>>>     'alpha': [1.0, 0.5],
>>>     'vertex': [0, 0.01],
>>>     'vertexcolor': ['green'],
>>> }
>>> grid = list(ub.named_product(basis))
>>> import kwplot
>>> kwplot.autompl()
>>> pnum_ = kwplot.PlotNums(nSubplots=len(grid))
>>> for kwargs in grid:
>>>     fig = kwplot.figure(fnum=1, pnum=pnum_())
>>>     ax = fig.gca()
>>>     self.draw(ax=ax, **kwargs)
>>>     title = ub.repr2(kwargs, compact=True)
>>>     title = '\n'.join(textwrap.wrap(
>>>         title.replace(',', ' '), break_long_words=False,
>>>         width=60))
>>>     ax.set_title(title, fontdict={'fontsize': 8})
>>>     ax.grid(False)
>>>     ax.set_xticks([])
>>>     ax.set_yticks([])
>>> fig.subplots_adjust(wspace=0.5, hspace=0.3, bottom=0.001, top=0.97)
>>> kwplot.show_if_requested()
```



class kwimage.structs.**PolygonList**(*data*, *meta=None*)

Bases: ObjectList

Stores and allows manipluation of multiple polygons, usually within the same image.

to_mask_list(*dims=None*, *pixels_are='points'*)

Converts all items to masks

Returns
kwimage.MaskList

to_polygon_list()

Returns
PolygonList

to_segmentation_list()

Converts all items to segmentation objects

Returns
kwimage.SegmentationList

swap_axes(*inplace=False*)

Returns
PolygonList

to_geojson(*as_collection=False*)

Converts a list of polygons/multipolygons to a geojson structure

Parameters
as_collection (*bool*) – if True, wraps the polygon geojson items in a geojson feature collection, otherwise just return a list of items.

Returns
items or geojson data

Return type
List[Dict] | Dict

Example

```
>>> import kwimage
>>> data = [kwimage.Polygon.random(),
>>>         kwimage.Polygon.random(n_holes=1),
>>>         kwimage.MultiPolygon.random(n_holes=1),
>>>         kwimage.MultiPolygon.random()]
>>> self = kwimage.PolygonList(data)
>>> geojson = self.to_geojson(as_collection=True)
>>> items = self.to_geojson(as_collection=False)
>>> print('geojson = {}'.format(ub.repr2(geojson, nl=-2, precision=1)))
>>> print('items = {}'.format(ub.repr2(items, nl=-2, precision=1)))
```

fill(*image*, *value=1*, *pixels_are='points'*)

Inplace fill in an image based on these polygons

Parameters

- **image** (*ndarray*) – image to draw on (inplace)
- **value** (*int | Tuple[int, ...]*) – value fill in with

Returns
the image that has been modified in place

Return type
ndarray

draw_on(**args*, ***kw*)

class kwimage.structs.**Segmentation**(*data*, *format=None*)

Bases: _WrapperObject

Either holds a MultiPolygon, Polygon, or Mask

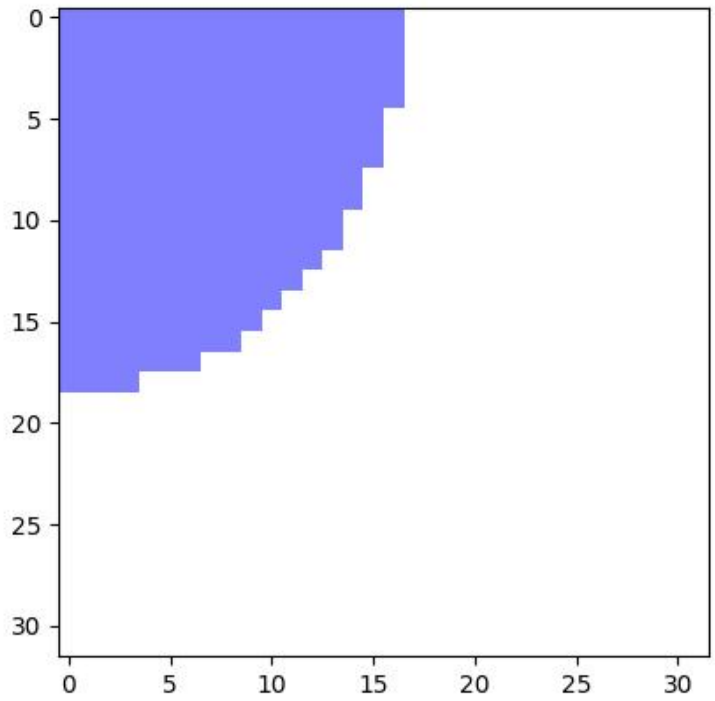
Parameters

- **data** (*object*) – the underlying object
- **format** (*str*) – either ‘mask’, ‘polygon’, or ‘multipolygon’

classmethod random(*rng=None*)

Example

```
>>> self = Segmentation.random()
>>> print('self = {!r}'.format(self))
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.figure(fnum=1, doclf=True)
>>> self.draw()
>>> kwplot.show_if_requested()
```



to_multi_polygon()

to_mask(*dims=None*, *pixels_are='points'*)

property meta

classmethod coerce(*data*, *dims=None*)

class kwimage.structs.**SegmentationList**(*data*, *meta=None*)

Bases: ObjectList

Store and manipulate multiple segmentations (masks or polygons), usually within the same image

to_polygon_list()

Converts all mask objects to multi-polygon objects

to_mask_list(*dims=None*, *pixels_are='points'*)

Converts all mask objects to multi-polygon objects

to_segmentation_list()

classmethod coerce(*data*)

Interpret data as a list of Segmentations

kwimage.structs.**smooth_prob**(*prob*, *k=3*, *inplace=False*, *eps=1e-09*)

Smooths the probability map, but preserves the magnitude of the peaks.

Note: even if inplace is true, we still need to make a copy of the input array, however, we do ensure that it is cleaned up before we leave the function scope.

sigma=0.8 @ k=3, sigma=1.1 @ k=5, sigma=1.4 @ k=7

1.1.2 Submodules

kwimage.im_alphablend module

Numpy implementation of alpha blending based on information in [SO25182421] and [WikiAlphaBlend].

References

kwimage.im_alphablend.**overlay_alpha_layers**(*layers*, *keepalpha=True*, *dtype=<class 'numpy.float32'>*)

Stacks a sequences of layers on top of one another. The first item is the topmost layer and the last item is the bottommost layer.

Parameters

- **layers** (*Sequence[ndarray]*) – stack of images
- **keepalpha** (*bool*) – if False, the alpha channel is removed after blending
- **dtype** (*np.dtype*) – format for blending computation (defaults to float32)

Returns

raster: the blended images

Return type

ndarray

Example

```
>>> import kwimage
>>> keys = ['astro', 'carl', 'stars']
>>> layers = [kwimage.grab_test_image(k, dsize=(100, 100)) for k in keys]
>>> layers = [kwimage.ensure_alpha_channel(g, alpha=.5) for g in layers]
>>> stacked = kwimage.overlay_alpha_layers(layers)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(stacked)
>>> kwplot.show_if_requested()
```

kwimage.im_alphablend.**overlay_alpha_images**(*img1*, *img2*, *keepalpha=True*, *dtype=<class 'numpy.float32'>*, *impl='inplace'*)

Places img1 on top of img2 respecting alpha channels. Works like the Photoshop layers with opacity.

Parameters

- **img1** (*ndarray*) – top image to overlay over img2
- **img2** (*ndarray*) – base image to superimpose on
- **keepalpha** (*bool*) – if False, the alpha channel is removed after blending
- **dtype** (*np.dtype*) – format for blending computation (defaults to float32)
- **impl** (*str*) – code specifying the backend implementation

Returns
raster: the blended images

Return type
ndarray

Todo:

- [ ] Make fast C++ version of this function

Example

```
>>> import kwimage
>>> img1 = kwimage.grab_test_image('astro', dsize=(100, 100))
>>> img2 = kwimage.grab_test_image('carl', dsize=(100, 100))
>>> img1 = kwimage.ensure_alpha_channel(img1, alpha=.5)
>>> img3 = kwimage.overlay_alpha_images(img1, img2)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(img3)
>>> kwplot.show_if_requested()
```

kwimage.im_alphablend.**ensure_alpha_channel**(*img*, *alpha=1.0*, *dtype=<class 'numpy.float32'>*, *copy=False*)

Returns the input image with 4 channels.

Parameters

- **img** (*ndarray*) – an image with shape [H, W], [H, W, 1], [H, W, 3], or [H, W, 4].
- **alpha** (*float | ndarray*) – default scalar value for missing alpha channel, or an ndarray with the same height / width to use explicitly.
- **dtype** (*type*) – The final output dtype. Should be numpy.float32 or numpy.float64.
- **copy** (*bool*) – always copy if True, else copy if needed.

Returns
an image with specified dtype with shape [H, W, 4].

Return type
ndarray

Raises
ValueError - if the input image does not have 1, 3, or 4 input channels – or if the image cannot be converted into a float01 representation

Example

```
>>> # Demo with a scalar default alpha value
>>> import kwimage
>>> data0 = np.zeros((5, 5))
>>> data1 = np.zeros((5, 5, 1))
>>> data2 = np.zeros((5, 5, 3))
>>> data3 = np.zeros((5, 5, 4))
>>> ensured0 = kwimage.ensure_alpha_channel(data0, alpha=0.5)
>>> ensured1 = kwimage.ensure_alpha_channel(data1, alpha=0.5)
>>> ensured2 = kwimage.ensure_alpha_channel(data2, alpha=0.5)
>>> ensured3 = kwimage.ensure_alpha_channel(data3, alpha=0.5)
>>> assert np.all(ensured0[..., 3] == 0.5), 'should have been populated'
>>> assert np.all(ensured1[..., 3] == 0.5), 'should have been populated'
>>> assert np.all(ensured2[..., 3] == 0.5), 'should have been populated'
>>> assert np.all(ensured3[..., 3] == 0.0), 'last image already had alpha'
```

Example

```
>>> import kwimage
>>> # Demo with a explicit alpha channel
>>> alpha = np.random.rand(5, 5)
>>> data0 = np.zeros((5, 5))
>>> data1 = np.zeros((5, 5, 1))
>>> data2 = np.zeros((5, 5, 3))
>>> data3 = np.zeros((5, 5, 4))
>>> ensured0 = kwimage.ensure_alpha_channel(data0, alpha=alpha)
>>> ensured1 = kwimage.ensure_alpha_channel(data1, alpha=alpha)
>>> ensured2 = kwimage.ensure_alpha_channel(data2, alpha=alpha)
>>> ensured3 = kwimage.ensure_alpha_channel(data3, alpha=alpha)
>>> assert np.all(ensured0[..., 3] == alpha), 'should have been populated'
>>> assert np.all(ensured1[..., 3] == alpha), 'should have been populated'
>>> assert np.all(ensured2[..., 3] == alpha), 'should have been populated'
>>> assert np.all(ensured3[..., 3] == 0.0), 'last image already had alpha'
```

kwimage.im_color module

class kwimage.im_color.**Color**(*color*, *alpha=None*, *space=None*)

Bases: NiceRepr

Used for converting a single color between spaces and encodings. This should only be used when handling small numbers of colors(e.g. 1), don't use this to represent an image.

Parameters

space (*str*) – colorspace of wrapped color. Assume RGB if not specified and it cannot be inferred

CommandLine

```
xdoctest -m ~/code/kwimage/kwimage/im_color.py Color
```

Example

```
>>> print(Color('g'))
>>> print(Color('orangered'))
>>> print(Color('#AAAAAA').as255())
>>> print(Color([0, 255, 0]))
>>> print(Color([1, 1, 1.]))
>>> print(Color([1, 1, 1]))
>>> print(Color(Color([1, 1, 1])).as255())
>>> print(Color(Color([1., 0, 1, 0])).ashex())
>>> print(Color([1, 1, 1], alpha=255))
>>> print(Color([1, 1, 1], alpha=255, space='lab'))
```

forimage(*image*, *space='auto'*)

Return a numeric value for this color that can be used in the given image.

Create a numeric color tuple that agrees with the format of the input image (i.e. float or int, with 3 or 4 channels).

Parameters

- **image** (*ndarray*) – image to return color for
- **space** (*str*) – colorspace of the input image. Defaults to 'auto', which will choose rgb or rgba

Returns

the color value

Return type

Tuple[Number, ...]

Example

```
>>> import kwimage
>>> img_f3 = np.zeros([8, 8, 3], dtype=np.float32)
>>> img_u3 = np.zeros([8, 8, 3], dtype=np.uint8)
>>> img_f4 = np.zeros([8, 8, 4], dtype=np.float32)
>>> img_u4 = np.zeros([8, 8, 4], dtype=np.uint8)
>>> kwimage.Color('red').forimage(img_f3)
(1.0, 0.0, 0.0)
>>> kwimage.Color('red').forimage(img_f4)
(1.0, 0.0, 0.0, 1.0)
>>> kwimage.Color('red').forimage(img_u3)
(255, 0, 0)
>>> kwimage.Color('red').forimage(img_u4)
(255, 0, 0, 255)
>>> kwimage.Color('red', alpha=0.5).forimage(img_f4)
(1.0, 0.0, 0.0, 0.5)
>>> kwimage.Color('red', alpha=0.5).forimage(img_u4)
(255, 0, 0, 127)
>>> kwimage.Color('red').forimage(np.uint8)
(255, 0, 0)
```

ashex(*space=None*)

Convert to hex values

Parameters
space (*None* | *str*) – if specified convert to this colorspace before returning

Returns
the hex representation

Return type
str

as255(*space=None*)

Convert to byte values

Parameters
space (*None* | *str*) – if specified convert to this colorspace before returning

Returns
The uint8 tuple of color values between 0 and 255.

Return type
Tuple[int, int, int] | Tuple[int, int, int, int]

as01(*space=None*)

Convert to float values

Parameters
space (*None* | *str*) – if specified convert to this colorspace before returning

Returns
The float tuple of color values between 0 and 1

Return type
Tuple[float, float, float] | Tuple[float, float, float, float]

classmethod named_colors()

Returns
names of colors that Color accepts

Return type
List[str]

Example

```
>>> import kwimage
>>> named_colors = kwimage.Color.named_colors()
>>> color_lut = {name: kwimage.Color(name).as01() for name in named_colors}
>>> # xdoctest: +REQUIRES(module:kwplot)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> # This is a very big table if we let it be, reduce it
>>> color_lut =dict(list(color_lut.items())[0:10])
>>> canvas = kwplot.make_legend_img(color_lut)
>>> kwplot.imshow(canvas)
```

classmethod distinct(*num*, *existing=None*, *space='rgb'*, *legacy='auto'*, *exclude_black=True*, *exclude_white=True*)

Make multiple distinct colors.

The legacy variant is based on a stack overflow post [HowToDistinct], but the modern variant is based on the `distinctipy` package.

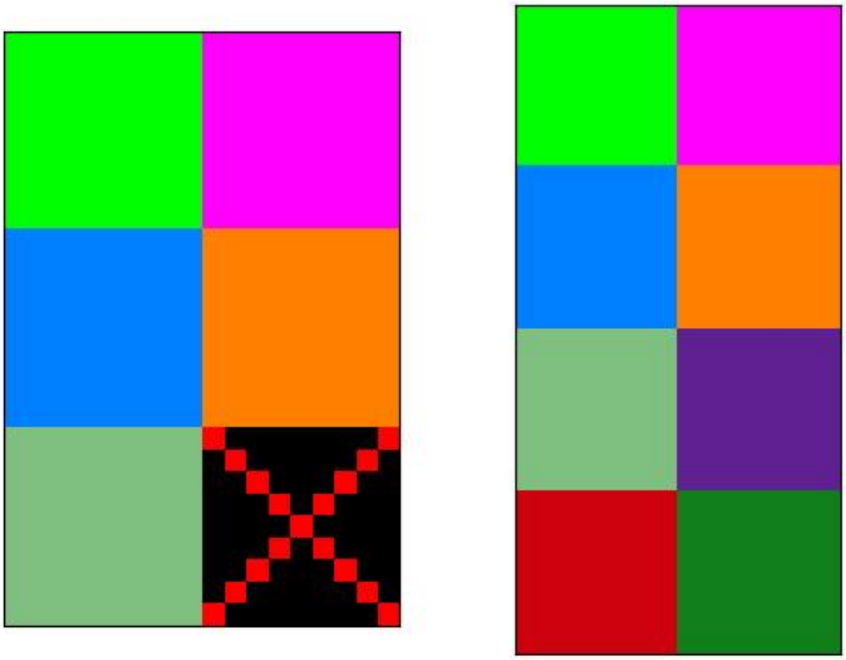
References

Returns
list of distinct float color values

Return type
List[Tuple]

Example

```
>>> # xdoctest: +REQUIRES(module:matplotlib)
>>> from kwimage.im_color import *  # NOQA
>>> import kwimage
>>> colors1 = kwimage.Color.distinct(5, legacy=False)
>>> colors2 = kwimage.Color.distinct(3, existing=colors1)
>>> # xdoctest: +REQUIRES(module:kwplot)
>>> # xdoctest: +REQUIRES(--show)
>>> from kwimage.im_color import _draw_color_swatch
>>> swatch1 = _draw_color_swatch(colors1, cellshape=9)
>>> swatch2 = _draw_color_swatch(colors1 + colors2, cellshape=9)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(swatch1, pnum=(1, 2, 1), fnum=1)
>>> kwplot.imshow(swatch2, pnum=(1, 2, 2), fnum=1)
>>> kwplot.show_if_requested()
```



classmethod random(*pool='named'*)

Returns
Color

distance(*other*, *space='lab'*)

Distance between self an another color

Parameters

- **other** (*Color*) – the color to compare
- **space** (*str*) – the colorspace to comapre in

Returns
float

kwimage.im_core module

Not sure how to best classify these functions

kwimage.im_core.**num_channels**(*img*)

Returns the number of color channels in an image.

Assumes images are 2D and the the channels are the trailing dimension. Returns 1 in the case with no trailing channel dimension, otherwise simply returns `img.shape[2]`.

Parameters
img (*ndarray*) – an image with 2 or 3 dimensions.

Returns
the number of color channels (1, 3, or 4)

Return type
int

Example

```
>>> H = W = 3
>>> assert num_channels(np.empty((W, H))) == 1
>>> assert num_channels(np.empty((W, H, 1))) == 1
>>> assert num_channels(np.empty((W, H, 3))) == 3
>>> assert num_channels(np.empty((W, H, 4))) == 4
>>> assert num_channels(np.empty((W, H, 2))) == 2
```

kwimage.im_core.**ensure_float01**(*img*, *dtype=<class 'numpy.float32'>*, *copy=True*)

Ensure that an image is encoded using a float32 properly

Parameters

- **img** (*ndarray*) – an image in uint255 or float01 format. Other formats will raise errors.
- **dtype** (*type*) – a numpy floating type defaults to np.float32
- **copy** (*bool*) – Always copy if True, else copy if needed. Defaults to True.

Returns
an array of floats in the range 0-1

Return type
ndarray

Raises
ValueError – if the image type is integer and not in [0-255]

Example

```
>>> ensure_float01(np.array([[0, .5, 1.0]]))
array([[0. , 0.5, 1. ]], dtype=float32)
>>> ensure_float01(np.array([[0, 1, 200]]))
array([[0..., 0.0039..., 0.784...]], dtype=float32)
```

kwimage.im_core.**ensure_uint255**(*img*, *copy=True*)

Ensure that an image is encoded using a uint8 properly. Either

Parameters

- **img** (*ndarray*) – an image in uint255 or float01 format. Other formats will raise errors.
- **copy** (*bool*) – always copy if True, else copy if needed. Defaults to True.

Returns
an array of bytes in the range 0-255

Return type
ndarray

Raises

- **ValueError** – if the image type is float and not in [0-1]
- **ValueError** – if the image type is integer and not in [0-255]

Example

```
>>> ensure_uint255(np.array([[0, .5, 1.0]]))
array([[  0, 127, 255]], dtype=uint8)
>>> ensure_uint255(np.array([[0, 1, 200]]))
array([[  0,   1, 200]], dtype=uint8)
```

kwimage.im_core.**make_channels_comparable**(*img1*, *img2*, *atleast3d=False*)

Broadcasts image arrays so they can have elementwise operations applied

Parameters

- **img1** (*ndarray*) – first image
- **img2** (*ndarray*) – second image
- **atleast3d** (*bool*) – if true we ensure that the channel dimension exists (only relevant for 1-channel images). Defaults to False.

Example

```
>>> import itertools as it
>>> wh_basis = [(5, 5), (3, 5), (5, 3), (1, 1), (1, 3), (3, 1)]
>>> for w, h in wh_basis:
>>>     shape_basis = [(w, h), (w, h, 1), (w, h, 3)]
>>>     # Test all permutations of shap inputs
>>>     for shape1, shape2 in it.product(shape_basis, shape_basis):
>>>         print('*    input shapes: %r, %r' % (shape1, shape2))
>>>         img1 = np.empty(shape1)
>>>         img2 = np.empty(shape2)
>>>         img1, img2 = make_channels_comparable(img1, img2)
>>>         print('... output shapes: %r, %r' % (img1.shape, img2.shape))
>>>         elem = (img1 + img2)
>>>         print('... elem(+) shape: %r' % (elem.shape,))
>>>         assert elem.size == img1.size, 'outputs should have same size'
>>>         assert img1.size == img2.size, 'new imgs should have same size'
>>>         print('--------')
```

kwimage.im_core.**atleast_3channels**(*arr*, *copy=True*)

Ensures that there are 3 channels in the image

Parameters

- **arr** (*ndarray*) – an image with 2 or 3 dims.
- **copy** (*bool*) – Always copies if True, if False, then copies only when the size of the array must change. Defaults to True.

Returns

with shape (N, M, C), where C in {3, 4}

Return type

ndarray

Doctest

```
>>> assert atleast_3channels(np.zeros((10, 10))).shape[-1] == 3
>>> assert atleast_3channels(np.zeros((10, 10, 1))).shape[-1] == 3
>>> assert atleast_3channels(np.zeros((10, 10, 3))).shape[-1] == 3
>>> assert atleast_3channels(np.zeros((10, 10, 4))).shape[-1] == 4
```

kwimage.im_core.**padded_slice**(*data*, *in_slice*, *pad=None*, *padkw=None*, *return_info=False*)

Allows slices with out-of-bound coordinates. Any out of bounds coordinate will be sampled via padding.

DEPRECATED FOR THE VERSION IN KWARRAY (slices are more array-ish than image-ish)

Note: Negative slices have a different meaning here then they usually do. Normally, they indicate a wrap-around or a reversed stride, but here they index into out-of-bounds space (which depends on the pad mode). For example a slice of -2:1 literally samples two pixels to the left of the data and one pixel from the data, so you get two padded values and one data value.

Parameters

- **data** (*Sliceable*) – data to slice into. Any channels must be the last dimension.
- **in_slice** (*slice | Tuple[slice, ...]*) – slice for each dimensions
- **ndim** (*int*) – number of spatial dimensions
- **pad** (*List[int|Tuple]*) – additional padding of the slice
- **padkw** (*Dict*) – if unspecified defaults to `{'mode': 'constant'}`
- **return_info** (*bool*) – if True, return extra information about the transform. Defaults to False.

SeeAlso:

_padded_slice_embed - finds the embedded slice and padding _padded_slice_apply - applies padding to sliced data

Returns

data_sliced: subregion of the input data (possibly with padding,
depending on if the original slice went out of bounds)

Tuple[Sliceable, Dict] :

data_sliced : as above

transform : information on how to return to the original coordinates

Currently a dict containing:

st_dims: a list indicating the low and high space-time
coordinate values of the returned data slice.

The structure of this dictionary mach change in the future

Return type

Sliceable

Example

```
>>> data = np.arange(5)
>>> in_slice = [slice(-2, 7)]
```

```
>>> data_sliced = padded_slice(data, in_slice)
>>> print(ub.repr2(data_sliced, with_dtype=False))
np.array([0, 0, 0, 1, 2, 3, 4, 0, 0])
```

```
>>> data_sliced = padded_slice(data, in_slice, pad=(3, 3))
>>> print(ub.repr2(data_sliced, with_dtype=False))
np.array([0, 0, 0, 0, 0, 0, 1, 2, 3, 4, 0, 0, 0, 0, 0])
```

```
>>> data_sliced = padded_slice(data, slice(3, 4), pad=[(1, 0)])
>>> print(ub.repr2(data_sliced, with_dtype=False))
np.array([2, 3])
```

kwimage.im_core.**normalize**(*arr*, *mode='linear'*, *alpha=None*, *beta=None*, *out=None*)

Rebalance pixel intensities via contrast stretching.

By default linearly stretches pixel intensities to minimum and maximum values.

Note: DEPRECATED: this function has been MOVED to `kwarray.normalize`

---

kwimage.im_core.**find_robust_normalizers**(*data*, *params='auto'*)

Finds robust normalization statistics for a single observation

Parameters

- **data** (*ndarray*) – a 1D numpy array where invalid data has already been removed
- **params** (*str | dict*) – normalization params

Returns

normalization parameters

Return type

Dict[str, str | float]

Todo:

- [ ] No Magic Numbers! Use first principles to deterimine defaults.
- [ ] Probably a lot of literature on the subject.
- [ ] Is this a kwarray function in general?

Example

```
>>> from kwimage.im_core import *  # NOQA
>>> data = np.random.rand(100)
>>> norm_params1 = find_robust_normalizers(data, params='auto')
>>> norm_params2 = find_robust_normalizers(data, params={'low': 0, 'high': 1.0})
>>> norm_params3 = find_robust_normalizers(np.empty(0), params='auto')
>>> print('norm_params1 = {}'.format(ub.repr2(norm_params1, nl=1)))
>>> print('norm_params2 = {}'.format(ub.repr2(norm_params2, nl=1)))
>>> print('norm_params3 = {}'.format(ub.repr2(norm_params3, nl=1)))
```

kwimage.im_core.**normalize_intensity**(*imdata*, *return_info=False*, *nodata=None*, *axis=None*, *dtype=<class 'numpy.float32'>*, *params='auto'*, *mask=None*)

Normalize data intensities using heuristics to help put sensor data with extremely high or low contrast into a visible range.

This function is designed with an emphasis on getting something that is reasonable for visualization.

Todo:

- [ ] Move to kwarray and renamed to robust_normalize?
- [ ] Support for M-estimators?

Parameters

- **imdata** (*ndarray*) – raw intensity data
- **return_info** (*bool*) – if True, return information about the chosen normalization heuristic.
- **params** (*str | dict*) – can contain keys, low, high, or center e.g. {'low': 0.1, 'center': 0.8, 'high': 0.9}
- **axis** (*None | int*) – The axis to normalize over, if unspecified, normalize jointly
- **nodata** (*None | int*) – A value representing nodata to leave unchanged during normalization, for example 0
- **dtype** (*type*) – can be float32 or float64
- **mask** (*ndarray | None*) – A mask indicating what pixels are valid and what pixels should be considered nodata. Mutually exclusive with `nodata` argument. A mask value of 1 indicates a VALID pixel. A mask value of 0 indicates an INVALID pixel.

Returns

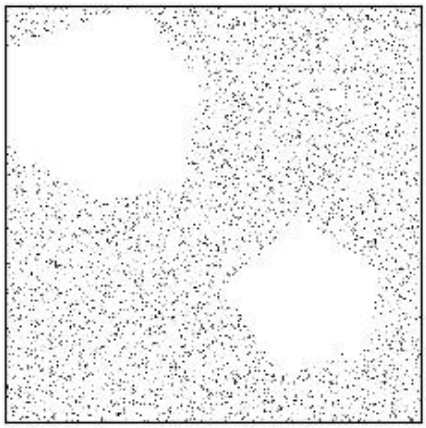
a floating point array with values between 0 and 1.

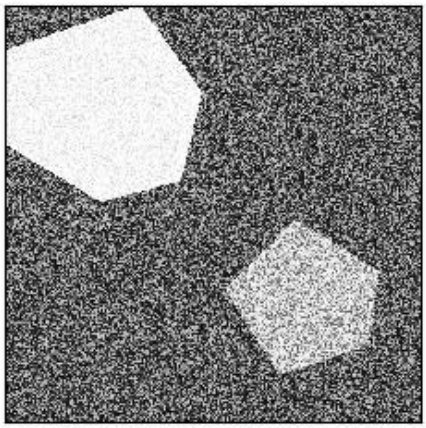
Return type

ndarray

Example

```
>>> from kwimage.im_core import *  # NOQA
>>> import ubelt as ub
>>> import kwimage
>>> import kwarray
>>> s = 512
>>> bit_depth = 11
>>> dtype = np.uint16
>>> max_val = int(2 ** bit_depth)
>>> min_val = int(0)
>>> rng = kwarray.ensure_rng(0)
>>> background = np.random.randint(min_val, max_val, size=(s, s), dtype=dtype)
>>> poly1 = kwimage.Polygon.random(rng=rng).scale(s / 2)
>>> poly2 = kwimage.Polygon.random(rng=rng).scale(s / 2).translate(s / 2)
>>> forground = np.zeros_like(background, dtype=np.uint8)
>>> forground = poly1.fill(forground, value=255)
>>> forground = poly2.fill(forground, value=122)
>>> forground = (kwimage.ensure_float01(forground) * max_val).astype(dtype)
>>> imdata = background + forground
>>> normed, info = normalize_intensity(imdata, return_info=True)
>>> print('info = {}'.format(ub.repr2(info, nl=1)))
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(imdata, pnum=(1, 2, 1), fnum=1)
>>> kwplot.imshow(normed, pnum=(1, 2, 2), fnum=1)
```





Example

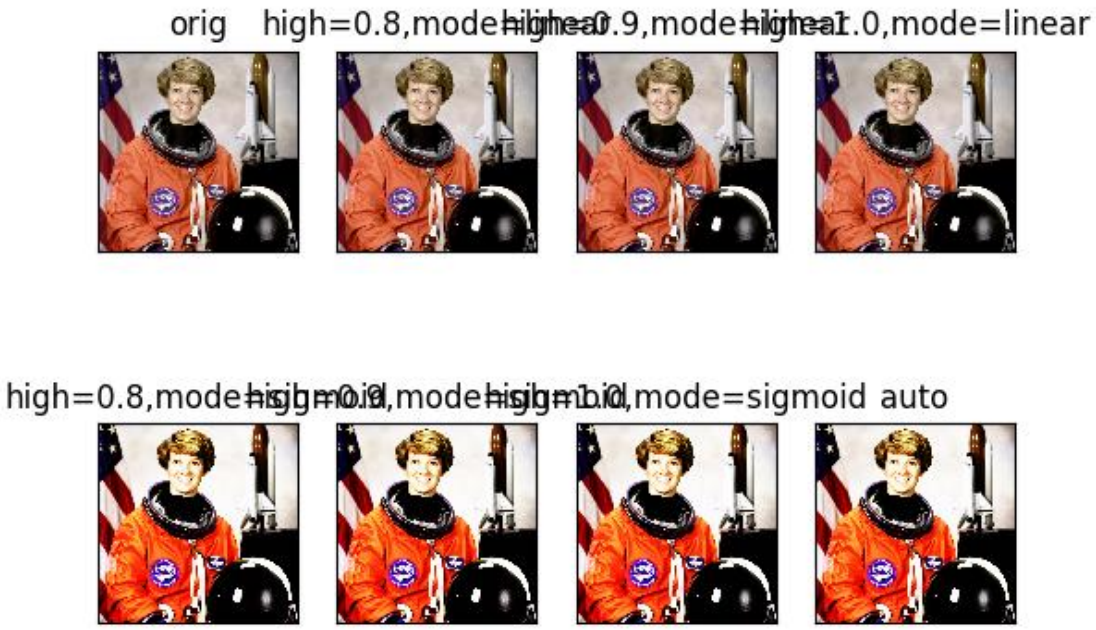
```
>>> from kwimage.im_core import *  # NOQA
>>> import ubelt as ub
>>> import kwimage
>>> # Test on an image that is already normalized to test how it
>>> # degrades
>>> imdata = kwimage.grab_test_image() / 255
```

```
>>> quantile_basis = {
>>>     'mode': ['linear', 'sigmoid'],
>>>     'high': [0.8, 0.9, 1.0],
>>> }
>>> quantile_grid = list(ub.named_product(quantile_basis))
>>> quantile_grid += ['auto']
>>> rows = []
>>> rows.append({'key': 'orig', 'result': imdata})
>>> for params in quantile_grid:
>>>     key = ub.repr2(params, compact=1)
>>>     result, info = normalize_intensity(imdata, return_info=True, params=params)
>>>     print('key = {}'.format(key))
>>>     print('info = {}'.format(ub.repr2(info, nl=1)))
>>>     rows.append({'key': key, 'info': info, 'result': result})
```

(continues on next page)

(continued from previous page)

```
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> pnum_ = kwplot.PlotNums(nSubplots=len(rows))
>>> for row in rows:
>>>     _, ax = kwplot.imshow(row['result'], fnum=1, pnum=pnum_())
>>>     ax.set_title(row['key'])
```



kwimage.im_cv2 module

Wrappers around cv2 functions

Note: all functions in kwimage work with RGB input by default instead of BGR.

`kwimage.im_cv2.`**`imscale`**(*img*, *scale*, *interpolation=None*, *return_scale=False*)

DEPRECATED and removed: use imresize instead

`kwimage.im_cv2.`**`imcrop`**(*img*, *dsize*, *about=None*, *origin=None*, *border_value=None*, *interpolation='nearest'*)

Crop an image about a specified point, padding if necessary.

This is like `PIL.Image.Image.crop()` with more convenient arguments, or `cv2.getRectSubPix()` without the baked-in bilinear interpolation.

Parameters

- **img** (*ndarray*) – image to crop

- **dsize** (*Tuple[None | int, None | int]*) – the desired width and height of the new image. If a dimension is None, then it is automatically computed to preserve aspect ratio. This can be larger than the original dims; if so, the cropped image is padded with border_value.
- **about** (*Tuple[str | int, str | int]*) – the location to crop about. Mutually exclusive with origin. Defaults to top left. If ints (w,h) are provided, that will be the center of the cropped image. There are also string codes available: 'lt': make the top left point of the image the top left point of the cropped image. This is equivalent to `img[:dsize[1], :dsize[0]]`, plus padding. 'rb': make the bottom right point of the image the bottom right point of the cropped image. This is equivalent to `img[-dsize[1]:, -dsize[0]:]`, plus padding. 'cc': make the center of the image the center of the cropped image. Any combination of these codes can be used, ex. 'lb', 'ct', ('r', 200), ...
- **origin** (*Tuple[int, int] | None*) – the origin of the crop in (x,y) order (same order as dsize/about). Mutually exclusive with about. Defaults to top left.
- **border_value** (*Number | Tuple | str*) – any border border_value accepted by cv2.copyMakeBorder, ex. [255, 0, 0] (blue). Default is 0.
- **interpolation** (*str*) – Can be 'nearest', in which case integral cropping is used. Can also be 'linear', in which case cv2.getRectSubPix is used. Defaults to 'nearest'.

Returns
the cropped image

Return type
ndarray

SeeAlso:

`kwarray.padded_slice()` - a similar function for working with "negative slices".

Example

```
>>> import kwimage
>>> import numpy as np
>>> #
>>> img = kwimage.grab_test_image('astro', dsize=(32, 32))[..., 0:3]
>>> #
>>> # regular crop
>>> new_img1 = kwimage.imcrop(img, dsize=(5,6))
>>> assert new_img1.shape[0:2] == (6, 5)
>>> #
>>> # padding for coords outside the image bounds
>>> new_img2 = kwimage.imcrop(img, dsize=(5,6),
>>>             origin=(-1,0), border_value=[1, 0, 0])
>>> assert np.all(new_img2[:, 0, 0:3] == [1, 0, 0])
>>> #
>>> # codes for corner- and edge-centered cropping
>>> new_img3 = kwimage.imcrop(img, dsize=(5,6),
>>>             about='cb')
>>> #
>>> # special code for bilinear interpolation
>>> # with floating-point coordinates
>>> new_img4 = kwimage.imcrop(img, dsize=(5,6),
```

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```
>>>             about=(5.5, 8.5), interpolation='linear')
>>> #
>>> # use with bounding boxes
>>> bbox = kwimage.Boxes.random(scale=5, rng=132).to_xywh().quantize()
>>> origin, dsize = np.split(bbox.data[0], 2)
>>> new_img5 = kwimage.imcrop(img, dsize=dsize,
>>>             origin=origin)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> pnum_ = kwplot.PlotNums(nSubplots=6)
>>> kwplot.imshow(img, pnum=pnum_())
>>> kwplot.imshow(new_img1, pnum=pnum_())
>>> kwplot.imshow(new_img2, pnum=pnum_())
>>> kwplot.imshow(new_img3, pnum=pnum_())
>>> kwplot.imshow(new_img4, pnum=pnum_())
>>> kwplot.imshow(new_img5, pnum=pnum_())
>>> kwplot.show_if_requested()
```

kwimage.im_cv2.**imresize**(*img*, *scale=None*, *dsize=None*, *max_dim=None*, *min_dim=None*, *interpolation=None*, *grow_interpolation=None*, *letterbox=False*, *return_info=False*, *antialias=False*, *border_value=0*)

Resize an image based on a scale factor, final size, or size and aspect ratio.

Slightly more general than cv2.resize, allows for specification of either a scale factor, a final size, or the final size for a particular dimension.

Parameters

- **img** (*ndarray*) – image to resize
- **scale** (*float | Tuple[float, float]*) – Desired floating point scale factor. If a tuple, the dimension ordering is x,y. Mutually exclusive with dsize, max_dim, and min_dim.
- **dsize** (*Tuple[int]*) – The desired with and height of the new image. If a dimension is None, then it is automatically computed to preserve aspect ratio. Mutually exclusive with size, max_dim, and min_dim.
- **max_dim** (*int*) – New size of the maximum dimension, the other dimension is scaled to maintain aspect ratio. Mutually exclusive with size, dsize, and min_dim.
- **min_dim** (*int*) – New size of the minimum dimension, the other dimension is scaled to maintain aspect ratio.Mutually exclusive with size, dsize, and max_dim.
- **interpolation** (*str | int*) – The interpolation key or code (e.g. linear lanczos). By default "area" is used if the image is shrinking and "lanczos" is used if the image is growing. Note, if this is explicitly set, then it will be used regardless of if the image is growing or shrinking. Set `grow_interpolation` to change the default for an enlarging interpolation.
- **grow_interpolation** (*str | int*) – The interpolation key or code to use when the image is being enlarged. Does nothing if "interpolation" is explicitly given. If "interpolation" is not specified "area" is used when shrinking. Defaults to "lanczos".
- **letterbox** (*bool*) – If used in conjunction with dsize, then the image is scaled and translated to fit in the center of the new image while maintaining aspect ratio. Border padding is added if necessary. Defaults to False.
- **return_info** (*bool*) – if True returns information about the final transformation in a dictionary. If there is an offset, the scale is applied before the offset when transforming to the new resized space. Defaults to False.
- **antialias** (*bool*) – if True blurs to anti-alias before downsampling. Defaults to False.
- **border_value** (*int | float | Iterable[int | float]*) – if letterbox is True, this is used as the constant fill value.

Returns

the new image and optionally an info dictionary if *return_info=True*

Return type

ndarray | Tuple[ndarray, Dict]

Example

```
>>> import kwimage
>>> import numpy as np
>>> # Test scale
>>> img = np.zeros((16, 10, 3), dtype=np.uint8)
>>> new_img, info = kwimage.imresize(img, scale=.85,
>>>                                  interpolation='area',
>>>                                  return_info=True)
>>> print('info = {!r}'.format(info))
>>> assert info['scale'].tolist() == [.8, 0.875]
```

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```
>>> # Test dsize without None
>>> new_img, info = kwimage.imresize(img, dsize=(5, 12),
>>>                                  interpolation='area',
>>>                                  return_info=True)
>>> print('info = {!r}'.format(info))
>>> assert info['scale'].tolist() == [0.5 , 0.75]
>>> # Test dsize with None
>>> new_img, info = kwimage.imresize(img, dsize=(6, None),
>>>                                  interpolation='area',
>>>                                  return_info=True)
>>> print('info = {!r}'.format(info))
>>> assert info['scale'].tolist() == [0.6, 0.625]
>>> # Test max_dim
>>> new_img, info = kwimage.imresize(img, max_dim=6,
>>>                                  interpolation='area',
>>>                                  return_info=True)
>>> print('info = {!r}'.format(info))
>>> assert info['scale'].tolist() == [0.4  , 0.375]
>>> # Test min_dim
>>> new_img, info = kwimage.imresize(img, min_dim=6,
>>>                                  interpolation='area',
>>>                                  return_info=True)
>>> print('info = {!r}'.format(info))
>>> assert info['scale'].tolist() == [0.6  , 0.625]
```

Example

```
>>> import kwimage
>>> import numpy as np
>>> # Test letterbox resize
>>> img = np.ones((5, 10, 3), dtype=np.float32)
>>> new_img, info = kwimage.imresize(img, dsize=(19, 19),
>>>                                  letterbox=True,
>>>                                  return_info=True)
>>> print('info = {!r}'.format(info))
>>> assert info['offset'].tolist() == [0, 4]
>>> img = np.ones((10, 5, 3), dtype=np.float32)
>>> new_img, info = kwimage.imresize(img, dsize=(19, 19),
>>>                                  letterbox=True,
>>>                                  return_info=True)
>>> print('info = {!r}'.format(info))
>>> assert info['offset'].tolist() == [4, 0]
```

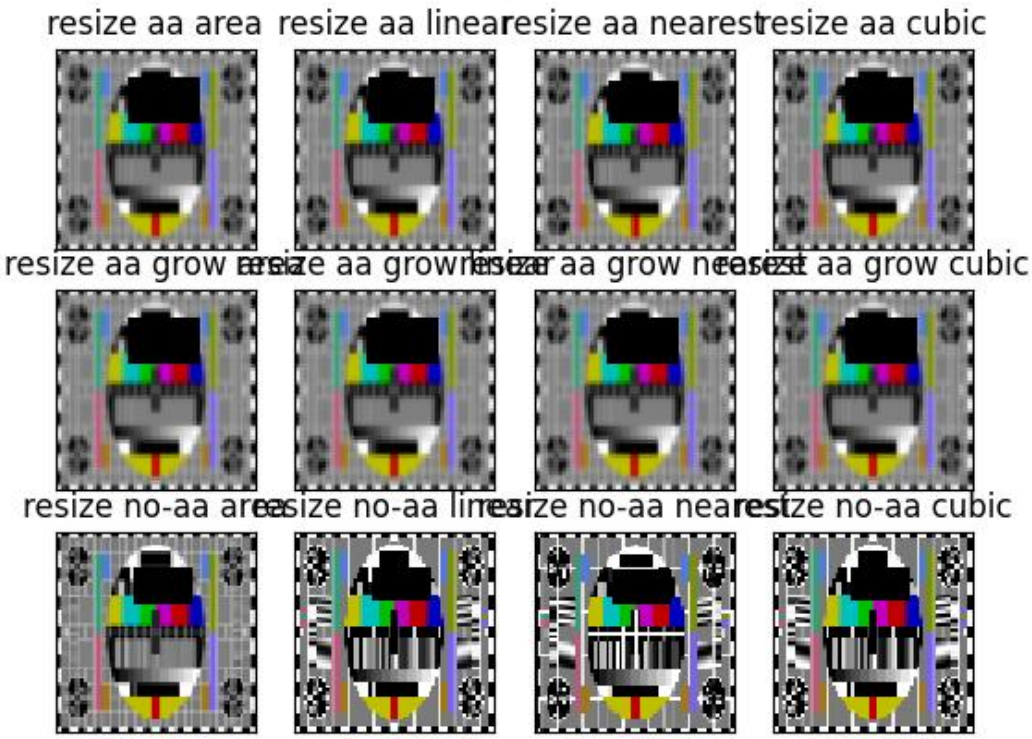
```
>>> import kwimage
>>> import numpy as np
>>> # Test letterbox resize
>>> img = np.random.rand(100, 200)
>>> new_img, info = kwimage.imresize(img, dsize=(300, 300), letterbox=True, return_
↪info=True)
```

Example

```
>>> # Check aliasing
>>> import kwimage
>>> #img = kwimage.grab_test_image('checkerboard')
>>> img = kwimage.grab_test_image('pm5644')
>>> # test with nans
>>> img = kwimage.ensure_float01(img)
>>> img[100:200, 400:700] = np.nan
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> dsize = (14, 14)
>>> dsize = (64, 64)
>>> # When we set "grow_interpolation" for a "shrinking" resize it should
>>> # still do the "area" interpolation to antialias the results. But if we
>>> # use explicit interpolation it should alias.
>>> pnum_ = kwplot.PlotNums(nSubplots=12, nCols=4)
>>> kwplot.imshow(kwimage.imresize(img, dsize=dsize, antialias=True,  interpolation=
↪'area'), pnum=pnum_(), title='resize aa area')
>>> kwplot.imshow(kwimage.imresize(img, dsize=dsize, antialias=True, interpolation=
↪'linear'), pnum=pnum_(), title='resize aa linear')
>>> kwplot.imshow(kwimage.imresize(img, dsize=dsize, antialias=True, interpolation=
↪'nearest'), pnum=pnum_(), title='resize aa nearest')
>>> kwplot.imshow(kwimage.imresize(img, dsize=dsize, antialias=True, interpolation=
↪'cubic'), pnum=pnum_(), title='resize aa cubic')
```

```
>>> kwplot.imshow(kwimage.imresize(img, dsize=dsize, antialias=True, grow_
↪interpolation='area'), pnum=pnum_(), title='resize aa grow area')
>>> kwplot.imshow(kwimage.imresize(img, dsize=dsize, antialias=True, grow_
↪interpolation='linear'), pnum=pnum_(), title='resize aa grow linear')
>>> kwplot.imshow(kwimage.imresize(img, dsize=dsize, antialias=True, grow_
↪interpolation='nearest'), pnum=pnum_(), title='resize aa grow nearest')
>>> kwplot.imshow(kwimage.imresize(img, dsize=dsize, antialias=True, grow_
↪interpolation='cubic'), pnum=pnum_(), title='resize aa grow cubic')
```

```
>>> kwplot.imshow(kwimage.imresize(img, dsize=dsize, antialias=False, interpolation=
↪'area'), pnum=pnum_(), title='resize no-aa area')
>>> kwplot.imshow(kwimage.imresize(img, dsize=dsize, antialias=False, interpolation=
↪'linear'), pnum=pnum_(), title='resize no-aa linear')
>>> kwplot.imshow(kwimage.imresize(img, dsize=dsize, antialias=False, interpolation=
↪'nearest'), pnum=pnum_(), title='resize no-aa nearest')
>>> kwplot.imshow(kwimage.imresize(img, dsize=dsize, antialias=False, interpolation=
↪'cubic'), pnum=pnum_(), title='resize no-aa cubic')
```



Todo:

- [X] When interpolation is area and the number of channels > 4 cv2.resize will error but it is fine for linear interpolation
- [ ] TODO: add padding options when letterbox=True
- [ ] Allow for pre-clipping when letterbox=True

kwimage.im_cv2.**convert_colorspace**(*img*, *src_space*, *dst_space*, *copy=False*, *implicit=False*, *dst=None*)

Converts colorspace of img.

Convenience function around `cv2.cvtColor()`

Parameters

- **img** (*ndarray*) – image data with float32 or uint8 precision
- **src_space** (*str*) – input image colorspace. (e.g. BGR, GRAY)
- **dst_space** (*str*) – desired output colorspace. (e.g. RGB, HSV, LAB)
- **implicit** (*bool*) –

  if False, the user must correctly specify if the input/output colorspaces contain alpha channels.

  If True and the input image has an alpha channel, we modify src_space and dst_space to ensure they both end with "A".

- **dst** (*ndarray[Any, UInt8]*) – inplace-output array.

Returns
img - image data

Return type
ndarray

Note: Note the LAB and HSV colorspaces in float do not go into the 0-1 range.

For HSV the floating point range is:
0:360, 0:1, 0:1

For LAB the floating point range is:
0:100, -86.1875:98.234375, -107.859375:94.46875 (Note, that some extreme combinations of a and b are not valid)

Example

```
>>> import numpy as np
>>> convert_colorspace(np.array([[[0, 0, 1]]], dtype=np.float32), 'RGB', 'LAB')
>>> convert_colorspace(np.array([[[0, 1, 0]]], dtype=np.float32), 'RGB', 'LAB')
>>> convert_colorspace(np.array([[[1, 0, 0]]], dtype=np.float32), 'RGB', 'LAB')
>>> convert_colorspace(np.array([[[1, 1, 1]]], dtype=np.float32), 'RGB', 'LAB')
>>> convert_colorspace(np.array([[[0, 0, 1]]], dtype=np.float32), 'RGB', 'HSV')
```

kwimage.im_cv2.**gaussian_patch**(*shape=(7, 7)*, *sigma=None*)

Creates a 2D gaussian patch with a specific size and sigma

Parameters

- **shape** (*Tuple[int, int]*) – patch height and width
- **sigma** (*float | Tuple[float, float] | None*) – Gaussian standard deviation. If unspecified, it is derived using the formulation described in [Cv2GaussKern].

Returns
ndarray

References

Todo:

- [ ] Look into this C-implementation https://kwgitlab.kitware.com/computer-vision/heatmap/blob/master/heatmap/heatmap.c

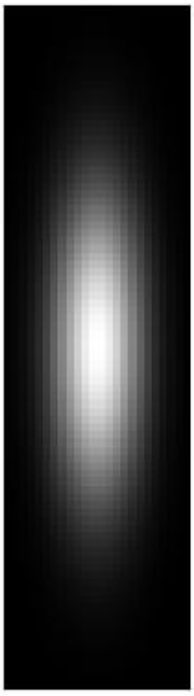
---

CommandLine

```
xdoctest -m kwimage.im_cv2 gaussian_patch --show
```

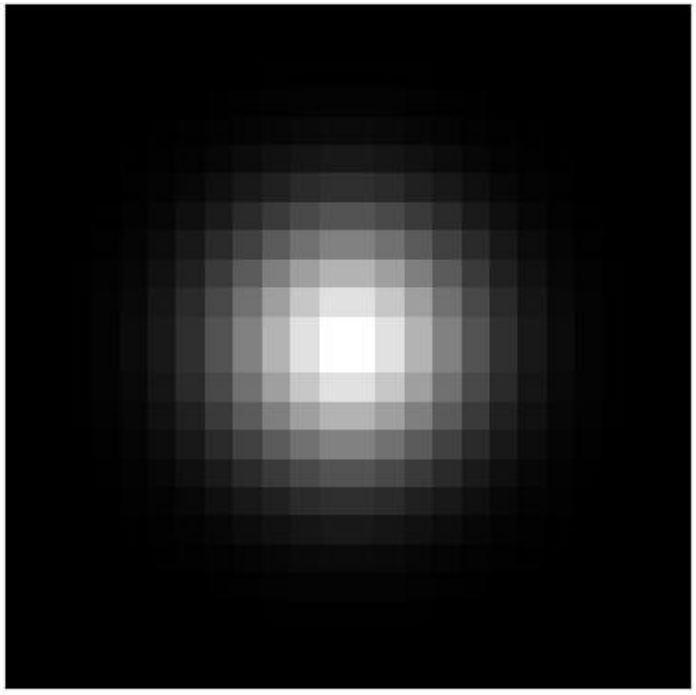
Example

```
>>> import numpy as np
>>> shape = (88, 24)
>>> sigma = None  # 1.0
>>> gausspatch = gaussian_patch(shape, sigma)
>>> sum_ = gausspatch.sum()
>>> assert np.all(np.isclose(sum_, 1.0))
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> norm = (gausspatch - gausspatch.min()) / (gausspatch.max() - gausspatch.min())
>>> kwplot.imshow(norm)
>>> kwplot.show_if_requested()
```



Example

```
>>> import numpy as np
>>> shape = (24, 24)
>>> sigma = 3.0
>>> gausspatch = gaussian_patch(shape, sigma)
>>> sum_ = gausspatch.sum()
>>> assert np.all(np.isclose(sum_, 1.0))
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> norm = (gausspatch - gausspatch.min()) / (gausspatch.max() - gausspatch.min())
>>> kwplot.imshow(norm)
>>> kwplot.show_if_requested()
```



kwimage.im_cv2.**gaussian_blur**(*image*, *kernel=None*, *sigma=None*, *border_mode=None*, *dst=None*)

Apply a gausian blur to an image.

This is a simple wrapper around `cv2.GaussianBlur()` with concise parametarization and sane defaults.

Parameters

- **image** (*ndarray*) – the input image
- **kernel** (*int | Tuple[int, int]*) – The kernel size in x and y directions.
- **sigma** (*float | Tuple[float, float]*) – The gaussian spread in x and y directions.

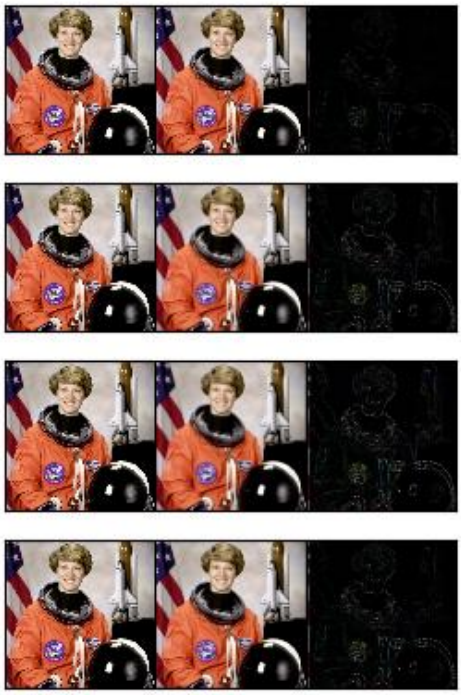
- **border_mode** (*str | int | None*) – Border text code or cv2 integer. Border codes are 'constant' (default), 'replicate', 'reflect', 'reflect101', and 'transparent'.
- **dst** (*ndarray | None*) – optional inplace-output array.

Returns
the blurred image

Return type
ndarray

Example

```
>>> import kwimage
>>> image = kwimage.ensure_float01(kwimage.grab_test_image('astro'))
>>> blurred1 = kwimage.gaussian_blur(image)
>>> blurred2 = kwimage.gaussian_blur(image, kernel=9)
>>> blurred3 = kwimage.gaussian_blur(image, sigma=2)
>>> blurred4 = kwimage.gaussian_blur(image, sigma=(2, 5), kernel=5)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> pnum_ = kwplot.PlotNums(nRows=4, nCols=1)
>>> blurs = [blurred1, blurred2, blurred3, blurred4]
>>> for blurred in blurs:
>>>     diff = np.abs(image - blurred)
>>>     stack = kwimage.stack_images([image, blurred, diff], pad=10, axis=1)
>>>     kwplot.imshow(stack, pnum=pnum_())
>>> kwplot.show_if_requested()
```



kwimage.im_cv2.**warp_affine**(*image*, *transform*, *dsize=None*, *antialias=False*, *interpolation='linear'*, *border_mode=None*, *border_value=0*, *large_warp_dim=None*, *return_info=False*)

Applies an affine transformation to an image with optional antialiasing.

Parameters

- **image** (*ndarray*) – the input image as a numpy array. Note: this is passed directly to cv2, so it is best to ensure that it is contiguous and using a dtype that cv2 can handle.
- **transform** (*ndarray | dict | kwimage.Affine*) – a coercable affine matrix. See `kwimage.Affine` for details on what can be coerced.
- **dsize** (*Tuple[int, int] | None | str*) – A integer width and height tuple of the resulting "canvas" image. If None, then the input image size is used.

  If specified as a string, dsize is computed based on the given heuristic.

  If 'positive' (or 'auto'), dsize is computed such that the positive coordinates of the warped image will fit in the new canvas. In this case, any pixel that maps to a negative coordinate will be clipped. This has the property that the input transformation is not modified.

  If 'content' (or 'max'), the transform is modified with an extra translation such that both the positive and negative coordinates of the warped image will fit in the new canvas.
- **antialias** (*bool*) – if True determines if the transform is downsampling and applies antialiasing via gaussian a blur. Defaults to False
- **interpolation** (*str | int*) – interpolation code or cv2 integer. Interpolation codes are linear, nearest, cubic, lancsoz, and area. Defaults to "linear".

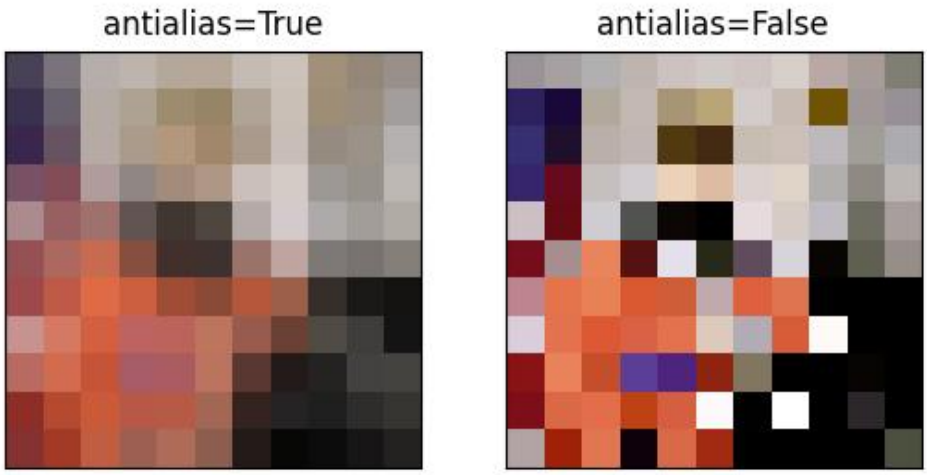
- **border_mode** (*str | int*) – Border code or cv2 integer. Border codes are constant (default) replicate, reflect, wrap, reflect101, and transparent.
- **border_value** (*int | float | Iterable[int | float]*) – Used as the fill value if border_mode is constant. Otherwise this is ignored. Defaults to 0, but can also be defaulted to nan. if border_value is a scalar and there are multiple channels, the value is applied to all channels. More than 4 unique border values for individual channels will cause an error. See OpenCV #22283 for details. In the future we may accept np.ma and return a masked array, but for now that is not implemented.
- **large_warp_dim** (*int | None | str*) – If specified, perform the warp piecewise in chunks of the specified size. If "auto", it is set to the maximum "short" value in numpy. This works around a limitation of cv2.warpAffine, which must have image dimensions < SHRT_MAX (=32767 in version 4.5.3)
- **return_info** (*bool*) – if True, returns information about the operation. In the case where dsize="content", this includes the modified transformation.

Returns
the warped image, or if return info is True, the warped image and the info dictionary.

Return type
ndarray | Tuple[ndarray, Dict]

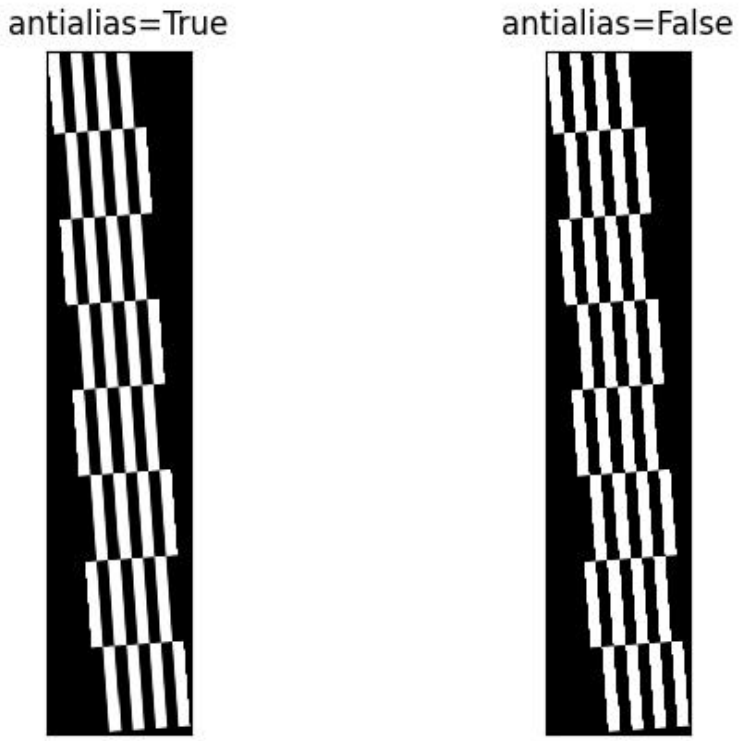
Example

```
>>> from kwimage.im_cv2 import *  # NOQA
>>> import kwimage
>>> from kwimage.transform import Affine
>>> image = kwimage.grab_test_image('astro')
>>> #image = kwimage.grab_test_image('checkerboard')
>>> transform = Affine.random() @ Affine.scale(0.05)
>>> transform = Affine.scale(0.02)
>>> warped1 = warp_affine(image, transform, dsize='positive', antialias=1,␣
↪interpolation='nearest')
>>> warped2 = warp_affine(image, transform, dsize='positive', antialias=0)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> pnum_ = kwplot.PlotNums(nRows=1, nCols=2)
>>> kwplot.imshow(warped1, pnum=pnum_(), title='antialias=True')
>>> kwplot.imshow(warped2, pnum=pnum_(), title='antialias=False')
>>> kwplot.show_if_requested()
```



Example

```
>>> from kwimage.im_cv2 import *  # NOQA
>>> import kwimage
>>> from kwimage.transform import Affine
>>> image = kwimage.grab_test_image('astro')
>>> image = kwimage.grab_test_image('checkerboard')
>>> transform = Affine.random() @ Affine.scale((.1, 1.2))
>>> warped1 = warp_affine(image, transform, dsize='positive', antialias=1)
>>> warped2 = warp_affine(image, transform, dsize='positive', antialias=0)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> pnum_ = kwplot.PlotNums(nRows=1, nCols=2)
>>> kwplot.imshow(warped1, pnum=pnum_(), title='antialias=True')
>>> kwplot.imshow(warped2, pnum=pnum_(), title='antialias=False')
>>> kwplot.show_if_requested()
```



Example

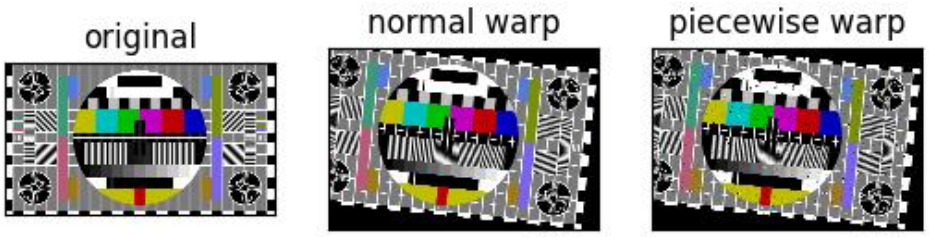
```
>>> # Test the case where the input data is empty or the target canvas
>>> # is empty, this should be handled like boundary effects
>>> import kwimage
>>> image = np.random.rand(1, 1, 3)
>>> transform = kwimage.Affine.random()
>>> result = kwimage.warp_affine(image, transform, dsize=(0, 0))
>>> assert result.shape == (0, 0, 3)
>>> #
>>> empty_image = np.random.rand(0, 1, 3)
>>> result = kwimage.warp_affine(empty_image, transform, dsize=(10, 10))
>>> assert result.shape == (10, 10, 3)
>>> #
>>> empty_image = np.random.rand(0, 1, 3)
>>> result = kwimage.warp_affine(empty_image, transform, dsize=(10, 0))
>>> assert result.shape == (0, 10, 3)
```

Example

```
>>> # Demo difference between positive and content dsize
>>> from kwimage.im_cv2 import *  # NOQA
>>> import kwimage
>>> from kwimage.transform import Affine
>>> image = kwimage.grab_test_image('astro', dsize=(512, 512))
>>> transform = Affine.coerce(offset=(-100, -50), scale=2, theta=0.1)
>>> # When warping other images or geometry along with this image
>>> # it is important to account for the modified transform when
>>> # setting dsize='content'. If dsize='positive', the transform
>>> # will remain unchanged wrt other aligned images / geometries.
>>> poly = kwimage.Boxes([[350, 5, 130, 290]], 'xywh').to_polygons()[0]
>>> # Apply the warping to the images
>>> warped_pos, info_pos = warp_affine(image, transform, dsize='positive', return_
↪info=True)
>>> warped_con, info_con = warp_affine(image, transform, dsize='content', return_
↪info=True)
>>> assert info_pos['dsize'] == (919, 1072)
>>> assert info_con['dsize'] == (1122, 1122)
>>> assert info_pos['transform'] == transform
>>> # Demo the correct and incorrect way to apply transforms
>>> poly_pos = poly.warp(transform)
>>> poly_con = poly.warp(info_con['transform'])
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> # show original
>>> kwplot.imshow(image, pnum=(1, 3, 1), title='original')
>>> poly.draw(color='green', alpha=0.5, border=True)
>>> # show positive warped
>>> kwplot.imshow(warped_pos, pnum=(1, 3, 2), title='dsize=positive')
>>> poly_pos.draw(color='purple', alpha=0.5, border=True)
>>> # show content warped
>>> ax = kwplot.imshow(warped_con, pnum=(1, 3, 3), title='dsize=content')[1]
>>> poly_con.draw(color='dodgerblue', alpha=0.5, border=True)   # correct
>>> poly_pos.draw(color='orangered', alpha=0.5, border=True)  # incorrect
>>> cc = poly_con.to_shapely().centroid
>>> cp = poly_pos.to_shapely().centroid
>>> ax.text(cc.x, cc.y + 250, 'correctly transformed', color='dodgerblue',
>>>         backgroundcolor=(0, 0, 0, 0.7), horizontalalignment='center')
>>> ax.text(cp.x, cp.y - 250, 'incorrectly transformed', color='orangered',
>>>         backgroundcolor=(0, 0, 0, 0.7), horizontalalignment='center')
>>> kwplot.show_if_requested()
```

Example

```
>>> # Demo piecewise transform
>>> from kwimage.im_cv2 import *  # NOQA
>>> import kwimage
>>> from kwimage.transform import Affine
>>> image = kwimage.grab_test_image('pm5644')
>>> transform = Affine.coerce(offset=(-100, -50), scale=2, theta=0.1)
>>> warped_piecewise, info = warp_affine(image, transform, dsize='positive', return_
↪info=True, large_warp_dim=32)
>>> warped_normal, info = warp_affine(image, transform, dsize='positive', return_
↪info=True, large_warp_dim=None)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(image, pnum=(1, 3, 1), title='original')
>>> kwplot.imshow(warped_normal, pnum=(1, 3, 2), title='normal warp')
>>> kwplot.imshow(warped_piecewise, pnum=(1, 3, 3), title='piecewise warp')
```



Example

```
>>> from kwimage.im_cv2 import *  # NOQA
>>> import kwimage
>>> # TODO: Explain why the bottom left is interpolated with 0's
>>> # And not 2s, probably has to do with interpretation of pixels
>>> # as points and not areas.
>>> image = np.full((6, 6), fill_value=3, dtype=np.uint8)
>>> transform = kwimage.Affine.eye()
>>> transform = kwimage.Affine.coerce(offset=.5) @ transform
>>> transform = kwimage.Affine.coerce(scale=2) @ transform
>>> warped = kwimage.warp_affine(image, transform, dsize=(12, 12))
```

Example

```
>>> # Demo how nans are handled
>>> from kwimage.im_cv2 import *  # NOQA
>>> import kwimage
>>> image = kwimage.grab_test_image('pm5644')
>>> image = kwimage.ensure_float01(image)
>>> image[100:300, 400:700] = np.nan
>>> transform = kwimage.Affine.coerce(scale=0.05, offset=10.5, theta=0.3, shearx=0.
```

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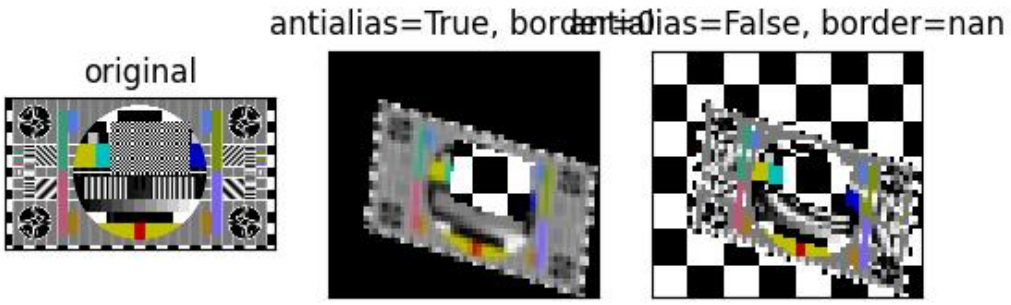
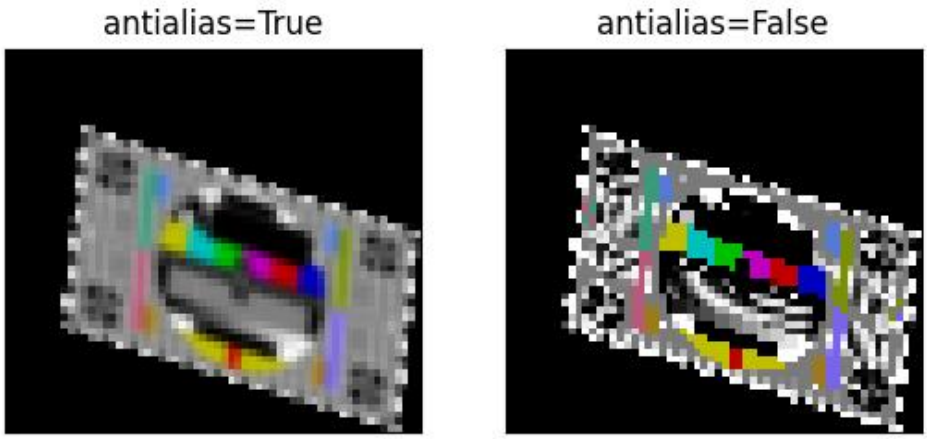
```
↪2)
>>> warped1 = warp_affine(image, transform, dsize='positive', antialias=1,␣
↪interpolation='linear', border_value=0)
>>> warped2 = warp_affine(image, transform, dsize='positive', antialias=0, border_
↪value=np.nan)
>>> assert np.isnan(warped1).any()
>>> assert np.isnan(warped2).any()
>>> assert warped1[np.isnan(warped1).any(axis=2)].all()
>>> assert warped2[np.isnan(warped2).any(axis=2)].all()
>>> print('warped1.shape = {!r}'.format(warped1.shape))
>>> print('warped2.shape = {!r}'.format(warped2.shape))
>>> assert warped2.shape == warped1.shape
>>> warped2[np.isnan(warped2).any(axis=2)]
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> pnum_ = kwplot.PlotNums(nRows=1, nCols=3)
>>> image_canvas = kwimage.fill_nans_with_checkers(image)
>>> warped1_canvas = kwimage.fill_nans_with_checkers(warped1)
>>> warped2_canvas = kwimage.fill_nans_with_checkers(warped2)
>>> kwplot.imshow(image_canvas, pnum=pnum_(), title='original')
>>> kwplot.imshow(warped1_canvas, pnum=pnum_(), title='antialias=True, border=0')
>>> kwplot.imshow(warped2_canvas, pnum=pnum_(), title='antialias=False, border=nan')
>>> kwplot.show_if_requested()
```



Example

```
>>> # Demo how of how we also handle masked arrays
>>> from kwimage.im_cv2 import *  # NOQA
>>> import kwimage
>>> _image = kwimage.grab_test_image('pm5644')
>>> _image = kwimage.ensure_float01(_image)
>>> _image[100:200, 400:700] = np.nan
>>> mask = np.isnan(_image)
>>> data = np.nan_to_num(_image)
>>> image = np.ma.MaskedArray(data=data, mask=mask)
>>> transform = kwimage.Affine.coerce(scale=0.05, offset=10.5, theta=0.3, shearx=0.
↪2)
>>> warped1 = warp_affine(image, transform, dsize='positive', antialias=1,␣
↪interpolation='linear')
>>> assert isinstance(warped1, np.ma.MaskedArray)
>>> warped2 = warp_affine(image, transform, dsize='positive', antialias=0)
>>> print('warped1.shape = {!r}'.format(warped1.shape))
>>> print('warped2.shape = {!r}'.format(warped2.shape))
>>> assert warped2.shape == warped1.shape
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> pnum_ = kwplot.PlotNums(nRows=1, nCols=2)
>>> kwplot.imshow(warped1, pnum=pnum_(), title='antialias=True')
>>> kwplot.imshow(warped2, pnum=pnum_(), title='antialias=False')
>>> kwplot.show_if_requested()
```



kwimage.im_cv2.**morphology**(*data*, *mode*, *kernel=5*, *element='rect'*, *iterations=1*, *border_mode='constant'*, *border_value=0*)

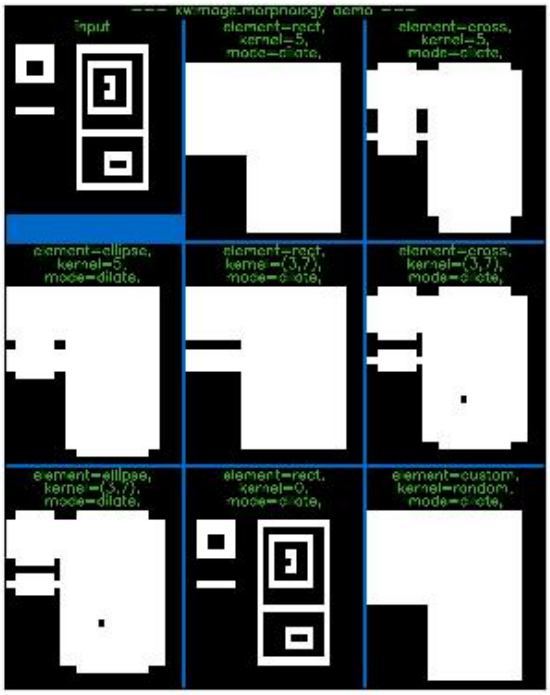
Executes a morphological operation.

Parameters

- **input** (*ndarray[dtype=uint8 | float64]*) – data (note if mode is hitmiss data must be uint8)
- **mode** (*str*) – morphology mode, can be one of: 'erode', 'dilate', 'open', 'close', 'gradient', 'tophat', 'blackhat', or 'hitmiss'.
- **kernel** (*ndarray | int | Tuple[int, int]*) – size of the morphology kernel (w, h) to be constructed according to "element". If the kernel size is 0, this function returns a copy of the data. Can also be a 2D array which is a custom structuring element. In this case "element" is ignored.
- **element** (*str*) – structural element, can be 'rect', 'cross', or 'ellipse'.
- **iterations** (*int*) – numer of times to repeat the operation
- **border_mode** (*str | int*) – Border code or cv2 integer. Border codes are constant (default) replicate, reflect, wrap, reflect101, and transparent.
- **border_value** (*int | float | Iterable[int | float]*) – Used as the fill value if border_mode is constant. Otherwise this is ignored.

Example

```
>>> from kwimage.im_cv2 import *  # NOQA
>>> import kwimage
>>> #image = kwimage.grab_test_image(dsize=(380, 380))
>>> image = kwimage.Mask.demo().data * 255
>>> basis = {
>>>     'mode': ['dilate'],
>>>     'kernel': [5, (3, 7)],
>>>     'element': ['rect', 'cross', 'ellipse'],
>>>     #'mode': ['dilate', 'erode'],
>>> }
>>> grid = list(ub.named_product(basis))
>>> grid += [{'mode': 'dilate', 'kernel': 0, 'element': 'rect', }]
>>> grid += [{'mode': 'dilate', 'kernel': 'random', 'element': 'custom'}]
>>> results = {}
>>> for params in grid:
...     key = ub.repr2(params, compact=1, si=0, nl=1)
...     if params['kernel'] == 'random':
...         params['kernel'] = np.random.rand(5, 5)
...     results[key] = morphology(image, **params)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> to_stack = []
>>> canvas = image
>>> canvas = kwimage.imresize(canvas, dsize=(380, 380), interpolation='nearest')
>>> canvas = kwimage.draw_header_text(canvas, 'input', color='kitware_green')
>>> to_stack.append(canvas)
>>> for key, result in results.items():
>>>     canvas = result
>>>     canvas = kwimage.imresize(canvas, dsize=(380, 380), interpolation='nearest')
>>>     canvas = kwimage.draw_header_text(canvas, key, color='kitware_green')
>>>     to_stack.append(canvas)
>>> canvas = kwimage.stack_images_grid(to_stack, pad=10, bg_value='kitware_blue')
>>> canvas = kwimage.draw_header_text(canvas, '--- kwimage.morphology demo ---',␣
↪color='kitware_green')
>>> kwplot.imshow(canvas)
>>> kwplot.show_if_requested()
```



Example

```
>>> from kwimage.im_cv2 import *  # NOQA
>>> from kwimage.im_cv2 import _CV2_MORPH_MODES  # NOQA
>>> from kwimage.im_cv2 import _CV2_STRUCT_ELEMENTS  # NOQA
>>> #shape = (32, 32)
>>> shape = (64, 64)
>>> data = (np.random.rand(*shape) > 0.5).astype(np.uint8)
>>> import kwimage
>>> data = kwimage.gaussian_patch(shape)
>>> data = data / data.max()
>>> data = kwimage.ensure_uint255(data)
>>> results = {}
>>> kernel = 5
>>> for mode in _CV2_MORPH_MODES.keys():
...     for element in _CV2_STRUCT_ELEMENTS.keys():
...         results[f'{mode}+{element}'] = morphology(data, mode, kernel=kernel,␣
↪element=element, iterations=2)
>>> results['raw'] = data
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> pnum_ = kwplot.PlotNums(nCols=3, nSubplots=len(results))
```

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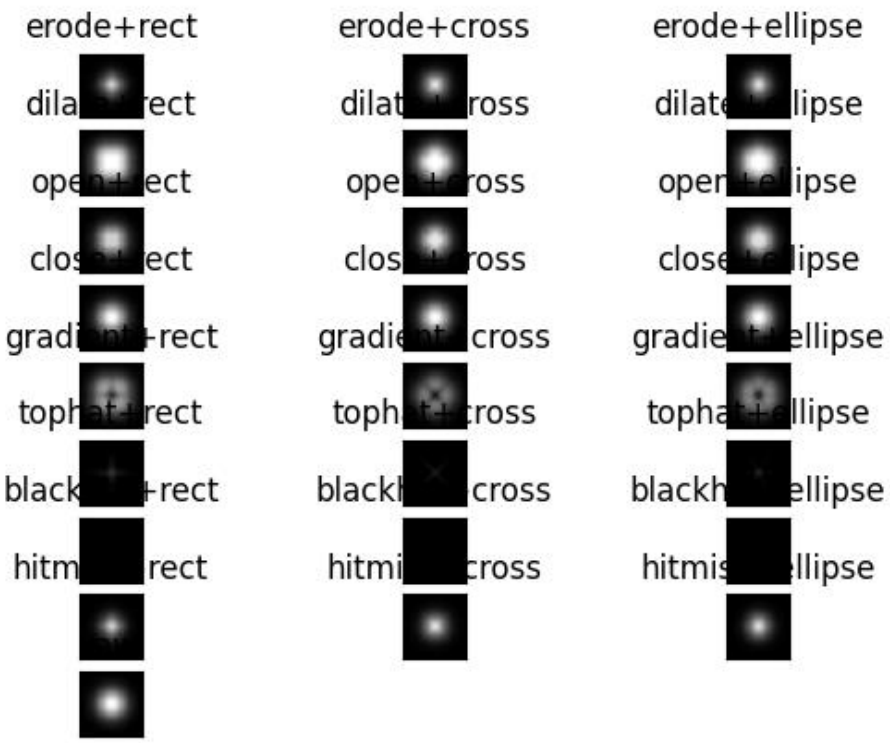
```
>>> for k, result in results.items():
>>>     kwplot.imshow(result, pnum=pnum_(), title=k)
>>> kwplot.show_if_requested()
```



References

https://opencv24-python-tutorials.readthedocs.io/en/latest/py_tutorials/py_imgproc/py_morphological_ops/py_morphological_ops.html

kwimage.im_cv2.**connected_components**(*image*, *connectivity=8*, *ltype=<class 'numpy.int32'>*, *with_stats=True*, *algo='default'*)

Find connected components in a binary image.

Wrapper around `cv2.connectedComponentsWithStats()`.

Parameters

- **image** (*ndarray*) – a binary uint8 image. Zeros denote the background, and non-zeros numbers are foreground regions that will be partitioned into connected components.
- **connectivity** (*int*) – either 4 or 8
- **ltype** (*dtype | str | int*) – The dtype for the output label array. Can be either 'int32' or 'uint16', and this can be specified as a cv2 code or a numpy dtype.

- **algo** (*str*) – The underlying algorithm to use. See [Cv2CCAlgos] for details. Options are spaghetti, sauf, bbdt. (default is spaghetti)

Returns
The label array and an information dictionary

Return type
Tuple[ndarray, dict]

Todo: Document the details of which type of coordinates we are using. I.e. are pixels points or areas? (I think this uses the points convention?)

Note: opencv 4.5.5 will segfault if connectivity=4 See: [CvIssue21366].

Note: Based on information in [SO35854197].

References

CommandLine

```
xdoctest -m kwimage.im_cv2 connected_components:0 --show
```

Example

```
>>> import kwimage
>>> from kwimage.im_cv2 import *  # NOQA
>>> mask = kwimage.Mask.demo()
>>> image = mask.data
>>> labels, info = connected_components(image)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> canvas0 = kwimage.atleast_3channels(mask.data * 255)
>>> canvas2 = canvas0.copy()
>>> canvas3 = canvas0.copy()
>>> boxes = info['label_boxes']
>>> centroids = info['label_centroids']
>>> label_colors = kwimage.Color.distinct(info['num_labels'])
>>> index_to_color = np.array([kwimage.Color('black').as01()] + label_colors)
>>> canvas2 = centroids.draw_on(canvas2, color=label_colors, radius=None)
>>> boxes.draw_on(canvas3, color=label_colors, thickness=1)
>>> legend = kwplot.make_legend_img(ub.dzip(range(len(index_to_color)), index_to_
↪color))
>>> colored_label_img = index_to_color[labels]
>>> canvas1 = kwimage.stack_images([colored_label_img, legend], axis=1, resize=
↪'smaller')
>>> kwplot.imshow(canvas0, pnum=(1, 4, 1), title='input image')
```

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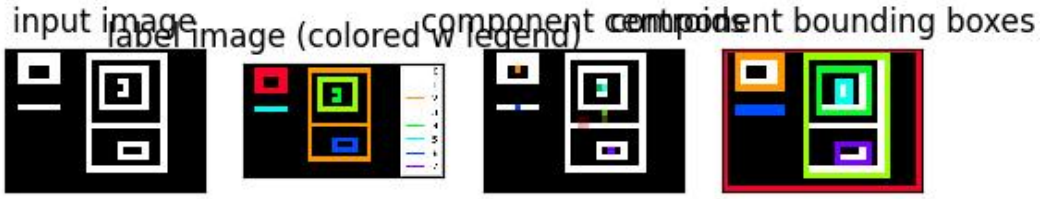
```
>>> kwplot.imshow(canvas1, pnum=(1, 4, 2), title='label image (colored w legend)')
>>> kwplot.imshow(canvas2, pnum=(1, 4, 3), title='component centroids')
>>> kwplot.imshow(canvas3, pnum=(1, 4, 4), title='component bounding boxes')
```



kwimage.im_cv2.**warp_projective**(*image*, *transform*, *dsize=None*, *antialias=False*, *interpolation='linear'*, *border_mode=None*, *border_value=0*, *large_warp_dim=None*, *return_info=False*)

Applies an projective transformation to an image with optional antialiasing.

Parameters

- **image** (*ndarray*) – the input image as a numpy array. Note: this is passed directly to cv2, so it is best to ensure that it is contiguous and using a dtype that cv2 can handle.
- **transform** (*ndarray | dict | kwimage.Projective*) – a coercable projective matrix. See `kwimage.Projective` for details on what can be coerced.
- **dsize** (*Tuple[int, int] | None | str*) – A integer width and height tuple of the resulting "canvas" image. If None, then the input image size is used.

  If specified as a string, dsize is computed based on the given heuristic.

  If 'positive' (or 'auto'), dsize is computed such that the positive coordinates of the warped image will fit in the new canvas. In this case, any pixel that maps to a negative coordinate will be clipped. This has the property that the input transformation is not modified.

  If 'content' (or 'max'), the transform is modified with an extra translation such that both

the positive and negative coordinates of the warped image will fit in the new canvas.

- **antialias** (*bool*) – if True determines if the transform is downsampling and applies antialiasing via gaussian a blur. Defaults to False
- **interpolation** (*str | int*) – interpolation code or cv2 integer. Interpolation codes are linear, nearest, cubic, lancsoz, and area. Defaults to "linear".
- **border_mode** (*str | int*) – Border code or cv2 integer. Border codes are constant (default) replicate, reflect, wrap, reflect101, and transparent.
- **border_value** (*int | float | Iterable[int | float]*) – Used as the fill value if border_mode is constant. Otherwise this is ignored. Defaults to 0, but can also be defaulted to nan. if border_value is a scalar and there are multiple channels, the value is applied to all channels. More than 4 unique border values for individual channels will cause an error. See OpenCV #22283 for details. In the future we may accept np.ma and return a masked array, but for now that is not implemented.
- **large_warp_dim** (*int | None | str*) – If specified, perform the warp piecewise in chunks of the specified size. If "auto", it is set to the maximum "short" value in numpy. This works around a limitation of cv2.warpAffine, which must have image dimensions < SHRT_MAX (=32767 in version 4.5.3)
- **return_info** (*bool*) – if True, returns information about the operation. In the case where dsize="content", this includes the modified transformation.

Returns

the warped image, or if return info is True, the warped image and the info dictionary.

Return type

ndarray | Tuple[ndarray, Dict]

kwimage.im_cv2.**warp_image**(*image*, *transform*, *dsize=None*, *antialias=False*, *interpolation='linear'*, *border_mode=None*, *border_value=0*, *large_warp_dim=None*, *return_info=False*)

Applies an transformation to an image with optional antialiasing.

Parameters

- **image** (*ndarray*) – the input image as a numpy array. Note: this is passed directly to cv2, so it is best to ensure that it is contiguous and using a dtype that cv2 can handle.
- **transform** (*ndarray | dict | kwimage.Matrix*) – a coercable affine or projective matrix. See `kwimage.Affine` and `kwimage.Projective` for details on what can be coerced.
- **dsize** (*Tuple[int, int] | None | str*) – A integer width and height tuple of the resulting "canvas" image. If None, then the input image size is used.

  If specified as a string, dsize is computed based on the given heuristic.

  If 'positive' (or 'auto'), dsize is computed such that the positive coordinates of the warped image will fit in the new canvas. In this case, any pixel that maps to a negative coordinate will be clipped. This has the property that the input transformation is not modified.

  If 'content' (or 'max'), the transform is modified with an extra translation such that both the positive and negative coordinates of the warped image will fit in the new canvas.
- **antialias** (*bool*) – if True determines if the transform is downsampling and applies antialiasing via gaussian a blur. Defaults to False
- **interpolation** (*str | int*) – interpolation code or cv2 integer. Interpolation codes are linear, nearest, cubic, lancsoz, and area. Defaults to "linear".

- **border_mode** (*str | int*) – Border code or cv2 integer. Border codes are constant (default) replicate, reflect, wrap, reflect101, and transparent.
- **border_value** (*int | float | Iterable[int | float]*) – Used as the fill value if border_mode is constant. Otherwise this is ignored. Defaults to 0, but can also be defaulted to nan. if border_value is a scalar and there are multiple channels, the value is applied to all channels. More than 4 unique border values for individual channels will cause an error. See OpenCV #22283 for details. In the future we may accept np.ma and return a masked array, but for now that is not implemented.
- **large_warp_dim** (*int | None | str*) – If specified, perform the warp piecewise in chunks of the specified size. If "auto", it is set to the maximum "short" value in numpy. This works around a limitation of cv2.warpAffine, which must have image dimensions < SHRT_MAX (=32767 in version 4.5.3)
- **return_info** (*bool*) – if True, returns information about the operation. In the case where dsize="content", this includes the modified transformation.

Returns

the warped image, or if return info is True, the warped image and the info dictionary.

Return type

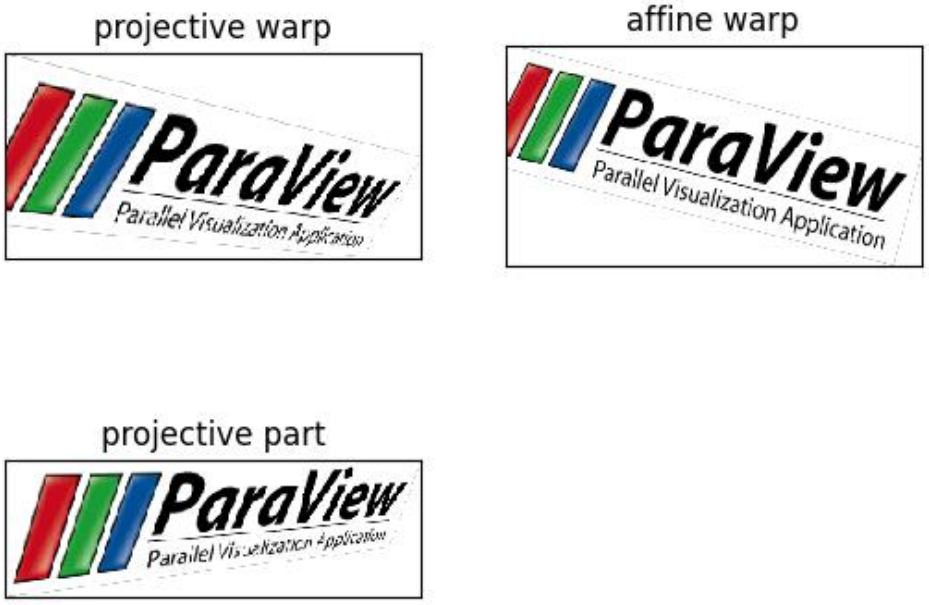
ndarray | Tuple[ndarray, Dict]

SeeAlso:

kwimage.warp_tensor() kwimage.warp_affine() kwimage.warp_projective()

Example

