kwarray Documentation

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CONTENTS

The `kwarray` module implements a small set of pure-python extensions to numpy and torch along with a few select algorithms. Each module contains module level docstring that gives a rough idea of the utilities in each module, and each function or class itself contains a docstring with more details and examples.

KWarray is part of Kitware's computer vision Python suite:

https://gitlab.kitware.com/computer-vision

CHAPTER

ONE

FUNCTION USEFULNESS

Function name	Usefulness
kwarray.ensure_rng	475
kwarray.ArrayAPI	202
kwarray.atleast_nd	98
kwarray.stats_dict	77
kwarray.group_indices	72
kwarray.DataFrameArray	60
kwarray.normalize	59
kwarray.isect_flags	53
kwarray.shuffle	48
kwarray.SlidingWindow	33
kwarray.robust_normalize	31
kwarray.Stitcher	30
kwarray.one_hot_embedding	29
kwarray.boolmask	27
kwarray.embed_slice	25
kwarray.RunningStats	20
kwarray.setcover	19
kwarray.argmaxima	15
kwarray.padded_slice	14
kwarray.seed_global	14
kwarray.standard_normal	10
kwarray.find_robust_normalizers	10
kwarray.DataFrameLight	10
kwarray.group_items	10
kwarray.maxvalue_assignment	9
kwarray.apply_grouping	9
kwarray.group_consecutive	7
kwarray.mincost_assignment	6
kwarray.uniform	6
kwarray.iter_reduce_ufunc	5
kwarray.FlatIndexer	5
kwarray.arglexmax	3
kwarray.dtype_info	3
kwarray.group_consecutive_indices	1
kwarray.equal_with_nan	1
kwarray.unique_rows	0
kwarray.uniform32	0
kwarray.standard_normal64	0

continues on next page

Table 1 – continued from previous page

Function name	Usefulness
kwarray.standard_normal32	0
kwarray.random_product	0
kwarray.random_combinations	0
kwarray.one_hot_lookup	0
kwarray.mindist_assignment	0
kwarray.generalized_logistic	0
kwarray.argminima	0
kwarray.apply_embedded_slice	0
kwarray.NoSupportError	0
kwarray.LocLight	0

1.1 kwarray package

1.1.1 Submodules

kwarray.algo_assignment module

A convinient interface to solving assignment problems with the Hungarian algorithm (also known as Munkres or maximum linear-sum-assignment).

The core implementation of munkres in in scipy. Recent versions are written in C, so their speed should be reflected here.

Todo:

- [ ] Implement linear-time maximum weight matching approximation algorithm from this paper: https://web.eecs.umich.edu/~pettie/papers/ApproxMWM-JACM.pdf

---

kwarray.algo_assignment.**mindist_assignment**(*vecs1*, *vecs2*, *p=2*)

Finds minimum cost assignment between two sets of D dimensional vectors.

Parameters

- **vecs1** (*np.ndarray*) – NxD array of vectors representing items in vecs1
- **vecs2** (*np.ndarray*) – MxD array of vectors representing items in vecs2
- **p** (*float*) – L-p norm to use. Default is 2 (aka Eucliedean)

Returns

tuple containing assignments of rows in vecs1 to
rows in vecs2, and the total distance between assigned pairs.

Return type
Tuple[list, float]

Note: Thin wrapper around mincost_assignment

CommandLine

```
xdoctest -m ~/code/kwarray/kwarray/algo_assignment.py mindist_assignment
```

CommandLine

```
xdoctest -m ~/code/kwarray/kwarray/algo_assignment.py mindist_assignment
```

Example

```
>>> # xdoctest: +REQUIRES(module:scipy)
>>> # Rows are detections in img1, cols are detections in img2
>>> rng = np.random.RandomState(43)
>>> vecs1 = rng.randint(0, 10, (5, 2))
>>> vecs2 = rng.randint(0, 10, (7, 2))
>>> ret = mindist_assignment(vecs1, vecs2)
>>> print('Total error: {:.4f}'.format(ret[1]))
Total error: 8.2361
>>> print('Assignment: {}'.format(ret[0]))  # xdoc: +IGNORE_WANT
Assignment: [(0, 0), (1, 3), (2, 5), (3, 2), (4, 6)]
```

kwarray.algo_assignment.**mincost_assignment**(*cost*)

Finds the minimum cost assignment based on a NxM cost matrix, subject to the constraint that each row can match at most one column and each column can match at most one row. Any pair with a cost of infinity will not be assigned.

Parameters

cost (*ndarray*) – NxM matrix, cost[i, j] is the cost to match i and j

Returns

tuple containing a list of assignment of rows
and columns, and the total cost of the assignment.

Return type

Tuple[list, float]

CommandLine

```
xdoctest -m ~/code/kwarray/kwarray/algo_assignment.py mincost_assignment
```

Example

```
>>> # xdoctest: +REQUIRES(module:scipy)
>>> # Costs to match item i in set1 with item j in set2.
>>> cost = np.array([
>>>     [9, 2, 1, 9],
>>>     [4, 1, 5, 5],
>>>     [9, 9, 2, 4],
>>> ])
>>> ret = mincost_assignment(cost)
>>> print('Assignment: {}'.format(ret[0]))
>>> print('Total cost: {}'.format(ret[1]))
Assignment: [(0, 2), (1, 1), (2, 3)]
Total cost: 6
```

Example

```
>>> # xdoctest: +REQUIRES(module:scipy)
>>> cost = np.array([
>>>     [0, 0, 0, 0],
>>>     [4, 1, 5, -np.inf],
>>>     [9, 9, np.inf, 4],
>>>     [9, -2, np.inf, 4],
>>> ])
>>> ret = mincost_assignment(cost)
>>> print('Assignment: {}'.format(ret[0]))
>>> print('Total cost: {}'.format(ret[1]))
Assignment: [(0, 2), (1, 3), (2, 0), (3, 1)]
Total cost: -inf
```

Example

```
>>> # xdoctest: +REQUIRES(module:scipy)
>>> cost = np.array([
>>>     [0, 0, 0, 0],
>>>     [4, 1, 5, -3],
>>>     [1, 9, np.inf, 0.1],
>>>     [np.inf, np.inf, np.inf, 100],
>>> ])
>>> ret = mincost_assignment(cost)
>>> print('Assignment: {}'.format(ret[0]))
>>> print('Total cost: {}'.format(ret[1]))
Assignment: [(0, 2), (1, 1), (2, 0), (3, 3)]
Total cost: 102.0
```

kwarray.algo_assignment.**maxvalue_assignment**(*value*)

Finds the maximum value assignment based on a NxM value matrix. Any pair with a non-positive value will not be assigned.

Parameters

value (*ndarray*) – NxM matrix, value[i, j] is the value of matching i and j

Returns

tuple containing a list of assignment of rows
and columns, and the total value of the assignment.

Return type
Tuple[list, float]

CommandLine

```
xdoctest -m ~/code/kwarray/kwarray/algo_assignment.py maxvalue_assignment
```

Example

```
>>> # xdoctest: +REQUIRES(module:scipy)
>>> # Costs to match item i in set1 with item j in set2.
>>> value = np.array([
>>>     [9, 2, 1, 3],
>>>     [4, 1, 5, 5],
>>>     [9, 9, 2, 4],
>>>     [-1, -1, -1, -1],
>>> ])
>>> ret = maxvalue_assignment(value)
>>> # Note, depending on the scipy version the assignment might change
>>> # but the value should always be the same.
>>> print('Total value: {}'.format(ret[1]))
Total value: 23.0
>>> print('Assignment: {}'.format(ret[0]))  # xdoc: +IGNORE_WANT
Assignment: [(0, 0), (1, 3), (2, 1)]
```

```
>>> ret = maxvalue_assignment(np.array([[np.inf]]))
>>> print('Assignment: {}'.format(ret[0]))
>>> print('Total value: {}'.format(ret[1]))
Assignment: [(0, 0)]
Total value: inf
```

```
>>> ret = maxvalue_assignment(np.array([[0]]))
>>> print('Assignment: {}'.format(ret[0]))
>>> print('Total value: {}'.format(ret[1]))
Assignment: []
Total value: 0
```

kwarray.algo_setcover module

Algorithms to find a solution to the setcover problem

SeeAlso:
https://github.com/keon/algorithms

kwarray.algo_setcover.**setcover**(*candidate_sets_dict*, *items=None*, *set_weights=None*, *item_values=None*, *max_weight=None*, *algo='approx'*)

Finds a feasible solution to the minimum weight maximum value set cover. The quality and runtime of the solution will depend on the backend algorithm selected.

Parameters

- **candidate_sets_dict** (*Dict[KT, List[VT]]*) – a dictionary where keys are the candidate set ids and each value is a candidate cover set.
- **items** (*Optional[VT]*) – the set of all items to be covered, if not specified, it is infered from the candidate cover sets
- **set_weights** (*Optional[Dict[KT, float]]*) – maps candidate set ids to a cost for using this candidate cover in the solution. If not specified the weight of each candiate cover defaults to 1.
- **item_values** (*Optional[Dict[VT, float]]*) – maps each item to a value we get for returning this item in the solution. If not specified the value of each item defaults to 1.
- **max_weight** (*Optional[float]*) – if specified, the total cost of the returned cover is constrained to be less than this number.
- **algo** (*str*) – specifies which algorithm to use. Can either be 'approx' for the greedy solution or 'exact' for the globally optimal solution. Note the 'exact' algorithm solves an integer-linear-program, which can be very slow and requires the *pulp* package to be installed.

Returns
a subdict of candidate_sets_dict containing the chosen solution.

Return type
Dict

Example

```
>>> candidate_sets_dict = {
>>>     'a': [1, 2, 3, 8, 9, 0],
>>>     'b': [1, 2, 3, 4, 5],
>>>     'c': [4, 5, 7],
>>>     'd': [5, 6, 7],
>>>     'e': [6, 7, 8, 9, 0],
>>> }
>>> greedy_soln = setcover(candidate_sets_dict, algo='greedy')
>>> print('greedy_soln = {}'.format(ub.urepr(greedy_soln, nl=0)))
greedy_soln = {'a': [1, 2, 3, 8, 9, 0], 'c': [4, 5, 7], 'd': [5, 6, 7]}
>>> # xdoc: +REQUIRES(module:pulp)
>>> exact_soln = setcover(candidate_sets_dict, algo='exact')
>>> print('exact_soln = {}'.format(ub.urepr(exact_soln, nl=0)))
exact_soln = {'b': [1, 2, 3, 4, 5], 'e': [6, 7, 8, 9, 0]}
```

kwarray.algo_setcover.**_setcover_greedy_old**(*candidate_sets_dict*, *items=None*, *set_weights=None*, *item_values=None*, *max_weight=None*)

Benchmark

items = np.arange(10000) candidate_sets_dict = { } for i in range(1000):

candidate_sets_dict[i] = np.random.choice(items, 200).tolist()

_setcover_greedy_new(candidate_sets_dict) == _setcover_greedy_old(candidate_sets_dict) _ = nh.util.profile_onthefly(_setcover_greedy_new)(candidate_sets_dict) _ = nh.util.profile_onthefly(_setcover_greedy_old)(candidate_sets_dict)

import ubelt as ub for timer in ub.Timerit(3, bestof=1, label='time'):

with timer:
len(_setcover_greedy_new(candidate_sets_dict))

import ubelt as ub for timer in ub.Timerit(3, bestof=1, label='time'):

with timer:
len(_setcover_greedy_old(candidate_sets_dict))

kwarray.algo_setcover.**_setcover_greedy_new**(*candidate_sets_dict*, *items=None*, *set_weights=None*, *item_values=None*, *max_weight=None*)

Implements Johnson's / Chvatal's greedy set-cover approximation algorithm.

The approximation gaurentees depend on specifications of set weights and item values

Running time:
N = number of universe items C = number of candidate covering sets

Worst case running time is: O(C^2 * CN)
(note this is via simple analysis, the big-oh might be better)

Set Cover: log(len(items) + 1) approximation algorithm Weighted Maximum Cover: 1 - 1/e == .632 approximation algorithm Generalized maximum coverage is not implemented [WikiMaxCov].

References

Example

```
>>> candidate_sets_dict = {
>>>     'a': [1, 2, 3, 8, 9, 0],
>>>     'b': [1, 2, 3, 4, 5],
>>>     'c': [4, 5, 7],
>>>     'd': [5, 6, 7],
>>>     'e': [6, 7, 8, 9, 0],
>>> }
>>> greedy_soln = _setcover_greedy_new(candidate_sets_dict)
>>> #print(repr(greedy_soln))
...
>>> print('greedy_soln = {}'.format(ub.urepr(greedy_soln, nl=0)))
greedy_soln = {'a': [1, 2, 3, 8, 9, 0], 'c': [4, 5, 7], 'd': [5, 6, 7]}
```

Example

```
>>> candidate_sets_dict = {
>>>     'a': [1, 2, 3, 8, 9, 0],
>>>     'b': [1, 2, 3, 4, 5],
>>>     'c': [4, 5, 7],
>>>     'd': [5, 6, 7],
>>>     'e': [6, 7, 8, 9, 0],
>>> }
>>> items = list(set(it.chain(*candidate_sets_dict.values())))
>>> set_weights = {i: 1 for i in candidate_sets_dict.keys()}
>>> item_values = {e: 1 for e in items}
>>> greedy_soln = _setcover_greedy_new(candidate_sets_dict,
>>>                                    item_values=item_values,
>>>                                    set_weights=set_weights)
>>> print('greedy_soln = {}'.format(ub.urepr(greedy_soln, nl=0)))
greedy_soln = {'a': [1, 2, 3, 8, 9, 0], 'c': [4, 5, 7], 'd': [5, 6, 7]}
```

Example

```
>>> candidate_sets_dict = {}
>>> greedy_soln = _setcover_greedy_new(candidate_sets_dict)
>>> print('greedy_soln = {}'.format(ub.urepr(greedy_soln, nl=0)))
greedy_soln = {}
```

kwarray.algo_setcover.**_setcover_ilp**(*candidate_sets_dict*, *items=None*, *set_weights=None*, *item_values=None*, *max_weight=None*, *verbose=False*)

Set cover / Weighted Maximum Cover exact algorithm using an integer linear program.

Todo:

- [ ] Use CPLEX solver if available

Example

```
>>> # xdoc: +REQUIRES(module:pulp)
>>> candidate_sets_dict = {}
>>> exact_soln = _setcover_ilp(candidate_sets_dict)
>>> print('exact_soln = {}'.format(ub.urepr(exact_soln, nl=0)))
exact_soln = {}
```

Example

```
>>> # xdoc: +REQUIRES(module:pulp)
>>> candidate_sets_dict = {
>>>     'a': [1, 2, 3, 8, 9, 0],
>>>     'b': [1, 2, 3, 4, 5],
>>>     'c': [4, 5, 7],
>>>     'd': [5, 6, 7],
>>>     'e': [6, 7, 8, 9, 0],
>>> }
>>> items = list(set(it.chain(*candidate_sets_dict.values())))
>>> set_weights = {i: 1 for i in candidate_sets_dict.keys()}
>>> item_values = {e: 1 for e in items}
>>> exact_soln1 = _setcover_ilp(candidate_sets_dict,
>>>                             item_values=item_values,
>>>                             set_weights=set_weights)
>>> exact_soln2 = _setcover_ilp(candidate_sets_dict)
>>> assert exact_soln1 == exact_soln2
```

kwarray.arrayapi module

The ArrayAPI is a common API that works exactly the same on both torch.Tensors and numpy.ndarrays.

The ArrayAPI is a combination of efficiency and convinience. It is convinient because you can just use an operation directly, it will type check the data, and apply the appropriate method. But it is also efficient because it can be used with minimal type checking by accessing a type-specific backend.

For example, you can do:

```
impl = kwarray.ArrayAPI.coerce(data)
```

And then impl will give you direct access to the appropriate methods without any type checking overhead. e..g. `impl.<op-you-want>(data)`

But you can also do `kwarray.ArrayAPI.<op-you-want>(data)` on anything and it will do type checking and then do the operation you want.

Idea:

Perhaps we could separate this into its own python package (maybe called "onearray"), where the module itself behaves like the ArrayAPI. Design goals are to provide easy to use (as drop-in as possible) replacements for torch or numpy function calls. It has to have near-zero overhead, or at least a way to make that happen.

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> import kwarray
>>> import torch
>>> import numpy as np
>>> data1 = torch.rand(10, 10)
>>> data2 = data1.numpy()
>>> # Method 1: grab the appropriate sub-impl
>>> impl1 = kwarray.ArrayAPI.impl(data1)
>>> impl2 = kwarray.ArrayAPI.impl(data2)
>>> result1 = impl1.sum(data1, axis=0)
>>> result2 = impl2.sum(data2, axis=0)
>>> res1_np = kwarray.ArrayAPI.numpy(result1)
>>> res2_np = kwarray.ArrayAPI.numpy(result2)
>>> print('res1_np = {!r}'.format(res1_np))
>>> print('res2_np = {!r}'.format(res2_np))
>>> assert np.allclose(res1_np, res2_np)
>>> # Method 2: choose the impl on the fly
>>> result1 = kwarray.ArrayAPI.sum(data1, axis=0)
>>> result2 = kwarray.ArrayAPI.sum(data2, axis=0)
>>> res1_np = kwarray.ArrayAPI.numpy(result1)
>>> res2_np = kwarray.ArrayAPI.numpy(result2)
>>> print('res1_np = {!r}'.format(res1_np))
>>> print('res2_np = {!r}'.format(res2_np))
>>> assert np.allclose(res1_np, res2_np)
```

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> import torch
>>> import numpy as np
>>> data1 = torch.rand(10, 10)
>>> data2 = data1.numpy()
```

class kwarray.arrayapi.**_ImplRegistry**

Bases: object

_register(*func*, *func_type*, *impl*)

_implmethod(*func=None*, *func_type='data_func'*, *impl=None*)

_apimethod(*key=None*, *func_type='data_func'*)

Creates wrapper for a "data method" — i.e. a ArrayAPI function that has only one main argument, which is an array.