```
>>> from kwimage.im_cv2 import *  # NOQA
>>> import kwimage
>>> image = kwimage.grab_test_image('paraview')
>>> tf_homog = kwimage.Projective.random(rng=30342110) @ kwimage.Projective.
↪coerce(uv=[0.001, 0.001])
>>> tf_aff = kwimage.Affine.coerce(ub.udict(tf_homog.decompose()) - {'uv'})
>>> tf_uv = kwimage.Projective.coerce(ub.udict(tf_homog.decompose()) & {'uv'})
>>> warped1 = kwimage.warp_image(image, tf_homog, dsize='positive')
>>> warped2 = kwimage.warp_image(image, tf_aff, dsize='positive')
>>> warped3 = kwimage.warp_image(image, tf_uv, dsize='positive')
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> pnum_ = kwplot.PlotNums(nRows=2, nCols=2)
>>> kwplot.imshow(warped1, pnum=pnum_(), title='projective warp')
>>> kwplot.imshow(warped2, pnum=pnum_(), title='affine warp')
>>> kwplot.imshow(warped3, pnum=pnum_(), title='projective part')
>>> kwplot.show_if_requested()
```



kwimage.im_demodata module

Keep a manifest of demo images used for testing

kwimage.im_demodata.**grab_test_image**(*key='astro'*, *space='rgb'*, *dsize=None*, *interpolation='lanczos'*)

Ensures that the test image exists (this might use the network), reads it and returns the the image pixels.

Parameters

- **key** (*str*) – which test image to grab. Valid choices are: astro - an astronaught carl - Carl Sagan paraview - ParaView logo stars - picture of stars in the sky airport - SkySat image of Beijing Capital International Airport on 18 February 2018 See `kwimage.grab_test_image.keys` for a full list.
- **space** (*str*) – which colorspace to return in. Defaults to 'rgb'
- **dsize** (*Tuple[int, int]*) – if specified resizes image to this size

Returns
the requested image

Return type
ndarray

CommandLine

```
xdoctest -m kwimage.im_demodata grab_test_image
```

Example

```
>>> # xdoctest: +REQUIRES(--network)
>>> import kwimage
>>> for key in kwimage.grab_test_image.keys():
>>>     print('attempt to grab key = {!r}'.format(key))
>>>     kwimage.grab_test_image(key)
>>>     print('grabbed key = {!r}'.format(key))
>>> kwimage.grab_test_image('astro', dsize=(255, 255)).shape
(255, 255, 3)
```

kwimage.im_demodata.**grab_test_image_fpath**(*key='astro'*, *dsize=None*, *overviews=None*)

Ensures that the test image exists (this might use the network) and returns the cached filepath to the requested image.

Parameters

- **key** (*str*) – which test image to grab. Valid choices are: astro - an astronaught carl - Carl Sagan paraview - ParaView logo stars - picture of stars in the sky
- **dsize** (*None | Tuple[int, int]*) – if specified, we will return a variant of the data with the specific dsize
- **overviews** (*None | int*) – if specified, will return a variant of the data with overviews

Returns

path to the requested image

Return type

str

CommandLine

```
python -c "import kwimage; print(kwimage.grab_test_image_fpath('airport'))"
```

Example

```
>>> # xdoctest: +REQUIRES(--network)
>>> import kwimage
>>> for key in kwimage.grab_test_image.keys():
...     print('attempt to grab key = {!r}'.format(key))
...     kwimage.grab_test_image_fpath(key)
...     print('grabbed grab key = {!r}'.format(key))
```

Example

```
>>> # xdoctest: +REQUIRES(--network)
>>> import kwimage
>>> key = ub.peek(kwimage.grab_test_image.keys())
>>> # specifying a dsize will construct a new image
>>> fpath1 = kwimage.grab_test_image_fpath(key)
>>> fpath2 = kwimage.grab_test_image_fpath(key, dsize=(32, 16))
>>> print('fpath1 = {}'.format(ub.repr2(fpath1, nl=1)))
>>> print('fpath2 = {}'.format(ub.repr2(fpath2, nl=1)))
>>> assert fpath1 != fpath2
>>> imdata2 = kwimage.imread(fpath2)
>>> assert imdata2.shape[0:2] == (16, 32)
```

kwimage.im_demodata.**checkerboard**(*num_squares='auto'*, *square_shape='auto'*, *dsize=(512, 512)*, *dtype=<class 'float'>*, *on_value=1*, *off_value=0*)

Creates a checkerboard image

Parameters

- **num_squares** (*int | str*) – Number of squares in a row. If 'auto' defaults to 8
- **square_shape** (*int | Tuple[int, int] | str*) – If 'auto', chosen based on *num_squares*. Otherwise this is the height, width of each square in pixels.
- **dsize** (*Tuple[int, int]*) – width and height
- **dtype** (*type*) – return data type
- **on_value** (*Number*) – The value of one checker. Defaults to 1.
- **off_value** (*Number*) – The value off the other checker. Defaults to 0.

References

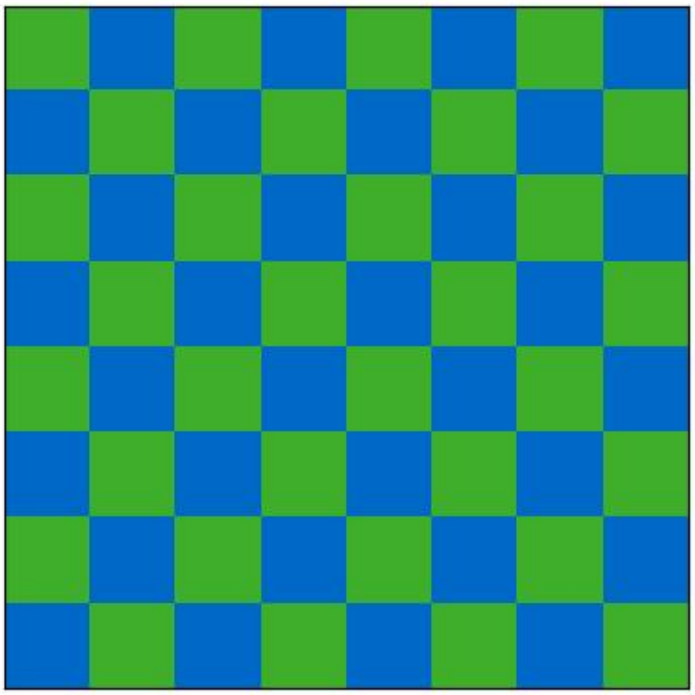
https://stackoverflow.com/questions/2169478/how-to-make-a-checkerboard-in-numpy

Example

```
>>> import kwimage
>>> import numpy as np
>>> img = kwimage.checkerboard()
>>> print(kwimage.checkerboard(dsize=(16, 16)).shape)
>>> print(kwimage.checkerboard(num_squares=4, dsize=(16, 16)).shape)
>>> print(kwimage.checkerboard(square_shape=3, dsize=(23, 17)).shape)
>>> print(kwimage.checkerboard(square_shape=3, dsize=(1451, 1163)).shape)
>>> print(kwimage.checkerboard(square_shape=3, dsize=(1202, 956)).shape)
>>> print(kwimage.checkerboard(dsize=(4, 4), on_value=(255, 0, 0), off_value=(0, 0,␣
↪1), dtype=np.uint8))
```

Example

```
>>> import kwimage
>>> img = kwimage.checkerboard(
>>>     dsize=(64, 64), on_value='kw_green', off_value='kw_blue')
>>> # xdoc: +REQUIRES(--show)
>>> # xdoc: +REQUIRES(module:kwplot)
>>> import kwplot
>>> kwplot.autoplt()
>>> kwplot.imshow(img)
>>> kwplot.show_if_requested()
```



kwimage.im_draw module

kwimage.im_draw.**draw_text_on_image**(*img*, *text*, *org=None*, *return_info=False*, ***kwargs*)

Draws multiline text on an image using opencv

Parameters

- **img** (*ndarray | None | dict*) – Generally a numpy image to draw on (inplace). Otherwise a canvas will be constructed such that the text will fit. The user may specify a dictionary with keys width and height to have more control over the constructed canvas.
- **text** (*str*) – text to draw

- **org** (*Tuple[int, int]*) – The x, y location of the text string "anchor" in the image as specified by halign and valign. For instance, If valign='bottom', halign='left', this where the bottom left corner of the text will be placed.
- **return_info** (*bool*) – if True, also returns information about the positions the text was drawn on.
- ****kwargs** – color (tuple): default blue

  thickness (int): defaults to 2

  fontFace (int): defaults to cv2.FONT_HERSHEY_SIMPLEX

  fontScale (float): defaults to 1.0

  valign (str): either top, center, or bottom. Defaults to "bottom" NOTE: this default may change to "top" in the future.

  halign (str): either left, center, or right. Defaults to "left".

  border (dict | int): If specified as an integer, draws a black border with that given thickness. If specified as a dictionary, draws a border with color specified parameters. "color": border color, defaults to "black". "thickness": border thickness, defaults to 1.

Returns
the image that was drawn on

Return type
ndarray

Note: The image is modified inplace. If the image is non-contiguous then this returns a UMat instead of a ndarray, so be carefull with that.

Related:
The logic in this function is related to the following stack overflow posts [SO27647424] [SO51285616]

References

Example

```
>>> import kwimage
>>> img = kwimage.grab_test_image(space='rgb')
>>> img2 = kwimage.draw_text_on_image(img.copy(), 'FOOBAR', org=(0, 0), valign='top
↪')
>>> assert img2.shape == img.shape
>>> assert np.any(img2 != img)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(img2)
>>> kwplot.show_if_requested()
```

Example

```
>>> import kwimage
>>> # Test valign
>>> img = kwimage.grab_test_image(space='rgb', dsize=(500, 500))
>>> img2 = kwimage.draw_text_on_image(img, 'FOOBAR\nbazbiz\nspam', org=(0, 0),␣
↪valign='top', border=2)
>>> img2 = kwimage.draw_text_on_image(img, 'FOOBAR\nbazbiz\nspam', org=(150, 0),␣
↪valign='center', border=2)
>>> img2 = kwimage.draw_text_on_image(img, 'FOOBAR\nbazbiz\nspam', org=(300, 0),␣
↪valign='bottom', border=2)
>>> # Test halign
>>> img2 = kwimage.draw_text_on_image(img, 'FOOBAR\nbazbiz\nspam', org=(250, 100),␣
↪halign='right', border=2)
>>> img2 = kwimage.draw_text_on_image(img, 'FOOBAR\nbazbiz\nspam', org=(250, 250),␣
↪halign='center', border=2)
>>> img2 = kwimage.draw_text_on_image(img, 'FOOBAR\nbazbiz\nspam', org=(250, 400),␣
↪halign='left', border=2)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(img2)
>>> kwplot.show_if_requested()
```

Example

```
>>> # Ensure the function works with float01 or uint255 images
>>> import kwimage
>>> img = kwimage.grab_test_image(space='rgb')
>>> img = kwimage.ensure_float01(img)
>>> img2 = kwimage.draw_text_on_image(img, 'FOOBAR\nbazbiz\nspam', org=(0, 0),␣
↪valign='top', border=2)
```

Example

```
>>> # Test dictionary border
>>> import kwimage
>>> img = kwimage.draw_text_on_image(None, 'Battery\nFraction', org=(100, 100),␣
↪valign='top', halign='center', border={'color': 'green', 'thickness': 9})
>>> #img = kwimage.draw_text_on_image(None, 'hello\neveryone', org=(0, 0), valign='top
↪')
>>> #img = kwimage.draw_text_on_image(None, 'hello', org=(0, 60), valign='top', halign=
↪'center', border=0)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
```

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```
>>> kwplot.imshow(img)
>>> kwplot.show_if_requested()
```

Example

```
>>> # Test dictionary image
>>> import kwimage
>>> img = kwimage.draw_text_on_image({'width': 300}, 'Unscrew\nGetting', org=(150,␣
↪0), valign='top', halign='center', border={'color': 'green', 'thickness': 0})
>>> print('img.shape = {!r}'.format(img.shape))
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(img)
>>> kwplot.show_if_requested()
```

Example

```
>>> import ubelt as ub
>>> import kwimage
>>> grid = list(ub.named_product({
>>>     'halign': ['left', 'center', 'right', None],
>>>     'valign': ['top', 'center', 'bottom', None],
>>>     'border': [0, 3]
>>> }))
>>> canvases = []
>>> text = 'small-line\na-much-much-much-bigger-line\nanother-small\n.'
>>> for kw in grid:
>>>     header = kwimage.draw_text_on_image({}, ub.repr2(kw, compact=1), color='blue
↪')
>>>     canvas = kwimage.draw_text_on_image({'color': 'white'}, text, org=None,␣
↪**kw)
>>>     canvases.append(kwimage.stack_images([header, canvas], axis=0, bg_
↪value=(255, 255, 255), pad=5))
>>> # xdoc: +REQUIRES(--show)
>>> canvas = kwimage.stack_images_grid(canvases, pad=10, bg_value=(255, 255, 255))
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(canvas)
>>> kwplot.show_if_requested()
```

kwimage.im_draw.**draw_clf_on_image**(*im*, *classes*, *tcx=None*, *probs=None*, *pcx=None*, *border=1*)

Draws classification label on an image.

Works best with image chips sized between 200x200 and 500x500

Parameters

- **im** (*ndarray*) – the image
- **classes** (*Sequence[str] | kwcoco.CategoryTree*) – list of class names
- **tcx** (*int*) – true class index if known
- **probs** (*ndarray*) – predicted class probs for each class
- **pcx** (*int*) – predicted class index. (if None but probs is specified uses argmax of probs)

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> import torch
>>> import kwarray
>>> import kwimage
>>> rng = kwarray.ensure_rng(0)
>>> im = (rng.rand(300, 300) * 255).astype(np.uint8)
>>> classes = ['cls_a', 'cls_b', 'cls_c']
>>> tcx = 1
```

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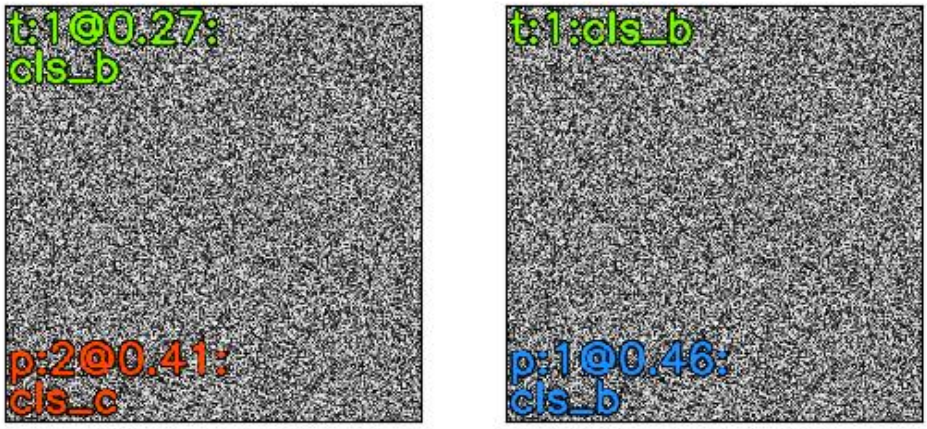
```
>>> probs = rng.rand(len(classes))
>>> probs[tcx] = 0
>>> probs = torch.FloatTensor(probs).softmax(dim=0).numpy()
>>> im1_ = kwimage.draw_clf_on_image(im, classes, tcx, probs)
>>> probs[tcx] = .9
>>> probs = torch.FloatTensor(probs).softmax(dim=0).numpy()
>>> im2_ = kwimage.draw_clf_on_image(im, classes, tcx, probs)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(im1_, colorspace='rgb', pnum=(1, 2, 1), fnum=1, doclf=True)
>>> kwplot.imshow(im2_, colorspace='rgb', pnum=(1, 2, 2), fnum=1)
>>> kwplot.show_if_requested()
```



kwimage.im_draw.**draw_boxes_on_image**(*img*, *boxes*, *color='blue'*, *thickness=1*, *box_format=None*, *colorspace='rgb'*)

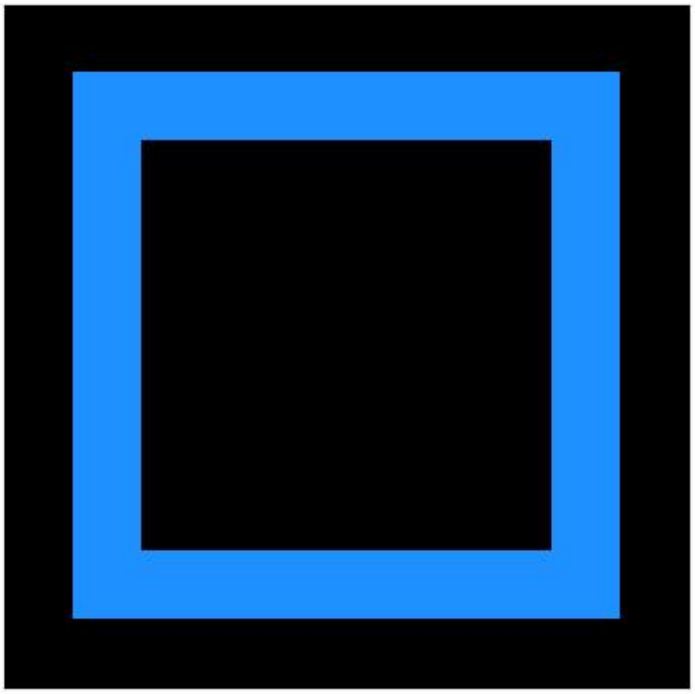
Draws boxes on an image.

Parameters

- **img** (*ndarray*) – image to copy and draw on
- **boxes** (*kwimage.Boxes | ndarray*) – boxes to draw
- **colorspace** (*str*) – string code of the input image colorspace

Example

```
>>> import kwimage
>>> import numpy as np
>>> img = np.zeros((10, 10, 3), dtype=np.uint8)
>>> color = 'dodgerblue'
>>> thickness = 1
>>> boxes = kwimage.Boxes([[1, 1, 8, 8]], 'ltrb')
>>> img2 = draw_boxes_on_image(img, boxes, color, thickness)
>>> assert tuple(img2[1, 1]) == (30, 144, 255)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()  # xdoc: +SKIP
>>> kwplot.figure(doclf=True, fnum=1)
>>> kwplot.imshow(img2)
```



kwimage.im_draw.**draw_line_segments_on_image**(*img*, *pts1*, *pts2*, *color='blue'*, *colorspace='rgb'*, *thickness=1*, ***kwargs*)

Draw line segments between pts1 and pts2 on an image.

Parameters

- **pts1** (*ndarray*) – xy coordinates of starting points
- **pts2** (*ndarray*) – corresponding xy coordinates of ending points
- **color** (*str | List*) – color code or a list of colors for each line segment

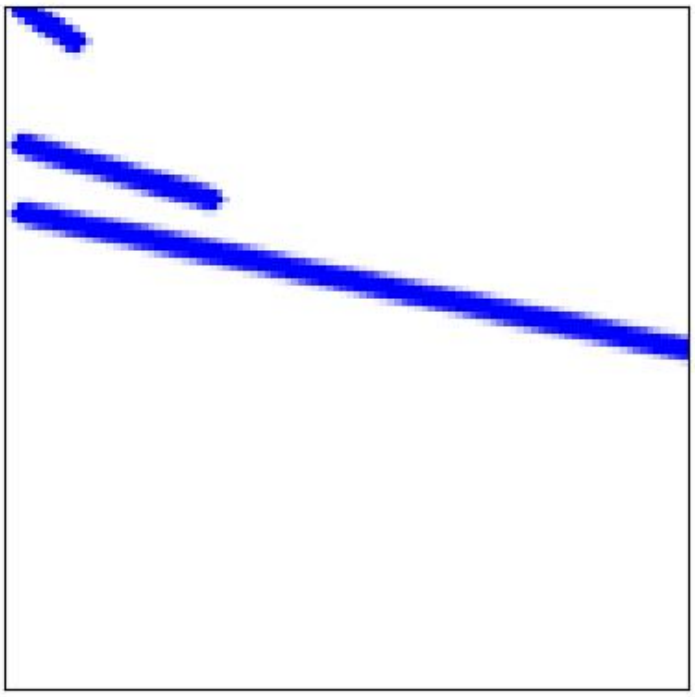
- **colorspace** (*str*) – colorspace of image. Defaults to 'rgb'
- **thickness** (*int*) – Defaults to 1
- **lineType** (*int*) – option for cv2.line

Returns
the modified image (inplace if possible)

Return type
ndarray

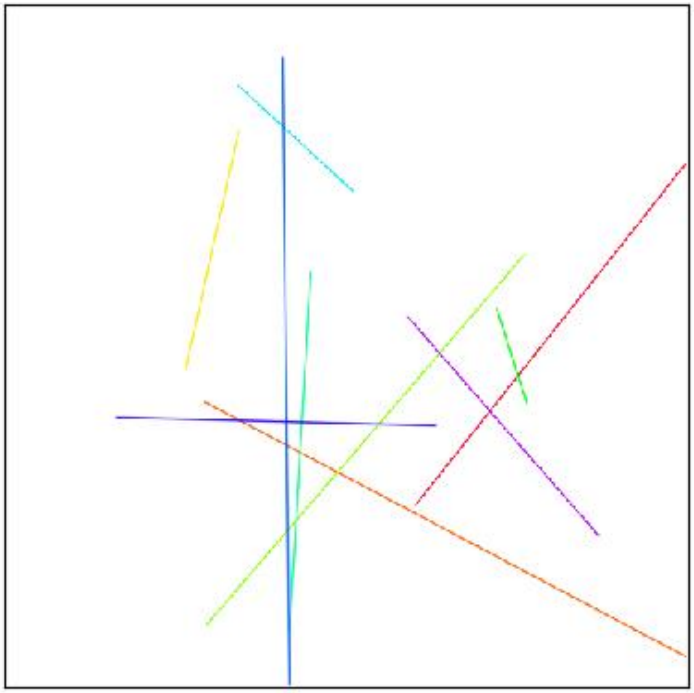
Example

```
>>> from kwimage.im_draw import *  # NOQA
>>> pts1 = np.array([[2, 0], [2, 20], [2.5, 30]])
>>> pts2 = np.array([[10, 5], [30, 28], [100, 50]])
>>> img = np.ones((100, 100, 3), dtype=np.uint8) * 255
>>> color = 'blue'
>>> colorspace = 'rgb'
>>> img2 = draw_line_segments_on_image(img, pts1, pts2, thickness=2)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()  # xdoc: +SKIP
>>> kwplot.figure(doclf=True, fnum=1)
>>> kwplot.imshow(img2)
```



Example

```
>>> import kwimage
>>> # xdoc: +REQUIRES(module:matplotlib)
>>> pts1 = kwimage.Points.random(10).scale(512).xy
>>> pts2 = kwimage.Points.random(10).scale(512).xy
>>> img = np.ones((512, 512, 3), dtype=np.uint8) * 255
>>> color = kwimage.Color.distinct(10)
>>> img2 = kwimage.draw_line_segments_on_image(img, pts1, pts2, color=color)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()  # xdoc: +SKIP
>>> kwplot.figure(doclf=True, fnum=1)
>>> kwplot.imshow(img2)
```



kwimage.im_draw.**make_heatmask**(*probs*, *cmap='plasma'*, *with_alpha=1.0*, *space='rgb'*, *dsize=None*)

Colorizes a single-channel intensity mask (with an alpha channel)

Parameters

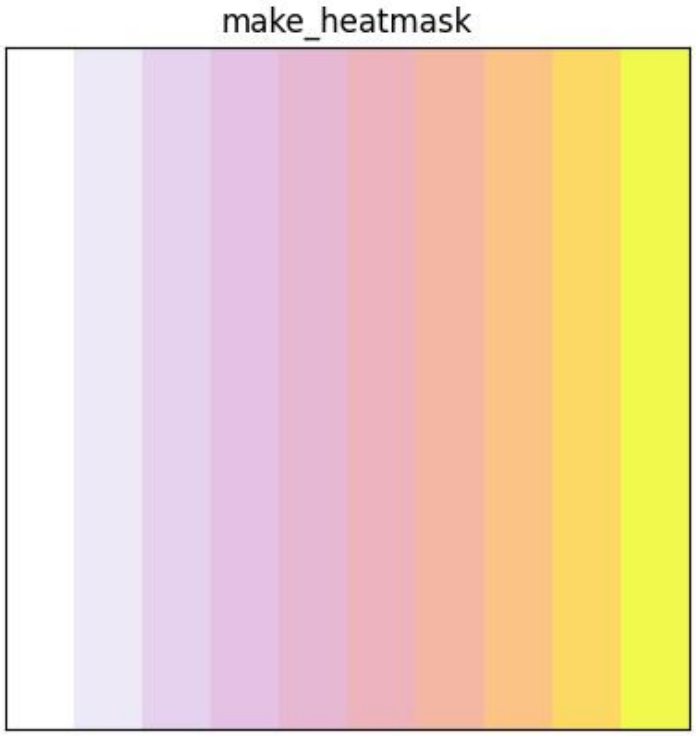
- **probs** (*ndarray*) – 2D probability map with values between 0 and 1
- **cmap** (*str*) – mpl colormap
- **with_alpha** (*float*) – between 0 and 1, uses probs as the alpha multipled by this number.
- **space** (*str*) – output colorspace

- **dsize** (*tuple*) – if not None, then output is resized to W,H=dsize

SeeAlso:
kwimage.overlay_alpha_images

Example

```
>>> # xdoc: +REQUIRES(module:matplotlib)
>>> from kwimage.im_draw import *  # NOQA
>>> probs = np.tile(np.linspace(0, 1, 10), (10, 1))
>>> heatmask = make_heatmask(probs, with_alpha=0.8, dsize=(100, 100))
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(heatmask, fnum=1, doclf=True, colorspace='rgb',
>>>               title='make_heatmask')
>>> kwplot.show_if_requested()
```



kwimage.im_draw.**make_orimask**(*radians*, *mag=None*, *alpha=1.0*)

Makes a colormap in HSV space where the orientation changes color and mag changes the saturation/value.

Parameters

- **radians** (*ndarray*) – orientation in radians
- **mag** (*ndarray*) – magnitude (must be normalized between 0 and 1)

- **alpha** (*float | ndarray*) – if False or None, then the image is returned without alpha if a float, then mag is scaled by this and used as the alpha channel if an ndarray, then this is explicilty set as the alpha channel

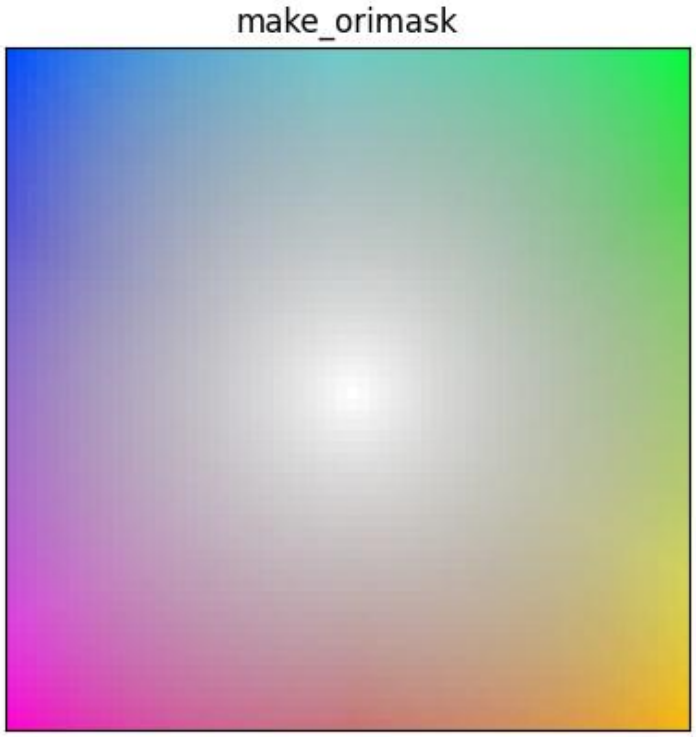
Returns
an rgb / rgba image in 01 space

Return type
ndarray[Any, Float32]

SeeAlso:
kwimage.overlay_alpha_images

Example

```
>>> # xdoc: +REQUIRES(module:matplotlib)
>>> from kwimage.im_draw import *  # NOQA
>>> x, y = np.meshgrid(np.arange(64), np.arange(64))
>>> dx, dy = x - 32, y - 32
>>> radians = np.arctan2(dx, dy)
>>> mag = np.sqrt(dx ** 2 + dy ** 2)
>>> orimask = make_orimask(radians, mag)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(orimask, fnum=1, doclf=True,
>>>               colorspace='rgb', title='make_orimask')
>>> kwplot.show_if_requested()
```



kwimage.im_draw.**make_vector_field**(*dx*, *dy*, *stride=0.02*, *thresh=0.0*, *scale=1.0*, *alpha=1.0*, *color='strawberry'*, *thickness=1*, *tipLength=0.1*, *line_type='aa'*)

Create an image representing a 2D vector field.

Parameters

- **dx** (*ndarray*) – grid of vector x components
- **dy** (*ndarray*) – grid of vector y components
- **stride** (*int | float*) – sparsity of vectors, int specifies stride step in pixels, a float specifies it as a percentage.
- **thresh** (*float*) – only plot vectors with magnitude greater than thres
- **scale** (*float*) – multiply magnitude for easier visualization
- **alpha** (*float*) – alpha value for vectors. Non-vector regions receive 0 alpha (if False, no alpha channel is used)
- **color** (*str | tuple | kwimage.Color*) – RGB color of the vectors
- **thickness** (*int*) – thickness of arrows
- **tipLength** (*float*) – fraction of line length
- **line_type** (*int | str*) – either cv2.LINE_4, cv2.LINE_8, or cv2.LINE_AA or a string code.

Returns

vec_img - an rgb/rgba image in 0-1 space

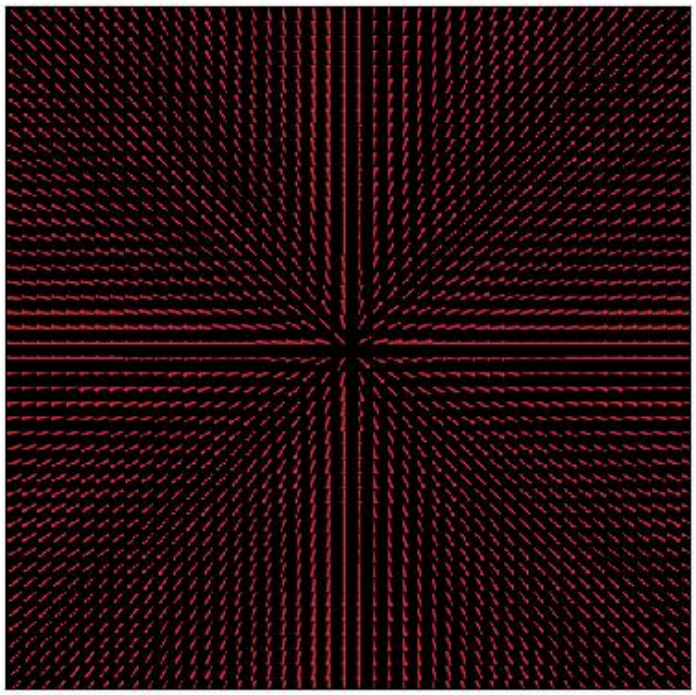
Return type
ndarray[Any, Float32]

SeeAlso:
kwimage.overlay_alpha_images

DEPRECATED USE: draw_vector_field instead

Example

```
>>> x, y = np.meshgrid(np.arange(512), np.arange(512))
>>> dx, dy = x - 256.01, y - 256.01
>>> radians = np.arctan2(dx, dy)
>>> mag = np.sqrt(dx ** 2 + dy ** 2)
>>> dx, dy = dx / mag, dy / mag
>>> img = make_vector_field(dx, dy, scale=10, alpha=False)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(img)
>>> kwplot.show_if_requested()
```



kwimage.im_draw.**draw_vector_field**(*image*, *dx*, *dy*, *stride=0.02*, *thresh=0.0*, *scale=1.0*, *alpha=1.0*, *color='strawberry'*, *thickness=1*, *tipLength=0.1*, *line_type='aa'*)

Create an image representing a 2D vector field.

Parameters

- **image** (*ndarray*) – image to draw on
- **dx** (*ndarray*) – grid of vector x components
- **dy** (*ndarray*) – grid of vector y components
- **stride** (*int | float*) – sparsity of vectors, int specifies stride step in pixels, a float specifies it as a percentage.
- **thresh** (*float*) – only plot vectors with magnitude greater than thres
- **scale** (*float*) – multiply magnitude for easier visualization
- **alpha** (*float*) – alpha value for vectors. Non-vector regions receive 0 alpha (if False, no alpha channel is used)
- **color** (*str | tuple | kwimage.Color*) – RGB color of the vectors
- **thickness** (*int*) – thickness of arrows
- **tipLength** (*float*) – fraction of line length
- **line_type** (*int | str*) – either cv2.LINE_4, cv2.LINE_8, or cv2.LINE_AA or 'aa'

Returns

The image with vectors overlaid. If image=None, then an rgb/a image is created and returned.

Return type

ndarray[Any, Float32]

Example

```
>>> from kwimage.im_draw import *  # NOQA
>>> import kwimage
>>> width, height = 512, 512
>>> image = kwimage.grab_test_image(dsize=(width, height))
>>> x, y = np.meshgrid(np.arange(height), np.arange(width))
>>> dx, dy = x - width / 2, y - height / 2
>>> radians = np.arctan2(dx, dy)
>>> mag = np.sqrt(dx ** 2 + dy ** 2) + 1e-3
>>> dx, dy = dx / mag, dy / mag
>>> img = kwimage.draw_vector_field(image, dx, dy, scale=10, alpha=False)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(img, title='draw_vector_field')
>>> kwplot.show_if_requested()
```

kwimage.im_draw.**draw_header_text**(*image*, *text*, *fit=False*, *color='strawberry'*, *halign='center'*, *stack='auto'*, *bg_color='black'*)

Places a black bar on top of an image and writes text in it

Parameters

- **image** (*ndarray | dict | None*) – numpy image or dictionary containing a key width
- **text** (*str*) – text to draw
- **fit** (*bool | str*) – If False, will draw as much text within the given width as possible. If True, will draw all text and then resize to fit in the given width If "shrink", will only resize the text if it is too big to fit, in other words this is like fit=True, but it wont enlarge the text.
- **color** (*str | Tuple*) – a color coercable to *kwimage.Color*.
- **halign** (*str*) – Horizontal alignment. Can be left, center, or right.
- **stack** (*bool | str*) – if True returns the stacked image, otherwise just returns the header. If 'auto', will only stack if an image is given as an ndarray.

Returns

ndarray

Example

```
>>> from kwimage.im_draw import *  # NOQA
>>> import kwimage
>>> image = kwimage.grab_test_image()
>>> tiny_image = kwimage.imresize(image, dsize=(64, 64))
>>> canvases = []
>>> canvases += [draw_header_text(image=image, text='unfit long header ' * 5,␣
↪fit=False)]
>>> canvases += [draw_header_text(image=image, text='shrunk long header ' * 5, fit=
↪'shrink')]
>>> canvases += [draw_header_text(image=image, text='left header', fit=False,␣
↪halign='left')]
>>> canvases += [draw_header_text(image=image, text='center header', fit=False,␣
↪halign='center')]
>>> canvases += [draw_header_text(image=image, text='right header', fit=False,␣
↪halign='right')]
>>> canvases += [draw_header_text(image=image, text='shrunk header', fit='shrink',␣
↪halign='left')]
>>> canvases += [draw_header_text(image=tiny_image, text='shrunk header-center',␣
↪fit='shrink', halign='center')]
>>> canvases += [draw_header_text(image=image, text='fit header', fit=True, halign=
↪'left')]
>>> canvases += [draw_header_text(image={'width': 200}, text='header only',␣
↪fit=True, halign='left')]
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> pnum_ = kwplot.PlotNums(nCols=3, nSubplots=len(canvases))
>>> for c in canvases:
>>>     kwplot.imshow(c, pnum=pnum_())
>>> kwplot.show_if_requested()
```

kwimage.im_draw.**fill_nans_with_checkers**(*canvas*, *square_shape=8*)

Fills nan values with a 2d checkerboard pattern.

Parameters

canvas (*np.ndarray*) – data replace nans in

Returns

the inplace modified canvas

Return type

np.ndarray

SeeAlso:

nodata_checkerboard() - similar, but operates on nans or masked arrays.

Example

```
>>> from kwimage.im_draw import *  # NOQA
>>> import kwimage
>>> orig_img = kwimage.ensure_float01(kwimage.grab_test_image())
>>> poly1 = kwimage.Polygon.random(rng=1).scale(orig_img.shape[0] // 2)
>>> poly2 = kwimage.Polygon.random(rng=3).scale(orig_img.shape[0])
>>> poly3 = kwimage.Polygon.random(rng=4).scale(orig_img.shape[0] // 2)
>>> poly3 = poly3.translate((0, 200))
>>> img = orig_img.copy()
```

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```
>>> img = poly1.fill(img, np.nan)
>>> img = poly3.fill(img, 0)
>>> img[:, :, 0] = poly2.fill(np.ascontiguousarray(img[:, :, 0]), np.nan)
>>> input_img = img.copy()
>>> canvas = fill_nans_with_checkers(input_img)
>>> assert input_img is canvas
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(img, pnum=(1, 2, 1), title='matplotlib treats nans as zeros')
>>> kwplot.imshow(canvas, pnum=(1, 2, 2), title='checkers highlight real nans')
```

Example

```
>>> # Test grayscale
>>> from kwimage.im_draw import *  # NOQA
>>> import kwimage
>>> orig_img = kwimage.ensure_float01(kwimage.grab_test_image())
>>> poly1 = kwimage.Polygon.random().scale(orig_img.shape[0] // 2)
>>> poly2 = kwimage.Polygon.random().scale(orig_img.shape[0])
>>> img = orig_img.copy()
>>> img = poly1.fill(img, np.nan)
```

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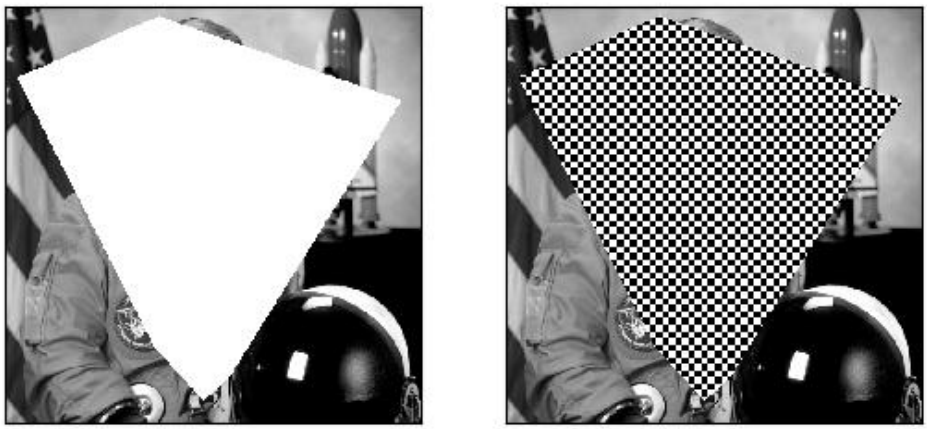
```
>>> img[:, :, 0] = poly2.fill(np.ascontiguousarray(img[:, :, 0]), np.nan)
>>> img = kwimage.convert_colorspace(img, 'rgb', 'gray')
>>> canvas = img.copy()
>>> canvas = fill_nans_with_checkers(canvas)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(img, pnum=(1, 2, 1))
>>> kwplot.imshow(canvas, pnum=(1, 2, 2))
```



kwimage.im_draw.**nodata_checkerboard**(*canvas*, *square_shape=8*)

Fills nans or masked values with a checkerbord pattern.

Parameters

- **canvas** (*ndarray*) – A 2D image with any number of channels.
- **square_shape** (*int*) – the pixel size of the checkers

Returns

an output array with imputed values.
if the input was a masked array, the mask will still exist.

Return type
ndarray

SeeAlso:
fill_nans_with_checkers() - similar, but only operates on nan values.

Example

```
>>> import kwimage
>>> # Test a masked array WITH nan values
>>> data = kwimage.grab_test_image(space='rgb')
>>> na_circle = kwimage.Polygon.circle((256 - 96, 256), 128)
>>> ma_circle = kwimage.Polygon.circle((256 + 96, 256), 128)
>>> ma_mask = na_circle.fill(np.zeros(data.shape, dtype=np.uint8), value=1).
↪astype(bool)
>>> na_mask = ma_circle.fill(np.zeros(data.shape, dtype=np.uint8), value=1).
↪astype(bool)
>>> # Hack the channels to make a ven diagram
>>> ma_mask[..., 0] = False
>>> na_mask[..., 2] = False
>>> data = kwimage.ensure_float01(data)
>>> data[na_mask] = np.nan
>>> canvas = np.ma.MaskedArray(data, ma_mask)
>>> kwimage.draw_text_on_image(canvas, 'masked values', (256 - 96, 256 - 128),␣
↪halign='center', valign='bottom', border=2)
>>> kwimage.draw_text_on_image(canvas, 'nan values',    (256 + 96, 256 + 128),␣
↪halign='center', valign='top', border=2)
>>> kwimage.draw_text_on_image(canvas, 'kwimage.nodata_checkerboard',    (256, 5),␣
↪halign='center', valign='top', border=2)
>>> kwimage.draw_text_on_image(canvas, '(pip install kwimage)', (512, 512 - 10),␣
↪halign='right', valign='bottom', border=2, fontScale=0.8)
>>> result = kwimage.nodata_checkerboard(canvas)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(result)
>>> kwplot.show_if_requested()
```

Example

```
>>> # Simple test with a masked array
>>> import kwimage
>>> data = kwimage.grab_test_image(space='rgb', dsize=(64, 64))
>>> data = kwimage.ensure_uint255(data)
>>> circle = kwimage.Polygon.circle((32, 32), 16)
>>> mask = circle.fill(np.zeros(data.shape, dtype=np.uint8), value=1).astype(bool)
>>> img = np.ma.MaskedArray(data, mask)
>>> canvas = img.copy()
>>> result = kwimage.nodata_checkerboard(canvas)
>>> canvas.data is result.data
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(result, title='nodata_checkers with masked uint8')
>>> kwplot.show_if_requested()
```

kwimage.im_filter module

kwimage.im_filter.**radial_fourier_mask**(*img_hwc*, *radius=11*, *axis=None*, *clip=None*)

In [1] they use a radius of 11.0 on CIFAR-10.

Parameters

img_hwc (*ndarray*) – assumed to be float 01

References

[1] Jo and Bengio “Measuring the tendency of CNNs to Learn Surface Statistical Regularities” 2017. https://docs.opencv.org/3.0-beta/doc/py_tutorials/py_imgproc/py_transforms/py_fourier_transform/py_fourier_transform.html

Example

```
>>> from kwimage.im_filter import *  # NOQA
>>> import kwimage
>>> img_hwc = kwimage.grab_test_image()
>>> img_hwc = kwimage.ensure_float01(img_hwc)
>>> out_hwc = radial_fourier_mask(img_hwc, radius=11)
>>> # xdoc: REQUIRES(--show)
>>> import kwplot
>>> plt = kwplot.autoplt()
>>> def keepdim(func):
>>>     def _wrap(im):
>>>         needs_transpose = (im.shape[0] == 3)
>>>         if needs_transpose:
>>>             im = im.transpose(1, 2, 0)
>>>         out = func(im)
>>>         if needs_transpose:
>>>             out = out.transpose(2, 0, 1)
>>>         return out
>>>     return _wrap
>>> @keepdim
>>> def rgb_to_lab(im):
>>>     return kwimage.convert_colorspace(im, src_space='rgb', dst_space='lab')
>>> @keepdim
>>> def lab_to_rgb(im):
>>>     return kwimage.convert_colorspace(im, src_space='lab', dst_space='rgb')
>>> @keepdim
>>> def rgb_to_yuv(im):
>>>     return kwimage.convert_colorspace(im, src_space='rgb', dst_space='yuv')
>>> @keepdim
>>> def yuv_to_rgb(im):
>>>     return kwimage.convert_colorspace(im, src_space='yuv', dst_space='rgb')
>>> def show_data(img_hwc):
>>>     # dpath = ub.ensuredir('./fouriertest')
>>>     kwplot.imshow(img_hwc, fnum=1)
>>>     pnum_ = kwplot.PlotNums(nRows=4, nCols=5)
>>>     for r in range(0, 17):
>>>         imgt = radial_fourier_mask(img_hwc, r, clip=(0, 1))
>>>         kwplot.imshow(imgt, pnum=pnum_(), fnum=2)
>>>         plt.gca().set_title('r = {}'.format(r))
>>>     kwplot.set_figtitle('RGB')
>>>     # plt.gcf().savefig(join(dpath, '{}_{:08d}.png'.format('rgb', x)))
>>>     pnum_ = kwplot.PlotNums(nRows=4, nCols=5)
>>>     for r in range(0, 17):
>>>         imgt = lab_to_rgb(radial_fourier_mask(rgb_to_lab(img_hwc), r))
>>>         kwplot.imshow(imgt, pnum=pnum_(), fnum=3)
```

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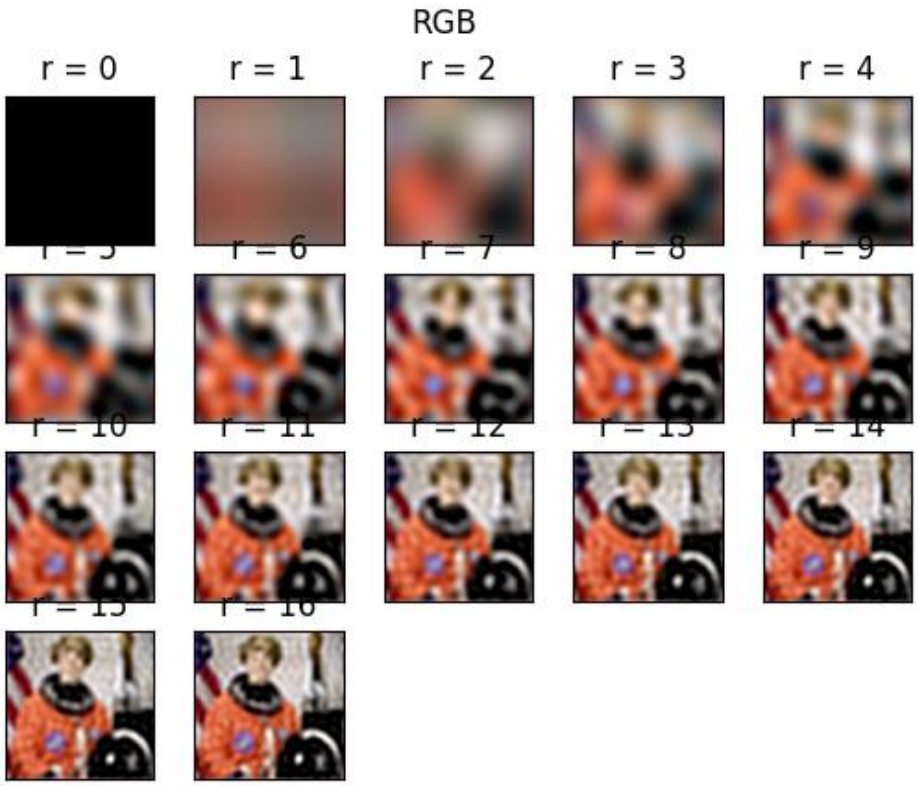
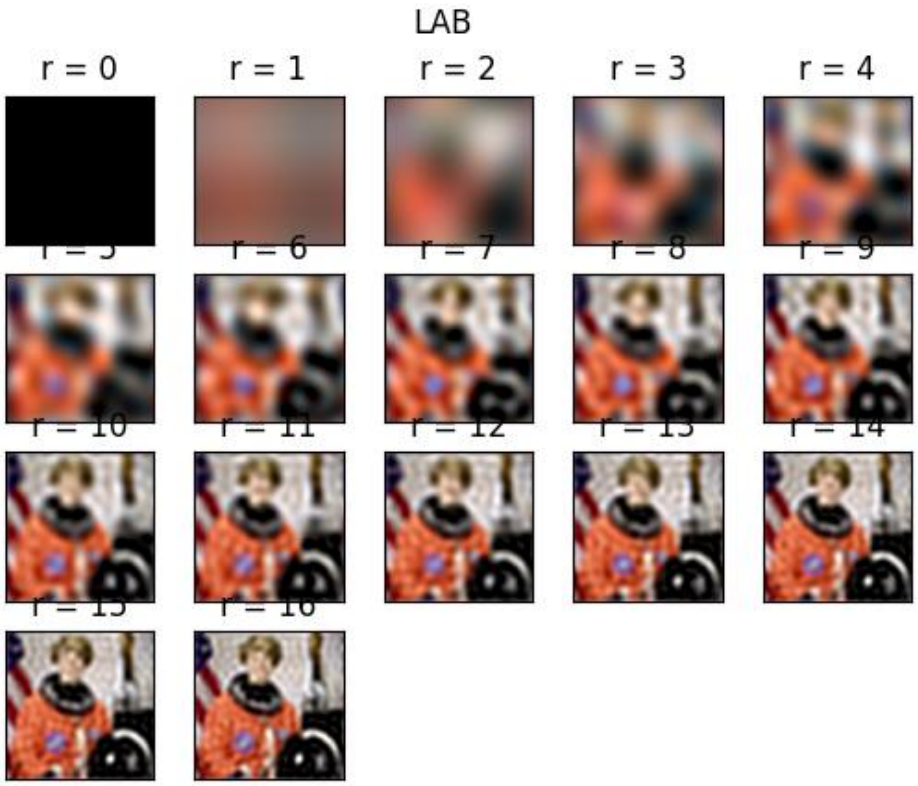
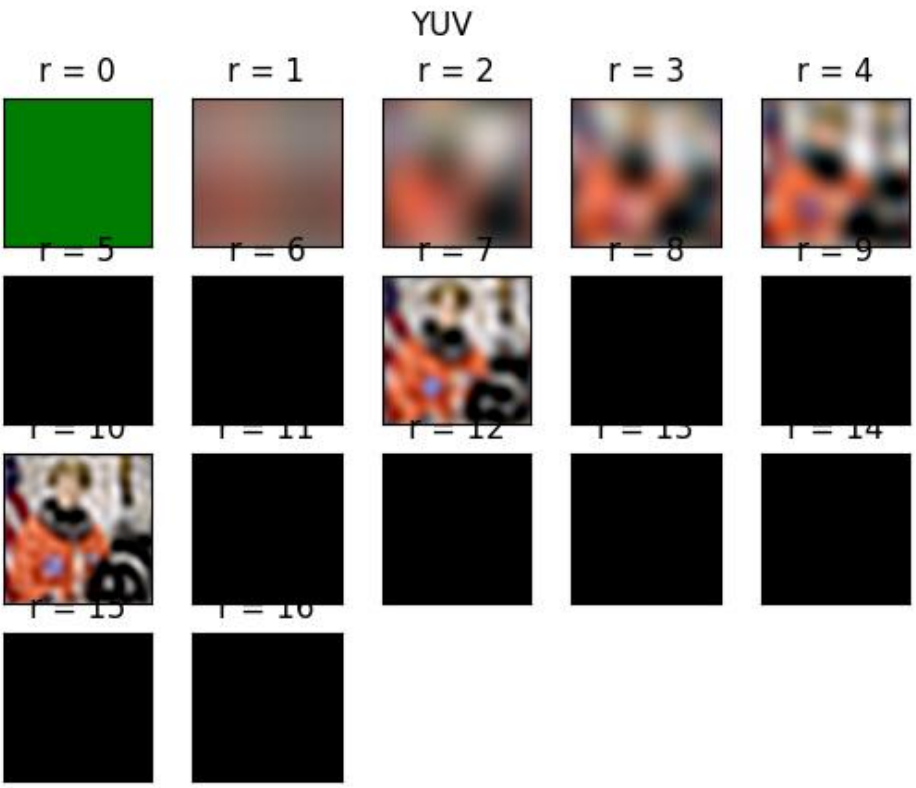
```
>>>         plt.gca().set_title('r = {}'.format(r))
>>>     kwplot.set_figtitle('LAB')
>>>     # plt.gcf().savefig(join(dpath, '{}_{:08d}.png'.format('lab', x)))
>>>     pnum_ = kwplot.PlotNums(nRows=4, nCols=5)
>>>     for r in range(0, 17):
>>>         imgt = yuv_to_rgb(radial_fourier_mask(rgb_to_yuv(img_hwc), r))
>>>         kwplot.imshow(imgt, pnum=pnum_(), fnum=4)
>>>         plt.gca().set_title('r = {}'.format(r))
>>>     kwplot.set_figtitle('YUV')
>>>     # plt.gcf().savefig(join(dpath, '{}_{:08d}.png'.format('yuv', x)))
>>> show_data(img_hwc)
>>> kwplot.show_if_requested()
```


RGB
r = 0
r = 1
r = 2
r = 3
r = 4
r = 6
r = 7
r = 8
r = 9
r = 10
r = 11
r = 12
r = 13
r = 14
r = 15
r = 16


LAB
r = 0
r = 1
r = 2
r = 3
r = 4
r = 5
r = 6
r = 7
r = 8
r = 9
r = 10
r = 11
r = 12
r = 13
r = 14
r = 15
r = 16



kwimage.im_filter.**fourier_mask**(*img_hwc*, *mask*, *axis=None*, *clip=None*)

Applies a mask to the fourier spectrum of an image

Parameters

- **img_hwc** (*ndarray*) – assumed to be float 01
- **mask** (*ndarray*) – mask used to modulate the image in the fourier domain. Usually these are boolean values (hence the name mask), but any numerical value is technically allowed.

CommandLine

```
xdoctest -m kwimage.im_filter fourier_mask --show
```

Example

```
>>> from kwimage.im_filter import *  # NOQA
>>> import kwimage
>>> img_hwc = kwimage.grab_test_image(space='gray')
>>> mask = np.random.rand(*img_hwc.shape[0:2])
>>> out_hwc = fourier_mask(img_hwc, mask)
>>> # xdoc: REQUIRES(--show)
>>> import kwplot
```

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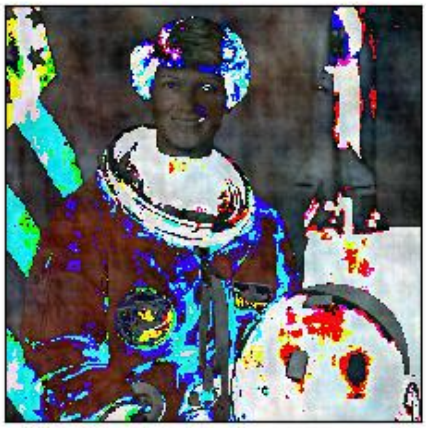
```
>>> kwplot.autompl()
>>> kwplot.imshow(img_hwc, pnum=(1, 2, 1), fnum=1)
>>> kwplot.imshow(out_hwc, pnum=(1, 2, 2), fnum=1)
>>> kwplot.show_if_requested()
```



kwimage.im_io module

This module provides functions `imread` and `imwrite` which are wrappers around concrete readers/writers provided by other libraries. This allows us to support a wider array of formats than any of individual backends.

`kwimage.im_io.`**`imread`**(*fpath*, *space='auto'*, *backend='auto'*, ***kw*)

Reads image data in a specified format using some backend implementation.

Parameters

- **fpath** (*str*) – path to the file to be read
- **space** (*str*) – The desired colorspace of the image. Can by any colorspace accepted by *convert_colorspace*, or it can be 'auto', in which case the colorspace of the image is unmodified (except in the case where a color image is read by opencv, in which case we convert BGR to RGB by default). If None, then no modification is made to whatever backend is used to read the image. Defaults to 'auto'.

  New in version 0.7.10: when the backend does not resolve to "cv2" the "auto" space resolves to None, thus the image is read as-is.

- **backend** (*str*) – which backend reader to use. By default the file extension is used to determine this, but it can be manually overridden. Valid backends are ‘gdal’, ‘skimage’, ‘itk’, ‘pil’, and ‘cv2’. Defaults to ‘auto’.
- ****kw** – backend-specific arguments

Returns
the image data in the specified color space.

Return type
ndarray

Note: if space is something non-standard like HSV or LAB, then the file must be a normal 8-bit color image, otherwise an error will occur.

Note: Some backends will respect EXIF orientation (skimage) and others will not (gdal, cv2).

Raises

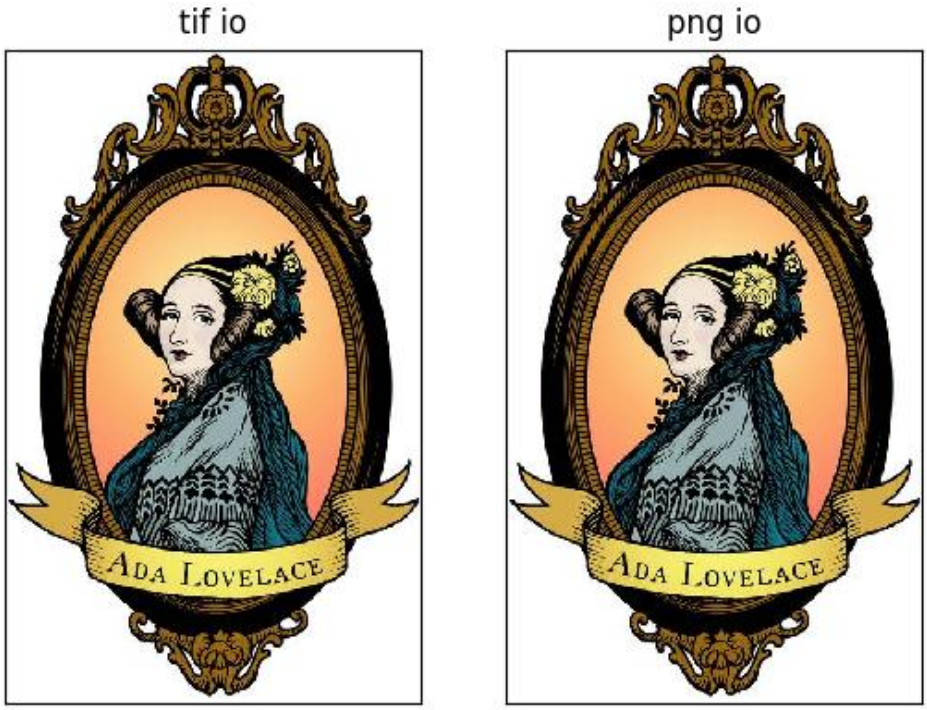
- **IOError - If the image cannot be read** –
- **ImportError - If trying to read a nitf without gdal** –
- **NotImplementedError - if trying to read a corner-case image** –

Example

```
>>> # xdoctest: +REQUIRES(--network)
>>> from kwimage.im_io import *  # NOQA
>>> import tempfile
>>> from os.path import splitext  # NOQA
>>> # Test a non-standard image, which encodes a depth map
>>> fpath = ub.grabdata(
>>>     'http://www.topcoder.com/contest/problem/UrbanMapper3D/JAX_Tile_043_DTM.tif
↪',
>>>     hasher='sha256', hash_prefix=
↪'64522acba6f0fb7060cd4c202ed32c5163c34e63d386afdada4190cce51ff4d4')
>>> img1 = kwimage.imread(fpath)
>>> # Check that write + read preserves data
>>> tmp = tempfile.NamedTemporaryFile(suffix=splitext(fpath)[1])
>>> kwimage.imwrite(tmp.name, img1)
>>> img2 = kwimage.imread(tmp.name)
>>> assert np.all(img2 == img1)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(img1, pnum=(1, 2, 1), fnum=1, norm=True, title='tif orig')
>>> kwplot.imshow(img2, pnum=(1, 2, 2), fnum=1, norm=True, title='tif io round-trip
↪')
```

Example

```
>>> # xdoctest: +REQUIRES(--network)
>>> import tempfile
>>> import kwimage
>>> img1 = kwimage.imread(ub.grabdata(
>>>     'http://i.imgur.com/iXNf4Me.png', fname='ada.png', hasher='sha256',
>>>     hash_prefix=
↪'898cf2588c40baf64d6e09b6a93b4c8dcc0db26140639a365b57619e17dd1c77'))
>>> tmp_tif = tempfile.NamedTemporaryFile(suffix='.tif')
>>> tmp_png = tempfile.NamedTemporaryFile(suffix='.png')
>>> kwimage.imwrite(tmp_tif.name, img1)
>>> kwimage.imwrite(tmp_png.name, img1)
>>> tif_im = kwimage.imread(tmp_tif.name)
>>> png_im = kwimage.imread(tmp_png.name)
>>> assert np.all(tif_im == png_im)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(png_im, pnum=(1, 2, 1), fnum=1, title='tif io')
>>> kwplot.imshow(tif_im, pnum=(1, 2, 2), fnum=1, title='png io')
```



Example

```
>>> # xdoctest: +REQUIRES(--network)
>>> import tempfile
>>> import kwimage
>>> tif_fpath = ub.grabdata(
>>>     'https://ghostscript.com/doc/tiff/test/images/rgb-3c-16b.tiff',
>>>     fname='pepper.tif', hasher='sha256',
>>>     hash_prefix=
↪'31ff3a1f416cb7281acfbcbb4b56ee8bb94e9f91489602ff2806e5a49abc03c0')
>>> img1 = kwimage.imread(tif_fpath)
>>> tmp_tif = tempfile.NamedTemporaryFile(suffix='.tif')
>>> tmp_png = tempfile.NamedTemporaryFile(suffix='.png')
>>> kwimage.imwrite(tmp_tif.name, img1)
>>> kwimage.imwrite(tmp_png.name, img1)
>>> tif_im = kwimage.imread(tmp_tif.name)
>>> png_im = kwimage.imread(tmp_png.name)
>>> assert np.all(tif_im == png_im)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(png_im / 2 ** 16, pnum=(1, 2, 1), fnum=1)
>>> kwplot.imshow(tif_im / 2 ** 16, pnum=(1, 2, 2), fnum=1)
```

Example

```
>>> # xdoctest: +REQUIRES(module:itk, --network)
>>> import kwimage
>>> import ubelt as ub
>>> # Grab an image that ITK can read
>>> fpath = ub.grabdata(
>>>     url='https://data.kitware.com/api/v1/file/606754e32fa25629b9476f9e/download
↪',
>>>     fname='brainweb1e5a10f17Rot20Tx20.mha',
>>>     hash_prefix='08f0812591691ae24a29788ba8cd1942e91', hasher='sha512')
>>> # Read the image (this is actually a DxHxW stack of images)
>>> img1_stack = kwimage.imread(fpath)
>>> # Check that write + read preserves data
>>> import tempfile
>>> tmp_file = tempfile.NamedTemporaryFile(suffix='.mha')
>>> kwimage.imwrite(tmp_file.name, img1_stack)
>>> recon = kwimage.imread(tmp_file.name)
>>> assert not np.may_share_memory(recon, img1_stack)
>>> assert np.all(recon == img1_stack)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(kwimage.stack_images_grid(recon[0::20]),
>>>               title='kwimage.imread with a .mha file')
>>> kwplot.show_if_requested()
```

Benchmark

```
>>> from kwimage.im_io import *  # NOQA
>>> import timerit
>>> import kwimage
>>> import tempfile
>>> #
>>> dsize = (1920, 1080)
>>> img1 = kwimage.grab_test_image('amazon', dsize=dsize)
>>> ti = timerit.Timerit(10, bestof=3, verbose=1, unit='us')
>>> formats = {}
>>> dpath = ub.ensure_app_cache_dir('cache')
>>> space = 'auto'
>>> formats['png'] = kwimage.imwrite(join(dpath, '.png'), img1, space=space,␣
↪backend='cv2')
>>> formats['jpg'] = kwimage.imwrite(join(dpath, '.jpg'), img1, space=space,␣
↪backend='cv2')
>>> formats['tif_raw'] = kwimage.imwrite(join(dpath, '.raw.tif'), img1, space=space,
↪ backend='gdal', compress='RAW')
>>> formats['tif_deflate'] = kwimage.imwrite(join(dpath, '.deflate.tif'), img1,␣
↪space=space, backend='gdal', compress='DEFLATE')
>>> formats['tif_lzw'] = kwimage.imwrite(join(dpath, '.lzw.tif'), img1, space=space,
↪ backend='gdal', compress='LZW')
>>> grid = [
```

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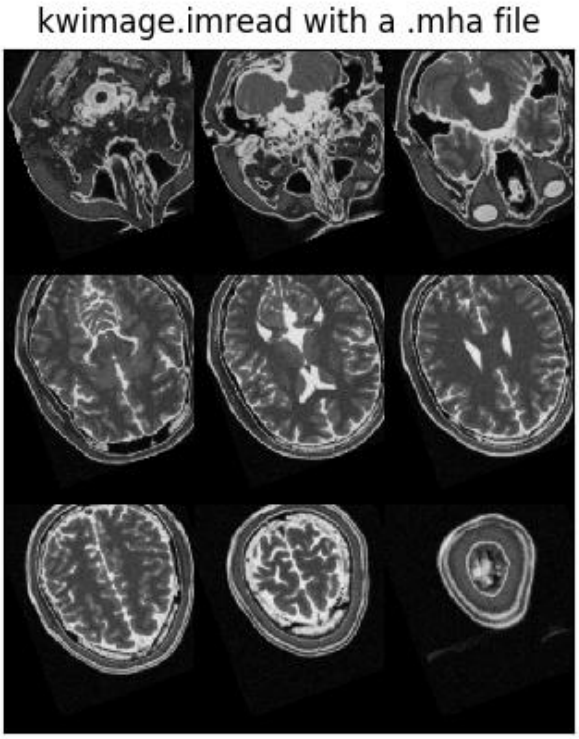
```
>>>     ('cv2', 'png'),
>>>     ('cv2', 'jpg'),
>>>     ('gdal', 'jpg'),
>>>     ('turbojpeg', 'jpg'),
>>>     ('gdal', 'tif_raw'),
>>>     ('gdal', 'tif_lzw'),
>>>     ('gdal', 'tif_deflate'),
>>>     ('skimage', 'tif_raw'),
>>> ]
>>> backend, filefmt = 'cv2', 'png'
>>> for backend, filefmt in grid:
>>>     for timer in ti.reset(f'imread-{filefmt}-{backend}'):
>>>         with timer:
>>>             kwimage.imread(formats[filefmt], space=space, backend=backend)
>>> # Test all formats in auto mode
>>> for filefmt in formats.keys():
>>>     for timer in ti.reset(f'kwimage.imread-{filefmt}-auto'):
>>>         with timer:
>>>             kwimage.imread(formats[filefmt], space=space, backend='auto')
>>> ti.measures = ub.map_vals(ub.sorted_vals, ti.measures)
>>> import netharn as nh
>>> print('ti.measures = {}'.format(nh.util.align(ub.repr2(ti.measures['min'],␣
↪nl=2), ':')))
Timed best=42891.504 µs, mean=44008.439 ± 1409.2 µs for imread-png-cv2
Timed best=33146.808 µs, mean=34185.172 ± 656.3 µs for imread-jpg-cv2
Timed best=40120.306 µs, mean=41220.927 ± 1010.9 µs for imread-jpg-gdal
Timed best=30798.162 µs, mean=31573.070 ± 737.0 µs for imread-jpg-turbojpeg
Timed best=6223.170 µs, mean=6370.462 ± 150.7 µs for imread-tif_raw-gdal
Timed best=42459.404 µs, mean=46519.940 ± 5664.9 µs for imread-tif_lzw-gdal
Timed best=36271.175 µs, mean=37301.108 ± 861.1 µs for imread-tif_deflate-gdal
Timed best=5239.503 µs, mean=6566.574 ± 1086.2 µs for imread-tif_raw-skimage
ti.measures = {
    'imread-tif_raw-skimage' : 0.0052395030070329085,
    'imread-tif_raw-gdal'    : 0.006223169999429956,
    'imread-jpg-turbojpeg'   : 0.030798161998973228,
    'imread-jpg-cv2'         : 0.03314680799667258,
    'imread-tif_deflate-gdal': 0.03627117499127053,
    'imread-jpg-gdal'        : 0.040120305988239124,
    'imread-tif_lzw-gdal'    : 0.042459404008695856,
    'imread-png-cv2'         : 0.042891503995633684,
}
```



kwimage.im_io.**imwrite**(*fpath*, *image*, *space='auto'*, *backend='auto'*, ***kwargs*)

Writes image data to disk.

Parameters

- **fpath** (*PathLike*) – location to save the image
- **image** (*ndarray*) – image data
- **space** (*str | None*) – the colorspace of the image to save. Can by any colorspace accepted by *convert_colorspace*, or it can be 'auto', in which case we assume the input image is either RGB, RGBA or grayscale. If None, then absolutely no color modification is made and whatever backend is used writes the image as-is.

  New in version 0.7.10: when the backend does not resolve to "cv2", the "auto" space resolves to None, thus the image is saved as-is.
- **backend** (*str*) – Which backend writer to use. By default the file extension is used to determine this. Valid backends are 'gdal', 'skimage', 'itk', and 'cv2'.
- ****kwargs** – args passed to the backend writer. When the backend is gdal, available options are: compress (str): Common options are auto, DEFLATE, LZW, JPEG. blocksize (int): size of tiled blocks (e.g. 256) overviews (None | str | int | list): Number of overviews. overview_resample (str): Common options NEAREST, CUBIC, LANCZOS options (List[str]): other gdal options. nodata (int): denotes a integer value as nodata. transform (kwimage.Affine): Transform into CRS crs (str): The coordinate reference system for transform. See `_imwrite_cloud_optimized_geotiff()` for more details each options. When the backend is itk, see `itk.imwrite()` for options When the backend is

skimage, see `skimage.io.imsave()` for options When the backend is cv2 see `cv2.imwrite()` for options.

Returns
path to the written file

Return type
str

Note: The image may be modified to preserve its colorspace depending on which backend is used to write the image.

When saving as a jpeg or png, the image must be encoded with the uint8 data type. When saving as a tiff, any data type is allowed.

Raises
Exception – if the image cannot be written

Example

```
>>> # xdoctest: +REQUIRES(--network)
>>> # This should be moved to a unit test
>>> from kwimage.im_io import _have_gdal  # NOQA
>>> import kwimage
>>> import tempfile
>>> test_image_paths = [
>>>     ub.grabdata('https://ghostscript.com/doc/tiff/test/images/rgb-3c-16b.tiff',␣
↪fname='pepper.tif'),
>>>     ub.grabdata('http://i.imgur.com/iXNf4Me.png', fname='ada.png'),
>>>     #ub.grabdata('http://www.topcoder.com/contest/problem/UrbanMapper3D/JAX_Tile_
↪043_DTM.tif'),
>>>     ub.grabdata('https://upload.wikimedia.org/wikipedia/commons/f/fa/Grayscale_
↪8bits_palette_sample_image.png', fname='parrot.png')
>>> ]
>>> for fpath in test_image_paths:
>>>     for space in ['auto', 'rgb', 'bgr', 'gray', 'rgba']:
>>>         img1 = kwimage.imread(fpath, space=space)
>>>         print('Test im-io consistency of fpath = {!r} in {} space, shape={}'.
↪format(fpath, space, img1.shape))
>>>         # Write the image in TIF and PNG format
>>>         tmp_tif = tempfile.NamedTemporaryFile(suffix='.tif')
>>>         tmp_png = tempfile.NamedTemporaryFile(suffix='.png')
>>>         kwimage.imwrite(tmp_tif.name, img1, space=space, backend='skimage')
>>>         kwimage.imwrite(tmp_png.name, img1, space=space)
>>>         tif_im = kwimage.imread(tmp_tif.name, space=space)
>>>         png_im = kwimage.imread(tmp_png.name, space=space)
>>>         assert np.all(tif_im == png_im), 'im-read/write inconsistency'
>>>         if _have_gdal:
>>>             tmp_tif2 = tempfile.NamedTemporaryFile(suffix='.tif')
>>>             kwimage.imwrite(tmp_tif2.name, img1, space=space, backend='gdal')
>>>             tif_im2 = kwimage.imread(tmp_tif2.name, space=space)
>>>             assert np.all(tif_im == tif_im2), 'im-read/write inconsistency'
```

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```
>>>         if space == 'gray':
>>>             assert tif_im.ndim == 2
>>>             assert png_im.ndim == 2
>>>         elif space in ['rgb', 'bgr']:
>>>             assert tif_im.shape[2] == 3
>>>             assert png_im.shape[2] == 3
>>>         elif space in ['rgba', 'bgra']:
>>>             assert tif_im.shape[2] == 4
>>>             assert png_im.shape[2] == 4
```

Benchmark

```
>>> import timerit
>>> import os
>>> import kwimage
>>> import tempfile
>>> #
>>> img1 = kwimage.grab_test_image('astro', dsize=(1920, 1080))
>>> space = 'auto'
>>> #
>>> file_sizes = {}
>>> #
>>> ti = timerit.Timerit(10, bestof=3, verbose=2)
>>> #
>>> for timer in ti.reset('imwrite-skimage-tif'):
>>>     with timer:
>>>         tmp = tempfile.NamedTemporaryFile(suffix='.tif')
>>>         kwimage.imwrite(tmp.name, img1, space=space, backend='skimage')
>>>     file_sizes[ti.label] = os.stat(tmp.name).st_size
>>> #
>>> for timer in ti.reset('imwrite-cv2-png'):
>>>     with timer:
>>>         tmp = tempfile.NamedTemporaryFile(suffix='.png')
>>>         kwimage.imwrite(tmp.name, img1, space=space, backend='cv2')
>>>     file_sizes[ti.label] = os.stat(tmp.name).st_size
>>> #
>>> for timer in ti.reset('imwrite-cv2-jpg'):
>>>     with timer:
>>>         tmp = tempfile.NamedTemporaryFile(suffix='.jpg')
>>>         kwimage.imwrite(tmp.name, img1, space=space, backend='cv2')
>>>     file_sizes[ti.label] = os.stat(tmp.name).st_size
>>> #
>>> for timer in ti.reset('imwrite-gdal-raw'):
>>>     with timer:
>>>         tmp = tempfile.NamedTemporaryFile(suffix='.tif')
>>>         kwimage.imwrite(tmp.name, img1, space=space, backend='gdal', compress=
↪'RAW')
>>>     file_sizes[ti.label] = os.stat(tmp.name).st_size
>>> #
>>> for timer in ti.reset('imwrite-gdal-lzw'):
```

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```
>>>     with timer:
>>>         tmp = tempfile.NamedTemporaryFile(suffix='.tif')
>>>         kwimage.imwrite(tmp.name, img1, space=space, backend='gdal', compress=
↪'LZW')
>>>     file_sizes[ti.label] = os.stat(tmp.name).st_size
>>> #
>>> for timer in ti.reset('imwrite-gdal-zstd'):
>>>     with timer:
>>>         tmp = tempfile.NamedTemporaryFile(suffix='.tif')
>>>         kwimage.imwrite(tmp.name, img1, space=space, backend='gdal', compress=
↪'ZSTD')
>>>     file_sizes[ti.label] = os.stat(tmp.name).st_size
>>> #
>>> for timer in ti.reset('imwrite-gdal-deflate'):
>>>     with timer:
>>>         tmp = tempfile.NamedTemporaryFile(suffix='.tif')
>>>         kwimage.imwrite(tmp.name, img1, space=space, backend='gdal', compress=
↪'DEFLATE')
>>>     file_sizes[ti.label] = os.stat(tmp.name).st_size
>>> #
>>> for timer in ti.reset('imwrite-gdal-jpeg'):
>>>     with timer:
>>>         tmp = tempfile.NamedTemporaryFile(suffix='.tif')
>>>         kwimage.imwrite(tmp.name, img1, space=space, backend='gdal', compress=
↪'JPEG')
>>>     file_sizes[ti.label] = os.stat(tmp.name).st_size
>>> #
>>> file_sizes = ub.sorted_vals(file_sizes)
>>> import xdev
>>> file_sizes_human = ub.map_vals(lambda x: xdev.byte_str(x, 'MB'), file_sizes)
>>> print('ti.rankings = {}'.format(ub.repr2(ti.rankings, nl=2)))
>>> print('file_sizes = {}'.format(ub.repr2(file_sizes_human, nl=1)))
```

Example

```
>>> # Test saving a multi-band file
>>> import kwimage
>>> import pytest
>>> import tempfile
>>> # In this case the backend will not resolve to cv2, so
>>> # we should not need to specify space.
>>> data = np.random.rand(32, 32, 13).astype(np.float32)
>>> temp = tempfile.NamedTemporaryFile(suffix='.tif')
>>> fpath = temp.name
>>> kwimage.imwrite(fpath, data)
>>> recon = kwimage.imread(fpath)
>>> assert np.all(recon == data)
>>> kwimage.imwrite(fpath, data, backend='skimage')
>>> recon = kwimage.imread(fpath, backend='skimage')
>>> assert np.all(recon == data)
```

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```
>>> # xdoctest: +REQUIRES(module:osgeo)
>>> # gdal should error when trying to read an image written by skimage
>>> with pytest.raises(NotImplementedError):
>>>     kwimage.imread(fpath, backend='gdal')
>>> # In this case the backend will resolve to cv2, and thus we expect
>>> # a failure
>>> temp = tempfile.NamedTemporaryFile(suffix='.png')
>>> fpath = temp.name
>>> with pytest.raises(NotImplementedError):
>>>     kwimage.imwrite(fpath, data)
```

Example

```
>>> import ubelt as ub
>>> import kwimage
>>> dpath = ub.Path(ub.ensure_app_cache_dir('kwimage/badwrite'))
>>> dpath.delete().ensuredir()
>>> imdata = kwimage.ensure_uint255(kwimage.grab_test_image())[:, :, 0]
>>> import pytest
>>> fpath = dpath / 'does-not-exist/img.jpg'
>>> with pytest.raises(IOError):
...     kwimage.imwrite(fpath, imdata, backend='cv2')
>>> with pytest.raises(IOError):
...     kwimage.imwrite(fpath, imdata, backend='skimage')
>>> # xdoctest: +SKIP
>>> # TODO: run tests conditionally
>>> with pytest.raises(IOError):
...     kwimage.imwrite(fpath, imdata, backend='gdal')
>>> with pytest.raises((IOError, RuntimeError)):
...     kwimage.imwrite(fpath, imdata, backend='itk')
```

kwimage.im_io.**load_image_shape**(*fpath*, *backend='auto'*)

Determine the height/width/channels of an image without reading the entire file.

Parameters

- **fpath** (*str*) – path to an image
- **backend** (*str*) – can be “auto”, “pil”, or “gdal”.

Returns

Tuple[int, int, int] - shape of the image

Recall this library uses the convention that “shape” is refers to height,width,channels array-style ordering and “size” is width,height cv2-style ordering.

Example

```
>>> # xdoctest: +REQUIRES(module:osgeo)
>>> # Test the loading the shape works the same as loading the image and
>>> # testing the shape
>>> import kwimage
>>> import tempfile
>>> temp_dir = tempfile.TemporaryDirectory()
>>> temp_dpath = ub.Path(temp_dir.name)
>>> data = kwimage.grab_test_image()
>>> datas = {
>>>     'rgb255': kwimage.ensure_uint255(data),
>>>     'rgb01': kwimage.ensure_float01(data),
>>>     'rgba01': kwimage.ensure_alpha_channel(data),
>>> }
>>> results = {}
>>> # These should be consistent
>>> # The was a problem where CV2_IMREAD_UNCHANGED read the alpha band,
>>> # but PIL did not, but maybe this is fixed now?
>>> for key, imdata in datas.items():
>>>     fpath = temp_dpath / f'{key}.png'
>>>     kwimage.imwrite(fpath, imdata)
>>>     shapes = {}
>>>     shapes['pil_load_shape'] = kwimage.load_image_shape(fpath, backend='pil')
>>>     shapes['gdal_load_shape'] = kwimage.load_image_shape(fpath, backend='gdal')
>>>     shapes['auto_load_shape'] = kwimage.load_image_shape(fpath, backend='auto')
>>>     shapes['pil'] = kwimage.imread(fpath, backend='pil').shape
>>>     shapes['cv2'] = kwimage.imread(fpath, backend='cv2').shape
>>>     shapes['gdal'] = kwimage.imread(fpath, backend='gdal').shape
>>>     shapes['skimage'] = kwimage.imread(fpath, backend='skimage').shape
>>>     results[key] = shapes
>>> print('results = {}'.format(ub.repr2(results, nl=2, align=':', sort=0)))
>>> for shapes in results.values():
>>>     assert ub.allsame(shapes.values())
```

Benchmark

```
>>> # For large files, PIL is much faster
>>> # xdoctest: +REQUIRES(module:osgeo)
>>> from osgeo import gdal
>>> from PIL import Image
>>> import timerit
>>> #
>>> import kwimage
>>> fpath = kwimage.grab_test_image_fpath()
>>> #
>>> ti = timerit.Timerit(100, bestof=10, verbose=2)
>>> for timer in ti.reset('gdal'):
>>>     with timer:
>>>         gdal_dset = gdal.Open(fpath, gdal.GA_ReadOnly)
>>>         width = gdal_dset.RasterXSize
```

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```
>>>         height = gdal_dset.RasterYSize
>>>         gdal_dset = None
>>> #
>>> for timer in ti.reset('PIL'):
>>>     with timer:
>>>         pil_img = Image.open(fpath)
>>>         width, height = pil_img.size
>>>         pil_img.close()
Timed gdal for: 100 loops, best of 10
    time per loop: best=62.967 µs, mean=63.991 ± 0.8 µs
Timed PIL for: 100 loops, best of 10
    time per loop: best=46.640 µs, mean=47.314 ± 0.4 µs
```

Example

```
>>> # xdoctest: +REQUIRES(module:osgeo)
>>> import ubelt as ub
>>> import kwimage
>>> dpath = ub.Path.appdir('kwimage/tests', type='cache').ensuredir()
>>> fpath = dpath / 'foo.tif'
>>> kwimage.imwrite(fpath, np.random.rand(64, 64, 3))
>>> shape = kwimage.load_image_shape(fpath)
>>> assert shape == (64, 64, 3)
```

kwimage.im_runlen module

Logic pertaining to run-length encodings. Can encode an ndarray as a RLE or decode an RLE into an ndarray.

SeeAlso:

kwimage.structs.mask - stores binary segmentation masks, using RLEs as a
backend representation. Also contains cython logic for handling the coco-rle format.

kwimage.im_runlen.**encode_run_length**(*img*, *binary=False*, *order='C'*)

Construct the run length encoding (RLE) of an image.

Parameters

- **img** (*ndarray*) – 2D image
- **binary** (*bool*) – If true, assume that the input image only contains 0's and 1's. Set to True for compatibility with COCO (which does not support multi-value RLE encodings).
- **order** (*str*) – Order of the encoding. Either 'C' for row major or 'F' for column-major. Defaults to 'C'.

Returns

encoding: dictionary items are:

counts (ndarray): the run length encoding

shape (Tuple): the original image shape.
This should be in standard shape row-major (e.g. h/w) order

binary (bool):
if True, the counts are assumed to encode only 0's and 1's, otherwise the counts encoding specifies any numeric values.

order (str):
Encoding order, either 'C' for row major or 'F' for column-major. Defaults to 'C'.

Return type
Dict[str, object]

SeeAlso:

kwimage.Mask **-**
cython-backed data structure to handle coco-style RLEs

Example

```
>>> import ubelt as ub
>>> lines = ub.codeblock(
>>>     '''
>>>     ..........
>>>     ......111.
>>>     ..2...111.
>>>     .222..111.
>>>     22222.....
>>>     .222......
>>>     ..2.......
>>>     ''').replace('.', '0').splitlines()
>>> img = np.array([list(map(int, line)) for line in lines])
>>> encoding = encode_run_length(img)
>>> target = np.array([0,16,1,3,0,3,2,1,0,3,1,3,0,2,2,3,0,2,1,3,0,1,2,5,0,6,2,3,0,8,
↪2,1,0,7])
>>> assert np.all(target == encoding['counts'])
```

Example

```
>>> binary = True
>>> img = np.array([[1, 0, 1, 1, 1, 0, 0, 1, 0]])
>>> encoding = encode_run_length(img, binary=True)
>>> assert encoding['counts'].tolist() == [0, 1, 1, 3, 2, 1, 1]
```

Example

```
>>> # Test empty case
>>> from kwimage.im_runlen import *  # NOQA
>>> binary = True
>>> img = np.zeros((0, 0), dtype=np.uint8)
>>> encoding = encode_run_length(img, binary=True)
>>> assert encoding['counts'].tolist() == []
```

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```
>>> recon = decode_run_length(**encoding)
>>> assert np.all(recon == img)
```

Example

```
>>> # Test small full cases
>>> for d in [0, 1, 2, 3]:
>>>     img = np.zeros((d, d), dtype=np.uint8)
>>>     encoding = encode_run_length(img, binary=True)
>>>     recon = decode_run_length(**encoding)
>>>     assert np.all(recon == img)
>>>     img = np.ones((d, d), dtype=np.uint8)
>>>     encoding = encode_run_length(img, binary=True)
>>>     recon = decode_run_length(**encoding)
>>>     assert np.all(recon == img)
```

kwimage.im_runlen.**decode_run_length**(*counts*, *shape*, *binary=False*, *dtype=<class 'numpy.uint8'>*, *order='C'*)

Decode run length encoding back into an image.

Parameters

- **counts** (*ndarray*) – the run-length encoding
- **shape** (*Tuple[int, int]*) – the height / width of the mask
- **binary** (*bool*) – if the RLE is binary or non-binary. Set to True for compatibility with COCO.
- **dtype** (*type*) – data type for decoded image. Defaults to np.uint8.
- **order** (*str*) – Order of the encoding. Either ‘C’ for row major or ‘F’ for column-major. Defaults to ‘C’.

Returns
the reconstructed image

Return type
ndarray

Example

```
>>> from kwimage.im_runlen import *  # NOQA
>>> img = np.array([[1, 0, 1, 1, 1, 0, 0, 1, 0]])
>>> encoded = encode_run_length(img, binary=True)
>>> recon = decode_run_length(**encoded)
>>> assert np.all(recon == img)
```

```
>>> import ubelt as ub
>>> lines = ub.codeblock(
>>>     '''
>>>     .........
>>>     ......111.
```

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```
>>>     ..2...111.
>>>     .222..111.
>>>     22222.....
>>>     .222......
>>>     ..2.......
>>>     ''').replace('.', '0').splitlines()
>>> img = np.array([list(map(int, line)) for line in lines])
>>> encoded = encode_run_length(img)
>>> recon = decode_run_length(**encoded)
>>> assert np.all(recon == img)
```

kwimage.im_runlen.**rle_translate**(*rle*, *offset*, *output_shape=None*)

Translates a run-length encoded image in RLE-space.

Parameters

- **rle** (*dict*) – an enconding dict returned by *kwimage.encode_run_length()*
- **offset** (*Tuple[int, int]*) – x, y integer offsets.
- **output_shape** (*Tuple[int, int]*) – h,w of transformed mask. If unspecified the input rle shape is used.

SeeAlso:

ITK has some RLE code that looks like it can perform translations https://github.com/KitwareMedical/ITKRLEImage/blob/master/include/itkRLERegionOfInterestImageFilter.h

Doctest

```
>>> # test that translate works on all zero images
>>> img = np.zeros((7, 8), dtype=np.uint8)
>>> rle = encode_run_length(img, binary=True, order='F')
>>> new_rle = rle_translate(rle, (1, 2), (6, 9))
>>> assert np.all(new_rle['counts'] == [54])
```

Example

```
>>> from kwimage.im_runlen import *  # NOQA
>>> img = np.array([
>>>     [1, 1, 1, 1],
>>>     [0, 1, 0, 0],
>>>     [0, 1, 0, 1],
>>>     [1, 1, 1, 1],], dtype=np.uint8)
>>> rle = encode_run_length(img, binary=True, order='C')
>>> offset = (1, -1)
>>> output_shape = (3, 5)
>>> new_rle = rle_translate(rle, offset, output_shape)
>>> decoded = decode_run_length(**new_rle)
>>> print(decoded)
[[0 0 1 0 0]
 [0 0 1 0 1]
 [0 1 1 1 1]]
```

Example

```
>>> from kwimage.im_runlen import *  # NOQA
>>> img = np.array([
>>>     [0, 0, 0],
>>>     [0, 1, 0],
>>>     [0, 0, 0]], dtype=np.uint8)
>>> rle = encode_run_length(img, binary=True, order='C')
>>> new_rle = rle_translate(rle, (1, 0))
>>> decoded = decode_run_length(**new_rle)
>>> print(decoded)
[[0 0 0]
 [0 0 1]
 [0 0 0]]
>>> new_rle = rle_translate(rle, (0, 1))
>>> decoded = decode_run_length(**new_rle)
>>> print(decoded)
[[0 0 0]
 [0 0 0]
 [0 1 0]]
```

kwimage.im_stack module

Functions for stacking images (of potentially different sizes) together in a single image.

Notes

- We may change the "bg_value" argument to "bg_color" in the future.

kwimage.im_stack.**stack_images**(*images*, *axis=0*, *resize=None*, *interpolation=None*, *overlap=0*, *return_info=False*, *bg_value=None*, *pad=None*, *allow_casting=True*)

Make a new image with the input images side-by-side

Parameters

- **images** (*Iterable[ndarray]*) – image data
- **axis** (*int*) – axis to stack on (either 0 or 1)
- **resize** (*int | str | None*) – if None image sizes are not modified, otherwise resize resize can be either 0 or 1. We resize the *resize*-th image to match the *1 - resize*-th image. Can also be strings "larger" or "smaller".
- **interpolation** (*int | str*) – string or cv2-style interpolation type. only used if resize or overlap > 0
- **overlap** (*int*) – number of pixels to overlap. Using a negative number results in a border.
- **pad** (*int*) – if specified overrides *overlap* as a the number of pixels to pad between images.
- **return_info** (*bool*) – if True, returns transforms (scales and translations) to map from original image to its new location.
- **bg_value** (*Number | ndarray | str*) – background value or color, if specified, uses this as a fill value.
- **allow_casting** (*bool*) – if True, then if "uint255" and "float01" format images are given they are converted to "float01". Defaults to True.

Returns

an image of stacked images side by side

Tuple[ndarray, List]: where the first item is the aformentioned stacked
image and the second item is a list of transformations for each input image mapping it to its location in the returned image.

Return type
ndarray

SeeAlso:
kwimage.im_stack.stack_images_grid()

Example

```
>>> import kwimage
>>> img1 = kwimage.grab_test_image('carl', space='rgb')
>>> img2 = kwimage.grab_test_image('astro', space='rgb')
>>> images = [img1, img2]
>>> imgB, transforms = kwimage.stack_images(
>>>     images, axis=0, resize='larger', pad=10, return_info=True)
>>> print('imgB.shape = {}'.format(imgB.shape))
>>> # xdoctest: +REQUIRES(--show)
>>> # xdoctest: +REQUIRES(module:kwplot)
>>> import kwplot
>>> import kwimage
>>> kwplot.autompl()
>>> kwplot.imshow(imgB, colorspace='rgb')
>>> wh1 = np.multiply(img1.shape[0:2][::-1], transforms[0].scale)
>>> wh2 = np.multiply(img2.shape[0:2][::-1], transforms[1].scale)
>>> xoff1, yoff1 = transforms[0].translation
>>> xoff2, yoff2 = transforms[1].translation
>>> xywh1 = (xoff1, yoff1, wh1[0], wh1[1])
>>> xywh2 = (xoff2, yoff2, wh2[0], wh2[1])
>>> kwplot.draw_boxes(kwimage.Boxes([xywh1], 'xywh'), color=(1.0, 0, 0))
>>> kwplot.draw_boxes(kwimage.Boxes([xywh2], 'xywh'), color=(1.0, 0, 0))
>>> kwplot.show_if_requested()
```

kwimage.im_stack.**stack_images_grid**(*images*, *chunksize=None*, *axis=0*, *overlap=0*, *pad=None*, *return_info=False*, *bg_value=None*, *resize=None*, *allow_casting=True*)

Stacks images in a grid. Optionally return transforms of original image positions in the output image.

Parameters

- **images** (*Iterable[ndarray]*) – image data
- **chunksize** (*int*) – number of rows per column or columns per row depending on the value of *axis*. If unspecified, computes this as *int(sqrt(len(images)))*.
- **axis** (*int*) – If 0, chunksize is columns per row. If 1, chunksize is rows per column. Defaults to 0.
- **overlap** (*int*) – number of pixels to overlap. Using a negative number results in a border.
- **pad** (*int*) – if specified overrides *overlap* as a the number of pixels to pad between images.
- **return_info** (*bool*) – if True, returns transforms (scales and translations) to map from original image to its new location.
- **resize** (*int | str | None*) – if None image sizes are not modified, otherwise can be set to "larger" or "smaller" to resize the images in each stack direction.
- **bg_value** (*Number | ndarray | str*) – background value or color, if specified, uses this as a fill value.
- **allow_casting** (*bool*) – if True, then if "uint255" and "float01" format images are given they are converted to "float01". Defaults to True.

Returns

an image of stacked images in a grid pattern

Tuple[ndarray, List]: where the first item is the aformentioned stacked
image and the second item is a list of transformations for each input image mapping it to its location in the returned image.

Return type
ndarray

SeeAlso:
kwimage.im_stack.stack_images()

Example

```
>>> import kwimage
>>> img1 = kwimage.grab_test_image('carl')
>>> img2 = kwimage.grab_test_image('astro')
>>> img3 = kwimage.grab_test_image('airport')
>>> img4 = kwimage.grab_test_image('paraview')[..., 0:3]
>>> img5 = kwimage.grab_test_image('pm5644')
>>> images = [img1, img2, img3, img4, img5]
>>> canvas, transforms = kwimage.stack_images_grid(
...     images, chunksize=3, axis=0, pad=10, bg_value='kitware_blue',
...     return_info=True, resize='larger')
>>> print('canvas.shape = {}'.format(canvas.shape))
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> import kwimage
>>> kwplot.autompl()
>>> kwplot.imshow(canvas)
>>> kwplot.show_if_requested()
```

kwimage.transform module

Objects for representing and manipulating image transforms.

class kwimage.transform.**Transform**

Bases: NiceRepr

class kwimage.transform.**Matrix**(*matrix*)

Bases: *Transform*

Base class for matrix-based transform.

Example

```
>>> from kwimage.transform import *  # NOQA
>>> ms = {}
>>> ms['random()'] = Matrix.random()
>>> ms['eye()'] = Matrix.eye()
>>> ms['random(3)'] = Matrix.random(3)
>>> ms['random(4, 4)'] = Matrix.random(4, 4)
>>> ms['eye(3)'] = Matrix.eye(3)
>>> ms['explicit'] = Matrix(np.array([[1.618]]))
>>> for k, m in ms.items():
>>>     print('----')
```

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```
>>>     print(f'{k} = {m}')
>>>     print(f'{k}.inv() = {m.inv()}')
>>>     print(f'{k}.T = {m.T}')
>>>     print(f'{k}.det() = {m.det()}')
```

property shape

classmethod coerce(*data=None*, ***kwargs*)

Example

```
>>> Matrix.coerce({'type': 'matrix', 'matrix': [[1, 0, 0], [0, 1, 0]]})
>>> Matrix.coerce(np.eye(3))
>>> Matrix.coerce(None)
```

inv()

Returns the inverse of this matrix

Returns
Matrix

property T

Transpose the underlying matrix

det()

Compute the determinant of the underlying matrix

Returns
float

classmethod eye(*shape=None*, *rng=None*)

Construct an identity

classmethod random(*shape=None*, *rng=None*)

rationalize()

Convert the underlying matrix to a rational type to avoid floating point errors. This does decrease efficiency.

Example

```
>>> # xdoctest: +REQUIRES(module:sympy)
>>> import kwimage
>>> self = mat = kwimage.Matrix.random((3, 3)).rationalize()
>>> mat2 = kwimage.Matrix.random((3, 3))
>>> mat3 = mat @ mat2
>>> assert 'sympy' in mat3.matrix.__class__.__module__
>>> mat3 = mat2 @ mat
>>> assert 'sympy' in mat3.matrix.__class__.__module__
>>> assert not mat.isclose_identity()
>>> assert (mat @ mat.inv()).isclose_identity(rtol=0, atol=0)
```

astype(*dtype*)

Convert the underlying matrix to a rational type to avoid floating point errors. This does decrease efficiency.

Parameters
dtype (*type*)

isclose_identity(*rtol=1e-05*, *atol=1e-08*)

Returns true if the matrix is nearly the identity.

class kwimage.transform.**Linear**(*matrix*)

Bases: *Matrix*

class kwimage.transform.**Projective**(*matrix*)

Bases: *Linear*

A thin wraper around a 3x3 matrix that represent a projective transform

Implements methods for:

- creating random projective transforms
- decomposing the matrix
- finding a best-fit transform between corresponding points
- TODO: - [ ] fully rational transform

Example

```
>>> import kwimage
>>> import math
>>> image = kwimage.grab_test_image()
>>> theta = 0.123 * math.tau
>>> components = {
>>>     'rotate': kwimage.Projective.projective(theta=theta),
>>>     'scale': kwimage.Projective.projective(scale=0.5),
>>>     'shear': kwimage.Projective.projective(shearx=0.2),
>>>     'translation': kwimage.Projective.projective(offset=(100, 200)),
>>>     'rotate+translate': kwimage.Projective.projective(theta=0.123 * math.tau,␣
↪about=(256, 256)),
>>>     'perspective': kwimage.Projective.projective(uv=(0.0003, 0.0007)),
>>>     'random-composed': kwimage.Projective.random(scale=(0.5, 1.5), translate=(-
↪20, 20), theta=(-theta, theta), shearx=(0, .4), rng=9005581762108086000),
>>> }
>>> warp_stack = []
>>> for key, mat in components.items():
...     warp = kwimage.warp_projective(image, mat)
...     warp = kwimage.draw_text_on_image(
...         warp,
...         ub.repr2(mat.matrix, nl=1, nobr=1, precision=4, si=1, sv=1, with_
↪dtype=0),
...         org=(1, 1),
...         valign='top', halign='left',
...         fontScale=0.8, color='kw_green',
...         border={'thickness': 3},
...         )
```

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```
...     warp = kwimage.draw_header_text(warp, key, color='kw_blue')
...     warp_stack.append(warp)
>>> warp_canvas = kwimage.stack_images_grid(warp_stack, chunksize=4, pad=10, bg_
↪value='kitware_gray')
>>> # xdoctest: +REQUIRES(module:sympy)
>>> import sympy
>>> # Shows the symbolic construction of the code
>>> # https://groups.google.com/forum/#!topic/sympy/k1HnZK_bNNA
>>> from sympy.abc import theta
>>> params = x0, y0, sx, sy, theta, shearx, tx, ty, u, v = sympy.symbols(
>>>     'x0, y0, sx, sy, theta, ex, tx, ty, u, v')
>>> # move the center to 0, 0
>>> tr1_ = sympy.Matrix([[1, 0,  -x0],
>>>                      [0, 1,  -y0],
>>>                      [0, 0,   1]])
>>> P = sympy.Matrix([  # projective part
>>>     [ 1,  0,  0],
>>>     [ 0,  1,  0],
>>>     [ u,  v,  1]])
>>> # Define core components of the affine transform
>>> S = sympy.Matrix([  # scale
>>>     [sx,  0, 0],
>>>     [ 0, sy, 0],
>>>     [ 0,  0, 1]])
>>> E = sympy.Matrix([  # x-shear
>>>     [1,  shearx, 0],
>>>     [0,  1, 0],
>>>     [0,  0, 1]])
>>> R = sympy.Matrix([  # rotation
>>>     [sympy.cos(theta), -sympy.sin(theta), 0],
>>>     [sympy.sin(theta),  sympy.cos(theta), 0],
>>>     [               0,                 0, 1]])
>>> T = sympy.Matrix([  # translation
>>>     [ 1,  0, tx],
>>>     [ 0,  1, ty],
>>>     [ 0,  0,  1]])
>>> # move 0, 0 back to the specified origin
>>> tr2_ = sympy.Matrix([[1, 0,  x0],
>>>                      [0, 1,  y0],
>>>                      [0, 0,   1]])
>>> # combine transformations
>>> homog_ = sympy.MatMul(tr2_, T, R, E, S, P, tr1_)
>>> #with sympy.evaluate(False):
>>> #    homog_ = sympy.MatMul(tr2_, T, R, E, S, P, tr1_)
>>> #    sympy.pprint(homog_)
>>> homog = homog_.doit()
>>> #sympy.pprint(homog)
>>> print('homog = {}'.format(ub.repr2(homog.tolist(), nl=1)))
>>> # This could be prettier
>>> texts = {
>>>     'Translation': sympy.pretty(R, use_unicode=0),
>>>     'Rotation': sympy.pretty(R, use_unicode=0),
```

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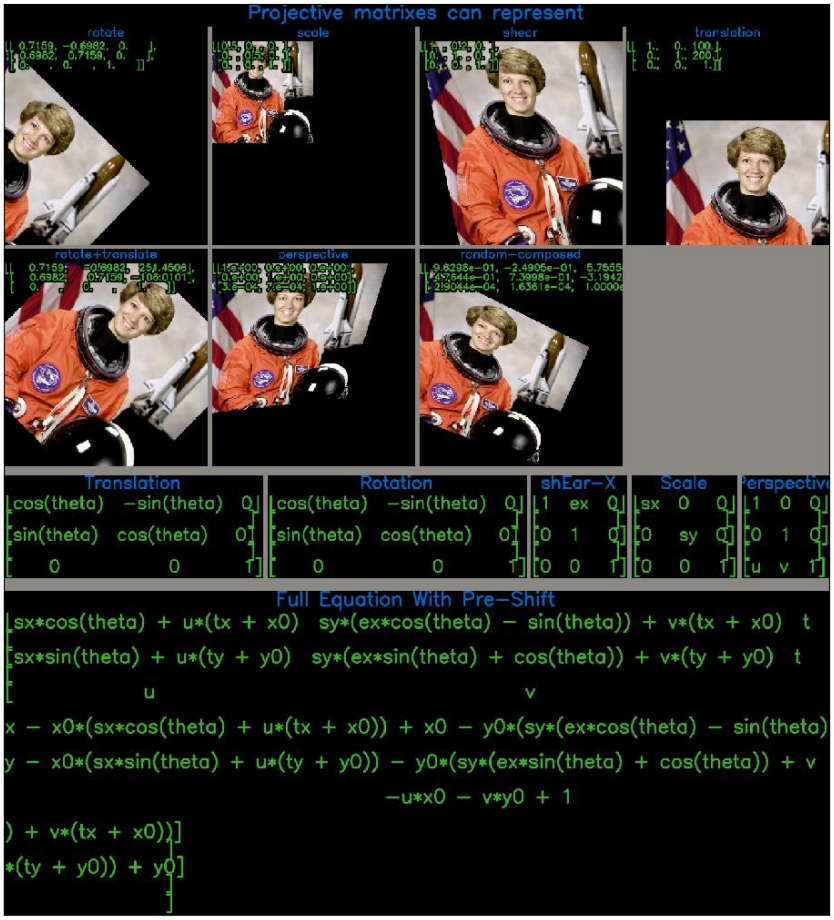
```
>>>     'shEar-X': sympy.pretty(E, use_unicode=0),
>>>     'Scale': sympy.pretty(S, use_unicode=0),
>>>     'Perspective': sympy.pretty(P, use_unicode=0),
>>> }
>>> print(ub.repr2(texts, nl=2, sv=1))
>>> equation_stack = []
>>> for text, m in texts.items():
>>>     render_canvas = kwimage.draw_text_on_image(None, m, color='kw_green',␣
↪fontScale=1.0)
>>>     render_canvas = kwimage.draw_header_text(render_canvas, text, color='kw_blue
↪')
>>>     render_canvas = kwimage.imresize(render_canvas, scale=1.3)
>>>     equation_stack.append(render_canvas)
>>> equation_canvas = kwimage.stack_images(equation_stack, pad=10, axis=1, bg_value=
↪'kitware_gray')
>>> render_canvas = kwimage.draw_text_on_image(None, sympy.pretty(homog, use_
↪unicode=0), color='kw_green', fontScale=1.0)
>>> render_canvas = kwimage.draw_header_text(render_canvas, 'Full Equation With Pre-
↪Shift', color='kw_blue')
>>> # xdoctest: -REQUIRES(module:sympy)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> plt = kwplot.autoplt()
>>> canvas = kwimage.stack_images([warp_canvas, equation_canvas, render_canvas],␣
↪pad=20, axis=0, bg_value='kitware_gray', resize='larger')
>>> canvas = kwimage.draw_header_text(canvas, 'Projective matrixes can represent',␣
↪color='kw_blue')
>>> kwplot.imshow(canvas)
>>> fig = plt.gcf()
>>> fig.set_size_inches(13, 13)
```



classmethod fit(*pts1*, *pts2*)

Fit an projective transformation between a set of corresponding points.

See [HomogEst] [SzeleskiBook] and [RansacDummies] for references on the subject.

Parameters

- **pts1** (*ndarray*) – An Nx2 array of points in “space 1”.
- **pts2** (*ndarray*) – A corresponding Nx2 array of points in “space 2”

Returns

a transform that warps from “space1” to “space2”.

Return type

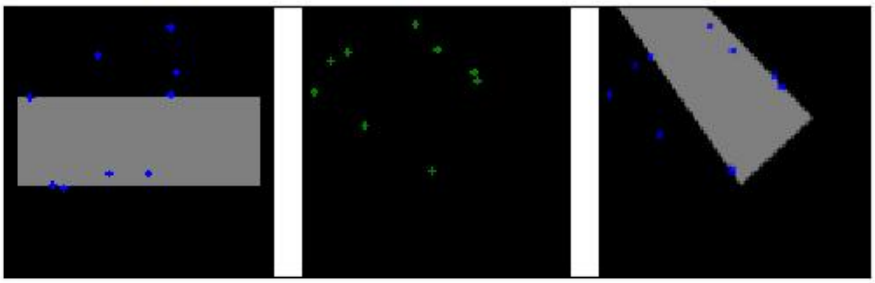
Projective

Note: A projective matrix has 8 degrees of freedome, so at least 8 point pairs are needed.

References

Example

```
>>> # Create a set of points, warp them, then recover the warp
>>> import kwimage
>>> points = kwimage.Points.random(9).scale(64)
>>> A1 = kwimage.Affine.affine(scale=0.9, theta=-3.2, offset=(2, 3), about=(32,
↪ 32), skew=2.3)
>>> A2 = kwimage.Affine.affine(scale=0.8, theta=0.8, offset=(2, 0), about=(32,␣
↪32))
>>> A12_real = A2 @ A1.inv()
>>> points1 = points.warp(A1)
>>> points2 = points.warp(A2)
>>> # Make the correspondence non-affine
>>> points2.data['xy'].data[0, 0] += 3.5
>>> points2.data['xy'].data[3, 1] += 8.5
>>> # Recover the warp
>>> pts1, pts2 = points1.xy, points2.xy
>>> A_recovered = kwimage.Projective.fit(pts1, pts2)
>>> #assert np.all(np.isclose(A_recovered.matrix, A12_real.matrix))
>>> # xdoctest: +REQUIRES(--show)
>>> import cv2
>>> import kwplot
>>> kwplot.autompl()
>>> base1 = np.zeros((96, 96, 3))
>>> base1[32:-32, 5:-5] = 0.5
>>> base2 = np.zeros((96, 96, 3))
>>> img1 = points1.draw_on(base1, radius=3, color='blue')
>>> img2 = points2.draw_on(base2, radius=3, color='green')
>>> img1_warp = kwimage.warp_projective(img1, A_recovered.matrix, dsize=img1.
↪shape[0:2][::-1])
>>> canvas = kwimage.stack_images([img1, img2, img1_warp], pad=10, axis=1, bg_
↪value=(1., 1., 1.))
>>> kwplot.imshow(canvas)
```



classmethod projective(*scale=None*, *offset=None*, *shearx=None*, *theta=None*, *uv=None*, *about=None*)

Reconstruct from parameters

Sympy

```
>>> # xdoctest: +SKIP
>>> import sympy
>>> # Shows the symbolic construction of the code
>>> # https://groups.google.com/forum/#!topic/sympy/k1HnZK_bNNA
>>> from sympy.abc import theta
>>> params = x0, y0, sx, sy, theta, shearx, tx, ty, u, v = sympy.symbols(
>>>     'x0, y0, sx, sy, theta, ex, tx, ty, u, v')
>>> # move the center to 0, 0
>>> tr1_ = sympy.Matrix([[1, 0,  -x0],
>>>                      [0, 1,  -y0],
>>>                      [0, 0,    1]])
>>> P = sympy.Matrix([  # projective part
>>>     [ 1,  0,  0],
>>>     [ 0,  1,  0],
>>>     [ u,  v,  1]])
>>> # Define core components of the affine transform
>>> S = sympy.Matrix([  # scale
>>>     [sx,  0, 0],
>>>     [ 0, sy, 0],
>>>     [ 0,  0, 1]])
```

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```
>>> E = sympy.Matrix([  # x-shear
>>>     [1,  shearx, 0],
>>>     [0,  1, 0],
>>>     [0,  0, 1]])
>>> R = sympy.Matrix([  # rotation
>>>     [sympy.cos(theta), -sympy.sin(theta), 0],
>>>     [sympy.sin(theta),  sympy.cos(theta), 0],
>>>     [               0,                 0, 1]])
>>> T = sympy.Matrix([  # translation
>>>     [ 1,  0, tx],
>>>     [ 0,  1, ty],
>>>     [ 0,  0,  1]])
>>> # move 0, 0 back to the specified origin
>>> tr2_ = sympy.Matrix([[1, 0,  x0],
>>>                      [0, 1,  y0],
>>>                      [0, 0,   1]])
>>> # combine transformations
>>> with sympy.evaluate(False):
>>>     homog_ = sympy.MatMul(tr2_, T, R, E, S, P, tr1_)
>>>     sympy.pprint(homog_)
>>> homog = homog_.doit()
>>> sympy.pprint(homog)
>>> print('homog = {}'.format(ub.repr2(homog.tolist(), nl=1)))
```

classmethod coerce(*data=None*, ***kwargs*)

Attempt to coerce the data into an Projective object

Parameters

- **data** – some data we attempt to coerce to an Projective matrix
- ****kwargs** – some data we attempt to coerce to an Projective matrix, mutually exclusive with *data*.

Returns

Projective

Example

```
>>> import kwimage
>>> kwimage.Projective.coerce({'type': 'affine', 'matrix': [[1, 0, 0], [0, 1,␣
↪0]]})
>>> kwimage.Projective.coerce({'type': 'affine', 'scale': 2})
>>> kwimage.Projective.coerce({'type': 'projective', 'scale': 2})
>>> kwimage.Projective.coerce({'scale': 2})
>>> kwimage.Projective.coerce({'offset': 3})
>>> kwimage.Projective.coerce(np.eye(3))
>>> kwimage.Projective.coerce(None)
>>> import skimage
>>> kwimage.Projective.coerce(skimage.transform.AffineTransform(scale=30))
>>> kwimage.Projective.coerce(skimage.transform.
↪ProjectiveTransform(matrix=None))
```

is_affine()

If the bottom row is [[0, 0, 1]], then this can be safely turned into an affine matrix.

Returns
bool

Example

```
>>> import kwimage
>>> kwimage.Projective.coerce(scale=2, uv=[1, 1]).is_affine()
False
>>> kwimage.Projective.coerce(scale=2, uv=[0, 0]).is_affine()
True
```

to_skimage()

Returns
skimage.transform.AffineTransform

Example

```
>>> import kwimage
>>> self = kwimage.Projective.random()
>>> tf = self.to_skimage()
>>> # Transform points with kwimage and scikit-image
>>> kw_poly = kwimage.Polygon.random()
>>> kw_warp_xy = kw_poly.warp(self.matrix).exterior.data
>>> sk_warp_xy = tf(kw_poly.exterior.data)
>>> assert np.allclose(sk_warp_xy, sk_warp_xy)
```

classmethod random(*shape=None*, *rng=None*, ***kw*)

Example/

```
>>> import kwimage
>>> self = kwimage.Projective.random()
>>> print(f'self={self}')
>>> params = self.decompose()
>>> aff_part = kwimage.Affine.affine(**ub.dict_diff(params, ['uv']))
>>> proj_part = kwimage.Projective.coerce(uv=params['uv'])
>>> # xdoctest: +REQUIRES(module:kwplot)
>>> # xdoctest: +REQUIRES(--show)
>>> import cv2
>>> import kwplot
>>> dsize = (256, 256)
>>> kwplot.autompl()
>>> img1 = kwimage.grab_test_image(dsize=dsize)
>>> img1_affonly = kwimage.warp_projective(img1, aff_part.matrix,␣
↪dsize=img1.shape[0:2][::-1])
>>> img1_projonly = kwimage.warp_projective(img1, proj_part.matrix,␣
↪dsize=img1.shape[0:2][::-1])
>>> ###
```

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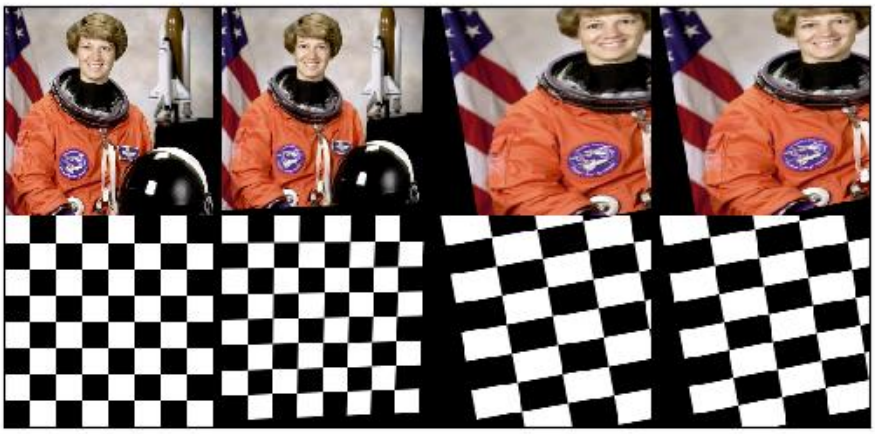
```
>>> img2 = kwimage.ensure_uint255(kwimage.atleast_3channels(kwimage.
↪checkerboard(dsize=dsize)))
>>> img1_fullwarp = kwimage.warp_projective(img1, self.matrix, dsize=img1.
↪shape[0:2][::-1])
>>> img2_affonly = kwimage.warp_projective(img2, aff_part.matrix,␣
↪dsize=img2.shape[0:2][::-1])
>>> img2_projonly = kwimage.warp_projective(img2, proj_part.matrix,␣
↪dsize=img2.shape[0:2][::-1])
>>> img2_fullwarp = kwimage.warp_projective(img2, self.matrix, dsize=img2.
↪shape[0:2][::-1])
>>> canvas1 = kwimage.stack_images([img1, img1_projonly, img1_affonly,␣
↪img1_fullwarp], pad=10, axis=1, bg_value=(0.5, 0.9, 0.1))
>>> canvas2 = kwimage.stack_images([img2, img2_projonly, img2_affonly,␣
↪img2_fullwarp], pad=10, axis=1, bg_value=(0.5, 0.9, 0.1))
>>> canvas = kwimage.stack_images([canvas1, canvas2], axis=0)
>>> kwplot.imshow(canvas)
```



decompose()

Based on the analysis done in [ME1319680].

Return type
Dict

References

Example

```
>>> # Create a set of points, warp them, then recover the warp
>>> import kwimage
>>> points = kwimage.Points.random(9).scale(64)
>>> A1 = kwimage.Affine.affine(scale=0.9, theta=-3.2, offset=(2, 3), about=(32,
↪ 32), skew=2.3)
>>> A2 = kwimage.Affine.affine(scale=0.8, theta=0.8, offset=(2, 0), about=(32,␣
↪32))
>>> A12_real = A2 @ A1.inv()
>>> points1 = points.warp(A1)
>>> points2 = points.warp(A2)
>>> # Make the correspondence non-affine
>>> points2.data['xy'].data[0, 0] += 3.5
>>> points2.data['xy'].data[3, 1] += 8.5
>>> # Recover the warp
>>> pts1, pts2 = points1.xy, points2.xy
>>> self = kwimage.Projective.random()
>>> self.decompose()
```

class kwimage.transform.**Affine**(*matrix*)

Bases: *Projective*

A thin wraper around a 3x3 matrix that represents an affine transform

Implements methods for:

- creating random affine transforms
- decomposing the matrix
- finding a best-fit transform between corresponding points
- TODO: - [ ] fully rational transform

Example

```
>>> import kwimage
>>> import math
>>> image = kwimage.grab_test_image()
>>> theta = 0.123 * math.tau
>>> components = {
>>>     'rotate': kwimage.Affine.affine(theta=theta),
>>>     'scale': kwimage.Affine.affine(scale=0.5),
>>>     'shear': kwimage.Affine.affine(shearx=0.2),
>>>     'translation': kwimage.Affine.affine(offset=(100, 200)),
>>>     'rotate+translate': kwimage.Affine.affine(theta=0.123 * math.tau,␣
↪about=(256, 256)),
>>>     'random composed': kwimage.Affine.random(scale=(0.5, 1.5), translate=(-20,␣
↪20), theta=(-theta, theta), shearx=(0, .4), rng=9005581762108086000),
>>> }
>>> warp_stack = []
>>> for key, aff in components.items():
```

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```
...     warp = kwimage.warp_affine(image, aff)
...     warp = kwimage.draw_text_on_image(
...         warp,
...         ub.repr2(aff.matrix, nl=1, nobr=1, precision=2, si=1, sv=1, with_
↪dtype=0),
...         org=(1, 1),
...         valign='top', halign='left',
...         fontScale=0.8, color='kw_blue',
...         border={'thickness': 3},
...         )
...     warp = kwimage.draw_header_text(warp, key, color='kw_green')
...     warp_stack.append(warp)
>>> warp_canvas = kwimage.stack_images_grid(warp_stack, chunksize=3, pad=10, bg_
↪value='kitware_gray')
>>> # xdoctest: +REQUIRES(module:sympy)
>>> import sympy
>>> # Shows the symbolic construction of the code
>>> # https://groups.google.com/forum/#!topic/sympy/k1HnZK_bNNA
>>> from sympy.abc import theta
>>> params = x0, y0, sx, sy, theta, shearx, tx, ty = sympy.symbols(
>>>     'x0, y0, sx, sy, theta, shearx, tx, ty')
>>> theta = sympy.symbols('theta')
>>> # move the center to 0, 0
>>> tr1_ = np.array([[1, 0,  -x0],
>>>                  [0, 1,  -y0],
>>>                  [0, 0,    1]])
>>> # Define core components of the affine transform
>>> S = np.array([  # scale
>>>     [sx,  0, 0],
>>>     [ 0, sy, 0],
>>>     [ 0,  0, 1]])
>>> E = np.array([  # x-shear
>>>     [1,  shearx, 0],
>>>     [0,  1, 0],
>>>     [0,  0, 1]])
>>> R = np.array([  # rotation
>>>     [sympy.cos(theta), -sympy.sin(theta), 0],
>>>     [sympy.sin(theta),  sympy.cos(theta), 0],
>>>     [               0,                 0, 1]])
>>> T = np.array([  # translation
>>>     [ 1,  0, tx],
>>>     [ 0,  1, ty],
>>>     [ 0,  0,  1]])
>>> # Contruct the affine 3x3 about the origin
>>> aff0 = np.array(sympy.simplify(T @ R @ E @ S))
>>> # move 0, 0 back to the specified origin
>>> tr2_ = np.array([[1, 0,  x0],
>>>                  [0, 1,  y0],
>>>                  [0, 0,   1]])
>>> # combine transformations
>>> aff = tr2_ @ aff0 @ tr1_
>>> print('aff = {}'.format(ub.repr2(aff.tolist(), nl=1)))
```

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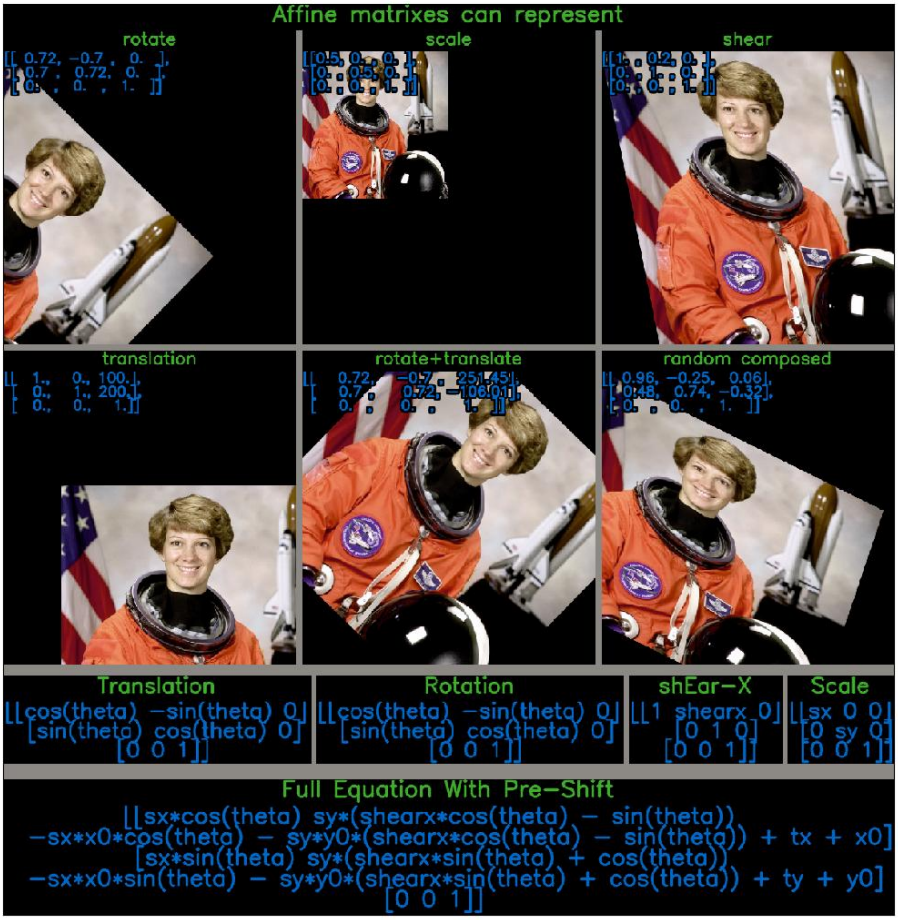
```
>>> # This could be prettier
>>> texts = {
>>>     'Translation': sympy.pretty(R),
>>>     'Rotation': sympy.pretty(R),
>>>     'shEar-X': sympy.pretty(E),
>>>     'Scale': sympy.pretty(S),
>>> }
>>> print(ub.repr2(texts, nl=2, sv=1))
>>> equation_stack = []
>>> for text, m in texts.items():
>>>     render_canvas = kwimage.draw_text_on_image(None, m, color='kw_blue',␣
↪fontScale=1.0)
>>>     render_canvas = kwimage.draw_header_text(render_canvas, text, color='kw_
↪green')
>>>     render_canvas = kwimage.imresize(render_canvas, scale=1.3)
>>>     equation_stack.append(render_canvas)
>>> equation_canvas = kwimage.stack_images(equation_stack, pad=10, axis=1, bg_value=
↪'kitware_gray')
>>> render_canvas = kwimage.draw_text_on_image(None, sympy.pretty(aff), color='kw_
↪blue', fontScale=1.0)
>>> render_canvas = kwimage.draw_header_text(render_canvas, 'Full Equation With Pre-
↪Shift', color='kw_green')
>>> # xdoctest: -REQUIRES(module:sympy)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> plt = kwplot.autoplt()
>>> canvas = kwimage.stack_images([warp_canvas, equation_canvas, render_canvas],␣
↪pad=20, axis=0, bg_value='kitware_gray', resize='larger')
>>> canvas = kwimage.draw_header_text(canvas, 'Affine matrixes can represent',␣
↪color='kw_green')
>>> kwplot.imshow(canvas)
>>> fig = plt.gcf()
>>> fig.set_size_inches(13, 13)
```



Example

```
>>> import kwimage
>>> self = kwimage.Affine(np.eye(3))
>>> m1 = np.eye(3) @ self
>>> m2 = self @ np.eye(3)
```

Example

```
>>> from kwimage.transform import *  # NOQA
>>> m = {}
>>> # Works, and returns a Affine
>>> m[len(m)] = x = Affine.random() @ np.eye(3)
>>> assert isinstance(x, Affine)
>>> m[len(m)] = x = Affine.random() @ None
>>> assert isinstance(x, Affine)
>>> # Works, and returns an ndarray
>>> m[len(m)] = x = np.eye(3) @ Affine.random()
>>> assert isinstance(x, np.ndarray)
>>> # Works, and returns an Matrix
>>> m[len(m)] = x = Affine.random() @ Matrix.random(3)
>>> assert isinstance(x, Matrix)
>>> m[len(m)] = x = Matrix.random(3) @ Affine.random()
>>> assert isinstance(x, Matrix)
>>> print('m = {}'.format(ub.repr2(m)))
```

property shape

concise()

Return a concise coercable dictionary representation of this matrix

Returns

a small serializable dict that can be passed
to *Affine.coerce()* to reconstruct this object.

Return type
Dict[str, object]

Returns
dictionary with consise parameters

Return type
Dict

Example

```
>>> import kwimage
>>> self = kwimage.Affine.random(rng=0, scale=1)
>>> params = self.concise()
>>> assert np.allclose(Affine.coerce(params).matrix, self.matrix)
>>> print('params = {}'.format(ub.repr2(params, nl=1, precision=2)))
params = {
    'offset': (0.08, 0.38),
    'theta': 0.08,
    'type': 'affine',
}
```

Example

```
>>> import kwimage
>>> self = kwimage.Affine.random(rng=0, scale=2, offset=0)
>>> params = self.concise()
>>> assert np.allclose(Affine.coerce(params).matrix, self.matrix)
>>> print('params = {}'.format(ub.repr2(params, nl=1, precision=2)))
params = {
    'scale': 2.00,
    'theta': 0.04,
    'type': 'affine',
}
```

classmethod coerce(*data=None*, ***kwargs*)

Attempt to coerce the data into an affine object

Parameters

- **data** – some data we attempt to coerce to an Affine matrix
- ****kwargs** – some data we attempt to coerce to an Affine matrix, mutually exclusive with *data*.

Returns
Affine

Example

```
>>> import kwimage
>>> kwimage.Affine.coerce({'type': 'affine', 'matrix': [[1, 0, 0], [0, 1, 0]]})
>>> kwimage.Affine.coerce({'scale': 2})
>>> kwimage.Affine.coerce({'offset': 3})
>>> kwimage.Affine.coerce(np.eye(3))
>>> kwimage.Affine.coerce(None)
>>> kwimage.Affine.coerce(skimage.transform.AffineTransform(scale=30))
```

eccentricity()

Eccentricity of the ellipse formed by this affine matrix

Returns

large when there are big scale differences in principle
directions or skews.

Return type
float

References

https://en.wikipedia.org/wiki/Conic_section https://github.com/rasterio/affine/blob/78c20a0cfbb5ec/affine/__init__.py#L368

Example

```
>>> import kwimage
>>> kwimage.Affine.random(rng=432).eccentricity()
```

to_shapely()

Returns a matrix suitable for shapely.affinity.affine_transform

Returns
Tuple[float, float, float, float, float, float]

Example

```
>>> import kwimage
>>> self = kwimage.Affine.random()
>>> sh_transform = self.to_shapely()
>>> # Transform points with kwimage and shapley
>>> import shapely
>>> from shapely.affinity import affine_transform
>>> kw_poly = kwimage.Polygon.random()
>>> kw_warp_poly = kw_poly.warp(self)
>>> sh_poly = kw_poly.to_shapely()
>>> sh_warp_poly = affine_transform(sh_poly, sh_transform)
>>> kw_warp_poly_recon = kwimage.Polygon.from_shapely(sh_warp_poly)
>>> assert np.allclose(kw_warp_poly_recon.exterior.data, kw_warp_poly_recon.
↪exterior.data)
```

to_skimage()

Returns
skimage.transform.AffineTransform

Example

```
>>> import kwimage
>>> self = kwimage.Affine.random()
>>> tf = self.to_skimage()
>>> # Transform points with kwimage and scikit-image
>>> kw_poly = kwimage.Polygon.random()
>>> kw_warp_xy = kw_poly.warp(self.matrix).exterior.data
>>> sk_warp_xy = tf(kw_poly.exterior.data)
>>> assert np.allclose(sk_warp_xy, sk_warp_xy)
```

classmethod scale(*scale*)

Create a scale Affine object

Parameters
scale (*float | Tuple[float, float]*) – x, y scale factor

Returns
Affine

classmethod translate(*offset*)

Create a translation Affine object

Parameters
offset (*float | Tuple[float, float]*) – x, y translation factor

Returns
Affine

Benchmark

```
>>> # xdoctest: +REQUIRES(--benchmark)
>>> # It is ~3x faster to use the more specific method
>>> import timerit
>>> import kwimage
>>> #
>>> offset = np.random.rand(2)
>>> ti = timerit.Timerit(100, bestof=10, verbose=2)
>>> for timer in ti.reset('time'):
>>>     with timer:
>>>         kwimage.Affine.translate(offset)
>>> #
>>> for timer in ti.reset('time'):
>>>     with timer:
>>>         kwimage.Affine.affine(offset=offset)
```

classmethod rotate(*theta*)

Create a rotation Affine object

Parameters
theta (*float*) – counter-clockwise rotation angle in radians

Returns
Affine

classmethod random(*shape=None*, *rng=None*, ***kw*)

Create a random Affine object

Parameters

- **rng** – random number generator
- ****kw** – passed to *Affine.random_params()*. can contain coercable random distributions for scale, offset, about, theta, and shearx.

Returns
Affine

classmethod random_params(*rng=None*, ***kw*)

Parameters

- **rng** – random number generator

- ****kw** – can contain coercable random distributions for scale, offset, about, theta, and shearx.

Returns
affine parameters suitable to be passed to Affine.affine

Return type
Dict

Todo:

- [ ] improve kwargs parameterization

`decompose()`

Decompose the affine matrix into its individual scale, translation, rotation, and skew parameters.

Returns
decomposed offset, scale, theta, and shearx params

Return type
Dict

References

https://math.stackexchange.com/questions/612006/decompose-affine https://math.stackexchange.com/a/3521141/353527 https://stackoverflow.com/questions/70357473/how-to-decompose-a-2x2-affine-matrix-with-sympy https://en.wikipedia.org/wiki/Transformation_matrix https://en.wikipedia.org/wiki/Shear_mapping

Example

```
>>> from kwimage.transform import *  # NOQA
>>> self = Affine.random()
>>> params = self.decompose()
>>> recon = Affine.coerce(**params)
>>> params2 = recon.decompose()
>>> pt = np.vstack([np.random.rand(2, 1), [1]])
>>> result1 = self.matrix[0:2] @ pt
>>> result2 = recon.matrix[0:2] @ pt
>>> assert np.allclose(result1, result2)
```

```
>>> self = Affine.scale(0.001) @ Affine.random()
>>> params = self.decompose()
>>> self.det()
```

Example

```
>>> # xdoctest: +REQUIRES(module:pandas)
>>> from kwimage.transform import *  # NOQA
>>> import kwimage
>>> import pandas as pd
>>> # Test consistency of decompose + reconstruct
>>> param_grid = list(ub.named_product({
>>>     'theta': np.linspace(-4 * np.pi, 4 * np.pi, 3),
>>>     'shearx': np.linspace(- 10 * np.pi, 10 * np.pi, 4),
>>> }))
>>> def normalize_angle(radian):
>>>     return np.arctan2(np.sin(radian), np.cos(radian))
>>> for pextra in param_grid:
>>>     params0 = dict(scale=(3.05, 3.07), offset=(10.5, 12.1), **pextra)
>>>     self = recon0 = kwimage.Affine.affine(**params0)
>>>     self.decompose()
>>>     # Test drift with multiple decompose / reconstructions
>>>     params_list = [params0]
>>>     recon_list = [recon0]
>>>     n = 4
>>>     for _ in range(n):
>>>         prev = recon_list[-1]
>>>         params = prev.decompose()
>>>         recon = kwimage.Affine.coerce(**params)
>>>         params_list.append(params)
>>>         recon_list.append(recon)
>>>     params_df = pd.DataFrame(params_list)
>>>     #print('params_list = {}'.format(ub.repr2(params_list, nl=1,␣
↪precision=5)))
>>>     print(params_df)
>>>     assert ub.allsame(normalize_angle(params_df['theta']), eq=np.isclose)
>>>     assert ub.allsame(params_df['shearx'], eq=np.allclose)
>>>     assert ub.allsame(params_df['scale'], eq=np.allclose)
>>>     assert ub.allsame(params_df['offset'], eq=np.allclose)
```

classmethod affine(*scale=None*, *offset=None*, *theta=None*, *shear=None*, *about=None*, *shearx=None*, *array_cls=None*, *math_mod=None*, ***kwargs*)

Create an affine matrix from high-level parameters

Parameters

- **scale** (*float | Tuple[float, float]*) – x, y scale factor
- **offset** (*float | Tuple[float, float]*) – x, y translation factor
- **theta** (*float*) – counter-clockwise rotation angle in radians
- **shearx** (*float*) – shear factor parallel to the x-axis.
- **about** (*float | Tuple[float, float]*) – x, y location of the origin
- **shear** (*float*) – BROKEN, dont use. counter-clockwise shear angle in radians

---

Todo:

- **[ ] Add aliases? -**
  origin : alias for about rotation : alias for theta translation : alias for offset

---

Returns
the constructed Affine object

Return type
Affine

Example

```
>>> from kwimage.transform import *  # NOQA
>>> rng = kwarray.ensure_rng(None)
>>> scale = rng.randn(2) * 10
>>> offset = rng.randn(2) * 10
>>> about = rng.randn(2) * 10
>>> theta = rng.randn() * 10
>>> shearx = rng.randn() * 10
>>> # Create combined matrix from all params
>>> F = Affine.affine(
>>>     scale=scale, offset=offset, theta=theta, shearx=shearx,
>>>     about=about)
>>> # Test that combining components matches
>>> S = Affine.affine(scale=scale)
>>> T = Affine.affine(offset=offset)
>>> R = Affine.affine(theta=theta)
>>> E = Affine.affine(shearx=shearx)
>>> O = Affine.affine(offset=about)
>>> # combine (note shear must be on the RHS of rotation)
>>> alt  = O @ T @ R @ E @ S @ O.inv()
>>> print('F    = {}'.format(ub.repr2(F.matrix.tolist(), nl=1)))
>>> print('alt  = {}'.format(ub.repr2(alt.matrix.tolist(), nl=1)))
>>> assert np.all(np.isclose(alt.matrix, F.matrix))
>>> pt = np.vstack([np.random.rand(2, 1), [[1]]])
>>> warp_pt1 = (F.matrix @ pt)
>>> warp_pt2 = (alt.matrix @ pt)
>>> assert np.allclose(warp_pt2, warp_pt1)
```

Sympy

```
>>> # xdoctest: +SKIP
>>> import sympy
>>> # Shows the symbolic construction of the code
>>> # https://groups.google.com/forum/#!topic/sympy/k1HnZK_bNNA
>>> from sympy.abc import theta
>>> params = x0, y0, sx, sy, theta, shearx, tx, ty = sympy.symbols(
>>>     'x0, y0, sx, sy, theta, shearx, tx, ty')
>>> # move the center to 0, 0
>>> tr1_ = np.array([[1, 0,  -x0],
>>>                  [0, 1,  -y0],
```

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```
>>>                  [0, 0,    1]])
>>> # Define core components of the affine transform
>>> S = np.array([  # scale
>>>     [sx,  0, 0],
>>>     [ 0, sy, 0],
>>>     [ 0,  0, 1]])
>>> E = np.array([  # x-shear
>>>     [1,  shearx, 0],
>>>     [0,  1, 0],
>>>     [0,  0, 1]])
>>> R = np.array([  # rotation
>>>     [sympy.cos(theta), -sympy.sin(theta), 0],
>>>     [sympy.sin(theta),  sympy.cos(theta), 0],
>>>     [               0,                 0, 1]])
>>> T = np.array([  # translation
>>>     [ 1,  0, tx],
>>>     [ 0,  1, ty],
>>>     [ 0,  0,  1]])
>>> # Contruct the affine 3x3 about the origin
>>> aff0 = np.array(sympy.simplify(T @ R @ E @ S))
>>> # move 0, 0 back to the specified origin
>>> tr2_ = np.array([[1, 0,  x0],
>>>                  [0, 1,  y0],
>>>                  [0, 0,   1]])
>>> # combine transformations
>>> aff = tr2_ @ aff0 @ tr1_
>>> print('aff = {}'.format(ub.repr2(aff.tolist(), nl=1)))
```

classmethod fit(*pts1*, *pts2*)

Fit an affine transformation between a set of corresponding points

Parameters

- **pts1** (*ndarray*) – An Nx2 array of points in “space 1”.
- **pts2** (*ndarray*) – A corresponding Nx2 array of points in “space 2”

Returns

a transform that warps from “space1” to “space2”.

Return type

Affine

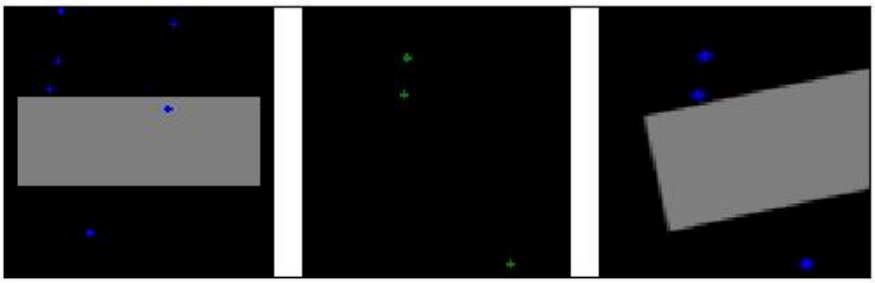
Note: An affine matrix has 6 degrees of freedome, so at least 6 point pairs are needed.

References

https://www.cs.ubc.ca/~lowe/papers/ijcv04.pdf page 22

Example

```
>>> # Create a set of points, warp them, then recover the warp
>>> import kwimage
>>> points = kwimage.Points.random(6).scale(64)
>>> #A1 = kwimage.Affine.affine(scale=0.9, theta=-3.2, offset=(2, 3),␣
↪about=(32, 32), skew=2.3)
>>> #A2 = kwimage.Affine.affine(scale=0.8, theta=0.8, offset=(2, 0), about=(32,
↪ 32))
>>> A1 = kwimage.Affine.random()
>>> A2 = kwimage.Affine.random()
>>> A12_real = A2 @ A1.inv()
>>> points1 = points.warp(A1)
>>> points2 = points.warp(A2)
>>> # Recover the warp
>>> pts1, pts2 = points1.xy, points2.xy
>>> A_recovered = kwimage.Affine.fit(pts1, pts2)
>>> assert np.all(np.isclose(A_recovered.matrix, A12_real.matrix))
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> base1 = np.zeros((96, 96, 3))
>>> base1[32:-32, 5:-5] = 0.5
>>> base2 = np.zeros((96, 96, 3))
>>> img1 = points1.draw_on(base1, radius=3, color='blue')
>>> img2 = points2.draw_on(base2, radius=3, color='green')
>>> img1_warp = kwimage.warp_affine(img1, A_recovered)
>>> canvas = kwimage.stack_images([img1, img2, img1_warp], pad=10, axis=1, bg_
↪value=(1., 1., 1.))
>>> kwplot.imshow(canvas)
```



kwimage.util_warp module

Todo:

- [ ] Replace internal padded slice with kwarray.padded_slice

kwimage.util_warp.**warp_tensor**(*inputs*, *mat*, *output_dims*, *mode='bilinear'*, *padding_mode='zeros'*, *isinv=False*, *ishomog=None*, *align_corners=False*, *new_mode=False*)

A pytorch implementation of warp affine that works similarly to `cv2.warpAffine()` and `cv2.warpPerspective()`.

It is possible to use 3x3 transforms to warp 2D image data. It is also possible to use 4x4 transforms to warp 3D volumetric data.

Parameters

- **inputs** (*Tensor*) – tensor to warp. Up to 3 (determined by output_dims) of the trailing space-time dimensions are warped. Best practice is to use inputs with the shape in [B, C, *DIMS].
- **mat** (*Tensor*) – either a 3x3 / 4x4 single transformation matrix to apply to all inputs or Bx3x3 or Bx4x4 tensor that specifies a transformation matrix for each batch item.
- **output_dims** (*Tuple[int, ...]*) – The output space-time dimensions. This can either be in the form (W,), (H, W), or (D, H, W).
- **mode** (*str*) – Can be bilinear or nearest. See *torch.nn.functional.grid_sample*

- **padding_mode** (*str*) – Can be zeros, border, or reflection. See *torch.nn.functional.grid_sample*.
- **isinv** (*bool*) – Set to true if *mat* is the inverse transform
- **ishomog** (*bool*) – Set to True if the matrix is non-affine
- **align_corners** (*bool*) – Note the default of False does not work correctly with grid_sample in torch <= 1.2, but using align_corners=True isnt typically what you want either. We will be stuck with buggy functionality until torch 1.3 is released.

  However, using align_corners=0 does seem to reasonably correspond with opencv behavior.

Returns
warped tensor

Return type
Tensor

Note: Also, it may be possible to speed up the code with *F.affine_grid*

KNOWN ISSUE: There appears to some difference with cv2.warpAffine when
rotation or shear are non-zero. I'm not sure what the cause is. It may just be floating point issues, but Im' not sure.

See issues in [TorchAffineTransform] and [TorchIssue15386].

Todo:

- [ ] FIXME: see example in Mask.scale where this algo breaks when the matrix is *2x3*
- [ ] Make this algo work when matrix ix 2x2

References

Example

```
>>> # Create a relatively simple affine matrix
>>> # xdoctest: +REQUIRES(module:torch)
>>> import skimage
>>> mat = torch.FloatTensor(skimage.transform.AffineTransform(
>>>     translation=[1, -1], scale=[.532, 2],
>>>     rotation=0, shear=0,
>>> ).params)
>>> # Create inputs and an output dimension
>>> input_shape = [1, 1, 4, 5]
>>> inputs = torch.arange(int(np.prod(input_shape))).reshape(*input_shape).float()
>>> output_dims = (11, 7)
>>> # Warp with our code
>>> result1 = warp_tensor(inputs, mat, output_dims=output_dims, align_corners=0)
>>> print('result1 =\n{}'.format(ub.repr2(result1.cpu().numpy()[0, 0],␣
↪precision=2)))
>>> # Warp with opencv
```

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```
>>> import cv2
>>> cv2_M = mat.cpu().numpy()[0:2]
>>> src = inputs[0, 0].cpu().numpy()
>>> dsize = tuple(output_dims[::-1])
>>> result2 = cv2.warpAffine(src, cv2_M, dsize=dsize, flags=cv2.INTER_LINEAR)
>>> print('result2 =\n{}'.format(ub.repr2(result2, precision=2)))
>>> # Ensure the results are the same (up to floating point errors)
>>> assert np.all(np.isclose(result1[0, 0].cpu().numpy(), result2, atol=1e-2,␣
↪rtol=1e-2))
```

Example

```
>>> # Create a relatively simple affine matrix
>>> # xdoctest: +REQUIRES(module:torch)
>>> import skimage
>>> mat = torch.FloatTensor(skimage.transform.AffineTransform(
>>>     rotation=0.01, shear=0.1).params)
>>> # Create inputs and an output dimension
>>> input_shape = [1, 1, 4, 5]
>>> inputs = torch.arange(int(np.prod(input_shape))).reshape(*input_shape).float()
>>> output_dims = (11, 7)
>>> # Warp with our code
>>> result1 = warp_tensor(inputs, mat, output_dims=output_dims)
>>> print('result1 =\n{}'.format(ub.repr2(result1.cpu().numpy()[0, 0], precision=2,␣
↪supress_small=True)))
>>> print('result1.shape = {}'.format(result1.shape))
>>> # Warp with opencv
>>> import cv2
>>> cv2_M = mat.cpu().numpy()[0:2]
>>> src = inputs[0, 0].cpu().numpy()
>>> dsize = tuple(output_dims[::-1])
>>> result2 = cv2.warpAffine(src, cv2_M, dsize=dsize, flags=cv2.INTER_LINEAR)
>>> print('result2 =\n{}'.format(ub.repr2(result2, precision=2)))
>>> print('result2.shape = {}'.format(result2.shape))
>>> # Ensure the results are the same (up to floating point errors)
>>> # NOTE: The floating point errors seem to be significant for rotation / shear
>>> assert np.all(np.isclose(result1[0, 0].cpu().numpy(), result2, atol=1, rtol=1e-
↪2))
```

Example

```
>>> # Create a random affine matrix
>>> # xdoctest: +REQUIRES(module:torch)
>>> import skimage
>>> rng = np.random.RandomState(0)
>>> mat = torch.FloatTensor(skimage.transform.AffineTransform(
>>>     translation=rng.randn(2), scale=1 + rng.randn(2),
>>>     rotation=rng.randn() / 10., shear=rng.randn() / 10.,
>>> ).params)
```

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```
>>> # Create inputs and an output dimension
>>> input_shape = [1, 1, 5, 7]
>>> inputs = torch.arange(int(np.prod(input_shape))).reshape(*input_shape).float()
>>> output_dims = (3, 11)
>>> # Warp with our code
>>> result1 = warp_tensor(inputs, mat, output_dims=output_dims, align_corners=0)
>>> print('result1 =\n{}'.format(ub.repr2(result1.cpu().numpy()[0, 0],␣
↪precision=2)))
>>> # Warp with opencv
>>> import cv2
>>> cv2_M = mat.cpu().numpy()[0:2]
>>> src = inputs[0, 0].cpu().numpy()
>>> dsize = tuple(output_dims[::-1])
>>> result2 = cv2.warpAffine(src, cv2_M, dsize=dsize, flags=cv2.INTER_LINEAR)
>>> print('result2 =\n{}'.format(ub.repr2(result2, precision=2)))
>>> # Ensure the results are the same (up to floating point errors)
>>> # NOTE: The errors seem to be significant for rotation / shear
>>> assert np.all(np.isclose(result1[0, 0].cpu().numpy(), result2, atol=1, rtol=1e-
↪2))
```

Example

```
>>> # Test 3D warping with identity
>>> # xdoctest: +REQUIRES(module:torch)
>>> mat = torch.eye(4)
>>> input_dims = [2, 3, 3]
>>> output_dims = (2, 3, 3)
>>> input_shape = [1, 1] + input_dims
>>> inputs = torch.arange(int(np.prod(input_shape))).reshape(*input_shape).float()
>>> result = warp_tensor(inputs, mat, output_dims=output_dims)
>>> print('result =\n{}'.format(ub.repr2(result.cpu().numpy()[0, 0], precision=2)))
>>> assert torch.all(inputs == result)
```

Example

```
>>> # Test 3D warping with scaling
>>> # xdoctest: +REQUIRES(module:torch)
>>> mat = torch.FloatTensor([
>>>     [0.8,   0,   0, 0],
>>>     [  0, 1.0,   0, 0],
>>>     [  0,   0, 1.2, 0],
>>>     [  0,   0,   0, 1],
>>> ])
>>> input_dims = [2, 3, 3]
>>> output_dims = (2, 3, 3)
>>> input_shape = [1, 1] + input_dims
>>> inputs = torch.arange(int(np.prod(input_shape))).reshape(*input_shape).float()
>>> result = warp_tensor(inputs, mat, output_dims=output_dims, align_corners=0)
>>> print('result =\n{}'.format(ub.repr2(result.cpu().numpy()[0, 0], precision=2)))
```

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```
result =
np.array([[[ 0.  ,  1.25,  1.  ],
           [ 3.  ,  4.25,  2.5 ],
           [ 6.  ,  7.25,  4.  ]],
          ...
          [[ 7.5 ,  8.75,  4.75],
           [10.5 , 11.75,  6.25],
           [13.5 , 14.75,  7.75]]], dtype=np.float32)
```

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> mat = torch.eye(3)
>>> input_dims = [5, 7]
>>> output_dims = (11, 7)
>>> for n_prefix_dims in [0, 1, 2, 3, 4, 5]:
>>>     input_shape = [2] * n_prefix_dims + input_dims
>>>     inputs = torch.arange(int(np.prod(input_shape))).reshape(*input_shape).
↪float()
>>>     result = warp_tensor(inputs, mat, output_dims=output_dims)
>>>     #print('result =\n{}'.format(ub.repr2(result.cpu().numpy(), precision=2)))
>>>     print(result.shape)
```

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> mat = torch.eye(4)
>>> input_dims = [5, 5, 5]
>>> output_dims = (6, 6, 6)
>>> for n_prefix_dims in [0, 1, 2, 3, 4, 5]:
>>>     input_shape = [2] * n_prefix_dims + input_dims
>>>     inputs = torch.arange(int(np.prod(input_shape))).reshape(*input_shape).
↪float()
>>>     result = warp_tensor(inputs, mat, output_dims=output_dims)
>>>     #print('result =\n{}'.format(ub.repr2(result.cpu().numpy(), precision=2)))
>>>     print(result.shape)
```

kwimage.util_warp.**subpixel_align**(*dst*, *src*, *index*, *interp_axes=None*)

Returns an aligned version of the source tensor and destination index.

Used as the backend to implement other subpixel functions like:
subpixel_accum, subpixel_maximum.

kwimage.util_warp.**subpixel_set**(*dst*, *src*, *index*, *interp_axes=None*)

Add the source values array into the destination array at a particular subpixel index.

Parameters

- **dst** (*ArrayLike*) – destination accumulation array
- **src** (*ArrayLike*) – source array containing values to add

- **index** (*Tuple[slice]*) – subpixel slice into dst that corresponds with src
- **interp_axes** (*tuple*) – specify which axes should be spatially interpolated

Todo:

- [ ]: allow index to be a sequence indices

Example

```
>>> import kwimage
>>> dst = np.zeros(5) + .1
>>> src = np.ones(2)
>>> index = [slice(1.5, 3.5)]
>>> kwimage.util_warp.subpixel_set(dst, src, index)
>>> print(ub.repr2(dst, precision=2, with_dtype=0))
np.array([0.1, 0.5, 1. , 0.5, 0.1])
```

kwimage.util_warp.**subpixel_accum**(*dst*, *src*, *index*, *interp_axes=None*)

Add the source values array into the destination array at a particular subpixel index.

Parameters

- **dst** (*ArrayLike*) – destination accumulation array
- **src** (*ArrayLike*) – source array containing values to add
- **index** (*Tuple[slice]*) – subpixel slice into dst that corresponds with src
- **interp_axes** (*tuple*) – specify which axes should be spatially interpolated

TextArt

```
Inputs:
    +---+---+---+---+---+  dst.shape = (5,)
          +---+---+        src.shape = (2,)
          |=======|        index = 1.5:3.5

Subpixel shift the source by -0.5.
When the index is non-integral, pad the aligned src with an extra value
to ensure all dst pixels that would be influenced by the smaller
subpixel shape are influenced by the aligned src. Note that we are not
scaling.

        +---+---+---+      aligned_src.shape = (3,)
        |===========|      aligned_index = 1:4
```

Example

```
>>> dst = np.zeros(5)
>>> src = np.ones(2)
>>> index = [slice(1.5, 3.5)]
>>> subpixel_accum(dst, src, index)
>>> print(ub.repr2(dst, precision=2, with_dtype=0))
np.array([0. , 0.5, 1. , 0.5, 0. ])
```

Example

```
>>> dst = np.zeros((6, 6))
>>> src = np.ones((3, 3))
>>> index = (slice(1.5, 4.5), slice(1, 4))
>>> subpixel_accum(dst, src, index)
>>> print(ub.repr2(dst, precision=2, with_dtype=0))
np.array([[0. , 0. , 0. , 0. , 0. , 0. ],
          [0. , 0.5, 0.5, 0.5, 0. , 0. ],
          [0. , 1. , 1. , 1. , 0. , 0. ],
          [0. , 1. , 1. , 1. , 0. , 0. ],
          [0. , 0.5, 0.5, 0.5, 0. , 0. ],
          [0. , 0. , 0. , 0. , 0. , 0. ]])
>>> # xdoctest: +REQUIRES(module:torch)
>>> dst = torch.zeros((1, 3, 6, 6))
>>> src = torch.ones((1, 3, 3, 3))
>>> index = (slice(None), slice(None), slice(1.5, 4.5), slice(1.25, 4.25))
>>> subpixel_accum(dst, src, index)
>>> print(ub.repr2(dst.numpy()[0, 0], precision=2, with_dtype=0))
np.array([[0.  , 0.  , 0.  , 0.  , 0.  , 0.  ],
          [0.  , 0.38, 0.5 , 0.5 , 0.12, 0.  ],
          [0.  , 0.75, 1.  , 1.  , 0.25, 0.  ],
          [0.  , 0.75, 1.  , 1.  , 0.25, 0.  ],
          [0.  , 0.38, 0.5 , 0.5 , 0.12, 0.  ],
          [0.  , 0.  , 0.  , 0.  , 0.  , 0.  ]])
```

Doctest

```
>>> # TODO: move to a unit test file
>>> subpixel_accum(np.zeros(5), np.ones(2), [slice(1.5, 3.5)]).tolist()
[0.0, 0.5, 1.0, 0.5, 0.0]
>>> subpixel_accum(np.zeros(5), np.ones(2), [slice(0, 2)]).tolist()
[1.0, 1.0, 0.0, 0.0, 0.0]
>>> subpixel_accum(np.zeros(5), np.ones(3), [slice(.5, 3.5)]).tolist()
[0.5, 1.0, 1.0, 0.5, 0.0]
>>> subpixel_accum(np.zeros(5), np.ones(3), [slice(-1, 2)]).tolist()
[1.0, 1.0, 0.0, 0.0, 0.0]
>>> subpixel_accum(np.zeros(5), np.ones(3), [slice(-1.5, 1.5)]).tolist()
[1.0, 0.5, 0.0, 0.0, 0.0]
>>> subpixel_accum(np.zeros(5), np.ones(3), [slice(10, 13)]).tolist()
[0.0, 0.0, 0.0, 0.0, 0.0]
```

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```
>>> subpixel_accum(np.zeros(5), np.ones(3), [slice(3.25, 6.25)]).tolist()
[0.0, 0.0, 0.0, 0.75, 1.0]
>>> subpixel_accum(np.zeros(5), np.ones(3), [slice(4.9, 7.9)]).tolist()
[0.0, 0.0, 0.0, 0.0, 0.099...]
>>> subpixel_accum(np.zeros(5), np.ones(9), [slice(-1.5, 7.5)]).tolist()
[1.0, 1.0, 1.0, 1.0, 1.0]
>>> subpixel_accum(np.zeros(5), np.ones(9), [slice(2.625, 11.625)]).tolist()
[0.0, 0.0, 0.375, 1.0, 1.0]
>>> subpixel_accum(np.zeros(5), 1, [slice(2.625, 11.625)]).tolist()
[0.0, 0.0, 0.375, 1.0, 1.0]
```

kwimage.util_warp.**subpixel_maximum**(*dst*, *src*, *index*, *interp_axes=None*)

Take the max of the source values array into and the destination array at a particular subpixel index. Modifies the destination array.

Parameters

- **dst** (*ArrayLike*) – destination array to index into
- **src** (*ArrayLike*) – source array that agrees with the index
- **index** (*Tuple[slice]*) – subpixel slice into dst that corresponds with src
- **interp_axes** (*tuple*) – specify which axes should be spatially interpolated

Example

```
>>> dst = np.array([0, 1.0, 1.0, 1.0, 0])
>>> src = np.array([2.0, 2.0])
>>> index = [slice(1.6, 3.6)]
>>> subpixel_maximum(dst, src, index)
>>> print(ub.repr2(dst, precision=2, with_dtype=0))
np.array([0. , 1. , 2. , 1.2, 0. ])
```

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> dst = torch.zeros((1, 3, 5, 5)) + .5
>>> src = torch.ones((1, 3, 3, 3))
>>> index = (slice(None), slice(None), slice(1.4, 4.4), slice(1.25, 4.25))
>>> subpixel_maximum(dst, src, index)
>>> print(ub.repr2(dst.numpy()[0, 0], precision=2, with_dtype=0))
np.array([[0.5 , 0.5 , 0.5 , 0.5 , 0.5 ],
          [0.5 , 0.5 , 0.6 , 0.6 , 0.5 ],
          [0.5 , 0.75, 1.  , 1.  , 0.5 ],
          [0.5 , 0.75, 1.  , 1.  , 0.5 ],
          [0.5 , 0.5 , 0.5 , 0.5 , 0.5 ]])
```

kwimage.util_warp.**subpixel_minimum**(*dst*, *src*, *index*, *interp_axes=None*)

Take the min of the source values array into and the destination array at a particular subpixel index. Modifies the destination array.

Parameters

- **dst** (*ArrayLike*) – destination array to index into
- **src** (*ArrayLike*) – source array that agrees with the index
- **index** (*Tuple[slice]*) – subpixel slice into dst that corresponds with src
- **interp_axes** (*tuple*) – specify which axes should be spatially interpolated

Example

```
>>> dst = np.array([0, 1.0, 1.0, 1.0, 0])
>>> src = np.array([2.0, 2.0])
>>> index = [slice(1.6, 3.6)]
>>> subpixel_minimum(dst, src, index)
>>> print(ub.repr2(dst, precision=2, with_dtype=0))
np.array([0. , 0.8, 1. , 1. , 0. ])
```

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> dst = torch.zeros((1, 3, 5, 5)) + .5
>>> src = torch.ones((1, 3, 3, 3))
>>> index = (slice(None), slice(None), slice(1.4, 4.4), slice(1.25, 4.25))
>>> subpixel_minimum(dst, src, index)
>>> print(ub.repr2(dst.numpy()[0, 0], precision=2, with_dtype=0))
np.array([[0.5 , 0.5 , 0.5 , 0.5 , 0.5 ],
          [0.5 , 0.45, 0.5 , 0.5 , 0.15],
          [0.5 , 0.5 , 0.5 , 0.5 , 0.25],
          [0.5 , 0.5 , 0.5 , 0.5 , 0.25],
          [0.5 , 0.3 , 0.4 , 0.4 , 0.1 ]])
```

kwimage.util_warp.**subpixel_slice**(*inputs*, *index*)

Take a subpixel slice from a larger image. The returned output is left-aligned with the requested slice.

Parameters

- **inputs** (*ArrayLike*) – data
- **index** (*Tuple[slice]*) – a slice to subpixel accuracy

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> import kwimage
>>> import torch
>>> # say we have a (576, 576) input space
>>> # and a (9, 9) output space downsampled by 64x
>>> ospc_feats = np.tile(np.arange(9 * 9).reshape(1, 9, 9), (1024, 1, 1))
>>> inputs = torch.from_numpy(ospc_feats)
>>> # We detected a box in the input space
>>> ispc_bbox = kwimage.Boxes([[64,  65, 100, 120]], 'ltrb')
>>> # Get coordinates in the output space
```

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```
>>> ospc_bbox = ispc_bbox.scale(1 / 64)
>>> tl_x, tl_y, br_x, br_y = ospc_bbox.data[0]
>>> # Convert the box to a slice
>>> index = [slice(None), slice(tl_y, br_y), slice(tl_x, br_x)]
>>> # Note: I'm not 100% sure this work right with non-intergral slices
>>> outputs = kwimage.subpixel_slice(inputs, index)
```

Example

```
>>> inputs = np.arange(5 * 5 * 3).reshape(5, 5, 3)
>>> index = [slice(0, 3), slice(0, 3)]
>>> outputs = subpixel_slice(inputs, index)
>>> index = [slice(0.5, 3.5), slice(-0.5, 2.5)]
>>> outputs = subpixel_slice(inputs, index)
```

```
>>> inputs = np.arange(5 * 5).reshape(1, 5, 5).astype(float)
>>> index = [slice(None), slice(3, 6), slice(3, 6)]
>>> outputs = subpixel_slice(inputs, index)
>>> print(outputs)
[[[18. 19.  0.]
  [23. 24.  0.]
  [ 0.  0.  0.]]]
>>> index = [slice(None), slice(3.5, 6.5), slice(2.5, 5.5)]
>>> outputs = subpixel_slice(inputs, index)
>>> print(outputs)
[[[20.   21.   10.75]
  [11.25 11.75  6.  ]
  [ 0.    0.    0.  ]]]
```

kwimage.util_warp.**subpixel_translate**(*inputs*, *shift*, *interp_axes=None*, *output_shape=None*)

Translates an image by a subpixel shift value using bilinear interpolation

Parameters

- **inputs** (*ArrayLike*) – data to translate
- **shift** (*Sequence*) – amount to translate each dimension specified by *interp_axes*. Note: if inputs contains more than one "image" then all "images" are translated by the same amount. This function contains no mechanism for translating each image differently. Note that by default this is a y,x shift for 2 dimensions.
- **interp_axes** (*Sequence*) – axes to perform interpolation on, if not specified the final *n* axes are interpolated, where *n=len(shift)*
- **output_shape** (*tuple*) – if specified the output is returned with this shape, otherwise

Note: This function powers most other functions in this file. Speedups here can go a long way.

Example

```
>>> inputs = np.arange(5) + 1
>>> print(inputs.tolist())
[1, 2, 3, 4, 5]
>>> outputs = subpixel_translate(inputs, 1.5)
>>> print(outputs.tolist())
[0.0, 0.5, 1.5, 2.5, 3.5]
```

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> inputs = torch.arange(9).view(1, 1, 3, 3).float()
>>> print(inputs.long())
tensor([[[[0, 1, 2],
          [3, 4, 5],
          [6, 7, 8]]]])
>>> outputs = subpixel_translate(inputs, (-.4, .5), output_shape=(1, 1, 2, 5))
>>> print(outputs)
tensor([[[[0.6000, 1.7000, 2.7000, 1.6000, 0.0000],
          [2.1000, 4.7000, 5.7000, 3.1000, 0.0000]]]])
```

kwimage.util_warp.**warp_points**(*matrix*, *pts*, *homog_mode='divide'*)

Warp ND points / coordinates using a transformation matrix.

Homogoenous coordinates are added on the fly if needed. Works with both numpy and torch.

Parameters

- **matrix** (*ArrayLike*) – [D1 x D2] transformation matrix. if using homogenous coordinates D2=D + 1, otherwise D2=D. if using homogenous coordinates and the matrix represents an Affine transformation, then either D1=D or D1=D2, i.e. the last row of zeros and a one is optional.
- **pts** (*ArrayLike*) – [N1 x ... x D] points (usually x, y). If points are already in homogenous space, then the output will be returned in homogenous space. D is the dimensionality of the points. The leading axis may take any shape, but usually, shape will be [N x D] where N is the number of points.
- **homog_mode** (*str*) – what to do for homogenous coordinates. Can either divide, keep, or drop. Defaults do 'divide'.

Retrns:

new_pts (ArrayLike): the points after being transformed by the matrix

Example

```
>>> from kwimage.util_warp import *  # NOQA
>>> # --- with numpy
>>> rng = np.random.RandomState(0)
>>> pts = rng.rand(10, 2)
>>> matrix = rng.rand(2, 2)
>>> warp_points(matrix, pts)
>>> # --- with torch
>>> # xdoctest: +REQUIRES(module:torch)
>>> pts = torch.Tensor(pts)
>>> matrix = torch.Tensor(matrix)
>>> warp_points(matrix, pts)
```

Example

```
>>> from kwimage.util_warp import *  # NOQA
>>> # --- with numpy
>>> pts = np.ones((10, 2))
>>> matrix = np.diag([2, 3, 1])
>>> ra = warp_points(matrix, pts)
>>> # xdoctest: +REQUIRES(module:torch)
>>> rb = warp_points(torch.Tensor(matrix), torch.Tensor(pts))
>>> assert np.allclose(ra, rb.numpy())
```

Example

```
>>> from kwimage.util_warp import *  # NOQA
>>> # test different cases
>>> rng = np.random.RandomState(0)
>>> # Test 3x3 style projective matrices
>>> pts = rng.rand(1000, 2)
>>> matrix = rng.rand(3, 3)
>>> ra33 = warp_points(matrix, pts)
>>> # xdoctest: +REQUIRES(module:torch)
>>> rb33 = warp_points(torch.Tensor(matrix), torch.Tensor(pts))
>>> assert np.allclose(ra33, rb33.numpy())
>>> # Test opencv style affine matrices
>>> pts = rng.rand(10, 2)
>>> matrix = rng.rand(2, 3)
>>> ra23 = warp_points(matrix, pts)
>>> rb23 = warp_points(torch.Tensor(matrix), torch.Tensor(pts))
>>> assert np.allclose(ra33, rb33.numpy())
```

kwimage.util_warp.**remove_homog**(*pts*, *mode='divide'*)

Remove homogenous coordinate to a point array.

This is a convinience function, it is not particularly efficient.

SeeAlso:

cv2.convertPointsFromHomogeneous

Example

```
>>> homog_pts = np.random.rand(10, 3)
>>> remove_homog(homog_pts, 'divide')
>>> remove_homog(homog_pts, 'drop')
```

kwimage.util_warp.**add_homog**(*pts*)

Add a homogenous coordinate to a point array

This is a convinience function, it is not particularly efficient.