_ensure_datamethods_names_are_registered()

Checks to make sure all methods are implemented in both torch and numpy implementations as well as exposed in the ArrayAPI.

kwarray.arrayapi.**_torchmethod**(*func=None*, *func_type='data_func'*, ***, *impl='torch'*)

kwarray.arrayapi.**_numpymethod**(*func=None*, *func_type='data_func'*, ***, *impl='numpy'*)

kwarray.arrayapi.**_apimethod**(*key=None*, *func_type='data_func'*)

Creates wrapper for a “data method” — i.e. a ArrayAPI function that has only one main argument, which is an array.

class kwarray.arrayapi.**TorchImpls**

Bases: object

Torch backend for the ArrayAPI API

is_tensor = True

is_numpy = False

static result_type(**arrays_and_dtypes*)

Return type from promotion rules
dtype, promote_types, min_scalar_type, can_cast

static cat(*datas*, *axis=-1*)

static hstack(*datas*)

Concatenates along axis=0 if inputs are are 1-D otherwise axis=1

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> import torch
>>> datas1 = [torch.arange(10), torch.arange(10)]
>>> datas2 = [d.numpy() for d in datas1]
>>> ans1 = TorchImpls.hstack(datas1)
>>> ans2 = NumpyImpls.hstack(datas2)
>>> assert np.all(ans1.numpy() == ans2)
```

static vstack(*datas*)

Ensures that inputs datas are at least 2D (prepending a dimension of 1) and then concats along axis=0.

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> import torch
>>> datas1 = [torch.arange(10), torch.arange(10)]
>>> datas2 = [d.numpy() for d in datas1]
>>> ans1 = TorchImpls.vstack(datas1)
>>> ans2 = NumpyImpls.vstack(datas2)
>>> assert np.all(ans1.numpy() == ans2)
```

static atleast_nd(*arr*, *n*, *front=False*)

static view(*data*, **shape*)

static take(*data*, *indices*, *axis=None*)

static compress(*data*, *flags*, *axis=None*)

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> import kwarray
>>> import torch
>>> data = torch.rand(10, 4, 2)
>>> impl = kwarray.ArrayAPI.coerce(data)
```

```
>>> axis = 0
>>> flags = (torch.arange(data.shape[axis]) % 2) == 0
>>> out = impl.compress(data, flags, axis=axis)
>>> assert tuple(out.shape) == (5, 4, 2)
```

```
>>> axis = 1
>>> flags = (torch.arange(data.shape[axis]) % 2) == 0
>>> out = impl.compress(data, flags, axis=axis)
>>> assert tuple(out.shape) == (10, 2, 2)
```

```
>>> axis = 2
>>> flags = (torch.arange(data.shape[axis]) % 2) == 0
>>> out = impl.compress(data, flags, axis=axis)
>>> assert tuple(out.shape) == (10, 4, 1)
```

```
>>> axis = None
>>> data = torch.rand(10)
>>> flags = (torch.arange(data.shape[0]) % 2) == 0
>>> out = impl.compress(data, flags, axis=axis)
>>> assert tuple(out.shape) == (5,)
```

static tile(*data*, *reps*)

Implement np.tile in torch

Example

```
>>> # xdoctest: +SKIP
>>> # xdoctest: +REQUIRES(module:torch)
>>> data = torch.arange(10)[:, None]
>>> ans1 = ArrayAPI.tile(data, [1, 2])
>>> ans2 = ArrayAPI.tile(data.numpy(), [1, 2])
>>> assert np.all(ans1.numpy() == ans2)
```

Doctest

```
>>> # xdoctest: +SKIP
>>> # xdoctest: +REQUIRES(module:torch)
>>> shapes = [(3,), (3, 4,), (3, 5, 7), (1,), (3, 1, 3)]
>>> for shape in shapes:
>>>     data = torch.rand(*shape)
>>>     for axis in range(len(shape)):
>>>         for reps in it.product(*[range(0, 4)] * len(shape)):
>>>             ans1 = ArrayAPI.tile(data, reps)
>>>             ans2 = ArrayAPI.tile(data.numpy(), reps)
>>>             #print('ans1.shape = {!r}'.format(tuple(ans1.shape)))
>>>             #print('ans2.shape = {!r}'.format(tuple(ans2.shape)))
>>>             assert np.all(ans1.numpy() == ans2)
```

static repeat(*data*, *repeats*, *axis=None*)

I'm not actually sure how to implement this efficiently

Example

```
>>> # xdoctest: +SKIP
>>> data = torch.arange(10)[:, None]
>>> ans1 = ArrayAPI.repeat(data, 2, axis=1)
>>> ans2 = ArrayAPI.repeat(data.numpy(), 2, axis=1)
>>> assert np.all(ans1.numpy() == ans2)
```

Doctest

```
>>> # xdoctest: +SKIP
>>> shapes = [(3,), (3, 4,), (3, 5, 7)]
>>> for shape in shapes:
>>>     data = torch.rand(*shape)
>>>     for axis in range(len(shape)):
>>>         for repeats in range(0, 4):
>>>             ans1 = ArrayAPI.repeat(data, repeats, axis=axis)
>>>             ans2 = ArrayAPI.repeat(data.numpy(), repeats, axis=axis)
>>>             assert np.all(ans1.numpy() == ans2)
```

ArrayAPI.repeat(data, 2, axis=0) ArrayAPI.repeat(data.numpy(), 2, axis=0)

x = np.array([[1,2],[3,4]]) np.repeat(x, [1, 2], axis=0)

ArrayAPI.repeat(data.numpy(), [1, 2])

static T(*data*)

static transpose(*data*, *axes*)

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> import torch
>>> data1 = torch.rand(2, 3, 5)
>>> data2 = data1.numpy()
>>> res1 = ArrayAPI.transpose(data1, (2, 0, 1))
>>> res2 = ArrayAPI.transpose(data2, (2, 0, 1))
>>> assert np.all(res1.numpy() == res2)
```

static numel(*data*)

static full_like(*data*, *fill_value*, *dtype=None*)

static empty_like(*data*, *dtype=None*)

static zeros_like(*data*, *dtype=None*)

static ones_like(*data*, *dtype=None*)

static full(*shape*, *fill_value*, *dtype=<class 'float'>*)

static empty(*shape*, *dtype=<class 'float'>*)

static zeros(*shape*, *dtype=<class 'float'>*)

static ones(*shape*, *dtype=<class 'float'>*)

static argmax(*data*, *axis=None*)

static argmin(*data*, *axis=None*)

static argsort(*data*, *axis=-1*, *descending=False*)

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> from kwarray.arrayapi import *  # NOQA
>>> import torch
>>> rng = np.random.RandomState(0)
>>> data2 = rng.rand(5, 5)
>>> data1 = torch.from_numpy(data2)
>>> res1 = ArrayAPI.argsort(data1)
>>> res2 = ArrayAPI.argsort(data2)
>>> assert np.all(res1.numpy() == res2)
>>> res1 = ArrayAPI.argsort(data1, axis=1)
>>> res2 = ArrayAPI.argsort(data2, axis=1)
>>> assert np.all(res1.numpy() == res2)
>>> res1 = ArrayAPI.argsort(data1, axis=1, descending=True)
>>> res2 = ArrayAPI.argsort(data2, axis=1, descending=True)
>>> assert np.all(res1.numpy() == res2)
>>> data2 = rng.rand(5)
>>> data1 = torch.from_numpy(data2)
>>> res1 = ArrayAPI.argsort(data1, axis=0, descending=True)
```

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```
>>> res2 = ArrayAPI.argsort(data2, axis=0, descending=True)
>>> assert np.all(res1.numpy() == res2)
```

static max(*data*, *axis=None*)

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> from kwarray.arrayapi import *  # NOQA
>>> from kwarray.arrayapi import _TORCH_HAS_MAX_BUG
>>> import torch
>>> import pytest
>>> if _TORCH_HAS_MAX_BUG:
>>>     pytest.skip('torch max has a bug, which was fixed in 1.7')
>>> data1 = torch.rand(5, 5, 5, 5, 5, 5)
>>> data2 = data1.numpy()
>>> res1 = ArrayAPI.max(data1)
>>> res2 = ArrayAPI.max(data2)
>>> assert np.all(res1.numpy() == res2)
>>> res1 = ArrayAPI.max(data1, axis=(4, 0, 1))
>>> res2 = ArrayAPI.max(data2, axis=(4, 0, 1))
>>> assert np.all(res1.numpy() == res2)
>>> res1 = ArrayAPI.max(data1, axis=(5, -2))
>>> res2 = ArrayAPI.max(data2, axis=(5, -2))
>>> assert np.all(res1.numpy() == res2)
```

static min(*data*, *axis=None*)

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> from kwarray.arrayapi import *  # NOQA
>>> from kwarray.arrayapi import _TORCH_HAS_MAX_BUG
>>> import pytest
>>> import torch
>>> if _TORCH_HAS_MAX_BUG:
>>>     pytest.skip('torch min has a bug, which was fixed in 1.7')
>>> data1 = torch.rand(5, 5, 5, 5, 5, 5)
>>> data2 = data1.numpy()
>>> res1 = ArrayAPI.min(data1)
>>> res2 = ArrayAPI.min(data2)
>>> assert np.all(res1.numpy() == res2)
>>> res1 = ArrayAPI.min(data1, axis=(4, 0, 1))
>>> res2 = ArrayAPI.min(data2, axis=(4, 0, 1))
>>> assert np.all(res1.numpy() == res2)
>>> res1 = ArrayAPI.min(data1, axis=(5, -2))
>>> res2 = ArrayAPI.min(data2, axis=(5, -2))
>>> assert np.all(res1.numpy() == res2)
```

static max_argmax(*data*, *axis=None*)

Parameters

- **data** (*Tensor*) – data to perform operation on
- **axis** (*None | int*) – axis to perform operation on

Returns
The max value(s) and argmax position(s).

Return type
Tuple[Numeric, Numeric]

Note: In modern versions of torch and numpy if there are multiple maximum values the index of the instance is returned. This is not true in older versions of torch. I'm unsure when this gaurentee was added to numpy.

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> from kwarray.arrayapi import *  # NOQA
>>> from kwarray.arrayapi import ArrayAPI
>>> import torch
>>> data = 1 / (1 + (torch.arange(12) - 6).view(3, 4) ** 2)
>>> ArrayAPI.max_argmax(data)
(tensor(1...), tensor(6))
>>> # When the values are all the same, there doesn't seem
>>> # to be a reliable spec on which one is returned first.
>>> np.ones(10).argmax()   # xdoctest: +IGNORE_WANT
0
>>> # Newer versions of torch (e.g. 1.12.0)
>>> torch.ones(10).argmax()   # xdoctest: +IGNORE_WANT
tensor(0)
>>> # Older versions of torch  (e.g 1.6.0)
>>> torch.ones(10).argmax()   # xdoctest: +IGNORE_WANT
tensor(9)
```

static min_argmin(*data*, *axis=None*)

Parameters

- **data** (*Tensor*) – data to perform operation on
- **axis** (*None | int*) – axis to perform operation on

Returns
The min value(s) and argmin position(s).

Return type
Tuple[Numeric, Numeric]

Note: In modern versions of torch and numpy if there are multiple minimum values the index of the instance is returned. This is not true in older versions of torch. I'm unsure when this gaurentee was added to numpy.

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> from kwarray.arrayapi import *  # NOQA
>>> from kwarray.arrayapi import ArrayAPI
>>> import torch
>>> data = (torch.arange(12) - 6).view(3, 4) ** 2
>>> ArrayAPI.min_argmin(data)
(tensor(0), tensor(6))
>>> # Issue demo:
>>> # When the values are all the same, there doesn't seem
>>> # to be a reliable spec on which one is returned first.
>>> np.ones(10).argmin()   # xdoctest: +IGNORE_WANT
0
>>> # Newer versions of torch (e.g. 1.12.0)
>>> torch.ones(10).argmin()   # xdoctest: +IGNORE_WANT
tensor(0)
>>> # Older versions of torch  (e.g 1.6.0)
>>> torch.ones(10).argmin()   # xdoctest: +IGNORE_WANT
tensor(9)
```

static maximum(*data1*, *data2*, *out=None*)

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> import sys, ubelt
>>> from kwarray.arrayapi import *  # NOQA
>>> import torch
>>> data1 = torch.rand(5, 5)
>>> data2 = torch.rand(5, 5)
>>> result1 = TorchImpls.maximum(data1, data2)
>>> result2 = NumpyImpls.maximum(data1.numpy(), data2.numpy())
>>> assert np.allclose(result1.numpy(), result2)
>>> result1 = TorchImpls.maximum(data1, 0)
>>> result2 = NumpyImpls.maximum(data1.numpy(), 0)
>>> assert np.allclose(result1.numpy(), result2)
```

static minimum(*data1*, *data2*, *out=None*)

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> import torch
>>> data1 = torch.rand(5, 5)
>>> data2 = torch.rand(5, 5)
>>> result1 = TorchImpls.minimum(data1, data2)
>>> result2 = NumpyImpls.minimum(data1.numpy(), data2.numpy())
>>> assert np.allclose(result1.numpy(), result2)
```

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> import sys, ubelt
>>> from kwarray.arrayapi import *  # NOQA
>>> import torch
>>> data1 = torch.rand(5, 5)
>>> data2 = torch.rand(5, 5)
>>> result1 = TorchImpls.minimum(data1, data2)
>>> result2 = NumpyImpls.minimum(data1.numpy(), data2.numpy())
>>> assert np.allclose(result1.numpy(), result2)
>>> result1 = TorchImpls.minimum(data1, 0)
>>> result2 = NumpyImpls.minimum(data1.numpy(), 0)
>>> assert np.allclose(result1.numpy(), result2)
```

static array_equal(*data1*, *data2*, *equal_nan=False*) → bool

Returns True if all elements in the array are equal. This mirrors the behavior of `numpy.array_equal()`.

Parameters

- **data1** (*Tensor*) – first array
- **data2** (*Tensor*) – second array
- **equal_nan** (*bool*) – Whether to compare NaN's as equal.

Returns

bool

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> from kwarray.arrayapi import *  # NOQA
>>> import torch
>>> data1 = torch.rand(5, 5)
>>> data2 = data1 + 1
>>> result1 = TorchImpls.array_equal(data1, data2)
>>> result2 = NumpyImpls.array_equal(data1.numpy(), data2.numpy())
>>> result3 = TorchImpls.array_equal(data1, data1)
>>> result4 = NumpyImpls.array_equal(data1.numpy(), data1.numpy())
>>> assert result1 is False
>>> assert result2 is False
>>> assert result3 is True
>>> assert result4 is True
```

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> from kwarray.arrayapi import *  # NOQA
>>> import torch
>>> data1 = torch.rand(5, 5)
>>> data1[0] = np.nan
>>> data2 = data1
>>> result1 = TorchImpls.array_equal(data1, data2)
>>> result2 = NumpyImpls.array_equal(data1.numpy(), data2.numpy())
>>> result3 = TorchImpls.array_equal(data1, data2, equal_nan=True)
>>> result4 = NumpyImpls.array_equal(data1.numpy(), data2.numpy(), equal_
↪nan=True)
>>> assert result1 is False
>>> assert result2 is False
>>> assert result3 is True
>>> assert result4 is True
```

static matmul(*data1*, *data2*, *out=None*)

static sum(*data*, *axis=None*)

static nan_to_num(*x*, *copy=True*)

static copy(*data*)

static log(*data*)

static log2(*data*)

static any(*data*)

static all(*data*)

static nonzero(*data*)

static astype(*data*, *dtype*, *copy=True*)

static tensor(*data*, *device=NoParam*)

static numpy(*data*)

static tolist(*data*)

static contiguous(*data*)

static pad(*data*, *pad_width*, *mode='constant'*)

static asarray(*data*, *dtype=None*)

Cast data into a tensor representation

Example

```
>>> data = np.empty((2, 0, 196, 196), dtype=np.float32)
```

static ensure(*data*, *dtype=None*)

Cast data into a tensor representation

Example

```
>>> data = np.empty((2, 0, 196, 196), dtype=np.float32)
```

static dtype_kind(*data*)

returns the numpy code for the data type kind

static floor(*data*, *out=None*)

static ceil(*data*, *out=None*)

static ifloor(*data*, *out=None*)

static iceil(*data*, *out=None*)

static round(*data*, *decimals=0*, *out=None*)

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> import kwarray
>>> import torch
>>> rng = kwarray.ensure_rng(0)
>>> np_data = rng.rand(10) * 100
>>> pt_data = torch.from_numpy(np_data)
>>> a = kwarray.ArrayAPI.round(np_data)
>>> b = kwarray.ArrayAPI.round(pt_data)
>>> assert np.all(a == b.numpy())
>>> a = kwarray.ArrayAPI.round(np_data, 2)
>>> b = kwarray.ArrayAPI.round(pt_data, 2)
>>> assert np.all(a == b.numpy())
```

static iround(*data*, *out=None*, *dtype=<class 'int'>*)

static clip(*data*, *a_min=None*, *a_max=None*, *out=None*)

static softmax(*data*, *axis=None*)

class kwarray.arrayapi.**NumpyImpls**

Bases: object

Numpy backend for the ArrayAPI API

is_tensor = False

is_numpy = True

static hstack(*tup*, ***, *dtype=None*, *casting='same_kind'*)

Stack arrays in sequence horizontally (column wise).

This is equivalent to concatenation along the second axis, except for 1-D arrays where it concatenates along the first axis. Rebuilds arrays divided by *hsplit*.

This function makes most sense for arrays with up to 3 dimensions. For instance, for pixel-data with a height (first axis), width (second axis), and r/g/b channels (third axis). The functions *concatenate*, *stack* and *block* provide more general stacking and concatenation operations.

Parameters

- **tup** (*sequence of ndarrays*) – The arrays must have the same shape along all but the second axis, except 1-D arrays which can be any length.
- **dtype** (*str or dtype*) – If provided, the destination array will have this dtype. Cannot be provided together with *out*.
- **.. versionadded:: 1.24**
- **casting** (*{'no', 'equiv', 'safe', 'same_kind', 'unsafe'}, optional*) – Controls what kind of data casting may occur. Defaults to 'same_kind'.
- **.. versionadded:: 1.24**

Returns

stacked – The array formed by stacking the given arrays.

Return type

ndarray

See also:

concatenate
Join a sequence of arrays along an existing axis.

stack
Join a sequence of arrays along a new axis.

block
Assemble an nd-array from nested lists of blocks.

vstack
Stack arrays in sequence vertically (row wise).

dstack
Stack arrays in sequence depth wise (along third axis).

column_stack
Stack 1-D arrays as columns into a 2-D array.

hsplit
Split an array into multiple sub-arrays horizontally (column-wise).

Examples

```
>>> a = np.array((1,2,3))
>>> b = np.array((4,5,6))
>>> np.hstack((a,b))
array([1, 2, 3, 4, 5, 6])
>>> a = np.array([[1],[2],[3]])
>>> b = np.array([[4],[5],[6]])
>>> np.hstack((a,b))
array([[1, 4],
       [2, 5],
       [3, 6]])
```

static vstack(*tup*, ***, *dtype=None*, *casting='same_kind'*)

Stack arrays in sequence vertically (row wise).

This is equivalent to concatenation along the first axis after 1-D arrays of shape *(N,)* have been reshaped to *(1,N)*. Rebuilds arrays divided by *vsplit*.

This function makes most sense for arrays with up to 3 dimensions. For instance, for pixel-data with a height (first axis), width (second axis), and r/g/b channels (third axis). The functions *concatenate*, *stack* and *block* provide more general stacking and concatenation operations.

`np.row_stack` is an alias for *vstack*. They are the same function.

Parameters

- **tup** (*sequence of ndarrays*) – The arrays must have the same shape along all but the first axis. 1-D arrays must have the same length.
- **dtype** (*str or dtype*) – If provided, the destination array will have this dtype. Cannot be provided together with *out*.
- **.. versionadded:: 1.24**
- **casting** (*{'no', 'equiv', 'safe', 'same_kind', 'unsafe'}, optional*) – Controls what kind of data casting may occur. Defaults to 'same_kind'.
- **.. versionadded:: 1.24**

Returns

stacked – The array formed by stacking the given arrays, will be at least 2-D.

Return type

ndarray

See also:

concatenate
Join a sequence of arrays along an existing axis.

stack
Join a sequence of arrays along a new axis.

block
Assemble an nd-array from nested lists of blocks.

hstack
Stack arrays in sequence horizontally (column wise).

dstack
Stack arrays in sequence depth wise (along third axis).

column_stack
Stack 1-D arrays as columns into a 2-D array.

vsplit
Split an array into multiple sub-arrays vertically (row-wise).

Examples

```
>>> a = np.array([1, 2, 3])
>>> b = np.array([4, 5, 6])
>>> np.vstack((a,b))
array([[1, 2, 3],
       [4, 5, 6]])
```

```
>>> a = np.array([[1], [2], [3]])
>>> b = np.array([[4], [5], [6]])
>>> np.vstack((a,b))
array([[1],
       [2],
       [3],
       [4],
       [5],
       [6]])
```

static result_type(**arrays_and_dtypes*)

Return type from promotion rules

SeeAlso:
`numpy.find_common_type()` `numpy.promote_types()` `numpy.result_type()`

static cat(*datas*, *axis=-1*)

static atleast_nd(*arr*, *n*, *front=False*)

static view(*data*, **shape*)

static take(*data*, *indices*, *axis=None*)

static compress(*data*, *flags*, *axis=None*)

static repeat(*data*, *repeats*, *axis=None*)

static tile(*data*, *reps*)

static T(*data*)

static transpose(*data*, *axes*)

static numel(*data*)

static empty_like(*data*, *dtype=None*)

static full_like(*data*, *fill_value*, *dtype=None*)

static **zeros_like**(*data*, *dtype=None*)

static **ones_like**(*data*, *dtype=None*)

static **full**(*shape*, *fill_value*, *dtype=<class 'float'>*)

static **empty**(*shape*, *dtype=<class 'float'>*)

static **zeros**(*shape*, *dtype=<class 'float'>*)

static **ones**(*shape*, *dtype=<class 'float'>*)

static **argmax**(*data*, *axis=None*)

static **argmin**(*data*, *axis=None*)

static **argsort**(*data*, *axis=-1*, *descending=False*)

static **max**(*data*, *axis=None*)

static **min**(*data*, *axis=None*)

static **max_argmax**(*data*, *axis=None*)

Parameters

- **data** (*ArrayLike*) – data to perform operation on
- **axis** (*None | int*) – axis to perform operation on

Returns
The max value(s) and argmax position(s).

Return type
Tuple[Numeric, Numeric]

static **min_argmin**(*data*, *axis=None*)

Parameters

- **data** (*ArrayLike*) – data to perform operation on
- **axis** (*None | int*) – axis to perform operation on

Returns
The min value(s) and argmin position(s).

Return type
Tuple[Numeric, Numeric]

static **sum**(*data*, *axis=None*)

static **maximum**(*data1*, *data2*, *out=None*)

static **minimum**(*data1*, *data2*, *out=None*)

matmul = <ufunc 'matmul'>

`static nan_to_num`(*x*, *copy=True*, *nan=0.0*, *posinf=None*, *neginf=None*)

Replace NaN with zero and infinity with large finite numbers (default behaviour) or with the numbers defined by the user using the *nan*, *posinf* and/or *neginf* keywords.

If *x* is inexact, NaN is replaced by zero or by the user defined value in *nan* keyword, infinity is replaced by the largest finite floating point values representable by `x.dtype` or by the user defined value in *posinf* keyword and -infinity is replaced by the most negative finite floating point values representable by `x.dtype` or by the user defined value in *neginf* keyword.

For complex dtypes, the above is applied to each of the real and imaginary components of *x* separately.

If *x* is not inexact, then no replacements are made.

Parameters

- **x** (*scalar or array_like*) – Input data.
- **copy** (*bool, optional*) – Whether to create a copy of *x* (True) or to replace values in-place (False). The in-place operation only occurs if casting to an array does not require a copy. Default is True.

  New in version 1.13.
- **nan** (*int, float, optional*) – Value to be used to fill NaN values. If no value is passed then NaN values will be replaced with 0.0.

  New in version 1.17.
- **posinf** (*int, float, optional*) – Value to be used to fill positive infinity values. If no value is passed then positive infinity values will be replaced with a very large number.

  New in version 1.17.
- **neginf** (*int, float, optional*) – Value to be used to fill negative infinity values. If no value is passed then negative infinity values will be replaced with a very small (or negative) number.

  New in version 1.17.

Returns

out – *x*, with the non-finite values replaced. If *copy* is False, this may be *x* itself.

Return type

ndarray

See also:

`isinf`
Shows which elements are positive or negative infinity.

`isneginf`
Shows which elements are negative infinity.

`isposinf`
Shows which elements are positive infinity.

`isnan`
Shows which elements are Not a Number (NaN).

`isfinite`
Shows which elements are finite (not NaN, not infinity)

Notes

NumPy uses the IEEE Standard for Binary Floating-Point for Arithmetic (IEEE 754). This means that Not a Number is not equivalent to infinity.

Examples

```
>>> np.nan_to_num(np.inf)
1.7976931348623157e+308
>>> np.nan_to_num(-np.inf)
-1.7976931348623157e+308
>>> np.nan_to_num(np.nan)
0.0
>>> x = np.array([np.inf, -np.inf, np.nan, -128, 128])
>>> np.nan_to_num(x)
array([ 1.79769313e+308, -1.79769313e+308,  0.00000000e+000, # may vary
       -1.28000000e+002,  1.28000000e+002])
>>> np.nan_to_num(x, nan=-9999, posinf=33333333, neginf=33333333)
array([ 3.3333333e+07,  3.3333333e+07, -9.9990000e+03,
       -1.2800000e+02,  1.2800000e+02])
>>> y = np.array([complex(np.inf, np.nan), np.nan, complex(np.nan, np.inf)])
array([  1.79769313e+308,  -1.79769313e+308,   0.00000000e+000, # may vary
     -1.28000000e+002,   1.28000000e+002])
>>> np.nan_to_num(y)
array([  1.79769313e+308 +0.00000000e+000j, # may vary
         0.00000000e+000 +0.00000000e+000j,
         0.00000000e+000 +1.79769313e+308j])
>>> np.nan_to_num(y, nan=111111, posinf=222222)
array([222222.+111111.j, 111111.     +0.j, 111111.+222222.j])
```

static array_equal(*a1*, *a2*, *equal_nan=False*)

True if two arrays have the same shape and elements, False otherwise.

Parameters

- **a1, a2** (*array_like*) – Input arrays.
- **equal_nan** (*bool*) – Whether to compare NaN's as equal. If the dtype of a1 and a2 is complex, values will be considered equal if either the real or the imaginary component of a given value is `nan`.

  New in version 1.19.0.

Returns

b – Returns True if the arrays are equal.

Return type

bool

See also:

allclose

Returns True if two arrays are element-wise equal within a tolerance.

array_equiv

Returns True if input arrays are shape consistent and all elements equal.

Examples

```
>>> np.array_equal([1, 2], [1, 2])
True
>>> np.array_equal(np.array([1, 2]), np.array([1, 2]))
True
>>> np.array_equal([1, 2], [1, 2, 3])
False
>>> np.array_equal([1, 2], [1, 4])
False
>>> a = np.array([1, np.nan])
>>> np.array_equal(a, a)
False
>>> np.array_equal(a, a, equal_nan=True)
True
```

When `equal_nan` is True, complex values with nan components are considered equal if either the real *or* the imaginary components are nan.

```
>>> a = np.array([1 + 1j])
>>> b = a.copy()
>>> a.real = np.nan
>>> b.imag = np.nan
>>> np.array_equal(a, b, equal_nan=True)
True
```

log = <ufunc 'log'>

log2 = <ufunc 'log2'>

static any(*a*, *axis=None*, *out=None*, *keepdims=<no value>*, *, *where=<no value>*)

Test whether any array element along a given axis evaluates to True.

Returns single boolean if *axis* is `None`

Parameters

- **a** (*array_like*) – Input array or object that can be converted to an array.
- **axis** (*None or int or tuple of ints, optional*) – Axis or axes along which a logical OR reduction is performed. The default (`axis=None`) is to perform a logical OR over all the dimensions of the input array. *axis* may be negative, in which case it counts from the last to the first axis.

  New in version 1.7.0.

  If this is a tuple of ints, a reduction is performed on multiple axes, instead of a single axis or all the axes as before.
- **out** (*ndarray, optional*) – Alternate output array in which to place the result. It must have the same shape as the expected output and its type is preserved (e.g., if it is of type float, then it will remain so, returning 1.0 for True and 0.0 for False, regardless of the type of *a*). See Output type determination for more details.
- **keepdims** (*bool, optional*) – If this is set to True, the axes which are reduced are left in the result as dimensions with size one. With this option, the result will broadcast correctly against the input array.

If the default value is passed, then *keepdims* will not be passed through to the *any* method of sub-classes of *ndarray*, however any non-default value will be. If the sub-class' method does not implement *keepdims* any exceptions will be raised.

- **where** (*array_like of bool, optional*) – Elements to include in checking for any *True* values. See *~numpy.ufunc.reduce* for details.

  New in version 1.20.0.

Returns

any – A new boolean or *ndarray* is returned unless *out* is specified, in which case a reference to *out* is returned.

Return type

bool or ndarray

See also:

ndarray.any
equivalent method

all
Test whether all elements along a given axis evaluate to True.

Notes

Not a Number (NaN), positive infinity and negative infinity evaluate to *True* because these are not equal to zero.

Examples

```
>>> np.any([[True, False], [True, True]])
True
```

```
>>> np.any([[True, False], [False, False]], axis=0)
array([ True, False])
```

```
>>> np.any([-1, 0, 5])
True
```

```
>>> np.any(np.nan)
True
```

```
>>> np.any([[True, False], [False, False]], where=[[False], [True]])
False
```

```
>>> o=np.array(False)
>>> z=np.any([-1, 4, 5], out=o)
>>> z, o
(array(True), array(True))
>>> # Check now that z is a reference to o
>>> z is o
True
```

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```
>>> id(z), id(o) # identity of z and o
(191614240, 191614240)
```

static all(*a*, *axis=None*, *out=None*, *keepdims=<no value>*, *, *where=<no value>*)

Test whether all array elements along a given axis evaluate to True.

Parameters

- **a** (*array_like*) – Input array or object that can be converted to an array.
- **axis** (*None or int or tuple of ints, optional*) – Axis or axes along which a logical AND reduction is performed. The default (`axis=None`) is to perform a logical AND over all the dimensions of the input array. *axis* may be negative, in which case it counts from the last to the first axis.

  New in version 1.7.0.

  If this is a tuple of ints, a reduction is performed on multiple axes, instead of a single axis or all the axes as before.
- **out** (*ndarray, optional*) – Alternate output array in which to place the result. It must have the same shape as the expected output and its type is preserved (e.g., if `dtype(out)` is float, the result will consist of 0.0's and 1.0's). See Output type determination for more details.
- **keepdims** (*bool, optional*) – If this is set to True, the axes which are reduced are left in the result as dimensions with size one. With this option, the result will broadcast correctly against the input array.

  If the default value is passed, then *keepdims* will not be passed through to the *all* method of sub-classes of *ndarray*, however any non-default value will be. If the sub-class' method does not implement *keepdims* any exceptions will be raised.
- **where** (*array_like of bool, optional*) – Elements to include in checking for all *True* values. See *~numpy.ufunc.reduce* for details.

  New in version 1.20.0.

Returns

all – A new boolean or array is returned unless *out* is specified, in which case a reference to *out* is returned.

Return type

ndarray, bool

See also:

ndarray.all

equivalent method

any

Test whether any element along a given axis evaluates to True.

Notes

Not a Number (NaN), positive infinity and negative infinity evaluate to *True* because these are not equal to zero.

Examples

```
>>> np.all([[True,False],[True,True]])
False
```

```
>>> np.all([[True,False],[True,True]], axis=0)
array([ True, False])
```

```
>>> np.all([-1, 4, 5])
True
```

```
>>> np.all([1.0, np.nan])
True
```

```
>>> np.all([[True, True], [False, True]], where=[[True], [False]])
True
```

```
>>> o=np.array(False)
>>> z=np.all([-1, 4, 5], out=o)
>>> id(z), id(o), z
(28293632, 28293632, array(True)) # may vary
```

static copy(*a*, *order='K'*, *subok=False*)

Return an array copy of the given object.

Parameters

- **a** (*array_like*) – Input data.
- **order** (*{'C', 'F', 'A', 'K'}, optional*) – Controls the memory layout of the copy. 'C' means C-order, 'F' means F-order, 'A' means 'F' if *a* is Fortran contiguous, 'C' otherwise. 'K' means match the layout of *a* as closely as possible. (Note that this function and `ndarray.copy()` are very similar, but have different default values for their order= arguments.)
- **subok** (*bool, optional*) – If True, then sub-classes will be passed-through, otherwise the returned array will be forced to be a base-class array (defaults to False).

  New in version 1.19.0.

Returns

arr – Array interpretation of *a*.

Return type

ndarray

See also:

ndarray.copy

Preferred method for creating an array copy

Notes

This is equivalent to:

```
>>> np.array(a, copy=True)
```

Examples

Create an array x, with a reference y and a copy z:

```
>>> x = np.array([1, 2, 3])
>>> y = x
>>> z = np.copy(x)
```

Note that, when we modify x, y changes, but not z:

```
>>> x[0] = 10
>>> x[0] == y[0]
True
>>> x[0] == z[0]
False
```

Note that, np.copy clears previously set WRITEABLE=False flag.

```
>>> a = np.array([1, 2, 3])
>>> a.flags["WRITEABLE"] = False
>>> b = np.copy(a)
>>> b.flags["WRITEABLE"]
True
>>> b[0] = 3
>>> b
array([3, 2, 3])
```

Note that np.copy is a shallow copy and will not copy object elements within arrays. This is mainly important for arrays containing Python objects. The new array will contain the same object which may lead to surprises if that object can be modified (is mutable):

```
>>> a = np.array([1, 'm', [2, 3, 4]], dtype=object)
>>> b = np.copy(a)
>>> b[2][0] = 10
>>> a
array([1, 'm', list([10, 3, 4])], dtype=object)
```

To ensure all elements within an `object` array are copied, use *copy.deepcopy*:

```
>>> import copy
>>> a = np.array([1, 'm', [2, 3, 4]], dtype=object)
>>> c = copy.deepcopy(a)
>>> c[2][0] = 10
>>> c
array([1, 'm', list([10, 3, 4])], dtype=object)
>>> a
array([1, 'm', list([2, 3, 4])], dtype=object)
```

`static nonzero(a)`

Return the indices of the elements that are non-zero.

Returns a tuple of arrays, one for each dimension of *a*, containing the indices of the non-zero elements in that dimension. The values in *a* are always tested and returned in row-major, C-style order.

To group the indices by element, rather than dimension, use *argwhere*, which returns a row for each non-zero element.

Note: When called on a zero-d array or scalar, `nonzero(a)` is treated as `nonzero(atleast_1d(a))`.

Deprecated since version 1.17.0: Use *atleast_1d* explicitly if this behavior is deliberate.

Parameters
a (*array_like*) – Input array.

Returns
tuple_of_arrays – Indices of elements that are non-zero.

Return type
tuple

See also:

`flatnonzero`
Return indices that are non-zero in the flattened version of the input array.

`ndarray.nonzero`
Equivalent ndarray method.

`count_nonzero`
Counts the number of non-zero elements in the input array.

Notes

While the nonzero values can be obtained with `a[nonzero(a)]`, it is recommended to use `x[x.astype(bool)]` or `x[x != 0]` instead, which will correctly handle 0-d arrays.

Examples

```
>>> x = np.array([[3, 0, 0], [0, 4, 0], [5, 6, 0]])
>>> x
array([[3, 0, 0],
       [0, 4, 0],
       [5, 6, 0]])
>>> np.nonzero(x)
(array([0, 1, 2, 2]), array([0, 1, 0, 1]))
```

```
>>> x[np.nonzero(x)]
array([3, 4, 5, 6])
>>> np.transpose(np.nonzero(x))
array([[0, 0],
       [1, 1],
```

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```
       [2, 0],
       [2, 1]])
```

A common use for nonzero is to find the indices of an array, where a condition is True. Given an array *a*, the condition *a* > 3 is a boolean array and since False is interpreted as 0, np.nonzero(a > 3) yields the indices of the *a* where the condition is true.

```
>>> a = np.array([[1, 2, 3], [4, 5, 6], [7, 8, 9]])
>>> a > 3
array([[False, False, False],
       [ True,  True,  True],
       [ True,  True,  True]])
>>> np.nonzero(a > 3)
(array([1, 1, 1, 2, 2, 2]), array([0, 1, 2, 0, 1, 2]))
```

Using this result to index *a* is equivalent to using the mask directly:

```
>>> a[np.nonzero(a > 3)]
array([4, 5, 6, 7, 8, 9])
>>> a[a > 3]  # prefer this spelling
array([4, 5, 6, 7, 8, 9])
```

nonzero can also be called as a method of the array.

```
>>> (a > 3).nonzero()
(array([1, 1, 1, 2, 2, 2]), array([0, 1, 2, 0, 1, 2]))
```

static astype(*data*, *dtype*, *copy=True*)

static tensor(*data*, *device=NoParam*)

static numpy(*data*)

static tolist(*data*)

static contiguous(*data*)

static pad(*data*, *pad_width*, *mode='constant'*)

static asarray(*data*, *dtype=None*)

Cast data into a numpy representation

static ensure(*data*, *dtype=None*)

Cast data into a numpy representation

static dtype_kind(*data*)

static floor(*data*, *out=None*)

static ceil(*data*, *out=None*)

static ifloor(*data*, *out=None*)

static iceil(*data*, *out=None*)

static round(*data*, *decimals=0*, *out=None*)

static iround(*data*, *out=None*, *dtype=<class 'int'>*)

static clip(*a*, *a_min*, *a_max*, *out=None*, ***kwargs*)

Clip (limit) the values in an array.

Given an interval, values outside the interval are clipped to the interval edges. For example, if an interval of `[0, 1]` is specified, values smaller than 0 become 0, and values larger than 1 become 1.

Equivalent to but faster than `np.minimum(a_max, np.maximum(a, a_min))`.

No check is performed to ensure `a_min < a_max`.

Parameters

- **a** (*array_like*) – Array containing elements to clip.
- **a_min, a_max** (*array_like or None*) – Minimum and maximum value. If `None`, clipping is not performed on the corresponding edge. Only one of *a_min* and *a_max* may be `None`. Both are broadcast against *a*.
- **out** (*ndarray, optional*) – The results will be placed in this array. It may be the input array for in-place clipping. *out* must be of the right shape to hold the output. Its type is preserved.
- ****kwargs** – For other keyword-only arguments, see the ufunc docs.

  New in version 1.17.0.

Returns

clipped_array – An array with the elements of *a*, but where values < *a_min* are replaced with *a_min*, and those > *a_max* with *a_max*.

Return type

ndarray

See also:

Output type determination

Notes

When *a_min* is greater than *a_max*, *clip* returns an array in which all values are equal to *a_max*, as shown in the second example.