SeeAlso:
cv2.convertPointsToHomogeneous

Example

```
>>> pts = np.random.rand(10, 2)
>>> add_homog(pts)
```

Benchmark

```
>>> import timerit
>>> ti = timerit.Timerit(1000, bestof=10, verbose=2)
>>> pts = np.random.rand(1000, 2)
>>> for timer in ti.reset('kwimage'):
>>>     with timer:
>>>         kwimage.add_homog(pts)
>>> for timer in ti.reset('cv2'):
>>>     with timer:
>>>         cv2.convertPointsToHomogeneous(pts)
>>> # cv2 is 4x faster, but has more restrictive inputs
```

kwimage.util_warp.**subpixel_getvalue**(*img*, *pts*, *coord_axes=None*, *interp='bilinear'*, *bordermode='edge'*)

Get values at subpixel locations

Parameters

- **img** (*ArrayLike*) – image to sample from
- **pts** (*ArrayLike*) – subpixel rc-coordinates to sample
- **coord_axes** (*Sequence*) – axes to perform interpolation on, if not specified the first *d* axes are interpolated, where *d=pts.shape[-1]*. IE: this indicates which axes each coordinate dimension corresponds to.
- **interp** (*str*) – interpolation mode
- **bordermode** (*str*) – how locations outside the image are handled

Example

```
>>> from kwimage.util_warp import *  # NOQA
>>> img = np.arange(3 * 3).reshape(3, 3)
>>> pts = np.array([[1, 1], [1.5, 1.5], [1.9, 1.1]])
>>> subpixel_getvalue(img, pts)
array([4. , 6. , 6.8])
>>> subpixel_getvalue(img, pts, coord_axes=(1, 0))
array([4. , 6. , 5.2])
>>> # xdoctest: +REQUIRES(module:torch)
>>> img = torch.Tensor(img)
>>> pts = torch.Tensor(pts)
>>> subpixel_getvalue(img, pts)
tensor([4.0000, 6.0000, 6.8000])
>>> subpixel_getvalue(img.numpy(), pts.numpy(), interp='nearest')
array([4., 8., 7.], dtype=float32)
>>> subpixel_getvalue(img.numpy(), pts.numpy(), interp='nearest', coord_axes=[1, 0])
array([4., 8., 5.], dtype=float32)
>>> subpixel_getvalue(img, pts, interp='nearest')
tensor([4., 8., 7.])
```

References

stackoverflow.com/uestions/12729228/simple-binlin-interp-images-numpy

SeeAlso:
cv2.getRectSubPix(image, patchSize, center[, patch[, patchType]])

kwimage.util_warp.**subpixel_setvalue**(*img*, *pts*, *value*, *coord_axes=None*, *interp='bilinear'*, *bordermode='edge'*)

Set values at subpixel locations

Parameters

- **img** (*ArrayLike*) – image to set values in
- **pts** (*ArrayLike*) – subpixel rc-coordinates to set
- **value** (*ArrayLike*) – value to place in the image
- **coord_axes** (*Sequence*) – axes to perform interpolation on, if not specified the first *d* axes are interpolated, where *d=pts.shape[-1]*. IE: this indicates which axes each coordinate dimension corresponds to.
- **interp** (*str*) – interpolation mode
- **bordermode** (*str*) – how locations outside the image are handled

Example

```
>>> from kwimage.util_warp import *  # NOQA
>>> img = np.arange(3 * 3).reshape(3, 3).astype(float)
>>> pts = np.array([[1, 1], [1.5, 1.5], [1.9, 1.1]])
>>> interp = 'bilinear'
>>> value = 0
>>> print('img = {!r}'.format(img))
>>> pts = np.array([[1.5, 1.5]])
>>> img2 = subpixel_setvalue(img.copy(), pts, value)
>>> print('img2 = {!r}'.format(img2))
>>> pts = np.array([[1.0, 1.0]])
>>> img2 = subpixel_setvalue(img.copy(), pts, value)
>>> print('img2 = {!r}'.format(img2))
>>> pts = np.array([[1.1, 1.9]])
>>> img2 = subpixel_setvalue(img.copy(), pts, value)
>>> print('img2 = {!r}'.format(img2))
>>> img2 = subpixel_setvalue(img.copy(), pts, value, coord_axes=[1, 0])
>>> print('img2 = {!r}'.format(img2))
```

1.1.3 Module contents

The Kitware Image Module (kwimage) contains functions to accomplish lower-level image operations via a high level API.

class kwimage.**Affine**(*matrix*)

Bases: *Projective*

A thin wraper around a 3x3 matrix that represents an affine transform

Implements methods for:

- creating random affine transforms
- decomposing the matrix
- finding a best-fit transform between corresponding points
- TODO: - [ ] fully rational transform

Example

```
>>> import kwimage
>>> import math
>>> image = kwimage.grab_test_image()
>>> theta = 0.123 * math.tau
>>> components = {
>>>     'rotate': kwimage.Affine.affine(theta=theta),
>>>     'scale': kwimage.Affine.affine(scale=0.5),
>>>     'shear': kwimage.Affine.affine(shearx=0.2),
>>>     'translation': kwimage.Affine.affine(offset=(100, 200)),
>>>     'rotate+translate': kwimage.Affine.affine(theta=0.123 * math.tau,␣
↪about=(256, 256)),
>>>     'random composed': kwimage.Affine.random(scale=(0.5, 1.5), translate=(-20,␣
```

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```
↪20), theta=(-theta, theta), shearx=(0, .4), rng=9005581762108086000),
>>> }
>>> warp_stack = []
>>> for key, aff in components.items():
...     warp = kwimage.warp_affine(image, aff)
...     warp = kwimage.draw_text_on_image(
...         warp,
...         ub.repr2(aff.matrix, nl=1, nobr=1, precision=2, si=1, sv=1, with_
↪dtype=0),
...         org=(1, 1),
...         valign='top', halign='left',
...         fontScale=0.8, color='kw_blue',
...         border={'thickness': 3},
...         )
...     warp = kwimage.draw_header_text(warp, key, color='kw_green')
...     warp_stack.append(warp)
>>> warp_canvas = kwimage.stack_images_grid(warp_stack, chunksize=3, pad=10, bg_
↪value='kitware_gray')
>>> # xdoctest: +REQUIRES(module:sympy)
>>> import sympy
>>> # Shows the symbolic construction of the code
>>> # https://groups.google.com/forum/#!topic/sympy/k1HnZK_bNNA
>>> from sympy.abc import theta
>>> params = x0, y0, sx, sy, theta, shearx, tx, ty = sympy.symbols(
>>>     'x0, y0, sx, sy, theta, shearx, tx, ty')
>>> theta = sympy.symbols('theta')
>>> # move the center to 0, 0
>>> tr1_ = np.array([[1, 0,  -x0],
>>>                  [0, 1,  -y0],
>>>                  [0, 0,    1]])
>>> # Define core components of the affine transform
>>> S = np.array([  # scale
>>>     [sx,  0, 0],
>>>     [ 0, sy, 0],
>>>     [ 0,  0, 1]])
>>> E = np.array([  # x-shear
>>>     [1,  shearx, 0],
>>>     [0,  1, 0],
>>>     [0,  0, 1]])
>>> R = np.array([  # rotation
>>>     [sympy.cos(theta), -sympy.sin(theta), 0],
>>>     [sympy.sin(theta),  sympy.cos(theta), 0],
>>>     [               0,                 0, 1]])
>>> T = np.array([  # translation
>>>     [ 1,  0, tx],
>>>     [ 0,  1, ty],
>>>     [ 0,  0,  1]])
>>> # Contruct the affine 3x3 about the origin
>>> aff0 = np.array(sympy.simplify(T @ R @ E @ S))
>>> # move 0, 0 back to the specified origin
>>> tr2_ = np.array([[1, 0,  x0],
>>>                  [0, 1,  y0],
```

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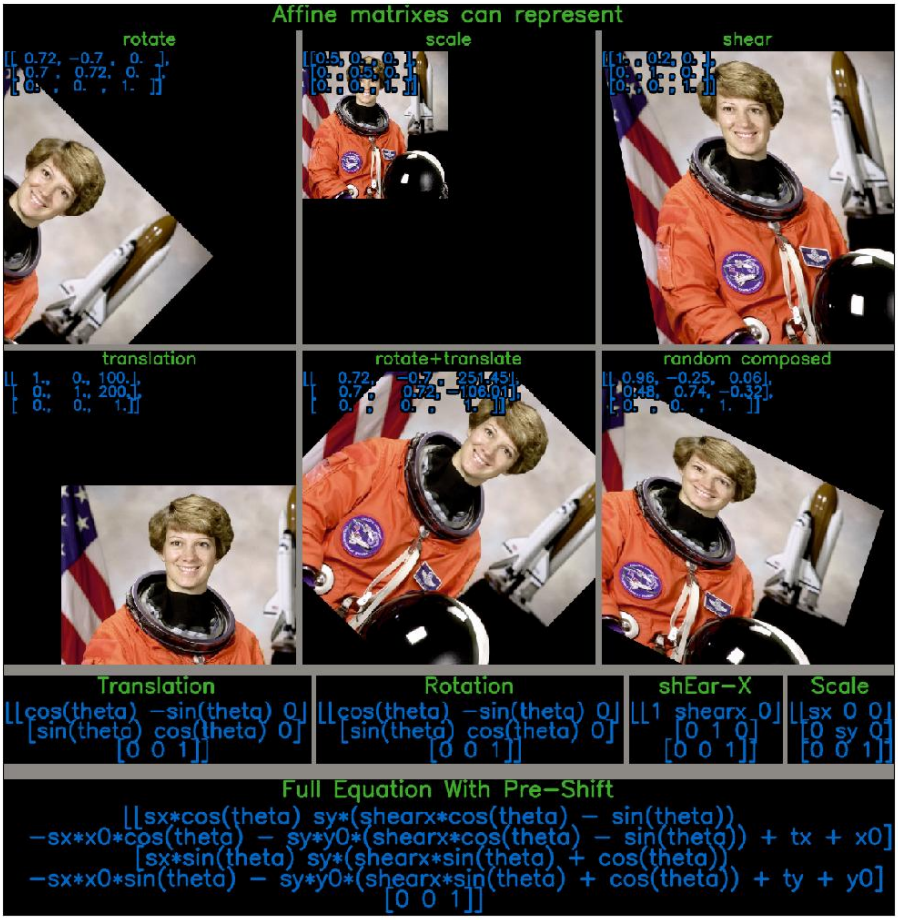
```
>>>                  [0, 0,   1]])
>>> # combine transformations
>>> aff = tr2_ @ aff0 @ tr1_
>>> print('aff = {}'.format(ub.repr2(aff.tolist(), nl=1)))
>>> # This could be prettier
>>> texts = {
>>>     'Translation': sympy.pretty(R),
>>>     'Rotation': sympy.pretty(R),
>>>     'shEar-X': sympy.pretty(E),
>>>     'Scale': sympy.pretty(S),
>>> }
>>> print(ub.repr2(texts, nl=2, sv=1))
>>> equation_stack = []
>>> for text, m in texts.items():
>>>     render_canvas = kwimage.draw_text_on_image(None, m, color='kw_blue',␣
↪fontScale=1.0)
>>>     render_canvas = kwimage.draw_header_text(render_canvas, text, color='kw_
↪green')
>>>     render_canvas = kwimage.imresize(render_canvas, scale=1.3)
>>>     equation_stack.append(render_canvas)
>>> equation_canvas = kwimage.stack_images(equation_stack, pad=10, axis=1, bg_value=
↪'kitware_gray')
>>> render_canvas = kwimage.draw_text_on_image(None, sympy.pretty(aff), color='kw_
↪blue', fontScale=1.0)
>>> render_canvas = kwimage.draw_header_text(render_canvas, 'Full Equation With Pre-
↪Shift', color='kw_green')
>>> # xdoctest: -REQUIRES(module:sympy)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> plt = kwplot.autoplt()
>>> canvas = kwimage.stack_images([warp_canvas, equation_canvas, render_canvas],␣
↪pad=20, axis=0, bg_value='kitware_gray', resize='larger')
>>> canvas = kwimage.draw_header_text(canvas, 'Affine matrixes can represent',␣
↪color='kw_green')
>>> kwplot.imshow(canvas)
>>> fig = plt.gcf()
>>> fig.set_size_inches(13, 13)
```



Example

```
>>> import kwimage
>>> self = kwimage.Affine(np.eye(3))
>>> m1 = np.eye(3) @ self
>>> m2 = self @ np.eye(3)
```

Example

```
>>> from kwimage.transform import *  # NOQA
>>> m = {}
>>> # Works, and returns a Affine
>>> m[len(m)] = x = Affine.random() @ np.eye(3)
>>> assert isinstance(x, Affine)
>>> m[len(m)] = x = Affine.random() @ None
>>> assert isinstance(x, Affine)
>>> # Works, and returns an ndarray
>>> m[len(m)] = x = np.eye(3) @ Affine.random()
>>> assert isinstance(x, np.ndarray)
>>> # Works, and returns an Matrix
>>> m[len(m)] = x = Affine.random() @ Matrix.random(3)
>>> assert isinstance(x, Matrix)
>>> m[len(m)] = x = Matrix.random(3) @ Affine.random()
>>> assert isinstance(x, Matrix)
>>> print('m = {}'.format(ub.repr2(m)))
```

property shape

concise()

Return a concise coercable dictionary representation of this matrix

Returns

a small serializable dict that can be passed
to *Affine.coerce()* to reconstruct this object.

Return type
Dict[str, object]

Returns
dictionary with consise parameters

Return type
Dict

Example

```
>>> import kwimage
>>> self = kwimage.Affine.random(rng=0, scale=1)
>>> params = self.concise()
>>> assert np.allclose(Affine.coerce(params).matrix, self.matrix)
>>> print('params = {}'.format(ub.repr2(params, nl=1, precision=2)))
params = {
    'offset': (0.08, 0.38),
    'theta': 0.08,
    'type': 'affine',
}
```

Example

```
>>> import kwimage
>>> self = kwimage.Affine.random(rng=0, scale=2, offset=0)
>>> params = self.concise()
>>> assert np.allclose(Affine.coerce(params).matrix, self.matrix)
>>> print('params = {}'.format(ub.repr2(params, nl=1, precision=2)))
params = {
    'scale': 2.00,
    'theta': 0.04,
    'type': 'affine',
}
```

classmethod coerce(*data=None*, ***kwargs*)

Attempt to coerce the data into an affine object

Parameters

- **data** – some data we attempt to coerce to an Affine matrix
- ****kwargs** – some data we attempt to coerce to an Affine matrix, mutually exclusive with *data*.

Returns
Affine

Example

```
>>> import kwimage
>>> kwimage.Affine.coerce({'type': 'affine', 'matrix': [[1, 0, 0], [0, 1, 0]]})
>>> kwimage.Affine.coerce({'scale': 2})
>>> kwimage.Affine.coerce({'offset': 3})
>>> kwimage.Affine.coerce(np.eye(3))
>>> kwimage.Affine.coerce(None)
>>> kwimage.Affine.coerce(skimage.transform.AffineTransform(scale=30))
```

eccentricity()

Eccentricity of the ellipse formed by this affine matrix

Returns

large when there are big scale differences in principle
directions or skews.

Return type
float

References

https://en.wikipedia.org/wiki/Conic_section https://github.com/rasterio/affine/blob/78c20a0cfbb5ec/affine/__init__.py#L368

Example

```
>>> import kwimage
>>> kwimage.Affine.random(rng=432).eccentricity()
```

to_shapely()

Returns a matrix suitable for shapely.affinity.affine_transform

Returns
Tuple[float, float, float, float, float, float]

Example

```
>>> import kwimage
>>> self = kwimage.Affine.random()
>>> sh_transform = self.to_shapely()
>>> # Transform points with kwimage and shapley
>>> import shapely
>>> from shapely.affinity import affine_transform
>>> kw_poly = kwimage.Polygon.random()
>>> kw_warp_poly = kw_poly.warp(self)
>>> sh_poly = kw_poly.to_shapely()
>>> sh_warp_poly = affine_transform(sh_poly, sh_transform)
>>> kw_warp_poly_recon = kwimage.Polygon.from_shapely(sh_warp_poly)
>>> assert np.allclose(kw_warp_poly_recon.exterior.data, kw_warp_poly_recon.
↪exterior.data)
```

to_skimage()

Returns
skimage.transform.AffineTransform

Example

```
>>> import kwimage
>>> self = kwimage.Affine.random()
>>> tf = self.to_skimage()
>>> # Transform points with kwimage and scikit-image
>>> kw_poly = kwimage.Polygon.random()
>>> kw_warp_xy = kw_poly.warp(self.matrix).exterior.data
>>> sk_warp_xy = tf(kw_poly.exterior.data)
>>> assert np.allclose(sk_warp_xy, sk_warp_xy)
```

classmethod scale(*scale*)

Create a scale Affine object

Parameters
scale (*float | Tuple[float, float]*) – x, y scale factor

Returns
Affine

classmethod translate(*offset*)

Create a translation Affine object

Parameters
offset (*float | Tuple[float, float]*) – x, y translation factor

Returns
Affine

Benchmark

```
>>> # xdoctest: +REQUIRES(--benchmark)
>>> # It is ~3x faster to use the more specific method
>>> import timerit
>>> import kwimage
>>> #
>>> offset = np.random.rand(2)
>>> ti = timerit.Timerit(100, bestof=10, verbose=2)
>>> for timer in ti.reset('time'):
>>>     with timer:
>>>         kwimage.Affine.translate(offset)
>>> #
>>> for timer in ti.reset('time'):
>>>     with timer:
>>>         kwimage.Affine.affine(offset=offset)
```

classmethod rotate(*theta*)

Create a rotation Affine object

Parameters
theta (*float*) – counter-clockwise rotation angle in radians

Returns
Affine

classmethod random(*shape=None*, *rng=None*, ***kw*)

Create a random Affine object

Parameters

- **rng** – random number generator
- ****kw** – passed to *Affine.random_params()*. can contain coercable random distributions for scale, offset, about, theta, and shearx.

Returns
Affine

classmethod random_params(*rng=None*, ***kw*)

Parameters

- **rng** – random number generator

- ****kw** – can contain coercable random distributions for scale, offset, about, theta, and shearx.

Returns
affine parameters suitable to be passed to Affine.affine

Return type
Dict

Todo:

- [ ] improve kwargs parameterization

`decompose()`

Decompose the affine matrix into its individual scale, translation, rotation, and skew parameters.

Returns
decomposed offset, scale, theta, and shearx params

Return type
Dict

References

https://math.stackexchange.com/questions/612006/decompose-affine https://math.stackexchange.com/a/3521141/353527 https://stackoverflow.com/questions/70357473/how-to-decompose-a-2x2-affine-matrix-with-sympy https://en.wikipedia.org/wiki/Transformation_matrix https://en.wikipedia.org/wiki/Shear_mapping

Example

```
>>> from kwimage.transform import *  # NOQA
>>> self = Affine.random()
>>> params = self.decompose()
>>> recon = Affine.coerce(**params)
>>> params2 = recon.decompose()
>>> pt = np.vstack([np.random.rand(2, 1), [1]])
>>> result1 = self.matrix[0:2] @ pt
>>> result2 = recon.matrix[0:2] @ pt
>>> assert np.allclose(result1, result2)
```

```
>>> self = Affine.scale(0.001) @ Affine.random()
>>> params = self.decompose()
>>> self.det()
```

Example

```
>>> # xdoctest: +REQUIRES(module:pandas)
>>> from kwimage.transform import *  # NOQA
>>> import kwimage
>>> import pandas as pd
>>> # Test consistency of decompose + reconstruct
>>> param_grid = list(ub.named_product({
>>>     'theta': np.linspace(-4 * np.pi, 4 * np.pi, 3),
>>>     'shearx': np.linspace(- 10 * np.pi, 10 * np.pi, 4),
>>> }))
>>> def normalize_angle(radian):
>>>     return np.arctan2(np.sin(radian), np.cos(radian))
>>> for pextra in param_grid:
>>>     params0 = dict(scale=(3.05, 3.07), offset=(10.5, 12.1), **pextra)
>>>     self = recon0 = kwimage.Affine.affine(**params0)
>>>     self.decompose()
>>>     # Test drift with multiple decompose / reconstructions
>>>     params_list = [params0]
>>>     recon_list = [recon0]
>>>     n = 4
>>>     for _ in range(n):
>>>         prev = recon_list[-1]
>>>         params = prev.decompose()
>>>         recon = kwimage.Affine.coerce(**params)
>>>         params_list.append(params)
>>>         recon_list.append(recon)
>>>     params_df = pd.DataFrame(params_list)
>>>     #print('params_list = {}'.format(ub.repr2(params_list, nl=1,␣
↪precision=5)))
>>>     print(params_df)
>>>     assert ub.allsame(normalize_angle(params_df['theta']), eq=np.isclose)
>>>     assert ub.allsame(params_df['shearx'], eq=np.allclose)
>>>     assert ub.allsame(params_df['scale'], eq=np.allclose)
>>>     assert ub.allsame(params_df['offset'], eq=np.allclose)
```

classmethod affine(*scale=None*, *offset=None*, *theta=None*, *shear=None*, *about=None*, *shearx=None*, *array_cls=None*, *math_mod=None*, ***kwargs*)

Create an affine matrix from high-level parameters

Parameters

- **scale** (*float | Tuple[float, float]*) – x, y scale factor
- **offset** (*float | Tuple[float, float]*) – x, y translation factor
- **theta** (*float*) – counter-clockwise rotation angle in radians
- **shearx** (*float*) – shear factor parallel to the x-axis.
- **about** (*float | Tuple[float, float]*) – x, y location of the origin
- **shear** (*float*) – BROKEN, dont use. counter-clockwise shear angle in radians

---

Todo:

- **[ ] Add aliases? -**
  origin : alias for about rotation : alias for theta translation : alias for offset

---

Returns
the constructed Affine object

Return type
Affine

Example

```
>>> from kwimage.transform import *  # NOQA
>>> rng = kwarray.ensure_rng(None)
>>> scale = rng.randn(2) * 10
>>> offset = rng.randn(2) * 10
>>> about = rng.randn(2) * 10
>>> theta = rng.randn() * 10
>>> shearx = rng.randn() * 10
>>> # Create combined matrix from all params
>>> F = Affine.affine(
>>>     scale=scale, offset=offset, theta=theta, shearx=shearx,
>>>     about=about)
>>> # Test that combining components matches
>>> S = Affine.affine(scale=scale)
>>> T = Affine.affine(offset=offset)
>>> R = Affine.affine(theta=theta)
>>> E = Affine.affine(shearx=shearx)
>>> O = Affine.affine(offset=about)
>>> # combine (note shear must be on the RHS of rotation)
>>> alt  = O @ T @ R @ E @ S @ O.inv()
>>> print('F    = {}'.format(ub.repr2(F.matrix.tolist(), nl=1)))
>>> print('alt  = {}'.format(ub.repr2(alt.matrix.tolist(), nl=1)))
>>> assert np.all(np.isclose(alt.matrix, F.matrix))
>>> pt = np.vstack([np.random.rand(2, 1), [[1]]])
>>> warp_pt1 = (F.matrix @ pt)
>>> warp_pt2 = (alt.matrix @ pt)
>>> assert np.allclose(warp_pt2, warp_pt1)
```

Sympy

```
>>> # xdoctest: +SKIP
>>> import sympy
>>> # Shows the symbolic construction of the code
>>> # https://groups.google.com/forum/#!topic/sympy/k1HnZK_bNNA
>>> from sympy.abc import theta
>>> params = x0, y0, sx, sy, theta, shearx, tx, ty = sympy.symbols(
>>>     'x0, y0, sx, sy, theta, shearx, tx, ty')
>>> # move the center to 0, 0
>>> tr1_ = np.array([[1, 0,  -x0],
>>>                  [0, 1,  -y0],
```

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```
>>>                  [0, 0,    1]])
>>> # Define core components of the affine transform
>>> S = np.array([  # scale
>>>     [sx,  0, 0],
>>>     [ 0, sy, 0],
>>>     [ 0,  0, 1]])
>>> E = np.array([  # x-shear
>>>     [1,  shearx, 0],
>>>     [0,  1, 0],
>>>     [0,  0, 1]])
>>> R = np.array([  # rotation
>>>     [sympy.cos(theta), -sympy.sin(theta), 0],
>>>     [sympy.sin(theta),  sympy.cos(theta), 0],
>>>     [               0,                 0, 1]])
>>> T = np.array([  # translation
>>>     [ 1,  0, tx],
>>>     [ 0,  1, ty],
>>>     [ 0,  0,  1]])
>>> # Contruct the affine 3x3 about the origin
>>> aff0 = np.array(sympy.simplify(T @ R @ E @ S))
>>> # move 0, 0 back to the specified origin
>>> tr2_ = np.array([[1, 0,  x0],
>>>                  [0, 1,  y0],
>>>                  [0, 0,   1]])
>>> # combine transformations
>>> aff = tr2_ @ aff0 @ tr1_
>>> print('aff = {}'.format(ub.repr2(aff.tolist(), nl=1)))
```

classmethod fit(*pts1*, *pts2*)

Fit an affine transformation between a set of corresponding points

Parameters

- **pts1** (*ndarray*) – An Nx2 array of points in “space 1”.
- **pts2** (*ndarray*) – A corresponding Nx2 array of points in “space 2”

Returns

a transform that warps from “space1” to “space2”.

Return type

Affine

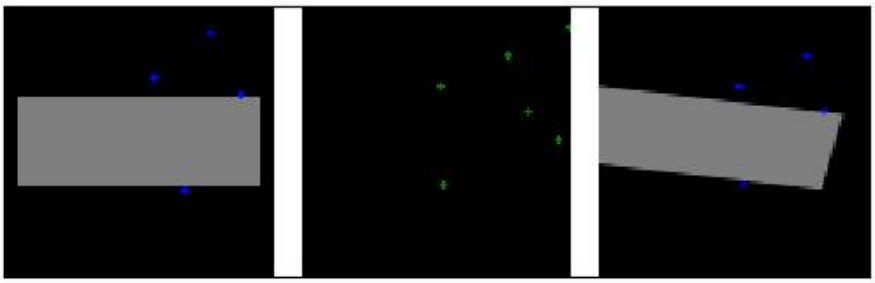
Note: An affine matrix has 6 degrees of freedome, so at least 6 point pairs are needed.

References

https://www.cs.ubc.ca/~lowe/papers/ijcv04.pdf page 22

Example

```
>>> # Create a set of points, warp them, then recover the warp
>>> import kwimage
>>> points = kwimage.Points.random(6).scale(64)
>>> #A1 = kwimage.Affine.affine(scale=0.9, theta=-3.2, offset=(2, 3),␣
↪about=(32, 32), skew=2.3)
>>> #A2 = kwimage.Affine.affine(scale=0.8, theta=0.8, offset=(2, 0), about=(32,
↪ 32))
>>> A1 = kwimage.Affine.random()
>>> A2 = kwimage.Affine.random()
>>> A12_real = A2 @ A1.inv()
>>> points1 = points.warp(A1)
>>> points2 = points.warp(A2)
>>> # Recover the warp
>>> pts1, pts2 = points1.xy, points2.xy
>>> A_recovered = kwimage.Affine.fit(pts1, pts2)
>>> assert np.all(np.isclose(A_recovered.matrix, A12_real.matrix))
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> base1 = np.zeros((96, 96, 3))
>>> base1[32:-32, 5:-5] = 0.5
>>> base2 = np.zeros((96, 96, 3))
>>> img1 = points1.draw_on(base1, radius=3, color='blue')
>>> img2 = points2.draw_on(base2, radius=3, color='green')
>>> img1_warp = kwimage.warp_affine(img1, A_recovered)
>>> canvas = kwimage.stack_images([img1, img2, img1_warp], pad=10, axis=1, bg_
↪value=(1., 1., 1.))
>>> kwplot.imshow(canvas)
```



class kwimage.**Boxes**(*data*, *format=None*, *check=True*)

Bases: _BoxConversionMixins, _BoxPropertyMixins, _BoxTransformMixins, _BoxDrawMixins, NiceRepr

Converts boxes between different formats as long as the last dimension contains 4 coordinates and the format is specified.

This is a convinience class, and should not not store the data for very long. The general idiom should be create class, convert data, and then get the raw data and let the class be garbage collected. This will help ensure that your code is portable and understandable if this class is not available.

Example

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> import kwimage
>>> import numpy as np
>>> # Given an array / tensor that represents one or more boxes
>>> data = np.array([[ 0,  0, 10, 10],
>>>                  [ 5,  5, 50, 50],
>>>                  [20,  0, 30, 10]])
>>> # The kwimage.Boxes data structure is a thin fast wrapper
>>> # that provides methods for operating on the boxes.
>>> # It requires that the user explicitly provide a code that denotes
>>> # the format of the boxes (i.e. what each column represents)
>>> boxes = kwimage.Boxes(data, 'ltrb')
>>> # This means that there is no ambiguity about box format
```

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```
>>> # The representation string of the Boxes object demonstrates this
>>> print('boxes = {!r}'.format(boxes))
boxes = <Boxes(ltrb,
    array([[ 0,  0, 10, 10],
           [ 5,  5, 50, 50],
           [20,  0, 30, 10]]))>
>>> # if you pass this data around. You can convert to other formats
>>> # For docs on available format codes see :class:`BoxFormat`.
>>> # In this example we will convert (left, top, right, bottom)
>>> # to (left-x, top-y, width, height).
>>> boxes.toformat('xywh')
<Boxes(xywh,
    array([[ 0,  0, 10, 10],
           [ 5,  5, 45, 45],
           [20,  0, 10, 10]]))>
>>> # In addition to format conversion there are other operations
>>> # We can quickly (using a C-backend) find IoUs
>>> ious = boxes.ious(boxes)
>>> print('{}'.format(ub.repr2(ious, nl=1, precision=2, with_dtype=False)))
np.array([[1.  , 0.01, 0.  ],
          [0.01, 1.  , 0.02],
          [0.  , 0.02, 1.  ]])
>>> # We can ask for the area of each box
>>> print('boxes.area = {}'.format(ub.repr2(boxes.area, nl=0, with_dtype=False)))
boxes.area = np.array([[ 100],[2025],[ 100]])
>>> # We can ask for the center of each box
>>> print('boxes.center = {}'.format(ub.repr2(boxes.center, nl=1, with_
↪dtype=False)))
boxes.center = (
    np.array([[ 5. ],[27.5],[25. ]]),
    np.array([[ 5. ],[27.5],[ 5. ]]),
)
>>> # We can translate / scale the boxes
>>> boxes.translate((10, 10)).scale(100)
<Boxes(ltrb,
    array([[1000., 1000., 2000., 2000.],
           [1500., 1500., 6000., 6000.],
           [3000., 1000., 4000., 2000.]]))>
>>> # We can clip the bounding boxes
>>> boxes.translate((10, 10)).scale(100).clip(1200, 1200, 1700, 1800)
<Boxes(ltrb,
    array([[1200., 1200., 1700., 1800.],
           [1500., 1500., 1700., 1800.],
           [1700., 1200., 1700., 1800.]]))>
>>> # We can perform arbitrary warping of the boxes
>>> # (note that if the transform is not axis aligned, the axis aligned
>>> #  bounding box of the transform result will be returned)
>>> transform = np.array([[-0.83907153,  0.54402111,  0. ],
>>>                       [-0.54402111, -0.83907153,  0. ],
>>>                       [ 0.        ,  0.        ,  1. ]])
>>> boxes.warp(transform)
<Boxes(ltrb,
```

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```
    array([[ -8.3907153 , -13.8309264 ,   5.4402111 ,   0.        ],
           [-39.23347095, -69.154632  ,  23.00569785,  -6.9154632 ],
           [-25.1721459 , -24.7113486 , -11.3412195 , -10.8804222 ]]))>
>>> # Note, that we can transform the box to a Polygon for more
>>> # accurate warping.
>>> transform = np.array([[-0.83907153,  0.54402111,  0. ],
>>>                       [-0.54402111, -0.83907153,  0. ],
>>>                       [ 0.        ,  0.        ,  1. ]])
>>> warped_polys = boxes.to_polygons().warp(transform)
>>> print(ub.repr2(warped_polys.data, sv=1))
[
    <Polygon({
        'exterior': <Coords(data=
                        array([[  0.       ,   0.       ],
                               [  5.4402111,  -8.3907153],
                               [ -2.9505042, -13.8309264],
                               [ -8.3907153,  -5.4402111],
                               [  0.       ,   0.       ]]))>,
        'interiors': [],
    })>,
    <Polygon({
        'exterior': <Coords(data=
                        array([[ -1.4752521 ,  -6.9154632 ],
                               [ 23.00569785, -44.67368205],
                               [-14.752521  , -69.154632  ],
                               [-39.23347095, -31.39641315],
                               [ -1.4752521 ,  -6.9154632 ]]))>,
        'interiors': [],
    })>,
    <Polygon({
        'exterior': <Coords(data=
                        array([[-16.7814306, -10.8804222],
                               [-11.3412195, -19.2711375],
                               [-19.7319348, -24.7113486],
                               [-25.1721459, -16.3206333],
                               [-16.7814306, -10.8804222]]))>,
        'interiors': [],
    })>,
]
>>> # The kwimage.Boxes data structure is also convertable to
>>> # several alternative data structures, like shapely, coco, and imgaug.
>>> print(ub.repr2(boxes.to_shapely(), sv=1))
[
    POLYGON ((0 0, 0 10, 10 10, 10 0, 0 0)),
    POLYGON ((5 5, 5 50, 50 50, 50 5, 5 5)),
    POLYGON ((20 0, 20 10, 30 10, 30 0, 20 0)),
]
>>> # xdoctest: +REQUIRES(module:imgaug)
>>> print(ub.repr2(boxes[0:1].to_imgaug(shape=(100, 100)), sv=1))
BoundingBoxesOnImage([BoundingBox(x1=0.0000, y1=0.0000, x2=10.0000, y2=10.0000,␣
↪label=None)], shape=(100, 100))
>>> # xdoctest: -REQUIRES(module:imgaug)
```

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```
>>> print(ub.repr2(list(boxes.to_coco()), sv=1))
[
    [0, 0, 10, 10],
    [5, 5, 45, 45],
    [20, 0, 10, 10],
]
>>> # Finally, when you are done with your boxes object, you can
>>> # unwrap the raw data by using the ``.data`` attribute
>>> # all operations are done on this data, which gives the
>>> # kwiamge.Boxes data structure almost no overhead when
>>> # inserted into existing code.
>>> print('boxes.data =\n{}'.format(ub.repr2(boxes.data, nl=1)))
boxes.data =
np.array([[ 0,  0, 10, 10],
          [ 5,  5, 50, 50],
          [20,  0, 30, 10]], dtype=np.int64)
>>> # xdoctest: +REQUIRES(module:torch)
>>> # This data structure was designed for use with both torch
>>> # and numpy, the underlying data can be either an array or tensor.
>>> boxes.tensor()
<Boxes(ltrb,
    tensor([[ 0,  0, 10, 10],
            [ 5,  5, 50, 50],
            [20,  0, 30, 10]]))>
>>> boxes.numpy()
<Boxes(ltrb,
    array([[ 0,  0, 10, 10],
           [ 5,  5, 50, 50],
           [20,  0, 30, 10]]))>
```

Example

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> from kwimage.structs.boxes import *  # NOQA
>>> # Demo of conversion methods
>>> import kwimage
>>> kwimage.Boxes([[25, 30, 15, 10]], 'xywh')
<Boxes(xywh, array([[25, 30, 15, 10]]))>
>>> kwimage.Boxes([[25, 30, 15, 10]], 'xywh').to_xywh()
<Boxes(xywh, array([[25, 30, 15, 10]]))>
>>> kwimage.Boxes([[25, 30, 15, 10]], 'xywh').to_cxywh()
<Boxes(cxywh, array([[32.5, 35. , 15. , 10. ]]))>
>>> kwimage.Boxes([[25, 30, 15, 10]], 'xywh').to_ltrb()
<Boxes(ltrb, array([[25, 30, 40, 40]]))>
>>> kwimage.Boxes([[25, 30, 15, 10]], 'xywh').scale(2).to_ltrb()
<Boxes(ltrb, array([[50., 60., 80., 80.]]))>
>>> # xdoctest: +REQUIRES(module:torch)
>>> kwimage.Boxes(torch.FloatTensor([[25, 30, 15, 20]]), 'xywh').scale(.1).to_ltrb()
<Boxes(ltrb, tensor([[ 2.5000,  3.0000,  4.0000,  5.0000]]))>
```

Note: In the following examples we show cases where *Boxes* can hold a single 1-dimensional box array. This is a holdover from an older codebase, and some functions may assume that the input is at least 2-D. Thus when representing a single bounding box it is best practice to view it as a list of 1 box. While many function will work in the 1-D case, not all functions have been tested and thus we cannot gaurentee correctness.

Example

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> Boxes([25, 30, 15, 10], 'xywh')
<Boxes(xywh, array([25, 30, 15, 10]))>
>>> Boxes([25, 30, 15, 10], 'xywh').to_xywh()
<Boxes(xywh, array([25, 30, 15, 10]))>
>>> Boxes([25, 30, 15, 10], 'xywh').to_cxywh()
<Boxes(cxywh, array([32.5, 35. , 15. , 10. ]))>
>>> Boxes([25, 30, 15, 10], 'xywh').to_ltrb()
<Boxes(ltrb, array([25, 30, 40, 40]))>
>>> Boxes([25, 30, 15, 10], 'xywh').scale(2).to_ltrb()
<Boxes(ltrb, array([50., 60., 80., 80.]))>
>>> # xdoctest: +REQUIRES(module:torch)
>>> Boxes(torch.FloatTensor([[25, 30, 15, 20]]), 'xywh').scale(.1).to_ltrb()
<Boxes(ltrb, tensor([[ 2.5000,  3.0000,  4.0000,  5.0000]]))>
```

Example

```
>>> datas = [
>>>     [1, 2, 3, 4],
>>>     [[1, 2, 3, 4], [4, 5, 6, 7]],
>>>     [[[1, 2, 3, 4], [4, 5, 6, 7]]],
>>> ]
>>> formats = BoxFormat.cannonical
>>> for format1 in formats:
>>>     for data in datas:
>>>         self = box1 = Boxes(data, format1)
>>>         for format2 in formats:
>>>             box2 = box1.toformat(format2)
>>>             back = box2.toformat(format1)
>>>             assert box1 == back
```

classmethod random(*num=1*, *scale=1.0*, *format='xywh'*, *anchors=None*, *anchor_std=0.16666666666666666*, *tensor=False*, *rng=None*)

Makes random boxes; typically for testing purposes

Parameters

- **num** (*int*) – number of boxes to generate
- **scale** (*float | Tuple[float, float]*) – size of imgdims
- **format** (*str*) – format of boxes to be created (e.g. ltrb, xywh)
- **anchors** (*ndarray*) – normalized width / heights of anchor boxes to perterb and randomly place. (must be in range 0-1)

- **anchor_std** (*float*) – magnitude of noise applied to anchor shapes
- **tensor** (*bool*) – if True, returns boxes in tensor format
- **rng** (*None | int | RandomState*) – initial random seed

Returns
random boxes

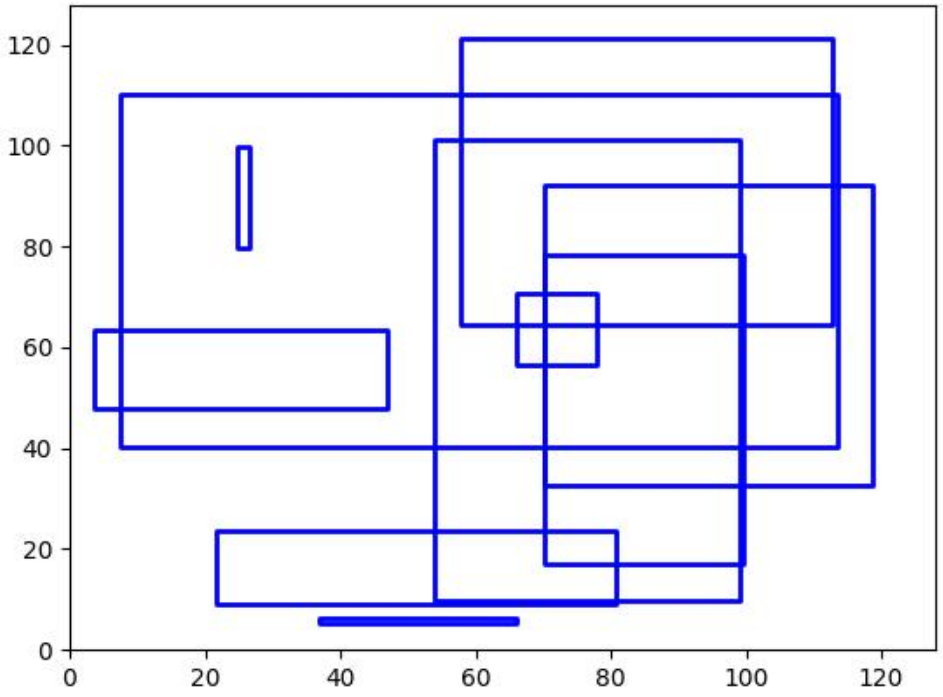
Return type
Boxes

Example

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> Boxes.random(3, rng=0, scale=100)
<Boxes(xywh,
    array([[54, 54,  6, 17],
           [42, 64,  1, 25],
           [79, 38, 17, 14]]))>
>>> # xdoctest: +REQUIRES(module:torch)
>>> Boxes.random(3, rng=0, scale=100).tensor()
<Boxes(xywh,
    tensor([[ 54,  54,   6,  17],
            [ 42,  64,   1,  25],
            [ 79,  38,  17,  14]]))>
>>> anchors = np.array([[.5, .5], [.3, .3]])
>>> Boxes.random(3, rng=0, scale=100, anchors=anchors)
<Boxes(xywh,
    array([[ 2, 13, 51, 51],
           [32, 51, 32, 36],
           [36, 28, 23, 26]]))>
```

Example

```
>>> # Boxes position/shape within 0-1 space should be uniform.
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> fig = kwplot.figure(fnum=1, doclf=True)
>>> fig.gca().set_xlim(0, 128)
>>> fig.gca().set_ylim(0, 128)
>>> import kwimage
>>> kwimage.Boxes.random(num=10).scale(128).draw()
```



`copy()`

Returns
a copy of these boxes

Return type
Boxes

`classmethod concatenate`(*boxes*, *axis=0*)

Concatenates multiple boxes together

Parameters

- **boxes** (*Sequence[Boxes]*) – list of boxes to concatenate
- **axis** (*int*) – axis to stack on. Defaults to 0.

Returns
stacked boxes

Return type
Boxes

Example

```
>>> boxes = [Boxes.random(3) for _ in range(3)]
>>> new = Boxes.concatenate(boxes)
>>> assert len(new) == 9
>>> assert np.all(new.data[3:6] == boxes[1].data)
```

Example

```
>>> boxes = [Boxes.random(3) for _ in range(3)]
>>> boxes[0].data = boxes[0].data[0]
>>> boxes[1].data = boxes[0].data[0:0]
>>> new = Boxes.concatenate(boxes)
>>> assert len(new) == 4
>>> # xdoctest: +REQUIRES(module:torch)
>>> new = Boxes.concatenate([b.tensor() for b in boxes])
>>> assert len(new) == 4
```

compress(*flags*, *axis=0*, *inplace=False*)

Filters boxes based on a boolean criterion

Parameters

- **flags** (*ArrayLike*) – true for items to be kept. Extended type: ArrayLike[bool]
- **axis** (*int*) – you usually want this to be 0
- **inplace** (*bool*) – if True, modifies this object

Returns

the boxes corresponding to where flags were true

Return type

Boxes

Example

```
>>> self = Boxes([[25, 30, 15, 10]], 'ltrb')
>>> self.compress([True])
<Boxes(ltrb, array([[25, 30, 15, 10]]))>
>>> self.compress([False])
<Boxes(ltrb, array([], shape=(0, 4), dtype=int64))>
```

take(*idxs*, *axis=0*, *inplace=False*)

Takes a subset of items at specific indices

Parameters

- **indices** (*ArrayLike*) – Indexes of items to take. Extended type ArrayLike[int].
- **axis** (*int*) – you usually want this to be 0
- **inplace** (*bool*) – if True, modifies this object

Returns

the boxes corresponding to the specified indices

Return type
Boxes

Example

```
>>> self = Boxes([[25, 30, 15, 10]], 'ltrb')
>>> self.take([0])
<Boxes(ltrb, array([[25, 30, 15, 10]]))>
>>> self.take([])
<Boxes(ltrb, array([], shape=(0, 4), dtype=int64))>
```

is_tensor()

is the backend fueled by torch?

Returns
True if the Boxes are torch tensors

Return type
bool

is_numpy()

is the backend fueled by numpy?

Returns
True if the Boxes are numpy arrays

Return type
bool

property device

If the backend is torch returns the data device, otherwise None

astype(*dtype*)

Changes the type of the internal array used to represent the boxes

Note: this operation is not inplace

Returns
the boxes with the chosen type

Return type
Boxes

Example

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> # xdoctest: +REQUIRES(module:torch)
>>> Boxes.random(3, 100, rng=0).tensor().astype('int32')
<Boxes(xywh,
    tensor([[54, 54,  6, 17],
            [42, 64,  1, 25],
            [79, 38, 17, 14]], dtype=torch.int32))>
>>> Boxes.random(3, 100, rng=0).numpy().astype('int32')
```

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```
<Boxes(xywh,
    array([[54, 54,  6, 17],
           [42, 64,  1, 25],
           [79, 38, 17, 14]], dtype=int32))>
>>> Boxes.random(3, 100, rng=0).tensor().astype('float32')
>>> Boxes.random(3, 100, rng=0).numpy().astype('float32')
```

round(*inplace=False*)

Rounds data coordinates to the nearest integer.

This operation is applied directly to the box coordinates, so its output will depend on the format the boxes are stored in.

Parameters
inplace (*bool*) – if True, modifies this object. Defaults to False.

Returns
the boxes with rounded coordinates

Return type
Boxes

SeeAlso:
Boxes.quantize()

Example

```
>>> import kwimage
>>> self = kwimage.Boxes.random(3, rng=0).scale(10)
>>> new = self.round()
>>> print('self = {!r}'.format(self))
>>> print('new = {!r}'.format(new))
self = <Boxes(xywh,
    array([[5.48813522, 5.44883192, 0.53949833, 1.70306146],
           [4.23654795, 6.4589411 , 0.13932407, 2.45878875],
           [7.91725039, 3.83441508, 1.71937704, 1.45453393]]))>
new = <Boxes(xywh,
    array([[5., 5., 1., 2.],
           [4., 6., 0., 2.],
           [8., 4., 2., 1.]]))>
```

quantize(*inplace=False*, *dtype=<class 'numpy.int32'>*)

Converts the box to integer coordinates.

This operation takes the floor of the left side and the ceil of the right side. Thus the area of the box will never decreases. But this will often increase the width / height of the box by a pixel.

Parameters

- **inplace** (*bool*) – if True, modifies this object
- **dtype** (*type*) – type to cast as

Returns
the boxes with quantized coordinates

Return type
Boxes

SeeAlso:
Boxes.round() Boxes.resize() if you need to ensure the size does not change

Example

```
>>> import kwimage
>>> self = kwimage.Boxes.random(3, rng=0).scale(10)
>>> new = self.quantize()
>>> print('self = {!r}'.format(self))
>>> print('new = {!r}'.format(new))
self = <Boxes(xywh,
    array([[5.48813522, 5.44883192, 0.53949833, 1.70306146],
           [4.23654795, 6.4589411 , 0.13932407, 2.45878875],
           [7.91725039, 3.83441508, 1.71937704, 1.45453393]]))>
new = <Boxes(xywh,
    array([[5, 5, 2, 3],
           [4, 6, 1, 3],
           [7, 3, 3, 3]], dtype=int32))>
```

Example

```
>>> import kwimage
>>> # Be careful if it is important to preserve the width/height
>>> self = kwimage.Boxes([[0, 0, 10, 10]], 'xywh')
>>> aff = kwimage.Affine.coerce(offset=(0.5, 0.0))
>>> warped = self.warp(aff)
>>> new = warped.quantize(dtype=int)
>>> print('self   = {!r}'.format(self))
>>> print('warped = {!r}'.format(warped))
>>> print('new    = {!r}'.format(new))
self   = <Boxes(xywh, array([[ 0,  0, 10, 10]]))>
warped = <Boxes(xywh, array([[ 0.5,  0. , 10. , 10. ]]))>
new    = <Boxes(xywh, array([[ 0,  0, 11, 10]]))>
```

Example

```
>>> import kwimage
>>> self = kwimage.Boxes.random(3, rng=0)
>>> orig = self.copy()
>>> self.quantize(inplace=True)
>>> assert np.any(self.data != orig.data)
```

numpy()

Converts tensors to numpy. Does not change memory if possible.

Returns
the boxes with a numpy backend

Return type
Boxes

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> self = Boxes.random(3).tensor()
>>> newself = self.numpy()
>>> self.data[0, 0] = 0
>>> assert newself.data[0, 0] == 0
>>> self.data[0, 0] = 1
>>> assert self.data[0, 0] == 1
```

tensor(*device=NoParam*)

Converts numpy to tensors. Does not change memory if possible.

Parameters
device (*int | None | torch.device*) – The torch device to put the backend tensors on

Returns
the boxes with a torch backend

Return type
Boxes

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> self = Boxes.random(3)
>>> # xdoctest: +REQUIRES(module:torch)
>>> newself = self.tensor()
>>> self.data[0, 0] = 0
>>> assert newself.data[0, 0] == 0
>>> self.data[0, 0] = 1
>>> assert self.data[0, 0] == 1
```

ious(*other*, *bias=0*, *impl='auto'*, *mode=None*)

Intersection over union.

Compute IOUs (intersection area over union area) between these boxes and another set of boxes. This is a symmetric measure of similarity between boxes.

Todo:

- **[ ] Add pairwise flag to toggle between one-vs-one and all-vs-all**
  computation. I.E. Add option for componentwise calculation.

Parameters

- **other** (*Boxes*) – boxes to compare IoUs against
- **bias** (*int*) – either 0 or 1, does TL=BR have area of 0 or 1? Defaults to 0.

- **impl** (*str*) – code to specify implementation used to ious. Can be either torch, py, c, or auto. Efficiency and the exact result will vary by implementation, but they will always be close. Some implementations only accept certain data types (e.g. impl='c', only accepts float32 numpy arrays). See ~/code/kwimage/dev/bench_bbox.py for benchmark details. On my system the torch impl was fastest (when the data was on the GPU). Defaults to 'auto'
- **mode** (*str*) – depricated, use impl

Returns
the ious

Return type
ndarray

SeeAlso:
iooas - for a measure of coverage between boxes

Examples

```
>>> import kwimage
>>> self = kwimage.Boxes(np.array([[ 0,  0, 10, 10],
>>>                                [10,  0, 20, 10],
>>>                                [20,  0, 30, 10]]), 'ltrb')
>>> other = kwimage.Boxes(np.array([6, 2, 20, 10]), 'ltrb')
>>> overlaps = self.ious(other, bias=1).round(2)
>>> assert np.all(np.isclose(overlaps, [0.21, 0.63, 0.04])), repr(overlaps)
```

Examples

```
>>> import kwimage
>>> boxes1 = kwimage.Boxes(np.array([[ 0,  0, 10, 10],
>>>                                  [10,  0, 20, 10],
>>>                                  [20,  0, 30, 10]]), 'ltrb')
>>> other = kwimage.Boxes(np.array([[6, 2, 20, 10],
>>>                                 [100, 200, 300, 300]]), 'ltrb')
>>> overlaps = boxes1.ious(other)
>>> print('{}'.format(ub.repr2(overlaps, precision=2, nl=1)))
np.array([[0.18, 0.  ],
          [0.61, 0.  ],
          [0.  , 0.  ]]...)
```

Examples

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> Boxes(np.empty(0), 'xywh').ious(Boxes(np.empty(4), 'xywh')).shape
(0,)
>>> #Boxes(np.empty(4), 'xywh').ious(Boxes(np.empty(0), 'xywh')).shape
>>> Boxes(np.empty((0, 4)), 'xywh').ious(Boxes(np.empty((0, 4)), 'xywh')).shape
(0, 0)
>>> Boxes(np.empty((1, 4)), 'xywh').ious(Boxes(np.empty((0, 4)), 'xywh')).shape
```

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```
(1, 0)
>>> Boxes(np.empty((0, 4)), 'xywh').ious(Boxes(np.empty((1, 4)), 'xywh')).shape
(0, 1)
```

Examples

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> formats = BoxFormat.cannonical
>>> istensors = [False, True]
>>> results = {}
>>> for format in formats:
>>>     for tensor in istensors:
>>>         boxes1 = Boxes.random(5, scale=10.0, rng=0, format=format,␣
↪tensor=tensor)
>>>         boxes2 = Boxes.random(7, scale=10.0, rng=1, format=format,␣
↪tensor=tensor)
>>>         ious = boxes1.ious(boxes2)
>>>         results[(format, tensor)] = ious
>>> results = {k: v.numpy() if torch.is_tensor(v) else v for k, v in results.
↪items() }
>>> results = {k: v.tolist() for k, v in results.items()}
>>> print(ub.repr2(results, sk=True, precision=3, nl=2))
>>> from functools import partial
>>> assert ub.allsame(results.values(), partial(np.allclose, atol=1e-07))
```

iooas(*other*, *bias=0*)

Intersection over other area.

This is an asymetric measure of coverage. How much of the "other" boxes are covered by these boxes. It is the area of intersection between each pair of boxes and the area of the "other" boxes.

SeeAlso:
ious - for a measure of similarity between boxes

Parameters

- **other** (*Boxes*) – boxes to compare IoOA against
- **bias** (*int*) – either 0 or 1, does TL=BR have area of 0 or 1? Defaults to 0.

Returns
the iooas

Return type
ndarray

Examples

```
>>> self = Boxes(np.array([[ 0,  0, 10, 10],
>>>                        [10,  0, 20, 10],
>>>                        [20,  0, 30, 10]]), 'ltrb')
>>> other = Boxes(np.array([[6, 2, 20, 10], [0, 0, 0, 3]]), 'xywh')
>>> coverage = self.iooas(other, bias=0).round(2)
>>> print('coverage = {!r}'.format(coverage))
```

isect_area(*other*, *bias=0*)

Intersection part of intersection over union computation

Parameters

- **other** (*Boxes*) – boxes to compare IoOA against
- **bias** (*int*) – either 0 or 1, does TL=BR have area of 0 or 1? Defaults to 0.

Returns
the iooas

Return type
ndarray

Examples

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> self = Boxes.random(5, scale=10.0, rng=0, format='ltrb')
>>> other = Boxes.random(3, scale=10.0, rng=1, format='ltrb')
>>> isect = self.isect_area(other, bias=0)
>>> ious_v1 = isect / ((self.area + other.area.T) - isect)
>>> ious_v2 = self.ious(other, bias=0)
>>> assert np.allclose(ious_v1, ious_v2)
```

intersection(*other*)

Componentwise intersection between two sets of Boxes

intersections of boxes are always boxes, so this works

Parameters
other (*Boxes*) – boxes to intersect with this object. (must be of same length)

Returns
the intersection geometry

Return type
Boxes

Examples

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> from kwimage.structs.boxes import *  # NOQA
>>> self = Boxes.random(5, rng=0).scale(10.)
>>> other = self.translate(1)
>>> new = self.intersection(other)
>>> new_area = np.nan_to_num(new.area).ravel()
>>> alt_area = np.diag(self.isect_area(other))
>>> close = np.isclose(new_area, alt_area)
>>> assert np.all(close)
```

union_hull(*other*)

Componentwise hull union between two sets of Boxes

NOTE: convert to polygon to do a real union.

Parameters
other (*Boxes*) – boxes to union with this object. (must be of same length)

Returns
unioned boxes

Return type
Boxes

Examples

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> from kwimage.structs.boxes import *  # NOQA
>>> self = Boxes.random(5, rng=0).scale(10.)
>>> other = self.translate(1)
>>> new = self.union_hull(other)
>>> new_area = np.nan_to_num(new.area).ravel()
```

bounding_box()

Returns the box that bounds all of the contained boxes

Returns
a single box

Return type
Boxes

Examples

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> from kwimage.structs.boxes import *  # NOQA
>>> self = Boxes.random(5, rng=0).scale(10.)
>>> other = self.translate(1)
>>> new = self.union_hull(other)
>>> new_area = np.nan_to_num(new.area).ravel()
```

contains(*other*)

Determine of points are completely contained by these boxes

Parameters
other (*kwimage.Points*) – points to test for containment. TODO: support generic data types

Returns

flags - N x M boolean matrix indicating which box
contains which points, where N is the number of boxes and M is the number of points.

Return type
ArrayLike

Examples

```
>>> import kwimage
>>> self = kwimage.Boxes.random(10).scale(10).round()
>>> other = kwimage.Points.random(10).scale(10).round()
>>> flags = self.contains(other)
>>> flags = self.contains(self.xy_center)
>>> assert np.all(np.diag(flags))
```

view(**shape*)

Passthrough method to view or reshape

Parameters
***shape** (*Tuple[int, ...]*) – new shape

Returns
data with a different view

Return type
Boxes

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> self = Boxes.random(6, scale=10.0, rng=0, format='xywh').tensor()
>>> assert list(self.view(3, 2, 4).data.shape) == [3, 2, 4]
>>> self = Boxes.random(6, scale=10.0, rng=0, format='ltrb').tensor()
>>> assert list(self.view(3, 2, 4).data.shape) == [3, 2, 4]
```

class kwimage.**Color**(*color*, *alpha=None*, *space=None*)

Bases: NiceRepr

Used for converting a single color between spaces and encodings. This should only be used when handling small numbers of colors(e.g. 1), don't use this to represent an image.

Parameters
space (*str*) – colorspace of wrapped color. Assume RGB if not specified and it cannot be inferred

CommandLine

```
xdoctest -m ~/code/kwimage/kwimage/im_color.py Color
```

Example

```
>>> print(Color('g'))
>>> print(Color('orangered'))
>>> print(Color('#AAAAAA').as255())
>>> print(Color([0, 255, 0]))
>>> print(Color([1, 1, 1.]))
>>> print(Color([1, 1, 1]))
>>> print(Color(Color([1, 1, 1])).as255())
>>> print(Color(Color([1., 0, 1, 0])).ashex())
>>> print(Color([1, 1, 1], alpha=255))
>>> print(Color([1, 1, 1], alpha=255, space='lab'))
```

forimage(*image*, *space='auto'*)

Return a numeric value for this color that can be used in the given image.

Create a numeric color tuple that agrees with the format of the input image (i.e. float or int, with 3 or 4 channels).

Parameters

- **image** (*ndarray*) – image to return color for
- **space** (*str*) – colorspace of the input image. Defaults to 'auto', which will choose rgb or rgba

Returns

the color value

Return type

Tuple[Number, ...]

Example

```
>>> import kwimage
>>> img_f3 = np.zeros([8, 8, 3], dtype=np.float32)
>>> img_u3 = np.zeros([8, 8, 3], dtype=np.uint8)
>>> img_f4 = np.zeros([8, 8, 4], dtype=np.float32)
>>> img_u4 = np.zeros([8, 8, 4], dtype=np.uint8)
>>> kwimage.Color('red').forimage(img_f3)
(1.0, 0.0, 0.0)
>>> kwimage.Color('red').forimage(img_f4)
(1.0, 0.0, 0.0, 1.0)
>>> kwimage.Color('red').forimage(img_u3)
(255, 0, 0)
>>> kwimage.Color('red').forimage(img_u4)
(255, 0, 0, 255)
>>> kwimage.Color('red', alpha=0.5).forimage(img_f4)
(1.0, 0.0, 0.0, 0.5)
```

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```
>>> kwimage.Color('red', alpha=0.5).forimage(img_u4)
(255, 0, 0, 127)
>>> kwimage.Color('red').forimage(np.uint8)
(255, 0, 0)
```

ashex(*space=None*)

Convert to hex values

Parameters
space (*None | str*) – if specified convert to this colorspace before returning

Returns
the hex representation

Return type
str

as255(*space=None*)

Convert to byte values

Parameters
space (*None | str*) – if specified convert to this colorspace before returning

Returns
The uint8 tuple of color values between 0 and 255.

Return type
Tuple[int, int, int] | Tuple[int, int, int, int]

as01(*space=None*)

Convert to float values

Parameters
space (*None | str*) – if specified convert to this colorspace before returning

Returns
The float tuple of color values between 0 and 1

Return type
Tuple[float, float, float] | Tuple[float, float, float, float]

classmethod named_colors()

Returns
names of colors that Color accepts

Return type
List[str]

Example

```
>>> import kwimage
>>> named_colors = kwimage.Color.named_colors()
>>> color_lut = {name: kwimage.Color(name).as01() for name in named_colors}
>>> # xdoctest: +REQUIRES(module:kwplot)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> # This is a very big table if we let it be, reduce it
>>> color_lut =dict(list(color_lut.items())[0:10])
>>> canvas = kwplot.make_legend_img(color_lut)
>>> kwplot.imshow(canvas)
```

classmethod distinct(*num*, *existing=None*, *space='rgb'*, *legacy='auto'*, *exclude_black=True*, *exclude_white=True*)

Make multiple distinct colors.

The legacy variant is based on a stack overflow post [HowToDistinct], but the modern variant is based on the `distinctipy` package.

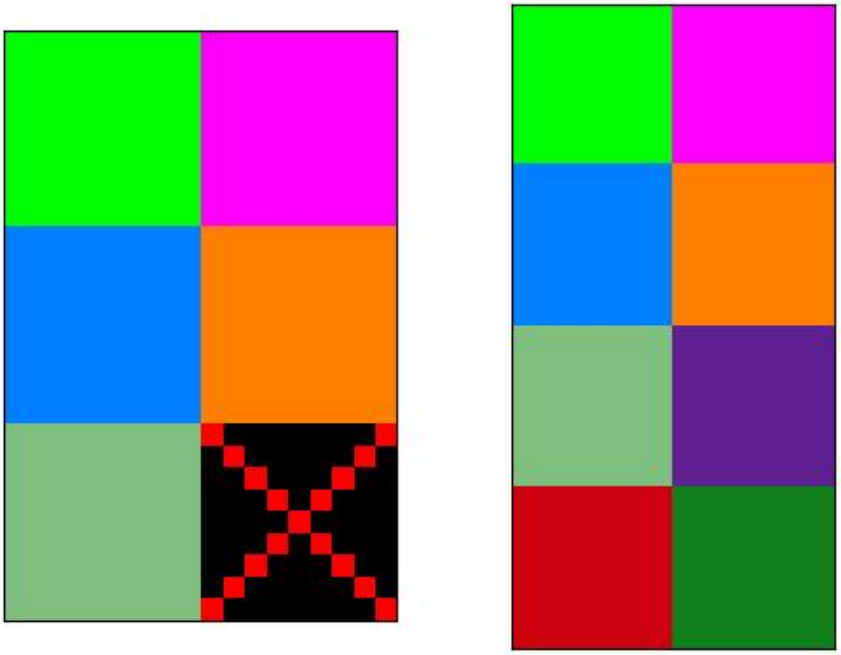
References

Returns
list of distinct float color values

Return type
List[Tuple]

Example

```
>>> # xdoctest: +REQUIRES(module:matplotlib)
>>> from kwimage.im_color import *  # NOQA
>>> import kwimage
>>> colors1 = kwimage.Color.distinct(5, legacy=False)
>>> colors2 = kwimage.Color.distinct(3, existing=colors1)
>>> # xdoctest: +REQUIRES(module:kwplot)
>>> # xdoctest: +REQUIRES(--show)
>>> from kwimage.im_color import _draw_color_swatch
>>> swatch1 = _draw_color_swatch(colors1, cellshape=9)
>>> swatch2 = _draw_color_swatch(colors1 + colors2, cellshape=9)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(swatch1, pnum=(1, 2, 1), fnum=1)
>>> kwplot.imshow(swatch2, pnum=(1, 2, 2), fnum=1)
>>> kwplot.show_if_requested()
```



classmethod random(*pool='named'*)

Returns
Color

distance(*other*, *space='lab'*)

Distance between self an another color

Parameters

- **other** (*Color*) – the color to compare
- **space** (*str*) – the colorspace to comapre in

Returns
float

class kwimage.**Coords**(*data=None*, *meta=None*)

Bases: Spatial, NiceRepr

A data structure to store n-dimensional coordinate geometry.

Currently it is up to the user to maintain what coordinate system this geometry belongs to.

Note: This class was designed to hold coordinates in r/c format, but in general this class is anostic to dimension ordering as long as you are consistent. However, there are two places where this matters: (1) drawing and (2) gdal/imgaug-warping. In these places we will assume x/y for legacy reasons. This may change in the future.

The term axes with resepct to `Coords` always refers to the final numpy axis. In other words the final numpy-axis represents ALL of the coordinate-axes.

CommandLine

```
xdoctest -m kwimage.structs.coords Coords
```

Example

```
>>> from kwimage.structs.coords import *  # NOQA
>>> import kwarray
>>> rng = kwarray.ensure_rng(0)
>>> self = Coords.random(num=4, dim=3, rng=rng)
>>> print('self = {}'.format(self))
self = <Coords(data=
    array([[0.5488135 , 0.71518937, 0.60276338],
           [0.54488318, 0.4236548 , 0.64589411],
           [0.43758721, 0.891773  , 0.96366276],
           [0.38344152, 0.79172504, 0.52889492]]))>
>>> matrix = rng.rand(4, 4)
>>> self.warp(matrix)
<Coords(data=
    array([[0.71037426, 1.25229659, 1.39498435],
           [0.60799503, 1.26483447, 1.42073131],
           [0.72106004, 1.39057144, 1.38757508],
```

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```
           [0.68384299, 1.23914654, 1.29258196]]))>
>>> self.translate(3, inplace=True)
<Coords(data=
    array([[3.5488135 , 3.71518937, 3.60276338],
           [3.54488318, 3.4236548 , 3.64589411],
           [3.43758721, 3.891773  , 3.96366276],
           [3.38344152, 3.79172504, 3.52889492]]))>
>>> self.translate(3, inplace=True)
<Coords(data=
    array([[6.5488135 , 6.71518937, 6.60276338],
           [6.54488318, 6.4236548 , 6.64589411],
           [6.43758721, 6.891773  , 6.96366276],
           [6.38344152, 6.79172504, 6.52889492]]))>
>>> self.scale(2)
<Coords(data=
    array([[13.09762701, 13.43037873, 13.20552675],
           [13.08976637, 12.8473096 , 13.29178823],
           [12.87517442, 13.783546  , 13.92732552],
           [12.76688304, 13.58345008, 13.05778984]]))>
>>> # xdoctest: +REQUIRES(module:torch)
>>> self.tensor()
>>> self.tensor().tensor().numpy().numpy()
>>> self.numpy()
>>> #self.draw_on()
```

property dtype

property dim

property shape

copy()

classmethod random(*num=1*, *dim=2*, *rng=None*, *meta=None*)

Makes random coordinates; typically for testing purposes

is_numpy()

is_tensor()

compress(*flags*, *axis=0*, *inplace=False*)

Filters items based on a boolean criterion

Parameters

- **flags** (*ArrayLike*) – true for items to be kept. Extended type: ArrayLike[bool].
- **axis** (*int*) – you usually want this to be 0
- **inplace** (*bool*) – if True, modifies this object

Returns

filtered coords

Return type

Coords

Example

```
>>> import kwimage
>>> self = kwimage.Coords.random(10, rng=0)
>>> self.compress([True] * len(self))
>>> self.compress([False] * len(self))
<Coords(data=array([], shape=(0, 2), dtype=float64))>
>>> # xdoctest: +REQUIRES(module:torch)
>>> self = self.tensor()
>>> self.compress([True] * len(self))
>>> self.compress([False] * len(self))
```

take(*indices*, *axis=0*, *inplace=False*)

Takes a subset of items at specific indices

Parameters

- **indices** (*ArrayLike*) – indexes of items to take. Extended type ArrayLike[int].
- **axis** (*int*) – you usually want this to be 0
- **inplace** (*bool*) – if True, modifies this object

Returns
filtered coords

Return type
Coords

Example

```
>>> import kwimage
>>> self = kwimage.Coords(np.array([[25, 30, 15, 10]]))
>>> self.take([0])
<Coords(data=array([[25, 30, 15, 10]]))>
>>> self.take([])
<Coords(data=array([], shape=(0, 4), dtype=int64))>
```

astype(*dtype*, *inplace=False*)

Changes the data type

Parameters

- **dtype** – new type
- **inplace** (*bool*) – if True, modifies this object

Returns
modified coordinates

Return type
Coords

round(*decimals=0*, *inplace=False*)

Rounds data to the specified decimal place

Parameters

- **inplace** (*bool*) – if True, modifies this object

- **decimals** (*int*) – number of decimal places to round to

Returns
modified coordinates

Return type
Coords

Example

```
>>> import kwimage
>>> self = kwimage.Coords.random(3).scale(10)
>>> self.round()
```

view(**shape*)

Passthrough method to view or reshape

Parameters
***shape** – new shape of the data

Returns
modified coordinates

Return type
Coords

Example

```
>>> self = Coords.random(6, dim=4).numpy()
>>> assert list(self.view(3, 2, 4).data.shape) == [3, 2, 4]
>>> # xdoctest: +REQUIRES(module:torch)
>>> self = Coords.random(6, dim=4).tensor()
>>> assert list(self.view(3, 2, 4).data.shape) == [3, 2, 4]
```

classmethod concatenate(*coords*, *axis=0*)

Concatenates lists of coordinates together

Parameters

- **coords** (*Sequence[Coords]*) – list of coords to concatenate
- **axis** (*int*) – axis to stack on. Defaults to 0.

Returns
stacked coords

Return type
Coords

CommandLine

```
xdoctest -m kwimage.structs.coords Coords.concatenate
```

Example

```
>>> coords = [Coords.random(3) for _ in range(3)]
>>> new = Coords.concatenate(coords)
>>> assert len(new) == 9
>>> assert np.all(new.data[3:6] == coords[1].data)
```

property device

If the backend is torch returns the data device, otherwise None

tensor(*device=NoParam*)

Converts numpy to tensors. Does not change memory if possible.

Returns
modified coordinates

Return type
Coords

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> self = Coords.random(3).numpy()
>>> newself = self.tensor()
>>> self.data[0, 0] = 0
>>> assert newself.data[0, 0] == 0
>>> self.data[0, 0] = 1
>>> assert self.data[0, 0] == 1
```

numpy()

Converts tensors to numpy. Does not change memory if possible.

Returns
modified coordinates

Return type
Coords

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> self = Coords.random(3).tensor()
>>> newself = self.numpy()
>>> self.data[0, 0] = 0
>>> assert newself.data[0, 0] == 0
>>> self.data[0, 0] = 1
>>> assert self.data[0, 0] == 1
```

reorder_axes(*new_order*, *inplace=False*)

Change the ordering of the coordinate axes.

Parameters

- **new_order** (*Tuple[int]*) – `new_order[i]` should specify which axes in the original coordinates should be mapped to the `i-th` position in the returned axes.
- **inplace** (*bool*) – if True, modifies data inplace

Returns

modified coordinates

Return type

Coords

Note: This is the ordering of the "columns" in final numpy axis, not the numpy axes themselves.

Example

```
>>> from kwimage.structs.coords import *  # NOQA
>>> self = Coords(data=np.array([
>>>     [7, 11],
>>>     [13, 17],
>>>     [21, 23],
>>> ]))
>>> new = self.reorder_axes((1, 0))
>>> print('new = {!r}'.format(new))
new = <Coords(data=
    array([[11,  7],
           [17, 13],
           [23, 21]]))>
```

Example

```
>>> from kwimage.structs.coords import *  # NOQA
>>> self = Coords.random(10, rng=0)
>>> new = self.reorder_axes((1, 0))
>>> # Remapping using 1, 0 reverses the axes
>>> assert np.all(new.data[:, 0] == self.data[:, 1])
>>> assert np.all(new.data[:, 1] == self.data[:, 0])
>>> # Remapping using 0, 1 does nothing
>>> eye = self.reorder_axes((0, 1))
>>> assert np.all(eye.data == self.data)
>>> # Remapping using 0, 0, destroys the 1-th column
>>> bad = self.reorder_axes((0, 0))
>>> assert np.all(bad.data[:, 0] == self.data[:, 0])
>>> assert np.all(bad.data[:, 1] == self.data[:, 0])
```

warp(*transform*, *input_dims=None*, *output_dims=None*, *inplace=False*)

Generalized coordinate transform.

Parameters

- **transform** (*GeometricTransform | ArrayLike | Augmenter | Callable*) – scikit-image tranform, a 3x3 transformation matrix, an imgaug Augmenter, or generic callable which transforms an NxD ndarray.
- **input_dims** (*Tuple*) – shape of the image these objects correspond to (only needed / used when transform is an imgaug augmenter)
- **output_dims** (*Tuple*) – unused in non-raster structures, only exists for compatibility.
- **inplace** (*bool*) – if True, modifies data inplace

Returns
modified coordinates

Return type
Coords

Note: Let D = self.dims

transformation matrices can be either:

- (D + 1) x (D + 1) # for homog
- D x D # for scale / rotate
- D x (D + 1) # for affine

Example

```
>>> from kwimage.structs.coords import *  # NOQA
>>> self = Coords.random(10, rng=0)
>>> transform = skimage.transform.AffineTransform(scale=(2, 2))
>>> new = self.warp(transform)
>>> assert np.all(new.data == self.scale(2).data)
```

Doctest

```
>>> self = Coords.random(10, rng=0)
>>> assert np.all(self.warp(np.eye(3)).data == self.data)
>>> assert np.all(self.warp(np.eye(2)).data == self.data)
```

Doctest

```
>>> # xdoctest: +REQUIRES(module:osgeo)
>>> from osgeo import osr
>>> wgs84_crs = osr.SpatialReference()
>>> wgs84_crs.ImportFromEPSG(4326)
>>> dst_crs = osr.SpatialReference()
>>> dst_crs.ImportFromEPSG(2927)
>>> transform = osr.CoordinateTransformation(wgs84_crs, dst_crs)
>>> self = Coords.random(10, rng=0)
>>> new = self.warp(transform)
>>> assert np.all(new.data != self.data)
```

```
>>> # Alternative using generic func
>>> def _gdal_coord_tranform(pts):
...     return np.array([transform.TransformPoint(x, y, 0)[0:2]
...                      for x, y in pts])
>>> alt = self.warp(_gdal_coord_tranform)
>>> assert np.all(alt.data != self.data)
>>> assert np.all(alt.data == new.data)
```

Doctest

```
>>> # can use a generic function
>>> def func(xy):
...     return np.zeros_like(xy)
>>> self = Coords.random(10, rng=0)
>>> assert np.all(self.warp(func).data == 0)
```

to_imgaug(*input_dims*)

Translate to an imgaug object

Returns
imgaug data structure

Return type
imgaug.KeypointsOnImage

Example

```
>>> # xdoctest: +REQUIRES(module:imgaug)
>>> import kwimage
>>> import numpy as np
>>> self = kwimage.Coords.random(10)
>>> input_dims = (10, 10)
>>> kpoi = self.to_imgaug(input_dims)
>>> new = kwimage.Coords.from_imgaug(kpoi)
>>> assert np.allclose(new.data, self.data)
```

classmethod from_imgaug(*kpoi*)

scale(*factor*, *about=None*, *output_dims=None*, *inplace=False*)

Scale coordinates by a factor

Parameters

- **factor** (*float | Tuple[float, float]*) – scale factor as either a scalar or per-dimension tuple.
- **about** (*Tuple | None*) – if unspecified scales about the origin (0, 0), otherwise the rotation is about this point.
- **output_dims** (*Tuple*) – unused in non-raster spatial structures
- **inplace** (*bool*) – if True, modifies data inplace

Returns
modified coordinates

Return type
Coords

Example

```
>>> from kwimage.structs.coords import *  # NOQA
>>> self = Coords.random(10, rng=0)
>>> new = self.scale(10)
>>> assert new.data.max() <= 10
```

```
>>> self = Coords.random(10, rng=0)
>>> self.data = (self.data * 10).astype(int)
>>> new = self.scale(10)
>>> assert new.data.dtype.kind == 'i'
>>> new = self.scale(10.0)
>>> assert new.data.dtype.kind == 'f'
```

translate(*offset*, *output_dims=None*, *inplace=False*)

Shift the coordinates

Parameters

- **offset** (*float | Tuple[float, float]*) – transation offset as either a scalar or a per-dimension tuple.
- **output_dims** (*Tuple*) – unused in non-raster spatial structures
- **inplace** (*bool*) – if True, modifies data inplace

Returns
modified coordinates

Return type
Coords

Example

```
>>> from kwimage.structs.coords import *  # NOQA
>>> self = Coords.random(10, dim=3, rng=0)
>>> new = self.translate(10)
>>> assert new.data.min() >= 10
>>> assert new.data.max() <= 11
>>> Coords.random(3, dim=3, rng=0)
>>> Coords.random(3, dim=3, rng=0).translate((1, 2, 3))
```

rotate(*theta*, *about=None*, *output_dims=None*, *inplace=False*)

Rotate the coordinates about a point.

Parameters

- **theta** (*float*) – rotation angle in radians
- **about** (*Tuple | None*) – if unspecified rotates about the origin (0, 0), otherwise the rotation is about this point.
- **output_dims** (*Tuple*) – unused in non-raster spatial structures

- **inplace** (*bool*) – if True, modifies data inplace

Returns
modified coordinates

Return type
Coords

Todo:

- [ ] Generalized ND Rotations?

References

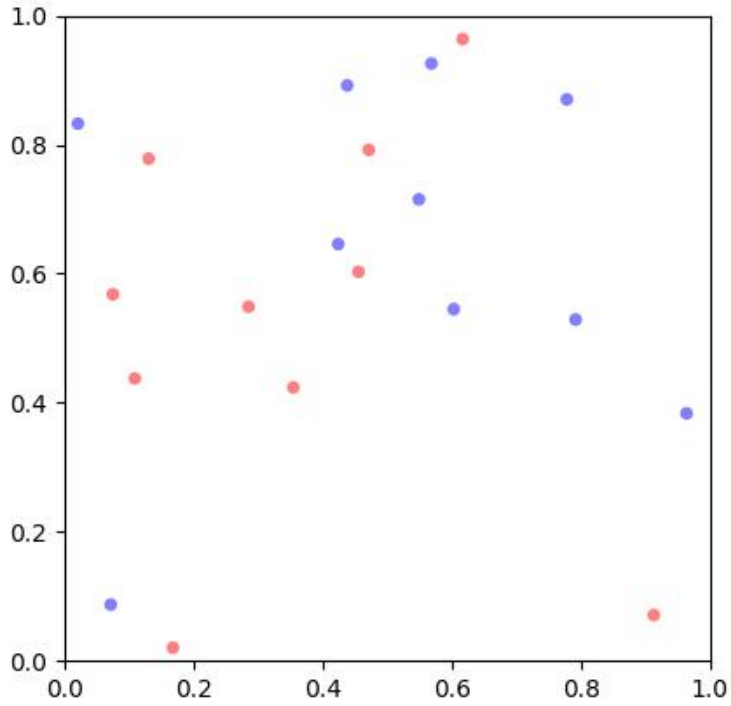
https://math.stackexchange.com/questions/197772/gen-rot-matrix

Example

```
>>> from kwimage.structs.coords import *  # NOQA
>>> self = Coords.random(10, dim=2, rng=0)
>>> theta = np.pi / 2
>>> new = self.rotate(theta)
```

```
>>> # Test rotate agrees with warp
>>> sin_ = np.sin(theta)
>>> cos_ = np.cos(theta)
>>> rot_ = np.array([[cos_, -sin_], [sin_,  cos_]])
>>> new2 = self.warp(rot_)
>>> assert np.allclose(new.data, new2.data)
```

```
>>> #
>>> # Rotate about a custom point
>>> theta = np.pi / 2
>>> new3 = self.rotate(theta, about=(0.5, 0.5))
>>> #
>>> # Rotate about the center of mass
>>> about = self.data.mean(axis=0)
>>> new4 = self.rotate(theta, about=about)
>>> # xdoc: +REQUIRES(--show)
>>> # xdoc: +REQUIRES(module:kwplot)
>>> import kwplot
>>> kwplot.figure(fnum=1, doclf=True)
>>> plt = kwplot.autoplt()
>>> self.draw(radius=0.01, color='blue', alpha=.5, coord_axes=[1, 0], setlim=
↪'grow')
>>> plt.gca().set_aspect('equal')
>>> new3.draw(radius=0.01, color='red', alpha=.5, coord_axes=[1, 0], setlim=
↪'grow')
```



fill(*image*, *value*, *coord_axes=None*, *interp='bilinear'*)

Sets sub-coordinate locations in a grid to a particular value

Parameters

coord_axes (*Tuple*) – specify which image axes each coordinate dim corresponds to. For 2D images, if you are storing r/c data, set to [0,1], if you are storing x/y data, set to [1,0].

Returns

image with coordinates rasterized on it

Return type

ndarray

soft_fill(*image*, *coord_axes=None*, *radius=5*)

Used for drawing keypoint truth in heatmaps

Parameters

coord_axes (*Tuple*) – specify which image axes each coordinate dim corresponds to. For 2D images, if you are storing r/c data, set to [0,1], if you are storing x/y data, set to [1,0].

In other words the i-th entry in coord_axes specifies which row-major spatial dimension the i-th column of a coordinate corresponds to. The index is the coordinate dimension and the value is the axes dimension.

Returns

image with coordinates rasterized on it

Return type

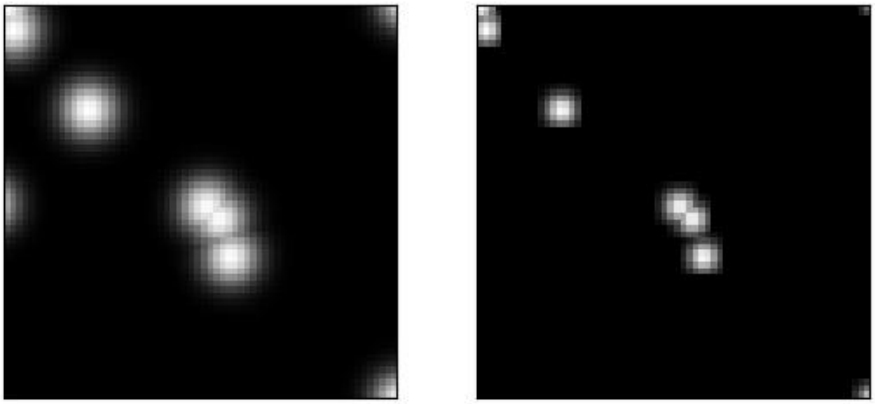
ndarray

References

https://stackoverflow.com/questions/54726703/generating-keypoint-heatmaps-in-tensorflow

Example

```
>>> from kwimage.structs.coords import *  # NOQA
>>> s = 64
>>> self = Coords.random(10, meta={'shape': (s, s)}).scale(s)
>>> # Put points on edges to to verify "edge cases"
>>> self.data[1] = [0, 0]       # top left
>>> self.data[2] = [s, s]       # bottom right
>>> self.data[3] = [0, s + 10]  # bottom left
>>> self.data[4] = [-3, s // 2] # middle left
>>> self.data[5] = [s + 1, -1]  # top right
>>> # Put points in the middle to verify overlap blending
>>> self.data[6] = [32.5, 32.5] # middle
>>> self.data[7] = [34.5, 34.5] # middle
>>> fill_value = 1
>>> coord_axes = [1, 0]
>>> radius = 10
>>> image1 = np.zeros((s, s))
>>> self.soft_fill(image1, coord_axes=coord_axes, radius=radius)
>>> radius = 3.0
>>> image2 = np.zeros((s, s))
>>> self.soft_fill(image2, coord_axes=coord_axes, radius=radius)
>>> # xdoc: +REQUIRES(--show)
>>> # xdoc: +REQUIRES(module:kwplot)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(image1, pnum=(1, 2, 1))
>>> kwplot.imshow(image2, pnum=(1, 2, 2))
```



draw_on(*image=None*, *fill_value=1*, *coord_axes=[1, 0]*, *interp='bilinear'*)

Note: unlike other methods, the defaults assume x/y internal data

Parameters

coord_axes (*Tuple*) – specify which image axes each coordinate dim corresponds to. For 2D images, if you are storing r/c data, set to [0,1], if you are storing x/y data, set to [1,0].

In other words the i-th entry in coord_axes specifies which row-major spatial dimension the i-th column of a coordinate corresponds to. The index is the coordinate dimension and the value is the axes dimension.

Returns

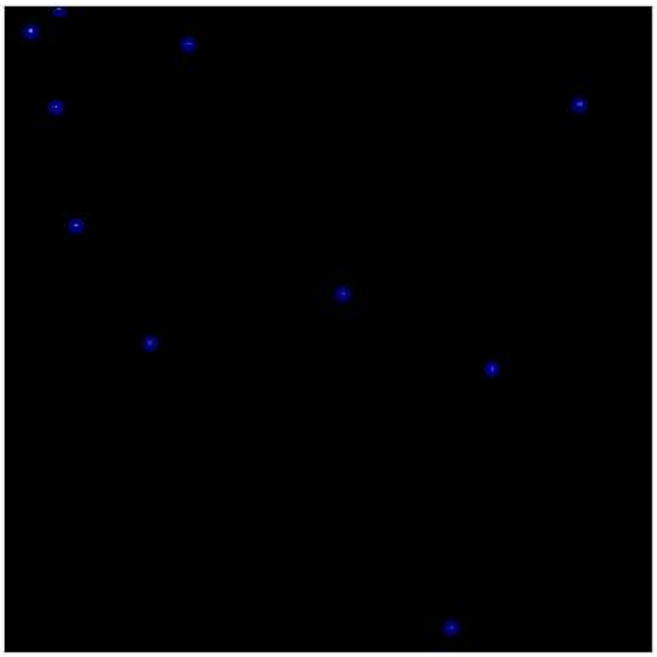
image with coordinates drawn on it

Return type

ndarray

Example

```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> from kwimage.structs.coords import *  # NOQA
>>> s = 256
>>> self = Coords.random(10, meta={'shape': (s, s)}).scale(s)
>>> self.data[0] = [10, 10]
>>> self.data[1] = [20, 40]
>>> image = np.zeros((s, s))
>>> fill_value = 1
>>> image = self.draw_on(image, fill_value, coord_axes=[1, 0], interp='bilinear
↪')
>>> # image = self.draw_on(image, fill_value, coord_axes=[0, 1], interp='nearest
↪')
>>> # image = self.draw_on(image, fill_value, coord_axes=[1, 0], interp=
↪'bilinear')
>>> # image = self.draw_on(image, fill_value, coord_axes=[1, 0], interp='nearest
↪')
>>> # xdoc: +REQUIRES(--show)
>>> # xdoc: +REQUIRES(module:kwplot)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.figure(fnum=1, doclf=True)
>>> kwplot.imshow(image)
>>> self.draw(radius=3, alpha=.5, coord_axes=[1, 0])
```



draw(*color='blue'*, *ax=None*, *alpha=None*, *coord_axes=[1, 0]*, *radius=1*, *setlim=False*)

Draw these coordinates via matplotlib

Note: unlike other methods, the defaults assume x/y internal data

Parameters

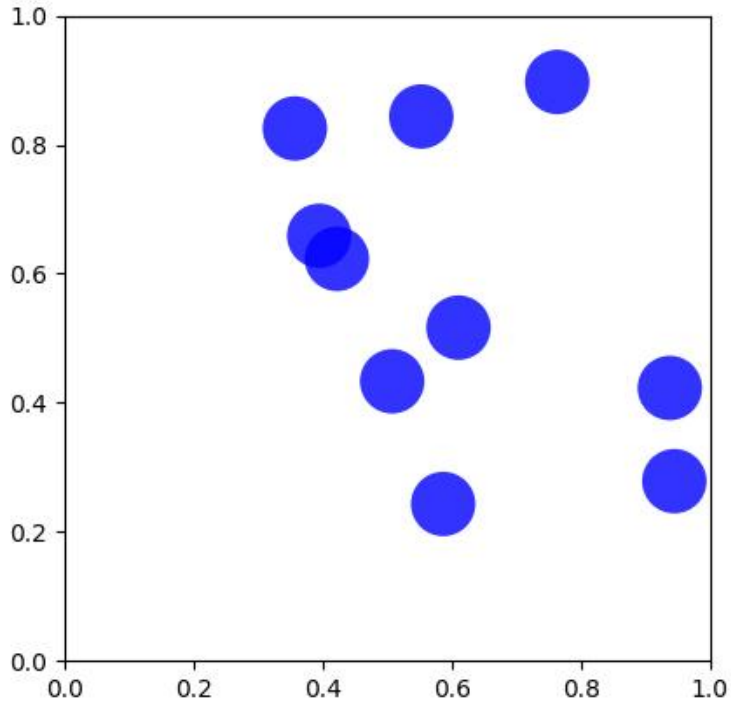
- **setlim** (*bool*) – if True ensures the limits of the axes contains the polygon
- **coord_axes** (*Tuple*) – specify which image axes each coordinate dim corresponds to. For 2D images, if you are storing r/c data, set to [0,1], if you are storing x/y data, set to [1,0].

Returns
drawn matplotlib objects

Return type
List[mpl.collections.PatchCollection]

Example

```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> from kwimage.structs.coords import *  # NOQA
>>> self = Coords.random(10)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> plt = kwplot.autoplt()
>>> self.draw(radius=0.05, alpha=0.8)
>>> plt.gca().set_xlim(0, 1)
>>> plt.gca().set_ylim(0, 1)
>>> plt.gca().set_aspect('equal')
```



class kwimage.**Detections**(*data=None*, *meta=None*, *datakeys=None*, *metakeys=None*, *checks=True*, ***kwargs*)

Bases: NiceRepr, _DetAlgoMixin, _DetDrawMixin

Container for holding and manipulating multiple detections.

Variables

- **data** (*Dict*) – dictionary containing corresponding lists. The length of each list is the number of detections. This contains the bounding boxes, confidence scores, and class indices. Details of the most common keys and types are as follows:

  boxes (kwimage.Boxes[ArrayLike]): multiple bounding boxes scores (ArrayLike): associated scores class_idxs (ArrayLike): associated class indices segmentations (ArrayLike): segmentations masks for each box, members can be *Mask* or *MultiPolygon*. keypoints (ArrayLike): keypoints for each box. Members should be *Points*.

  Additional custom keys may be specified as long as (a) the values are array-like and the first axis corresponds to the standard data values and (b) are custom keys are listed in the *datakeys* kwargs when constructing the Detections.

- **meta** (*Dict*) – This contains contextual information about the detections. This includes the class names, which can be indexed into via the class indexes.

Example

```
>>> import kwimage
>>> dets = kwimage.Detections(
>>>     # there are expected keys that do not need registration
>>>     boxes=kwimage.Boxes.random(3),
>>>     class_idxs=[0, 1, 1],
>>>     classes=['a', 'b'],
>>>     # custom data attrs must align with boxes
>>>     myattr1=np.random.rand(3),
>>>     myattr2=np.random.rand(3, 2, 8),
>>>     # there are no restrictions on metadata
>>>     mymeta='a custom metadata string',
>>>     # Note that any key not in kwimage.Detections.__datakeys__ or
>>>     # kwimage.Detections.__metakeys__ must be registered at the
>>>     # time of construction.
>>>     datakeys=['myattr1', 'myattr2'],
>>>     metakeys=['mymeta'],
>>>     checks=True,
>>> )
>>> print('dets = {}'.format(dets))
dets = <Detections(3)>
```

copy()

Returns a deep copy of this Detections object

classmethod coerce(*data=None*, ***kwargs*)

The "try-anything to get what I want" constructor

Parameters

- **data**
- ****kwargs** – currently boxes and cnames

Example

```
>>> from kwimage.structs.detections import *  # NOQA
>>> import kwimage
>>> kwargs = dict(
>>>     boxes=kwimage.Boxes.random(4),
>>>     cnames=['a', 'b', 'c', 'c'],
>>> )
>>> data = {}
>>> self = kwimage.Detections.coerce(data, **kwargs)
```

classmethod from_coco_annots(*anns*, *cats=None*, *classes=None*, *kp_classes=None*, *shape=None*, *dset=None*)

Create a Detections object from a list of coco-like annotations.

Parameters

- **anns** (*List[Dict]*) – list of coco-like annotation objects
- **dset** (*kwcoco.CocoDataset*) – if specified, cats, classes, and kp_classes can are ignored.

- **cats** (*List[Dict]*) – coco-format category information. Used only if *dset* is not specified.
- **classes** (*kwcoco.CategoryTree*) – category tree with coco class info. Used only if *dset* is not specified.
- **kp_classes** (*kwcoco.CategoryTree*) – keypoint category tree with coco keypoint class info. Used only if *dset* is not specified.
- **shape** (*tuple*) – shape of parent image

Returns
a detections object

Return type
Detections

Example

```
>>> from kwimage.structs.detections import *  # NOQA
>>> # xdoctest: +REQUIRES(--module:ndsampler)
>>> anns = [{
>>>     'id': 0,
>>>     'image_id': 1,
>>>     'category_id': 2,
>>>     'bbox': [2, 3, 10, 10],
>>>     'keypoints': [4.5, 4.5, 2],
>>>     'segmentation': {
>>>         'counts': '_11a04M2O0O20N101N3L_5',
>>>         'size': [20, 20],
>>>     },
>>> }]
>>> dataset = {
>>>     'images': [],
>>>     'annotations': [],
>>>     'categories': [
>>>         {'id': 0, 'name': 'background'},
>>>         {'id': 2, 'name': 'class1', 'keypoints': ['spot']}
>>>     ]
>>> }
>>> #import ndsampler
>>> #dset = ndsampler.CocoDataset(dataset)
>>> cats = dataset['categories']
>>> dets = Detections.from_coco_annots(anns, cats)
```

Example

```
>>> # xdoctest: +REQUIRES(--module:ndsampler)
>>> # Test case with no category information
>>> from kwimage.structs.detections import *  # NOQA
>>> anns = [{
>>>     'id': 0,
>>>     'image_id': 1,
>>>     'category_id': None,
>>>     'bbox': [2, 3, 10, 10],
>>>     'prob': [.1, .9],
>>> }]
>>> cats = [
>>>     {'id': 0, 'name': 'background'},
>>>     {'id': 2, 'name': 'class1'}
>>> ]
>>> dets = Detections.from_coco_annots(anns, cats)
```

Example

```
>>> import kwimage
>>> # xdoctest: +REQUIRES(--module:ndsampler)
>>> import ndsampler
>>> sampler = ndsampler.CocoSampler.demo('photos')
>>> iminfo, anns = sampler.load_image_with_annots(1)
>>> shape = iminfo['imdata'].shape[0:2]
>>> kp_classes = sampler.dset.keypoint_categories()
>>> dets = kwimage.Detections.from_coco_annots(
>>>     anns, sampler.dset.dataset['categories'], sampler.catgraph,
>>>     kp_classes, shape=shape)
```

to_coco(*cname_to_cat=None*, *style='orig'*, *image_id=None*, *dset=None*)

Converts this set of detections into coco-like annotation dictionaries.

Note: Not all aspects of the MS-COCO format can be accurately represented, so some liberties are taken. The MS-COCO standard defines that annotations should specifiy a category_id field, but in some cases this information is not available so we will populate a 'category_name' field if possible and in the worst case fall back to 'category_index'.

Additionally, detections may contain additional information beyond the MS-COCO standard, and this information (e.g. weight, prob, score) is added as forign fields.

Parameters

- **cname_to_cat** – currently ignored.
- **style** (*str*) – either 'orig' (for the original coco format) or 'new' for the more general kwcoco-style coco format. Defaults to 'orig'
- **image_id** (*int*) – if specified, populates the image_id field of each image.
- **dset** (*kwcoco.CocoDataset | None*) – if specified, attempts to populate the category_id field to be compatible with this coco dataset.

Yields
dict – coco-like annotation structures

Example

```
>>> # xdoctest: +REQUIRES(module:ndsampler)
>>> from kwimage.structs.detections import *
>>> self = Detections.demo()[0]
>>> cname_to_cat = None
>>> list(self.to_coco())
```

property boxes

property class_idxs

property scores
typically only populated for predicted detections

property probs
typically only populated for predicted detections

property weights
typically only populated for groundtruth detections

property classes

num_boxes()

warp(*transform*, *input_dims=None*, *output_dims=None*, *inplace=False*)
Spatially warp the detections.

Parameters

- **transform** (*kwimage.Affine | ndarray | Callable | Any*) – Something coercable to a transform. Usually a kwimage.Affine object
- **input_dims** (*Tuple[int, int]*) – shape of the expected input canvas
- **output_dims** (*Tuple[int, int]*) – shape of the expected output canvas
- **inplace** (*bool*) – if true operate inplace

Returns
the warped detections object

Return type
Detections

Example

```
>>> import skimage
>>> transform = skimage.transform.AffineTransform(scale=(2, 3), translation=(4,
↪ 5))
>>> self = Detections.random(2)
>>> new = self.warp(transform)
>>> assert new.boxes == self.boxes.warp(transform)
>>> assert new != self
```

scale(*factor*, *output_dims=None*, *inplace=False*)

Spatially scale the detections.

Example

```
>>> import skimage
>>> transform = skimage.transform.AffineTransform(scale=(2, 3), translation=(4,
↪ 5))
>>> self = Detections.random(2)
>>> new = self.warp(transform)
>>> assert new.boxes == self.boxes.warp(transform)
>>> assert new != self
```

translate(*offset*, *output_dims=None*, *inplace=False*)

Spatially translate the detections.

Example

```
>>> import skimage
>>> self = Detections.random(2)
>>> new = self.translate(10)
```

classmethod concatenate(*dets*)

Parameters
boxes (*Sequence[Detections]*) – list of detections to concatenate

Returns
stacked detections

Return type
Detections

Example

```
>>> self = Detections.random(2)
>>> other = Detections.random(3)
>>> dets = [self, other]
>>> new = Detections.concatenate(dets)
>>> assert new.num_boxes() == 5
```

```
>>> self = Detections.random(2, segmentations=True)
>>> other = Detections.random(3, segmentations=True)
>>> dets = [self, other]
>>> new = Detections.concatenate(dets)
>>> assert new.num_boxes() == 5
```

argsort(*reverse=True*)

Sorts detection indices by descending (or ascending) scores

Returns
sorted indices torch.Tensor: sorted indices if using torch backends

Return type
ndarray[Shape['*'], Integer]

sort(*reverse=True*)

Sorts detections by descending (or ascending) scores

Returns
sorted copy of self

Return type
kwimage.structs.Detections

compress(*flags*, *axis=0*)

Returns a subset where corresponding locations are True.

Parameters
flags (*ndarray[Any, Bool] | torch.Tensor*) – mask marking selected items

Returns
subset of self

Return type
kwimage.structs.Detections

CommandLine

```
xdoctest -m kwimage.structs.detections Detections.compress
```

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> import kwimage
>>> dets = kwimage.Detections.random(keypoints='dense')
>>> flags = np.random.rand(len(dets)) > 0.5
>>> subset = dets.compress(flags)
>>> assert len(subset) == flags.sum()
>>> subset = dets.tensor().compress(flags)
>>> assert len(subset) == flags.sum()
```

take(*indices*, *axis=0*)

Returns a subset specified by indices

Parameters
indices (*ndarray[Any, Integer]*) – indices to select

Returns
subset of self

Return type
kwimage.structs.Detections

Example

```
>>> import kwimage
>>> dets = kwimage.Detections(boxes=kwimage.Boxes.random(10))
>>> subset = dets.take([2, 3, 5, 7])
>>> assert len(subset) == 4
>>> # xdoctest: +REQUIRES(module:torch)
>>> subset = dets.tensor().take([2, 3, 5, 7])
>>> assert len(subset) == 4
```

property device

If the backend is torch returns the data device, otherwise None

is_tensor()

is the backend fueled by torch?

is_numpy()

is the backend fueled by numpy?

numpy()

Converts tensors to numpy. Does not change memory if possible.