Examples

```
>>> a = np.arange(10)
>>> a
array([0, 1, 2, 3, 4, 5, 6, 7, 8, 9])
>>> np.clip(a, 1, 8)
array([1, 1, 2, 3, 4, 5, 6, 7, 8, 8])
>>> np.clip(a, 8, 1)
array([1, 1, 1, 1, 1, 1, 1, 1, 1, 1])
>>> np.clip(a, 3, 6, out=a)
array([3, 3, 3, 3, 4, 5, 6, 6, 6, 6])
>>> a
array([3, 3, 3, 3, 4, 5, 6, 6, 6, 6])
>>> a = np.arange(10)
>>> a
```

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```
array([0, 1, 2, 3, 4, 5, 6, 7, 8, 9])
>>> np.clip(a, [3, 4, 1, 1, 1, 4, 4, 4, 4, 4], 8)
array([3, 4, 2, 3, 4, 5, 6, 7, 8, 8])
```

static softmax(*data*, *axis=None*)

static kron(*a*, *b*)

Outer product

Parameters

- **a** (*ndarray*) – Array of shape (r0, r1, … rN)
- **b** (*ndarray*) – Array of shape (s0, s1, … sN)

Returns

with shape (r0*s0, r1*s1, …, rN*SN).

Return type

ndarray

Note: # From numpy doc kron(a,b)[k0,k1,…,kN] = a[i0,i1,…,iN] * b[j0,j1,…,jN]

kt = it * st + jt, t = 0,…,N

Notes

If a.shape = (r0,r1,..,rN) and b.shape = (s0,s1,…,sN), the Kronecker product has shape (r0*s0, r1*s1, …, rN*SN).

class kwarray.arrayapi.**ArrayAPI**

Bases: object

Compatability API between torch and numpy.

The API defines classmethods that work on both Tensors and ndarrays. As such the user can simply use `kwarray.ArrayAPI.<funcname>` and it will return the expected result for both Tensor and ndarray types.

However, this is inefficient because it requires us to check the type of the input for every API call. Therefore it is recommended that you use the *ArrayAPI.coerce()* function, which takes as input the data you want to operate on. It performs the type check once, and then returns another object that defines with an identical API, but specific to the given data type. This means that we can ignore type checks on future calls of the specific implementation. See examples for more details.

Example

```
>>> # Use the easy-to-use, but inefficient array api
>>> # xdoctest: +REQUIRES(module:torch)
>>> import kwarray
>>> import torch
>>> take = kwarray.ArrayAPI.take
>>> np_data = np.arange(0, 143).reshape(11, 13)
>>> pt_data = torch.LongTensor(np_data)
>>> indices = [1, 3, 5, 7, 11, 13, 17, 21]
```

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```
>>> idxs0 = [1, 3, 5, 7]
>>> idxs1 = [1, 3, 5, 7, 11]
>>> assert np.allclose(take(np_data, indices), take(pt_data, indices))
>>> assert np.allclose(take(np_data, idxs0, 0), take(pt_data, idxs0, 0))
>>> assert np.allclose(take(np_data, idxs1, 1), take(pt_data, idxs1, 1))
```

Example

```
>>> # Use the easy-to-use, but inefficient array api
>>> # xdoctest: +REQUIRES(module:torch)
>>> import kwarray
>>> import torch
>>> compress = kwarray.ArrayAPI.compress
>>> np_data = np.arange(0, 143).reshape(11, 13)
>>> pt_data = torch.LongTensor(np_data)
>>> flags = (np_data % 2 == 0).ravel()
>>> f0 = (np_data % 2 == 0)[:, 0]
>>> f1 = (np_data % 2 == 0)[0, :]
>>> assert np.allclose(compress(np_data, flags), compress(pt_data, flags))
>>> assert np.allclose(compress(np_data, f0, 0), compress(pt_data, f0, 0))
>>> assert np.allclose(compress(np_data, f1, 1), compress(pt_data, f1, 1))
```

Example

```
>>> # Use ArrayAPI to coerce an identical API that doesnt do type checks
>>> # xdoctest: +REQUIRES(module:torch)
>>> import kwarray
>>> import torch
>>> np_data = np.arange(0, 15).reshape(3, 5)
>>> pt_data = torch.LongTensor(np_data)
>>> # The new ``impl`` object has the same API as ArrayAPI, but works
>>> # specifically on torch Tensors.
>>> impl = kwarray.ArrayAPI.coerce(pt_data)
>>> flat_data = impl.view(pt_data, -1)
>>> print('flat_data = {!r}'.format(flat_data))
flat_data = tensor([ 0,  1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11, 12, 13, 14])
>>> # The new ``impl`` object has the same API as ArrayAPI, but works
>>> # specifically on numpy ndarrays.
>>> impl = kwarray.ArrayAPI.coerce(np_data)
>>> flat_data = impl.view(np_data, -1)
>>> print('flat_data = {!r}'.format(flat_data))
flat_data = array([ 0,  1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11, 12, 13, 14])
```

_torch

alias of *TorchImpls*

_numpy

alias of *NumpyImpls*

static impl(*data*)

Returns a namespace suitable for operating on the input data type

Parameters
data (*ndarray | Tensor*) – data to be operated on

static coerce(*data*)

Coerces some form of inputs into an array api (either numpy or torch).

static result_type(**arrays_and_dtypes*)

Return type from promotion rules

Example

```
>>> import kwarray
>>> kwarray.ArrayAPI.result_type(float, np.uint8, np.float32, np.float16)
>>> # xdoctest: +REQUIRES(module:torch)
>>> import torch
>>> kwarray.ArrayAPI.result_type(torch.int32, torch.int64)
```

static cat(*datas*, **args*, ***kwargs*)

static hstack(*datas*, **args*, ***kwargs*)

static vstack(*datas*, **args*, ***kwargs*)

static take(*data*, **args*, ***kwargs*)

static compress(*data*, **args*, ***kwargs*)

static repeat(*data*, **args*, ***kwargs*)

static tile(*data*, **args*, ***kwargs*)

static view(*data*, **args*, ***kwargs*)

static numel(*data*, **args*, ***kwargs*)

static atleast_nd(*data*, **args*, ***kwargs*)

static full_like(*data*, **args*, ***kwargs*)

static ones_like(*data*, **args*, ***kwargs*)

static zeros_like(*data*, **args*, ***kwargs*)

static empty_like(*data*, **args*, ***kwargs*)

static sum(*data*, **args*, ***kwargs*)

static argsort(*data*, **args*, ***kwargs*)

static argmax(*data*, **args*, ***kwargs*)

static argmin(*data*, **args*, ***kwargs*)

static max(*data*, **args*, ***kwargs*)

static **min**(*data*, **args*, ***kwargs*)

static **max_argmax**(*data*, **args*, ***kwargs*)

static **min_argmin**(*data*, **args*, ***kwargs*)

static **maximum**(*data*, **args*, ***kwargs*)

static **minimum**(*data*, **args*, ***kwargs*)

static **matmul**(*data*, **args*, ***kwargs*)

static **astype**(*data*, **args*, ***kwargs*)

static **nonzero**(*data*, **args*, ***kwargs*)

static **nan_to_num**(*data*, **args*, ***kwargs*)

static **tensor**(*data*, **args*, ***kwargs*)

static **numpy**(*data*, **args*, ***kwargs*)

static **tolist**(*data*, **args*, ***kwargs*)

static **asarray**(*data*, **args*, ***kwargs*)

static **T**(*data*, **args*, ***kwargs*)

static **transpose**(*data*, **args*, ***kwargs*)

static **contiguous**(*data*, **args*, ***kwargs*)

static **pad**(*data*, **args*, ***kwargs*)

static **dtype_kind**(*data*, **args*, ***kwargs*)

static **any**(*data*, **args*, ***kwargs*)

static **all**(*data*, **args*, ***kwargs*)

static **array_equal**(*data*, **args*, ***kwargs*)

static **log2**(*data*, **args*, ***kwargs*)

static **log**(*data*, **args*, ***kwargs*)

static **copy**(*data*, **args*, ***kwargs*)

static **iceil**(*data*, **args*, ***kwargs*)

static **ifloor**(*data*, **args*, ***kwargs*)

static **floor**(*data*, **args*, ***kwargs*)

static **ceil**(*data*, **args*, ***kwargs*)

static **round**(*data*, **args*, ***kwargs*)

static **iround**(*data*, **args*, ***kwargs*)

static **clip**(*data*, **args*, ***kwargs*)

static softmax(*data*, **args*, ***kwargs*)

kwarray.arrayapi.**TorchNumpyCompat**

alias of *ArrayAPI*

kwarray.arrayapi.**_torch_dtype_lut**()

kwarray.arrayapi.**dtype_info**(*dtype*)

Lookup datatype information

Parameters

dtype (*type*) – a numpy, torch, or python numeric data type

Returns

an iinfo of finfo structure depending on the input type.

Return type

numpy.iinfo | numpy.finfo | torch.iinfo | torch.finfo

References

..[DtypeNotes] https://higra.readthedocs.io/en/stable/_modules/higra/hg_utils.html#dtype_info

Example

```
>>> from kwarray.arrayapi import *  # NOQA
>>> try:
>>>     import torch
>>> except ImportError:
>>>     torch = None
>>> results = []
>>> results += [dtype_info(float)]
>>> results += [dtype_info(int)]
>>> results += [dtype_info(complex)]
>>> results += [dtype_info(np.float32)]
>>> results += [dtype_info(np.int32)]
>>> results += [dtype_info(np.uint32)]
>>> if hasattr(np, 'complex256'):
>>>     results += [dtype_info(np.complex256)]
>>> if torch is not None:
>>>     results += [dtype_info(torch.float32)]
>>>     results += [dtype_info(torch.int64)]
>>>     results += [dtype_info(torch.complex64)]
>>> for info in results:
>>>     print('info = {!r}'.format(info))
>>> for info in results:
>>>     print('info.bits = {!r}'.format(info.bits))
```

kwarray.dataframe_light module

A faster-than-pandas pandas-like interface to column-major data, in the case where the data only needs to be accessed by index.

For data where more complex ids are needed you must use pandas.

class kwarray.dataframe_light.**LocLight**(*parent*)

Bases: object

class kwarray.dataframe_light.**DataFrameLight**(*data=None*, *columns=None*)

Bases: NiceRepr

Implements a subset of the pandas.DataFrame API

The API is restricted to facilitate speed tradeoffs

Note: Assumes underlying data is Dict[list|ndarray]. If the data is known to be a Dict[ndarray] use DataFrameArray instead, which has faster implementations for some operations.

Note: pandas.DataFrame is slow. DataFrameLight is faster. It is a tad more restrictive though.

Example

```
>>> self = DataFrameLight({})
>>> print('self = {!r}'.format(self))
>>> self = DataFrameLight({'a': [0, 1, 2], 'b': [2, 3, 4]})
>>> print('self = {!r}'.format(self))
>>> item = self.iloc[0]
>>> print('item = {!r}'.format(item))
```

Benchmark

```
>>> # BENCHMARK
>>> # xdoc: +REQUIRES(--bench)
>>> from kwarray.dataframe_light import *  # NOQA
>>> import ubelt as ub
>>> NUM = 1000
>>> print('NUM = {!r}'.format(NUM))
>>> # to_dict conversions
>>> print('===============')
>>> print('====== to_dict conversions =====')
>>> _keys = ['list', 'dict', 'series', 'split', 'records', 'index']
>>> results = []
>>> df = DataFrameLight._demodata(num=NUM).pandas()
>>> ti = ub.Timerit(verbose=False, unit='ms')
>>> for key in _keys:
>>>     result = ti.reset(key).call(lambda: df.to_dict(orient=key))
>>>     results.append((result.mean(), result.report()))
>>> key = 'series+numpy'
```

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```
>>> result = ti.reset(key).call(lambda: {k: v.values for k, v in df.to_dict(orient=
↪'series').items()})
>>> results.append((result.mean(), result.report()))
>>> print('\n'.join([t[1] for t in sorted(results)]))
>>> print('===============')
>>> print('====== DFLight Conversions =======')
>>> ti = ub.Timerit(verbose=True, unit='ms')
>>> key = 'self.pandas'
>>> self = DataFrameLight(df)
>>> ti.reset(key).call(lambda: self.pandas())
>>> key = 'light-from-pandas'
>>> ti.reset(key).call(lambda: DataFrameLight(df))
>>> key = 'light-from-dict'
>>> ti.reset(key).call(lambda: DataFrameLight(self._data))
>>> print('===============')
>>> print('====== BENCHMARK: .LOC[] =======')
>>> ti = ub.Timerit(num=20, bestof=4, verbose=True, unit='ms')
>>> df_light = DataFrameLight._demodata(num=NUM)
>>> # xdoctest: +REQUIRES(module:pandas)
>>> df_heavy = df_light.pandas()
>>> series_data = df_heavy.to_dict(orient='series')
>>> list_data = df_heavy.to_dict(orient='list')
>>> np_data = {k: v.values for k, v in df_heavy.to_dict(orient='series').items()}
>>> for timer in ti.reset('DF-heavy.iloc'):
>>>     with timer:
>>>         for i in range(NUM):
>>>             df_heavy.iloc[i]
>>> for timer in ti.reset('DF-heavy.loc'):
>>>     with timer:
>>>         for i in range(NUM):
>>>             df_heavy.iloc[i]
>>> for timer in ti.reset('dict[SERIES].loc'):
>>>     with timer:
>>>         for i in range(NUM):
>>>             {key: series_data[key].loc[i] for key in series_data.keys()}
>>> for timer in ti.reset('dict[SERIES].iloc'):
>>>     with timer:
>>>         for i in range(NUM):
>>>             {key: series_data[key].iloc[i] for key in series_data.keys()}
>>> for timer in ti.reset('dict[SERIES][]'):
>>>     with timer:
>>>         for i in range(NUM):
>>>             {key: series_data[key][i] for key in series_data.keys()}
>>> for timer in ti.reset('dict[NDARRAY][]'):
>>>     with timer:
>>>         for i in range(NUM):
>>>             {key: np_data[key][i] for key in np_data.keys()}
>>> for timer in ti.reset('dict[list][]'):
>>>     with timer:
>>>         for i in range(NUM):
>>>             {key: list_data[key][i] for key in np_data.keys()}
>>> for timer in ti.reset('DF-Light.iloc/loc'):
```

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```
>>>     with timer:
>>>         for i in range(NUM):
>>>             df_light.iloc[i]
>>> for timer in ti.reset('DF-Light._getrow'):
>>>     with timer:
>>>         for i in range(NUM):
>>>             df_light._getrow(i)
NUM = 1000
==============
====== to_dict conversions =====
Timed best=0.022 ms, mean=0.022 ± 0.0 ms for series
Timed best=0.059 ms, mean=0.059 ± 0.0 ms for series+numpy
Timed best=0.315 ms, mean=0.315 ± 0.0 ms for list
Timed best=0.895 ms, mean=0.895 ± 0.0 ms for dict
Timed best=2.705 ms, mean=2.705 ± 0.0 ms for split
Timed best=5.474 ms, mean=5.474 ± 0.0 ms for records
Timed best=7.320 ms, mean=7.320 ± 0.0 ms for index
==============
====== DFLight Conversions =======
Timed best=1.798 ms, mean=1.798 ± 0.0 ms for self.pandas
Timed best=0.064 ms, mean=0.064 ± 0.0 ms for light-from-pandas
Timed best=0.010 ms, mean=0.010 ± 0.0 ms for light-from-dict
==============
====== BENCHMARK: .LOC[] =======
Timed best=101.365 ms, mean=101.564 ± 0.2 ms for DF-heavy.iloc
Timed best=102.038 ms, mean=102.273 ± 0.2 ms for DF-heavy.loc
Timed best=29.357 ms, mean=29.449 ± 0.1 ms for dict[SERIES].loc
Timed best=21.701 ms, mean=22.014 ± 0.3 ms for dict[SERIES].iloc
Timed best=11.469 ms, mean=11.566 ± 0.1 ms for dict[SERIES][]
Timed best=0.807 ms, mean=0.826 ± 0.0 ms for dict[NDARRAY][]
Timed best=0.478 ms, mean=0.492 ± 0.0 ms for dict[list][]
Timed best=0.969 ms, mean=0.994 ± 0.0 ms for DF-Light.iloc/loc
Timed best=0.760 ms, mean=0.776 ± 0.0 ms for DF-Light._getrow
```

property iloc

property values

property loc

to_string(**args*, ***kwargs*)

Return type
str

to_dict(*orient='dict'*, *into=<class 'dict'>*)

Convert the data frame into a dictionary.

Parameters

- **orient** (*str*) – Currently naitively suports orient in {'dict', 'list'}, otherwise we fallback to pandas conversion and call its to_dict method.
- **into** (*type*) – type of dictionary to transform into

Returns
dict

Example

```
>>> from kwarray.dataframe_light import *  # NOQA
>>> self = DataFrameLight._demodata(num=7)
>>> print(self.to_dict(orient='dict'))
>>> print(self.to_dict(orient='list'))
```

pandas()

Convert back to pandas if you need the full API

Return type
pd.DataFrame

Example

```
>>> # xdoctest: +REQUIRES(module:pandas)
>>> df_light = DataFrameLight._demodata(num=7)
>>> df_heavy = df_light.pandas()
>>> got = DataFrameLight(df_heavy)
>>> assert got._data == df_light._data
```

_pandas()

Deprecated, use self.pandas instead

classmethod _demodata(*num=7*)

Example

```
>>> self = DataFrameLight._demodata(num=7)
>>> print('self = {!r}'.format(self))
>>> other = DataFrameLight._demodata(num=11)
>>> print('other = {!r}'.format(other))
>>> both = self.union(other)
>>> print('both = {!r}'.format(both))
>>> assert both is not self
>>> assert other is not self
```

property columns

sort_values(*key*, *inplace=False*, *ascending=True*)

keys()

_getrow(*index*)

_getcol(*key*)

_getcols(*keys*)

get(*key*, *default=None*)

Get item for given key. Returns default value if not found.

clear()

Removes all rows inplace

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

NOTE: NOT A PART OF THE PANDAS API

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

Return the elements in the given *positional* indices along an axis.

Parameters
inplace (*bool*) – NOT PART OF PANDAS API

Note: assumes axis=0

Example

```
>>> df_light = DataFrameLight._demodata(num=7)
>>> indices = [0, 2, 3]
>>> sub1 = df_light.take(indices)
>>> # xdoctest: +REQUIRES(module:pandas)
>>> df_heavy = df_light.pandas()
>>> sub2 = df_heavy.take(indices)
>>> assert np.all(sub1 == sub2)
```

copy()

extend(*other*)

Extend `self` inplace using another dataframe array

Parameters
other (*DataFrameLight | dict[str, Sequence]*) – values to concat to end of this object

Note: Not part of the pandas API

Example

```
>>> self = DataFrameLight(columns=['foo', 'bar'])
>>> other = {'foo': [0], 'bar': [1]}
>>> self.extend(other)
>>> assert len(self) == 1
```

union(**others*)

Note: Note part of the pandas API

classmethod concat(*others*)

classmethod from_pandas(*df*)

classmethod from_dict(*records*)

reset_index(*drop=False*)

noop for compatability, the light version doesnt store an index

groupby(*by=None*, **args*, ***kwargs*)

Group rows by the value of a column. Unlike pandas this simply returns a zip object. To ensure compatiability call list on the result of groupby.

Parameters

- **by** (*str*) – column name to group by
- ***args** – if specified, the dataframe is coerced to pandas
- ****kwargs** – if specified, the dataframe is coerced to pandas

Example

```
>>> df_light = DataFrameLight._demodata(num=7)
>>> res1 = list(df_light.groupby('bar'))
>>> # xdoctest: +REQUIRES(module:pandas)
>>> df_heavy = df_light.pandas()
>>> res2 = list(df_heavy.groupby('bar'))
>>> assert len(res1) == len(res2)
>>> assert all([np.all(a[1] == b[1]) for a, b in zip(res1, res2)])
```

rename(*mapper=None*, *columns=None*, *axis=None*, *inplace=False*)

Rename the columns (index renaming is not supported)

Example

```
>>> df_light = DataFrameLight._demodata(num=7)
>>> mapper = {'foo': 'fi'}
>>> res1 = df_light.rename(columns=mapper)
>>> res3 = df_light.rename(mapper, axis=1)
>>> # xdoctest: +REQUIRES(module:pandas)
>>> df_heavy = df_light.pandas()
>>> res2 = df_heavy.rename(columns=mapper)
>>> res4 = df_heavy.rename(mapper, axis=1)
>>> assert np.all(res1 == res2)
>>> assert np.all(res3 == res2)
>>> assert np.all(res3 == res4)
```

iterrows()

Iterate over rows as (index, Dict) pairs.

Yields

Tuple[int, Dict] – the index and a dictionary representing a row

Example

```
>>> from kwarray.dataframe_light import *  # NOQA
>>> self = DataFrameLight._demodata(num=3)
>>> print(ub.urepr(list(self.iterrows()), sort=1))
[
    (0, {'bar': 0, 'baz': 2.73, 'foo': 0}),
    (1, {'bar': 1, 'baz': 2.73, 'foo': 0}),
    (2, {'bar': 2, 'baz': 2.73, 'foo': 0}),
]
```

Benchmark

```
>>> # xdoc: +REQUIRES(--bench)
>>> from kwarray.dataframe_light import *  # NOQA
>>> import ubelt as ub
>>> df_light = DataFrameLight._demodata(num=1000)
>>> df_heavy = df_light.pandas()
>>> ti = ub.Timerit(21, bestof=3, verbose=2, unit='ms')
>>> ti.reset('light').call(lambda: list(df_light.iterrows()))
>>> ti.reset('heavy').call(lambda: list(df_heavy.iterrows()))
>>> # xdoctest: +IGNORE_WANT
Timed light for: 21 loops, best of 3
    time per loop: best=0.834 ms, mean=0.850 ± 0.0 ms
Timed heavy for: 21 loops, best of 3
    time per loop: best=45.007 ms, mean=45.633 ± 0.5 ms
```

class kwarray.dataframe_light.**DataFrameArray**(*data=None*, *columns=None*)

Bases: *DataFrameLight*

DataFrameLight assumes the backend is a Dict[list] DataFrameArray assumes the backend is a Dict[ndarray]

Take and compress are much faster, but extend and union are slower

extend(*other*)

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

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

kwarray.distributions module

Defines data structures for efficient repeated sampling of specific distributions (e.g. Normal, Uniform, Binomial) with specific parameters.

Inspired by ~/code/imgaug/imgaug/parameters.py

Similar Libraries:

- https://docs.pymc.io/api/distributions.html
- https://github.com/phobson/paramnormal

Todo:

- [ ] change sample shape to just a single num.
- [ ] Some Distributions will output vectors. Maybe we could just postpend the dimensions?
- [ ] Expose as kwstats?
- [ ] Improve coerce syntax for concise distribution specification

---

References

https://stackoverflow.com/questions/21100716/fast-arbitrary-distribution-random-sampling https://stackoverflow.com/questions/4265988/generate-random-numbers-with-a-given-numerical-distribution https://codereview.stackexchange.com/questions/196286/inverse-transform-sampling

class kwarray.distributions.**Value**(*default=None*, *min=None*, *max=None*, *help=None*, *constraints=None*, *type=None*, *name=None*)

Bases: NiceRepr

Container for class *__params__* values.

Used to store metadata about distribution arguments, including default values, numeric constraints, typing, and help text.

Example

```
>>> from kwarray.distributions import *  # NOQA
>>> self = Value(43.5)
>>> print(Value(name='lucy'))
>>> print(Value(name='jeff', default=1))
>>> self = Value(name='fred', default=1.0)
>>> print('self = {}'.format(ub.urepr(self, nl=1)))
>>> print(Value(name='bob', default=1.0, min=-5, max=5))
>>> print(Value(name='alice', default=1.0, min=-5))
```

sample(*rng*)

Get a random value for this parameter.

kwarray.distributions.**_issubclass2**(*child*, *parent*)

Uses string comparisons to avoid ipython reload errors. Much less robust though.

kwarray.distributions.**_isinstance2**(*obj*, *cls*)

Internal hacked version is isinstance for debugging

obj = self cls = distributions.Distribution

child = obj.__class__ parent = cls

class kwarray.distributions.**Parameterized**

Bases: NiceRepr

Keeps track of all registered params and classes with registered params

_setparam(*key*, *value*)

_setchild(*key*, *value*)

children()

seed(*rng=None*)

parameters()

Returns parameters in this object and its children

_body_str()

idstr(*nl=None*, *thresh=80*)

Example

```
>>> # xdoctest: +REQUIRES(module:scipy)
>>> self = TruncNormal()
>>> self.idstr()
>>> #
>>> #
>>> class Dummy(Distribution):
>>>     def __init__(self):
>>>         super(Dummy, self).__init__()
>>>         self._setparam('a', 3)
>>>         self.b = Normal()
>>>         self.c = Uniform()
>>> self = Dummy()
>>> print(self.idstr())
>>> #
>>> class Tail5(Distribution):
>>>     def __init__(self):
>>>         super(Tail5, self).__init__()
>>>         self._setparam('a_parameter', 3)
>>>         for i in range(5):
>>>             self._setparam(chr(i + 97), i)
>>> #
>>> class Tail6(Distribution):
>>>     def __init__(self):
>>>         super(Tail6, self).__init__()
>>>         for i in range(9):
>>>             self._setparam(chr(i + 97) + '_parameter', i)
>>> #
>>> class Dummy2(Distribution):
>>>     def __init__(self):
>>>         super(Dummy2, self).__init__()
>>>         self._setparam('x', 3)
>>>         self._setparam('y', 3)
>>>         self.d = Dummy()
>>>         self.f = Tail6()
>>>         self.y = Tail5()
>>> self = Dummy2()
>>> print(self.idstr())
>>> print(ub.urepr(self.json_id()))
```

json_id()

_make_body(*self_part*, *child_part*, *nl=None*, *thresh=80*)

class kwarray.distributions.**ParameterizedList**(*items*)

Bases: *Parameterized*

Example

```
>>> from kwarray import distributions as stoch
>>> self1 = stoch.ParameterizedList([
>>>     stoch.Normal(),
>>>     stoch.Uniform(),
>>> ])
>>> print(self1.idstr())
>>> self = stoch.ParameterizedList([stoch.ParameterizedList([
>>>     stoch.Normal(),
>>>     stoch.Uniform(),
>>>     self1,
>>> ])])
>>> print(self.idstr())
>>> print(self.idstr(0))
```

_setparam(*key*, *value*)

append(*item*)

idstr(*nl=None*, *thresh=80*)

class kwarray.distributions.**_BinOpMixin**

Bases: object

Allows binary operations to be performed on distributions to create composed distributions.

int()

round(*ndigits=None*)

clip(*a_min=None*, *a_max=None*)

log()

log10()

exp()

sqrt()

abs()

class kwarray.distributions.**_RBinOpMixin**

Bases: *_BinOpMixin*

https://docs.python.org/3/reference/datamodel.html

class kwarray.distributions.**Distribution**(**args*, ***kwargs*)

Bases: *Parameterized*, *_RBinOpMixin*

Base class for all distributions.

There are 3 main subtypes:
ContinuousDistribution DiscreteDistribution MixedDistribution

---

Note: In [DiscVsCont] notes that there are only 3 types of random variables: discrete, continuous, or mixed. And these types are mutually exclusive.

Note: When inheriting from this class, you typically do not need to define an *__init__* method. Instead, overwrite the *__params__* class attribute with an *OrderedDict[str, Value]* to indicate what the signature of the *__init__* method should be. This allows for (1) concise expression of new distributions and (2) for new distributions to inherit a *random* classmethod that works according to constraints specified in each parameter Value.

If you do overwrite *__init__*, be sure to call *super()*.

References

seed(*rng=None*)

sample(**shape*)

classmethod random(*rng=None*)

Returns a random distribution

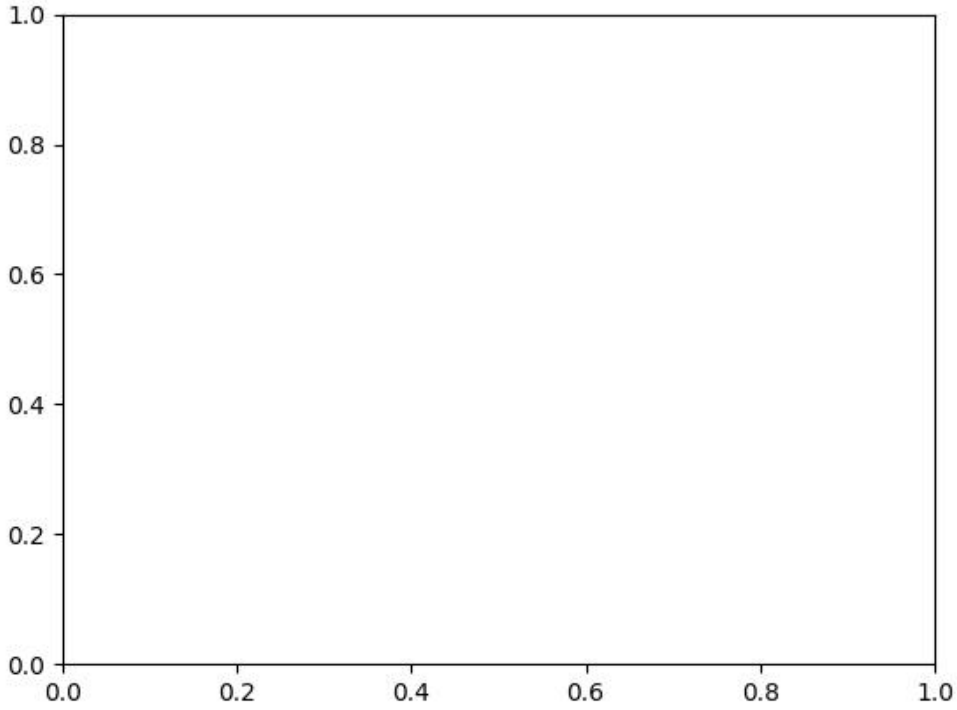
Parameters
rng (*int | float | None | numpy.random.RandomState | random.Random*) – random coercable

CommandLine

```
xdoctest -m /home/joncrall/code/kwarray/kwarray/distributions.py Distribution.
↪random --show
```

Example

```
>>> # xdoctest: +REQUIRES(module:scipy)
>>> from kwarray.distributions import *  # NOQA
>>> self = Distribution.random()
>>> print('self = {!r}'.format(self))
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.figure(fnum=1, doclf=True)
>>> self.plot('0.001s', bins=256)
>>> kwplot.show_if_requested()
```



classmethod coerce(*arg*, *rng=None*)

classmethod cast(*arg*)

classmethod seeded(*rng=0*)

plot(*n='0.01s'*, *bins='auto'*, *stat='count'*, *color=None*, *kde=True*, *ax=None*, ***kwargs*)

Plots n samples from the distribution.

Parameters

- **bins** (*int | List[Number] | str*) – number of bins, bin edges, or special numpy method for finding the number of bins.
- **stat** (*str*) – density, count, probability, frequency
- ****kwargs** – other args passed to `seaborn.histplot()`

Example

```
>>> from kwarray.distributions import Normal  # NOQA
>>> self = Normal()
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> self.plot(n=1000)
```

_show(*n*, *bins=None*, *ax=None*, *color=None*, *label=None*)

plot samples monte-carlo style

kwarray.distributions.**_coerce_timedelta**(*data*)

kwarray.distributions.**_generate_on_a_time_budget**(*func*, *maxiters*, *budget*)

budget = 60

class kwarray.distributions.**DiscreteDistribution**(**args*, ***kwargs*)

Bases: *Distribution*

class kwarray.distributions.**ContinuousDistribution**(**args*, ***kwargs*)

Bases: *Distribution*

class kwarray.distributions.**MixedDistribution**(**args*, ***kwargs*)

Bases: *Distribution*

class kwarray.distributions.**Mixture**(*pdfs*, *weights=None*, *rng=None*)

Bases: *MixedDistribution*

Creates a mixture model of multiple distributions

Contains a set of distributions with associated weights. Sampling is done by first choosing a distribution with probability proportional to its weighthing, and then sampling from the chosen distribution.

In general, a mixture model generates data by first first we sample from z, and then we sample the observables x from a distribution which depends on z. , i.e. p(z, x) = p(z) p(x | z) [GrosseMixture] [StephensMixture].

Parameters

- **pdfs** (*List[Distribution]*) – list of distributions
- **weights** (*List[float]*) – corresponding weights of each distribution
- **rng** (*np.random.RandomState*) – seed random number generator

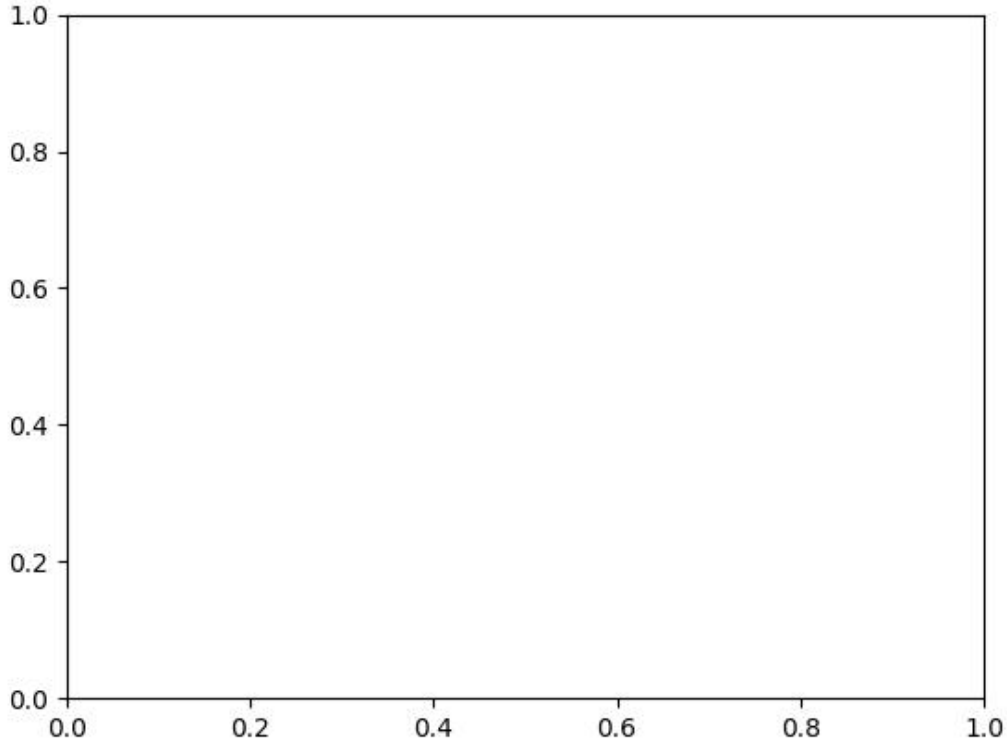
References

CommandLine

```
xdoctest -m kwarray.distributions Mixture:0 --show
```

Example

```
>>> # In this examle we create a bimodal mixture of normals
>>> from kwarray.distributions import *  # NOQA
>>> pdfs = [Normal(mean=10, std=2), Normal(18, 2)]
>>> self = Mixture(pdfs)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.figure(fnum=1, doclf=True)
>>> self.plot(500, bins=25)
>>> kwplot.show_if_requested()
```



Example

```
>>> # Compare Composed versus Mixture Distributions
>>> # Given two normal distributions,
>>> from kwarray.distributions import Normal  # NOQA
>>> from kwarray.distributions import *  # NOQA
>>> n1 = Normal(mean=11, std=3)
>>> n2 = Normal(mean=53, std=5)
>>> composed = (n1 * 0.3) + (n2 * 0.7)
>>> mixture = Mixture([n1, n2], [0.3, 0.7])
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.figure(fnum=1, pnum=(2, 2, 1))
>>> ax = kwplot.figure(pnum=(2, 1, 1), title='n1 & n2').gca()
>>> n = 10000
>>> plotkw = dict(stat='density', kde=1, bins=1000)
>>> plotkw = dict(stat='count', kde=1, bins=1000)
>>> #plotkw = dict(stat='frequency', kde=1, bins='auto')
>>> n1.plot(n, ax=ax, **plotkw)
>>> n2.plot(n, ax=ax, **plotkw)
>>> ax=kwplot.figure(pnum=(2, 2, 3), title='composed').gca()
>>> composed.plot(n, ax=ax, **plotkw)
```

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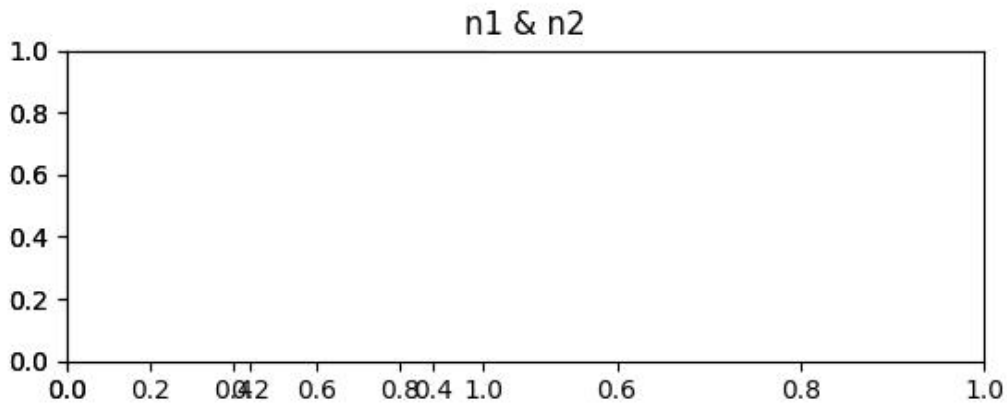
```
>>> ax=kwplot.figure(pnum=(2, 2, 4), title='mixture').gca()
>>> mixture.plot(n, ax=ax, **plotkw)
>>> kwplot.show_if_requested()
```



sample(**shape*)

Sampling from a mixture of k distributions with weights w_k is equivalent to picking a distribution with probability w_k, and then sampling from the picked distribution. *SOuser6655984 <https://stackoverflow.com/a/47762586/887074>*

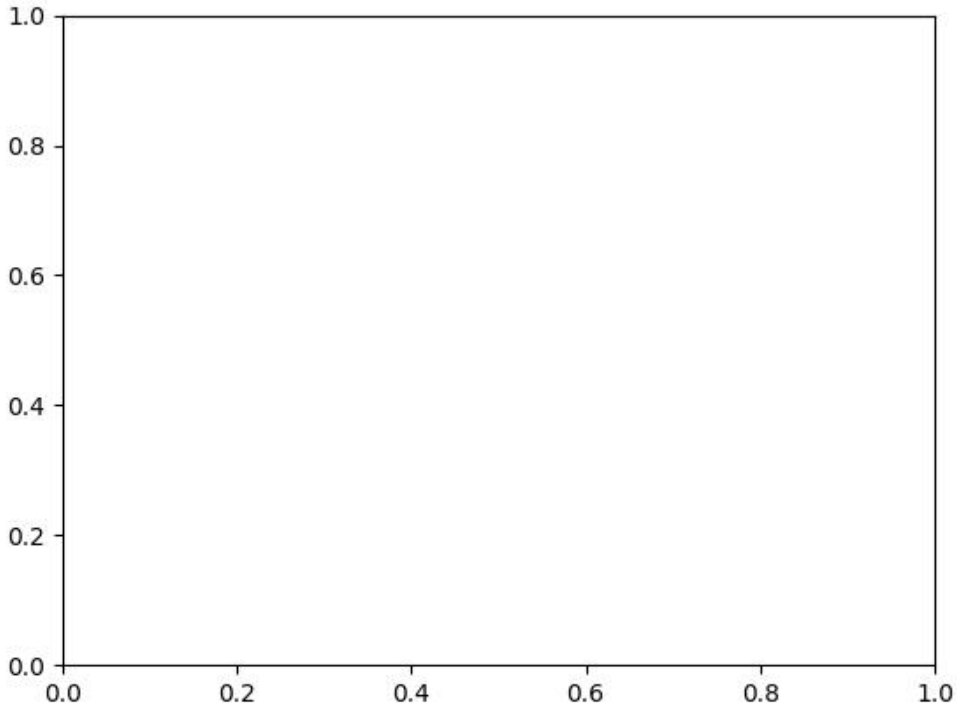
classmethod random(*rng=None*, *n=3*)

Parameters

- **rng** (*int | float | None | numpy.random.RandomState | random.Random*) – random coercable
- **n** (*int*) – number of random distributions in the mixture

Example

```
>>> # xdoctest: +REQUIRES(module:scipy)
>>> from kwarray.distributions import *  # NOQA
>>> print('Mixture = {!r}'.format(Mixture))
>>> print('Mixture = {!r}'.format(dir(Mixture)))
>>> self = Mixture.random(3)
>>> print('self = {!r}'.format(self))
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.figure(fnum=1, doclf=True)
>>> self.plot('0.1s', bins=256)
>>> kwplot.show_if_requested()
```



class kwarray.distributions.**Composed**(**args*, ***kwargs*)

Bases: *MixedDistribution*

A distribution generated by composing different base distributions or numbers (which are considered as constant distributions).