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> self = Detections.random(3).tensor()
>>> newself = self.numpy()
>>> self.scores[0] = 0
>>> assert newself.scores[0] == 0
>>> self.scores[0] = 1
>>> assert self.scores[0] == 1
>>> self.numpy().numpy()
```

property dtype

tensor(*device=NoParam*)

Converts numpy to tensors. Does not change memory if possible.

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> from kwimage.structs.detections import *
>>> self = Detections.random(3)
>>> newself = self.tensor()
>>> self.scores[0] = 0
>>> assert newself.scores[0] == 0
>>> self.scores[0] = 1
>>> assert self.scores[0] == 1
>>> self.tensor().tensor()
```

classmethod demo()

classmethod random(*num=10*, *scale=1.0*, *classes=3*, *keypoints=False*, *segmentations=False*, *tensor=False*, *rng=None*)

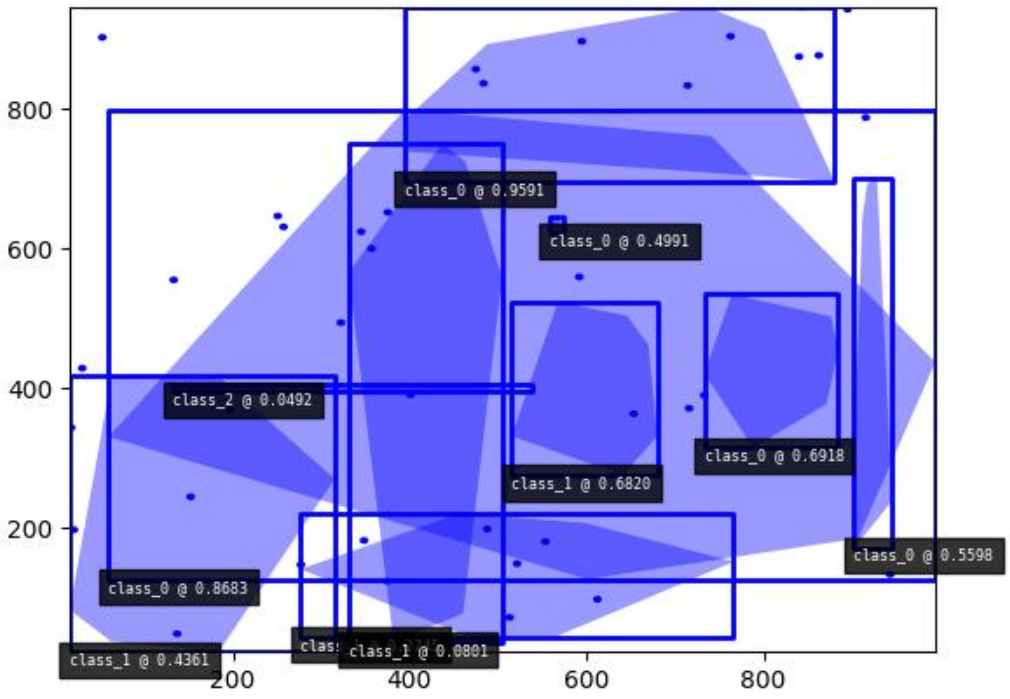
Creates dummy data, suitable for use in tests and benchmarks

Parameters

- **num** (*int*) – number of boxes
- **scale** (*float | tuple*) – bounding image size. Defaults to 1.0
- **classes** (*int | Sequence*) – list of class labels or number of classes
- **keypoints** (*bool*) – if True include random keypoints for each box. Defaults to False.
- **segmentations** (*bool*) – if True include random segmentations for each box. Defaults to False.
- **tensor** (*bool*) – determines backend. DEPRECATED. Call `.tensor()` on resulting object instead.
- **rng** (*np.random.RandomState*) – random state

Example

```
>>> import kwimage
>>> dets = kwimage.Detections.random(keypoints='jagged')
>>> dets.data['keypoints'].data[0].data
>>> dets.data['keypoints'].meta
>>> dets = kwimage.Detections.random(keypoints='dense')
>>> dets = kwimage.Detections.random(keypoints='dense', segmentations=True).
↪scale(1000)
>>> # xdoctest:+REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> dets.draw(setlim=True)
```



Example

```
>>> import kwimage
>>> dets = kwimage.Detections.random(
>>>     keypoints='jagged', segmentations=True, rng=0).scale(1000)
>>> print('dets = {}'.format(dets))
dets = <Detections(10)>
>>> dets.data['boxes'].quantize(inplace=True)
>>> print('dets.data = {}'.format(ub.repr2(
>>>     dets.data, nl=1, with_dtype=False, strvals=True)))
dets.data = {
    'boxes': <Boxes(xywh,
                 array([[548, 544,  55, 172],
                        [423, 645,  15, 247],
                        [791, 383, 173, 146],
                        [ 71,  87, 498, 839],
                        [ 20, 832, 759,  39],
                        [461, 780, 518,  20],
                        [118, 639,  26, 306],
                        [264, 414, 258, 361],
                        [ 18, 568, 439,  50],
                        [612, 616, 332,  66]], dtype=int32))>,
    'class_idxs': [1, 2, 0, 0, 2, 0, 0, 0, 0, 0],
    'keypoints': <PointsList(n=10)>,
    'scores': [0.3595079 , 0.43703195, 0.6976312 , 0.06022547, 0.66676672, 0.
```

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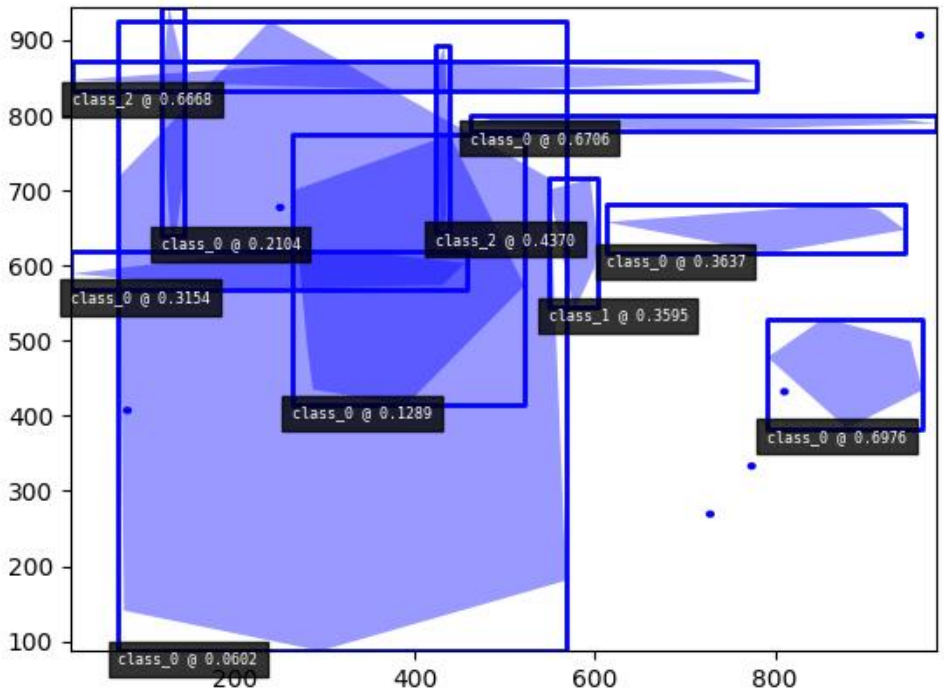
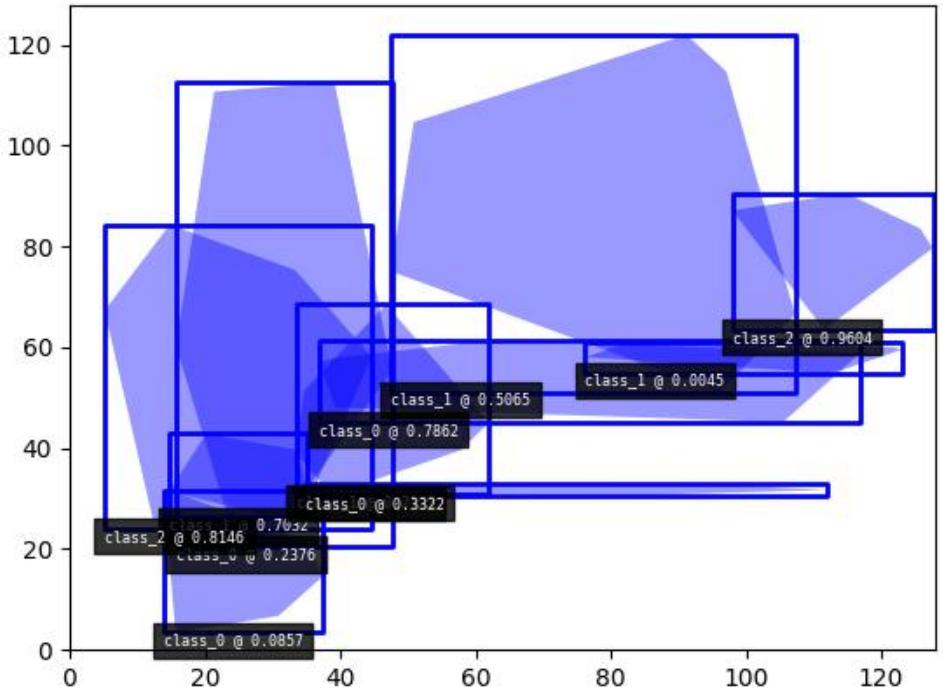
```
↪67063787,0.21038256, 0.1289263 , 0.31542835, 0.36371077],
    'segmentations': <SegmentationList(n=10)>,
}
>>> # xdoctest:+REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> dets.draw(setlim=True)
```



Example

```
>>> # Boxes position/shape within 0-1 space should be uniform.
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> fig = kwplot.figure(fnum=1, doclf=True)
>>> fig.gca().set_xlim(0, 128)
>>> fig.gca().set_ylim(0, 128)
>>> import kwimage
>>> kwimage.Detections.random(num=10, segmentations=True).scale(128).draw()
```



class kwimage.**Heatmap**(*data=None*, *meta=None*, ***kwargs*)

Bases: Spatial, _HeatmapDrawMixin, _HeatmapWarpMixin, _HeatmapAlgoMixin

Keeps track of a downscaled heatmap and how to transform it to overlay the original input image. Heatmaps generally are used to estimate class probabilites at each pixel. This data struction additionally contains logic to augment pixel with offset (dydx) and scale (diamter) information.

Variables

- **data** (*Dict[str, ArrayLike]*) – dictionary containing spatially aligned heatmap data. Valid keys are as follows.

  class_probs (ArrayLike[C, H, W] | ArrayLike[C, D, H, W]):
  A probability map for each class. C is the number of classes.

  offset (ArrayLike[2, H, W] | ArrayLike[3, D, H, W], optional):
  object center position offset in y,x / t,y,x coordinates

  diamter (ArrayLike[2, H, W] | ArrayLike[3, D, H, W], optional):
  object bounding box sizes in h,w / d,h,w coordinates

  keypoints (ArrayLike[2, K, H, W] | ArrayLike[3, K, D, H, W], optional):
  y/x offsets for K different keypoint classes

- **meta** (*Dict[str, object]*) – dictionary containing miscellanious metadata about the heatmap data. Valid keys are as follows.

  img_dims (Tuple[H, W] | Tuple[D, H, W]):
  original image dimension

  tf_data_to_image (skimage.transform._geometric.GeometricTransform):
  transformation matrix (typically similarity or affine) that projects the given, heatmap

onto the image dimensions such that the image and heatmap are spatially aligned.

classes (List[str] | ndsampler.CategoryTree):
information about which index in `data['class_probs']` corresponds to which semantic class.

- **dims** (*Tuple*) – dimensions of the heatmap (See `image_dims`) for the original image dimensions.
- ****kwargs** – any key that is accepted by the *data* or *meta* dictionaries can be specified as a keyword argument to this class and it will be properly placed in the appropriate internal dictionary.

CommandLine

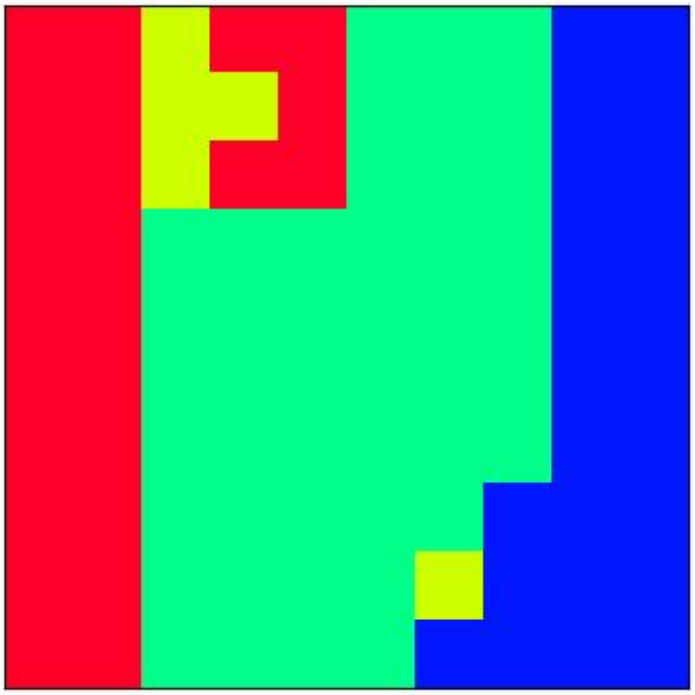
```
xdoctest -m ~/code/kwimage/kwimage/structs/heatmap.py Heatmap --show
```

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> from kwimage.structs.heatmap import *  # NOQA
>>> import kwimage
>>> class_probs = kwimage.grab_test_image(dsize=(32, 32), space='gray')[None, ...,␣
↪0] / 255.0
>>> img_dims = (220, 220)
>>> tf_data_to_img = skimage.transform.AffineTransform(translation=(-18, -18),␣
↪scale=(8, 8))
>>> self = Heatmap(class_probs=class_probs, img_dims=img_dims,
>>>                tf_data_to_img=tf_data_to_img)
>>> aligned = self.upscale()
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(aligned[0])
>>> kwplot.show_if_requested()
```

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> import kwimage
>>> self = Heatmap.random()
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> self.draw()
```



property shape

property bounds

property dims

space-time dimensions of this heatmap

is_numpy()

is_tensor()

classmethod random(*dims=(10, 10)*, *classes=3*, *diameter=True*, *offset=True*, *keypoints=False*, *img_dims=None*, *dets=None*, *nblips=10*, *noise=0.0*, *smooth_k=3*, *rng=None*, *ensure_background=True*)

Creates dummy data, suitable for use in tests and benchmarks

Parameters

- **dims** (*Tuple[int, int]*) – dimensions of the heatmap
- **classes** (*int | List[str] | kwcoco.CategoryTree*) – foreground classes
- **diameter** (*bool*) – if True, include a "diameter" heatmap
- **offset** (*bool*) – if True, include an "offset" heatmap
- **keypoints** (*bool*)
- **smooth_k** (*int*) – kernel size for gaussian blur to smooth out the heatmaps.

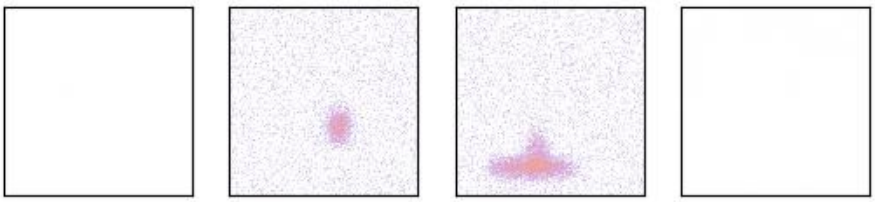
- **img_dims** (*Tuple*) – dimensions of an upscaled image the heatmap corresponds to. (This should be removed and simply handled with a transform

  in the future).

Returns
Heatmap

Example

```
>>> from kwimage.structs.heatmap import *  # NOQA
>>> self = Heatmap.random((128, 128), img_dims=(200, 200),
>>>     classes=3, nblips=10, rng=0, noise=0.1)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(self.colorize(0, imgspace=0), fnum=1, pnum=(1, 4, 1),␣
↪doclf=1)
>>> kwplot.imshow(self.colorize(1, imgspace=0), fnum=1, pnum=(1, 4, 2))
>>> kwplot.imshow(self.colorize(2, imgspace=0), fnum=1, pnum=(1, 4, 3))
>>> kwplot.imshow(self.colorize(3, imgspace=0), fnum=1, pnum=(1, 4, 4))
```



Example

```
>>> # xdoctest: +REQUIRES(module:ndsampler)
>>> import kwimage
>>> self = kwimage.Heatmap.random(dims=(50, 200), dets='coco',
>>>                               keypoints=True)
>>> image = np.zeros(self.img_dims)
>>> # xdoctest: +REQUIRES(module:kwplot)
>>> toshow = self.draw_on(image, 1, vecs=True, kpts=0, with_alpha=0.85)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.figure(fnum=1, doclf=True)
>>> kwplot.imshow(toshow)
```

property class_probs

property offset

property diameter

property img_dims

property tf_data_to_img

property classes

numpy()

Converts underlying data to numpy arrays

tensor(*device=NoParam*)

Converts underlying data to torch tensors

class kwimage.**Linear**(*matrix*)

Bases: *Matrix*

class kwimage.**Mask**(*data=None*, *format=None*)

Bases: NiceRepr, _MaskConversionMixin, _MaskConstructorMixin, _MaskTransformMixin, _MaskDrawMixin

Manages a single segmentation mask and can convert to and from multiple formats including:

- bytes_rle - byte encoded run length encoding
- array_rle - raw run length encoding
- c_mask - c-style binary mask
- f_mask - fortran-style binary mask

Example

```
>>> # xdoc: +REQUIRES(--mask)
>>> # a ms-coco style compressed bytes rle segmentation
>>> segmentation = {'size': [5, 9], 'counts': ';?1B10O30O4'}
>>> mask = Mask(segmentation, 'bytes_rle')
>>> # convert to binary numpy representation
>>> binary_mask = mask.to_c_mask().data
>>> print(ub.repr2(binary_mask.tolist(), nl=1, nobr=1))
[0, 0, 0, 1, 1, 1, 1, 1, 0],
[0, 0, 1, 1, 1, 0, 0, 0, 0],
[0, 0, 1, 1, 1, 1, 1, 1, 0],
[0, 0, 1, 1, 1, 0, 1, 1, 0],
[0, 0, 1, 1, 1, 0, 1, 1, 0],
```

property dtype

classmethod random(*rng=None*, *shape=(32, 32)*)

Create a random binary mask object

Parameters

- **rng** (*int | RandomState | None*) – the random seed
- **shape** (*Tuple[int, int]*) – the height / width of the returned mask

Returns

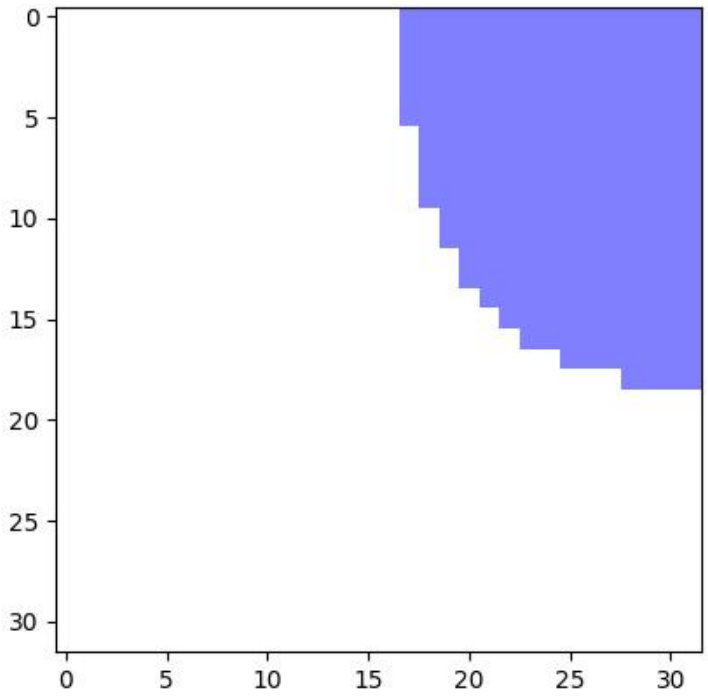
the random mask

Return type

Mask

Example

```
>>> import kwimage
>>> mask = kwimage.Mask.random()
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> mask.draw()
>>> kwplot.show_if_requested()
```



classmethod demo()

Demo mask with holes and disjoint shapes

Returns
the demo mask

Return type
Mask

classmethod from_text(*text*, *zero_chr='.'*, *shape=None*, *has_border=False*)

Construct a mask from a text art representation

Parameters

- **text** (*str*) – the text representing a mask
- **zero_chr** (*str*) – the character that represents a zero
- **shape** (*None | Tuple[int, int]*) – if specified force a specific height / width, otherwise the character extent determines this.
- **has_border** (*bool*) – if True, assume the characters at the edge are representing a border and remove them.

Example

```
>>> import kwimage
>>> import ubelt as ub
>>> text = ub.indent(ub.codeblock(
>>>     '''
>>>     ooo
>>>     ooo
>>>     ooooo
>>>         o
>>>     '''))
>>> mask = kwimage.Mask.from_text(text, zero_chr=' ')
>>> print(mask.data)
[[0 0 0 0 1 1 1 0 0]
 [0 0 0 0 1 1 1 0 0]
 [0 0 0 0 1 1 1 1 1]
 [0 0 0 0 0 0 0 0 1]]
```

Example

```
>>> import kwimage
>>> import ubelt as ub
>>> text = ub.codeblock(
>>>     '''
>>>     +------------+
>>>     |            |
>>>     |    ooo     |
>>>     |    ooo     |
>>>     |    ooooo   |
>>>     |        o   |
>>>     |            |
>>>     +------------+
>>>     ''')
>>> mask = kwimage.Mask.from_text(text, has_border=True, zero_chr=' ')
>>> print(mask.data)
[[0 0 0 0 0 0 0 0 0 0 0 0]
 [0 0 0 0 1 1 1 0 0 0 0 0]
 [0 0 0 0 1 1 1 0 0 0 0 0]
 [0 0 0 0 1 1 1 1 1 0 0 0]
 [0 0 0 0 0 0 0 0 1 0 0 0]
 [0 0 0 0 0 0 0 0 0 0 0 0]]
```

copy()

Performs a deep copy of the mask data

Returns
the copied mask

Return type
Mask

Example

```
>>> self = Mask.random(shape=(8, 8), rng=0)
>>> other = self.copy()
>>> assert other.data is not self.data
```

union(**others*)

This can be used as a staticmethod or an instancemethod

Parameters
***others** – multiple input masks to union

Returns
the unioned mask

Return type
Mask

Example

```
>>> # xdoc: +REQUIRES(--mask)
>>> from kwimage.structs.mask import *  # NOQA
>>> masks = [Mask.random(shape=(8, 8), rng=i) for i in range(2)]
>>> mask = Mask.union(*masks)
>>> print(mask.area)
>>> masks = [m.to_c_mask() for m in masks]
>>> mask = Mask.union(*masks)
>>> print(mask.area)
```

```
>>> masks = [m.to_bytes_rle() for m in masks]
>>> mask = Mask.union(*masks)
>>> print(mask.area)
```

intersection(**others*)

This can be used as a staticmethod or an instancemethod

Parameters
***others** – multiple input masks to intersect

Returns
the intersection of the masks

Return type
Mask

Example

```
>>> n = 3
>>> masks = [Mask.random(shape=(8, 8), rng=i) for i in range(n)]
>>> items = masks
>>> mask = Mask.intersection(*masks)
>>> areas = [item.area for item in items]
>>> print('areas = {!r}'.format(areas))
>>> print(mask.area)
>>> print(Mask.intersection(*masks).area / Mask.union(*masks).area)
```

property shape

property area

Returns the number of non-zero pixels

Returns
the number of non-zero pixels

Return type
int

Example

```
>>> self = Mask.demo()
>>> self.area
150
```

get_patch()

Extract the patch with non-zero data

Example

```
>>> # xdoc: +REQUIRES(--mask)
>>> from kwimage.structs.mask import *  # NOQA
>>> self = Mask.random(shape=(8, 8), rng=0)
>>> self.get_patch()
```

get_xywh()

Gets the bounding xywh box coordinates of this mask

Returns

x, y, w, h: Note we dont use a Boxes object because
a general singular version does not yet exist.

Return type
ndarray

Example

```
>>> # xdoc: +REQUIRES(--mask)
>>> self = Mask.random(shape=(8, 8), rng=0)
>>> self.get_xywh().tolist()
>>> self = Mask.random(rng=0).translate((10, 10))
>>> self.get_xywh().tolist()
```

Example

```
>>> # test empty case
>>> import kwimage
>>> self = kwimage.Mask(np.empty((0, 0), dtype=np.uint8), format='c_mask')
>>> assert self.get_xywh().tolist() == [0, 0, 0, 0]
```

bounding_box()

Returns an axis-aligned bounding box for this mask

Returns
kwimage.Boxes

get_polygon()

DEPRECATED: USE to_multi_polygon

Returns a list of (x,y)-coordinate lists. The length of the list is equal to the number of disjoint regions in the mask.

Returns

polygon around each connected component of the
mask. Each ndarray is an Nx2 array of xy points.

Return type
List[ndarray]

Note: The returned polygon may not surround points that are only one pixel thick.

Example

```
>>> # xdoc: +REQUIRES(--mask)
>>> from kwimage.structs.mask import *  # NOQA
>>> self = Mask.random(shape=(8, 8), rng=0)
>>> polygons = self.get_polygon()
>>> print('polygons = ' + ub.repr2(polygons))
>>> polygons = self.get_polygon()
>>> self = self.to_bytes_rle()
>>> other = Mask.from_polygons(polygons, self.shape)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> image = np.ones(self.shape)
```

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```
>>> image = self.draw_on(image, color='blue')
>>> image = other.draw_on(image, color='red')
>>> kwplot.imshow(image)
```

to_mask(*dims=None*)

Converts to a mask object (which does nothing because this already is mask object!)

Returns
kwimage.Mask

to_boxes()

Returns the bounding box of the mask.

Returns
kwimage.Boxes

to_multi_polygon(*pixels_are='points'*)

Returns a MultiPolygon object fit around this raster including disjoint pieces and holes.

Parameters
pixel_are (*str*) – Can either be “points” or “areas”.

If pixels are “points”, the we treat each pixel (i, j) as a single infinitely small point at (i, j). As such, some polygons may have zero area.

If pixels are “areas”, then each pixel (i, j) represents a square with coordinates ([i - 0.5, j - 0.5], [i + 0.5, j - 0.5], [i + 0.5, j + 0.5], and [i - 0.5, j + 0.5]). Must have rasterio installed to use this method.

Returns
vectorized representation

Return type
kwimage.MultiPolygon

Note: The OpenCV (and thus this function) coordinate system places coordinates at the center of pixels, and the polygon is traced tightly around these coordinates. A single pixel is not considered to have any width, so polygon edges will directly trace through the centers of pixels, and in the case where an object is only 1 pixel thick, this will produce a polygon that is not a valid shapely polygon.

Todo:

- [x] add a flag where polygons consider pixels to have width and the resulting polygon is traced around the pixel edges, not the pixel centers.
- [ ] Polygons and Masks should keep track of what “pixels_are”

Example

```
>>> # xdoc: +REQUIRES(--mask)
>>> from kwimage.structs.mask import *  # NOQA
>>> self = Mask.demo()
>>> self = self.scale(5)
>>> multi_poly = self.to_multi_polygon()
>>> # xdoc: +REQUIRES(module:kwplot)
>>> # xdoc: +REQUIRES(--show)
>>> self.draw(color='red')
>>> multi_poly.scale(1.1).draw(color='blue')
```

```
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> image = np.ones(self.shape)
>>> image = self.draw_on(image, color='blue')
>>> #image = other.draw_on(image, color='red')
>>> kwplot.imshow(image)
>>> multi_poly.draw()
```

Example

```
>>> # Test empty cases
>>> import kwimage
>>> mask0 = kwimage.Mask(np.zeros((0, 0), dtype=np.uint8), format='c_mask')
>>> mask1 = kwimage.Mask(np.zeros((1, 1), dtype=np.uint8), format='c_mask')
>>> mask2 = kwimage.Mask(np.zeros((2, 2), dtype=np.uint8), format='c_mask')
>>> mask3 = kwimage.Mask(np.zeros((3, 3), dtype=np.uint8), format='c_mask')
>>> pixels_are = 'points'
>>> poly0 = mask0.to_multi_polygon(pixels_are=pixels_are)
>>> poly1 = mask1.to_multi_polygon(pixels_are=pixels_are)
>>> poly2 = mask2.to_multi_polygon(pixels_are=pixels_are)
>>> poly3 = mask3.to_multi_polygon(pixels_are=pixels_are)
>>> assert len(poly0) == 0
>>> assert len(poly1) == 0
>>> assert len(poly2) == 0
>>> assert len(poly3) == 0
>>> # xdoctest: +REQUIRES(module:rasterio)
>>> pixels_are = 'areas'
>>> poly0 = mask0.to_multi_polygon(pixels_are=pixels_are)
>>> poly1 = mask1.to_multi_polygon(pixels_are=pixels_are)
>>> poly2 = mask2.to_multi_polygon(pixels_are=pixels_are)
>>> poly3 = mask3.to_multi_polygon(pixels_are=pixels_are)
>>> assert len(poly0) == 0
>>> assert len(poly1) == 0
>>> assert len(poly2) == 0
>>> assert len(poly3) == 0
```

Example

```
>>> # Test full ones cases
>>> import kwimage
>>> mask1 = kwimage.Mask(np.ones((1, 1), dtype=np.uint8), format='c_mask')
>>> mask2 = kwimage.Mask(np.ones((2, 2), dtype=np.uint8), format='c_mask')
>>> mask3 = kwimage.Mask(np.ones((3, 3), dtype=np.uint8), format='c_mask')
>>> pixels_are = 'points'
>>> poly1 = mask1.to_multi_polygon(pixels_are=pixels_are)
>>> poly2 = mask2.to_multi_polygon(pixels_are=pixels_are)
>>> poly3 = mask3.to_multi_polygon(pixels_are=pixels_are)
>>> assert np.all(poly1.to_mask(mask1.shape).data == 1)
>>> assert np.all(poly2.to_mask(mask2.shape).data == 1)
>>> assert np.all(poly3.to_mask(mask3.shape).data == 1)
>>> # xdoctest: +REQUIRES(module:rasterio)
>>> pixels_are = 'areas'
>>> poly1 = mask1.to_multi_polygon(pixels_are=pixels_are)
>>> poly2 = mask2.to_multi_polygon(pixels_are=pixels_are)
>>> poly3 = mask3.to_multi_polygon(pixels_are=pixels_are)
>>> assert np.all(poly1.to_mask(mask1.shape).data == 1)
>>> assert np.all(poly2.to_mask(mask2.shape).data == 1)
>>> assert np.all(poly3.to_mask(mask3.shape).data == 1)
```

Example

```
>>> # Corner case, only two pixels are on
>>> import kwimage
>>> self = kwimage.Mask(np.zeros((768, 768), dtype=np.uint8), format='c_mask')
>>> x_coords = np.array([621, 752])
>>> y_coords = np.array([366, 292])
>>> self.data[y_coords, x_coords] = 1
>>> poly = self.to_multi_polygon()
```

Example

```
>>> # xdoctest: +REQUIRES(module:rasterio)
>>> import kwimage
>>> dims = (10, 10)
>>> data = np.zeros(dims, dtype=np.uint8)
>>> data[0, 3:5] = 1
>>> data[9, 1:3] = 1
>>> data[3:5, 0:2] = 1
>>> data[1, 1] = 1
>>> # 1 pixel L shape
>>> data[3, 5] = 1
>>> data[4, 5] = 1
>>> data[4, 6] = 1
>>> data[1, 5] = 1
>>> data[2, 6] = 1
>>> data[3, 7] = 1
```

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```
>>> data[6, 1] = 1
>>> data[7, 1] = 1
>>> data[7, 2] = 1
>>> data[6:10, 5] = 1
>>> data[6:10, 8] = 1
>>> data[9, 5:9] = 1
>>> data[6, 5:9] = 1
>>> #data = kwimage.imresize(data, scale=2.0, interpolation='nearest')
>>> self = kwimage.Mask.coerce(data)
>>> #self = self.translate((0, 0), output_dims=(10, 9))
>>> self = self.translate((0, 1), output_dims=(11, 11))
>>> dims = self.shape[0:2]
>>> multi_poly1 = self.to_multi_polygon(pixels_are='points')
>>> multi_poly2 = self.to_multi_polygon(pixels_are='areas')
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> pretty_data = kwplot.make_heatmask(self.data/1.0, cmap='magma')[..., 0:3]
>>> def _pixel_grid_lines(self, ax):
>>>     h, w = self.data.shape[0:2]
>>>     ybasis = np.arange(0, h) + 0.5
>>>     xbasis = np.arange(0, w) + 0.5
>>>     xmin = 0 - 0.5
>>>     xmax = w - 0.5
>>>     ymin = 0 - 0.5
>>>     ymax = h - 0.5
>>>     ax.hlines(y=ybasis, xmin=xmin, xmax=xmax, color="gainsboro")
>>>     ax.vlines(x=xbasis, ymin=ymin, ymax=ymax, color="gainsboro")
>>> def _setup_grid(self, pnum):
>>>     ax = kwplot.imshow(pretty_data, show_ticks=True, pnum=pnum)[1]
>>>     # The gray ticks show the center of the pixels
>>>     ax.grid(color='dimgray', linewidth=0.5)
>>>     ax.set_xticks(np.arange(self.data.shape[1]))
>>>     ax.set_yticks(np.arange(self.data.shape[0]))
>>>     # Also draw black lines around the edges of the pixels
>>>     _pixel_grid_lines(self, ax=ax)
>>>     return ax
>>> # Overlay the extracted polygons
>>> ax = _setup_grid(self, pnum=(2, 3, 1))
>>> ax.set_title('input binary mask data')
>>> ax = _setup_grid(self, pnum=(2, 3, 2))
>>> multi_poly1.draw(linewidth=5, alpha=0.5, radius=0.2, ax=ax, fill=False,␣
↪vertex=0.2)
>>> ax.set_title('opencv "point" polygons')
>>> ax = _setup_grid(self, pnum=(2, 3, 3))
>>> multi_poly2.draw(linewidth=5, alpha=0.5, radius=0.2, color='limegreen',␣
↪ax=ax, fill=False, vertex=0.2)
>>> ax.set_title('raterio "area" polygons')
>>> ax.figure.suptitle(ub.codeblock(
>>>     '''
>>>     Gray lines are coordinates and pass through pixel centers (integer␣
↪coords)
```

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```
>>>     White lines trace pixel boundaries (fractional coords)
>>>     '''))
>>> raster1 = multi_poly1.to_mask(dims, pixels_are='points')
>>> raster2 = multi_poly2.to_mask(dims, pixels_are='areas')
>>> kwplot.imshow(raster1.draw_on(), pnum=(2, 3, 5), title='rasterized')
>>> kwplot.imshow(raster2.draw_on(), pnum=(2, 3, 6), title='rasterized')
```

get_convex_hull()

Returns a list of xy points around the convex hull of this mask

Note: The returned polygon may not surround points that are only one pixel thick.

Example

```
>>> # xdoc: +REQUIRES(--mask)
>>> self = Mask.random(shape=(8, 8), rng=0)
>>> polygons = self.get_convex_hull()
>>> print('polygons = ' + ub.repr2(polygons))
>>> other = Mask.from_polygons(polygons, self.shape)
```

iou(*other*)

The area of intersection over the area of union

Todo:

- [ ] Write plural Masks version of this class, which should be able to perform this operation more efficiently.

CommandLine

```
xdoctest -m kwimage.structs.mask Mask.iou
```

Example

```
>>> # xdoc: +REQUIRES(--mask)
>>> self = Mask.demo()
>>> other = self.translate(1)
>>> iou = self.iou(other)
>>> print('iou = {:.4f}'.format(iou))
iou = 0.0830
>>> iou2 = self.intersection(other).area / self.union(other).area
>>> print('iou2 = {:.4f}'.format(iou2))
```

classmethod coerce(*data*, *dims=None*)

Attempts to auto-inspect the format of the data and conver to Mask

Parameters

- **data** (*Any*) – the data to coerce
- **dims** (*Tuple*) – required for certain formats like polygons height / width of the source image

Returns
the constructed mask object

Return type
Mask

Example

```
>>> # xdoc: +REQUIRES(--mask)
>>> segmentation = {'size': [5, 9], 'counts': ';?1B10O30O4'}
>>> polygon = [
>>>     [np.array([[3, 0],[2, 1],[2, 4],[4, 4],[4, 3],[7, 0]])],
>>>     [np.array([[2, 1],[2, 2],[4, 2],[4, 1]])],
>>> ]
>>> dims = (9, 5)
>>> mask = (np.random.rand(32, 32) > .5).astype(np.uint8)
>>> Mask.coerce(polygon, dims).to_bytes_rle()
>>> Mask.coerce(segmentation).to_bytes_rle()
>>> Mask.coerce(mask).to_bytes_rle()
```

`to_coco`(*style='orig'*)

Convert the Mask to a COCO json representation based on the current format.

A COCO mask is formatted as a run-length-encoding (RLE), of which there are two variants: (1) a array RLE, which is slightly more readable and extensible, and (2) a bytes RLE, which is slightly more concise. The returned format will depend on the current format of the Mask object. If it is in "bytes_rle" format, it will be returned in that format, otherwise it will be converted to the "array_rle" format and returned as such.

Parameters
style (*str*) – Does nothing for this particular method, exists for API compatibility and if alternate encoding styles are implemented in the future.

Returns

either a bytes-rle or array-rle encoding, depending
on the current mask format. The keys in this dictionary are as follows:

counts (List[int] | str): the array or bytes rle encoding

size (Tuple[int]): the height and width of the encoded mask
see note.

shape (Tuple[int]): only present in array-rle mode. This
is also the height/width of the underlying encoded array. This exists for semantic consistency with other kwimage conventions, and is not part of the original coco spec.

order (str): only present in array-rle mode.
Either C or F, indicating if counts is aranged in row-major or column-major order. For COCO-compatibility this is always returned in F (column-major) order.

binary (bool): only present in array-rle mode.
For COCO-compatibility this is always returned as False, indicating the mask only contains binary 0 or 1 values.

Return type
dict

Note: The output dictionary will contain a key named "size", this is the only location in kwimage where "size" refers to a tuple in (height/width) order, in order to be backwards compatible with the original coco spec. In all other locations in kwimage a "size" will refer to a (width/height) ordered tuple.

SeeAlso:

func
kwimage.im_runlen.encode_run_length - backend function that does array-style run length encoding.

Example

```
>>> # xdoc: +REQUIRES(--mask)
>>> from kwimage.structs.mask import *  # NOQA
>>> self = Mask.demo()
>>> coco_data1 = self.toformat('array_rle').to_coco()
>>> coco_data2 = self.toformat('bytes_rle').to_coco()
>>> print('coco_data1 = {}'.format(ub.repr2(coco_data1, nl=1)))
>>> print('coco_data2 = {}'.format(ub.repr2(coco_data2, nl=1)))
coco_data1 = {
    'binary': True,
    'counts': [47, 5, 3, 1, 14, ... 1, 4, 19, 141],
    'order': 'F',
    'shape': (23, 32),
    'size': (23, 32),
}
coco_data2 = {
    'counts': '_153L;4EL...ON3060L0N060L0Nb0Y4',
    'size': [23, 32],
}
```

class kwimage.**MaskList**(*data*, *meta=None*)

Bases: ObjectList

Store and manipulate multiple masks, usually within the same image

to_polygon_list()

Converts all mask objects to multi-polygon objects

Returns
kwimage.PolygonList

to_segmentation_list()

Converts all items to segmentation objects

Returns
kwimage.SegmentationList

to_mask_list()

returns this object

Returns
kwimage.MaskList

class kwimage.**Matrix**(*matrix*)

Bases: *Transform*

Base class for matrix-based transform.

Example

```
>>> from kwimage.transform import *  # NOQA
>>> ms = {}
>>> ms['random()'] = Matrix.random()
>>> ms['eye()'] = Matrix.eye()
>>> ms['random(3)'] = Matrix.random(3)
>>> ms['random(4, 4)'] = Matrix.random(4, 4)
>>> ms['eye(3)'] = Matrix.eye(3)
>>> ms['explicit'] = Matrix(np.array([[1.618]]))
>>> for k, m in ms.items():
>>>     print('----')
>>>     print(f'{k} = {m}')
>>>     print(f'{k}.inv() = {m.inv()}')
>>>     print(f'{k}.T = {m.T}')
>>>     print(f'{k}.det() = {m.det()}')
```

property shape

classmethod coerce(*data=None*, ***kwargs*)

Example

```
>>> Matrix.coerce({'type': 'matrix', 'matrix': [[1, 0, 0], [0, 1, 0]]})
>>> Matrix.coerce(np.eye(3))
>>> Matrix.coerce(None)
```

inv()

Returns the inverse of this matrix

Returns
Matrix

property T

Transpose the underlying matrix

det()

Compute the determinant of the underlying matrix

Returns
float

classmethod eye(*shape=None*, *rng=None*)

Construct an identity

classmethod random(*shape=None*, *rng=None*)

rationalize()

Convert the underlying matrix to a rational type to avoid floating point errors. This does decrease efficiency.

Example

```
>>> # xdoctest: +REQUIRES(module:sympy)
>>> import kwimage
>>> self = mat = kwimage.Matrix.random((3, 3)).rationalize()
>>> mat2 = kwimage.Matrix.random((3, 3))
>>> mat3 = mat @ mat2
>>> assert 'sympy' in mat3.matrix.__class__.__module__
>>> mat3 = mat2 @ mat
>>> assert 'sympy' in mat3.matrix.__class__.__module__
>>> assert not mat.isclose_identity()
>>> assert (mat @ mat.inv()).isclose_identity(rtol=0, atol=0)
```

astype(*dtype*)

Convert the underlying matrix to a rational type to avoid floating point errors. This does decrease efficiency.

Parameters
dtype (*type*)

isclose_identity(*rtol=1e-05*, *atol=1e-08*)

Returns true if the matrix is nearly the identity.

class kwimage.**MultiPolygon**(*data*, *meta=None*)

Bases: ObjectList

Data structure for storing multiple polygons (typically related to the same underlying but potentitally disjoing object)

Variables
data (*List[Polygon]*) –

property area

Computes are via shapley conversion

Returns
float

classmethod random(*n=3*, *n_holes=0*, *rng=None*, *tight=False*)

Create a random MultiPolygon

Returns
MultiPolygon

fill(*image*, *value=1*, *pixels_are='points'*)

Inplace fill in an image based on this multi-polyon.

Parameters

- **image** (*ndarray*) – image to draw on (inplace)

- **value** (*int | Tuple[int, ...]*) – value fill in with. Defaults to 1.0

Returns
the image that has been modified in place

Return type
ndarray

`to_multi_polygon()`

Returns
MultiPolygon

`to_boxes()`

Deprecated: lossy conversion use 'bounding_box' instead

Returns
kwimage.Boxes

`bounding_box()`

Return the bounding box of the multi polygon

Returns

a Boxes object with one box that encloses all
polygons

Return type
kwimage.Boxes

Example

```
>>> from kwimage.structs.polygon import *  # NOQA
>>> self = MultiPolygon.random(rng=0, n=10)
>>> boxes = self.to_boxes()
>>> sub_boxes = [d.to_boxes() for d in self.data]
>>> areas1 = np.array([s.intersection(boxes).area[0] for s in sub_boxes])
>>> areas2 = np.array([s.area[0] for s in sub_boxes])
>>> assert np.allclose(areas1, areas2)
```

`to_mask(dims=None, pixels_are='points')`

Returns a mask object indication regions occupied by this multipolygon

Returns
kwimage.Mask

Example

```
>>> from kwimage.structs.polygon import *  # NOQA
>>> s = 100
>>> self = MultiPolygon.random(rng=0).scale(s)
>>> dims = (s, s)
>>> mask = self.to_mask(dims)
>>> # xdoc: +REQUIRES(--show)
>>> # xdoc: +REQUIRES(module:kwplot)
>>> import kwplot
```

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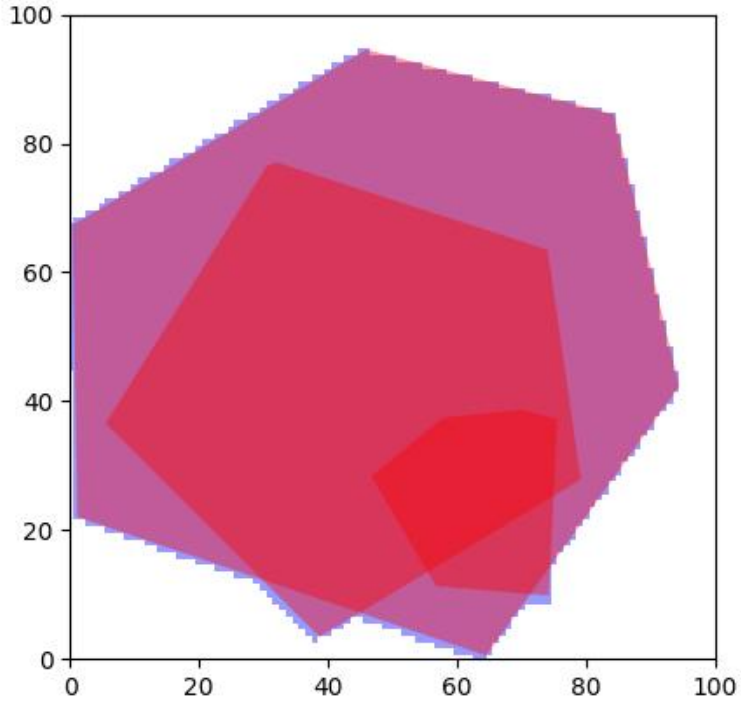
```
>>> plt = kwplot.autoplt()
>>> kwplot.figure(fnum=1, doclf=True)
>>> ax = plt.gca()
>>> ax.set_xlim(0, s)
>>> ax.set_ylim(0, s)
>>> self.draw(color='red', alpha=.4)
>>> mask.draw(color='blue', alpha=.4)
```



to_relative_mask(*return_offset=False*)

Returns a translated mask such the mask dimensions are minimal.

In other words, we move the polygon all the way to the top-left and return a mask just big enough to fit the polygon.

Returns

kwimage.Mask

classmethod coerce(*data*, *dims=None*)

Attempts to construct a MultiPolygon instance from the input data

See Segmentation.coerce

Returns

None | MultiPolygon

Example

```
>>> import kwimage
>>> dims = (32, 32)
>>> kw_poly = kwimage.Polygon.random().scale(dims)
>>> kw_multi_poly = kwimage.MultiPolygon.random().scale(dims)
>>> forms = [kw_poly, kw_multi_poly]
>>> forms.append(kw_poly.to_shapely())
>>> forms.append(kw_poly.to_mask((32, 32)))
>>> forms.append(kw_poly.to_geojson())
>>> forms.append(kw_poly.to_coco(style='orig'))
>>> forms.append(kw_poly.to_coco(style='new'))
>>> forms.append(kw_multi_poly.to_shapely())
>>> forms.append(kw_multi_poly.to_mask((32, 32)))
>>> forms.append(kw_multi_poly.to_geojson())
>>> forms.append(kw_multi_poly.to_coco(style='orig'))
>>> forms.append(kw_multi_poly.to_coco(style='new'))
>>> for data in forms:
>>>     result = kwimage.MultiPolygon.coerce(data, dims=dims)
>>>     assert isinstance(result, kwimage.MultiPolygon)
```

to_shapely()

Returns
shapely.geometry.MultiPolygon

Example

```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> # xdoc: +REQUIRES(module:shapely)
>>> from kwimage.structs.polygon import *  # NOQA
>>> self = MultiPolygon.random(rng=0)
>>> geom = self.to_shapely()
>>> print('geom = {!r}'.format(geom))
```

classmethod from_shapely(*geom*)

Convert a shapely polygon or multipolygon to a kwimage.MultiPolygon

Parameters
geom (*shapely.geometry.MultiPolygon* | *shapely.geometry.Polygon*)

Returns
MultiPolygon

Example

```
>>> import kwimage
>>> sh_poly = kwimage.Polygon.random().to_shapely()
>>> sh_multi_poly = kwimage.MultiPolygon.random().to_shapely()
>>> kwimage.MultiPolygon.from_shapely(sh_poly)
>>> kwimage.MultiPolygon.from_shapely(sh_multi_poly)
```

classmethod from_geojson(*data_geojson*)

Convert a geojson polygon or multipolygon to a kwimage.MultiPolygon

Parameters
data_geojson (*Dict*) – geojson data

Returns
MultiPolygon

Example

```
>>> import kwimage
>>> orig = kwimage.MultiPolygon.random()
>>> data_geojson = orig.to_geojson()
>>> self = kwimage.MultiPolygon.from_geojson(data_geojson)
```

to_geojson()

Converts polygon to a geojson structure

Returns
Dict

classmethod from_coco(*data*, *dims=None*)

Accepts either new-style or old-style coco multi-polygons

Parameters

- **data** (*List[List[Number] | Dict]*) – a new or old style coco multi polygon
- **dims** (*None | Tuple[int, ...]*) – the shape dimensions of the canvas. Unused. Exists for compatibility with masks.

Returns
MultiPolygon

to_coco(*style='orig'*)

Parameters
style (*str*) – can be “orig” or “new”

Example

```
>>> from kwimage.structs.polygon import *  # NOQA
>>> self = MultiPolygon.random(1, rng=0)
>>> self.to_coco()
```

swap_axes(*inplace=False*)

Swap x and y axis

Parameters
inplace (*bool*)

Returns
MultiPolygon

draw_on(*image*, ***kwargs*)

class kwimage.**Points**(*data=None*, *meta=None*, *datakeys=None*, *metakeys=None*, ***kwargs*)

Bases: Spatial, _PointsWarpMixin

Stores multiple keypoints for a single object.

This stores both the geometry and the class metadata if available

Example

```
>>> from kwimage.structs.points import *  # NOQA
>>> xy = np.random.rand(10, 2)
>>> pts = Points(xy=xy)
>>> print('pts = {!r}'.format(pts))
```

property shape

property xy

classmethod random(*num=1*, *classes=None*, *rng=None*)

Makes random points; typically for testing purposes

Example

```
>>> import kwimage
>>> self = kwimage.Points.random(classes=[1, 2, 3])
>>> self.data
>>> print('self.data = {!r}'.format(self.data))
```

is_numpy()

is_tensor()

tensor(*device=NoParam*)

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> from kwimage.structs.points import *  # NOQA
>>> self = Points.random(10)
>>> self.tensor()
```

round(*inplace=False*)

Rounds data to the nearest integer

Parameters
inplace (*bool*) – if True, modifies this object

Example

```
>>> import kwimage
>>> self = kwimage.Points.random(3).scale(10)
>>> self.round()
```

numpy()

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> from kwimage.structs.points import *  # NOQA
>>> self = Points.random(10)
>>> self.tensor().numpy().tensor().numpy()
```

draw_on(*image=None*, *color='white'*, *radius=None*, *copy=False*)

Parameters

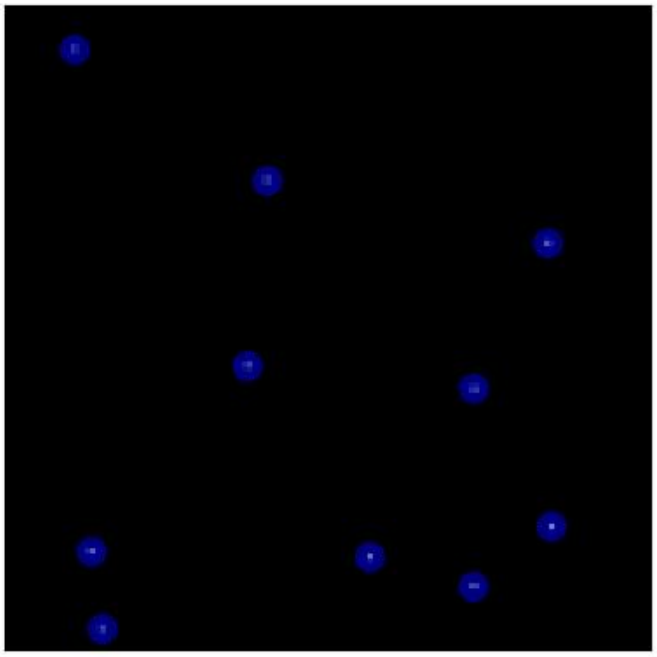
- **image** (*ndarray*) – image to draw points on.
- **color** (*str | Any | List[Any]*) – one color for all boxes or a list of colors for each box Can be any type accepted by kwimage.Color.coerce. Extended types: str | ColorLike | List[ColorLike]
- **radius** (*None | int*) – if an integer, an circle is drawn at each xy point with this radius. if None, attempts to fill a single point with subpixel accuracy, which generally means 4 pixels will be given some weight. Note: color can only be a single value for all points in this case.
- **copy** (*bool*) – if True, force a copy of the image, otherwise try to draw inplace (may not work depending on dtype).

CommandLine

```
xdoctest -m ~/code/kwimage/kwimage/structs/points.py Points.draw_on --show
```

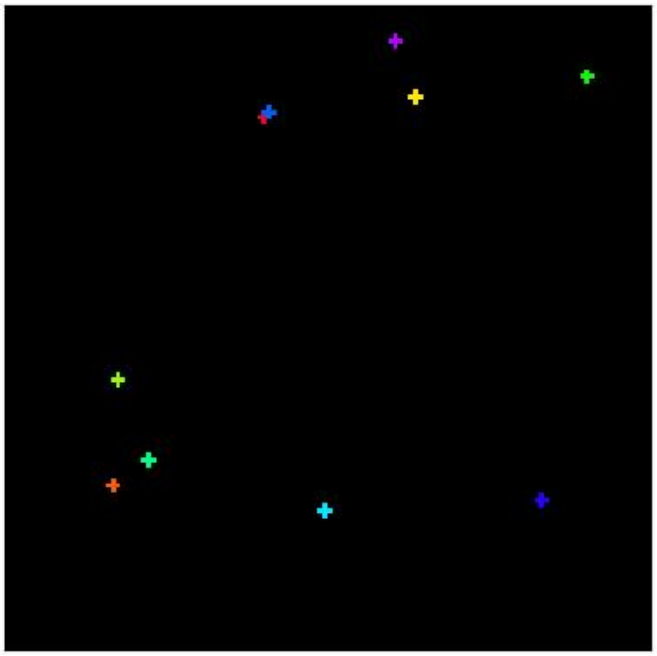
Example

```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> from kwimage.structs.points import *  # NOQA
>>> s = 128
>>> image = np.zeros((s, s))
>>> self = Points.random(10).scale(s)
>>> image = self.draw_on(image)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.figure(fnum=1, doclf=True)
>>> kwplot.autompl()
>>> kwplot.imshow(image)
>>> self.draw(radius=3, alpha=.5)
>>> kwplot.show_if_requested()
```



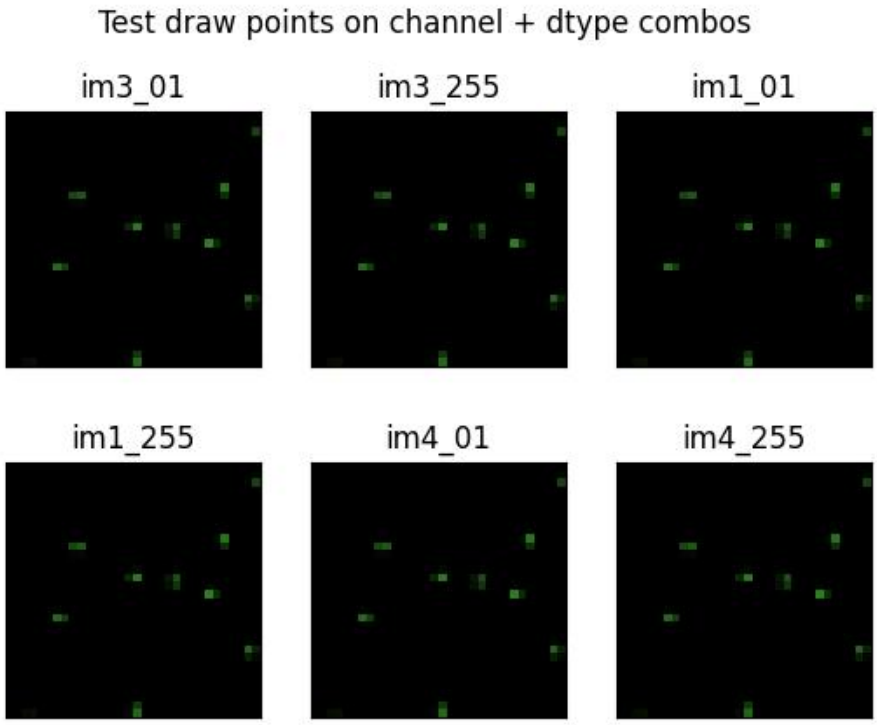
Example

```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> from kwimage.structs.points import *  # NOQA
>>> s = 128
>>> image = np.zeros((s, s))
>>> self = Points.random(10).scale(s)
>>> image = self.draw_on(image, radius=3, color='distinct')
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.figure(fnum=1, doclf=True)
>>> kwplot.autompl()
>>> kwplot.imshow(image)
>>> #self.draw(radius=3, alpha=.5, color='classes')
>>> kwplot.show_if_requested()
```



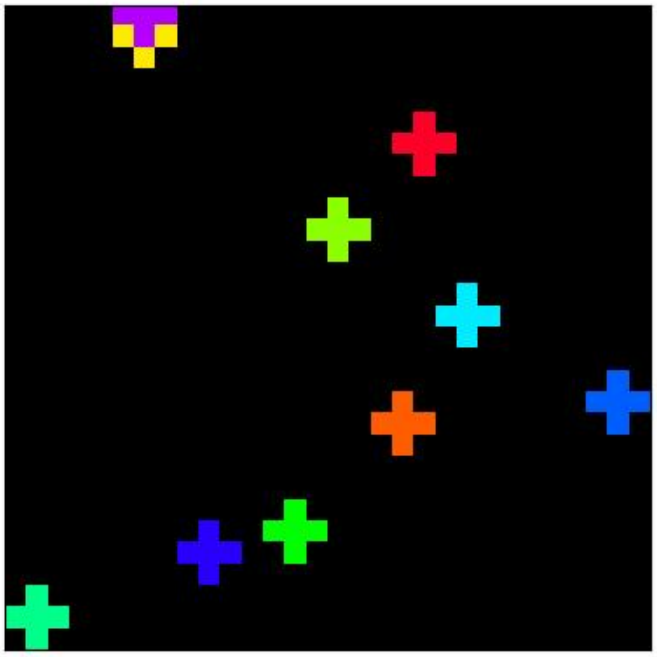
Example

```
>>> import kwimage
>>> s = 32
>>> self = kwimage.Points.random(10).scale(s)
>>> color = 'kitware_green'
>>> # Test drawing on all channel + dtype combinations
>>> im3 = np.zeros((s, s, 3), dtype=np.float32)
>>> im_chans = {
>>>     'im3': im3,
>>>     'im1': kwimage.convert_colorspace(im3, 'rgb', 'gray'),
>>>     'im4': kwimage.convert_colorspace(im3, 'rgb', 'rgba'),
>>> }
>>> inputs = {}
>>> for k, im in im_chans.items():
>>>     inputs[k + '_01'] = (kwimage.ensure_float01(im.copy()), {'radius':␣
↪None})
>>>     inputs[k + '_255'] = (kwimage.ensure_uint255(im.copy()), {'radius':␣
↪None})
>>> outputs = {}
>>> for k, v in inputs.items():
>>>     im, kw = v
>>>     outputs[k] = self.draw_on(im, color=color, **kw)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.figure(fnum=2, doclf=True)
>>> plt = kwplot.autoplt()
>>> pnum_ = kwplot.PlotNums(nRows=2, nSubplots=len(inputs))
>>> for k in inputs.keys():
>>>     kwplot.imshow(outputs[k], fnum=2, pnum=pnum_(), title=k)
>>> plt.gcf().suptitle('Test draw points on channel + dtype combos')
>>> kwplot.show_if_requested()
```



Example

```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> from kwimage.structs.points import *  # NOQA
>>> self = Points.random(10).scale(32)
>>> image = self.draw_on(radius=3, color='distinct')
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(image)
>>> kwplot.show_if_requested()
```



Example

```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> # Test cases where single and multiple colors are given
>>> # with radius=None and radius=scalar
>>> from kwimage.structs.points import *  # NOQA
>>> import kwimage
>>> self = kwimage.Points.random(10).scale(32)
>>> image1 = self.draw_on(radius=2, color='blue')
>>> image2 = self.draw_on(radius=None, color='blue')
>>> image3 = self.draw_on(radius=2, color='distinct')
>>> image4 = self.draw_on(radius=None, color='distinct')
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> canvas = kwimage.stack_images_grid(
>>>     [image1, image2, image3, image4],
>>>     pad=3, bg_value=(1, 1, 1))
>>> kwplot.autompl()
>>> kwplot.imshow(canvas)
>>> kwplot.show_if_requested()
```

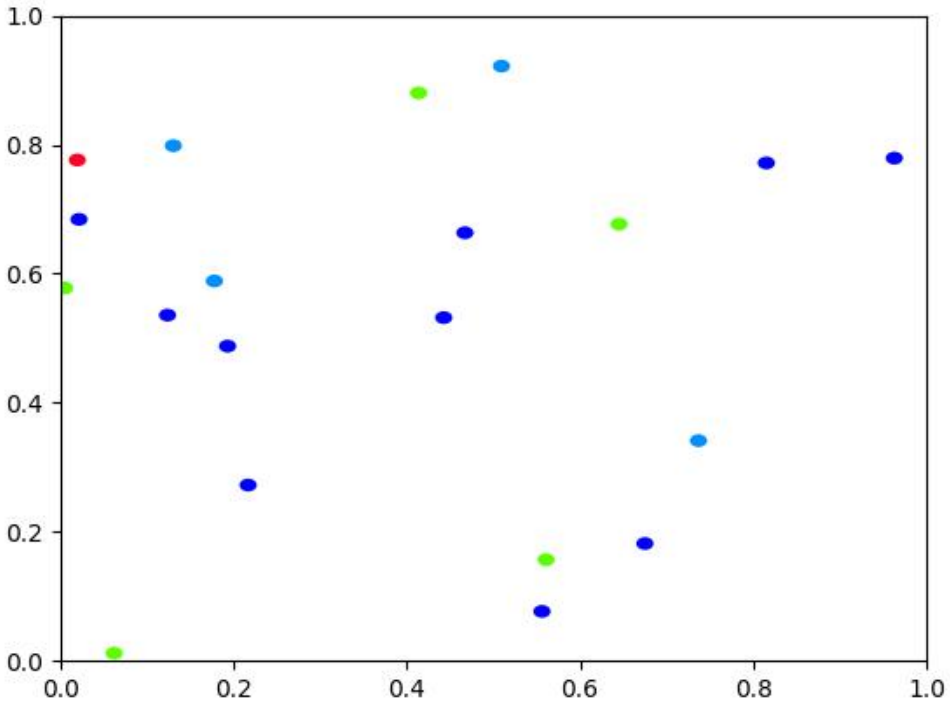
draw(*color='blue'*, *ax=None*, *alpha=None*, *radius=1*, ***kwargs*)

TODO: can use kwplot.draw_points

Example

```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> from kwimage.structs.points import *  # NOQA
>>> pts = Points.random(10)
>>> # xdoc: +REQUIRES(--show)
>>> pts.draw(radius=0.01)
```

```
>>> from kwimage.structs.points import *  # NOQA
>>> self = Points.random(10, classes=['a', 'b', 'c'])
>>> self.draw(radius=0.01, color='classes')
```



compress(*flags*, *axis=0*, *inplace=False*)

Filters items based on a boolean criterion

Example

```
>>> from kwimage.structs.points import *  # NOQA
>>> self = Points.random(4)
>>> flags = [1, 0, 1, 1]
>>> other = self.compress(flags)
>>> assert len(self) == 4
>>> assert len(other) == 3
```

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> other = self.tensor().compress(flags)
>>> assert len(other) == 3
```

take(*indices*, *axis=0*, *inplace=False*)

Takes a subset of items at specific indices

Example

```
>>> from kwimage.structs.points import *  # NOQA
>>> self = Points.random(4)
>>> indices = [1, 3]
>>> other = self.take(indices)
>>> assert len(self) == 4
>>> assert len(other) == 2
```

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> other = self.tensor().take(indices)
>>> assert len(other) == 2
```

classmethod concatenate(*points*, *axis=0*)

to_coco(*style='orig'*)

Converts to an mscoco-like representation

Note: items that are usually id-references to other objects may need to be rectified.

Parameters

style (*str*) – either orig, new, new-id, or new-name

Returns

mscoco-like representation

Return type

Dict

Example

```
>>> from kwimage.structs.points import *  # NOQA
>>> self = Points.random(4, classes=['a', 'b'])
>>> orig = self._to_coco(style='orig')
>>> print('orig = {!r}'.format(orig))
>>> new_name = self._to_coco(style='new-name')
>>> print('new_name = {}'.format(ub.repr2(new_name, nl=-1)))
>>> # xdoctest: +REQUIRES(module:kwcoco)
>>> import kwcoco
>>> self.meta['classes'] = kwcoco.CategoryTree.coerce(self.meta['classes'])
>>> new_id = self._to_coco(style='new-id')
>>> print('new_id = {}'.format(ub.repr2(new_id, nl=-1)))
```

classmethod coerce(*data*)

Attempt to coerce data into a Points object

classmethod from_coco(*coco_kpts*, *class_idxs=None*, *classes=None*, *warn=False*)

Parameters

- **coco_kpts** (*list | dict*) – either the original list keypoint encoding or the new dict keypoint encoding.

- **class_idxs** (*list*) – only needed if using old style
- **classes** (*list | kwcoco.CategoryTree*) – list of all keypoint category names
- **warn** (*bool*) – if True raise warnings

Example

```
>>> ##
>>> classes = ['mouth', 'left-hand', 'right-hand']
>>> coco_kpts = [
>>>     {'xy': (0, 0), 'visible': 2, 'keypoint_category': 'left-hand'},
>>>     {'xy': (1, 2), 'visible': 2, 'keypoint_category': 'mouth'},
>>> ]
>>> Points.from_coco(coco_kpts, classes=classes)
>>> # Test without classes
>>> Points.from_coco(coco_kpts)
>>> # Test without any category info
>>> coco_kpts2 = [ub.dict_diff(d, {'keypoint_category'}) for d in coco_kpts]
>>> Points.from_coco(coco_kpts2)
>>> # Test without category instead of keypoint_category
>>> coco_kpts3 = [ub.map_keys(lambda x: x.replace('keypoint_', ''), d) for d␣
↪in coco_kpts]
>>> Points.from_coco(coco_kpts3)
>>> #
>>> # Old style
>>> coco_kpts = [0, 0, 2, 0, 1, 2]
>>> Points.from_coco(coco_kpts)
>>> # Fail case
>>> coco_kpts4 = [{'xy': [4686.5, 1341.5], 'category': 'dot'}]
>>> Points.from_coco(coco_kpts4, classes=[])
```

Example

```
>>> # xdoctest: +REQUIRES(module:kwcoco)
>>> import kwcoco
>>> classes = kwcoco.CategoryTree.from_coco([
>>>     {'name': 'mouth', 'id': 2}, {'name': 'left-hand', 'id': 3}, {'name':
↪'right-hand', 'id': 5}
>>> ])
>>> coco_kpts = [
>>>     {'xy': (0, 0), 'visible': 2, 'keypoint_category_id': 5},
>>>     {'xy': (1, 2), 'visible': 2, 'keypoint_category_id': 2},
>>> ]
>>> pts = Points.from_coco(coco_kpts, classes=classes)
>>> assert pts.data['class_idxs'].tolist() == [2, 0]
```

class kwimage.**PointsList**(*data*, *meta=None*)

Bases: ObjectList

Stores a list of Points, each item usually corresponds to a different object.

Note: # TODO: when the data is homogenous we can use a more efficient # representation, otherwise we have to use heterogenous storage.

class kwimage.**Polygon**(*data=None*, *meta=None*, *datakeys=None*, *metakeys=None*, ***kwargs*)

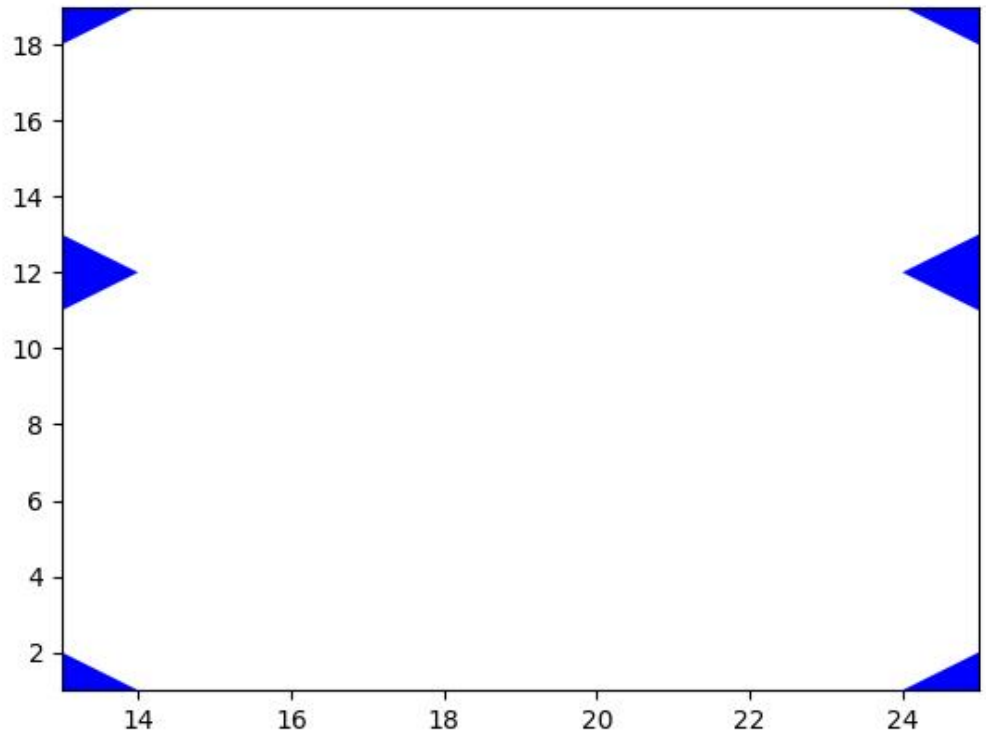
Bases: Spatial, _PolyArrayBackend, _PolyWarpMixin, NiceRepr

Represents a single polygon as set of exterior boundary points and a list of internal polygons representing holes.

By convention exterior boundaries should be counterclockwise and interior holes should be clockwise.

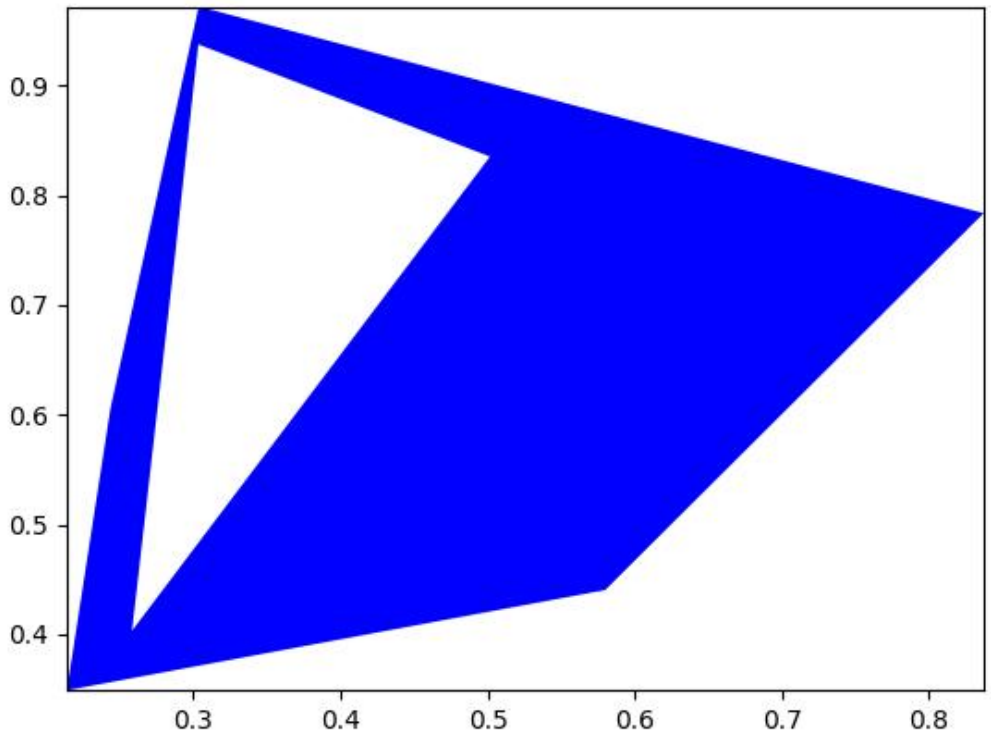
Example

```
>>> import kwimage
>>> data = {
>>>     'exterior': np.array([[13,  1], [13, 19], [25, 19], [25,  1]]),
>>>     'interiors': [
>>>         np.array([[13, 13], [14, 12], [24, 12], [25, 13], [25, 18],
>>>                   [24, 19], [14, 19], [13, 18]]),
>>>         np.array([[13,  2], [14,  1], [24,  1], [25, 2], [25, 11],
>>>                   [24, 12], [14, 12], [13, 11]])]
>>> }
>>> self = kwimage.Polygon(**data)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> self.draw(setlim=True)
```



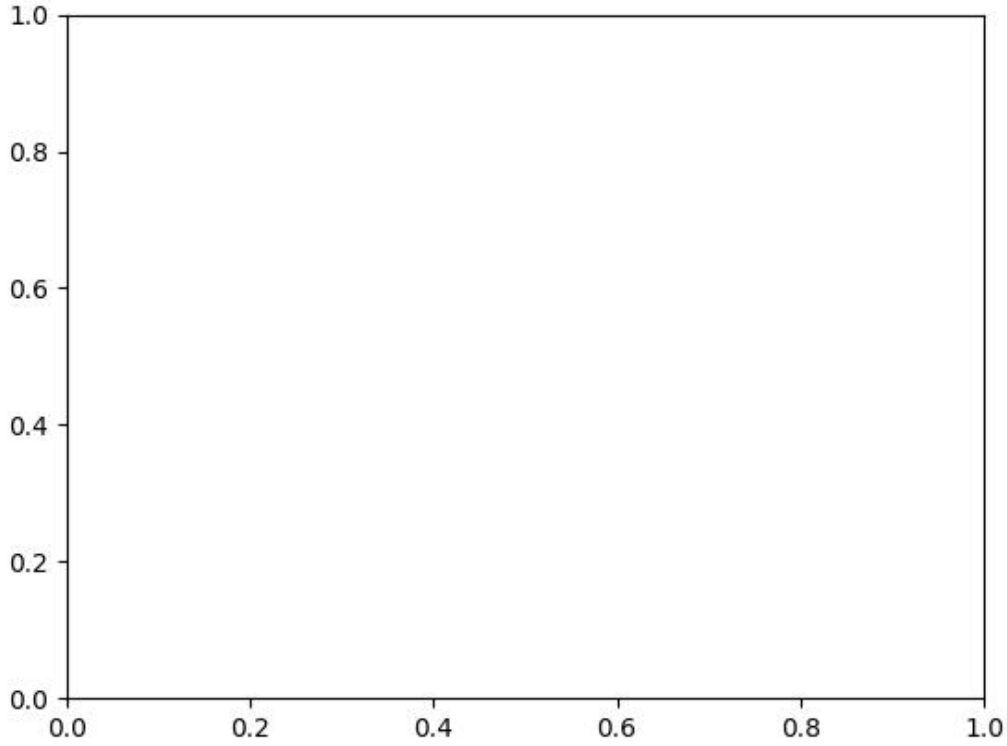
Example

```
>>> import kwimage
>>> self = kwimage.Polygon.random(
>>>     n=5, n_holes=1, convex=False, rng=0)
>>> print('self = {}'.format(self))
self = <Polygon({
    'exterior': <Coords(data=
                    array([[0.30371392, 0.97195856],
                           [0.24372304, 0.60568445],
                           [0.21408694, 0.34884262],
                           [0.5799477 , 0.44020379],
                           [0.83720288, 0.78367234]]))>,
    'interiors': [<Coords(data=
                     array([[0.50164209, 0.83520279],
                            [0.25835064, 0.40313428],
                            [0.28778562, 0.74758761],
                            [0.30341266, 0.93748088]]))>],
})>
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> self.draw(setlim=True)
```



Example

```
>>> # Test empty polygon
>>> import kwimage
>>> data = {
>>>     'exterior': np.array([]),
>>>     'interiors': [],}
>>> self = kwimage.Polygon(**data)
>>> geos = self.to_geojson()
>>> kwimage.Polygon.from_geojson(geos)
>>> geom = self.to_shapely()
>>> kwimage.Polygon.from_shapely(geom)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> self.draw(setlim=True)
```



property exterior

Returns: kwimage.Coords

property interiors

Returns: List[kwimage.Coords]

classmethod circle(*xy*, *r*, *resolution=64*)

Create a circular or elliptical polygon.

Might rename to ellipse later?

Parameters

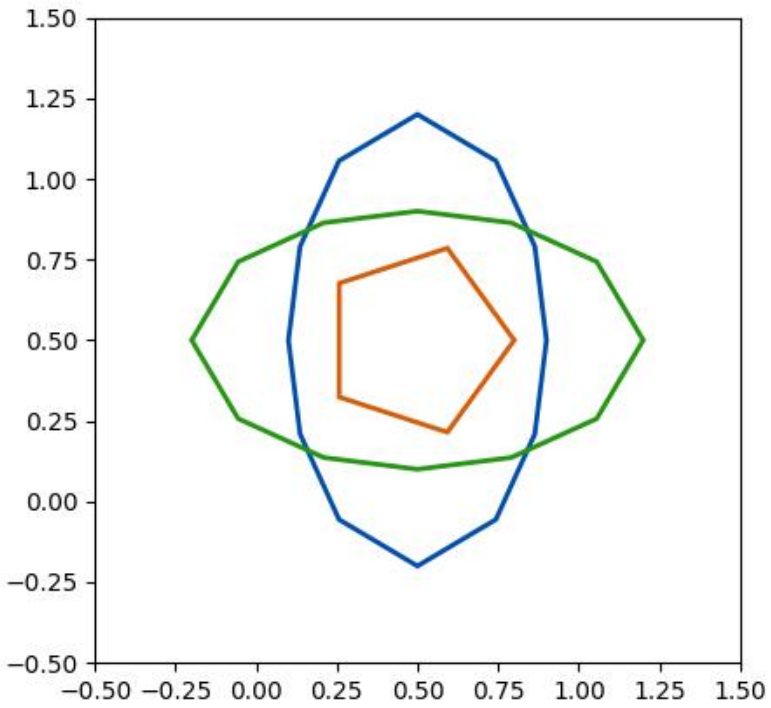
- **xy** (*Iterable[Number]*) – x and y center coordinate
- **r** (*Number | Tuple[Number, Number]*) – circular radius or major and minor elliptical radius
- **resolution** (*int*) – number of sides

Returns

Polygon

Example

```
>>> import kwimage
>>> xy = (0.5, 0.5)
>>> r = .3
>>> # Demo with circle
>>> circle = kwimage.Polygon.circle(xy, r, resolution=6)
>>> # Demo with ellipse
>>> xy = (0.5, 0.5)
>>> r = (.4, .7)
>>> ellipse1 = kwimage.Polygon.circle(xy, r, resolution=12)
>>> ellipse2 = kwimage.Polygon.circle(xy, (.7, .4), resolution=12)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> plt = kwplot.autoplt()
>>> kwplot.figure(fnum=1, doclf=True)
>>> circle.draw(setlim=True, border=1, fill=0, color='kitware_orange')
>>> ellipse1.draw(setlim=True, border=1, fill=0, color='kitware_blue')
>>> ellipse2.draw(setlim=True, border=1, fill=0, color='kitware_green')
>>> plt.gca().set_xlim(-0.5, 1.5)
>>> plt.gca().set_ylim(-0.5, 1.5)
>>> plt.gca().set_aspect('equal')
```



classmethod random(*n=6*, *n_holes=0*, *convex=True*, *tight=False*, *rng=None*)

Parameters

- **n** (*int*) – number of points in the polygon (must be 3 or more)

- **n_holes** (*int*) – number of holes
- **tight** (*bool*) – fits the minimum and maximum points between 0 and 1
- **convex** (*bool*) – force resulting polygon will be convex (may remove exterior points)

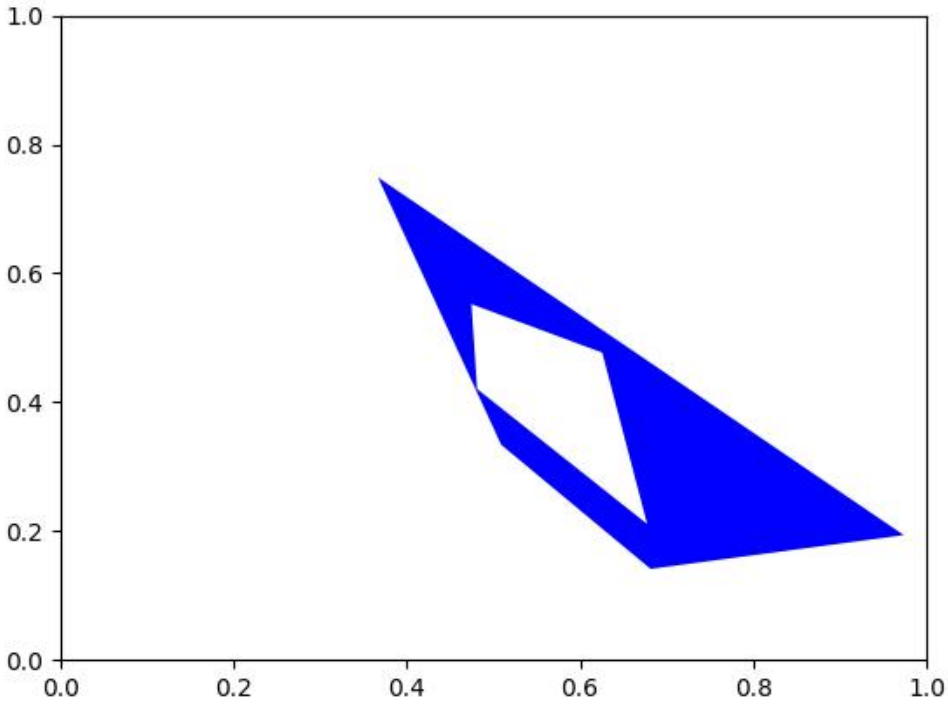
Returns
Polygon

CommandLine