Given the operation and its arguments, the sampling process of a "Composed" distribution will sample from each of the operands, and then apply the operation to the sampled points. For instance if we add two Normal distributions, this will first sample from each distribution and then add the results.

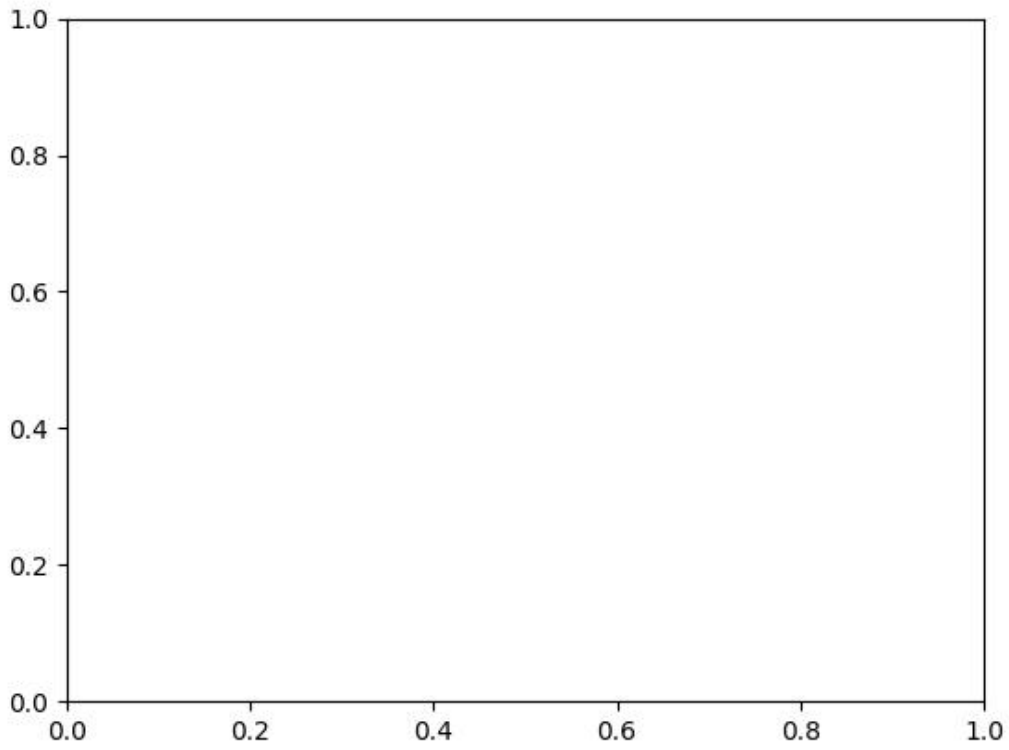
Note: This is not the same as mixing distributions!

Variables

- **self.operation** (*Function*) – operation (add / sub / mult / div) to perform on operands
- **self.operands** (*Sequence[Distribution | Number]*) – arguments passed to operation

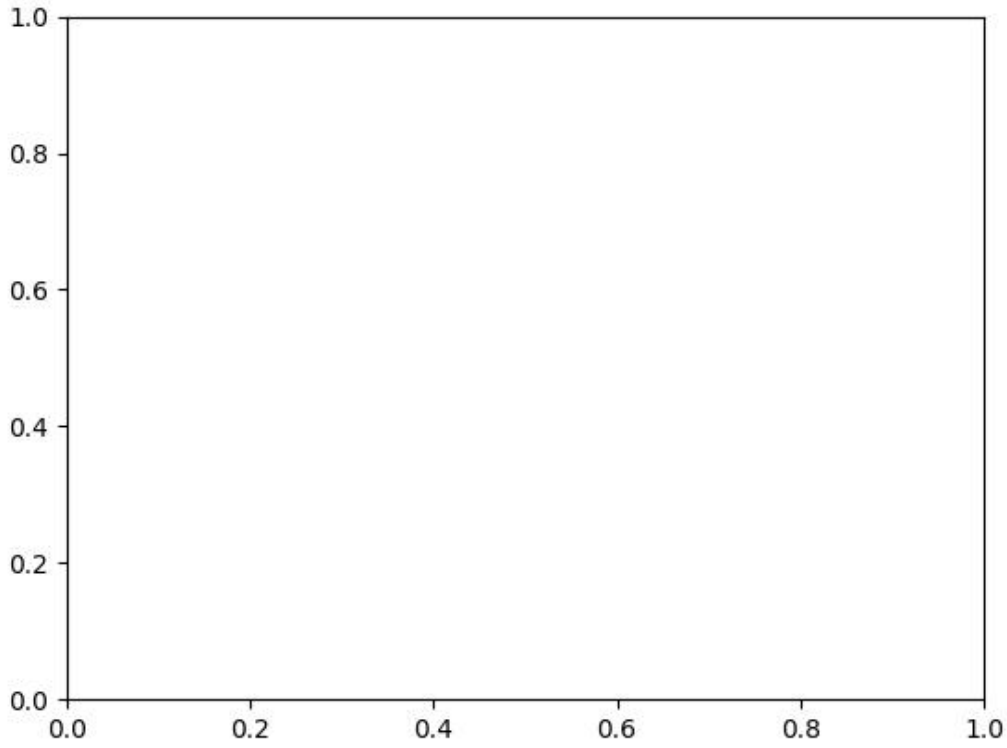
Example

```
>>> # In this examle you can see that the sum of two Normal random
>>> # variables is also normal
>>> from kwarray.distributions import *  # NOQA
>>> operands = [Normal(mean=10, std=2), Normal(15, 2)]
>>> operation = np.add
>>> self = Composed(operation, operands)
>>> data = self.sample(5)
>>> print(ub.urepr(list(data), nl=0, precision=5))
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.figure(fnum=1, doclf=True)
>>> self.plot(1000, bins=100)
```



Example

```
>>> # Binary operations result in composed distributions
>>> # We can make a (bounded) exponential distribution using a uniform
>>> from kwarray.distributions import *  # NOQA
>>> X = Uniform(.001, 7)
>>> lam = .7
>>> e = np.exp(1)
>>> self = lam * e ** (-lam * X)
>>> data = self.sample(5)
>>> print(ub.urepr(list(data), nl=0, precision=5))
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.figure(fnum=1, doclf=True)
>>> self.plot(5000, bins=100)
```



Parameters

- **operation** (*Any*) – no help given. Defaults to None.
- **operands** (*Any*) – no help given. Defaults to None.

sample(**shape*)

kwarray.distributions.**_trysample**(*arg*, *shape*)

samples if arg is a distribution, otherwise returns arg

exception kwarray.distributions.**CoerceError**

Bases: ValueError

kwarray.distributions.**CastError**

alias of *CoerceError*

class kwarray.distributions.**Uniform**(**args*, ***kwargs*)

Bases: *ContinuousDistribution*

Defaults to a uniform distribution over floats between 0 and 1

Example

```
>>> from kwarray.distributions import *  # NOQA
>>> self = Uniform(rng=0)
>>> self.sample()
0.548813...
>>> float(self.sample(1))
0.7151...
```

Benchmark

```
>>> import ubelt as ub
>>> self = Uniform()
>>> for timer in ub.Timerit(100, bestof=10):
>>>     with timer:
>>>         [self() for _ in range(100)]
>>> for timer in ub.Timerit(100, bestof=10):
>>>     with timer:
>>>         self(100)
```

Parameters

- **high** (*int*) – no help given. Defaults to 1.
- **low** (*int*) – no help given. Defaults to 0.

sample(**shape*)

classmethod coerce(*arg*)

class kwarray.distributions.**Exponential**(**args*, ***kwargs*)

Bases: *ContinuousDistribution*

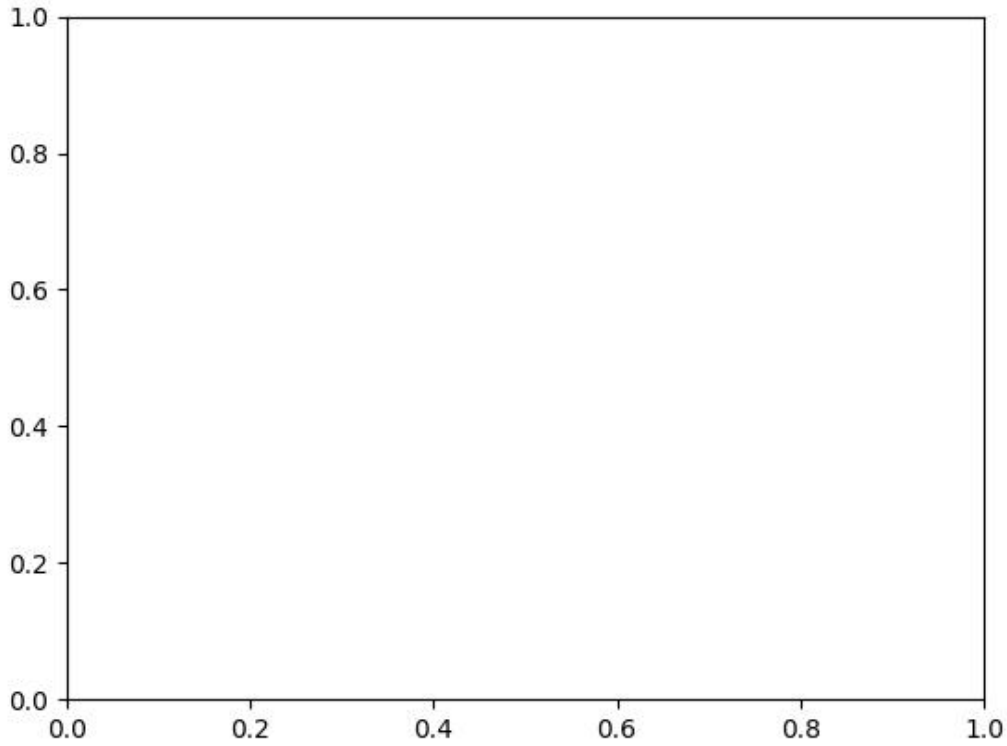
The exponential distribution is the probability distribution of the time between events in a Poisson point process, i.e., a process in which events occur continuously and independently at a constant average rate[1].

Referencs:

[1] https://en.wikipedia.org/wiki/Exponential_distribution

Example

```
>>> from kwarray.distributions import *  # NOQA
>>> self = Exponential(rng=0)
>>> self.sample()
>>> self.sample(2, 3)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.figure(fnum=1, doclf=True)
>>> self.plot(500, bins=25)
```



Parameters

scale (*int*) – no help given. Defaults to 1.

sample(**shape*)

class kwarray.distributions.**Constant**(**args*, ***kwargs*)

Bases: *DiscreteDistribution*

Example

```
>>> self = Constant(42, rng=0)
>>> self.sample()
42
>>> self.sample(3)
array([42, 42, 42])
```

Parameters
value (*int*) – constant value. Defaults to 1.

sample(**shape*)

class kwarray.distributions.**DiscreteUniform**(**args*, ***kwargs*)

Bases: *DiscreteDistribution*

Uniform distribution over integers.

Parameters

- **min** (*int*) – inclusive minimum
- **max** (*int*) – exclusive maximum

Example

```
>>> self = DiscreteUniform.coerce(4)
>>> self.sample(100)
```

sample(**shape*)

classmethod coerce(*arg*, *rng=None*)

class kwarray.distributions.**Normal**(**args*, ***kwargs*)

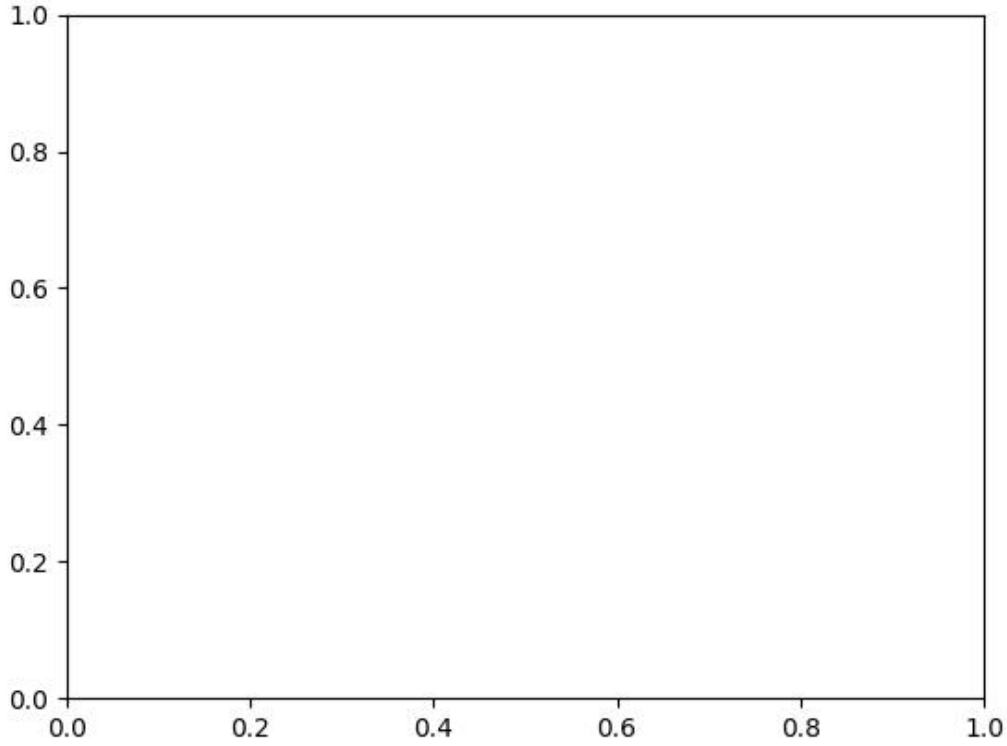
Bases: *ContinuousDistribution*

A normal distribution. See [WikiNormal] [WikiCLT].

References

Example

```
>>> from kwarray.distributions import *  # NOQA
>>> self = Normal(mean=100, rng=0)
>>> self.sample()
>>> self.sample(100)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.figure(fnum=1, doclf=True)
>>> self.plot(500, bins=25)
```



Parameters

- **mean** (*float*) – no help given. Defaults to 0.0.
- **std** (*float*) – no help given. Defaults to 1.0.

`sample`(**shape*)

`classmethod random`(*rng=None*)

`class` kwarray.distributions.`TruncNormal`(**args*, ***kwargs*)

Bases: *ContinuousDistribution*

A truncated normal distribution.

A normal distribution, but bounded by low and high values. Note this is much different from just using a clipped normal.

Parameters

- **mean** (*float*) – mean of the distribution
- **std** (*float*) – standard deviation of the distribution
- **low** (*float*) – lower bound
- **high** (*float*) – upper bound
- **rng** (*np.random.RandomState*)

References

https://en.wikipedia.org/wiki/Truncated_normal_distribution https://docs.scipy.org/doc/scipy/reference/generated/scipy.stats.truncnorm.html

CommandLine

```
xdoctest -m /home/joncrall/code/kwarray/kwarray/distributions.py TruncNormal
```

Example

```
>>> # xdoctest: +REQUIRES(module:scipy)
>>> self = TruncNormal(rng=0)
>>> self()  # output of this changes before/after scipy version 1.5
...0.1226...
```

Example

```
>>> # xdoctest: +REQUIRES(module:scipy)
>>> from kwarray.distributions import *  # NOQA
>>> low = -np.pi / 16
>>> high = np.pi / 16
>>> std = np.pi / 8
>>> self = TruncNormal(low=low, high=high, std=std, rng=0)
>>> shape = (3, 3)
>>> data = self(*shape)
>>> print(ub.urepr(data, precision=5))
np.array([[ 0.01841,  0.0817 ,  0.0388 ],
          [ 0.01692, -0.0288 ,  0.05517],
          [-0.02354,  0.15134,  0.18098]], dtype=np.float64)
```

_update_internals()

classmethod random(*rng=None*)

sample(**shape*)

class kwarray.distributions.**Bernoulli**(**args*, ***kwargs*)

Bases: *DiscreteDistribution*

The Bernoulli distribution is the discrete probability distribution of a random variable which takes the value 1 with probability p and the value 0 with probability $q = 1 - p$.

References

https://en.wikipedia.org/wiki/Bernoulli_distribution

Parameters
p (*float*) – probability of success. Defaults to 0.5.

sample(**shape*)

classmethod coerce(*arg*)

class kwarray.distributions.**Binomial**(**args*, ***kwargs*)

Bases: *DiscreteDistribution*

The Binomial distribution represents the discrete probabilities of obtaining some number of successes in n "binary-experiments" each with a probability of success p and a probability of failure 1 - p.

References

https://en.wikipedia.org/wiki/Binomial_distribution

Parameters

- **p** (*float*) – probability of success. Defaults to 0.5.
- **n** (*int*) – probability of success. Defaults to 1.

sample(**shape*)

class kwarray.distributions.**Categorical**(*categories*, *weights=None*, *rng=None*)

Bases: *DiscreteDistribution*

Example

```
>>> categories = [3, 5, 1]
>>> weights = [.05, .5, .45]
>>> self = Categorical(categories, weights, rng=0)
>>> self.sample()
5
>>> list(self.sample(2))
[1, 1]
>>> self.sample(2, 3)
array([[5, 5, 1],
       [5, 1, 1]])
```

Parameters

- **categories** (*Any*) – no help given. Defaults to None.
- **weights** (*Any*) – no help given. Defaults to None.

sample(**shape*)

class kwarray.distributions.**NonlinearUniform**(*min*, *max*, *nonlinearity=None*, *reverse=False*, *rng=None*)

Bases: *ContinuousDistribution*

Weighted sample between two points depending on some nonlinearity

---

Todo: could refactor part of this into a PowerLaw distribution

---

Parameters

nonlinearity (*func or str*) – needs to be a function that maps the range 0-1 to the range 0-1

Example

```
>>> self = NonlinearUniform(0, 100, np.sqrt, rng=0)
>>> print(ub.urepr(list(self.sample(2)), precision=2, nl=0))
[74.08, 84.57]
>>> print(ub.urepr(self.sample(2, 3), precision=2, nl=1))
np.array([[77.64, 73.82, 65.09],
          [80.37, 66.15, 94.43]], dtype=np.float64)
```

sample(**shape*)

class kwarray.distributions.**CategoryUniform**(*categories=[None]*, *rng=None*)

Bases: *DiscreteUniform*

Discrete Uniform over a list of categories

Parameters

- **min** (*int*) – no help given. Defaults to 0.
- **max** (*int*) – no help given. Defaults to 1.

sample(**shape*)

class kwarray.distributions.**PDF**(*x*, *p*, *rng=None*)

Bases: *Distribution*

BROKEN?

Similar to Categorical, but interpolates to approximate a continuous random variable.

Returns a value x with probability p.

References

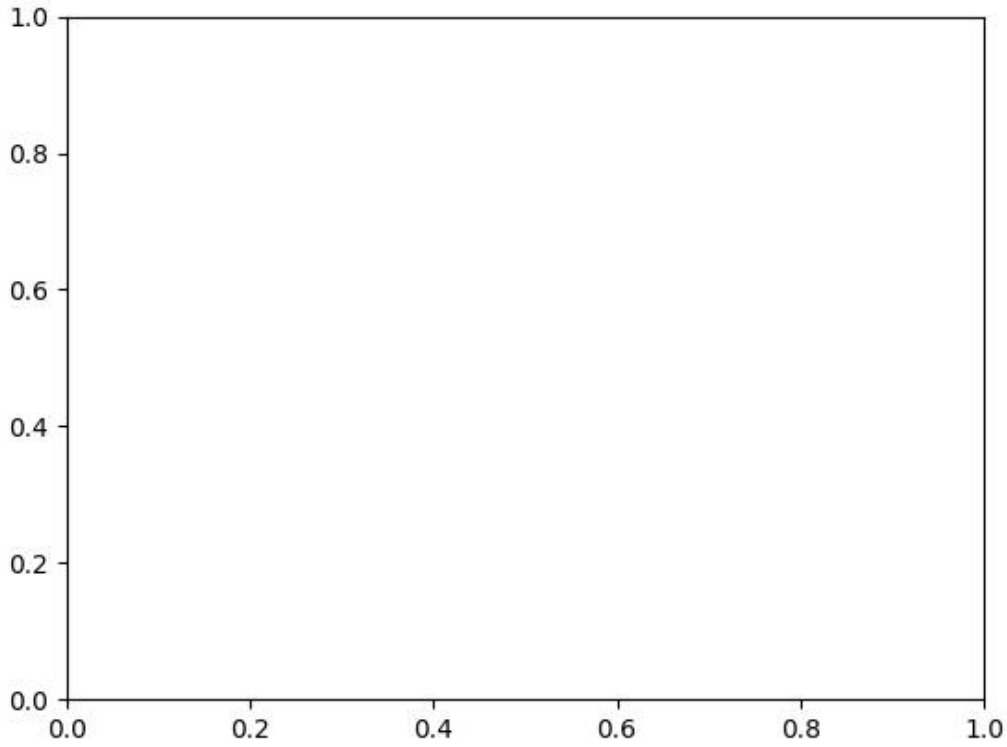
http://www.nehalemlabs.net/prototype/blog/2013/12/16/how-to-do-inverse-transformation-sampling-in-scipy-and-numpy/

Parameters

- **x** (*list or tuple*) – domain in which this PDF is defined
- **p** (*list*) – probability sample for each domain sample

Example

```
>>> # xdoctest: +REQUIRES(module:scipy)
>>> from kwarray.distributions import PDF # NOQA
>>> x = np.linspace(800, 4500)
>>> p = np.log10(x)
>>> p = x ** 2
>>> self = PDF(x, p)
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.figure(fnum=1, doclf=True)
>>> self.plot(5000, bins=50)
```



sample(**shape*)

class kwarray.distributions.**Seeded**(*rng=None*, *cls=None*)

Bases: object

Helper for grabbing pre-seeded distributions

kwarray.distributions.**_test_distributions**()

kwarray.distributions.**_process_docstrings**()

Iterate over the definitions with __params__ defined and dynamically add relevant information to their docstrings. We should modify this so it can rewrite the docstrings statically. I don't like dynamic docstrings at runtime.

CommandLine

```
xdoctest -m kwarray.distributions _process_docstrings
```

Example

```
>>> # Show the results of the docstring formatting
>>> from kwarray import distributions
>>> candidates = []
>>> for val in distributions.__dict__.values():
>>>     if hasattr(val, '__params__') and val.__params__ is not NotImplemented:
>>>         candidates.append(val)
>>> for val in candidates:
>>>     print('======')
>>>     print(val)
>>>     print('-----')
>>>     print(val.__doc__)
>>>     print('======')
```

kwarray.fast_rand module

Fast 32-bit random functions for numpy as of 2018. (More recent versions of numpy may have these natively supported).

kwarray.fast_rand.**uniform**(*low=0.0*, *high=1.0*, *size=None*, *dtype=<class 'numpy.float32'>*, *rng=<module 'numpy.random' from '/home/docs/checkouts/readthedocs.org/user_builds/kwarray/envs/release/lib/python3.11/site-packages/numpy/random/__init__.py'>*)

Draws float32 samples from a uniform distribution.

Samples are uniformly distributed over the half-open interval `[low, high)` (includes low, but excludes high).

Parameters

- **low** (*float*) – Lower boundary of the output interval. All values generated will be greater than or equal to low. Defaults to 0.
- **high** (*float*) – Upper boundary of the output interval. All values generated will be less than high. Default to 1.
- **size** (*int | Tuple[int, ...] | None*) – Output shape. If the given shape is, e.g., `(m, n, k)`, then `m * n * k` samples are drawn. If size is `None` (default), a single value is returned if `low` and `high` are both scalars. Otherwise, `np.broadcast(low, high).size` samples are drawn.
- **dtype** (*type*) – either np.float32 or np.float64. Defaults to float32
- **rng** (*numpy.random.RandomState*) – underlying random state

Returns

uniformly distributed random numbers with chosen size and dtype Extended typing `NDArray[Literal[size], Literal[dtype]]`

Return type

ndarray

Benchmark

```
>>> from timerit import Timerit
>>> import kwarray
>>> size = (300, 300, 3)
>>> for timer in Timerit(100, bestof=10, label='dtype=np.float32'):
>>>     rng = kwarray.ensure_rng(0)
>>>     with timer:
>>>         ours = standard_normal(size, rng=rng, dtype=np.float32)
>>> # Timed best=4.705 ms, mean=4.75 ± 0.085 ms for dtype=np.float32
>>> for timer in Timerit(100, bestof=10, label='dtype=np.float64'):
>>>     rng = kwarray.ensure_rng(0)
>>>     with timer:
>>>         theirs = standard_normal(size, rng=rng, dtype=np.float64)
>>> # Timed best=9.327 ms, mean=9.794 ± 0.4 ms for rng.np.float64
```

kwarray.fast_rand.**standard_normal**(*size*, *mean=0*, *std=1*, *dtype=<class 'float'>*, *rng=<module 'numpy.random' from '/home/docs/checkouts/readthedocs.org/user_builds/kwarray/envs/release/lib/python3.11/site-packages/numpy/random/__init__.py'>*)

Draw samples from a standard Normal distribution with a specified mean and standard deviation.

Parameters

- **size** (*int | Tuple[int, ...]*) – shape of the returned ndarray
- **mean** (*float*) – mean of the normal distribution. defaults to 0
- **std** (*float*) – standard deviation of the normal distribution. defaults to 1.
- **dtype** (*type*) – either np.float32 (default) or np.float64
- **rng** (*numpy.random.RandomState*) – underlying random state

Returns

normally distributed random numbers with chosen size and dtype Extended typing `NDArray[Literal[size], Literal[dtype]]`

Return type

ndarray

Benchmark

```
>>> from timerit import Timerit
>>> import kwarray
>>> size = (300, 300, 3)
>>> for timer in Timerit(100, bestof=10, label='dtype=np.float32'):
>>>     rng = kwarray.ensure_rng(0)
>>>     with timer:
>>>         ours = standard_normal(size, rng=rng, dtype=np.float32)
>>> # Timed best=4.705 ms, mean=4.75 ± 0.085 ms for dtype=np.float32
>>> for timer in Timerit(100, bestof=10, label='dtype=np.float64'):
>>>     rng = kwarray.ensure_rng(0)
>>>     with timer:
>>>         theirs = standard_normal(size, rng=rng, dtype=np.float64)
>>> # Timed best=9.327 ms, mean=9.794 ± 0.4 ms for rng.np.float64
```

kwarray.fast_rand.**standard_normal32**(*size*, *mean=0*, *std=1*, *rng=<module 'numpy.random' from '/home/docs/checkouts/readthedocs.org/user_builds/kwarray/envs/release/lib/python3.11/site-packages/numpy/random/__init__.py'>*)

Fast normally distributed random variables.

Uses the Box–Muller transform [WikiBoxMuller].

The difference between this function and `numpy.random.standard_normal()` is that we use float32 arrays in the backend instead of float64. Halving the amount of bits that need to be manipulated can significantly reduce the execution time, and 32-bit precision is often good enough.

Parameters

- **size** (*int | Tuple[int, ...]*) – shape of the returned ndarray
- **mean** (*float, default=0*) – mean of the normal distribution
- **std** (*float, default=1*) – standard deviation of the normal distribution
- **rng** (*numpy.random.RandomState*) – underlying random state

Returns

normally distributed random numbers with chosen size.

Return type

ndarray[Any, Float32]

References

SeeAlso:

- *standard_normal()*
- *standard_normal64()*

Example

```
>>> # xdoctest: +REQUIRES(module:scipy)
>>> import scipy
>>> import scipy.stats
>>> pts = 1000
>>> # Our numbers are normally distributed with high probability
>>> rng = np.random.RandomState(28041990)
>>> ours_a = standard_normal32(pts, rng=rng)
>>> ours_b = standard_normal32(pts, rng=rng) + 2
>>> ours = np.concatenate((ours_a, ours_b))  # numerical stability?
>>> p = scipy.stats.normaltest(ours)[1]
>>> print('Probability our data is non-normal is: {:.4g}'.format(p))
Probability our data is non-normal is: 1.573e-14
>>> rng = np.random.RandomState(28041990)
>>> theirs_a = rng.standard_normal(pts)
>>> theirs_b = rng.standard_normal(pts) + 2
>>> theirs = np.concatenate((theirs_a, theirs_b))
>>> p = scipy.stats.normaltest(theirs)[1]
>>> print('Probability their data is non-normal is: {:.4g}'.format(p))
Probability their data is non-normal is: 3.272e-11
```

Example

```
>>> pts = 1000
>>> rng = np.random.RandomState(28041990)
>>> ours = standard_normal32(pts, mean=10, std=3, rng=rng)
>>> assert np.abs(ours.std() - 3.0) < 0.1
>>> assert np.abs(ours.mean() - 10.0) < 0.1
```

Example

```
>>> # Test an even and odd numbers of points
>>> assert standard_normal32(3).shape == (3,)
>>> assert standard_normal32(2).shape == (2,)
>>> assert standard_normal32(1).shape == (1,)
>>> assert standard_normal32(0).shape == (0,)
>>> assert standard_normal32((3, 1)).shape == (3, 1)
>>> assert standard_normal32((3, 0)).shape == (3, 0)
```

kwarray.fast_rand.**standard_normal64**(*size*, *mean=0*, *std=1*, *rng=<module 'numpy.random' from '/home/docs/checkouts/readthedocs.org/user_builds/kwarray/envs/release/lib/python3.11/site-packages/numpy/random/__init__.py'>*)

Simple wrapper around rng.standard_normal to make an API compatible with *standard_normal32()*.

Parameters

- **size** (*int | Tuple[int, ...]*) – shape of the returned ndarray
- **mean** (*float*) – mean of the normal distribution. defaults to 0
- **std** (*float*) – standard deviation of the normal distribution. defaults to 1.
- **rng** (*numpy.random.RandomState*) – underlying random state

Returns

normally distributed random numbers with chosen size.

Return type

ndarray[Any, Float64]

SeeAlso:

- standard_normal
- standard_normal32

Example

```
>>> pts = 1000
>>> rng = np.random.RandomState(28041994)
>>> out = standard_normal64(pts, mean=10, std=3, rng=rng)
>>> assert np.abs(out.std() - 3.0) < 0.1
>>> assert np.abs(out.mean() - 10.0) < 0.1
```

kwarray.fast_rand.**uniform32**(*low=0.0*, *high=1.0*, *size=None*, *rng=<module 'numpy.random' from '/home/docs/checkouts/readthedocs.org/user_builds/kwarray/envs/release/lib/python3.11/site-packages/numpy/random/__init__.py'>*)

Draws float32 samples from a uniform distribution.

Samples are uniformly distributed over the half-open interval `[low, high)` (includes low, but excludes high).

Parameters

- **low** (*float, default=0.0*) – Lower boundary of the output interval. All values generated will be greater than or equal to low.
- **high** (*float, default=1.0*) – Upper boundary of the output interval. All values generated will be less than high.
- **size** (*int | Tuple[int, ...] | None*) – Output shape. If the given shape is, e.g., `(m, n, k)`, then `m * n * k` samples are drawn. If size is `None` (default), a single value is returned if `low` and `high` are both scalars. Otherwise, `np.broadcast(low, high).size` samples are drawn.

Returns
uniformly distributed random numbers with chosen size.

Return type
ndarray[Any, Float32]

Example

```
>>> rng = np.random.RandomState(0)
>>> uniform32(low=0.0, high=1.0, size=None, rng=rng)
0.5488...
>>> uniform32(low=0.0, high=1.0, size=2000, rng=rng).sum()
1004.94...
>>> uniform32(low=-10, high=10.0, size=2000, rng=rng).sum()
202.44...
```

Benchmark

```
>>> from timerit import Timerit
>>> import kwarray
>>> size = 512 * 512
>>> for timer in Timerit(100, bestof=10, label='theirs: dtype=np.float64'):
>>>     rng = kwarray.ensure_rng(0)
>>>     with timer:
>>>         theirs = rng.uniform(size=size)
>>> for timer in Timerit(100, bestof=10, label='theirs: dtype=np.float32'):
>>>     rng = kwarray.ensure_rng(0)
>>>     with timer:
>>>         theirs = rng.rand(size).astype(np.float32)
>>> for timer in Timerit(100, bestof=10, label='ours: dtype=np.float32'):
>>>     rng = kwarray.ensure_rng(0)
>>>     with timer:
>>>         ours = uniform32(size=size)
```

kwarray.util_averages module

Currently just defines "stats_dict", which is a nice way to gather multiple numeric statistics (e.g. max, min, median, mode, arithmetic-mean, geometric-mean, standard-deviation, etc...) about data in an array.

kwarray.util_averages.**stats_dict**(*inputs*, *axis=None*, *nan=False*, *sum=False*, *extreme=True*, *n_extreme=False*, *median=False*, *shape=True*, *size=False*, *quantile='auto'*)

Describe statistics about an input array

Parameters

- **inputs** (*ArrayLike*) – set of values to get statistics of
- **axis** (*int*) – if `inputs` is ndarray then this specifies the axis
- **nan** (*bool*) – report number of nan items (TODO: rename to skipna)
- **sum** (*bool*) – report sum of values
- **extreme** (*bool*) – report min and max values
- **n_extreme** (*bool*) – report extreme value frequencies
- **median** (*bool*) – report median
- **size** (*bool*) – report array size
- **shape** (*bool*) – report array shape
- **quantile** (*str | bool | List[float]*) – defaults to 'auto'. Can also be a list of quantiles to compute. if truthy computes quantiles.

Returns

dictionary of common numpy statistics (min, max, mean, std, nMin, nMax, shape)

Return type

collections.OrderedDict

SeeAlso:

`scipy.stats.describe()` `pandas.DataFrame.describe()`

Example

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> from kwarray.util_averages import *  # NOQA
>>> axis = 0
>>> rng = np.random.RandomState(0)
>>> inputs = rng.rand(10, 2).astype(np.float32)
>>> stats = stats_dict(inputs, axis=axis, nan=False, median=True)
>>> import ubelt as ub  # NOQA
>>> result = str(ub.urepr(stats, nl=1, precision=4, with_dtype=True))
>>> print(result)
{
    'mean': np.array([[0.5206, 0.6425]], dtype=np.float32),
    'std': np.array([[0.2854, 0.2517]], dtype=np.float32),
    'min': np.array([[0.0202, 0.0871]], dtype=np.float32),
    'max': np.array([[0.9637, 0.9256]], dtype=np.float32),
    'q_0.25': np.array([0.4271, 0.5329], dtype=np.float64),
```

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```
    'q_0.50': np.array([0.5584, 0.6805], dtype=np.float64),
    'q_0.75': np.array([0.7343, 0.8607], dtype=np.float64),
    'med': np.array([0.5584, 0.6805], dtype=np.float32),
    'shape': (10, 2),
}
```

Example

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> from kwarray.util_averages import *  # NOQA
>>> axis = 0
>>> rng = np.random.RandomState(0)
>>> inputs = rng.randint(0, 42, size=100).astype(np.float32)
>>> inputs[4] = np.nan
>>> stats = stats_dict(inputs, axis=axis, nan=True, quantile='auto')
>>> import ubelt as ub  # NOQA
>>> result = str(ub.urepr(stats, nl=0, precision=1, strkeys=True))
>>> print(result)
```

Example

```
>>> import kwarray
>>> import ubelt as ub
>>> rng = kwarray.ensure_rng(0)
>>> orig_inputs = rng.rand(1, 1, 2, 3)
>>> param_grid = ub.named_product({
>>>     #'axis': (None, 0, (0, 1), -1),
>>>     'axis': [None],
>>>     'percent_nan': [0, 0.5, 1.0],
>>>     'nan': [True, False],
>>>     'sum': [1],
>>>     'extreme': [True],
>>>     'n_extreme': [True],
>>>     'median': [1],
>>>     'size': [1],
>>>     'shape': [1],
>>>     'quantile': ['auto'],
>>> })
>>> for params in param_grid:
>>>     kwargs = params.copy()
>>>     percent_nan = kwargs.pop('percent_nan', 0)
>>>     if percent_nan:
>>>         inputs = orig_inputs.copy()
>>>         inputs[rng.rand(*inputs.shape) < percent_nan] = np.nan
>>>     else:
>>>         inputs = orig_inputs
>>>     stats = kwarray.stats_dict(inputs, **kwargs)
>>>     print('---')
```

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```
>>>     print('params = {}'.format(ub.urepr(params, nl=1)))
>>>     print('stats = {}'.format(ub.urepr(stats, nl=1)))
```

kwarray.util_averages._gmean(*a*, *axis=0*, *dtype=None*, *clobber=False*)

Compute the geometric mean along the specified axis.

Modification of the scikit-learn method to be more memory efficient

Example

```
>>> rng = np.random.RandomState(0)
>>> C, H, W = 8, 32, 32
>>> axis = 0
>>> a = [rng.rand(C, H, W).astype(np.float16),
>>>      rng.rand(C, H, W).astype(np.float16)]
```

exception kwarray.util_averages.**NoSupportError**

Bases: RuntimeError

class kwarray.util_averages.**RunningStats**(*nan_policy='omit'*, *check_weights=True*, ***kwargs*)

Bases: NiceRepr

Track mean, std, min, and max values over time with constant memory.

Dynamically records per-element array statistics and can summarized them per-element, across channels, or globally.