```
xdoctest -m kwimage.structs.polygon Polygon.random
```

Example

```
>>> rng = None
>>> n = 4
>>> n_holes = 1
>>> cls = Polygon
>>> self = Polygon.random(n=n, rng=rng, n_holes=n_holes, convex=1)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.figure(fnum=1, doclf=True)
>>> self.draw()
```



References

https://gis.stackexchange.com/questions/207731/random-multipolygon https://stackoverflow.com/questions/8997099/random-polygon https://stackoverflow.com/questions/27548363/from-voronoi-tessellation-to-shapely-polygons https://stackoverflow.com/questions/8997099/algorithm-to-generate-random-2d-polygon

to_mask(*dims=None*, *pixels_are='points'*)

Convert this polygon to a mask

Todo:

- [ ] currently not efficient

Parameters

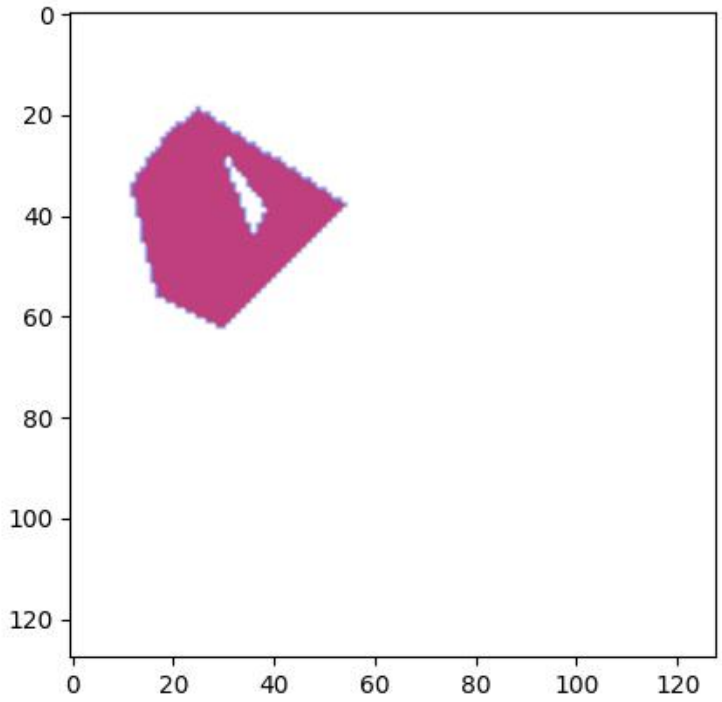
- **dims** (*Tuple*) – height and width of the output mask
- **pixels_are** (*str*) – either “points” or “areas”

Returns

kwimage.Mask

Example

```
>>> from kwimage.structs.polygon import *  # NOQA
>>> self = Polygon.random(n_holes=1).scale(128)
>>> mask = self.to_mask((128, 128))
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.figure(fnum=1, doclf=True)
>>> mask.draw(color='blue')
>>> mask.to_multi_polygon().draw(color='red', alpha=.5)
```



to_relative_mask(*return_offset=False*)

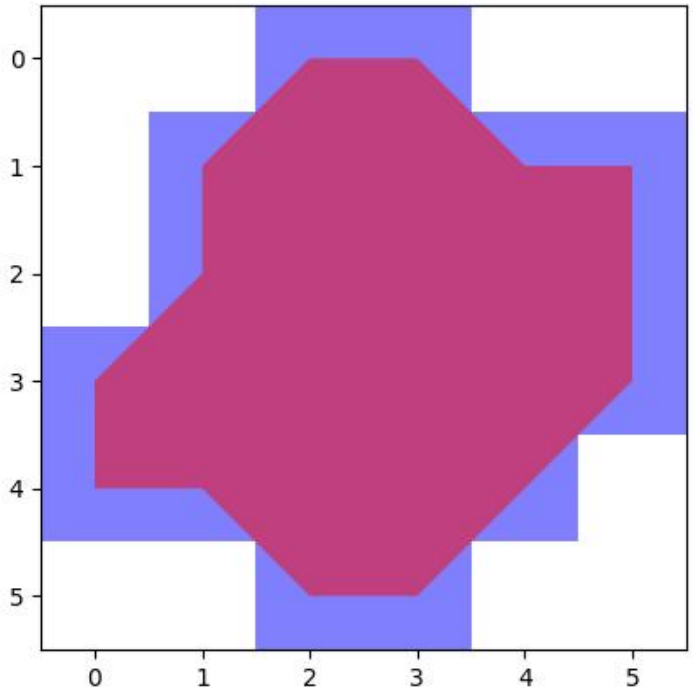
Returns a translated mask such the mask dimensions are minimal.

In other words, we move the polygon all the way to the top-left and return a mask just big enough to fit the polygon.

Returns
kwimage.Mask

Example

```
>>> from kwimage.structs.polygon import *  # NOQA
>>> self = Polygon.random().scale(8).translate(100, 100)
>>> mask = self.to_relative_mask()
>>> assert mask.shape <= (8, 8)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.figure(fnum=1, doclf=True)
>>> mask.draw(color='blue')
>>> mask.to_multi_polygon().draw(color='red', alpha=.5)
```



classmethod coerce(*data*)

Routes the input to the proper constructor

Try to autodetermine format of input polygon and coerce it into a kwimage.Polygon.

Parameters
data (*object*) – some type of data that can be interpreted as a polygon.

Returns
kwimage.Polygon

Example

```
>>> import kwimage
>>> self = kwimage.Polygon.random()
>>> kwimage.Polygon.coerce(self)
>>> kwimage.Polygon.coerce(self.exterior)
>>> kwimage.Polygon.coerce(self.exterior.data)
>>> kwimage.Polygon.coerce(self.data)
>>> kwimage.Polygon.coerce(self.to_geojson())
>>> kwimage.Polygon.coerce('POLYGON ((0.11 0.61, 0.07 0.588, 0.015 0.50, 0.11␣
↪0.61))')
```

classmethod from_shapely(*geom*)

Convert a shapely polygon to a kwimage.Polygon

Parameters
geom (*shapely.geometry.polygon.Polygon*) – a shapely polygon

Returns
kwimage.Polygon

classmethod from_wkt(*data*)

Convert a WKT string to a kwimage.Polygon

Parameters
data (*str*) – a WKT polygon string

Returns
kwimage.Polygon

Example

```
>>> import kwimage
>>> data = 'POLYGON ((0.11 0.61, 0.07 0.588, 0.015 0.50, 0.11 0.61))'
>>> self = kwimage.Polygon.from_wkt(data)
>>> assert len(self.exterior) == 4
```

classmethod from_geojson(*data_geojson*)

Convert a geojson polygon to a kwimage.Polygon

Parameters
data_geojson (*dict*) – geojson data

Returns
Polygon

References

https://geojson.org/geojson-spec.html

Example

```
>>> from kwimage.structs.polygon import *  # NOQA
>>> self = Polygon.random(n_holes=2)
>>> data_geojson = self.to_geojson()
>>> new = Polygon.from_geojson(data_geojson)
```

to_shapely()

Returns
shapely.geometry.polygon.Polygon

Example

```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> # xdoc: +REQUIRES(module:shapely)
>>> from kwimage.structs.polygon import *  # NOQA
>>> self = Polygon.random(n_holes=1)
>>> self = self.scale(100)
>>> geom = self.to_shapely()
>>> print('geom = {!r}'.format(geom))
```

property area

Computes are via shapley conversion

Returns
float

to_geojson()

Converts polygon to a geojson structure

Returns
Dict[str, object]

Example

```
>>> import kwimage
>>> self = kwimage.Polygon.random()
>>> print(self.to_geojson())
```

to_wkt()

Convert a kwimage.Polygon to WKT string

Returns
str

Example

```
>>> import kwimage
>>> self = kwimage.Polygon.random()
>>> print(self.to_wkt())
```

classmethod from_coco(*data*, *dims=None*)

Accepts either new-style or old-style coco polygons

Parameters

- **data** (*List[Number] | Dict*) – A new or old-style coco polygon
- **dims** (*None | Tuple[int, ...]*) – the shape dimensions of the canvas. Unused. Exists for compatibility with masks.

Returns
Polygon

`to_coco`(*style='orig'*)

Parameters
style (*str*) – can be “orig” or “new”

Returns
coco-style polygons

Return type
List | Dict

`to_multi_polygon`()

Returns
MultiPolygon

`to_boxes`()

Deprecated: lossy conversion use ‘bounding_box’ instead

Returns
kwimage.Boxes

`property centroid`

Returns: Tuple[Number, Number]

`bounding_box`()

Returns an axis-aligned bounding box for the segmentation

Returns
kwimage.Boxes

`bounding_box_polygon`()

Returns an axis-aligned bounding polygon for the segmentation.

Note: This Polygon will be a Box, not a convex hull! Use shapely for convex hulls.

Returns
kwimage.Polygon

`copy`()

Returns
a copy

Return type
Polygon

`clip`(*x_min*, *y_min*, *x_max*, *y_max*, *inplace=False*)

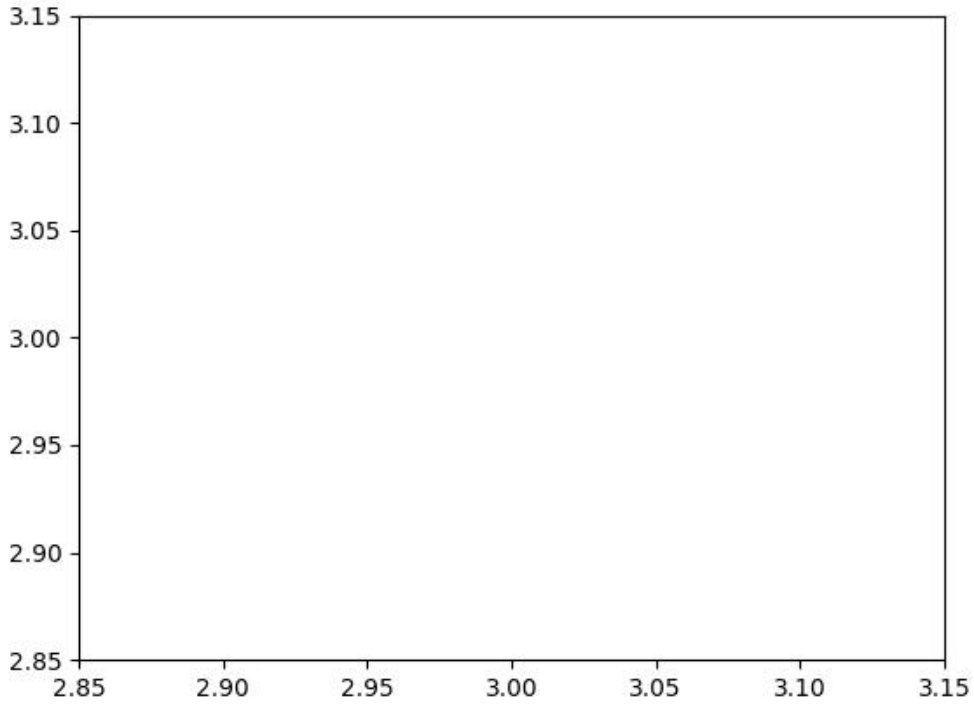
Clip polygon to specified boundaries.

Returns
clipped polygon

Return type
Polygon

Example

```
>>> from kwimage.structs.polygon import *
>>> self = Polygon.random().scale(10).translate(-1)
>>> self2 = self.clip(1, 1, 3, 3)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> self2.draw(setlim=True)
```



fill(*image*, *value=1*, *pixels_are='points'*)

Inplace fill in an image based on this polyon.

Parameters

- **image** (*ndarray*) – image to draw on
- **value** (*int | Tuple[int]*) – value fill in with. Defaults to 1.
- **pixels_are** (*str*) – either points or areas

Returns

the image that has been modified in place

Return type

ndarray

Example

```
>>> # xdoctest: +REQUIRES(module:rasterio)
>>> import kwimage
>>> mask = kwimage.Mask.random()
>>> self = mask.to_multi_polygon(pixels_are='areas').data[0]
>>> image = np.zeros_like(mask.data)
>>> self.fill(image, pixels_are='areas')
```

Example

```
>>> # Test case where there are multiple channels
>>> import kwimage
>>> mask = kwimage.Mask.random(shape=(4, 4), rng=0)
>>> self = mask.to_multi_polygon()
>>> image = np.zeros(mask.shape[0:2] + (2,))
>>> fill_v1 = self.fill(image.copy(), value=1)
>>> fill_v2 = self.fill(image.copy(), value=(1, 2))
>>> assert np.all((fill_v1 > 0) == (fill_v2 > 0))
```

draw_on(*image*, *color='blue'*, *fill=True*, *border=False*, *alpha=1.0*, *edgecolor=None*, *facecolor=None*, *copy=False*)

Rasterizes a polygon on an image. See *draw* for a vectorized matplotlib version.

Parameters

- **image** (*ndarray*) – image to raster polygon on.
- **color** (*str | tuple*) – data coercable to a color
- **fill** (*bool*) – draw the center mass of the polygon. Note: this will be deprecated. Use facecolor instead.
- **border** (*bool*) – draw the border of the polygon Note: this will be deprecated. Use edgecolor instead.
- **alpha** (*float*) – polygon transparency (setting alpha < 1 makes this function much slower). Defaults to 1.0
- **copy** (*bool*) – if False only copies if necessary
- **edgecolor** (*str | tuple*) – color for the border
- **facecolor** (*str | tuple*) – color for the fill

Returns

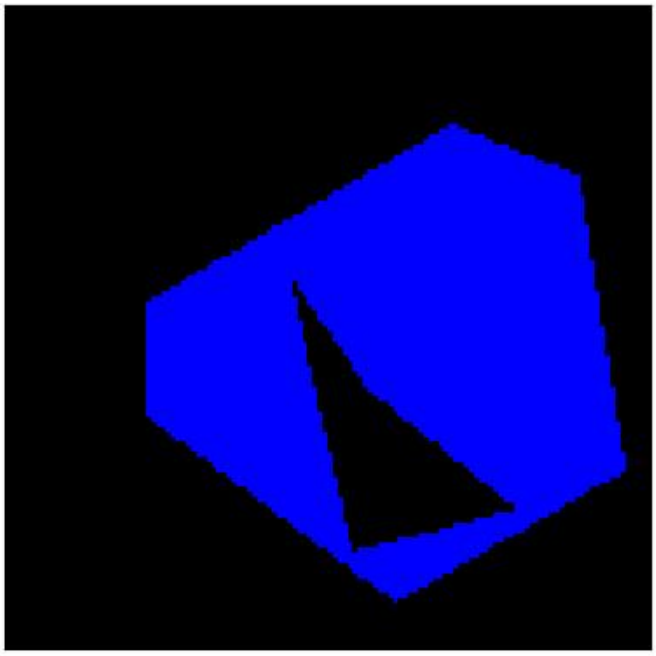
np.ndarray

Note: This function will only be inplace if alpha=1.0 and the input has 3 or 4 channels. Otherwise the output canvas is coerced so colors can be drawn on it. In the case where alpha < 1.0,

---

Example

```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> from kwimage.structs.polygon import *  # NOQA
>>> self = Polygon.random(n_holes=1).scale(128)
>>> image_in = np.zeros((128, 128), dtype=np.float32)
>>> image_out = self.draw_on(image_in)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(image_out, fnum=1)
```



Example

```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> # Demo drawing on a RGBA canvas
>>> # If you initialize an zero rgba canvas, the alpha values are
>>> # filled correctly.
>>> from kwimage.structs.polygon import *  # NOQA
>>> s = 16
>>> self = Polygon.random(n_holes=1, rng=32).scale(s)
>>> image_in = np.zeros((s, s, 4), dtype=np.float32)
>>> image_out = self.draw_on(image_in, color='black')
>>> assert np.all(image_out[..., 0:3] == 0)
```

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```
>>> assert not np.all(image_out[..., 3] == 1)
>>> assert not np.all(image_out[..., 3] == 0)
```

Example

```
>>> import kwimage
>>> color = 'blue'
>>> self = kwimage.Polygon.random(n_holes=1).scale(128)
>>> image = np.zeros((128, 128), dtype=np.float32)
>>> # Test drawing on all channel + dtype combinations
>>> im3 = np.random.rand(128, 128, 3)
>>> im_chans = {
>>>     'im3': im3,
>>>     'im1': kwimage.convert_colorspace(im3, 'rgb', 'gray'),
>>>     #'im0': im3[..., 0],
>>>     'im4': kwimage.convert_colorspace(im3, 'rgb', 'rgba'),
>>> }
>>> inputs = {}
>>> for k, im in im_chans.items():
>>>     inputs[k + '_f01'] = (kwimage.ensure_float01(im.copy()), {'alpha':␣
↪None})
>>>     inputs[k + '_u255'] = (kwimage.ensure_uint255(im.copy()), {'alpha':␣
↪None})
>>>     inputs[k + '_f01_a'] = (kwimage.ensure_float01(im.copy()), {'alpha': 0.
↪5})
>>>     inputs[k + '_u255_a'] = (kwimage.ensure_uint255(im.copy()), {'alpha':␣
↪0.5})
>>> # Check cases when image is/isnot written inplace Construct images
>>> # with different dtypes / channels and run a draw_on with different
>>> # keyword args.  For each combination, demo if that results in an
>>> # implace operation or not.
>>> rows = []
>>> outputs = {}
>>> for k, v in inputs.items():
>>>     im, kw = v
>>>     outputs[k] = self.draw_on(im, color=color, **kw)
>>>     inplace = outputs[k] is im
>>>     rows.append({'key': k, 'inplace': inplace})
>>> # xdoc: +REQUIRES(module:pandas)
>>> import pandas as pd
>>> df = pd.DataFrame(rows).sort_values('inplace')
>>> print(df.to_string())
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.figure(fnum=2, doclf=True)
>>> kwplot.autompl()
>>> pnum_ = kwplot.PlotNums(nCols=2, nRows=len(inputs))
>>> for k in inputs.keys():
>>>     kwplot.imshow(inputs[k][0], fnum=2, pnum=pnum_(), title=k)
>>>     kwplot.imshow(outputs[k], fnum=2, pnum=pnum_(), title=k)
>>> kwplot.show_if_requested()
```

Example

```
>>> # Test empty polygon draw
>>> from kwimage.structs.polygon import *  # NOQA
>>> self = Polygon.from_coco([])
>>> image_in = np.zeros((128, 128), dtype=np.float32)
>>> image_out = self.draw_on(image_in)
```

Example

```
>>> # Test stupid large polygon draw
>>> from kwimage.structs.polygon import *  # NOQA
>>> from kwimage.structs.polygon import _generic
>>> import kwimage
>>> self = kwimage.Polygon.random().scale(2e11)
>>> image = np.zeros((128, 128), dtype=np.float32)
>>> image_out = self.draw_on(image)
```

draw(*color='blue'*, *ax=None*, *alpha=1.0*, *radius=1*, *setlim=False*, *border=None*, *linewidth=None*, *edgecolor=None*, *facecolor=None*, *fill=True*, *vertex=False*, *vertexcolor=None*)

Draws polygon in a matplotlib axes. See *draw_on* for in-memory image modification.

Parameters

- **setlim** (*bool*) – if True ensures the limits of the axes contains the polygon
- **color** (*str | Tuple*) – coercable color. Default color if specific colors are not given.
- **alpha** (*float*) – fill transparency
- **fill** (*bool*) – if True fill the polygon with facecolor, otherwise just draw the border if linewidth > 0
- **setlim** (*bool*) – if True, modify the x and y limits of the matplotlib axes such that the polygon is can be seen.
- **border** (*bool*) – if True, draws an edge border on the polygon. DEPRECATED. Use linewidth instead.
- **linewidth** (*bool*) – width of the border
- **edgecolor** (*None | Any*) – if None, uses the value of `color`. Otherwise the color of the border when linewidth > 0. Extended types Coercable[kwimage.Color].
- **facecolor** (*None | Any*) – if None, uses the value of `color`. Otherwise, color of the border when fill=True. Extended types Coercable[kwimage.Color].
- **vertex** (*float*) – if non-zero, draws vertexes on the polygon with this radius.
- **vertexcolor** (*Any*) – color of vertexes Extended types Coercable[kwimage.Color].

Returns
None for am empty polygon

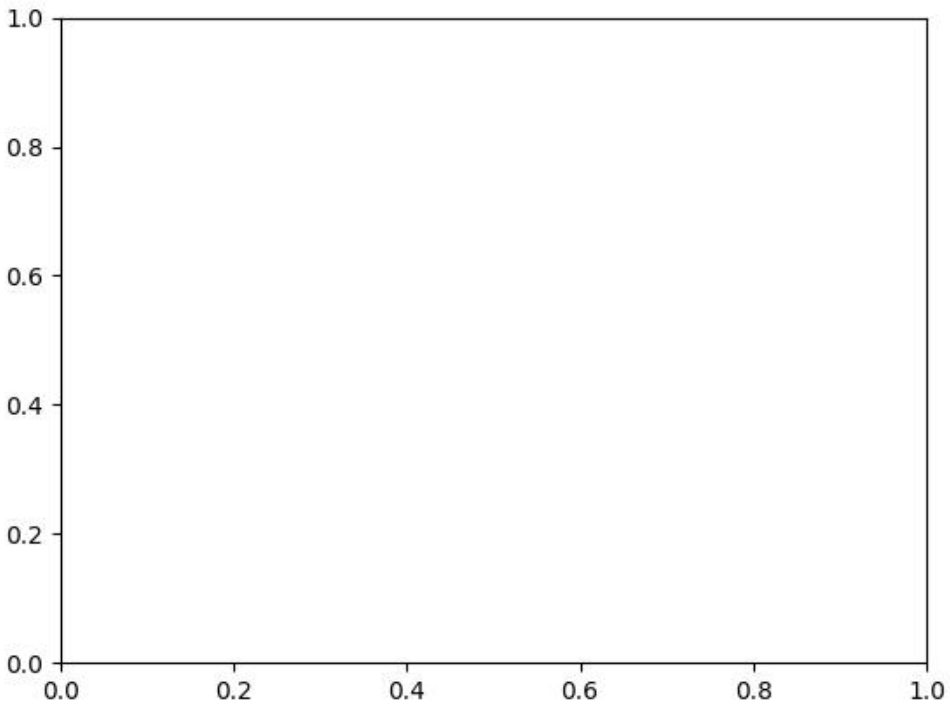
Return type
matplotlib.patches.PathPatch | None

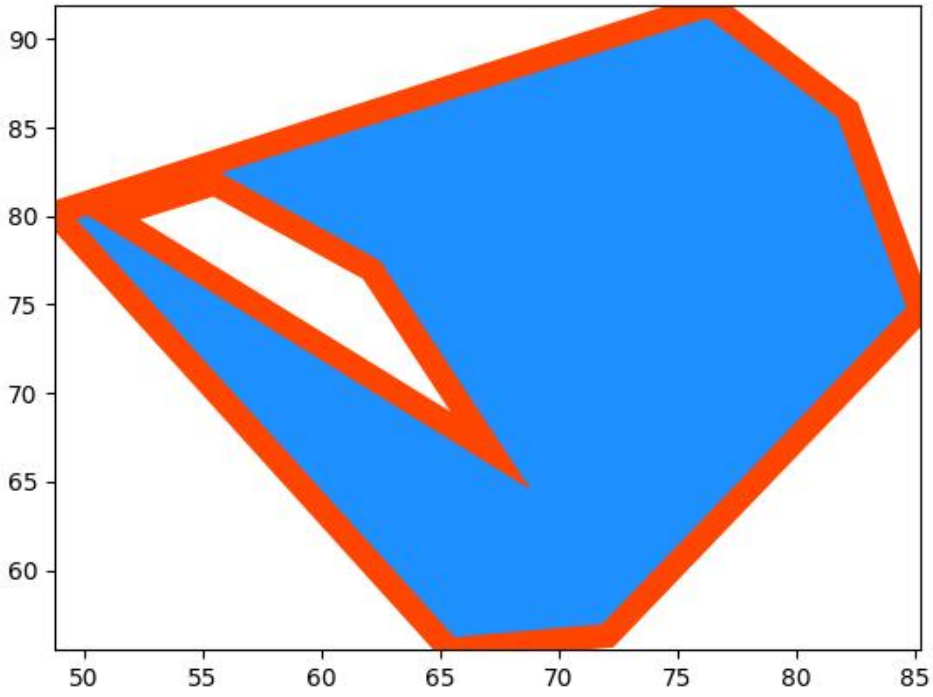
Todo:

- [ ] Rework arguments in favor of matplotlib standards

Example

```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> from kwimage.structs.polygon import *  # NOQA
>>> self = Polygon.random(n_holes=1)
>>> self = self.scale(100)
>>> # xdoc: +REQUIRES(--show)
>>> kwargs = dict(edgecolor='orangered', facecolor='dodgerblue', linewidth=10)
>>> self.draw(**kwargs)
>>> import kwplot
>>> kwplot.autompl()
>>> from matplotlib import pyplot as plt
>>> kwplot.figure(fnum=2)
>>> self.draw(setlim=True, **kwargs)
```





Example

```
>>> # xdoc: +REQUIRES(module:kwplot)
>>> # xdoc: +REQUIRES(--show)
>>> from kwimage.structs.polygon import *  # NOQA
>>> self = Polygon.random(n_holes=1, rng=33202)
>>> import textwrap
>>> # Test over a range of parameters
>>> basis = {
>>>     'linewidth': [0, 4],
>>>     'edgecolor': [None, 'gold'],
>>>     'facecolor': ['purple'],
>>>     'fill': [True, False],
>>>     'alpha': [1.0, 0.5],
>>>     'vertex': [0, 0.01],
>>>     'vertexcolor': ['green'],
>>> }
>>> grid = list(ub.named_product(basis))
>>> import kwplot
>>> kwplot.autompl()
>>> pnum_ = kwplot.PlotNums(nSubplots=len(grid))
>>> for kwargs in grid:
>>>     fig = kwplot.figure(fnum=1, pnum=pnum_())
>>>     ax = fig.gca()
>>>     self.draw(ax=ax, **kwargs)
```

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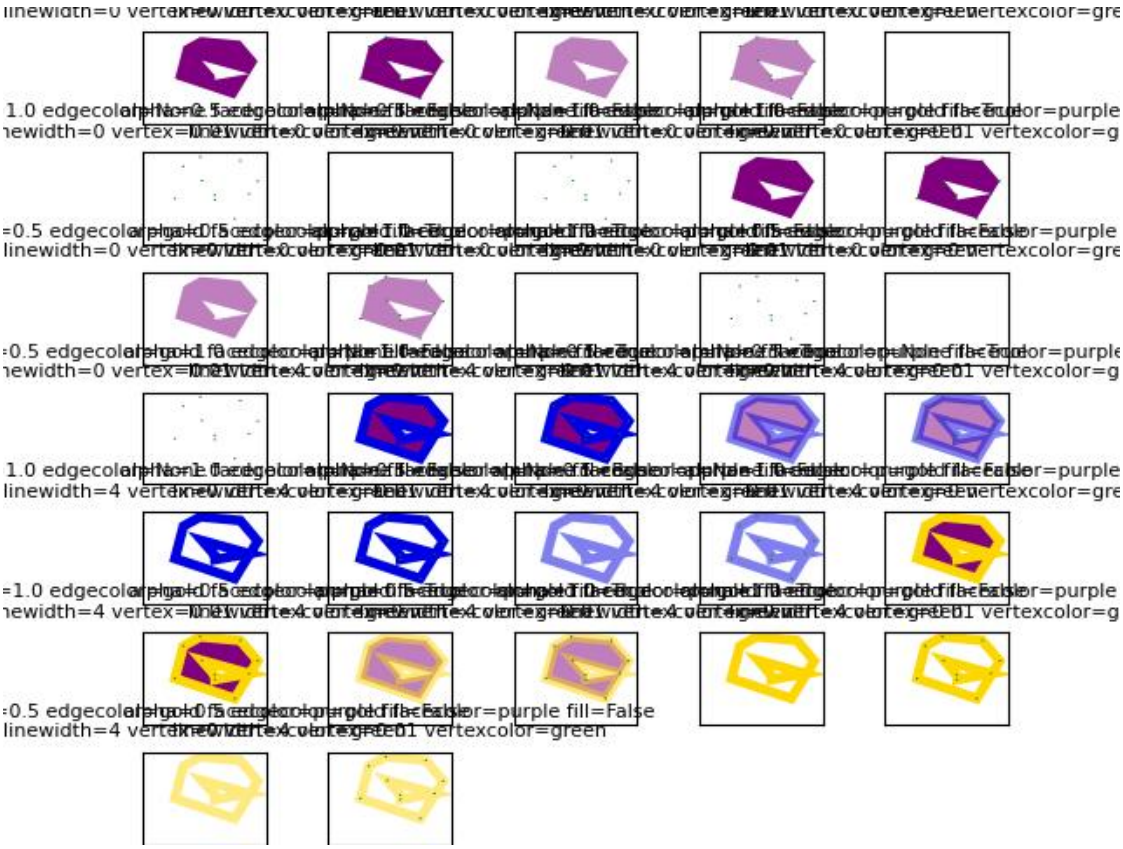
```
>>>     title = ub.repr2(kwargs, compact=True)
>>>     title = '\n'.join(textwrap.wrap(
>>>         title.replace(',', ' '), break_long_words=False,
>>>         width=60))
>>>     ax.set_title(title, fontdict={'fontsize': 8})
>>>     ax.grid(False)
>>>     ax.set_xticks([])
>>>     ax.set_yticks([])
>>> fig.subplots_adjust(wspace=0.5, hspace=0.3, bottom=0.001, top=0.97)
>>> kwplot.show_if_requested()
```



class kwimage.**PolygonList**(*data*, *meta=None*)

Bases: ObjectList

Stores and allows manipluation of multiple polygons, usually within the same image.

to_mask_list(*dims=None*, *pixels_are='points'*)

Converts all items to masks

Returns

kwimage.MaskList

to_polygon_list()

Returns

PolygonList

`to_segmentation_list`()

Converts all items to segmentation objects

Returns
kwimage.SegmentationList

`swap_axes`(*inplace=False*)

Returns
PolygonList

`to_geojson`(*as_collection=False*)

Converts a list of polygons/multipolygons to a geojson structure

Parameters
as_collection (*bool*) – if True, wraps the polygon geojson items in a geojson feature collection, otherwise just return a list of items.

Returns
items or geojson data

Return type
List[Dict] | Dict

Example

```
>>> import kwimage
>>> data = [kwimage.Polygon.random(),
>>>         kwimage.Polygon.random(n_holes=1),
>>>         kwimage.MultiPolygon.random(n_holes=1),
>>>         kwimage.MultiPolygon.random()]
>>> self = kwimage.PolygonList(data)
>>> geojson = self.to_geojson(as_collection=True)
>>> items = self.to_geojson(as_collection=False)
>>> print('geojson = {}'.format(ub.repr2(geojson, nl=-2, precision=1)))
>>> print('items = {}'.format(ub.repr2(items, nl=-2, precision=1)))
```

`fill`(*image*, *value=1*, *pixels_are='points'*)

Inplace fill in an image based on these polygons

Parameters

- **image** (*ndarray*) – image to draw on (inplace)
- **value** (*int | Tuple[int, ...]*) – value fill in with

Returns
the image that has been modified in place

Return type
ndarray

`draw_on`(**args*, ***kw*)

`class kwimage.Projective`(*matrix*)

Bases: *Linear*

A thin wraper around a 3x3 matrix that represent a projective transform

Implements methods for:

- creating random projective transforms
- decomposing the matrix
- finding a best-fit transform between corresponding points
- TODO: - [ ] fully rational transform

Example

```
>>> import kwimage
>>> import math
>>> image = kwimage.grab_test_image()
>>> theta = 0.123 * math.tau
>>> components = {
>>>     'rotate': kwimage.Projective.projective(theta=theta),
>>>     'scale': kwimage.Projective.projective(scale=0.5),
>>>     'shear': kwimage.Projective.projective(shearx=0.2),
>>>     'translation': kwimage.Projective.projective(offset=(100, 200)),
>>>     'rotate+translate': kwimage.Projective.projective(theta=0.123 * math.tau,␣
↪about=(256, 256)),
>>>     'perspective': kwimage.Projective.projective(uv=(0.0003, 0.0007)),
>>>     'random-composed': kwimage.Projective.random(scale=(0.5, 1.5), translate=(-
↪20, 20), theta=(-theta, theta), shearx=(0, .4), rng=90055817621080860O),
>>> }
>>> warp_stack = []
>>> for key, mat in components.items():
...     warp = kwimage.warp_projective(image, mat)
...     warp = kwimage.draw_text_on_image(
...         warp,
...         ub.repr2(mat.matrix, nl=1, nobr=1, precision=4, si=1, sv=1, with_
↪dtype=0),
...         org=(1, 1),
...         valign='top', halign='left',
...         fontScale=0.8, color='kw_green',
...         border={'thickness': 3},
...         )
...     warp = kwimage.draw_header_text(warp, key, color='kw_blue')
...     warp_stack.append(warp)
>>> warp_canvas = kwimage.stack_images_grid(warp_stack, chunksize=4, pad=10, bg_
↪value='kitware_gray')
>>> # xdoctest: +REQUIRES(module:sympy)
>>> import sympy
>>> # Shows the symbolic construction of the code
>>> # https://groups.google.com/forum/#!topic/sympy/k1HnZK_bNNA
>>> from sympy.abc import theta
>>> params = x0, y0, sx, sy, theta, shearx, tx, ty, u, v = sympy.symbols(
>>>     'x0, y0, sx, sy, theta, ex, tx, ty, u, v')
>>> # move the center to 0, 0
>>> tr1_ = sympy.Matrix([[1, 0,  -x0],
>>>                      [0, 1,  -y0],
>>>                      [0, 0,    1]])
>>> P = sympy.Matrix([  # projective part
>>>     [ 1,  0,  0],
```

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```
>>>     [ 0,  1,  0],
>>>     [ u,  v,  1]])
>>> # Define core components of the affine transform
>>> S = sympy.Matrix([  # scale
>>>     [sx,  0, 0],
>>>     [ 0, sy, 0],
>>>     [ 0,  0, 1]])
>>> E = sympy.Matrix([  # x-shear
>>>     [1,  shearx, 0],
>>>     [0,  1, 0],
>>>     [0,  0, 1]])
>>> R = sympy.Matrix([  # rotation
>>>     [sympy.cos(theta), -sympy.sin(theta), 0],
>>>     [sympy.sin(theta),  sympy.cos(theta), 0],
>>>     [                0,                 0, 1]])
>>> T = sympy.Matrix([  # translation
>>>     [ 1,  0, tx],
>>>     [ 0,  1, ty],
>>>     [ 0,  0,  1]])
>>> # move 0, 0 back to the specified origin
>>> tr2_ = sympy.Matrix([[1, 0,  x0],
>>>                      [0, 1,  y0],
>>>                      [0, 0,   1]])
>>> # combine transformations
>>> homog_ = sympy.MatMul(tr2_, T, R, E, S, P, tr1_)
>>> #with sympy.evaluate(False):
>>> #    homog_ = sympy.MatMul(tr2_, T, R, E, S, P, tr1_)
>>> #    sympy.pprint(homog_)
>>> homog = homog_.doit()
>>> #sympy.pprint(homog)
>>> print('homog = {}'.format(ub.repr2(homog.tolist(), nl=1)))
>>> # This could be prettier
>>> texts = {
>>>     'Translation': sympy.pretty(R, use_unicode=0),
>>>     'Rotation': sympy.pretty(R, use_unicode=0),
>>>     'shEar-X': sympy.pretty(E, use_unicode=0),
>>>     'Scale': sympy.pretty(S, use_unicode=0),
>>>     'Perspective': sympy.pretty(P, use_unicode=0),
>>> }
>>> print(ub.repr2(texts, nl=2, sv=1))
>>> equation_stack = []
>>> for text, m in texts.items():
>>>     render_canvas = kwimage.draw_text_on_image(None, m, color='kw_green',␣
↪fontScale=1.0)
>>>     render_canvas = kwimage.draw_header_text(render_canvas, text, color='kw_blue
↪')
>>>     render_canvas = kwimage.imresize(render_canvas, scale=1.3)
>>>     equation_stack.append(render_canvas)
>>> equation_canvas = kwimage.stack_images(equation_stack, pad=10, axis=1, bg_value=
↪'kitware_gray')
>>> render_canvas = kwimage.draw_text_on_image(None, sympy.pretty(homog, use_
↪unicode=0), color='kw_green', fontScale=1.0)
```

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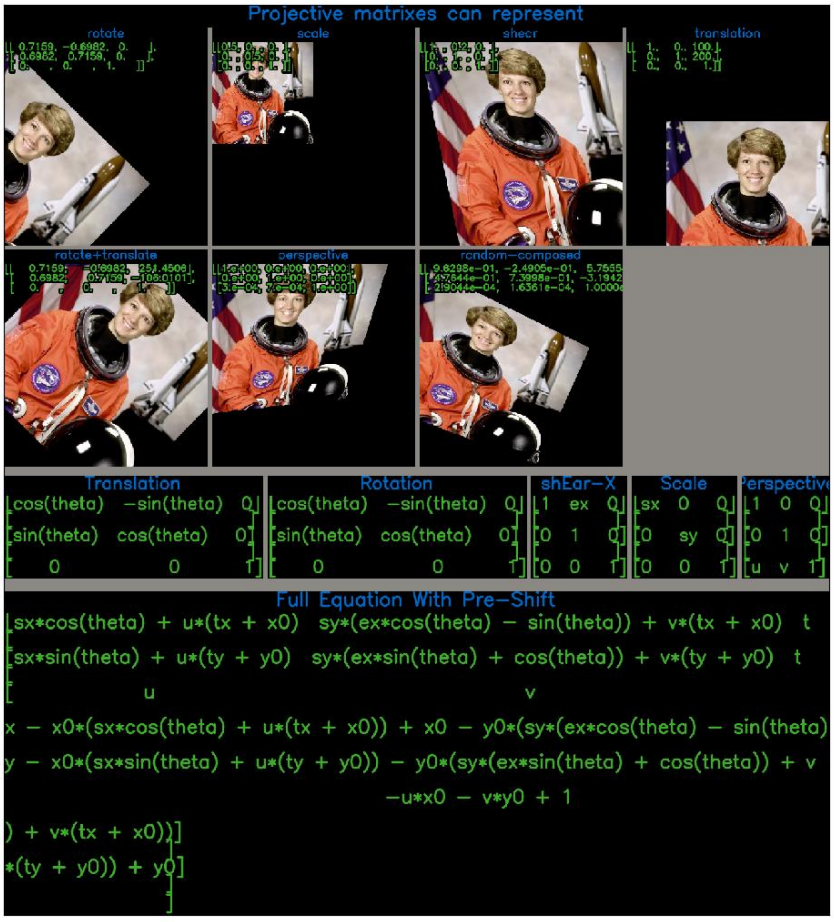
```
>>> render_canvas = kwimage.draw_header_text(render_canvas, 'Full Equation With Pre-
↪Shift', color='kw_blue')
>>> # xdoctest: -REQUIRES(module:sympy)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> plt = kwplot.autoplt()
>>> canvas = kwimage.stack_images([warp_canvas, equation_canvas, render_canvas],␣
↪pad=20, axis=0, bg_value='kitware_gray', resize='larger')
>>> canvas = kwimage.draw_header_text(canvas, 'Projective matrixes can represent',␣
↪color='kw_blue')
>>> kwplot.imshow(canvas)
>>> fig = plt.gcf()
>>> fig.set_size_inches(13, 13)
```



classmethod fit(*pts1*, *pts2*)

Fit an projective transformation between a set of corresponding points.

See [HomogEst] [SzeleskiBook] and [RansacDummies] for references on the subject.

Parameters

- **pts1** (*ndarray*) – An Nx2 array of points in “space 1”.
- **pts2** (*ndarray*) – A corresponding Nx2 array of points in “space 2”

Returns
a transform that warps from “space1” to “space2”.

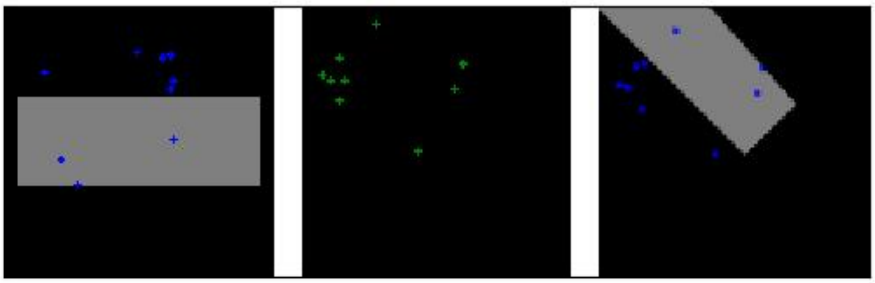
Return type
Projective

Note: A projective matrix has 8 degrees of freedome, so at least 8 point pairs are needed.

References

Example

```
>>> # Create a set of points, warp them, then recover the warp
>>> import kwimage
>>> points = kwimage.Points.random(9).scale(64)
>>> A1 = kwimage.Affine.affine(scale=0.9, theta=-3.2, offset=(2, 3), about=(32,
↪ 32), skew=2.3)
>>> A2 = kwimage.Affine.affine(scale=0.8, theta=0.8, offset=(2, 0), about=(32,␣
↪32))
>>> A12_real = A2 @ A1.inv()
>>> points1 = points.warp(A1)
>>> points2 = points.warp(A2)
>>> # Make the correspondence non-affine
>>> points2.data['xy'].data[0, 0] += 3.5
>>> points2.data['xy'].data[3, 1] += 8.5
>>> # Recover the warp
>>> pts1, pts2 = points1.xy, points2.xy
>>> A_recovered = kwimage.Projective.fit(pts1, pts2)
>>> #assert np.all(np.isclose(A_recovered.matrix, A12_real.matrix))
>>> # xdoctest: +REQUIRES(--show)
>>> import cv2
>>> import kwplot
>>> kwplot.autompl()
>>> base1 = np.zeros((96, 96, 3))
>>> base1[32:-32, 5:-5] = 0.5
>>> base2 = np.zeros((96, 96, 3))
>>> img1 = points1.draw_on(base1, radius=3, color='blue')
>>> img2 = points2.draw_on(base2, radius=3, color='green')
>>> img1_warp = kwimage.warp_projective(img1, A_recovered.matrix, dsize=img1.
↪shape[0:2][::-1])
>>> canvas = kwimage.stack_images([img1, img2, img1_warp], pad=10, axis=1, bg_
↪value=(1., 1., 1.))
>>> kwplot.imshow(canvas)
```



classmethod projective(*scale=None*, *offset=None*, *shearx=None*, *theta=None*, *uv=None*, *about=None*)

Reconstruct from parameters

Sympy

```
>>> # xdoctest: +SKIP
>>> import sympy
>>> # Shows the symbolic construction of the code
>>> # https://groups.google.com/forum/#!topic/sympy/k1HnZK_bNNA
>>> from sympy.abc import theta
>>> params = x0, y0, sx, sy, theta, shearx, tx, ty, u, v = sympy.symbols(
>>>     'x0, y0, sx, sy, theta, ex, tx, ty, u, v')
>>> # move the center to 0, 0
>>> tr1_ = sympy.Matrix([[1, 0,  -x0],
>>>                      [0, 1,  -y0],
>>>                      [0, 0,    1]])
>>> P = sympy.Matrix([  # projective part
>>>     [ 1,  0,  0],
>>>     [ 0,  1,  0],
>>>     [ u,  v,  1]])
>>> # Define core components of the affine transform
>>> S = sympy.Matrix([  # scale
>>>     [sx,  0, 0],
>>>     [ 0, sy, 0],
>>>     [ 0,  0, 1]])
```

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```
>>> E = sympy.Matrix([  # x-shear
>>>     [1,  shearx, 0],
>>>     [0,  1, 0],
>>>     [0,  0, 1]])
>>> R = sympy.Matrix([  # rotation
>>>     [sympy.cos(theta), -sympy.sin(theta), 0],
>>>     [sympy.sin(theta),  sympy.cos(theta), 0],
>>>     [               0,                 0, 1]])
>>> T = sympy.Matrix([  # translation
>>>     [ 1,  0, tx],
>>>     [ 0,  1, ty],
>>>     [ 0,  0,  1]])
>>> # move 0, 0 back to the specified origin
>>> tr2_ = sympy.Matrix([[1, 0,  x0],
>>>                      [0, 1,  y0],
>>>                      [0, 0,   1]])
>>> # combine transformations
>>> with sympy.evaluate(False):
>>>     homog_ = sympy.MatMul(tr2_, T, R, E, S, P, tr1_)
>>>     sympy.pprint(homog_)
>>> homog = homog_.doit()
>>> sympy.pprint(homog)
>>> print('homog = {}'.format(ub.repr2(homog.tolist(), nl=1)))
```

classmethod coerce(*data=None*, ***kwargs*)

Attempt to coerce the data into an Projective object

Parameters

- **data** – some data we attempt to coerce to an Projective matrix
- ****kwargs** – some data we attempt to coerce to an Projective matrix, mutually exclusive with *data*.

Returns

Projective

Example

```
>>> import kwimage
>>> kwimage.Projective.coerce({'type': 'affine', 'matrix': [[1, 0, 0], [0, 1,␣
↪0]]})
>>> kwimage.Projective.coerce({'type': 'affine', 'scale': 2})
>>> kwimage.Projective.coerce({'type': 'projective', 'scale': 2})
>>> kwimage.Projective.coerce({'scale': 2})
>>> kwimage.Projective.coerce({'offset': 3})
>>> kwimage.Projective.coerce(np.eye(3))
>>> kwimage.Projective.coerce(None)
>>> import skimage
>>> kwimage.Projective.coerce(skimage.transform.AffineTransform(scale=30))
>>> kwimage.Projective.coerce(skimage.transform.
↪ProjectiveTransform(matrix=None))
```

is_affine()

If the bottom row is [[0, 0, 1]], then this can be safely turned into an affine matrix.

Returns
bool

Example

```
>>> import kwimage
>>> kwimage.Projective.coerce(scale=2, uv=[1, 1]).is_affine()
False
>>> kwimage.Projective.coerce(scale=2, uv=[0, 0]).is_affine()
True
```

to_skimage()

Returns
skimage.transform.AffineTransform

Example

```
>>> import kwimage
>>> self = kwimage.Projective.random()
>>> tf = self.to_skimage()
>>> # Transform points with kwimage and scikit-image
>>> kw_poly = kwimage.Polygon.random()
>>> kw_warp_xy = kw_poly.warp(self.matrix).exterior.data
>>> sk_warp_xy = tf(kw_poly.exterior.data)
>>> assert np.allclose(sk_warp_xy, sk_warp_xy)
```

classmethod random(*shape=None*, *rng=None*, ***kw*)

Example/

```
>>> import kwimage
>>> self = kwimage.Projective.random()
>>> print(f'self={self}')
>>> params = self.decompose()
>>> aff_part = kwimage.Affine.affine(**ub.dict_diff(params, ['uv']))
>>> proj_part = kwimage.Projective.coerce(uv=params['uv'])
>>> # xdoctest: +REQUIRES(module:kwplot)
>>> # xdoctest: +REQUIRES(--show)
>>> import cv2
>>> import kwplot
>>> dsize = (256, 256)
>>> kwplot.autompl()
>>> img1 = kwimage.grab_test_image(dsize=dsize)
>>> img1_affonly = kwimage.warp_projective(img1, aff_part.matrix,␣
↪dsize=img1.shape[0:2][::-1])
>>> img1_projonly = kwimage.warp_projective(img1, proj_part.matrix,␣
↪dsize=img1.shape[0:2][::-1])
>>> ###
```

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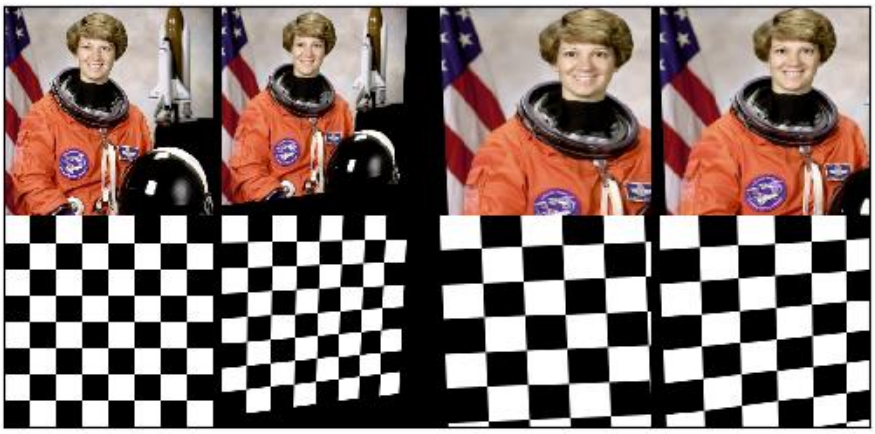
```
>>> img2 = kwimage.ensure_uint255(kwimage.atleast_3channels(kwimage.
↪checkerboard(dsize=dsize)))
>>> img1_fullwarp = kwimage.warp_projective(img1, self.matrix, dsize=img1.
↪shape[0:2][::-1])
>>> img2_affonly = kwimage.warp_projective(img2, aff_part.matrix,␣
↪dsize=img2.shape[0:2][::-1])
>>> img2_projonly = kwimage.warp_projective(img2, proj_part.matrix,␣
↪dsize=img2.shape[0:2][::-1])
>>> img2_fullwarp = kwimage.warp_projective(img2, self.matrix, dsize=img2.
↪shape[0:2][::-1])
>>> canvas1 = kwimage.stack_images([img1, img1_projonly, img1_affonly,␣
↪img1_fullwarp], pad=10, axis=1, bg_value=(0.5, 0.9, 0.1))
>>> canvas2 = kwimage.stack_images([img2, img2_projonly, img2_affonly,␣
↪img2_fullwarp], pad=10, axis=1, bg_value=(0.5, 0.9, 0.1))
>>> canvas = kwimage.stack_images([canvas1, canvas2], axis=0)
>>> kwplot.imshow(canvas)
```



decompose()

Based on the analysis done in [ME1319680].

Return type
Dict

References

Example

```
>>> # Create a set of points, warp them, then recover the warp
>>> import kwimage
>>> points = kwimage.Points.random(9).scale(64)
>>> A1 = kwimage.Affine.affine(scale=0.9, theta=-3.2, offset=(2, 3), about=(32,
↪ 32), skew=2.3)
>>> A2 = kwimage.Affine.affine(scale=0.8, theta=0.8, offset=(2, 0), about=(32,␣
↪32))
>>> A12_real = A2 @ A1.inv()
>>> points1 = points.warp(A1)
>>> points2 = points.warp(A2)
>>> # Make the correspondence non-affine
>>> points2.data['xy'].data[0, 0] += 3.5
>>> points2.data['xy'].data[3, 1] += 8.5
>>> # Recover the warp
>>> pts1, pts2 = points1.xy, points2.xy
>>> self = kwimage.Projective.random()
>>> self.decompose()
```

class kwimage.**Segmentation**(*data*, *format=None*)

Bases: _WrapperObject

Either holds a MultiPolygon, Polygon, or Mask

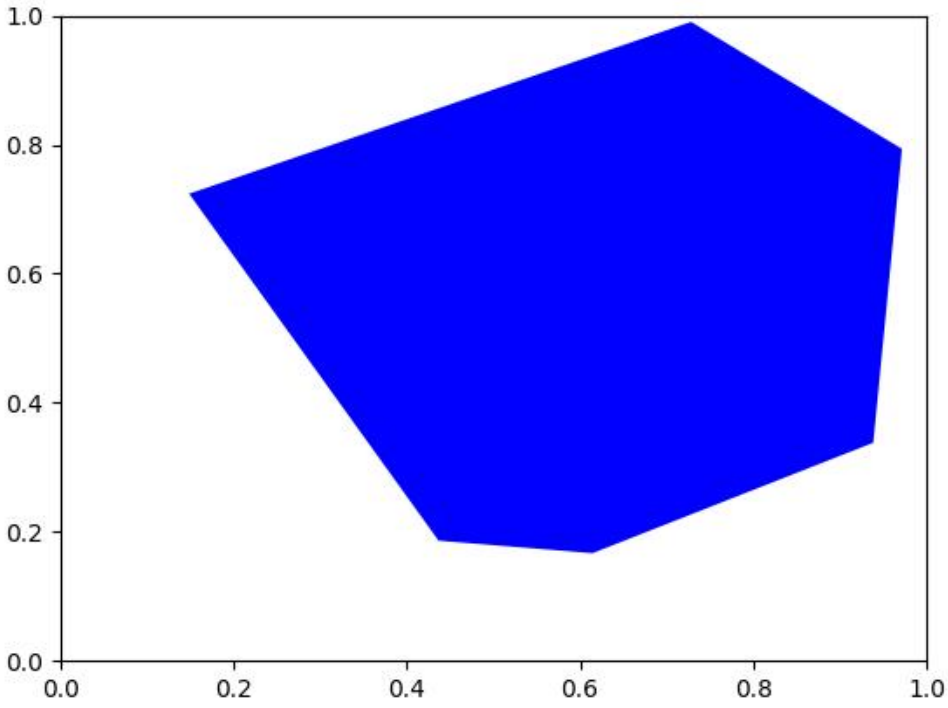
Parameters

- **data** (*object*) – the underlying object
- **format** (*str*) – either ‘mask’, ‘polygon’, or ‘multipolygon’

classmethod random(*rng=None*)

Example

```
>>> self = Segmentation.random()
>>> print('self = {!r}'.format(self))
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.figure(fnum=1, doclf=True)
>>> self.draw()
>>> kwplot.show_if_requested()
```



to_multi_polygon()

to_mask(*dims=None*, *pixels_are='points'*)

property meta

classmethod coerce(*data*, *dims=None*)

class kwimage.**SegmentationList**(*data*, *meta=None*)

Bases: ObjectList

Store and manipulate multiple segmentations (masks or polygons), usually within the same image

to_polygon_list()

Converts all mask objects to multi-polygon objects

to_mask_list(*dims=None*, *pixels_are='points'*)

Converts all mask objects to multi-polygon objects

to_segmentation_list()

classmethod coerce(*data*)

Interpret data as a list of Segmentations

class kwimage.**Transform**

Bases: NiceRepr

kwimage.**add_homog**(*pts*)

Add a homogenous coordinate to a point array

This is a convinience function, it is not particularly efficient.

SeeAlso:
cv2.convertPointsToHomogeneous

Example

```
>>> pts = np.random.rand(10, 2)
>>> add_homog(pts)
```

Benchmark

```
>>> import timerit
>>> ti = timerit.Timerit(1000, bestof=10, verbose=2)
>>> pts = np.random.rand(1000, 2)
>>> for timer in ti.reset('kwimage'):
>>>     with timer:
>>>         kwimage.add_homog(pts)
>>> for timer in ti.reset('cv2'):
>>>     with timer:
>>>         cv2.convertPointsToHomogeneous(pts)
>>> # cv2 is 4x faster, but has more restrictive inputs
```

kwimage.**atleast_3channels**(*arr*, *copy=True*)

Ensures that there are 3 channels in the image

Parameters

- **arr** (*ndarray*) – an image with 2 or 3 dims.
- **copy** (*bool*) – Always copies if True, if False, then copies only when the size of the array must change. Defaults to True.

Returns
with shape (N, M, C), where C in {3, 4}

Return type
ndarray

Doctest

```
>>> assert atleast_3channels(np.zeros((10, 10))).shape[-1] == 3
>>> assert atleast_3channels(np.zeros((10, 10, 1))).shape[-1] == 3
>>> assert atleast_3channels(np.zeros((10, 10, 3))).shape[-1] == 3
>>> assert atleast_3channels(np.zeros((10, 10, 4))).shape[-1] == 4
```

kwimage.**available_nms_impls**()

List available values for the *impl* kwarg of *non_max_supression*

CommandLine

```
xdoctest -m kwimage.algo.algo_nms available_nms_impls
```

Example

```
>>> impls = available_nms_impls()
>>> assert 'numpy' in impls
>>> print('impls = {!r}'.format(impls))
```

kwimage.**checkerboard**(*num_squares='auto'*, *square_shape='auto'*, *dsize=(512*, *512)*, *dtype=<class 'float'>*, *on_value=1*, *off_value=0*)

Creates a checkerboard image

Parameters

- **num_squares** (*int | str*) – Number of squares in a row. If 'auto' defaults to 8
- **square_shape** (*int | Tuple[int, int] | str*) – If 'auto', chosen based on *num_squares*. Otherwise this is the height, width of each square in pixels.
- **dsize** (*Tuple[int, int]*) – width and height
- **dtype** (*type*) – return data type
- **on_value** (*Number*) – The value of one checker. Defaults to 1.
- **off_value** (*Number*) – The value off the other checker. Defaults to 0.

References

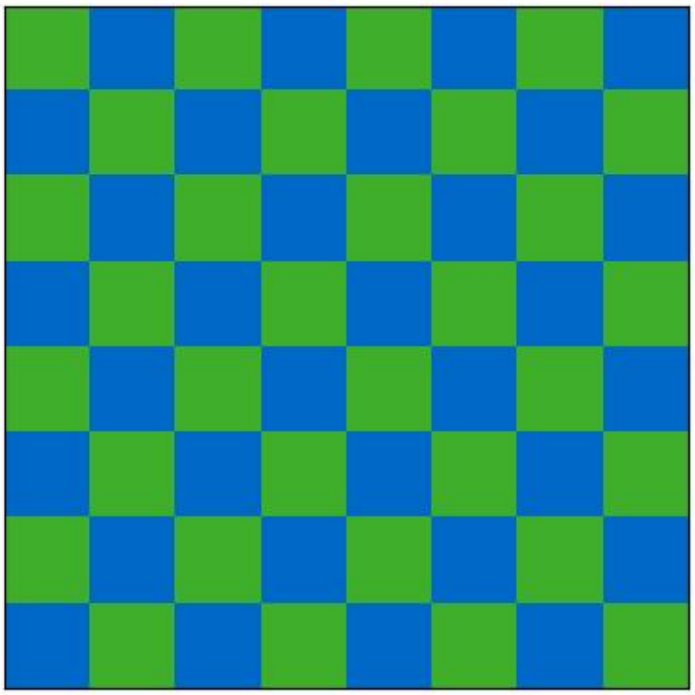
https://stackoverflow.com/questions/2169478/how-to-make-a-checkerboard-in-numpy

Example

```
>>> import kwimage
>>> import numpy as np
>>> img = kwimage.checkerboard()
>>> print(kwimage.checkerboard(dsize=(16, 16)).shape)
>>> print(kwimage.checkerboard(num_squares=4, dsize=(16, 16)).shape)
>>> print(kwimage.checkerboard(square_shape=3, dsize=(23, 17)).shape)
>>> print(kwimage.checkerboard(square_shape=3, dsize=(1451, 1163)).shape)
>>> print(kwimage.checkerboard(square_shape=3, dsize=(1202, 956)).shape)
>>> print(kwimage.checkerboard(dsize=(4, 4), on_value=(255, 0, 0), off_value=(0, 0,␣
↪1), dtype=np.uint8))
```

Example

```
>>> import kwimage
>>> img = kwimage.checkerboard(
>>>     dsize=(64, 64), on_value='kw_green', off_value='kw_blue')
>>> # xdoc: +REQUIRES(--show)
>>> # xdoc: +REQUIRES(module:kwplot)
>>> import kwplot
>>> kwplot.autoplt()
>>> kwplot.imshow(img)
>>> kwplot.show_if_requested()
```



kwimage.**connected_components**(*image*, *connectivity=8*, *ltype=<class 'numpy.int32'>*, *with_stats=True*, *algo='default'*)

Find connected components in a binary image.

Wrapper around `cv2.connectedComponentsWithStats()`.

Parameters

- **image** (*ndarray*) – a binary uint8 image. Zeros denote the background, and non-zeros numbers are foreground regions that will be partitioned into connected components.
- **connectivity** (*int*) – either 4 or 8
- **ltype** (*dtype | str | int*) – The dtype for the output label array. Can be either 'int32' or 'uint16', and this can be specified as a cv2 code or a numpy dtype.

- **algo** (*str*) – The underlying algorithm to use. See [Cv2CCAlgos] for details. Options are spaghetti, sauf, bbdt. (default is spaghetti)

Returns
The label array and an information dictionary

Return type
Tuple[ndarray, dict]

Todo: Document the details of which type of coordinates we are using. I.e. are pixels points or areas? (I think this uses the points convention?)

Note: opencv 4.5.5 will segfault if connectivity=4 See: [CvIssue21366].

Note: Based on information in [SO35854197].

References

CommandLine

```
xdoctest -m kwimage.im_cv2 connected_components:0 --show
```

Example

```
>>> import kwimage
>>> from kwimage.im_cv2 import *  # NOQA
>>> mask = kwimage.Mask.demo()
>>> image = mask.data
>>> labels, info = connected_components(image)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> canvas0 = kwimage.atleast_3channels(mask.data * 255)
>>> canvas2 = canvas0.copy()
>>> canvas3 = canvas0.copy()
>>> boxes = info['label_boxes']
>>> centroids = info['label_centroids']
>>> label_colors = kwimage.Color.distinct(info['num_labels'])
>>> index_to_color = np.array([kwimage.Color('black').as01()] + label_colors)
>>> canvas2 = centroids.draw_on(canvas2, color=label_colors, radius=None)
>>> boxes.draw_on(canvas3, color=label_colors, thickness=1)
>>> legend = kwplot.make_legend_img(ub.dzip(range(len(index_to_color)), index_to_
↪color))
>>> colored_label_img = index_to_color[labels]
>>> canvas1 = kwimage.stack_images([colored_label_img, legend], axis=1, resize=
↪'smaller')
>>> kwplot.imshow(canvas0, pnum=(1, 4, 1), title='input image')
```

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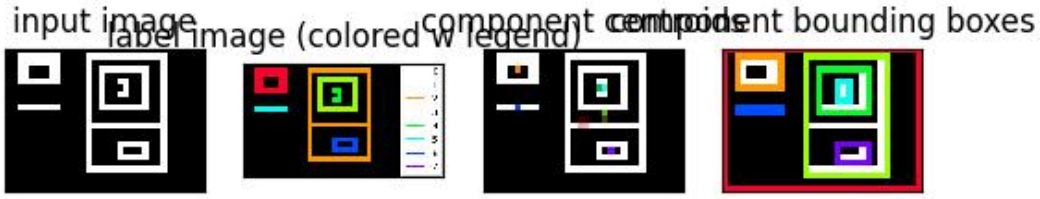
```
>>> kwplot.imshow(canvas1, pnum=(1, 4, 2), title='label image (colored w legend)')
>>> kwplot.imshow(canvas2, pnum=(1, 4, 3), title='component centroids')
>>> kwplot.imshow(canvas3, pnum=(1, 4, 4), title='component bounding boxes')
```



kwimage.**convert_colorspace**(*img*, *src_space*, *dst_space*, *copy=False*, *implicit=False*, *dst=None*)

Converts colorspace of img.

Convenience function around `cv2.cvtColor()`

Parameters

- **img** (*ndarray*) – image data with float32 or uint8 precision
- **src_space** (*str*) – input image colorspace. (e.g. BGR, GRAY)
- **dst_space** (*str*) – desired output colorspace. (e.g. RGB, HSV, LAB)
- **implicit** (*bool*) –

  if False, the user must correctly specify if the input/output colorspaces contain alpha channels.

  If True and the input image has an alpha channel, we modify src_space and dst_space to ensure they both end with "A".
- **dst** (*ndarray[Any, UInt8]*) – inplace-output array.

Returns

img - image data

Return type
ndarray

Note: Note the LAB and HSV colorspaces in float do not go into the 0-1 range.

For HSV the floating point range is:
0:360, 0:1, 0:1

For LAB the floating point range is:
0:100, -86.1875:98.234375, -107.859375:94.46875 (Note, that some extreme combinations of a and b are not valid)

Example

```
>>> import numpy as np
>>> convert_colorspace(np.array([[[0, 0, 1]]], dtype=np.float32), 'RGB', 'LAB')
>>> convert_colorspace(np.array([[[0, 1, 0]]], dtype=np.float32), 'RGB', 'LAB')
>>> convert_colorspace(np.array([[[1, 0, 0]]], dtype=np.float32), 'RGB', 'LAB')
>>> convert_colorspace(np.array([[[1, 1, 1]]], dtype=np.float32), 'RGB', 'LAB')
>>> convert_colorspace(np.array([[[0, 0, 1]]], dtype=np.float32), 'RGB', 'HSV')
```

kwimage.**daq_spatial_nms**(*ltrb*, *scores*, *diameter*, *thresh*, *max_depth=6*, *stop_size=2048*, *recsize=2048*, *impl='auto'*, *device_id=None*)

Divide and conquor speedup non-max-supression algorithm for when bboxes have a known max size

Parameters

- **ltrb** (*ndarray*) – boxes in (tlx, tly, brx, bry) format
- **scores** (*ndarray*) – scores of each box
- **diameter** (*int | Tuple[int, int]*) – Distance from split point to consider rectification. If specified as an integer, then number is used for both height and width. If specified as a tuple, then dims are assumed to be in [height, width] format.
- **thresh** (*float*) – iou threshold. Boxes are removed if they overlap greater than this threshold. 0 is the most strict, resulting in the fewest boxes, and 1 is the most permissive resulting in the most.
- **max_depth** (*int*) – maximum number of times we can divide and conquor
- **stop_size** (*int*) – number of boxes that triggers full NMS computation
- **recsize** (*int*) – number of boxes that triggers full NMS recombination
- **impl** (*str*) – algorithm to use

LookInfo:
Didn't read yet but it seems similar http://www.cyberneum.de/fileadmin/user_upload/files/publications/CVPR2010-Lampert_{[}0{]}.pdf

https://www.researchgate.net/publication/220929789_Efficient_Non-Maximum_Suppression

This seems very similar https://projet.liris.cnrs.fr/m2disco/pub/Congres/2006-ICPR/DATA/C03_0406.PDF

Example

```
>>> import kwimage
>>> # Make a bunch of boxes with the same width and height
>>> #boxes = kwimage.Boxes.random(230397, scale=1000, format='cxywh')
>>> boxes = kwimage.Boxes.random(237, scale=1000, format='cxywh')
>>> boxes.data.T[2] = 10
>>> boxes.data.T[3] = 10
>>> #
>>> ltrb = boxes.to_ltrb().data.astype(np.float32)
>>> scores = np.arange(0, len(ltrb)).astype(np.float32)
>>> #
>>> n_megabytes = (ltrb.size * ltrb.dtype.itemsize) / (2 ** 20)
>>> print('n_megabytes = {!r}'.format(n_megabytes))
>>> #
>>> thresh = iou_thresh = 0.01
>>> impl = 'auto'
>>> max_depth = 20
>>> diameter = 10
>>> stop_size = 2000
>>> recsize = 500
>>> #
>>> import ubelt as ub
>>> #
>>> with ub.Timer(label='daq'):
>>>     keep1 = daq_spatial_nms(ltrb, scores,
>>>         diameter=diameter, thresh=thresh, max_depth=max_depth,
>>>         stop_size=stop_size, recsize=recsize, impl=impl)
>>> #
>>> with ub.Timer(label='full'):
>>>     keep2 = non_max_supression(ltrb, scores,
>>>         thresh=thresh, impl=impl)
>>> #
>>> # Due to the greedy nature of the algorithm, there will be slight
>>> # differences in results, but they will be mostly similar.
>>> similarity = len(set(keep1) & set(keep2)) / len(set(keep1) | set(keep2))
>>> print('similarity = {!r}'.format(similarity))
```

kwimage.**decode_run_length**(*counts*, *shape*, *binary=False*, *dtype=<class 'numpy.uint8'>*, *order='C'*)

Decode run length encoding back into an image.

Parameters

- **counts** (*ndarray*) – the run-length encoding
- **shape** (*Tuple[int, int]*) – the height / width of the mask
- **binary** (*bool*) – if the RLE is binary or non-binary. Set to True for compatibility with COCO.
- **dtype** (*type*) – data type for decoded image. Defaults to np.uint8.
- **order** (*str*) – Order of the encoding. Either ‘C’ for row major or ‘F’ for column-major. Defaults to ‘C’.

Returns

the reconstructed image

Return type
ndarray

Example

```
>>> from kwimage.im_runlen import *  # NOQA
>>> img = np.array([[1, 0, 1, 1, 1, 0, 0, 1, 0]])
>>> encoded = encode_run_length(img, binary=True)
>>> recon = decode_run_length(**encoded)
>>> assert np.all(recon == img)
```

```
>>> import ubelt as ub
>>> lines = ub.codeblock(
>>>     '''
>>>     .........
>>>     ......111.
>>>     ..2...111.
>>>     .222..111.
>>>     22222.....
>>>     .222......
>>>     ..2.......
>>>     ''').replace('.', '0').splitlines()
>>> img = np.array([list(map(int, line)) for line in lines])
>>> encoded = encode_run_length(img)
>>> recon = decode_run_length(**encoded)
>>> assert np.all(recon == img)
```

kwimage.**draw_boxes_on_image**(*img*, *boxes*, *color='blue'*, *thickness=1*, *box_format=None*, *colorspace='rgb'*)

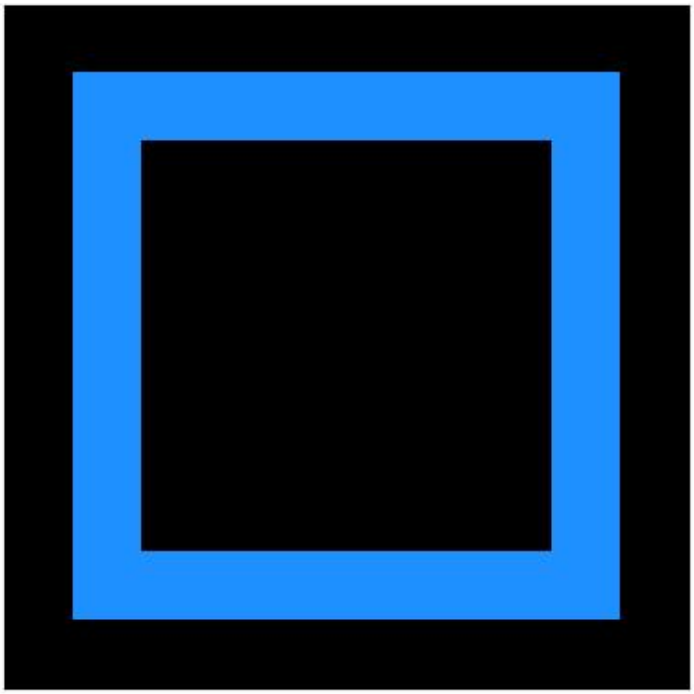
Draws boxes on an image.

Parameters

- **img** (*ndarray*) – image to copy and draw on
- **boxes** (*kwimage.Boxes | ndarray*) – boxes to draw
- **colorspace** (*str*) – string code of the input image colorspace

Example

```
>>> import kwimage
>>> import numpy as np
>>> img = np.zeros((10, 10, 3), dtype=np.uint8)
>>> color = 'dodgerblue'
>>> thickness = 1
>>> boxes = kwimage.Boxes([[1, 1, 8, 8]], 'ltrb')
>>> img2 = draw_boxes_on_image(img, boxes, color, thickness)
>>> assert tuple(img2[1, 1]) == (30, 144, 255)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()  # xdoc: +SKIP
>>> kwplot.figure(doclf=True, fnum=1)
>>> kwplot.imshow(img2)
```



kwimage.**draw_clf_on_image**(*im*, *classes*, *tcx=None*, *probs=None*, *pcx=None*, *border=1*)

Draws classification label on an image.

Works best with image chips sized between 200x200 and 500x500

Parameters

- **im** (*ndarray*) – the image
- **classes** (*Sequence[str] | kwcoco.CategoryTree*) – list of class names
- **tcx** (*int*) – true class index if known
- **probs** (*ndarray*) – predicted class probs for each class
- **pcx** (*int*) – predicted class index. (if None but probs is specified uses argmax of probs)

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> import torch
>>> import kwarray
>>> import kwimage
>>> rng = kwarray.ensure_rng(0)
>>> im = (rng.rand(300, 300) * 255).astype(np.uint8)
>>> classes = ['cls_a', 'cls_b', 'cls_c']
>>> tcx = 1
```

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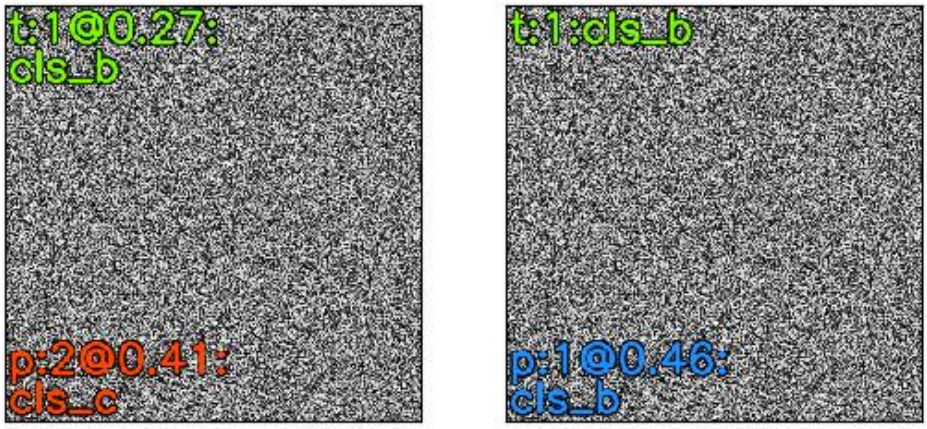
```
>>> probs = rng.rand(len(classes))
>>> probs[tcx] = 0
>>> probs = torch.FloatTensor(probs).softmax(dim=0).numpy()
>>> im1_ = kwimage.draw_clf_on_image(im, classes, tcx, probs)
>>> probs[tcx] = .9
>>> probs = torch.FloatTensor(probs).softmax(dim=0).numpy()
>>> im2_ = kwimage.draw_clf_on_image(im, classes, tcx, probs)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(im1_, colorspace='rgb', pnum=(1, 2, 1), fnum=1, doclf=True)
>>> kwplot.imshow(im2_, colorspace='rgb', pnum=(1, 2, 2), fnum=1)
>>> kwplot.show_if_requested()
```



kwimage.**draw_header_text**(*image*, *text*, *fit=False*, *color='strawberry'*, *halign='center'*, *stack='auto'*, *bg_color='black'*)

Places a black bar on top of an image and writes text in it

Parameters

- **image** (*ndarray | dict | None*) – numpy image or dictionary containing a key width
- **text** (*str*) – text to draw
- **fit** (*bool | str*) – If False, will draw as much text within the given width as possible. If True, will draw all text and then resize to fit in the given width If “shrink”, will only resize

the text if it is too big to fit, in other words this is like fit=True, but it wont enlarge the text.

- **color** (*str | Tuple*) – a color coercable to *kwimage.Color*.
- **halign** (*str*) – Horizontal alignment. Can be left, center, or right.
- **stack** (*bool | str*) – if True returns the stacked image, otherwise just returns the header. If 'auto', will only stack if an image is given as an ndarray.

Returns

ndarray

Example

```
>>> from kwimage.im_draw import *  # NOQA
>>> import kwimage
>>> image = kwimage.grab_test_image()
>>> tiny_image = kwimage.imresize(image, dsize=(64, 64))
>>> canvases = []
>>> canvases += [draw_header_text(image=image, text='unfit long header ' * 5,␣
↪fit=False)]
>>> canvases += [draw_header_text(image=image, text='shrunk long header ' * 5, fit=
↪'shrink')]
>>> canvases += [draw_header_text(image=image, text='left header', fit=False,␣
↪halign='left')]
>>> canvases += [draw_header_text(image=image, text='center header', fit=False,␣
↪halign='center')]
>>> canvases += [draw_header_text(image=image, text='right header', fit=False,␣
↪halign='right')]
>>> canvases += [draw_header_text(image=image, text='shrunk header', fit='shrink',␣
↪halign='left')]
>>> canvases += [draw_header_text(image=tiny_image, text='shrunk header-center',␣
↪fit='shrink', halign='center')]
>>> canvases += [draw_header_text(image=image, text='fit header', fit=True, halign=
↪'left')]
>>> canvases += [draw_header_text(image={'width': 200}, text='header only',␣
↪fit=True, halign='left')]
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> pnum_ = kwplot.PlotNums(nCols=3, nSubplots=len(canvases))
>>> for c in canvases:
>>>     kwplot.imshow(c, pnum=pnum_())
>>> kwplot.show_if_requested()
```

kwimage.**draw_line_segments_on_image**(*img*, *pts1*, *pts2*, *color='blue'*, *colorspace='rgb'*, *thickness=1*, ***kwargs*)

Draw line segments between pts1 and pts2 on an image.

Parameters

- **pts1** (*ndarray*) – xy coordinates of starting points
- **pts2** (*ndarray*) – corresponding xy coordinates of ending points
- **color** (*str | List*) – color code or a list of colors for each line segment
- **colorspace** (*str*) – colorspace of image. Defaults to 'rgb'
- **thickness** (*int*) – Defaults to 1
- **lineType** (*int*) – option for cv2.line

Returns

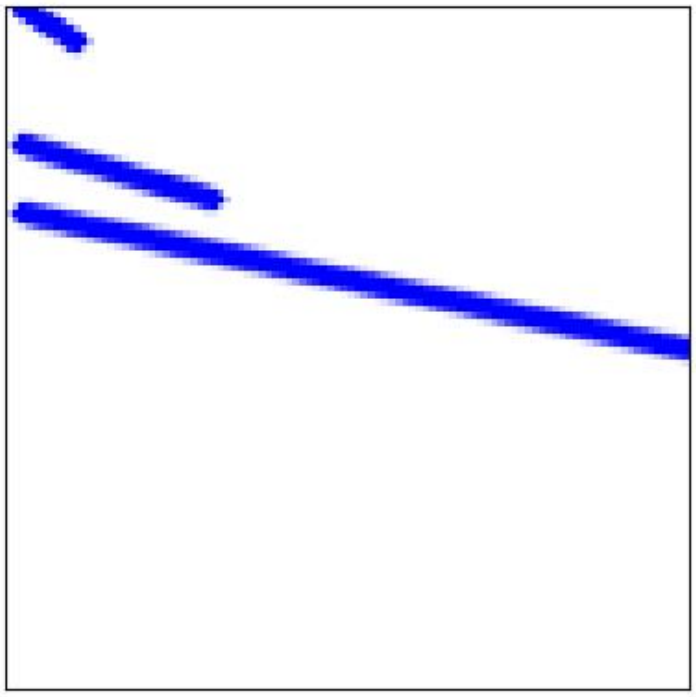
the modified image (inplace if possible)

Return type

ndarray

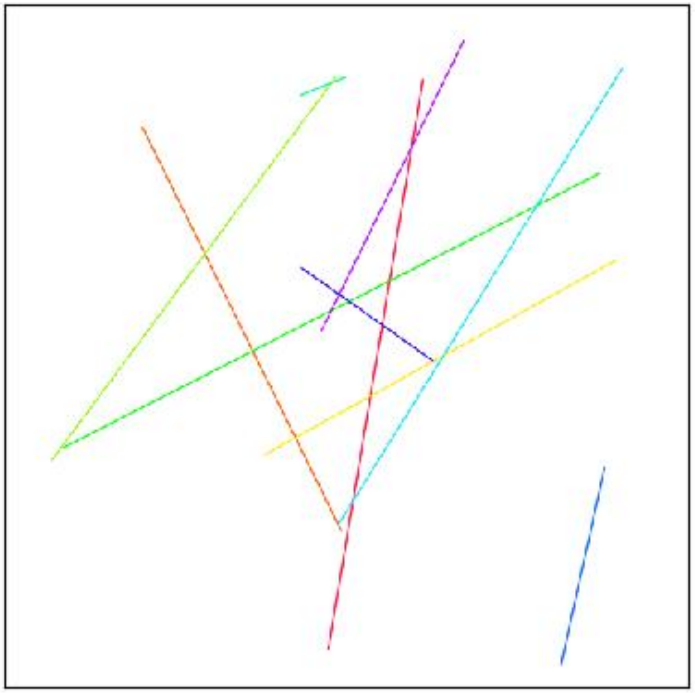
Example

```
>>> from kwimage.im_draw import *  # NOQA
>>> pts1 = np.array([[2, 0], [2, 20], [2.5, 30]])
>>> pts2 = np.array([[10, 5], [30, 28], [100, 50]])
>>> img = np.ones((100, 100, 3), dtype=np.uint8) * 255
>>> color = 'blue'
>>> colorspace = 'rgb'
>>> img2 = draw_line_segments_on_image(img, pts1, pts2, thickness=2)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()  # xdoc: +SKIP
>>> kwplot.figure(doclf=True, fnum=1)
>>> kwplot.imshow(img2)
```



Example

```
>>> import kwimage
>>> # xdoc: +REQUIRES(module:matplotlib)
>>> pts1 = kwimage.Points.random(10).scale(512).xy
>>> pts2 = kwimage.Points.random(10).scale(512).xy
>>> img = np.ones((512, 512, 3), dtype=np.uint8) * 255
>>> color = kwimage.Color.distinct(10)
>>> img2 = kwimage.draw_line_segments_on_image(img, pts1, pts2, color=color)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()  # xdoc: +SKIP
>>> kwplot.figure(doclf=True, fnum=1)
>>> kwplot.imshow(img2)
```



kwimage.**draw_text_on_image**(*img*, *text*, *org=None*, *return_info=False*, ***kwargs*)

Draws multiline text on an image using opencv

Parameters

- **img** (*ndarray | None | dict*) – Generally a numpy image to draw on (inplace). Otherwise a canvas will be constructed such that the text will fit. The user may specify a dictionary with keys width and height to have more control over the constructed canvas.
- **text** (*str*) – text to draw
- **org** (*Tuple[int, int]*) – The x, y location of the text string "anchor" in the image as specified

by halign and valign. For instance, If valign='bottom', halign='left', this where the bottom left corner of the text will be placed.

- **return_info** (*bool*) – if True, also returns information about the positions the text was drawn on.
- ****kwargs** – color (tuple): default blue

  thickness (int): defaults to 2

  fontFace (int): defaults to cv2.FONT_HERSHEY_SIMPLEX

  fontScale (float): defaults to 1.0

  valign (str): either top, center, or bottom. Defaults to "bottom" NOTE: this default may change to "top" in the future.

  halign (str): either left, center, or right. Defaults to "left".

  border (dict | int): If specified as an integer, draws a black border with that given thickness. If specified as a dictionary, draws a border with color specified parameters. "color": border color, defaults to "black". "thickness": border thickness, defaults to 1.

Returns
the image that was drawn on

Return type
ndarray

Note: The image is modified inplace. If the image is non-contiguous then this returns a UMat instead of a ndarray, so be carefull with that.

Related:
The logic in this function is related to the following stack overflow posts [SO27647424] [SO51285616]

References

Example

```
>>> import kwimage
>>> img = kwimage.grab_test_image(space='rgb')
>>> img2 = kwimage.draw_text_on_image(img.copy(), 'FOOBAR', org=(0, 0), valign='top
↪')
>>> assert img2.shape == img.shape
>>> assert np.any(img2 != img)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(img2)
>>> kwplot.show_if_requested()
```

Example

```
>>> import kwimage
>>> # Test valign
>>> img = kwimage.grab_test_image(space='rgb', dsize=(500, 500))
>>> img2 = kwimage.draw_text_on_image(img, 'FOOBAR\nbazbiz\nspam', org=(0, 0),␣
↪valign='top', border=2)
>>> img2 = kwimage.draw_text_on_image(img, 'FOOBAR\nbazbiz\nspam', org=(150, 0),␣
↪valign='center', border=2)
>>> img2 = kwimage.draw_text_on_image(img, 'FOOBAR\nbazbiz\nspam', org=(300, 0),␣
↪valign='bottom', border=2)
>>> # Test halign
>>> img2 = kwimage.draw_text_on_image(img, 'FOOBAR\nbazbiz\nspam', org=(250, 100),␣
↪halign='right', border=2)
>>> img2 = kwimage.draw_text_on_image(img, 'FOOBAR\nbazbiz\nspam', org=(250, 250),␣
↪halign='center', border=2)
>>> img2 = kwimage.draw_text_on_image(img, 'FOOBAR\nbazbiz\nspam', org=(250, 400),␣
↪halign='left', border=2)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(img2)
>>> kwplot.show_if_requested()
```

Example

```
>>> # Ensure the function works with float01 or uint255 images
>>> import kwimage
>>> img = kwimage.grab_test_image(space='rgb')
>>> img = kwimage.ensure_float01(img)
>>> img2 = kwimage.draw_text_on_image(img, 'FOOBAR\nbazbiz\nspam', org=(0, 0),␣
↪valign='top', border=2)
```

Example

```
>>> # Test dictionary border
>>> import kwimage
>>> img = kwimage.draw_text_on_image(None, 'Battery\nFraction', org=(100, 100),␣
↪valign='top', halign='center', border={'color': 'green', 'thickness': 9})
>>> #img = kwimage.draw_text_on_image(None, 'hello\neveryone', org=(0, 0), valign='top
↪')
>>> #img = kwimage.draw_text_on_image(None, 'hello', org=(0, 60), valign='top', halign=
↪'center', border=0)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
```

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```
>>> kwplot.imshow(img)
>>> kwplot.show_if_requested()
```

Example

```
>>> # Test dictionary image
>>> import kwimage
>>> img = kwimage.draw_text_on_image({'width': 300}, 'Unscrew\nGetting', org=(150,␣
↪0), valign='top', halign='center', border={'color': 'green', 'thickness': 0})
>>> print('img.shape = {!r}'.format(img.shape))
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(img)
>>> kwplot.show_if_requested()
```

Example

```
>>> import ubelt as ub
>>> import kwimage
>>> grid = list(ub.named_product({
>>>     'halign': ['left', 'center', 'right', None],
>>>     'valign': ['top', 'center', 'bottom', None],
>>>     'border': [0, 3]
>>> }))
>>> canvases = []
>>> text = 'small-line\na-much-much-much-bigger-line\nanother-small\n.'
>>> for kw in grid:
>>>     header = kwimage.draw_text_on_image({}, ub.repr2(kw, compact=1), color='blue
↪')
>>>     canvas = kwimage.draw_text_on_image({'color': 'white'}, text, org=None,␣
↪**kw)
>>>     canvases.append(kwimage.stack_images([header, canvas], axis=0, bg_
↪value=(255, 255, 255), pad=5))
>>> # xdoc: +REQUIRES(--show)
>>> canvas = kwimage.stack_images_grid(canvases, pad=10, bg_value=(255, 255, 255))
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(canvas)
>>> kwplot.show_if_requested()
```

kwimage.**draw_vector_field**(*image*, *dx*, *dy*, *stride=0.02*, *thresh=0.0*, *scale=1.0*, *alpha=1.0*, *color='strawberry'*, *thickness=1*, *tipLength=0.1*, *line_type='aa'*)

Create an image representing a 2D vector field.

Parameters

- **image** (*ndarray*) – image to draw on
- **dx** (*ndarray*) – grid of vector x components
- **dy** (*ndarray*) – grid of vector y components
- **stride** (*int | float*) – sparsity of vectors, int specifies stride step in pixels, a float specifies it as a percentage.
- **thresh** (*float*) – only plot vectors with magnitude greater than thres
- **scale** (*float*) – multiply magnitude for easier visualization
- **alpha** (*float*) – alpha value for vectors. Non-vector regions receive 0 alpha (if False, no alpha channel is used)
- **color** (*str | tuple | kwimage.Color*) – RGB color of the vectors
- **thickness** (*int*) – thickness of arrows
- **tipLength** (*float*) – fraction of line length
- **line_type** (*int | str*) – either cv2.LINE_4, cv2.LINE_8, or cv2.LINE_AA or 'aa'

Returns

The image with vectors overlaid. If image=None, then an rgb/a image is created and returned.

Return type
ndarray[Any, Float32]

Example

```
>>> from kwimage.im_draw import *  # NOQA
>>> import kwimage
>>> width, height = 512, 512
>>> image = kwimage.grab_test_image(dsize=(width, height))
>>> x, y = np.meshgrid(np.arange(height), np.arange(width))
>>> dx, dy = x - width / 2, y - height / 2
>>> radians = np.arctan2(dx, dy)
>>> mag = np.sqrt(dx ** 2 + dy ** 2) + 1e-3
>>> dx, dy = dx / mag, dy / mag
>>> img = kwimage.draw_vector_field(image, dx, dy, scale=10, alpha=False)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(img, title='draw_vector_field')
>>> kwplot.show_if_requested()
```

kwimage.**encode_run_length**(*img*, *binary=False*, *order='C'*)

Construct the run length encoding (RLE) of an image.

Parameters

- **img** (*ndarray*) – 2D image
- **binary** (*bool*) – If true, assume that the input image only contains 0's and 1's. Set to True for compatibility with COCO (which does not support multi-value RLE encodings).
- **order** (*str*) – Order of the encoding. Either 'C' for row major or 'F' for column-major. Defaults to 'C'.

Returns

encoding: dictionary items are:

counts (ndarray): the run length encoding

shape (Tuple): the original image shape.
This should be in standard shape row-major (e.g. h/w) order

binary (bool):
if True, the counts are assumed to encode only 0's and 1's, otherwise the counts encoding specifies any numeric values.

order (str):
Encoding order, either 'C' for row major or 'F' for column-major. Defaults to 'C'.

Return type
Dict[str, object]

SeeAlso:

kwimage.Mask **-**
cython-backed data structure to handle coco-style RLEs

Example

```
>>> import ubelt as ub
>>> lines = ub.codeblock(
>>>     '''
>>>     ..........
>>>     ......111.
>>>     ..2...111.
>>>     .222..111.
>>>     22222.....
>>>     .222......
>>>     ..2.......
>>>     ''').replace('.', '0').splitlines()
>>> img = np.array([list(map(int, line)) for line in lines])
>>> encoding = encode_run_length(img)
>>> target = np.array([0,16,1,3,0,3,2,1,0,3,1,3,0,2,2,3,0,2,1,3,0,1,2,5,0,6,2,3,0,8,
↪2,1,0,7])
>>> assert np.all(target == encoding['counts'])
```

Example

```
>>> binary = True
>>> img = np.array([[1, 0, 1, 1, 1, 0, 0, 1, 0]])
>>> encoding = encode_run_length(img, binary=True)
>>> assert encoding['counts'].tolist() == [0, 1, 1, 3, 2, 1, 1]
```

Example

```
>>> # Test empty case
>>> from kwimage.im_runlen import *  # NOQA
>>> binary = True
>>> img = np.zeros((0, 0), dtype=np.uint8)
>>> encoding = encode_run_length(img, binary=True)
>>> assert encoding['counts'].tolist() == []
>>> recon = decode_run_length(**encoding)
>>> assert np.all(recon == img)
```

Example

```
>>> # Test small full cases
>>> for d in [0, 1, 2, 3]:
>>>     img = np.zeros((d, d), dtype=np.uint8)
>>>     encoding = encode_run_length(img, binary=True)
>>>     recon = decode_run_length(**encoding)
>>>     assert np.all(recon == img)
>>>     img = np.ones((d, d), dtype=np.uint8)
>>>     encoding = encode_run_length(img, binary=True)
>>>     recon = decode_run_length(**encoding)
>>>     assert np.all(recon == img)
```

kwimage.**ensure_alpha_channel**(*img*, *alpha=1.0*, *dtype=<class 'numpy.float32'>*, *copy=False*)

Returns the input image with 4 channels.

Parameters

- **img** (*ndarray*) – an image with shape [H, W], [H, W, 1], [H, W, 3], or [H, W, 4].
- **alpha** (*float | ndarray*) – default scalar value for missing alpha channel, or an ndarray with the same height / width to use explicitly.
- **dtype** (*type*) – The final output dtype. Should be numpy.float32 or numpy.float64.
- **copy** (*bool*) – always copy if True, else copy if needed.

Returns

an image with specified dtype with shape [H, W, 4].

Return type

ndarray

Raises

ValueError - if the input image does not have 1, 3, or 4 input channels – or if the image cannot be converted into a float01 representation

Example

```
>>> # Demo with a scalar default alpha value
>>> import kwimage
>>> data0 = np.zeros((5, 5))
>>> data1 = np.zeros((5, 5, 1))
>>> data2 = np.zeros((5, 5, 3))
>>> data3 = np.zeros((5, 5, 4))
>>> ensured0 = kwimage.ensure_alpha_channel(data0, alpha=0.5)
>>> ensured1 = kwimage.ensure_alpha_channel(data1, alpha=0.5)
>>> ensured2 = kwimage.ensure_alpha_channel(data2, alpha=0.5)
>>> ensured3 = kwimage.ensure_alpha_channel(data3, alpha=0.5)
>>> assert np.all(ensured0[..., 3] == 0.5), 'should have been populated'
>>> assert np.all(ensured1[..., 3] == 0.5), 'should have been populated'
>>> assert np.all(ensured2[..., 3] == 0.5), 'should have been populated'
>>> assert np.all(ensured3[..., 3] == 0.0), 'last image already had alpha'
```

Example

```
>>> import kwimage
>>> # Demo with a explicit alpha channel
>>> alpha = np.random.rand(5, 5)
>>> data0 = np.zeros((5, 5))
>>> data1 = np.zeros((5, 5, 1))
>>> data2 = np.zeros((5, 5, 3))
>>> data3 = np.zeros((5, 5, 4))
>>> ensured0 = kwimage.ensure_alpha_channel(data0, alpha=alpha)
>>> ensured1 = kwimage.ensure_alpha_channel(data1, alpha=alpha)
>>> ensured2 = kwimage.ensure_alpha_channel(data2, alpha=alpha)
>>> ensured3 = kwimage.ensure_alpha_channel(data3, alpha=alpha)
>>> assert np.all(ensured0[..., 3] == alpha), 'should have been populated'
>>> assert np.all(ensured1[..., 3] == alpha), 'should have been populated'
>>> assert np.all(ensured2[..., 3] == alpha), 'should have been populated'
>>> assert np.all(ensured3[..., 3] == 0.0), 'last image already had alpha'
```

kwimage.**ensure_float01**(*img*, *dtype=<class 'numpy.float32'>*, *copy=True*)

Ensure that an image is encoded using a float32 properly

Parameters

- **img** (*ndarray*) – an image in uint255 or float01 format. Other formats will raise errors.
- **dtype** (*type*) – a numpy floating type defaults to np.float32
- **copy** (*bool*) – Always copy if True, else copy if needed. Defaults to True.

Returns

an array of floats in the range 0-1

Return type

ndarray

Raises

ValueError – if the image type is integer and not in [0-255]

Example

```
>>> ensure_float01(np.array([[0, .5, 1.0]]))
array([[0. , 0.5, 1. ]], dtype=float32)
>>> ensure_float01(np.array([[0, 1, 200]]))
array([[0..., 0.0039..., 0.784...]], dtype=float32)
```

kwimage.**ensure_uint255**(*img*, *copy=True*)

Ensure that an image is encoded using a uint8 properly. Either

Parameters

- **img** (*ndarray*) – an image in uint255 or float01 format. Other formats will raise errors.
- **copy** (*bool*) – always copy if True, else copy if needed. Defaults to True.

Returns
an array of bytes in the range 0-255

Return type
ndarray

Raises

- **ValueError** – if the image type is float and not in [0-1]
- **ValueError** – if the image type is integer and not in [0-255]

Example

```
>>> ensure_uint255(np.array([[0, .5, 1.0]]))
array([[  0, 127, 255]], dtype=uint8)
>>> ensure_uint255(np.array([[0, 1, 200]]))
array([[  0,   1, 200]], dtype=uint8)
```

kwimage.**fill_nans_with_checkers**(*canvas*, *square_shape=8*)

Fills nan values with a 2d checkerboard pattern.

Parameters
canvas (*np.ndarray*) – data replace nans in

Returns
the inplace modified canvas

Return type
np.ndarray

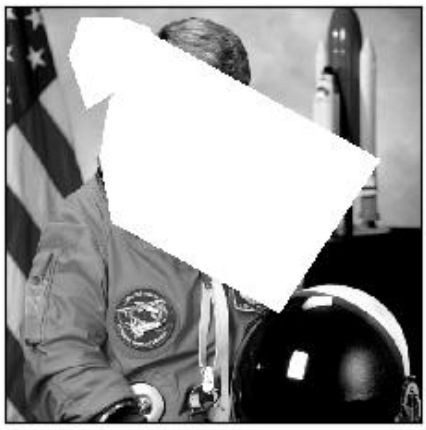
SeeAlso:
nodata_checkerboard() - similar, but operates on nans or masked arrays.

Example

```
>>> from kwimage.im_draw import *  # NOQA
>>> import kwimage
>>> orig_img = kwimage.ensure_float01(kwimage.grab_test_image())
>>> poly1 = kwimage.Polygon.random(rng=1).scale(orig_img.shape[0] // 2)
>>> poly2 = kwimage.Polygon.random(rng=3).scale(orig_img.shape[0])
>>> poly3 = kwimage.Polygon.random(rng=4).scale(orig_img.shape[0] // 2)
>>> poly3 = poly3.translate((0, 200))
>>> img = orig_img.copy()
>>> img = poly1.fill(img, np.nan)
>>> img = poly3.fill(img, 0)
>>> img[:, :, 0] = poly2.fill(np.ascontiguousarray(img[:, :, 0]), np.nan)
>>> input_img = img.copy()
>>> canvas = fill_nans_with_checkers(input_img)
>>> assert input_img is canvas
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(img, pnum=(1, 2, 1), title='matplotlib treats nans as zeros')
>>> kwplot.imshow(canvas, pnum=(1, 2, 2), title='checkers highlight real nans')
```

Example

```
>>> # Test grayscale
>>> from kwimage.im_draw import *  # NOQA
>>> import kwimage
>>> orig_img = kwimage.ensure_float01(kwimage.grab_test_image())
>>> poly1 = kwimage.Polygon.random().scale(orig_img.shape[0] // 2)
>>> poly2 = kwimage.Polygon.random().scale(orig_img.shape[0])
>>> img = orig_img.copy()
>>> img = poly1.fill(img, np.nan)
>>> img[:, :, 0] = poly2.fill(np.ascontiguousarray(img[:, :, 0]), np.nan)
>>> img = kwimage.convert_colorspace(img, 'rgb', 'gray')
>>> canvas = img.copy()
>>> canvas = fill_nans_with_checkers(canvas)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(img, pnum=(1, 2, 1))
>>> kwplot.imshow(canvas, pnum=(1, 2, 2))
```



kwimage.**find_robust_normalizers**(*data*, *params='auto'*)

Finds robust normalization statistics for a single observation

Parameters

- **data** (*ndarray*) – a 1D numpy array where invalid data has already been removed

- **params** (*str | dict*) – normalization params

Returns
normalization parameters

Return type
Dict[str, str | float]

Todo:

- [ ] No Magic Numbers! Use first principles to deterimine defaults.
- [ ] Probably a lot of literature on the subject.
- [ ] Is this a kwarray function in general?

Example

```
>>> from kwimage.im_core import *  # NOQA
>>> data = np.random.rand(100)
>>> norm_params1 = find_robust_normalizers(data, params='auto')
>>> norm_params2 = find_robust_normalizers(data, params={'low': 0, 'high': 1.0})
>>> norm_params3 = find_robust_normalizers(np.empty(0), params='auto')
>>> print('norm_params1 = {}'.format(ub.repr2(norm_params1, nl=1)))
>>> print('norm_params2 = {}'.format(ub.repr2(norm_params2, nl=1)))
>>> print('norm_params3 = {}'.format(ub.repr2(norm_params3, nl=1)))
```

kwimage.**fourier_mask**(*img_hwc*, *mask*, *axis=None*, *clip=None*)

Applies a mask to the fourier spectrum of an image

Parameters

- **img_hwc** (*ndarray*) – assumed to be float 01
- **mask** (*ndarray*) – mask used to modulate the image in the fourier domain. Usually these are boolean values (hence the name mask), but any numerical value is technically allowed.

CommandLine

```
xdoctest -m kwimage.im_filter fourier_mask --show
```

Example

```
>>> from kwimage.im_filter import *  # NOQA
>>> import kwimage
>>> img_hwc = kwimage.grab_test_image(space='gray')
>>> mask = np.random.rand(*img_hwc.shape[0:2])
>>> out_hwc = fourier_mask(img_hwc, mask)
>>> # xdoc: REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(img_hwc, pnum=(1, 2, 1), fnum=1)
```

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```
>>> kwplot.imshow(out_hwc, pnum=(1, 2, 2), fnum=1)
>>> kwplot.show_if_requested()
```

kwimage.**gaussian_blur**(*image*, *kernel=None*, *sigma=None*, *border_mode=None*, *dst=None*)

Apply a gausian blur to an image.

This is a simple wrapper around `cv2.GaussianBlur()` with concise parametarization and sane defaults.

Parameters

- **image** (*ndarray*) – the input image
- **kernel** (*int | Tuple[int, int]*) – The kernel size in x and y directions.
- **sigma** (*float | Tuple[float, float]*) – The gaussian spread in x and y directions.
- **border_mode** (*str | int | None*) – Border text code or cv2 integer. Border codes are 'constant' (default), 'replicate', 'reflect', 'reflect101', and 'transparent'.
- **dst** (*ndarray | None*) – optional inplace-output array.

Returns

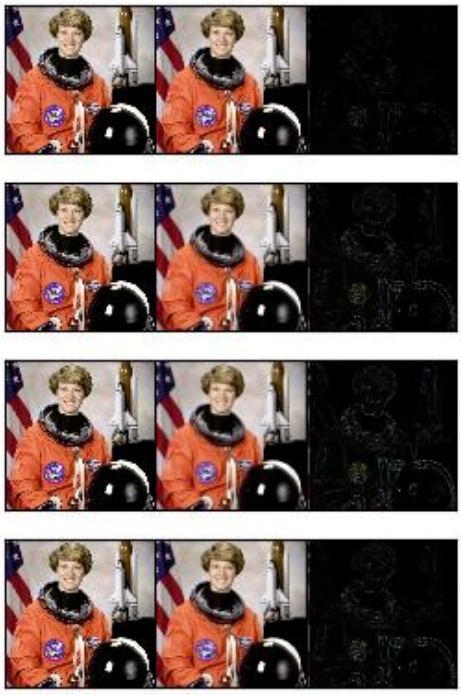
the blurred image

Return type

ndarray

Example

```
>>> import kwimage
>>> image = kwimage.ensure_float01(kwimage.grab_test_image('astro'))
>>> blurred1 = kwimage.gaussian_blur(image)
>>> blurred2 = kwimage.gaussian_blur(image, kernel=9)
>>> blurred3 = kwimage.gaussian_blur(image, sigma=2)
>>> blurred4 = kwimage.gaussian_blur(image, sigma=(2, 5), kernel=5)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> pnum_ = kwplot.PlotNums(nRows=4, nCols=1)
>>> blurs = [blurred1, blurred2, blurred3, blurred4]
>>> for blurred in blurs:
>>>     diff = np.abs(image - blurred)
>>>     stack = kwimage.stack_images([image, blurred, diff], pad=10, axis=1)
>>>     kwplot.imshow(stack, pnum=pnum_())
>>> kwplot.show_if_requested()
```



kwimage.**gaussian_patch**(*shape=(7, 7)*, *sigma=None*)

Creates a 2D gaussian patch with a specific size and sigma

Parameters

- **shape** (*Tuple[int, int]*) – patch height and width

- **sigma** (*float | Tuple[float, float] | None*) – Gaussian standard deviation. If unspecified, it is derived using the formulation described in [Cv2GaussKern].

Returns
ndarray

References

Todo:

- [ ] Look into this C-implementation https://kwgitlab.kitware.com/computer-vision/heatmap/blob/master/heatmap/heatmap.c

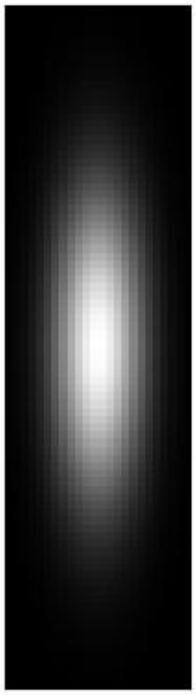
---

CommandLine

```
xdoctest -m kwimage.im_cv2 gaussian_patch --show
```

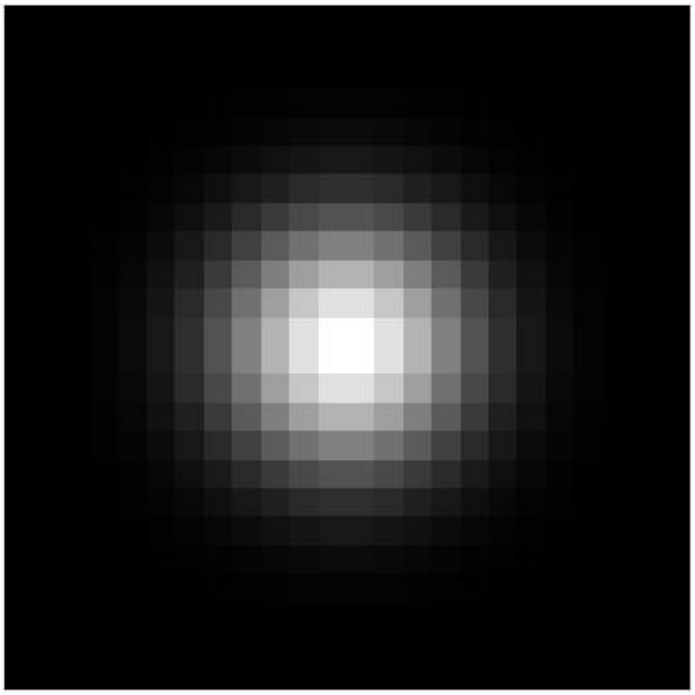
Example

```
>>> import numpy as np
>>> shape = (88, 24)
>>> sigma = None  # 1.0
>>> gausspatch = gaussian_patch(shape, sigma)
>>> sum_ = gausspatch.sum()
>>> assert np.all(np.isclose(sum_, 1.0))
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> norm = (gausspatch - gausspatch.min()) / (gausspatch.max() - gausspatch.min())
>>> kwplot.imshow(norm)
>>> kwplot.show_if_requested()
```



Example

```
>>> import numpy as np
>>> shape = (24, 24)
>>> sigma = 3.0
>>> gausspatch = gaussian_patch(shape, sigma)
>>> sum_ = gausspatch.sum()
>>> assert np.all(np.isclose(sum_, 1.0))
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> norm = (gausspatch - gausspatch.min()) / (gausspatch.max() - gausspatch.min())
>>> kwplot.imshow(norm)
>>> kwplot.show_if_requested()
```



kwimage.**grab_test_image**(*key='astro'*, *space='rgb'*, *dsize=None*, *interpolation='lanczos'*)

Ensures that the test image exists (this might use the network), reads it and returns the the image pixels.

Parameters

- **key** (*str*) – which test image to grab. Valid choices are: astro - an astronaught carl - Carl Sagan paraview - ParaView logo stars - picture of stars in the sky airport - SkySat image of Beijing Capital International Airport on 18 February 2018 See `kwimage.grab_test_image.keys` for a full list.
- **space** (*str*) – which colorspace to return in. Defaults to 'rgb'
- **dsize** (*Tuple[int, int]*) – if specified resizes image to this size

Returns
the requested image

Return type
ndarray

CommandLine

```
xdoctest -m kwimage.im_demodata grab_test_image
```

Example

```
>>> # xdoctest: +REQUIRES(--network)
>>> import kwimage
>>> for key in kwimage.grab_test_image.keys():
>>>     print('attempt to grab key = {!r}'.format(key))
>>>     kwimage.grab_test_image(key)
>>>     print('grabbed key = {!r}'.format(key))
>>> kwimage.grab_test_image('astro', dsize=(255, 255)).shape
(255, 255, 3)
```

kwimage.**grab_test_image_fpath**(*key='astro'*, *dsize=None*, *overviews=None*)

Ensures that the test image exists (this might use the network) and returns the cached filepath to the requested image.

Parameters

- **key** (*str*) – which test image to grab. Valid choices are: astro - an astronaught carl - Carl Sagan paraview - ParaView logo stars - picture of stars in the sky
- **dsize** (*None | Tuple[int, int]*) – if specified, we will return a variant of the data with the specific dsize
- **overviews** (*None | int*) – if specified, will return a variant of the data with overviews

Returns

path to the requested image

Return type

str

CommandLine

```
python -c "import kwimage; print(kwimage.grab_test_image_fpath('airport'))"
```

Example

```
>>> # xdoctest: +REQUIRES(--network)
>>> import kwimage
>>> for key in kwimage.grab_test_image.keys():
...     print('attempt to grab key = {!r}'.format(key))
...     kwimage.grab_test_image_fpath(key)
...     print('grabbed grab key = {!r}'.format(key))
```

Example

```
>>> # xdoctest: +REQUIRES(--network)
>>> import kwimage
>>> key = ub.peek(kwimage.grab_test_image.keys())
>>> # specifying a dsize will construct a new image
>>> fpath1 = kwimage.grab_test_image_fpath(key)
>>> fpath2 = kwimage.grab_test_image_fpath(key, dsize=(32, 16))
>>> print('fpath1 = {}'.format(ub.repr2(fpath1, nl=1)))
>>> print('fpath2 = {}'.format(ub.repr2(fpath2, nl=1)))
>>> assert fpath1 != fpath2
>>> imdata2 = kwimage.imread(fpath2)
>>> assert imdata2.shape[0:2] == (16, 32)
```

kwimage.**imcrop**(*img*, *dsize*, *about=None*, *origin=None*, *border_value=None*, *interpolation='nearest'*)

Crop an image about a specified point, padding if necessary.

This is like `PIL.Image.Image.crop()` with more convenient arguments, or `cv2.getRectSubPix()` without the baked-in bilinear interpolation.

Parameters

- **img** (*ndarray*) – image to crop
- **dsize** (*Tuple[None | int, None | int]*) – the desired width and height of the new image. If a dimension is None, then it is automatically computed to preserve aspect ratio. This can be larger than the original dims; if so, the cropped image is padded with border_value.
- **about** (*Tuple[str | int, str | int]*) – the location to crop about. Mutually exclusive with origin. Defaults to top left. If ints (w,h) are provided, that will be the center of the cropped image. There are also string codes available: 'lt': make the top left point of the image the top left point of the cropped image. This is equivalent to `img[:dsize[1], :dsize[0]]`, plus padding. 'rb': make the bottom right point of the image the bottom right point of the cropped image. This is equivalent to `img[-dsize[1]:, -dsize[0]:]`, plus padding. 'cc': make the center of the image the center of the cropped image. Any combination of these codes can be used, ex. 'lb', 'ct', ('r', 200), ...
- **origin** (*Tuple[int, int] | None*) – the origin of the crop in (x,y) order (same order as dsize/about). Mutually exclusive with about. Defaults to top left.
- **border_value** (*Number | Tuple | str*) – any border border_value accepted by cv2.copyMakeBorder, ex. [255, 0, 0] (blue). Default is 0.
- **interpolation** (*str*) – Can be 'nearest', in which case integral cropping is used. Can also be 'linear', in which case cv2.getRectSubPix is used. Defaults to 'nearest'.

Returns
the cropped image

Return type
ndarray

SeeAlso:

`kwarray.padded_slice()` **- a similar function for working with** "negative slices".

Example

```
>>> import kwimage
>>> import numpy as np
>>> #
>>> img = kwimage.grab_test_image('astro', dsize=(32, 32))[..., 0:3]
>>> #
>>> # regular crop
>>> new_img1 = kwimage.imcrop(img, dsize=(5,6))
>>> assert new_img1.shape[0:2] == (6, 5)
>>> #
>>> # padding for coords outside the image bounds
>>> new_img2 = kwimage.imcrop(img, dsize=(5,6),
>>>             origin=(-1,0), border_value=[1, 0, 0])
>>> assert np.all(new_img2[:, 0, 0:3] == [1, 0, 0])
>>> #
>>> # codes for corner- and edge-centered cropping
>>> new_img3 = kwimage.imcrop(img, dsize=(5,6),
>>>             about='cb')
>>> #
>>> # special code for bilinear interpolation
>>> # with floating-point coordinates
>>> new_img4 = kwimage.imcrop(img, dsize=(5,6),
>>>             about=(5.5, 8.5), interpolation='linear')
>>> #
>>> # use with bounding boxes
>>> bbox = kwimage.Boxes.random(scale=5, rng=132).to_xywh().quantize()
>>> origin, dsize = np.split(bbox.data[0], 2)
>>> new_img5 = kwimage.imcrop(img, dsize=dsize,
>>>             origin=origin)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> pnum_ = kwplot.PlotNums(nSubplots=6)
>>> kwplot.imshow(img, pnum=pnum_())
>>> kwplot.imshow(new_img1, pnum=pnum_())
>>> kwplot.imshow(new_img2, pnum=pnum_())
>>> kwplot.imshow(new_img3, pnum=pnum_())
>>> kwplot.imshow(new_img4, pnum=pnum_())
>>> kwplot.imshow(new_img5, pnum=pnum_())
>>> kwplot.show_if_requested()
```

kwimage.**imread**(*fpath*, *space='auto'*, *backend='auto'*, ***kw*)

Reads image data in a specified format using some backend implementation.

Parameters

- **fpath** (*str*) – path to the file to be read
- **space** (*str*) – The desired colorspace of the image. Can by any colorspace accepted by *convert_colorspace*, or it can be 'auto', in which case the colorspace of the image is unmodified (except in the case where a color image is read by opencv, in which case we convert BGR to RGB by default). If None, then no modification is made to whatever backend is used to read the image. Defaults to 'auto'.

  New in version 0.7.10: when the backend does not resolve to "cv2" the "auto" space resolves to None, thus the image is read as-is.
- **backend** (*str*) – which backend reader to use. By default the file extension is used to determine this, but it can be manually overridden. Valid backends are 'gdal', 'skimage', 'itk', 'pil', and 'cv2'. Defaults to 'auto'.
- ****kw** – backend-specific arguments

Returns

the image data in the specified color space.

Return type

ndarray

Note: if space is something non-standard like HSV or LAB, then the file must be a normal 8-bit color image,

otherwise an error will occur.

Note: Some backends will respect EXIF orientation (skimage) and others will not (gdal, cv2).

Raises

- **IOError - If the image cannot be read** –
- **ImportError - If trying to read a nitf without gdal** –
- **NotImplementedError - if trying to read a corner-case image** –

Example

```
>>> # xdoctest: +REQUIRES(--network)
>>> from kwimage.im_io import *  # NOQA
>>> import tempfile
>>> from os.path import splitext  # NOQA
>>> # Test a non-standard image, which encodes a depth map
>>> fpath = ub.grabdata(
>>>     'http://www.topcoder.com/contest/problem/UrbanMapper3D/JAX_Tile_043_DTM.tif
↪',
>>>     hasher='sha256', hash_prefix=
↪'64522acba6f0fb7060cd4c202ed32c5163c34e63d386afdada4190cce51ff4d4')
>>> img1 = kwimage.imread(fpath)
>>> # Check that write + read preserves data
>>> tmp = tempfile.NamedTemporaryFile(suffix=splitext(fpath)[1])
>>> kwimage.imwrite(tmp.name, img1)
>>> img2 = kwimage.imread(tmp.name)
>>> assert np.all(img2 == img1)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(img1, pnum=(1, 2, 1), fnum=1, norm=True, title='tif orig')
>>> kwplot.imshow(img2, pnum=(1, 2, 2), fnum=1, norm=True, title='tif io round-trip
↪')
```

Example

```
>>> # xdoctest: +REQUIRES(--network)
>>> import tempfile
>>> import kwimage
>>> img1 = kwimage.imread(ub.grabdata(
>>>     'http://i.imgur.com/iXNf4Me.png', fname='ada.png', hasher='sha256',
>>>     hash_prefix=
↪'898cf2588c40baf64d6e09b6a93b4c8dcc0db26140639a365b57619e17dd1c77'))
>>> tmp_tif = tempfile.NamedTemporaryFile(suffix='.tif')
>>> tmp_png = tempfile.NamedTemporaryFile(suffix='.png')
>>> kwimage.imwrite(tmp_tif.name, img1)
>>> kwimage.imwrite(tmp_png.name, img1)
```

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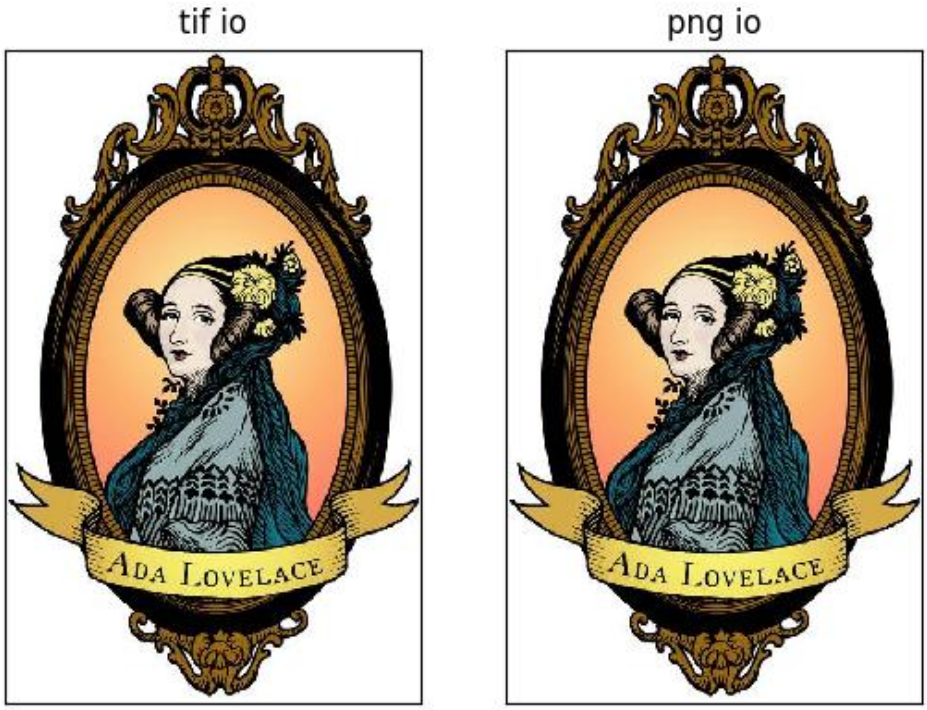
```
>>> tif_im = kwimage.imread(tmp_tif.name)
>>> png_im = kwimage.imread(tmp_png.name)
>>> assert np.all(tif_im == png_im)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(png_im, pnum=(1, 2, 1), fnum=1, title='tif io')
>>> kwplot.imshow(tif_im, pnum=(1, 2, 2), fnum=1, title='png io')
```



Example

```
>>> # xdoctest: +REQUIRES(--network)
>>> import tempfile
>>> import kwimage
>>> tif_fpath = ub.grabdata(
>>>     'https://ghostscript.com/doc/tiff/test/images/rgb-3c-16b.tiff',
>>>     fname='pepper.tif', hasher='sha256',
>>>     hash_prefix=
↪'31ff3a1f416cb7281acfbcbb4b56ee8bb94e9f91489602ff2806e5a49abc03c0')
>>> img1 = kwimage.imread(tif_fpath)
>>> tmp_tif = tempfile.NamedTemporaryFile(suffix='.tif')
>>> tmp_png = tempfile.NamedTemporaryFile(suffix='.png')
```

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```
>>> kwimage.imwrite(tmp_tif.name, img1)
>>> kwimage.imwrite(tmp_png.name, img1)
>>> tif_im = kwimage.imread(tmp_tif.name)
>>> png_im = kwimage.imread(tmp_png.name)
>>> assert np.all(tif_im == png_im)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(png_im / 2 ** 16, pnum=(1, 2, 1), fnum=1)
>>> kwplot.imshow(tif_im / 2 ** 16, pnum=(1, 2, 2), fnum=1)
```

Example

```
>>> # xdoctest: +REQUIRES(module:itk, --network)
>>> import kwimage
>>> import ubelt as ub
>>> # Grab an image that ITK can read
>>> fpath = ub.grabdata(
>>>     url='https://data.kitware.com/api/v1/file/606754e32fa25629b9476f9e/download
↪',
>>>     fname='brainweb1e5a10f17Rot20Tx20.mha',
>>>     hash_prefix='08f0812591691ae24a29788ba8cd1942e91', hasher='sha512')
```

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```
>>> # Read the image (this is actually a DxHxW stack of images)
>>> img1_stack = kwimage.imread(fpath)
>>> # Check that write + read preserves data
>>> import tempfile
>>> tmp_file = tempfile.NamedTemporaryFile(suffix='.mha')
>>> kwimage.imwrite(tmp_file.name, img1_stack)
>>> recon = kwimage.imread(tmp_file.name)
>>> assert not np.may_share_memory(recon, img1_stack)
>>> assert np.all(recon == img1_stack)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(kwimage.stack_images_grid(recon[0::20]),
>>>               title='kwimage.imread with a .mha file')
>>> kwplot.show_if_requested()
```

Benchmark

```
>>> from kwimage.im_io import *  # NOQA
>>> import timerit
>>> import kwimage
>>> import tempfile
>>> #
>>> dsize = (1920, 1080)
>>> img1 = kwimage.grab_test_image('amazon', dsize=dsize)
>>> ti = timerit.Timerit(10, bestof=3, verbose=1, unit='us')
>>> formats = {}
>>> dpath = ub.ensure_app_cache_dir('cache')
>>> space = 'auto'
>>> formats['png'] = kwimage.imwrite(join(dpath, '.png'), img1, space=space,␣
↪backend='cv2')
>>> formats['jpg'] = kwimage.imwrite(join(dpath, '.jpg'), img1, space=space,␣
↪backend='cv2')
>>> formats['tif_raw'] = kwimage.imwrite(join(dpath, '.raw.tif'), img1, space=space,
↪ backend='gdal', compress='RAW')
>>> formats['tif_deflate'] = kwimage.imwrite(join(dpath, '.deflate.tif'), img1,␣
↪space=space, backend='gdal', compress='DEFLATE')
>>> formats['tif_lzw'] = kwimage.imwrite(join(dpath, '.lzw.tif'), img1, space=space,
↪ backend='gdal', compress='LZW')
>>> grid = [
>>>     ('cv2', 'png'),
>>>     ('cv2', 'jpg'),
>>>     ('gdal', 'jpg'),
>>>     ('turbojpeg', 'jpg'),
>>>     ('gdal', 'tif_raw'),
>>>     ('gdal', 'tif_lzw'),
>>>     ('gdal', 'tif_deflate'),
>>>     ('skimage', 'tif_raw'),
>>> ]
>>> backend, filefmt = 'cv2', 'png'
```

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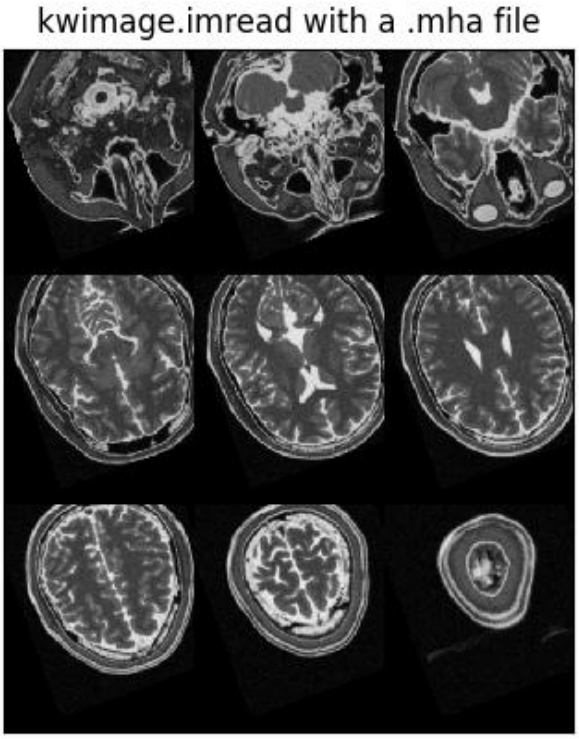
```
>>> for backend, filefmt in grid:
>>>     for timer in ti.reset(f'imread-{filefmt}-{backend}'):
>>>         with timer:
>>>             kwimage.imread(formats[filefmt], space=space, backend=backend)
>>> # Test all formats in auto mode
>>> for filefmt in formats.keys():
>>>     for timer in ti.reset(f'kwimage.imread-{filefmt}-auto'):
>>>         with timer:
>>>             kwimage.imread(formats[filefmt], space=space, backend='auto')
>>> ti.measures = ub.map_vals(ub.sorted_vals, ti.measures)
>>> import netharn as nh
>>> print('ti.measures = {}'.format(nh.util.align(ub.repr2(ti.measures['min'],␣
↪nl=2), ':')))
Timed best=42891.504 µs, mean=44008.439 ± 1409.2 µs for imread-png-cv2
Timed best=33146.808 µs, mean=34185.172 ± 656.3 µs for imread-jpg-cv2
Timed best=40120.306 µs, mean=41220.927 ± 1010.9 µs for imread-jpg-gdal
Timed best=30798.162 µs, mean=31573.070 ± 737.0 µs for imread-jpg-turbojpeg
Timed best=6223.170 µs, mean=6370.462 ± 150.7 µs for imread-tif_raw-gdal
Timed best=42459.404 µs, mean=46519.940 ± 5664.9 µs for imread-tif_lzw-gdal
Timed best=36271.175 µs, mean=37301.108 ± 861.1 µs for imread-tif_deflate-gdal
Timed best=5239.503 µs, mean=6566.574 ± 1086.2 µs for imread-tif_raw-skimage
ti.measures = {
    'imread-tif_raw-skimage' : 0.0052395030070329085,
    'imread-tif_raw-gdal'    : 0.006223169999429956,
    'imread-jpg-turbojpeg'   : 0.030798161998973228,
    'imread-jpg-cv2'         : 0.03314680799667258,
    'imread-tif_deflate-gdal': 0.03627117499127053,
    'imread-jpg-gdal'        : 0.040120305988239124,
    'imread-tif_lzw-gdal'    : 0.042459404008695856,
    'imread-png-cv2'         : 0.042891503995633684,
}
```



kwimage.**imresize**(*img*, *scale=None*, *dsize=None*, *max_dim=None*, *min_dim=None*, *interpolation=None*, *grow_interpolation=None*, *letterbox=False*, *return_info=False*, *antialias=False*, *border_value=0*)

Resize an image based on a scale factor, final size, or size and aspect ratio.

Slightly more general than cv2.resize, allows for specification of either a scale factor, a final size, or the final size for a particular dimension.

Parameters

- **img** (*ndarray*) – image to resize
- **scale** (*float | Tuple[float, float]*) – Desired floating point scale factor. If a tuple, the dimension ordering is x,y. Mutually exclusive with dsize, max_dim, and min_dim.
- **dsize** (*Tuple[int]*) – The desired with and height of the new image. If a dimension is None, then it is automatically computed to preserve aspect ratio. Mutually exclusive with size, max_dim, and min_dim.
- **max_dim** (*int*) – New size of the maximum dimension, the other dimension is scaled to maintain aspect ratio. Mutually exclusive with size, dsize, and min_dim.
- **min_dim** (*int*) – New size of the minimum dimension, the other dimension is scaled to maintain aspect ratio.Mutually exclusive with size, dsize, and max_dim.
- **interpolation** (*str | int*) – The interpolation key or code (e.g. linear lanczos). By default “area” is used if the image is shrinking and “lanczos” is used if the image is growing. Note, if this is explicitly set, then it will be used regardless of if the image is growing or shrinking. Set `grow_interpolation` to change the default for an enlarging interpolation.

- **grow_interpolation** (*str | int*) – The interpolation key or code to use when the image is being enlarged. Does nothing if “interpolation” is explicitly given. If “interpolation” is not specified “area” is used when shrinking. Defaults to “lanczos”.
- **letterbox** (*bool*) – If used in conjunction with dsize, then the image is scaled and translated to fit in the center of the new image while maintaining aspect ratio. Border padding is added if necessary. Defaults to False.
- **return_info** (*bool*) – if True returns information about the final transformation in a dictionary. If there is an offset, the scale is applied before the offset when transforming to the new resized space. Defaults to False.
- **antialias** (*bool*) – if True blurs to anti-alias before downsampling. Defaults to False.
- **border_value** (*int | float | Iterable[int | float]*) – if letterbox is True, this is used as the constant fill value.

Returns
the new image and optionally an info dictionary if *return_info=True*

Return type
ndarray | Tuple[ndarray, Dict]

Example

```
>>> import kwimage
>>> import numpy as np
>>> # Test scale
>>> img = np.zeros((16, 10, 3), dtype=np.uint8)
>>> new_img, info = kwimage.imresize(img, scale=.85,
>>>                                  interpolation='area',
>>>                                  return_info=True)
>>> print('info = {!r}'.format(info))
>>> assert info['scale'].tolist() == [.8, 0.875]
>>> # Test dsize without None
>>> new_img, info = kwimage.imresize(img, dsize=(5, 12),
>>>                                  interpolation='area',
>>>                                  return_info=True)
>>> print('info = {!r}'.format(info))
>>> assert info['scale'].tolist() == [0.5 , 0.75]
>>> # Test dsize with None
>>> new_img, info = kwimage.imresize(img, dsize=(6, None),
>>>                                  interpolation='area',
>>>                                  return_info=True)
>>> print('info = {!r}'.format(info))
>>> assert info['scale'].tolist() == [0.6, 0.625]
>>> # Test max_dim
>>> new_img, info = kwimage.imresize(img, max_dim=6,
>>>                                  interpolation='area',
>>>                                  return_info=True)
>>> print('info = {!r}'.format(info))
>>> assert info['scale'].tolist() == [0.4  , 0.375]
>>> # Test min_dim
>>> new_img, info = kwimage.imresize(img, min_dim=6,
>>>                                  interpolation='area',
```

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```
>>>                                     return_info=True)
>>> print('info = {!r}'.format(info))
>>> assert info['scale'].tolist() == [0.6  , 0.625]
```

Example

```
>>> import kwimage
>>> import numpy as np
>>> # Test letterbox resize
>>> img = np.ones((5, 10, 3), dtype=np.float32)
>>> new_img, info = kwimage.imresize(img, dsize=(19, 19),
>>>                                  letterbox=True,
>>>                                  return_info=True)
>>> print('info = {!r}'.format(info))
>>> assert info['offset'].tolist() == [0, 4]
>>> img = np.ones((10, 5, 3), dtype=np.float32)
>>> new_img, info = kwimage.imresize(img, dsize=(19, 19),
>>>                                  letterbox=True,
>>>                                  return_info=True)
>>> print('info = {!r}'.format(info))
>>> assert info['offset'].tolist() == [4, 0]
```

```
>>> import kwimage
>>> import numpy as np
>>> # Test letterbox resize
>>> img = np.random.rand(100, 200)
>>> new_img, info = kwimage.imresize(img, dsize=(300, 300), letterbox=True, return_
↪info=True)
```

Example

```
>>> # Check aliasing
>>> import kwimage
>>> #img = kwimage.grab_test_image('checkerboard')
>>> img = kwimage.grab_test_image('pm5644')
>>> # test with nans
>>> img = kwimage.ensure_float01(img)
>>> img[100:200, 400:700] = np.nan
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> dsize = (14, 14)
>>> dsize = (64, 64)
>>> # When we set "grow_interpolation" for a "shrinking" resize it should
>>> # still do the "area" interpolation to antialias the results. But if we
>>> # use explicit interpolation it should alias.
>>> pnum_ = kwplot.PlotNums(nSubplots=12, nCols=4)
>>> kwplot.imshow(kwimage.imresize(img, dsize=dsize, antialias=True,  interpolation=
↪'area'), pnum=pnum_(), title='resize aa area')
```

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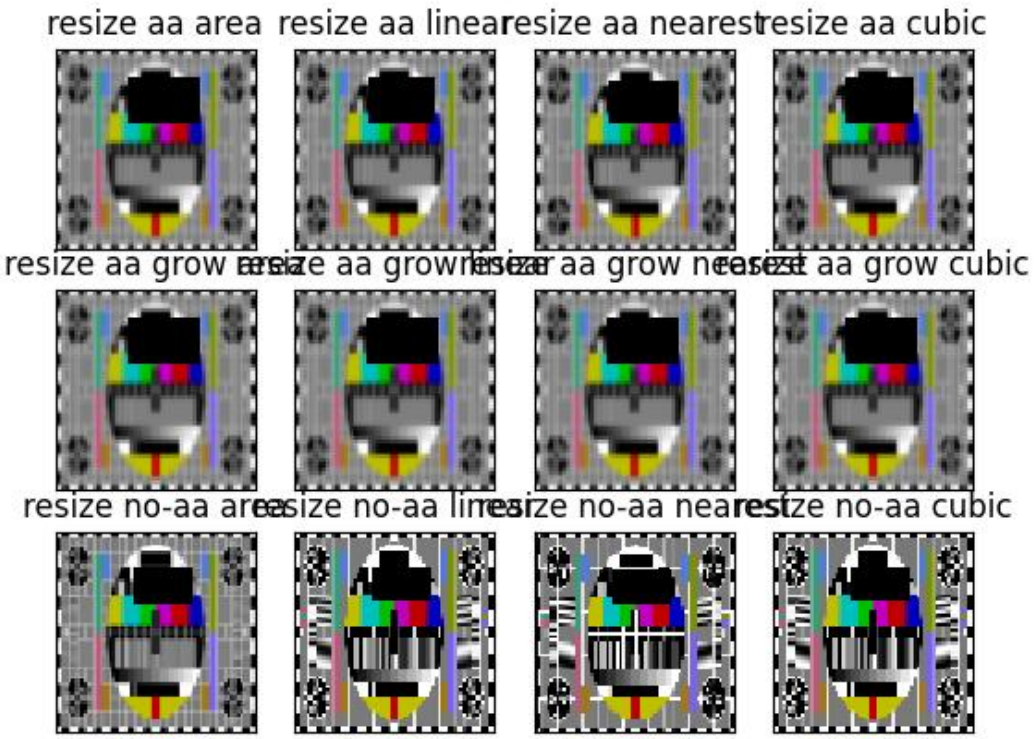
```
>>> kwplot.imshow(kwimage.imresize(img, dsize=dsize, antialias=True, interpolation=
↪'linear'), pnum=pnum_(), title='resize aa linear')
>>> kwplot.imshow(kwimage.imresize(img, dsize=dsize, antialias=True, interpolation=
↪'nearest'), pnum=pnum_(), title='resize aa nearest')
>>> kwplot.imshow(kwimage.imresize(img, dsize=dsize, antialias=True, interpolation=
↪'cubic'), pnum=pnum_(), title='resize aa cubic')
```

```
>>> kwplot.imshow(kwimage.imresize(img, dsize=dsize, antialias=True, grow_
↪interpolation='area'), pnum=pnum_(), title='resize aa grow area')
>>> kwplot.imshow(kwimage.imresize(img, dsize=dsize, antialias=True, grow_
↪interpolation='linear'), pnum=pnum_(), title='resize aa grow linear')
>>> kwplot.imshow(kwimage.imresize(img, dsize=dsize, antialias=True, grow_
↪interpolation='nearest'), pnum=pnum_(), title='resize aa grow nearest')
>>> kwplot.imshow(kwimage.imresize(img, dsize=dsize, antialias=True, grow_
↪interpolation='cubic'), pnum=pnum_(), title='resize aa grow cubic')
```

```
>>> kwplot.imshow(kwimage.imresize(img, dsize=dsize, antialias=False, interpolation=
↪'area'), pnum=pnum_(), title='resize no-aa area')
>>> kwplot.imshow(kwimage.imresize(img, dsize=dsize, antialias=False, interpolation=
↪'linear'), pnum=pnum_(), title='resize no-aa linear')
>>> kwplot.imshow(kwimage.imresize(img, dsize=dsize, antialias=False, interpolation=
↪'nearest'), pnum=pnum_(), title='resize no-aa nearest')
>>> kwplot.imshow(kwimage.imresize(img, dsize=dsize, antialias=False, interpolation=
↪'cubic'), pnum=pnum_(), title='resize no-aa cubic')
```



Todo:

- [X] When interpolation is area and the number of channels > 4 cv2.resize will error but it is fine for linear interpolation
- [ ] TODO: add padding options when letterbox=True
- [ ] Allow for pre-clipping when letterbox=True

`kwimage.`**`imscale`**(*img*, *scale*, *interpolation=None*, *return_scale=False*)

DEPRECATED and removed: use imresize instead

`kwimage.`**`imwrite`**(*fpath*, *image*, *space='auto'*, *backend='auto'*, ***kwargs*)

Writes image data to disk.

Parameters

- **fpath** (*PathLike*) – location to save the image
- **image** (*ndarray*) – image data
- **space** (*str | None*) – the colorspace of the image to save. Can by any colorspace accepted by *convert_colorspace*, or it can be 'auto', in which case we assume the input image is either RGB, RGBA or grayscale. If None, then absolutely no color modification is made and whatever backend is used writes the image as-is.

  New in version 0.7.10: when the backend does not resolve to "cv2", the "auto" space resolves to None, thus the image is saved as-is.

- **backend** (*str*) – Which backend writer to use. By default the file extension is used to determine this. Valid backends are 'gdal', 'skimage', 'itk', and 'cv2'.
- ****kwargs** – args passed to the backend writer. When the backend is gdal, available options are: compress (str): Common options are auto, DEFLATE, LZW, JPEG. blocksize (int): size of tiled blocks (e.g. 256) overviews (None | str | int | list): Number of overviews. overview_resample (str): Common options NEAREST, CUBIC, LANCZOS options (List[str]): other gdal options. nodata (int): denotes a integer value as nodata. transform (kwimage.Affine): Transform into CRS crs (str): The coordinate reference system for transform. See `_imwrite_cloud_optimized_geotiff()` for more details each options. When the backend is itk, see `itk.imwrite()` for options When the backend is skimage, see `skimage.io.imsave()` for options When the backend is cv2 see `cv2.imwrite()` for options.

Returns
path to the written file

Return type
str

Note: The image may be modified to preserve its colorspace depending on which backend is used to write the image.

When saving as a jpeg or png, the image must be encoded with the uint8 data type. When saving as a tiff, any data type is allowed.

Raises
`Exception` – if the image cannot be written

Example

```
>>> # xdoctest: +REQUIRES(--network)
>>> # This should be moved to a unit test
>>> from kwimage.im_io import _have_gdal  # NOQA
>>> import kwimage
>>> import tempfile
>>> test_image_paths = [
>>>     ub.grabdata('https://ghostscript.com/doc/tiff/test/images/rgb-3c-16b.tiff',␣
↪fname='pepper.tif'),
>>>     ub.grabdata('http://i.imgur.com/iXNf4Me.png', fname='ada.png'),
>>>     #ub.grabdata('http://www.topcoder.com/contest/problem/UrbanMapper3D/JAX_Tile_
↪043_DTM.tif'),
>>>     ub.grabdata('https://upload.wikimedia.org/wikipedia/commons/f/fa/Grayscale_
↪8bits_palette_sample_image.png', fname='parrot.png')
>>> ]
>>> for fpath in test_image_paths:
>>>     for space in ['auto', 'rgb', 'bgr', 'gray', 'rgba']:
>>>         img1 = kwimage.imread(fpath, space=space)
>>>         print('Test im-io consistency of fpath = {!r} in {} space, shape={}'.
↪format(fpath, space, img1.shape))
>>>         # Write the image in TIF and PNG format
>>>         tmp_tif = tempfile.NamedTemporaryFile(suffix='.tif')
>>>         tmp_png = tempfile.NamedTemporaryFile(suffix='.png')
```

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```
>>>         kwimage.imwrite(tmp_tif.name, img1, space=space, backend='skimage')
>>>         kwimage.imwrite(tmp_png.name, img1, space=space)
>>>         tif_im = kwimage.imread(tmp_tif.name, space=space)
>>>         png_im = kwimage.imread(tmp_png.name, space=space)
>>>         assert np.all(tif_im == png_im), 'im-read/write inconsistency'
>>>         if _have_gdal:
>>>             tmp_tif2 = tempfile.NamedTemporaryFile(suffix='.tif')
>>>             kwimage.imwrite(tmp_tif2.name, img1, space=space, backend='gdal')
>>>             tif_im2 = kwimage.imread(tmp_tif2.name, space=space)
>>>             assert np.all(tif_im == tif_im2), 'im-read/write inconsistency'
>>>         if space == 'gray':
>>>             assert tif_im.ndim == 2
>>>             assert png_im.ndim == 2
>>>         elif space in ['rgb', 'bgr']:
>>>             assert tif_im.shape[2] == 3
>>>             assert png_im.shape[2] == 3
>>>         elif space in ['rgba', 'bgra']:
>>>             assert tif_im.shape[2] == 4
>>>             assert png_im.shape[2] == 4
```

Benchmark

```
>>> import timerit
>>> import os
>>> import kwimage
>>> import tempfile
>>> #
>>> img1 = kwimage.grab_test_image('astro', dsize=(1920, 1080))
>>> space = 'auto'
>>> #
>>> file_sizes = {}
>>> #
>>> ti = timerit.Timerit(10, bestof=3, verbose=2)
>>> #
>>> for timer in ti.reset('imwrite-skimage-tif'):
>>>     with timer:
>>>         tmp = tempfile.NamedTemporaryFile(suffix='.tif')
>>>         kwimage.imwrite(tmp.name, img1, space=space, backend='skimage')
>>>     file_sizes[ti.label] = os.stat(tmp.name).st_size
>>> #
>>> for timer in ti.reset('imwrite-cv2-png'):
>>>     with timer:
>>>         tmp = tempfile.NamedTemporaryFile(suffix='.png')
>>>         kwimage.imwrite(tmp.name, img1, space=space, backend='cv2')
>>>     file_sizes[ti.label] = os.stat(tmp.name).st_size
>>> #
>>> for timer in ti.reset('imwrite-cv2-jpg'):
>>>     with timer:
>>>         tmp = tempfile.NamedTemporaryFile(suffix='.jpg')
>>>         kwimage.imwrite(tmp.name, img1, space=space, backend='cv2')
```

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```
>>>     file_sizes[ti.label] = os.stat(tmp.name).st_size
>>> #
>>> for timer in ti.reset('imwrite-gdal-raw'):
>>>     with timer:
>>>         tmp = tempfile.NamedTemporaryFile(suffix='.tif')
>>>         kwimage.imwrite(tmp.name, img1, space=space, backend='gdal', compress=
↪'RAW')
>>>     file_sizes[ti.label] = os.stat(tmp.name).st_size
>>> #
>>> for timer in ti.reset('imwrite-gdal-lzw'):
>>>     with timer:
>>>         tmp = tempfile.NamedTemporaryFile(suffix='.tif')
>>>         kwimage.imwrite(tmp.name, img1, space=space, backend='gdal', compress=
↪'LZW')
>>>     file_sizes[ti.label] = os.stat(tmp.name).st_size
>>> #
>>> for timer in ti.reset('imwrite-gdal-zstd'):
>>>     with timer:
>>>         tmp = tempfile.NamedTemporaryFile(suffix='.tif')
>>>         kwimage.imwrite(tmp.name, img1, space=space, backend='gdal', compress=
↪'ZSTD')
>>>     file_sizes[ti.label] = os.stat(tmp.name).st_size
>>> #
>>> for timer in ti.reset('imwrite-gdal-deflate'):
>>>     with timer:
>>>         tmp = tempfile.NamedTemporaryFile(suffix='.tif')
>>>         kwimage.imwrite(tmp.name, img1, space=space, backend='gdal', compress=
↪'DEFLATE')
>>>     file_sizes[ti.label] = os.stat(tmp.name).st_size
>>> #
>>> for timer in ti.reset('imwrite-gdal-jpeg'):
>>>     with timer:
>>>         tmp = tempfile.NamedTemporaryFile(suffix='.tif')
>>>         kwimage.imwrite(tmp.name, img1, space=space, backend='gdal', compress=
↪'JPEG')
>>>     file_sizes[ti.label] = os.stat(tmp.name).st_size
>>> #
>>> file_sizes = ub.sorted_vals(file_sizes)
>>> import xdev
>>> file_sizes_human = ub.map_vals(lambda x: xdev.byte_str(x, 'MB'), file_sizes)
>>> print('ti.rankings = {}'.format(ub.repr2(ti.rankings, nl=2)))
>>> print('file_sizes = {}'.format(ub.repr2(file_sizes_human, nl=1)))
```

Example

```
>>> # Test saving a multi-band file
>>> import kwimage
>>> import pytest
>>> import tempfile
>>> # In this case the backend will not resolve to cv2, so
>>> # we should not need to specify space.
>>> data = np.random.rand(32, 32, 13).astype(np.float32)
>>> temp = tempfile.NamedTemporaryFile(suffix='.tif')
>>> fpath = temp.name
>>> kwimage.imwrite(fpath, data)
>>> recon = kwimage.imread(fpath)
>>> assert np.all(recon == data)
>>> kwimage.imwrite(fpath, data, backend='skimage')
>>> recon = kwimage.imread(fpath, backend='skimage')
>>> assert np.all(recon == data)
>>> # xdoctest: +REQUIRES(module:osgeo)
>>> # gdal should error when trying to read an image written by skimage
>>> with pytest.raises(NotImplementedError):
>>>     kwimage.imread(fpath, backend='gdal')
>>> # In this case the backend will resolve to cv2, and thus we expect
>>> # a failure
>>> temp = tempfile.NamedTemporaryFile(suffix='.png')
>>> fpath = temp.name
>>> with pytest.raises(NotImplementedError):
>>>     kwimage.imwrite(fpath, data)
```

Example

```
>>> import ubelt as ub
>>> import kwimage
>>> dpath = ub.Path(ub.ensure_app_cache_dir('kwimage/badwrite'))
>>> dpath.delete().ensuredir()
>>> imdata = kwimage.ensure_uint255(kwimage.grab_test_image())[:, :, 0]
>>> import pytest
>>> fpath = dpath / 'does-not-exist/img.jpg'
>>> with pytest.raises(IOError):
...     kwimage.imwrite(fpath, imdata, backend='cv2')
>>> with pytest.raises(IOError):
...     kwimage.imwrite(fpath, imdata, backend='skimage')
>>> # xdoctest: +SKIP
>>> # TODO: run tests conditionally
>>> with pytest.raises(IOError):
...     kwimage.imwrite(fpath, imdata, backend='gdal')
>>> with pytest.raises((IOError, RuntimeError)):
...     kwimage.imwrite(fpath, imdata, backend='itk')
```

kwimage.**load_image_shape**(*fpath*, *backend='auto'*)

Determine the height/width/channels of an image without reading the entire file.

Parameters

- **fpath** (*str*) – path to an image
- **backend** (*str*) – can be “auto”, “pil”, or “gdal”.

Returns

Tuple[int, int, int] - shape of the image
Recall this library uses the convention that “shape” is refers to height,width,channels array-style ordering and “size” is width,height cv2-style ordering.

Example

```
>>> # xdoctest: +REQUIRES(module:osgeo)
>>> # Test the loading the shape works the same as loading the image and
>>> # testing the shape
>>> import kwimage
>>> import tempfile
>>> temp_dir = tempfile.TemporaryDirectory()
>>> temp_dpath = ub.Path(temp_dir.name)
>>> data = kwimage.grab_test_image()
>>> datas = {
>>>     'rgb255': kwimage.ensure_uint255(data),
>>>     'rgb01': kwimage.ensure_float01(data),
>>>     'rgba01': kwimage.ensure_alpha_channel(data),
>>> }
>>> results = {}
>>> # These should be consistent
>>> # The was a problem where CV2_IMREAD_UNCHANGED read the alpha band,
>>> # but PIL did not, but maybe this is fixed now?
>>> for key, imdata in datas.items():
>>>     fpath = temp_dpath / f'{key}.png'
>>>     kwimage.imwrite(fpath, imdata)
>>>     shapes = {}
>>>     shapes['pil_load_shape'] = kwimage.load_image_shape(fpath, backend='pil')
>>>     shapes['gdal_load_shape'] = kwimage.load_image_shape(fpath, backend='gdal')
>>>     shapes['auto_load_shape'] = kwimage.load_image_shape(fpath, backend='auto')
>>>     shapes['pil'] = kwimage.imread(fpath, backend='pil').shape
>>>     shapes['cv2'] = kwimage.imread(fpath, backend='cv2').shape
>>>     shapes['gdal'] = kwimage.imread(fpath, backend='gdal').shape
>>>     shapes['skimage'] = kwimage.imread(fpath, backend='skimage').shape
>>>     results[key] = shapes
>>> print('results = {}'.format(ub.repr2(results, nl=2, align=':', sort=0)))
>>> for shapes in results.values():
>>>     assert ub.allsame(shapes.values())
```

Benchmark

```
>>> # For large files, PIL is much faster
>>> # xdoctest: +REQUIRES(module:osgeo)
>>> from osgeo import gdal
>>> from PIL import Image
>>> import timerit
>>> #
>>> import kwimage
>>> fpath = kwimage.grab_test_image_fpath()
>>> #
>>> ti = timerit.Timerit(100, bestof=10, verbose=2)
>>> for timer in ti.reset('gdal'):
>>>     with timer:
>>>         gdal_dset = gdal.Open(fpath, gdal.GA_ReadOnly)
>>>         width = gdal_dset.RasterXSize
>>>         height = gdal_dset.RasterYSize
>>>         gdal_dset = None
>>> #
>>> for timer in ti.reset('PIL'):
>>>     with timer:
>>>         pil_img = Image.open(fpath)
>>>         width, height = pil_img.size
>>>         pil_img.close()
Timed gdal for: 100 loops, best of 10
    time per loop: best=62.967 µs, mean=63.991 ± 0.8 µs
Timed PIL for: 100 loops, best of 10
    time per loop: best=46.640 µs, mean=47.314 ± 0.4 µs
```

Example

```
>>> # xdoctest: +REQUIRES(module:osgeo)
>>> import ubelt as ub
>>> import kwimage
>>> dpath = ub.Path.appdir('kwimage/tests', type='cache').ensuredir()
>>> fpath = dpath / 'foo.tif'
>>> kwimage.imwrite(fpath, np.random.rand(64, 64, 3))
>>> shape = kwimage.load_image_shape(fpath)
>>> assert shape == (64, 64, 3)
```

kwimage.**make_channels_comparable**(*img1*, *img2*, *atleast3d=False*)

Broadcasts image arrays so they can have elementwise operations applied

Parameters

- **img1** (*ndarray*) – first image
- **img2** (*ndarray*) – second image
- **atleast3d** (*bool*) – if true we ensure that the channel dimension exists (only relevant for 1-channel images). Defaults to False.

Example

```
>>> import itertools as it
>>> wh_basis = [(5, 5), (3, 5), (5, 3), (1, 1), (1, 3), (3, 1)]
>>> for w, h in wh_basis:
>>>     shape_basis = [(w, h), (w, h, 1), (w, h, 3)]
>>>     # Test all permutations of shap inputs
>>>     for shape1, shape2 in it.product(shape_basis, shape_basis):
>>>         print('*    input shapes: %r, %r' % (shape1, shape2))
>>>         img1 = np.empty(shape1)
>>>         img2 = np.empty(shape2)
>>>         img1, img2 = make_channels_comparable(img1, img2)
>>>         print('... output shapes: %r, %r' % (img1.shape, img2.shape))
>>>         elem = (img1 + img2)
>>>         print('... elem(+) shape: %r' % (elem.shape,))
>>>         assert elem.size == img1.size, 'outputs should have same size'
>>>         assert img1.size == img2.size, 'new imgs should have same size'
>>>         print('--------')
```

kwimage.**make_heatmask**(*probs*, *cmap='plasma'*, *with_alpha=1.0*, *space='rgb'*, *dsize=None*)

Colorizes a single-channel intensity mask (with an alpha channel)

Parameters

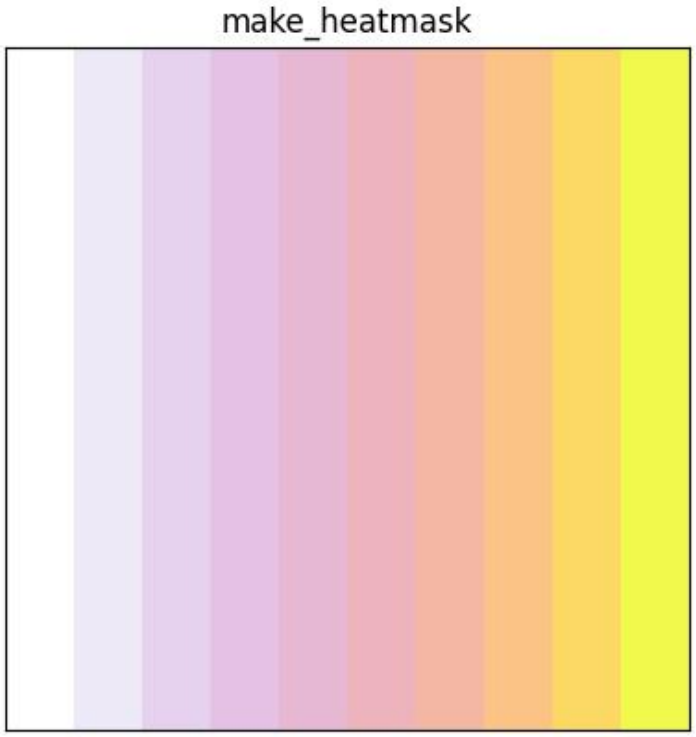
- **probs** (*ndarray*) – 2D probability map with values between 0 and 1
- **cmap** (*str*) – mpl colormap
- **with_alpha** (*float*) – between 0 and 1, uses probs as the alpha multipled by this number.
- **space** (*str*) – output colorspace
- **dsize** (*tuple*) – if not None, then output is resized to W,H=dsize

SeeAlso:

kwimage.overlay_alpha_images

Example

```
>>> # xdoc: +REQUIRES(module:matplotlib)
>>> from kwimage.im_draw import *  # NOQA
>>> probs = np.tile(np.linspace(0, 1, 10), (10, 1))
>>> heatmask = make_heatmask(probs, with_alpha=0.8, dsize=(100, 100))
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(heatmask, fnum=1, doclf=True, colorspace='rgb',
>>>               title='make_heatmask')
>>> kwplot.show_if_requested()
```



kwimage.**make_orimask**(*radians*, *mag=None*, *alpha=1.0*)

Makes a colormap in HSV space where the orientation changes color and mag changes the saturation/value.

Parameters

- **radians** (*ndarray*) – orientation in radians
- **mag** (*ndarray*) – magnitude (must be normalized between 0 and 1)
- **alpha** (*float | ndarray*) – if False or None, then the image is returned without alpha if a float, then mag is scaled by this and used as the alpha channel if an ndarray, then this is explicilty set as the alpha channel

Returns

an rgb / rgba image in 01 space

Return type

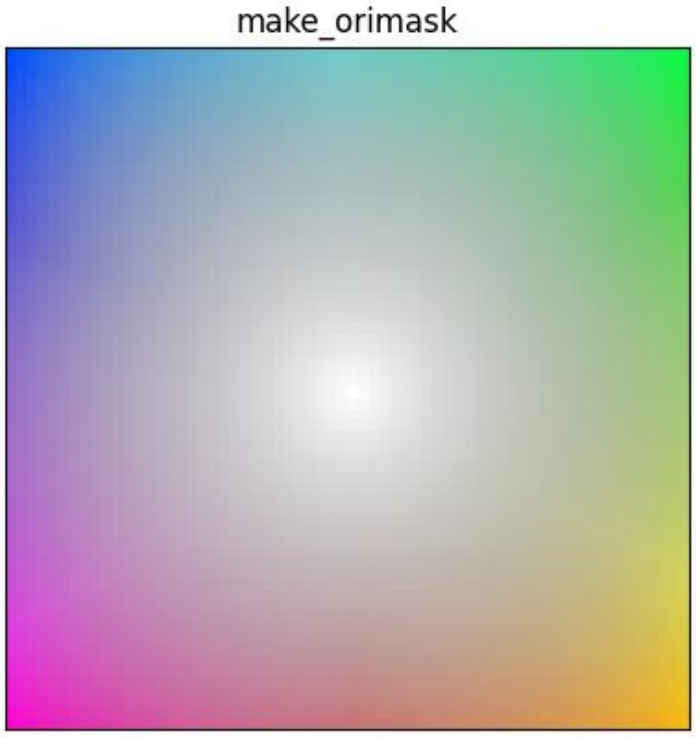
ndarray[Any, Float32]

SeeAlso:

kwimage.overlay_alpha_images

Example

```
>>> # xdoc: +REQUIRES(module:matplotlib)
>>> from kwimage.im_draw import *  # NOQA
>>> x, y = np.meshgrid(np.arange(64), np.arange(64))
>>> dx, dy = x - 32, y - 32
>>> radians = np.arctan2(dx, dy)
>>> mag = np.sqrt(dx ** 2 + dy ** 2)
>>> orimask = make_orimask(radians, mag)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(orimask, fnum=1, doclf=True,
>>>               colorspace='rgb', title='make_orimask')
>>> kwplot.show_if_requested()
```



kwimage.**make_vector_field**(*dx*, *dy*, *stride=0.02*, *thresh=0.0*, *scale=1.0*, *alpha=1.0*, *color='strawberry'*, *thickness=1*, *tipLength=0.1*, *line_type='aa'*)

Create an image representing a 2D vector field.

Parameters

- **dx** (*ndarray*) – grid of vector x components
- **dy** (*ndarray*) – grid of vector y components
- **stride** (*int | float*) – sparsity of vectors, int specifies stride step in pixels, a float specifies

it as a percentage.

- **thresh** (*float*) – only plot vectors with magnitude greater than thres
- **scale** (*float*) – multiply magnitude for easier visualization
- **alpha** (*float*) – alpha value for vectors. Non-vector regions receive 0 alpha (if False, no alpha channel is used)
- **color** (*str | tuple | kwimage.Color*) – RGB color of the vectors
- **thickness** (*int*) – thickness of arrows
- **tipLength** (*float*) – fraction of line length
- **line_type** (*int | str*) – either cv2.LINE_4, cv2.LINE_8, or cv2.LINE_AA or a string code.

Returns
vec_img - an rgb/rgba image in 0-1 space

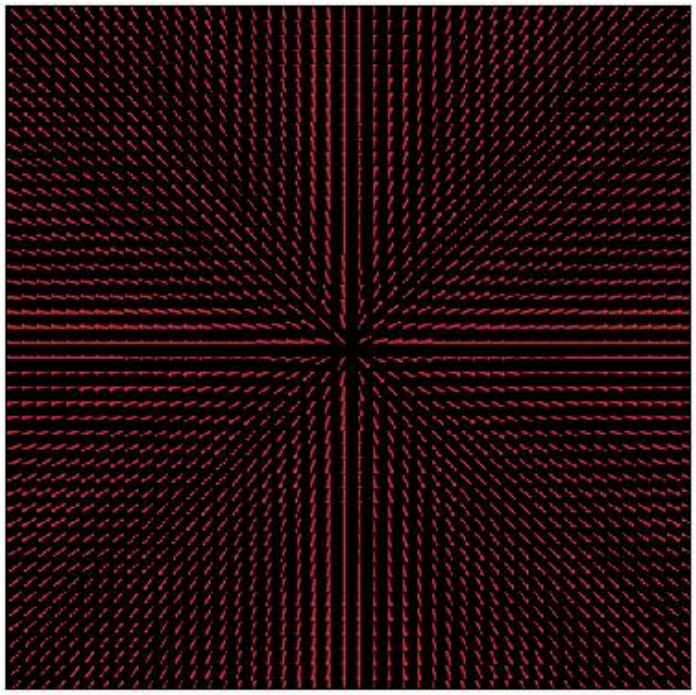
Return type
ndarray[Any, Float32]

SeeAlso:
kwimage.overlay_alpha_images

DEPRECATED USE: draw_vector_field instead

Example

```
>>> x, y = np.meshgrid(np.arange(512), np.arange(512))
>>> dx, dy = x - 256.01, y - 256.01
>>> radians = np.arctan2(dx, dy)
>>> mag = np.sqrt(dx ** 2 + dy ** 2)
>>> dx, dy = dx / mag, dy / mag
>>> img = make_vector_field(dx, dy, scale=10, alpha=False)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(img)
>>> kwplot.show_if_requested()
```



kwimage.**morphology**(*data*, *mode*, *kernel=5*, *element='rect'*, *iterations=1*, *border_mode='constant'*, *border_value=0*)

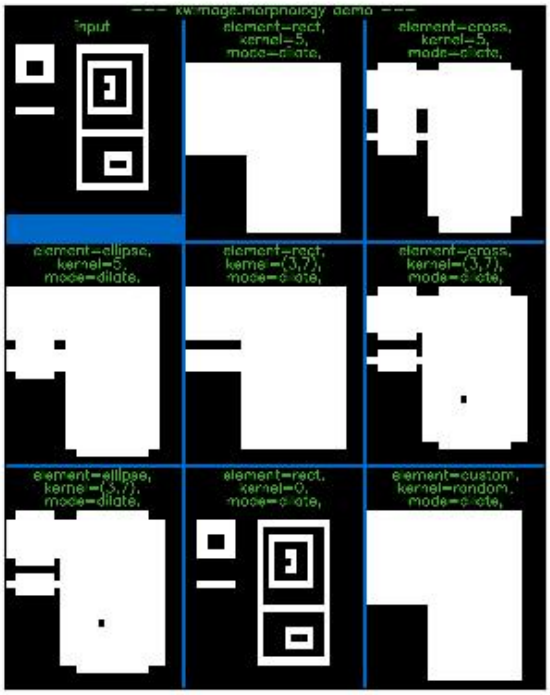
Executes a morphological operation.

Parameters

- **input** (*ndarray[dtype=uint8 | float64]*) – data (note if mode is hitmiss data must be uint8)
- **mode** (*str*) – morphology mode, can be one of: 'erode', 'dilate', 'open', 'close', 'gradient', 'tophat', 'blackhat', or 'hitmiss'.
- **kernel** (*ndarray | int | Tuple[int, int]*) – size of the morphology kernel (w, h) to be constructed according to "element". If the kernel size is 0, this function returns a copy of the data. Can also be a 2D array which is a custom structuring element. In this case "element" is ignored.
- **element** (*str*) – structural element, can be 'rect', 'cross', or 'ellipse'.
- **iterations** (*int*) – numer of times to repeat the operation
- **border_mode** (*str | int*) – Border code or cv2 integer. Border codes are constant (default) replicate, reflect, wrap, reflect101, and transparent.
- **border_value** (*int | float | Iterable[int | float]*) – Used as the fill value if border_mode is constant. Otherwise this is ignored.

Example

```
>>> from kwimage.im_cv2 import *  # NOQA
>>> import kwimage
>>> #image = kwimage.grab_test_image(dsize=(380, 380))
>>> image = kwimage.Mask.demo().data * 255
>>> basis = {
>>>     'mode': ['dilate'],
>>>     'kernel': [5, (3, 7)],
>>>     'element': ['rect', 'cross', 'ellipse'],
>>>     #'mode': ['dilate', 'erode'],
>>> }
>>> grid = list(ub.named_product(basis))
>>> grid += [{'mode': 'dilate', 'kernel': 0, 'element': 'rect', }]
>>> grid += [{'mode': 'dilate', 'kernel': 'random', 'element': 'custom'}]
>>> results = {}
>>> for params in grid:
...     key = ub.repr2(params, compact=1, si=0, nl=1)
...     if params['kernel'] == 'random':
...         params['kernel'] = np.random.rand(5, 5)
...     results[key] = morphology(image, **params)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> to_stack = []
>>> canvas = image
>>> canvas = kwimage.imresize(canvas, dsize=(380, 380), interpolation='nearest')
>>> canvas = kwimage.draw_header_text(canvas, 'input', color='kitware_green')
>>> to_stack.append(canvas)
>>> for key, result in results.items():
>>>     canvas = result
>>>     canvas = kwimage.imresize(canvas, dsize=(380, 380), interpolation='nearest')
>>>     canvas = kwimage.draw_header_text(canvas, key, color='kitware_green')
>>>     to_stack.append(canvas)
>>> canvas = kwimage.stack_images_grid(to_stack, pad=10, bg_value='kitware_blue')
>>> canvas = kwimage.draw_header_text(canvas, '--- kwimage.morphology demo ---',␣
↪color='kitware_green')
>>> kwplot.imshow(canvas)
>>> kwplot.show_if_requested()
```



Example

```
>>> from kwimage.im_cv2 import *  # NOQA
>>> from kwimage.im_cv2 import _CV2_MORPH_MODES  # NOQA
>>> from kwimage.im_cv2 import _CV2_STRUCT_ELEMENTS  # NOQA
>>> #shape = (32, 32)
>>> shape = (64, 64)
>>> data = (np.random.rand(*shape) > 0.5).astype(np.uint8)
>>> import kwimage
>>> data = kwimage.gaussian_patch(shape)
>>> data = data / data.max()
>>> data = kwimage.ensure_uint255(data)
>>> results = {}
>>> kernel = 5
>>> for mode in _CV2_MORPH_MODES.keys():
...     for element in _CV2_STRUCT_ELEMENTS.keys():
...         results[f'{mode}+{element}'] = morphology(data, mode, kernel=kernel,␣
↪element=element, iterations=2)
>>> results['raw'] = data
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> pnum_ = kwplot.PlotNums(nCols=3, nSubplots=len(results))
```

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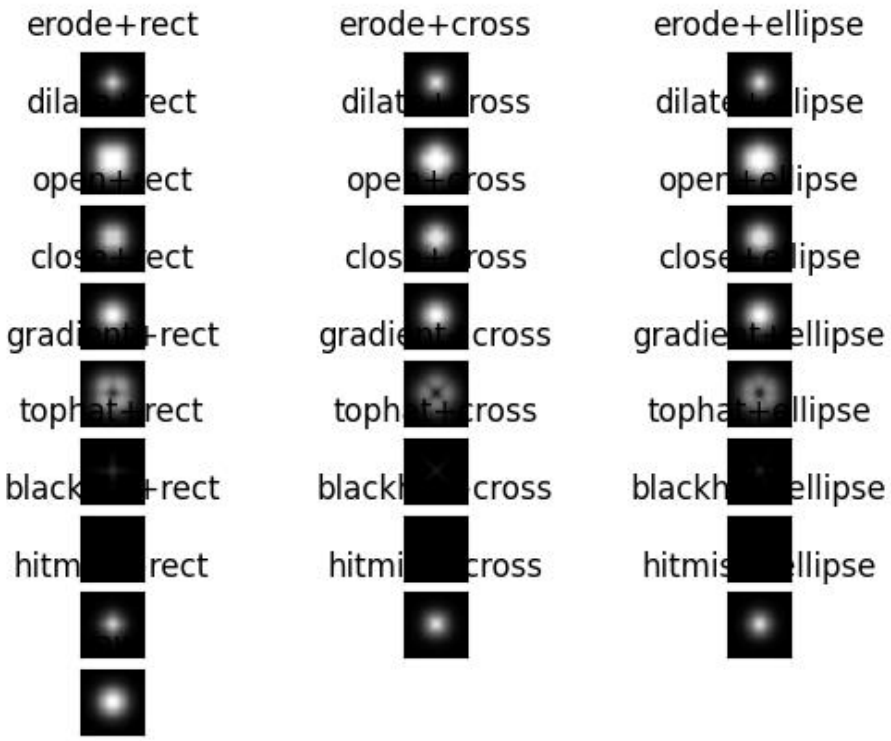
```
>>> for k, result in results.items():
>>>     kwplot.imshow(result, pnum=pnum_(), title=k)
>>> kwplot.show_if_requested()
```



References

https://opencv24-python-tutorials.readthedocs.io/en/latest/py_tutorials/py_imgproc/py_morphological_ops/py_morphological_ops.html

kwimage.**nodata_checkerboard**(*canvas*, *square_shape=8*)

Fills nans or masked values with a checkerbord pattern.

Parameters

- **canvas** (*ndarray*) – A 2D image with any number of channels.
- **square_shape** (*int*) – the pixel size of the checkers

Returns

an output array with imputed values.
if the input was a masked array, the mask will still exist.

Return type
ndarray

SeeAlso:
fill_nans_with_checkers() - similar, but only operates on nan values.

Example

```
>>> import kwimage
>>> # Test a masked array WITH nan values
>>> data = kwimage.grab_test_image(space='rgb')
>>> na_circle = kwimage.Polygon.circle((256 - 96, 256), 128)
>>> ma_circle = kwimage.Polygon.circle((256 + 96, 256), 128)
>>> ma_mask = na_circle.fill(np.zeros(data.shape, dtype=np.uint8), value=1).
↪astype(bool)
>>> na_mask = ma_circle.fill(np.zeros(data.shape, dtype=np.uint8), value=1).
↪astype(bool)
>>> # Hack the channels to make a ven diagram
>>> ma_mask[..., 0] = False
>>> na_mask[..., 2] = False
>>> data = kwimage.ensure_float01(data)
>>> data[na_mask] = np.nan
>>> canvas = np.ma.MaskedArray(data, ma_mask)
>>> kwimage.draw_text_on_image(canvas, 'masked values', (256 - 96, 256 - 128),␣
↪halign='center', valign='bottom', border=2)
>>> kwimage.draw_text_on_image(canvas, 'nan values',    (256 + 96, 256 + 128),␣
↪halign='center', valign='top', border=2)
>>> kwimage.draw_text_on_image(canvas, 'kwimage.nodata_checkerboard',    (256, 5),␣
↪halign='center', valign='top', border=2)
>>> kwimage.draw_text_on_image(canvas, '(pip install kwimage)', (512, 512 - 10),␣
↪halign='right', valign='bottom', border=2, fontScale=0.8)
>>> result = kwimage.nodata_checkerboard(canvas)
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(result)
>>> kwplot.show_if_requested()
```

Example

```
>>> # Simple test with a masked array
>>> import kwimage
>>> data = kwimage.grab_test_image(space='rgb', dsize=(64, 64))
>>> data = kwimage.ensure_uint255(data)
>>> circle = kwimage.Polygon.circle((32, 32), 16)
>>> mask = circle.fill(np.zeros(data.shape, dtype=np.uint8), value=1).astype(bool)
>>> img = np.ma.MaskedArray(data, mask)
>>> canvas = img.copy()
>>> result = kwimage.nodata_checkerboard(canvas)
>>> canvas.data is result.data
>>> # xdoc: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(result, title='nodata_checkers with masked uint8')
>>> kwplot.show_if_requested()
```

kwimage.**non_max_supression**(*ltrb*, *scores*, *thresh*, *bias=0.0*, *classes=None*, *impl='auto'*, *device_id=None*)

Non-Maximum Suppression - remove redundant bounding boxes

Parameters

- **ltrb** (*ndarray[Any, Float32]*) – Float32 array of shape Nx4 representing boxes in ltrb format
- **scores** (*ndarray[Any, Float32]*) – Float32 array of shape N representing scores for each box
- **thresh** (*float*) – iou threshold. Boxes are removed if they overlap greater than this threshold (i.e. Boxes are removed if iou > threshold). Thresh = 0 is the most strict, resulting in the fewest boxes, and 1 is the most permissive resulting in the most.
- **bias** (*float*) – bias for iou computation either 0 or 1
- **classes** (*ndarray[Shape[''*], Int64] | None*) – integer classes. If specified NMS is done on a perclass basis.
- **impl** (*str*) – implementation can be "auto", "python", "cython_cpu", "gpu", "torch", or "torchvision".
- **device_id** (*int*) – used if impl is gpu, device id to work on. If not specified *torch.cuda.current_device()* is used.

Note: Using impl='cython_gpu' may result in an CUDA memory error that is not exposed to the python processes. In other words your program will hard crash if impl='cython_gpu', and you feed it too many bounding

boxes. Ideally this will be fixed in the future.

References

https://github.com/facebookresearch/Detectron/blob/master/detectron/utils/cython_nms.pyx https://www.pyimagesearch.com/2015/02/16/faster-non-maximum-suppression-python/ https://github.com/bharatsingh430/soft-nms/blob/master/lib/nms/cpu_nms.pyx <- TODO

CommandLine

```
xdoctest -m ~/code/kwimage/kwimage/algo/algo_nms.py non_max_supression
```

Example

```
>>> from kwimage.algo.algo_nms import *
>>> from kwimage.algo.algo_nms import _impls
>>> ltrb = np.array([
>>>     [0, 0, 100, 100],
>>>     [100, 100, 10, 10],
>>>     [10, 10, 100, 100],
>>>     [50, 50, 100, 100],
>>> ], dtype=np.float32)
>>> scores = np.array([.1, .5, .9, .1])
>>> keep = non_max_supression(ltrb, scores, thresh=0.5, impl='numpy')
>>> print('keep = {!r}'.format(keep))
>>> assert keep == [2, 1, 3]
>>> thresh = 0.0
>>> non_max_supression(ltrb, scores, thresh, impl='numpy')
>>> if 'numpy' in available_nms_impls():
>>>     keep = non_max_supression(ltrb, scores, thresh, impl='numpy')
>>>     assert list(keep) == [2, 1]
>>> if 'cython_cpu' in available_nms_impls():
>>>     keep = non_max_supression(ltrb, scores, thresh, impl='cython_cpu')
>>>     assert list(keep) == [2, 1]
>>> if 'cython_gpu' in available_nms_impls():
>>>     keep = non_max_supression(ltrb, scores, thresh, impl='cython_gpu')
>>>     assert list(keep) == [2, 1]
>>> if 'torch' in available_nms_impls():
>>>     keep = non_max_supression(ltrb, scores, thresh, impl='torch')
>>>     assert set(keep.tolist()) == {2, 1}
>>> if 'torchvision' in available_nms_impls():
>>>     keep = non_max_supression(ltrb, scores, thresh, impl='torchvision')  # note␣
↪torchvision has no bias
>>>     assert list(keep) == [2]
>>> thresh = 1.0
>>> if 'numpy' in available_nms_impls():
>>>     keep = non_max_supression(ltrb, scores, thresh, impl='numpy')
>>>     assert list(keep) == [2, 1, 3, 0]
>>> if 'cython_cpu' in available_nms_impls():
```

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```
>>>     keep = non_max_supression(ltrb, scores, thresh, impl='cython_cpu')
>>>     assert list(keep) == [2, 1, 3, 0]
>>> if 'cython_gpu' in available_nms_impls():
>>>     keep = non_max_supression(ltrb, scores, thresh, impl='cython_gpu')
>>>     assert list(keep) == [2, 1, 3, 0]
>>> if 'torch' in available_nms_impls():
>>>     keep = non_max_supression(ltrb, scores, thresh, impl='torch')
>>>     assert set(keep.tolist()) == {2, 1, 3, 0}
>>> if 'torchvision' in available_nms_impls():
>>>     keep = non_max_supression(ltrb, scores, thresh, impl='torchvision')  # note␣
↪torchvision has no bias
>>>     assert set(kwarray.ArrayAPI.tolist(keep)) == {2, 1, 3, 0}
```

Example

```
>>> import ubelt as ub
>>> ltrb = np.array([
>>>     [0, 0, 100, 100],
>>>     [100, 100, 10, 10],
>>>     [10, 10, 100, 100],
>>>     [50, 50, 100, 100],
>>>     [100, 100, 150, 101],
>>>     [120, 100, 180, 101],
>>>     [150, 100, 200, 101],
>>> ], dtype=np.float32)
>>> scores = np.linspace(0, 1, len(ltrb))
>>> thresh = .2
>>> solutions = {}
>>> if not _impls._funcs:
>>>     _impls._lazy_init()
>>> for impl in _impls._funcs:
>>>     keep = non_max_supression(ltrb, scores, thresh, impl=impl)
>>>     solutions[impl] = sorted(keep)
>>> assert 'numpy' in solutions
>>> print('solutions = {}'.format(ub.repr2(solutions, nl=1)))
>>> assert ub.allsame(solutions.values())
```

CommandLine

```
xdoctest -m ~/code/kwimage/kwimage/algo/algo_nms.py non_max_supression
```

Example

```
>>> import ubelt as ub
>>> # Check that zero-area boxes are ok
>>> ltrb = np.array([
>>>     [0, 0, 0, 0],
>>>     [0, 0, 0, 0],
>>>     [10, 10, 10, 10],
>>> ], dtype=np.float32)
>>> scores = np.array([1, 2, 3], dtype=np.float32)
>>> thresh = .2
>>> solutions = {}
>>> if not _impls._funcs:
>>>     _impls._lazy_init()
>>> for impl in _impls._funcs:
>>>     keep = non_max_supression(ltrb, scores, thresh, impl=impl)
>>>     solutions[impl] = sorted(keep)
>>> assert 'numpy' in solutions
>>> print('solutions = {}'.format(ub.repr2(solutions, nl=1)))
>>> assert ub.allsame(solutions.values())
```

kwimage.**normalize**(*arr*, *mode='linear'*, *alpha=None*, *beta=None*, *out=None*)

Rebalance pixel intensities via contrast stretching.

By default linearly stretches pixel intensities to minimum and maximum values.

Note: DEPRECATED: this function has been MOVED to `kwarray.normalize`

---

kwimage.**normalize_intensity**(*imdata*, *return_info=False*, *nodata=None*, *axis=None*, *dtype=<class 'numpy.float32'>*, *params='auto'*, *mask=None*)

Normalize data intensities using heuristics to help put sensor data with extremely high or low contrast into a visible range.

This function is designed with an emphasis on getting something that is reasonable for visualization.

Todo:

- [ ] Move to kwarray and renamed to robust_normalize?
- [ ] Support for M-estimators?

Parameters

- **imdata** (*ndarray*) – raw intensity data
- **return_info** (*bool*) – if True, return information about the chosen normalization heuristic.
- **params** (*str | dict*) – can contain keys, low, high, or center e.g. {'low': 0.1, 'center': 0.8, 'high': 0.9}

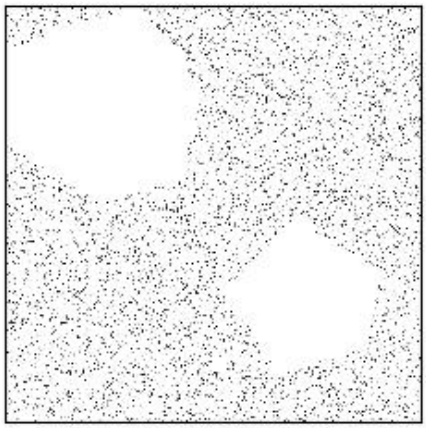
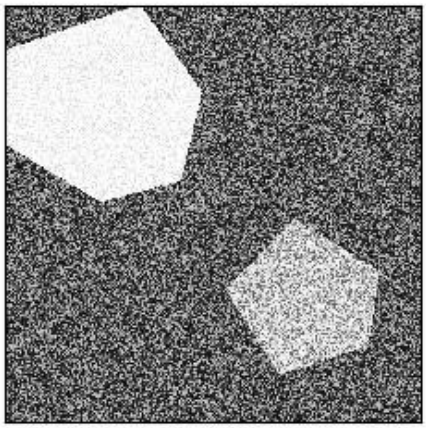
- **axis** (*None | int*) – The axis to normalize over, if unspecified, normalize jointly
- **nodata** (*None | int*) – A value representing nodata to leave unchanged during normalization, for example 0
- **dtype** (*type*) – can be float32 or float64
- **mask** (*ndarray | None*) – A mask indicating what pixels are valid and what pixels should be considered nodata. Mutually exclusive with `nodata` argument. A mask value of 1 indicates a VALID pixel. A mask value of 0 indicates an INVALID pixel.

Returns
a floating point array with values between 0 and 1.

Return type
ndarray

Example

```
>>> from kwimage.im_core import *  # NOQA
>>> import ubelt as ub
>>> import kwimage
>>> import kwarray
>>> s = 512
>>> bit_depth = 11
>>> dtype = np.uint16
>>> max_val = int(2 ** bit_depth)
>>> min_val = int(0)
>>> rng = kwarray.ensure_rng(0)
>>> background = np.random.randint(min_val, max_val, size=(s, s), dtype=dtype)
>>> poly1 = kwimage.Polygon.random(rng=rng).scale(s / 2)
>>> poly2 = kwimage.Polygon.random(rng=rng).scale(s / 2).translate(s / 2)
>>> forground = np.zeros_like(background, dtype=np.uint8)
>>> forground = poly1.fill(forground, value=255)
>>> forground = poly2.fill(forground, value=122)
>>> forground = (kwimage.ensure_float01(forground) * max_val).astype(dtype)
>>> imdata = background + forground
>>> normed, info = normalize_intensity(imdata, return_info=True)
>>> print('info = {}'.format(ub.repr2(info, nl=1)))
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(imdata, pnum=(1, 2, 1), fnum=1)
>>> kwplot.imshow(normed, pnum=(1, 2, 2), fnum=1)
```

Example

```
>>> from kwimage.im_core import *  # NOQA
>>> import ubelt as ub
>>> import kwimage
>>> # Test on an image that is already normalized to test how it
>>> # degrades
>>> imdata = kwimage.grab_test_image() / 255
```

```
>>> quantile_basis = {
>>>     'mode': ['linear', 'sigmoid'],
>>>     'high': [0.8, 0.9, 1.0],
>>> }
>>> quantile_grid = list(ub.named_product(quantile_basis))
>>> quantile_grid += ['auto']
>>> rows = []
>>> rows.append({'key': 'orig', 'result': imdata})
>>> for params in quantile_grid:
>>>     key = ub.repr2(params, compact=1)
>>>     result, info = normalize_intensity(imdata, return_info=True, params=params)
>>>     print('key = {}'.format(key))
>>>     print('info = {}'.format(ub.repr2(info, nl=1)))
>>>     rows.append({'key': key, 'info': info, 'result': result})
```

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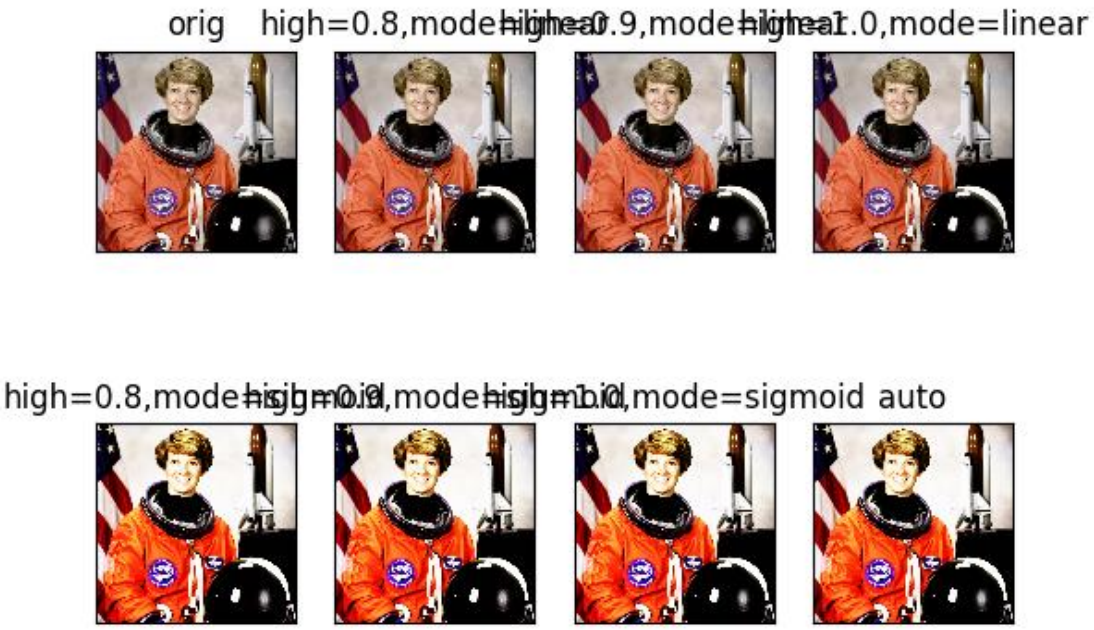
```
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> pnum_ = kwplot.PlotNums(nSubplots=len(rows))
>>> for row in rows:
>>>     _, ax = kwplot.imshow(row['result'], fnum=1, pnum=pnum_())
>>>     ax.set_title(row['key'])
```



kwimage.**num_channels**(*img*)

Returns the number of color channels in an image.

Assumes images are 2D and the the channels are the trailing dimension. Returns 1 in the case with no trailing channel dimension, otherwise simply returns `img.shape[2]`.

Parameters

img (*ndarray*) – an image with 2 or 3 dimensions.

Returns

the number of color channels (1, 3, or 4)

Return type

int

Example

```
>>> H = W = 3
>>> assert num_channels(np.empty((W, H))) == 1
>>> assert num_channels(np.empty((W, H, 1))) == 1
>>> assert num_channels(np.empty((W, H, 3))) == 3
>>> assert num_channels(np.empty((W, H, 4))) == 4
>>> assert num_channels(np.empty((W, H, 2))) == 2
```

kwimage.**overlay_alpha_images**(*img1*, *img2*, *keepalpha=True*, *dtype=<class 'numpy.float32'>*, *impl='inplace'*)

Places img1 on top of img2 respecting alpha channels. Works like the Photoshop layers with opacity.

Parameters

- **img1** (*ndarray*) – top image to overlay over img2
- **img2** (*ndarray*) – base image to superimpose on
- **keepalpha** (*bool*) – if False, the alpha channel is removed after blending
- **dtype** (*np.dtype*) – format for blending computation (defaults to float32)
- **impl** (*str*) – code specifying the backend implementation

Returns

raster: the blended images

Return type

ndarray

Todo:

- [ ] Make fast C++ version of this function

Example

```
>>> import kwimage
>>> img1 = kwimage.grab_test_image('astro', dsize=(100, 100))
>>> img2 = kwimage.grab_test_image('carl', dsize=(100, 100))
>>> img1 = kwimage.ensure_alpha_channel(img1, alpha=.5)
>>> img3 = kwimage.overlay_alpha_images(img1, img2)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(img3)
>>> kwplot.show_if_requested()
```

kwimage.**overlay_alpha_layers**(*layers*, *keepalpha=True*, *dtype=<class 'numpy.float32'>*)

Stacks a sequences of layers on top of one another. The first item is the topmost layer and the last item is the bottommost layer.

Parameters

- **layers** (*Sequence[ndarray]*) – stack of images
- **keepalpha** (*bool*) – if False, the alpha channel is removed after blending
- **dtype** (*np.dtype*) – format for blending computation (defaults to float32)

Returns

raster: the blended images

Return type

ndarray

Example

```
>>> import kwimage
>>> keys = ['astro', 'carl', 'stars']
>>> layers = [kwimage.grab_test_image(k, dsize=(100, 100)) for k in keys]
>>> layers = [kwimage.ensure_alpha_channel(g, alpha=.5) for g in layers]
>>> stacked = kwimage.overlay_alpha_layers(layers)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(stacked)
>>> kwplot.show_if_requested()
```

kwimage.**padded_slice**(*data*, *in_slice*, *pad=None*, *padkw=None*, *return_info=False*)

Allows slices with out-of-bound coordinates. Any out of bounds coordinate will be sampled via padding.

DEPRECATED FOR THE VERSION IN KWARRAY (slices are more array-ish than image-ish)

Note: Negative slices have a different meaning here then they usually do. Normally, they indicate a wrap-around or a reversed stride, but here they index into out-of-bounds space (which depends on the pad mode). For example a slice of -2:1 literally samples two pixels to the left of the data and one pixel from the data, so you get two padded values and one data value.

Parameters

- **data** (*Sliceable*) – data to slice into. Any channels must be the last dimension.
- **in_slice** (*slice | Tuple[slice, ...]*) – slice for each dimensions
- **ndim** (*int*) – number of spatial dimensions
- **pad** (*List[int|Tuple]*) – additional padding of the slice
- **padkw** (*Dict*) – if unspecified defaults to `{'mode': 'constant'}`
- **return_info** (*bool*) – if True, return extra information about the transform. Defaults to False.

SeeAlso:
_padded_slice_embed - finds the embedded slice and padding _padded_slice_apply - applies padding to sliced data

Returns

data_sliced: subregion of the input data (possibly with padding,
depending on if the original slice went out of bounds)

Tuple[Sliceable, Dict] :
data_sliced : as above

transform : information on how to return to the original coordinates

Currently a dict containing:

st_dims: a list indicating the low and high space-time
coordinate values of the returned data slice.

The structure of this dictionary mach change in the future

Return type
Sliceable

Example

```
>>> data = np.arange(5)
>>> in_slice = [slice(-2, 7)]
```

```
>>> data_sliced = padded_slice(data, in_slice)
>>> print(ub.repr2(data_sliced, with_dtype=False))
np.array([0, 0, 0, 1, 2, 3, 4, 0, 0])
```

```
>>> data_sliced = padded_slice(data, in_slice, pad=(3, 3))
>>> print(ub.repr2(data_sliced, with_dtype=False))
np.array([0, 0, 0, 0, 0, 0, 1, 2, 3, 4, 0, 0, 0, 0, 0])
```

```
>>> data_sliced = padded_slice(data, slice(3, 4), pad=[(1, 0)])
>>> print(ub.repr2(data_sliced, with_dtype=False))
np.array([2, 3])
```

kwimage.**profile**(*arg=None*, **args*, ***kwargs*)

Return the value of the first argument unchanged.

All other positional and keyword inputs are ignored. Defaults to None if called without any args.

The name identity is used in the mathematical sense [WikiIdentity]. This is slightly different than the pure identity function, which is defined strictly with a single argument. This implementation allows but ignores extra arguments, making it easier to use as a drop in replacement for functions that accept extra configuration arguments that change their behavior and aren't true inputs.

The value of this utility is a cleaner way to write `lambda x:  x` or more precisely `lambda x=None, *a, **k:  x` or writing the function inline. Unlike the lambda variant, this does not trigger common linter errors when assigning it to a value.

Parameters

- **arg** (*Any, default=None*) – The value to return unchanged.
- ***args** – Ignored
- ****kwargs** – Ignored

Returns

arg - The same value of the first positional argument.

Return type

Any

References

Example

```
>>> import ubelt as ub
>>> ub.identity(42)
42
>>> ub.identity(42, 43)
42
>>> ub.identity()
None
```

kwimage.**radial_fourier_mask**(*img_hwc*, *radius=11*, *axis=None*, *clip=None*)

In [1] they use a radius of 11.0 on CIFAR-10.

Parameters

img_hwc (*ndarray*) – assumed to be float 01

References

[1] Jo and Bengio "Measuring the tendency of CNNs to Learn Surface Statistical Regularities" 2017. https://docs.opencv.org/3.0-beta/doc/py_tutorials/py_imgproc/py_transforms/py_fourier_transform/py_fourier_transform.html

Example

```
>>> from kwimage.im_filter import *  # NOQA
>>> import kwimage
>>> img_hwc = kwimage.grab_test_image()
>>> img_hwc = kwimage.ensure_float01(img_hwc)
>>> out_hwc = radial_fourier_mask(img_hwc, radius=11)
>>> # xdoc: REQUIRES(--show)
>>> import kwplot
>>> plt = kwplot.autoplt()
>>> def keepdim(func):
>>>     def _wrap(im):
>>>         needs_transpose = (im.shape[0] == 3)
>>>         if needs_transpose:
>>>             im = im.transpose(1, 2, 0)
>>>         out = func(im)
>>>         if needs_transpose:
>>>             out = out.transpose(2, 0, 1)
>>>         return out
>>>     return _wrap
>>> @keepdim
>>> def rgb_to_lab(im):
>>>     return kwimage.convert_colorspace(im, src_space='rgb', dst_space='lab')
>>> @keepdim
>>> def lab_to_rgb(im):
>>>     return kwimage.convert_colorspace(im, src_space='lab', dst_space='rgb')
>>> @keepdim
>>> def rgb_to_yuv(im):
>>>     return kwimage.convert_colorspace(im, src_space='rgb', dst_space='yuv')
>>> @keepdim
>>> def yuv_to_rgb(im):
>>>     return kwimage.convert_colorspace(im, src_space='yuv', dst_space='rgb')
>>> def show_data(img_hwc):
>>>     # dpath = ub.ensuredir('./fouriertest')
>>>     kwplot.imshow(img_hwc, fnum=1)
>>>     pnum_ = kwplot.PlotNums(nRows=4, nCols=5)
>>>     for r in range(0, 17):
>>>         imgt = radial_fourier_mask(img_hwc, r, clip=(0, 1))
>>>         kwplot.imshow(imgt, pnum=pnum_(), fnum=2)
>>>         plt.gca().set_title('r = {}'.format(r))
>>>     kwplot.set_figtitle('RGB')
>>>     # plt.gcf().savefig(join(dpath, '{}_{:08d}.png'.format('rgb', x)))
>>>     pnum_ = kwplot.PlotNums(nRows=4, nCols=5)
>>>     for r in range(0, 17):
>>>         imgt = lab_to_rgb(radial_fourier_mask(rgb_to_lab(img_hwc), r))
>>>         kwplot.imshow(imgt, pnum=pnum_(), fnum=3)
>>>         plt.gca().set_title('r = {}'.format(r))
>>>     kwplot.set_figtitle('LAB')
>>>     # plt.gcf().savefig(join(dpath, '{}_{:08d}.png'.format('lab', x)))
>>>     pnum_ = kwplot.PlotNums(nRows=4, nCols=5)
>>>     for r in range(0, 17):
>>>         imgt = yuv_to_rgb(radial_fourier_mask(rgb_to_yuv(img_hwc), r))
>>>         kwplot.imshow(imgt, pnum=pnum_(), fnum=4)
```

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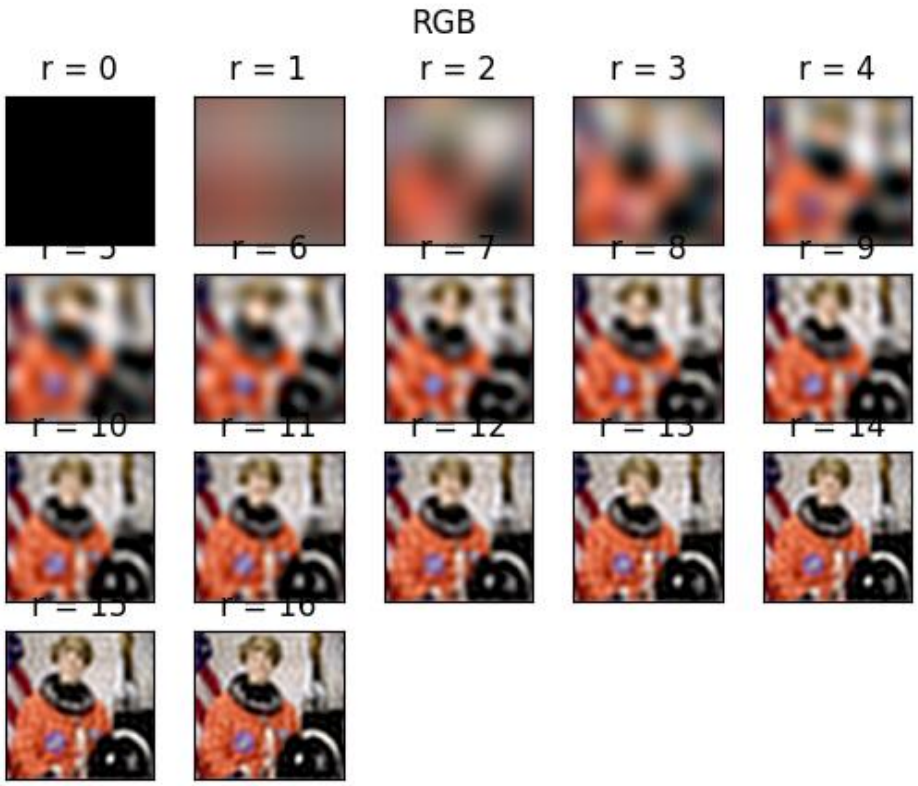
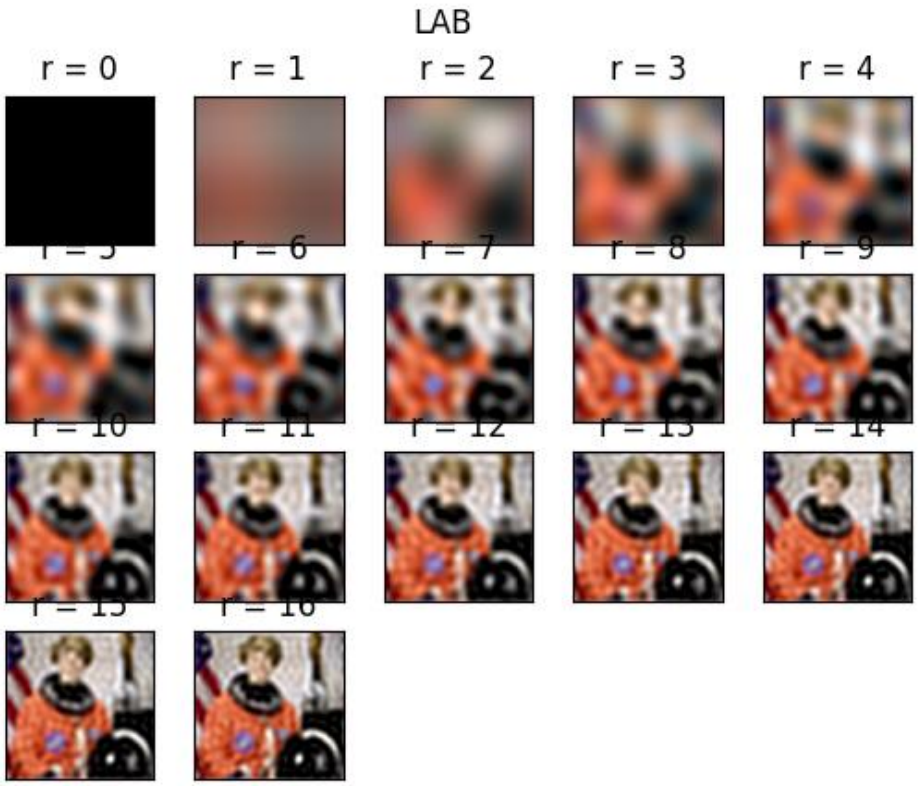
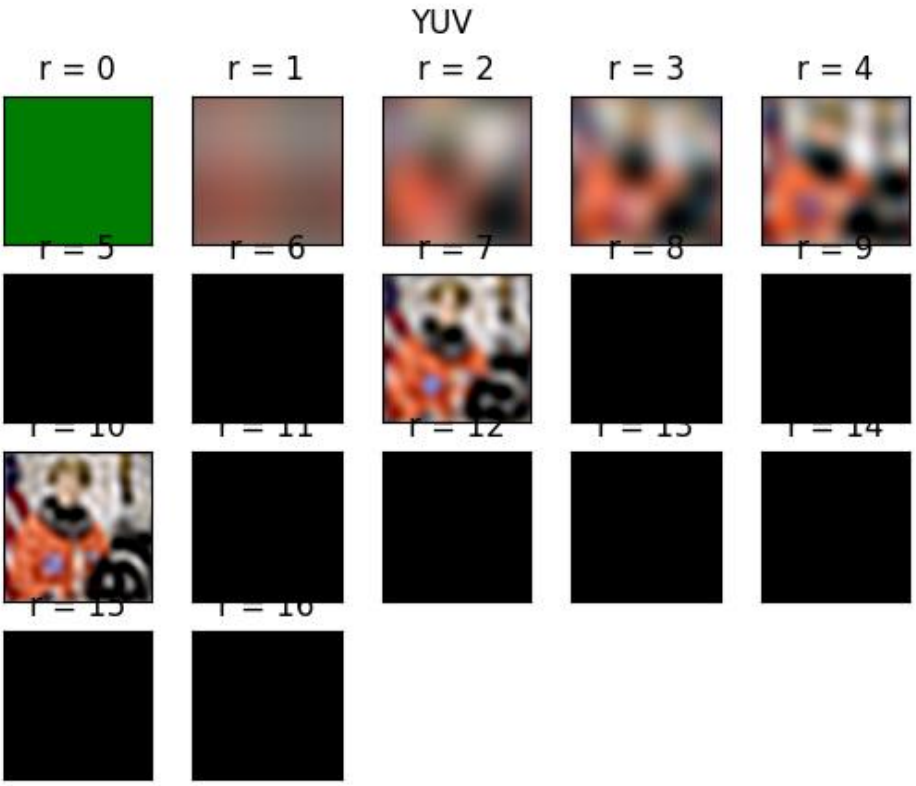
```
>>>         plt.gca().set_title('r = {}'.format(r))
>>>     kwplot.set_figtitle('YUV')
>>>     # plt.gcf().savefig(join(dpath, '{}_{:08d}.png'.format('yuv', x)))
>>> show_data(img_hwc)
>>> kwplot.show_if_requested()
```


RGB
r = 0
r = 1
r = 2
r = 3
r = 4
r = 6
r = 7
r = 8
r = 9
r = 10
r = 11
r = 12
r = 13
r = 14
r = 16


LAB
r = 0
r = 1
r = 2
r = 3
r = 4
r = 6
r = 7
r = 8
r = 9
r = 10
r = 11
r = 12
r = 13
r = 14
r = 15
r = 16



kwimage.**remove_homog**(*pts*, *mode='divide'*)

Remove homogenous coordinate to a point array.

This is a convinience function, it is not particularly efficient.

SeeAlso:
cv2.convertPointsFromHomogeneous

Example

```
>>> homog_pts = np.random.rand(10, 3)
>>> remove_homog(homog_pts, 'divide')
>>> remove_homog(homog_pts, 'drop')
```

kwimage.**rle_translate**(*rle*, *offset*, *output_shape=None*)

Translates a run-length encoded image in RLE-space.

Parameters

- **rle** (*dict*) – an enconding dict returned by *kwimage.encode_run_length()*
- **offset** (*Tuple[int, int]*) – x, y integer offsets.
- **output_shape** (*Tuple[int, int]*) – h,w of transformed mask. If unspecified the input rle shape is used.

SeeAlso:

ITK has some RLE code that looks like it can perform translations https://github.com/KitwareMedical/ITKRLEImage/blob/master/include/itkRLERegionOfInterestImageFilter.h

Doctest

```
>>> # test that translate works on all zero images
>>> img = np.zeros((7, 8), dtype=np.uint8)
>>> rle = encode_run_length(img, binary=True, order='F')
>>> new_rle = rle_translate(rle, (1, 2), (6, 9))
>>> assert np.all(new_rle['counts'] == [54])
```

Example

```
>>> from kwimage.im_runlen import *  # NOQA
>>> img = np.array([
>>>     [1, 1, 1, 1],
>>>     [0, 1, 0, 0],
>>>     [0, 1, 0, 1],
>>>     [1, 1, 1, 1],], dtype=np.uint8)
>>> rle = encode_run_length(img, binary=True, order='C')
>>> offset = (1, -1)
>>> output_shape = (3, 5)
>>> new_rle = rle_translate(rle, offset, output_shape)
>>> decoded = decode_run_length(**new_rle)
>>> print(decoded)
[[0 0 1 0 0]
 [0 0 1 0 1]
 [0 1 1 1 1]]
```

Example

```
>>> from kwimage.im_runlen import *  # NOQA
>>> img = np.array([
>>>     [0, 0, 0],
>>>     [0, 1, 0],
>>>     [0, 0, 0]], dtype=np.uint8)
>>> rle = encode_run_length(img, binary=True, order='C')
>>> new_rle = rle_translate(rle, (1, 0))
>>> decoded = decode_run_length(**new_rle)
>>> print(decoded)
[[0 0 0]
 [0 0 1]
 [0 0 0]]
>>> new_rle = rle_translate(rle, (0, 1))
>>> decoded = decode_run_length(**new_rle)
>>> print(decoded)
[[0 0 0]
 [0 0 0]
 [0 1 0]]
```

kwimage.**smooth_prob**(*prob*, *k=3*, *inplace=False*, *eps=1e-09*)

Smooths the probability map, but preserves the magnitude of the peaks.

Note: even if inplace is true, we still need to make a copy of the input array, however, we do ensure that it is cleaned up before we leave the function scope.

sigma=0.8 @ k=3, sigma=1.1 @ k=5, sigma=1.4 @ k=7

---

kwimage.**stack_images**(*images*, *axis=0*, *resize=None*, *interpolation=None*, *overlap=0*, *return_info=False*, *bg_value=None*, *pad=None*, *allow_casting=True*)

Make a new image with the input images side-by-side

Parameters

- **images** (*Iterable[ndarray]*) – image data
- **axis** (*int*) – axis to stack on (either 0 or 1)
- **resize** (*int | str | None*) – if None image sizes are not modified, otherwise resize resize can be either 0 or 1. We resize the *resize*-th image to match the *1 - resize*-th image. Can also be strings "larger" or "smaller".
- **interpolation** (*int | str*) – string or cv2-style interpolation type. only used if resize or overlap > 0
- **overlap** (*int*) – number of pixels to overlap. Using a negative number results in a border.
- **pad** (*int*) – if specified overrides *overlap* as a the number of pixels to pad between images.
- **return_info** (*bool*) – if True, returns transforms (scales and translations) to map from original image to its new location.
- **bg_value** (*Number | ndarray | str*) – background value or color, if specified, uses this as a fill value.
- **allow_casting** (*bool*) – if True, then if "uint255" and "float01" format images are given they are converted to "float01". Defaults to True.

Returns

an image of stacked images side by side

Tuple[ndarray, List]: where the first item is the aformentioned stacked
image and the second item is a list of transformations for each input image mapping it to its location in the returned image.

Return type
ndarray

SeeAlso:
kwimage.im_stack.stack_images_grid()

Example

```
>>> import kwimage
>>> img1 = kwimage.grab_test_image('carl', space='rgb')
>>> img2 = kwimage.grab_test_image('astro', space='rgb')
>>> images = [img1, img2]
>>> imgB, transforms = kwimage.stack_images(
>>>     images, axis=0, resize='larger', pad=10, return_info=True)
>>> print('imgB.shape = {}'.format(imgB.shape))
>>> # xdoctest: +REQUIRES(--show)
>>> # xdoctest: +REQUIRES(module:kwplot)
>>> import kwplot
>>> import kwimage
>>> kwplot.autompl()
>>> kwplot.imshow(imgB, colorspace='rgb')
>>> wh1 = np.multiply(img1.shape[0:2][::-1], transforms[0].scale)
>>> wh2 = np.multiply(img2.shape[0:2][::-1], transforms[1].scale)
>>> xoff1, yoff1 = transforms[0].translation
>>> xoff2, yoff2 = transforms[1].translation
>>> xywh1 = (xoff1, yoff1, wh1[0], wh1[1])
>>> xywh2 = (xoff2, yoff2, wh2[0], wh2[1])
>>> kwplot.draw_boxes(kwimage.Boxes([xywh1], 'xywh'), color=(1.0, 0, 0))
>>> kwplot.draw_boxes(kwimage.Boxes([xywh2], 'xywh'), color=(1.0, 0, 0))
>>> kwplot.show_if_requested()
```

kwimage.**stack_images_grid**(*images*, *chunksize=None*, *axis=0*, *overlap=0*, *pad=None*, *return_info=False*, *bg_value=None*, *resize=None*, *allow_casting=True*)

Stacks images in a grid. Optionally return transforms of original image positions in the output image.

Parameters

- **images** (*Iterable[ndarray]*) – image data
- **chunksize** (*int*) – number of rows per column or columns per row depending on the value of *axis*. If unspecified, computes this as *int(sqrt(len(images)))*.
- **axis** (*int*) – If 0, chunksize is columns per row. If 1, chunksize is rows per column. Defaults to 0.
- **overlap** (*int*) – number of pixels to overlap. Using a negative number results in a border.
- **pad** (*int*) – if specified overrides *overlap* as a the number of pixels to pad between images.
- **return_info** (*bool*) – if True, returns transforms (scales and translations) to map from original image to its new location.
- **resize** (*int | str | None*) – if None image sizes are not modified, otherwise can be set to "larger" or "smaller" to resize the images in each stack direction.
- **bg_value** (*Number | ndarray | str*) – background value or color, if specified, uses this as a fill value.
- **allow_casting** (*bool*) – if True, then if "uint255" and "float01" format images are given they are converted to "float01". Defaults to True.

Returns

an image of stacked images in a grid pattern

Tuple[ndarray, List]: where the first item is the aformentioned stacked
image and the second item is a list of transformations for each input image mapping it to its location in the returned image.

Return type
ndarray

SeeAlso:
kwimage.im_stack.stack_images()

Example

```
>>> import kwimage
>>> img1 = kwimage.grab_test_image('carl')
>>> img2 = kwimage.grab_test_image('astro')
>>> img3 = kwimage.grab_test_image('airport')
>>> img4 = kwimage.grab_test_image('paraview')[..., 0:3]
>>> img5 = kwimage.grab_test_image('pm5644')
>>> images = [img1, img2, img3, img4, img5]
>>> canvas, transforms = kwimage.stack_images_grid(
...     images, chunksize=3, axis=0, pad=10, bg_value='kitware_blue',
...     return_info=True, resize='larger')
>>> print('canvas.shape = {}'.format(canvas.shape))
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
```

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```
>>> import kwimage
>>> kwplot.autompl()
>>> kwplot.imshow(canvas)
>>> kwplot.show_if_requested()
```

kwimage.**subpixel_accum**(*dst*, *src*, *index*, *interp_axes=None*)

Add the source values array into the destination array at a particular subpixel index.

Parameters

- **dst** (*ArrayLike*) – destination accumulation array
- **src** (*ArrayLike*) – source array containing values to add
- **index** (*Tuple[slice]*) – subpixel slice into dst that corresponds with src
- **interp_axes** (*tuple*) – specify which axes should be spatially interpolated

TextArt

```
Inputs:
    +---+---+---+---+---+  dst.shape = (5,)
          +---+---+        src.shape = (2,)
          |=======|        index = 1.5:3.5

Subpixel shift the source by -0.5.
When the index is non-integral, pad the aligned src with an extra value
to ensure all dst pixels that would be influenced by the smaller
subpixel shape are influenced by the aligned src. Note that we are not
scaling.

        +---+---+---+      aligned_src.shape = (3,)
        |===========|      aligned_index = 1:4
```

Example

```
>>> dst = np.zeros(5)
>>> src = np.ones(2)
>>> index = [slice(1.5, 3.5)]
>>> subpixel_accum(dst, src, index)
>>> print(ub.repr2(dst, precision=2, with_dtype=0))
np.array([0. , 0.5, 1. , 0.5, 0. ])
```

Example

```
>>> dst = np.zeros((6, 6))
>>> src = np.ones((3, 3))
>>> index = (slice(1.5, 4.5), slice(1, 4))
>>> subpixel_accum(dst, src, index)
>>> print(ub.repr2(dst, precision=2, with_dtype=0))
np.array([[0. , 0. , 0. , 0. , 0. , 0. ],
          [0. , 0.5, 0.5, 0.5, 0. , 0. ],
          [0. , 1. , 1. , 1. , 0. , 0. ],
          [0. , 1. , 1. , 1. , 0. , 0. ],
          [0. , 0.5, 0.5, 0.5, 0. , 0. ],
          [0. , 0. , 0. , 0. , 0. , 0. ]])
>>> # xdoctest: +REQUIRES(module:torch)
>>> dst = torch.zeros((1, 3, 6, 6))
>>> src = torch.ones((1, 3, 3, 3))
>>> index = (slice(None), slice(None), slice(1.5, 4.5), slice(1.25, 4.25))
>>> subpixel_accum(dst, src, index)
>>> print(ub.repr2(dst.numpy()[0, 0], precision=2, with_dtype=0))
np.array([[0.  , 0.  , 0.  , 0.  , 0.  , 0.  ],
          [0.  , 0.38, 0.5 , 0.5 , 0.12, 0.  ],
          [0.  , 0.75, 1.  , 1.  , 0.25, 0.  ],
          [0.  , 0.75, 1.  , 1.  , 0.25, 0.  ],
          [0.  , 0.38, 0.5 , 0.5 , 0.12, 0.  ],
          [0.  , 0.  , 0.  , 0.  , 0.  , 0.  ]])
```

Doctest

```
>>> # TODO: move to a unit test file
>>> subpixel_accum(np.zeros(5), np.ones(2), [slice(1.5, 3.5)]).tolist()
[0.0, 0.5, 1.0, 0.5, 0.0]
>>> subpixel_accum(np.zeros(5), np.ones(2), [slice(0, 2)]).tolist()
[1.0, 1.0, 0.0, 0.0, 0.0]
>>> subpixel_accum(np.zeros(5), np.ones(3), [slice(.5, 3.5)]).tolist()
[0.5, 1.0, 1.0, 0.5, 0.0]
>>> subpixel_accum(np.zeros(5), np.ones(3), [slice(-1, 2)]).tolist()
[1.0, 1.0, 0.0, 0.0, 0.0]
>>> subpixel_accum(np.zeros(5), np.ones(3), [slice(-1.5, 1.5)]).tolist()
[1.0, 0.5, 0.0, 0.0, 0.0]
>>> subpixel_accum(np.zeros(5), np.ones(3), [slice(10, 13)]).tolist()
[0.0, 0.0, 0.0, 0.0, 0.0]
>>> subpixel_accum(np.zeros(5), np.ones(3), [slice(3.25, 6.25)]).tolist()
[0.0, 0.0, 0.0, 0.75, 1.0]
>>> subpixel_accum(np.zeros(5), np.ones(3), [slice(4.9, 7.9)]).tolist()
[0.0, 0.0, 0.0, 0.0, 0.099...]
>>> subpixel_accum(np.zeros(5), np.ones(9), [slice(-1.5, 7.5)]).tolist()
[1.0, 1.0, 1.0, 1.0, 1.0]
>>> subpixel_accum(np.zeros(5), np.ones(9), [slice(2.625, 11.625)]).tolist()
[0.0, 0.0, 0.375, 1.0, 1.0]
>>> subpixel_accum(np.zeros(5), 1, [slice(2.625, 11.625)]).tolist()
[0.0, 0.0, 0.375, 1.0, 1.0]
```

kwimage.**subpixel_align**(*dst*, *src*, *index*, *interp_axes=None*)

Returns an aligned version of the source tensor and destination index.

Used as the backend to implement other subpixel functions like:
subpixel_accum, subpixel_maximum.

kwimage.**subpixel_getvalue**(*img*, *pts*, *coord_axes=None*, *interp='bilinear'*, *bordermode='edge'*)

Get values at subpixel locations

Parameters

- **img** (*ArrayLike*) – image to sample from
- **pts** (*ArrayLike*) – subpixel rc-coordinates to sample
- **coord_axes** (*Sequence*) – axes to perform interpolation on, if not specified the first *d* axes are interpolated, where *d=pts.shape[-1]*. IE: this indicates which axes each coordinate dimension corresponds to.
- **interp** (*str*) – interpolation mode
- **bordermode** (*str*) – how locations outside the image are handled

Example

```
>>> from kwimage.util_warp import *  # NOQA
>>> img = np.arange(3 * 3).reshape(3, 3)
>>> pts = np.array([[1, 1], [1.5, 1.5], [1.9, 1.1]])
>>> subpixel_getvalue(img, pts)
array([4. , 6. , 6.8])
>>> subpixel_getvalue(img, pts, coord_axes=(1, 0))
array([4. , 6. , 5.2])
>>> # xdoctest: +REQUIRES(module:torch)
>>> img = torch.Tensor(img)
>>> pts = torch.Tensor(pts)
>>> subpixel_getvalue(img, pts)
tensor([4.0000, 6.0000, 6.8000])
>>> subpixel_getvalue(img.numpy(), pts.numpy(), interp='nearest')
array([4., 8., 7.], dtype=float32)
>>> subpixel_getvalue(img.numpy(), pts.numpy(), interp='nearest', coord_axes=[1, 0])
array([4., 8., 5.], dtype=float32)
>>> subpixel_getvalue(img, pts, interp='nearest')
tensor([4., 8., 7.])
```

References

stackoverflow.com/uestions/12729228/simple-binlin-interp-images-numpy

SeeAlso:
cv2.getRectSubPix(image, patchSize, center[, patch[, patchType]])

kwimage.**subpixel_maximum**(*dst*, *src*, *index*, *interp_axes=None*)

Take the max of the source values array into and the destination array at a particular subpixel index. Modifies the destination array.

Parameters

- **dst** (*ArrayLike*) – destination array to index into
- **src** (*ArrayLike*) – source array that agrees with the index
- **index** (*Tuple[slice]*) – subpixel slice into dst that corresponds with src
- **interp_axes** (*tuple*) – specify which axes should be spatially interpolated

Example

```
>>> dst = np.array([0, 1.0, 1.0, 1.0, 0])
>>> src = np.array([2.0, 2.0])
>>> index = [slice(1.6, 3.6)]
>>> subpixel_maximum(dst, src, index)
>>> print(ub.repr2(dst, precision=2, with_dtype=0))
np.array([0. , 1. , 2. , 1.2, 0. ])
```

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> dst = torch.zeros((1, 3, 5, 5)) + .5
>>> src = torch.ones((1, 3, 3, 3))
>>> index = (slice(None), slice(None), slice(1.4, 4.4), slice(1.25, 4.25))
>>> subpixel_maximum(dst, src, index)
>>> print(ub.repr2(dst.numpy()[0, 0], precision=2, with_dtype=0))
np.array([[0.5 , 0.5 , 0.5 , 0.5 , 0.5 ],
          [0.5 , 0.5 , 0.6 , 0.6 , 0.5 ],
          [0.5 , 0.75, 1.  , 1.  , 0.5 ],
          [0.5 , 0.75, 1.  , 1.  , 0.5 ],
          [0.5 , 0.5 , 0.5 , 0.5 , 0.5 ]])
```

kwimage.**subpixel_minimum**(*dst*, *src*, *index*, *interp_axes=None*)

Take the min of the source values array into and the destination array at a particular subpixel index. Modifies the destination array.

Parameters

- **dst** (*ArrayLike*) – destination array to index into
- **src** (*ArrayLike*) – source array that agrees with the index
- **index** (*Tuple[slice]*) – subpixel slice into dst that corresponds with src
- **interp_axes** (*tuple*) – specify which axes should be spatially interpolated

Example

```
>>> dst = np.array([0, 1.0, 1.0, 1.0, 0])
>>> src = np.array([2.0, 2.0])
>>> index = [slice(1.6, 3.6)]
>>> subpixel_minimum(dst, src, index)
>>> print(ub.repr2(dst, precision=2, with_dtype=0))
np.array([0. , 0.8, 1. , 1. , 0. ])
```

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> dst = torch.zeros((1, 3, 5, 5)) + .5
>>> src = torch.ones((1, 3, 3, 3))
>>> index = (slice(None), slice(None), slice(1.4, 4.4), slice(1.25, 4.25))
>>> subpixel_minimum(dst, src, index)
>>> print(ub.repr2(dst.numpy()[0, 0], precision=2, with_dtype=0))
np.array([[0.5 , 0.5 , 0.5 , 0.5 , 0.5 ],
          [0.5 , 0.45, 0.5 , 0.5 , 0.15],
          [0.5 , 0.5 , 0.5 , 0.5 , 0.25],
          [0.5 , 0.5 , 0.5 , 0.5 , 0.25],
          [0.5 , 0.3 , 0.4 , 0.4 , 0.1 ]])
```

kwimage.**subpixel_set**(*dst*, *src*, *index*, *interp_axes=None*)

Add the source values array into the destination array at a particular subpixel index.

Parameters

- **dst** (*ArrayLike*) – destination accumulation array
- **src** (*ArrayLike*) – source array containing values to add
- **index** (*Tuple[slice]*) – subpixel slice into dst that corresponds with src
- **interp_axes** (*tuple*) – specify which axes should be spatially interpolated

---

Todo:

- [ ]: allow index to be a sequence indices

Example

```
>>> import kwimage
>>> dst = np.zeros(5) + .1
>>> src = np.ones(2)
>>> index = [slice(1.5, 3.5)]
>>> kwimage.util_warp.subpixel_set(dst, src, index)
>>> print(ub.repr2(dst, precision=2, with_dtype=0))
np.array([0.1, 0.5, 1. , 0.5, 0.1])
```

kwimage.**subpixel_setvalue**(*img*, *pts*, *value*, *coord_axes=None*, *interp='bilinear'*, *bordermode='edge'*)

Set values at subpixel locations

Parameters

- **img** (*ArrayLike*) – image to set values in
- **pts** (*ArrayLike*) – subpixel rc-coordinates to set
- **value** (*ArrayLike*) – value to place in the image
- **coord_axes** (*Sequence*) – axes to perform interpolation on, if not specified the first *d* axes are interpolated, where *d=pts.shape[-1]*. IE: this indicates which axes each coordinate dimension corresponds to.
- **interp** (*str*) – interpolation mode
- **bordermode** (*str*) – how locations outside the image are handled

Example

```
>>> from kwimage.util_warp import *  # NOQA
>>> img = np.arange(3 * 3).reshape(3, 3).astype(float)
>>> pts = np.array([[1, 1], [1.5, 1.5], [1.9, 1.1]])
>>> interp = 'bilinear'
>>> value = 0
>>> print('img = {!r}'.format(img))
>>> pts = np.array([[1.5, 1.5]])
>>> img2 = subpixel_setvalue(img.copy(), pts, value)
>>> print('img2 = {!r}'.format(img2))
>>> pts = np.array([[1.0, 1.0]])
```

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```
>>> img2 = subpixel_setvalue(img.copy(), pts, value)
>>> print('img2 = {!r}'.format(img2))
>>> pts = np.array([[1.1, 1.9]])
>>> img2 = subpixel_setvalue(img.copy(), pts, value)
>>> print('img2 = {!r}'.format(img2))
>>> img2 = subpixel_setvalue(img.copy(), pts, value, coord_axes=[1, 0])
>>> print('img2 = {!r}'.format(img2))
```

kwimage.**subpixel_slice**(*inputs*, *index*)

Take a subpixel slice from a larger image. The returned output is left-aligned with the requested slice.

Parameters

- **inputs** (*ArrayLike*) – data
- **index** (*Tuple[slice]*) – a slice to subpixel accuracy

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> import kwimage
>>> import torch
>>> # say we have a (576, 576) input space
>>> # and a (9, 9) output space downsampled by 64x
>>> ospc_feats = np.tile(np.arange(9 * 9).reshape(1, 9, 9), (1024, 1, 1))
>>> inputs = torch.from_numpy(ospc_feats)
>>> # We detected a box in the input space
>>> ispc_bbox = kwimage.Boxes([[64,  65, 100, 120]], 'ltrb')
>>> # Get coordinates in the output space
>>> ospc_bbox = ispc_bbox.scale(1 / 64)
>>> tl_x, tl_y, br_x, br_y = ospc_bbox.data[0]
>>> # Convert the box to a slice
>>> index = [slice(None), slice(tl_y, br_y), slice(tl_x, br_x)]
>>> # Note: I'm not 100% sure this work right with non-intergral slices
>>> outputs = kwimage.subpixel_slice(inputs, index)
```

Example

```
>>> inputs = np.arange(5 * 5 * 3).reshape(5, 5, 3)
>>> index = [slice(0, 3), slice(0, 3)]
>>> outputs = subpixel_slice(inputs, index)
>>> index = [slice(0.5, 3.5), slice(-0.5, 2.5)]
>>> outputs = subpixel_slice(inputs, index)
```

```
>>> inputs = np.arange(5 * 5).reshape(1, 5, 5).astype(float)
>>> index = [slice(None), slice(3, 6), slice(3, 6)]
>>> outputs = subpixel_slice(inputs, index)
>>> print(outputs)
[[[18. 19.  0.]
  [23. 24.  0.]
```

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```
  [ 0.  0.  0.]]]
>>> index = [slice(None), slice(3.5, 6.5), slice(2.5, 5.5)]
>>> outputs = subpixel_slice(inputs, index)
>>> print(outputs)
[[[20.   21.   10.75]
  [11.25 11.75  6.  ]
  [ 0.    0.    0.  ]]]
```

kwimage.**subpixel_translate**(*inputs*, *shift*, *interp_axes=None*, *output_shape=None*)

Translates an image by a subpixel shift value using bilinear interpolation

Parameters

- **inputs** (*ArrayLike*) – data to translate
- **shift** (*Sequence*) – amount to translate each dimension specified by *interp_axes*. Note: if inputs contains more than one "image" then all "images" are translated by the same amount. This function contains no mechanism for translating each image differently. Note that by default this is a y,x shift for 2 dimensions.
- **interp_axes** (*Sequence*) – axes to perform interpolation on, if not specified the final *n* axes are interpolated, where *n=len(shift)*
- **output_shape** (*tuple*) – if specified the output is returned with this shape, otherwise

Note: This function powers most other functions in this file. Speedups here can go a long way.

Example

```
>>> inputs = np.arange(5) + 1
>>> print(inputs.tolist())
[1, 2, 3, 4, 5]
>>> outputs = subpixel_translate(inputs, 1.5)
>>> print(outputs.tolist())
[0.0, 0.5, 1.5, 2.5, 3.5]
```

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> inputs = torch.arange(9).view(1, 1, 3, 3).float()
>>> print(inputs.long())
tensor([[[[0, 1, 2],
          [3, 4, 5],
          [6, 7, 8]]]])
>>> outputs = subpixel_translate(inputs, (-.4, .5), output_shape=(1, 1, 2, 5))
>>> print(outputs)
tensor([[[[0.6000, 1.7000, 2.7000, 1.6000, 0.0000],
          [2.1000, 4.7000, 5.7000, 3.1000, 0.0000]]]])
```

kwimage.**warp_affine**(*image*, *transform*, *dsize=None*, *antialias=False*, *interpolation='linear'*, *border_mode=None*, *border_value=0*, *large_warp_dim=None*, *return_info=False*)

Applies an affine transformation to an image with optional antialiasing.

Parameters

- **image** (*ndarray*) – the input image as a numpy array. Note: this is passed directly to cv2, so it is best to ensure that it is contiguous and using a dtype that cv2 can handle.
- **transform** (*ndarray | dict | kwimage.Affine*) – a coercable affine matrix. See `kwimage.Affine` for details on what can be coerced.
- **dsize** (*Tuple[int, int] | None | str*) – A integer width and height tuple of the resulting "canvas" image. If None, then the input image size is used.

  If specified as a string, dsize is computed based on the given heuristic.

  If 'positive' (or 'auto'), dsize is computed such that the positive coordinates of the warped image will fit in the new canvas. In this case, any pixel that maps to a negative coordinate will be clipped. This has the property that the input transformation is not modified.

  If 'content' (or 'max'), the transform is modified with an extra translation such that both the positive and negative coordinates of the warped image will fit in the new canvas.
- **antialias** (*bool*) – if True determines if the transform is downsampling and applies antialiasing via gaussian a blur. Defaults to False
- **interpolation** (*str | int*) – interpolation code or cv2 integer. Interpolation codes are linear, nearest, cubic, lancsoz, and area. Defaults to "linear".
- **border_mode** (*str | int*) – Border code or cv2 integer. Border codes are constant (default) replicate, reflect, wrap, reflect101, and transparent.
- **border_value** (*int | float | Iterable[int | float]*) – Used as the fill value if border_mode is constant. Otherwise this is ignored. Defaults to 0, but can also be defaulted to nan. if border_value is a scalar and there are multiple channels, the value is applied to all channels. More than 4 unique border values for individual channels will cause an error. See OpenCV #22283 for details. In the future we may accept np.ma and return a masked array, but for now that is not implemented.
- **large_warp_dim** (*int | None | str*) – If specified, perform the warp piecewise in chunks of the specified size. If "auto", it is set to the maximum "short" value in numpy. This works around a limitation of cv2.warpAffine, which must have image dimensions < SHRT_MAX (=32767 in version 4.5.3)
- **return_info** (*bool*) – if True, returns information about the operation. In the case where dsize="content", this includes the modified transformation.

Returns

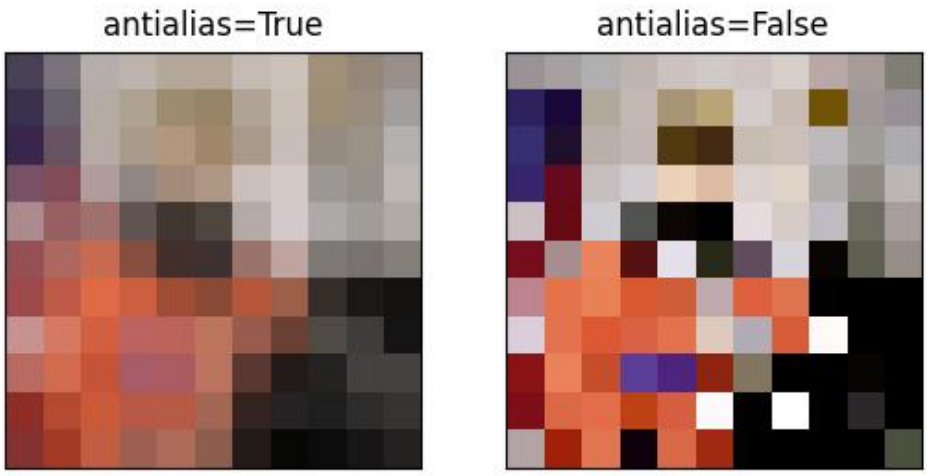
the warped image, or if return info is True, the warped image and the info dictionary.

Return type

ndarray | Tuple[ndarray, Dict]

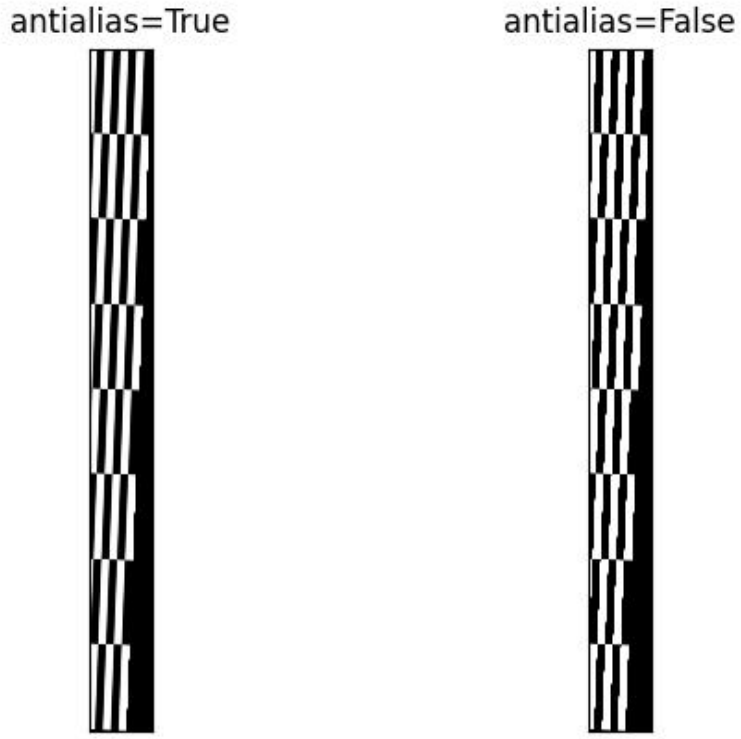
Example

```
>>> from kwimage.im_cv2 import *  # NOQA
>>> import kwimage
>>> from kwimage.transform import Affine
>>> image = kwimage.grab_test_image('astro')
>>> #image = kwimage.grab_test_image('checkerboard')
>>> transform = Affine.random() @ Affine.scale(0.05)
>>> transform = Affine.scale(0.02)
>>> warped1 = warp_affine(image, transform, dsize='positive', antialias=1,␣
↪interpolation='nearest')
>>> warped2 = warp_affine(image, transform, dsize='positive', antialias=0)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> pnum_ = kwplot.PlotNums(nRows=1, nCols=2)
>>> kwplot.imshow(warped1, pnum=pnum_(), title='antialias=True')
>>> kwplot.imshow(warped2, pnum=pnum_(), title='antialias=False')
>>> kwplot.show_if_requested()
```



Example

```
>>> from kwimage.im_cv2 import *  # NOQA
>>> import kwimage
>>> from kwimage.transform import Affine
>>> image = kwimage.grab_test_image('astro')
>>> image = kwimage.grab_test_image('checkerboard')
>>> transform = Affine.random() @ Affine.scale((.1, 1.2))
>>> warped1 = warp_affine(image, transform, dsize='positive', antialias=1)
>>> warped2 = warp_affine(image, transform, dsize='positive', antialias=0)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> pnum_ = kwplot.PlotNums(nRows=1, nCols=2)
>>> kwplot.imshow(warped1, pnum=pnum_(), title='antialias=True')
>>> kwplot.imshow(warped2, pnum=pnum_(), title='antialias=False')
>>> kwplot.show_if_requested()
```



Example

```
>>> # Test the case where the input data is empty or the target canvas
>>> # is empty, this should be handled like boundary effects
>>> import kwimage
>>> image = np.random.rand(1, 1, 3)
>>> transform = kwimage.Affine.random()
>>> result = kwimage.warp_affine(image, transform, dsize=(0, 0))
>>> assert result.shape == (0, 0, 3)
>>> #
>>> empty_image = np.random.rand(0, 1, 3)
>>> result = kwimage.warp_affine(empty_image, transform, dsize=(10, 10))
>>> assert result.shape == (10, 10, 3)
>>> #
>>> empty_image = np.random.rand(0, 1, 3)
>>> result = kwimage.warp_affine(empty_image, transform, dsize=(10, 0))
>>> assert result.shape == (0, 10, 3)
```

Example

```
>>> # Demo difference between positive and content dsize
>>> from kwimage.im_cv2 import *  # NOQA
>>> import kwimage
>>> from kwimage.transform import Affine
>>> image = kwimage.grab_test_image('astro', dsize=(512, 512))
>>> transform = Affine.coerce(offset=(-100, -50), scale=2, theta=0.1)
>>> # When warping other images or geometry along with this image
>>> # it is important to account for the modified transform when
>>> # setting dsize='content'. If dsize='positive', the transform
>>> # will remain unchanged wrt other aligned images / geometries.
>>> poly = kwimage.Boxes([[350, 5, 130, 290]], 'xywh').to_polygons()[0]
>>> # Apply the warping to the images
>>> warped_pos, info_pos = warp_affine(image, transform, dsize='positive', return_
↪info=True)
>>> warped_con, info_con = warp_affine(image, transform, dsize='content', return_
↪info=True)
>>> assert info_pos['dsize'] == (919, 1072)
>>> assert info_con['dsize'] == (1122, 1122)
>>> assert info_pos['transform'] == transform
>>> # Demo the correct and incorrect way to apply transforms
>>> poly_pos = poly.warp(transform)
>>> poly_con = poly.warp(info_con['transform'])
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> # show original
>>> kwplot.imshow(image, pnum=(1, 3, 1), title='original')
>>> poly.draw(color='green', alpha=0.5, border=True)
>>> # show positive warped
>>> kwplot.imshow(warped_pos, pnum=(1, 3, 2), title='dsize=positive')
>>> poly_pos.draw(color='purple', alpha=0.5, border=True)
```

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```
>>> # show content warped
>>> ax = kwplot.imshow(warped_con, pnum=(1, 3, 3), title='dsize=content')[1]
>>> poly_con.draw(color='dodgerblue', alpha=0.5, border=True)   # correct
>>> poly_pos.draw(color='orangered', alpha=0.5, border=True)  # incorrect
>>> cc = poly_con.to_shapely().centroid
>>> cp = poly_pos.to_shapely().centroid
>>> ax.text(cc.x, cc.y + 250, 'correctly transformed', color='dodgerblue',
>>>         backgroundcolor=(0, 0, 0, 0.7), horizontalalignment='center')
>>> ax.text(cp.x, cp.y - 250, 'incorrectly transformed', color='orangered',
>>>         backgroundcolor=(0, 0, 0, 0.7), horizontalalignment='center')
>>> kwplot.show_if_requested()
```

Example

```
>>> # Demo piecewise transform
>>> from kwimage.im_cv2 import *  # NOQA
>>> import kwimage
>>> from kwimage.transform import Affine
>>> image = kwimage.grab_test_image('pm5644')
>>> transform = Affine.coerce(offset=(-100, -50), scale=2, theta=0.1)
>>> warped_piecewise, info = warp_affine(image, transform, dsize='positive', return_
↪info=True, large_warp_dim=32)
```

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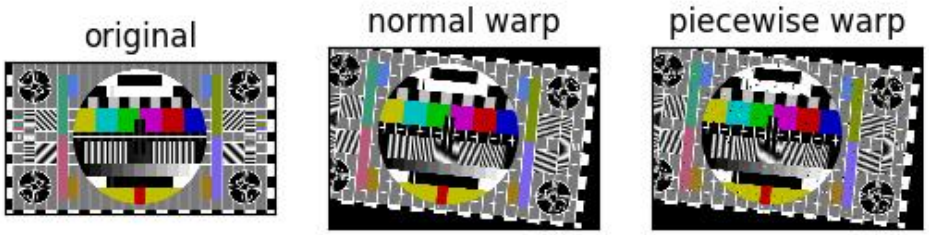
```
>>> warped_normal, info = warp_affine(image, transform, dsize='positive', return_
↪info=True, large_warp_dim=None)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(image, pnum=(1, 3, 1), title='original')
>>> kwplot.imshow(warped_normal, pnum=(1, 3, 2), title='normal warp')
>>> kwplot.imshow(warped_piecewise, pnum=(1, 3, 3), title='piecewise warp')
```

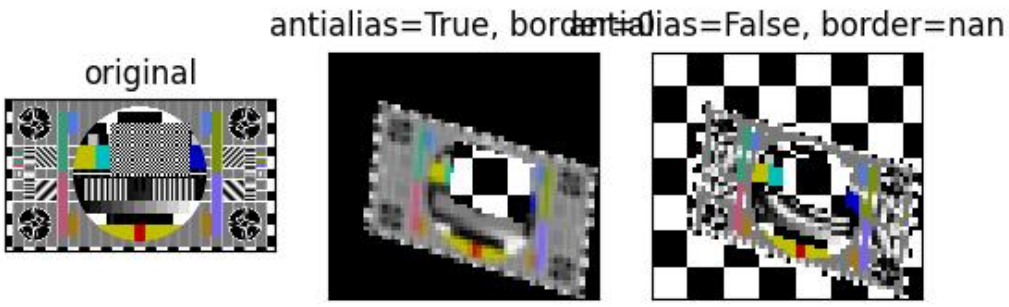


Example

```
>>> from kwimage.im_cv2 import *  # NOQA
>>> import kwimage
>>> # TODO: Explain why the bottom left is interpolated with 0's
>>> # And not 2s, probably has to do with interpretation of pixels
>>> # as points and not areas.
>>> image = np.full((6, 6), fill_value=3, dtype=np.uint8)
>>> transform = kwimage.Affine.eye()
>>> transform = kwimage.Affine.coerce(offset=.5) @ transform
>>> transform = kwimage.Affine.coerce(scale=2) @ transform
>>> warped = kwimage.warp_affine(image, transform, dsize=(12, 12))
```

Example

```
>>> # Demo how nans are handled
>>> from kwimage.im_cv2 import *  # NOQA
>>> import kwimage
>>> image = kwimage.grab_test_image('pm5644')
>>> image = kwimage.ensure_float01(image)
>>> image[100:300, 400:700] = np.nan
>>> transform = kwimage.Affine.coerce(scale=0.05, offset=10.5, theta=0.3, shearx=0.
↪2)
>>> warped1 = warp_affine(image, transform, dsize='positive', antialias=1,␣
↪interpolation='linear', border_value=0)
>>> warped2 = warp_affine(image, transform, dsize='positive', antialias=0, border_
↪value=np.nan)
>>> assert np.isnan(warped1).any()
>>> assert np.isnan(warped2).any()
>>> assert warped1[np.isnan(warped1).any(axis=2)].all()
>>> assert warped2[np.isnan(warped2).any(axis=2)].all()
>>> print('warped1.shape = {!r}'.format(warped1.shape))
>>> print('warped2.shape = {!r}'.format(warped2.shape))
>>> assert warped2.shape == warped1.shape
>>> warped2[np.isnan(warped2).any(axis=2)]
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> pnum_ = kwplot.PlotNums(nRows=1, nCols=3)
>>> image_canvas = kwimage.fill_nans_with_checkers(image)
>>> warped1_canvas = kwimage.fill_nans_with_checkers(warped1)
>>> warped2_canvas = kwimage.fill_nans_with_checkers(warped2)
>>> kwplot.imshow(image_canvas, pnum=pnum_(), title='original')
>>> kwplot.imshow(warped1_canvas, pnum=pnum_(), title='antialias=True, border=0')
>>> kwplot.imshow(warped2_canvas, pnum=pnum_(), title='antialias=False, border=nan')
>>> kwplot.show_if_requested()
```



Example

```
>>> # Demo how of how we also handle masked arrays
>>> from kwimage.im_cv2 import *  # NOQA
>>> import kwimage
>>> _image = kwimage.grab_test_image('pm5644')
>>> _image = kwimage.ensure_float01(_image)
>>> _image[100:200, 400:700] = np.nan
>>> mask = np.isnan(_image)
>>> data = np.nan_to_num(_image)
>>> image = np.ma.MaskedArray(data=data, mask=mask)
>>> transform = kwimage.Affine.coerce(scale=0.05, offset=10.5, theta=0.3, shearx=0.
↪2)
>>> warped1 = warp_affine(image, transform, dsize='positive', antialias=1,␣
↪interpolation='linear')
>>> assert isinstance(warped1, np.ma.MaskedArray)
>>> warped2 = warp_affine(image, transform, dsize='positive', antialias=0)
>>> print('warped1.shape = {!r}'.format(warped1.shape))
>>> print('warped2.shape = {!r}'.format(warped2.shape))
>>> assert warped2.shape == warped1.shape
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
```

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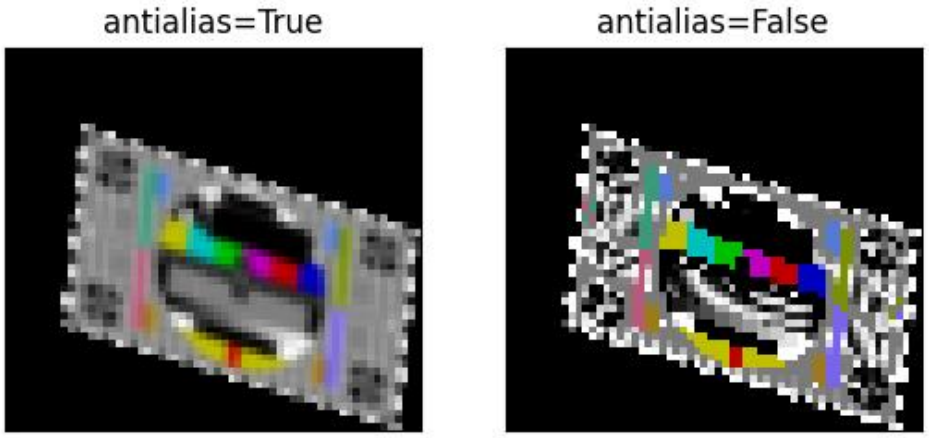
```
>>> pnum_ = kwplot.PlotNums(nRows=1, nCols=2)
>>> kwplot.imshow(warped1, pnum=pnum_(), title='antialias=True')
>>> kwplot.imshow(warped2, pnum=pnum_(), title='antialias=False')
>>> kwplot.show_if_requested()
```



kwimage.**warp_image**(*image*, *transform*, *dsize=None*, *antialias=False*, *interpolation='linear'*, *border_mode=None*, *border_value=0*, *large_warp_dim=None*, *return_info=False*)

Applies an transformation to an image with optional antialiasing.

Parameters

- **image** (*ndarray*) – the input image as a numpy array. Note: this is passed directly to cv2, so it is best to ensure that it is contiguous and using a dtype that cv2 can handle.
- **transform** (*ndarray | dict | kwimage.Matrix*) – a coercable affine or projective matrix. See `kwimage.Affine` and `kwimage.Projective` for details on what can be coerced.
- **dsize** (*Tuple[int, int] | None | str*) – A integer width and height tuple of the resulting "canvas" image. If None, then the input image size is used.

  If specified as a string, dsize is computed based on the given heuristic.

  If 'positive' (or 'auto'), dsize is computed such that the positive coordinates of the warped image will fit in the new canvas. In this case, any pixel that maps to a negative coordinate will be clipped. This has the property that the input transformation is not modified.

  If 'content' (or 'max'), the transform is modified with an extra translation such that both

the positive and negative coordinates of the warped image will fit in the new canvas.

- **antialias** (*bool*) – if True determines if the transform is downsampling and applies antialiasing via gaussian a blur. Defaults to False
- **interpolation** (*str | int*) – interpolation code or cv2 integer. Interpolation codes are linear, nearest, cubic, lancsoz, and area. Defaults to "linear".
- **border_mode** (*str | int*) – Border code or cv2 integer. Border codes are constant (default) replicate, reflect, wrap, reflect101, and transparent.
- **border_value** (*int | float | Iterable[int | float]*) – Used as the fill value if border_mode is constant. Otherwise this is ignored. Defaults to 0, but can also be defaulted to nan. if border_value is a scalar and there are multiple channels, the value is applied to all channels. More than 4 unique border values for individual channels will cause an error. See OpenCV #22283 for details. In the future we may accept np.ma and return a masked array, but for now that is not implemented.
- **large_warp_dim** (*int | None | str*) – If specified, perform the warp piecewise in chunks of the specified size. If "auto", it is set to the maximum "short" value in numpy. This works around a limitation of cv2.warpAffine, which must have image dimensions < SHRT_MAX (=32767 in version 4.5.3)
- **return_info** (*bool*) – if True, returns information about the operation. In the case where dsize="content", this includes the modified transformation.

Returns

the warped image, or if return info is True, the warped image and the info dictionary.

Return type

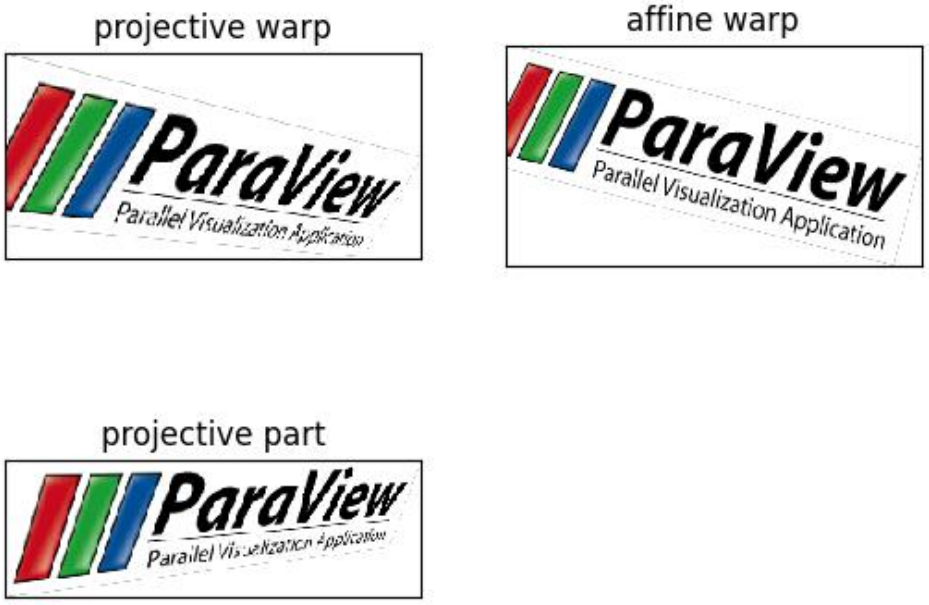
ndarray | Tuple[ndarray, Dict]

SeeAlso:

kwimage.warp_tensor() kwimage.warp_affine() kwimage.warp_projective()

Example

```
>>> from kwimage.im_cv2 import *  # NOQA
>>> import kwimage
>>> image = kwimage.grab_test_image('paraview')
>>> tf_homog = kwimage.Projective.random(rng=30342110) @ kwimage.Projective.
↪coerce(uv=[0.001, 0.001])
>>> tf_aff = kwimage.Affine.coerce(ub.udict(tf_homog.decompose()) - {'uv'})
>>> tf_uv = kwimage.Projective.coerce(ub.udict(tf_homog.decompose()) & {'uv'})
>>> warped1 = kwimage.warp_image(image, tf_homog, dsize='positive')
>>> warped2 = kwimage.warp_image(image, tf_aff, dsize='positive')
>>> warped3 = kwimage.warp_image(image, tf_uv, dsize='positive')
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> pnum_ = kwplot.PlotNums(nRows=2, nCols=2)
>>> kwplot.imshow(warped1, pnum=pnum_(), title='projective warp')
>>> kwplot.imshow(warped2, pnum=pnum_(), title='affine warp')
>>> kwplot.imshow(warped3, pnum=pnum_(), title='projective part')
>>> kwplot.show_if_requested()
```



kwimage.**warp_points**(*matrix*, *pts*, *homog_mode='divide'*)

Warp ND points / coordinates using a transformation matrix.

Homogoenous coordinates are added on the fly if needed. Works with both numpy and torch.

Parameters

- **matrix** (*ArrayLike*) – [D1 x D2] transformation matrix. if using homogenous coordinates D2=D + 1, otherwise D2=D. if using homogenous coordinates and the matrix represents an Affine transformation, then either D1=D or D1=D2, i.e. the last row of zeros and a one is optional.
- **pts** (*ArrayLike*) – [N1 x ... x D] points (usually x, y). If points are already in homogenous space, then the output will be returned in homogenous space. D is the dimensionality of the points. The leading axis may take any shape, but usually, shape will be [N x D] where N is the number of points.
- **homog_mode** (*str*) – what to do for homogenous coordinates. Can either divide, keep, or drop. Defaults do 'divide'.

Retrns:

new_pts (ArrayLike): the points after being transformed by the matrix

Example

```
>>> from kwimage.util_warp import *  # NOQA
>>> # --- with numpy
>>> rng = np.random.RandomState(0)
>>> pts = rng.rand(10, 2)
>>> matrix = rng.rand(2, 2)
>>> warp_points(matrix, pts)
>>> # --- with torch
>>> # xdoctest: +REQUIRES(module:torch)
>>> pts = torch.Tensor(pts)
>>> matrix = torch.Tensor(matrix)
>>> warp_points(matrix, pts)
```

Example

```
>>> from kwimage.util_warp import *  # NOQA
>>> # --- with numpy
>>> pts = np.ones((10, 2))
>>> matrix = np.diag([2, 3, 1])
>>> ra = warp_points(matrix, pts)
>>> # xdoctest: +REQUIRES(module:torch)
>>> rb = warp_points(torch.Tensor(matrix), torch.Tensor(pts))
>>> assert np.allclose(ra, rb.numpy())
```

Example

```
>>> from kwimage.util_warp import *  # NOQA
>>> # test different cases
>>> rng = np.random.RandomState(0)
>>> # Test 3x3 style projective matrices
>>> pts = rng.rand(1000, 2)
>>> matrix = rng.rand(3, 3)
>>> ra33 = warp_points(matrix, pts)
>>> # xdoctest: +REQUIRES(module:torch)
>>> rb33 = warp_points(torch.Tensor(matrix), torch.Tensor(pts))
>>> assert np.allclose(ra33, rb33.numpy())
>>> # Test opencv style affine matrices
>>> pts = rng.rand(10, 2)
>>> matrix = rng.rand(2, 3)
>>> ra23 = warp_points(matrix, pts)
>>> rb23 = warp_points(torch.Tensor(matrix), torch.Tensor(pts))
>>> assert np.allclose(ra33, rb33.numpy())
```

kwimage.**warp_projective**(*image*, *transform*, *dsize=None*, *antialias=False*, *interpolation='linear'*, *border_mode=None*, *border_value=0*, *large_warp_dim=None*, *return_info=False*)

Applies an projective transformation to an image with optional antialiasing.

Parameters

- **image** (*ndarray*) – the input image as a numpy array. Note: this is passed directly to cv2, so it is best to ensure that it is contiguous and using a dtype that cv2 can handle.

- **transform** (*ndarray | dict | kwimage.Projective*) – a coercable projective matrix. See `kwimage.Projective` for details on what can be coerced.
- **dsize** (*Tuple[int, int] | None | str*) – A integer width and height tuple of the resulting "canvas" image. If None, then the input image size is used.

  If specified as a string, dsize is computed based on the given heuristic.

  If 'positive' (or 'auto'), dsize is computed such that the positive coordinates of the warped image will fit in the new canvas. In this case, any pixel that maps to a negative coordinate will be clipped. This has the property that the input transformation is not modified.

  If 'content' (or 'max'), the transform is modified with an extra translation such that both the positive and negative coordinates of the warped image will fit in the new canvas.
- **antialias** (*bool*) – if True determines if the transform is downsampling and applies antialiasing via gaussian a blur. Defaults to False
- **interpolation** (*str | int*) – interpolation code or cv2 integer. Interpolation codes are linear, nearest, cubic, lancsoz, and area. Defaults to "linear".
- **border_mode** (*str | int*) – Border code or cv2 integer. Border codes are constant (default) replicate, reflect, wrap, reflect101, and transparent.
- **border_value** (*int | float | Iterable[int | float]*) – Used as the fill value if border_mode is constant. Otherwise this is ignored. Defaults to 0, but can also be defaulted to nan. if border_value is a scalar and there are multiple channels, the value is applied to all channels. More than 4 unique border values for individual channels will cause an error. See OpenCV #22283 for details. In the future we may accept np.ma and return a masked array, but for now that is not implemented.
- **large_warp_dim** (*int | None | str*) – If specified, perform the warp piecewise in chunks of the specified size. If "auto", it is set to the maximum "short" value in numpy. This works around a limitation of cv2.warpAffine, which must have image dimensions < SHRT_MAX (=32767 in version 4.5.3)
- **return_info** (*bool*) – if True, returns information about the operation. In the case where dsize="content", this includes the modified transformation.

Returns
the warped image, or if return info is True, the warped image and the info dictionary.

Return type
ndarray | Tuple[ndarray, Dict]

kwimage.**warp_tensor**(*inputs*, *mat*, *output_dims*, *mode='bilinear'*, *padding_mode='zeros'*, *isinv=False*, *ishomog=None*, *align_corners=False*, *new_mode=False*)

A pytorch implementation of warp affine that works similarly to `cv2.warpAffine()` and `cv2.warpPerspective()`.

It is possible to use 3x3 transforms to warp 2D image data. It is also possible to use 4x4 transforms to warp 3D volumetric data.

Parameters

- **inputs** (*Tensor*) – tensor to warp. Up to 3 (determined by output_dims) of the trailing space-time dimensions are warped. Best practice is to use inputs with the shape in [B, C, *DIMS].
- **mat** (*Tensor*) – either a 3x3 / 4x4 single transformation matrix to apply to all inputs or Bx3x3 or Bx4x4 tensor that specifies a transformation matrix for each batch item.

- **output_dims** (*Tuple[int, ...]*) – The output space-time dimensions. This can either be in the form (W,), (H, W), or (D, H, W).
- **mode** (*str*) – Can be bilinear or nearest. See *torch.nn.functional.grid_sample*
- **padding_mode** (*str*) – Can be zeros, border, or reflection. See *torch.nn.functional.grid_sample*.
- **isinv** (*bool*) – Set to true if *mat* is the inverse transform
- **ishomog** (*bool*) – Set to True if the matrix is non-affine
- **align_corners** (*bool*) – Note the default of False does not work correctly with grid_sample in torch <= 1.2, but using align_corners=True isnt typically what you want either. We will be stuck with buggy functionality until torch 1.3 is released.

  However, using align_corners=0 does seem to reasonably correspond with opencv behavior.

Returns
warped tensor

Return type
Tensor

Note: Also, it may be possible to speed up the code with *F.affine_grid*

KNOWN ISSUE: There appears to some difference with cv2.warpAffine when
rotation or shear are non-zero. I'm not sure what the cause is. It may just be floating point issues, but Im' not sure.

See issues in [TorchAffineTransform] and [TorchIssue15386].

Todo:

- [ ] FIXME: see example in Mask.scale where this algo breaks when the matrix is *2x3*
- [ ] Make this algo work when matrix ix 2x2

References

Example

```
>>> # Create a relatively simple affine matrix
>>> # xdoctest: +REQUIRES(module:torch)
>>> import skimage
>>> mat = torch.FloatTensor(skimage.transform.AffineTransform(
>>>     translation=[1, -1], scale=[.532, 2],
>>>     rotation=0, shear=0,
>>> ).params)
>>> # Create inputs and an output dimension
>>> input_shape = [1, 1, 4, 5]
>>> inputs = torch.arange(int(np.prod(input_shape))).reshape(*input_shape).float()
>>> output_dims = (11, 7)
>>> # Warp with our code
```

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```
>>> result1 = warp_tensor(inputs, mat, output_dims=output_dims, align_corners=0)
>>> print('result1 =\n{}'.format(ub.repr2(result1.cpu().numpy()[0, 0],␣
↪precision=2)))
>>> # Warp with opencv
>>> import cv2
>>> cv2_M = mat.cpu().numpy()[0:2]
>>> src = inputs[0, 0].cpu().numpy()
>>> dsize = tuple(output_dims[::-1])
>>> result2 = cv2.warpAffine(src, cv2_M, dsize=dsize, flags=cv2.INTER_LINEAR)
>>> print('result2 =\n{}'.format(ub.repr2(result2, precision=2)))
>>> # Ensure the results are the same (up to floating point errors)
>>> assert np.all(np.isclose(result1[0, 0].cpu().numpy(), result2, atol=1e-2,␣
↪rtol=1e-2))
```

Example

```
>>> # Create a relatively simple affine matrix
>>> # xdoctest: +REQUIRES(module:torch)
>>> import skimage
>>> mat = torch.FloatTensor(skimage.transform.AffineTransform(
>>>     rotation=0.01, shear=0.1).params)
>>> # Create inputs and an output dimension
>>> input_shape = [1, 1, 4, 5]
>>> inputs = torch.arange(int(np.prod(input_shape))).reshape(*input_shape).float()
>>> output_dims = (11, 7)
>>> # Warp with our code
>>> result1 = warp_tensor(inputs, mat, output_dims=output_dims)
>>> print('result1 =\n{}'.format(ub.repr2(result1.cpu().numpy()[0, 0], precision=2,␣
↪supress_small=True)))
>>> print('result1.shape = {}'.format(result1.shape))
>>> # Warp with opencv
>>> import cv2
>>> cv2_M = mat.cpu().numpy()[0:2]
>>> src = inputs[0, 0].cpu().numpy()
>>> dsize = tuple(output_dims[::-1])
>>> result2 = cv2.warpAffine(src, cv2_M, dsize=dsize, flags=cv2.INTER_LINEAR)
>>> print('result2 =\n{}'.format(ub.repr2(result2, precision=2)))
>>> print('result2.shape = {}'.format(result2.shape))
>>> # Ensure the results are the same (up to floating point errors)
>>> # NOTE: The floating point errors seem to be significant for rotation / shear
>>> assert np.all(np.isclose(result1[0, 0].cpu().numpy(), result2, atol=1, rtol=1e-
↪2))
```

Example

```
>>> # Create a random affine matrix
>>> # xdoctest: +REQUIRES(module:torch)
>>> import skimage
>>> rng = np.random.RandomState(0)
>>> mat = torch.FloatTensor(skimage.transform.AffineTransform(
>>>     translation=rng.randn(2), scale=1 + rng.randn(2),
>>>     rotation=rng.randn() / 10., shear=rng.randn() / 10.,
>>> ).params)
>>> # Create inputs and an output dimension
>>> input_shape = [1, 1, 5, 7]
>>> inputs = torch.arange(int(np.prod(input_shape))).reshape(*input_shape).float()
>>> output_dims = (3, 11)
>>> # Warp with our code
>>> result1 = warp_tensor(inputs, mat, output_dims=output_dims, align_corners=0)
>>> print('result1 =\n{}'.format(ub.repr2(result1.cpu().numpy()[0, 0],␣
↪precision=2)))
>>> # Warp with opencv
>>> import cv2
>>> cv2_M = mat.cpu().numpy()[0:2]
>>> src = inputs[0, 0].cpu().numpy()
>>> dsize = tuple(output_dims[::-1])
>>> result2 = cv2.warpAffine(src, cv2_M, dsize=dsize, flags=cv2.INTER_LINEAR)
>>> print('result2 =\n{}'.format(ub.repr2(result2, precision=2)))
>>> # Ensure the results are the same (up to floating point errors)
>>> # NOTE: The errors seem to be significant for rotation / shear
>>> assert np.all(np.isclose(result1[0, 0].cpu().numpy(), result2, atol=1, rtol=1e-
↪2))
```

Example

```
>>> # Test 3D warping with identity
>>> # xdoctest: +REQUIRES(module:torch)
>>> mat = torch.eye(4)
>>> input_dims = [2, 3, 3]
>>> output_dims = (2, 3, 3)
>>> input_shape = [1, 1] + input_dims
>>> inputs = torch.arange(int(np.prod(input_shape))).reshape(*input_shape).float()
>>> result = warp_tensor(inputs, mat, output_dims=output_dims)
>>> print('result =\n{}'.format(ub.repr2(result.cpu().numpy()[0, 0], precision=2)))
>>> assert torch.all(inputs == result)
```

Example

```
>>> # Test 3D warping with scaling
>>> # xdoctest: +REQUIRES(module:torch)
>>> mat = torch.FloatTensor([
>>>     [0.8,   0,   0, 0],
>>>     [  0, 1.0,   0, 0],
>>>     [  0,   0, 1.2, 0],
>>>     [  0,   0,   0, 1],
>>> ])
>>> input_dims = [2, 3, 3]
>>> output_dims = (2, 3, 3)
>>> input_shape = [1, 1] + input_dims
>>> inputs = torch.arange(int(np.prod(input_shape))).reshape(*input_shape).float()
>>> result = warp_tensor(inputs, mat, output_dims=output_dims, align_corners=0)
>>> print('result =\n{}'.format(ub.repr2(result.cpu().numpy()[0, 0], precision=2)))
result =
np.array([[[ 0.  ,  1.25,  1.  ],
           [ 3.  ,  4.25,  2.5 ],
           [ 6.  ,  7.25,  4.  ]],
          ...
          [[ 7.5 ,  8.75,  4.75],
           [10.5 , 11.75,  6.25],
           [13.5 , 14.75,  7.75]]], dtype=np.float32)
```

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> mat = torch.eye(3)
>>> input_dims = [5, 7]
>>> output_dims = (11, 7)
>>> for n_prefix_dims in [0, 1, 2, 3, 4, 5]:
>>>     input_shape = [2] * n_prefix_dims + input_dims
>>>     inputs = torch.arange(int(np.prod(input_shape))).reshape(*input_shape).
↪float()
>>>     result = warp_tensor(inputs, mat, output_dims=output_dims)
>>>     #print('result =\n{}'.format(ub.repr2(result.cpu().numpy(), precision=2)))
>>>     print(result.shape)
```

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> mat = torch.eye(4)
>>> input_dims = [5, 5, 5]
>>> output_dims = (6, 6, 6)
>>> for n_prefix_dims in [0, 1, 2, 3, 4, 5]:
>>>     input_shape = [2] * n_prefix_dims + input_dims
>>>     inputs = torch.arange(int(np.prod(input_shape))).reshape(*input_shape).
↪float()
>>>     result = warp_tensor(inputs, mat, output_dims=output_dims)
```

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```
>>>     #print('result =\n{}'.format(ub.repr2(result.cpu().numpy(), precision=2)))
>>>     print(result.shape)
```

CHAPTER

TWO

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