Todo:

- [ ] This may need a few API tweaks and good documentation

Example

```
>>> import kwarray
>>> run = kwarray.RunningStats()
>>> ch1 = np.array([[0, 1], [3, 4]])
>>> ch2 = np.zeros((2, 2))
>>> img = np.dstack([ch1, ch2])
>>> run.update(np.dstack([ch1, ch2]))
>>> run.update(np.dstack([ch1 + 1, ch2]))
>>> run.update(np.dstack([ch1 + 2, ch2]))
>>> # No marginalization
>>> print('current-ave = ' + ub.urepr(run.summarize(axis=ub.NoParam), nl=2,␣
↪precision=3))
>>> # Average over channels (keeps spatial dims separate)
>>> print('chann-ave(k=1) = ' + ub.urepr(run.summarize(axis=0), nl=2, precision=3))
>>> print('chann-ave(k=0) = ' + ub.urepr(run.summarize(axis=0, keepdims=0), nl=2,␣
↪precision=3))
>>> # Average over spatial dims (keeps channels separate)
>>> print('spatial-ave(k=1) = ' + ub.urepr(run.summarize(axis=(1, 2)), nl=2,␣
↪precision=3))
>>> print('spatial-ave(k=0) = ' + ub.urepr(run.summarize(axis=(1, 2), keepdims=0),␣
```

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```
↪nl=2, precision=3))
>>> # Average over all dims
>>> print('alldim-ave(k=1) = ' + ub.urepr(run.summarize(axis=None), nl=2,␣
↪precision=3))
>>> print('alldim-ave(k=0) = ' + ub.urepr(run.summarize(axis=None, keepdims=0),␣
↪nl=2, precision=3))
```

Parameters

nan_policy (*str*) – indicates how we will handle nan values

- if “omit” - set weights of nan items to zero.
- if “propogate” - propogate nans.
- if “raise” - then raise a ValueError if nans are given.

check_weights (bool):
if True, we check the weights for zeros (which can also implicitly occur when data has nans). Disabling this check will result in faster computation, but it is your responsibility to ensure all data passed to update is valid.

property shape

_update_from_other(*other*)

Combine this runner with another one.

update_many(*data*, *weights=1*)

Assumes first data axis represents multiple observations

Example

```
>>> import kwarray
>>> rng = kwarray.ensure_rng(0)
>>> run = kwarray.RunningStats()
>>> data = rng.randn(1, 2, 3)
>>> run.update_many(data)
>>> print(run.current())
>>> data = rng.randn(2, 2, 3)
>>> run.update_many(data)
>>> print(run.current())
>>> data = rng.randn(3, 2, 3)
>>> run.update_many(data)
>>> print(run.current())
>>> run.update_many(1000)
>>> print(run.current())
>>> assert np.all(run.current()['n'] == 7)
```

Example

```
>>> import kwarray
>>> rng = kwarray.ensure_rng(0)
>>> run = kwarray.RunningStats()
>>> data = rng.randn(1, 2, 3)
>>> run.update_many(data.ravel())
>>> print(run.current())
>>> data = rng.randn(2, 2, 3)
>>> run.update_many(data.ravel())
>>> print(run.current())
>>> data = rng.randn(3, 2, 3)
>>> run.update_many(data.ravel())
>>> print(run.current())
>>> run.update_many(1000)
>>> print(run.current())
>>> assert np.all(run.current()['n'] == 37)
```

update(*data*, *weights=1*)

Updates statistics across all data dimensions on a per-element basis

Example

```
>>> import kwarray
>>> data = np.full((7, 5), fill_value=1.3)
>>> weights = np.ones((7, 5), dtype=np.float32)
>>> run = kwarray.RunningStats()
>>> run.update(data, weights=1)
>>> run.update(data, weights=weights)
>>> rng = np.random
>>> weights[rng.rand(*weights.shape) > 0.5] = 0
>>> run.update(data, weights=weights)
```

Example

```
>>> import kwarray
>>> run = kwarray.RunningStats()
>>> data = np.array([[1, np.nan, np.nan], [0, np.nan, 1.]])
>>> run.update(data)
>>> print('current = {}'.format(ub.urepr(run.current(), nl=1)))
>>> print('summary(axis=None) = {}'.format(ub.urepr(run.summarize(), nl=1)))
>>> print('summary(axis=1) = {}'.format(ub.urepr(run.summarize(axis=1), nl=1)))
>>> print('summary(axis=0) = {}'.format(ub.urepr(run.summarize(axis=0), nl=1)))
>>> data = np.array([[2, 0, 1], [0, 1, np.nan]])
>>> run.update(data)
>>> data = np.array([[3, 1, 1], [0, 1, np.nan]])
>>> run.update(data)
>>> data = np.array([[4, 1, 1], [0, 1, 1.]])
>>> run.update(data)
>>> print('----')
```

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```
>>> print('current = {}'.format(ub.urepr(run.current(), nl=1)))
>>> print('summary(axis=None) = {}'.format(ub.urepr(run.summarize(), nl=1)))
>>> print('summary(axis=1) = {}'.format(ub.urepr(run.summarize(axis=1), nl=1)))
>>> print('summary(axis=0) = {}'.format(ub.urepr(run.summarize(axis=0), nl=1)))
```

_sumsq_std(*total*, *squares*, *n*)

Sum of squares method to compute standard deviation

summarize(*axis=None*, *keepdims=True*)

Compute summary statistics across a one or more dimension

Parameters

- **axis** (*int | List[int] | None | NoParamType*) – axis or axes to summarize over, if None, all axes are summarized. if ub.NoParam, no axes are summarized the current result is returned.
- **keepdims** (*bool, default=True*) – if False removes the dimensions that are summarized over

Returns

containing minimum, maximum, mean, std, etc..

Return type

Dict

Raises

NoSupportError – if update was never called with valid data

Example

```
>>> # Test to make sure summarize works across different shapes
>>> base = np.array([1, 1, 1, 1, 0, 0, 0, 1])
>>> run0 = RunningStats()
>>> for _ in range(3):
>>>     run0.update(base.reshape(8, 1))
>>> run1 = RunningStats()
>>> for _ in range(3):
>>>     run1.update(base.reshape(4, 2))
>>> run2 = RunningStats()
>>> for _ in range(3):
>>>     run2.update(base.reshape(2, 2, 2))
>>> #
>>> # Summarizing over everything should be exactly the same
>>> s0N = run0.summarize(axis=None, keepdims=0)
>>> s1N = run1.summarize(axis=None, keepdims=0)
>>> s2N = run2.summarize(axis=None, keepdims=0)
>>> #assert ub.util_indexable.indexable_allclose(s0N, s1N, rel_tol=0.0, abs_
↪tol=0.0)
>>> #assert ub.util_indexable.indexable_allclose(s1N, s2N, rel_tol=0.0, abs_
↪tol=0.0)
>>> assert s0N['mean'] == 0.625
```

current()

Returns current staticis on a per-element basis (not summarized over any axis)

kwarray.util_averages.**_combine_mean_stds**(*means*, *stds*, *nums=None*, *axis=None*, *keepdims=False*, *bessel=True*)

Parameters

- **means** (*array*) – means[i] is the mean of the ith entry to combine
- **stds** (*array*) – stds[i] is the std of the ith entry to combine
- **nums** (*array | None*) – nums[i] is the number of samples in the ith entry to combine. if None, assumes sample sizes are infinite.
- **axis** (*int | Tuple[int] | None*) – axis to combine the statistics over
- **keepdims** (*bool*) – if True return arrays with the same number of dimensions they were given in.
- **bessel** (*int*) – Set to 1 to enables bessel correction to unbias the combined std estimate. Only disable if you have the true population means, or you think you know what you are doing.

References

https://stats.stackexchange.com/questions/55999/is-it-possible-to-find-the-combined-standard-deviation

Sympy

```
>>> # xdoctest: +REQUIRES(env:SHOW_SYMPY)
>>> # What about the case where we don't know population size of the
>>> # estimates. We could treat it as a fixed number, or perhaps take the
>>> # limit as n -> infinity.
>>> import sympy
>>> import sympy as sym
>>> from sympy import symbols, sqrt, limit, IndexedBase, summation
>>> from sympy import Indexed, Idx, symbols
>>> means = IndexedBase('m')
>>> stds = IndexedBase('s')
>>> nums = IndexedBase('n')
>>> i = symbols('i', cls=Idx)
>>> k = symbols('k', cls=Idx)
>>> #
>>> combo_mean = symbols('C')
>>> #
>>> bessel = 1
>>> total = summation(nums[i], (i, 1, k))
>>> combo_mean_expr = summation(nums[i] * means[i], (i, 1, k)) / total
>>> p1 = summation((nums[i] - bessel) * stds[i], (i, 1, k))
>>> p2 = summation(nums[i] * ((means[i] - combo_mean) ** 2), (i, 1, k))
>>> #
>>> combo_std_expr = sqrt((p1 + p2) / (total - bessel))
>>> print('------------------------------------')
>>> print('General Combined Mean / Std Formulas')
>>> print('C = combined mean')
>>> print('S = combined std')
>>> print('------------------------------------')
>>> print(ub.hzcat(['C = ', sym.pretty(combo_mean_expr, use_unicode=True, use_
```

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```
↪unicode_sqrt_char=True)]))
>>> print(ub.hzcat(['S = ', sym.pretty(combo_std_expr, use_unicode=True, use_
↪unicode_sqrt_char=True)]))
>>> print('')
>>> print('---------')
>>> print('Now assuming all sample sizes are the same constant value N')
>>> print('---------')
>>> # Now assume all n[i] = N (i.e. a constant value)
>>> N = symbols('N')
>>> combo_mean_const_n_expr = combo_mean_expr.copy().xreplace({nums[i]: N})
>>> combo_std_const_n_expr = combo_std_expr.copy().xreplace({nums[i]: N})
>>> p1_const_n = p1.copy().xreplace({nums[i]: N})
>>> p2_const_n = p2.copy().xreplace({nums[i]: N})
>>> total_const_n = total.copy().xreplace({nums[i]: N})
>>> #
>>> print(ub.hzcat(['C = ', sym.pretty(combo_mean_const_n_expr, use_unicode=True,␣
↪use_unicode_sqrt_char=True)]))
>>> print(ub.hzcat(['S = ', sym.pretty(combo_std_const_n_expr, use_unicode=True,␣
↪use_unicode_sqrt_char=True)]))
>>> #
>>> print('')
>>> print('---------')
>>> print('Take the limit as N -> infinity')
>>> print('---------')
>>> #
>>> # Limit doesnt directly but we can break it into parts
>>> lim_C = limit(combo_mean_const_n_expr, N, float('inf'))
>>> lim_p1 = limit(p1_const_n / (total_const_n - bessel), N, float('inf'))
>>> lim_p2 = limit(p2_const_n / (total_const_n - bessel), N, float('inf'))
>>> lim_expr = sym.sqrt(lim_p1 + lim_p2)
>>> print(ub.hzcat(['lim(C, N->inf) = ', sym.pretty(lim_C)]))
>>> print(ub.hzcat(['lim(S, N->inf) = ', sym.pretty(lim_expr)]))
```

Example

```
>>> from kwarray.util_averages import *  # NOQA
>>> from kwarray.util_averages import _combine_mean_stds
>>> means = np.array([1.2, 3.2, 4.1])
>>> stds = np.array([4.2, 0.2, 2.1])
>>> nums = np.array([10, 100, 10])
>>> _combine_mean_stds(means, stds, nums)
>>> means = np.array([1, 2, 3])
>>> stds = np.array([1, 2, 3])
>>> #
>>> nums = np.array([1, 1, 1]) / 3
>>> print(_combine_mean_stds(means, stds, nums, bessel=True), '- .3 B')
>>> print(_combine_mean_stds(means, stds, nums, bessel=False), '- .3')
>>> nums = np.array([1, 1, 1])
>>> print(_combine_mean_stds(means, stds, nums, bessel=True), '- 1 B')
>>> print(_combine_mean_stds(means, stds, nums, bessel=False), '- 1')
```

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```
>>> nums = np.array([10, 10, 10])
>>> print(_combine_mean_stds(means, stds, nums, bessel=True), '- 10 B')
>>> print(_combine_mean_stds(means, stds, nums, bessel=False), '- 10')
>>> nums = np.array([1000, 1000, 1000])
>>> print(_combine_mean_stds(means, stds, nums, bessel=True), '- 1000 B')
>>> print(_combine_mean_stds(means, stds, nums, bessel=False), '- 1000')
>>> #
>>> nums = None
>>> print(_combine_mean_stds(means, stds, nums, bessel=True), '- inf B')
>>> print(_combine_mean_stds(means, stds, nums, bessel=False), '- inf')
```

Example

```
>>> from kwarray.util_averages import *  # NOQA
>>> from kwarray.util_averages import _combine_mean_stds
>>> means = np.stack([np.array([1.2, 3.2, 4.1])] * 100, axis=0)
>>> stds = np.stack([np.array([4.2, 0.2, 2.1])] * 100, axis=0)
>>> nums = np.stack([np.array([10, 100, 10])] * 100, axis=0)
>>> cm1, cs1, _ = _combine_mean_stds(means, stds, nums, axis=None)
>>> print('combo_mean = {}'.format(ub.urepr(cm1, nl=1)))
>>> print('combo_std  = {}'.format(ub.urepr(cs1, nl=1)))
>>> means = np.stack([np.array([1.2, 3.2, 4.1])] * 1, axis=0)
>>> stds = np.stack([np.array([4.2, 0.2, 2.1])] * 1, axis=0)
>>> nums = np.stack([np.array([10, 100, 10])] * 1, axis=0)
>>> cm2, cs2, _ = _combine_mean_stds(means, stds, nums, axis=None)
>>> print('combo_mean = {}'.format(ub.urepr(cm2, nl=1)))
>>> print('combo_std  = {}'.format(ub.urepr(cs2, nl=1)))
>>> means = np.stack([np.array([1.2, 3.2, 4.1])] * 5, axis=0)
>>> stds = np.stack([np.array([4.2, 0.2, 2.1])] * 5, axis=0)
>>> nums = np.stack([np.array([10, 100, 10])] * 5, axis=0)
>>> cm3, cs3, combo_num = _combine_mean_stds(means, stds, nums, axis=1)
>>> print('combo_mean = {}'.format(ub.urepr(cm3, nl=1)))
>>> print('combo_std  = {}'.format(ub.urepr(cs3, nl=1)))
>>> assert np.allclose(cm1, cm2) and np.allclose(cm2,  cm3)
>>> assert not np.allclose(cs1, cs2)
>>> assert np.allclose(cs2, cs3)
```

Example

```
>>> from kwarray.util_averages import *  # NOQA
>>> from kwarray.util_averages import _combine_mean_stds
>>> means = np.random.rand(2, 3, 5, 7)
>>> stds = np.random.rand(2, 3, 5, 7)
>>> nums = (np.random.rand(2, 3, 5, 7) * 10) + 1
>>> cm, cs, cn = _combine_mean_stds(means, stds, nums, axis=1, keepdims=1)
>>> assert cm.shape == cs.shape == cn.shape
>>> print(f'cm.shape={cm.shape}')
>>> cm, cs, cn = _combine_mean_stds(means, stds, nums, axis=(0, 2), keepdims=1)
>>> assert cm.shape == cs.shape == cn.shape
```

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```
>>> print(f'cm.shape={cm.shape}')
>>> cm, cs, cn = _combine_mean_stds(means, stds, nums, axis=(1, 3), keepdims=1)
>>> assert cm.shape == cs.shape == cn.shape
>>> print(f'cm.shape={cm.shape}')
>>> cm, cs, cn = _combine_mean_stds(means, stds, nums, axis=None)
>>> assert cm.shape == cs.shape == cn.shape
>>> print(f'cm.shape={cm.shape}')
cm.shape=(2, 1, 5, 7)
cm.shape=(1, 3, 1, 7)
cm.shape=(2, 1, 5, 1)
cm.shape=()
```

kwarray.util_averages.**_no_keepdim_indexer**(*result*, *axis*)

Computes an indexer to postprocess a result with keepdims=True that will modify the result as if keepdims=False

kwarray.util_averages.**_postprocess_keepdims**(*original*, *result*, *axis*)

Can update the result of a function that does not support keepdims to look as if keepdims was supported.

kwarray.util_groups module

Functions for partitioning numpy arrays into groups.

kwarray.util_groups.**group_items**(*item_list*, *groupid_list*, *assume_sorted=False*, *axis=None*)

Groups a list of items by group id.

Works like `ubelt.group_items()`, but with numpy optimizations. This can be quite a bit faster than using `itertools.groupby()`[1][2].

In cases where there are many lists of items to group (think column-major data), consider using *`group_indices()`* and *`apply_grouping()`* instead.

Parameters

- **item_list** (*NDArray*) – The input array of items to group. Extended typing `NDArray[Any, VT]`
- **groupid_list** (*NDArray*) – Each item is an id corresponding to the item at the same position in `item_list`. For the fastest runtime, the input array must be numeric (ideally with integer types). This list must be 1-dimensional. Extended typing `NDArray[Any, KT]`
- **assume_sorted** (*bool*) – If the input array is sorted, then setting this to True will avoid an unnecessary sorting operation and improve efficiency. Defaults to False.
- **axis** (*int | None*) – Group along a particular axis in `items` if it is n-dimensional.

Returns

mapping from groupids to corresponding items. Extended typing `Dict[KT, NDArray[Any, VT]]`.

Return type

Dict[Any, NDArray]

[1] http://stackoverflow.com/questions/4651683/

[2] numpy-grouping-using-itertools-groupby-performance

References

Example

```
>>> from kwarray.util_groups import *  # NOQA
>>> items = np.array([0, 1, 2, 3, 4, 5, 6, 7, 1, 1])
>>> keys = np.array( [2, 2, 1, 1, 0, 1, 0, 1, 1, 1])
>>> grouped = group_items(items, keys)
>>> print('grouped = ' + ub.urepr(grouped, nl=1, with_dtype=False, sort=1))
grouped = {
    0: np.array([4, 6]),
    1: np.array([2, 3, 5, 7, 1, 1]),
    2: np.array([0, 1]),
}
```

kwarray.util_groups.**group_indices**(*idx_to_groupid*, *assume_sorted=False*)

Find unique items and the indices at which they appear in an array.

A common use case of this function is when you have a list of objects (often numeric but sometimes not) and an array of "group-ids" corresponding to that list of objects.

Using this function will return a list of indices that can be used in conjunction with *apply_grouping()* to group the elements. This is most useful when you have many lists (think column-major data) corresponding to the group-ids.

In cases where there is only one list of objects or knowing the indices doesn't matter, then consider using func:*group_items* instead.

Parameters

- **idx_to_groupid** (*NDArray*) – The input array, where each item is interpreted as a group id. For the fastest runtime, the input array must be numeric (ideally with integer types). If the type is non-numeric then the less efficient `ubelt.group_items()` is used.
- **assume_sorted** (*bool*) – If the input array is sorted, then setting this to True will avoid an unnecessary sorting operation and improve efficiency. Defaults to False.

Returns

(keys, groupxs) -

keys (NDArray):
The unique elements of the input array in order

groupxs (List[NDArray]):
Corresponding list of indexes. The i-th item is an array indicating the indices where the item `key[i]` appeared in the input array.

Return type
Tuple[NDArray, List[NDArray]]

Example

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> import kwarray
>>> import ubelt as ub
>>> idx_to_groupid = np.array([2, 1, 2, 1, 2, 1, 2, 3, 3, 3, 3])
>>> (keys, groupxs) = kwarray.group_indices(idx_to_groupid)
>>> print('keys = ' + ub.urepr(keys, with_dtype=False))
>>> print('groupxs = ' + ub.urepr(groupxs, with_dtype=False))
keys = np.array([1, 2, 3])
groupxs = [
    np.array([1, 3, 5]),
    np.array([0, 2, 4, 6]),
    np.array([ 7,  8,  9, 10]),
]
```

Example

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> import kwarray
>>> import ubelt as ub
>>> # 2d arrays must be flattened before coming into this function so
>>> # information is on the last axis
>>> idx_to_groupid = np.array([[  24], [ 129], [ 659], [ 659], [ 24],
...       [659], [ 659], [ 822], [ 659], [ 659], [24]]).T[0]
>>> (keys, groupxs) = kwarray.group_indices(idx_to_groupid)
>>> # Different versions of numpy may produce different orderings
>>> # so normalize these to make test output consistent
>>> #[gxs.sort() for gxs in groupxs]
>>> print('keys = ' + ub.urepr(keys, with_dtype=False))
>>> print('groupxs = ' + ub.urepr(groupxs, with_dtype=False))
keys = np.array([ 24, 129, 659, 822])
groupxs = [
    np.array([ 0,  4, 10]),
    np.array([1]),
    np.array([2, 3, 5, 6, 8, 9]),
    np.array([7]),
]
```

Example

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> import kwarray
>>> import ubelt as ub
>>> idx_to_groupid = np.array([True, True, False, True, False, False, True])
>>> (keys, groupxs) = kwarray.group_indices(idx_to_groupid)
>>> print(ub.urepr(keys, with_dtype=False))
>>> print(ub.urepr(groupxs, with_dtype=False))
np.array([False,  True])
[
```

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```
    np.array([2, 4, 5]),
    np.array([0, 1, 3, 6]),
]
```

Example

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> import ubelt as ub
>>> import kwarray
>>> idx_to_groupid = [('a', 'b'),  ('d', 'b'), ('a', 'b'), ('a', 'b')]
>>> (keys, groupxs) = kwarray.group_indices(idx_to_groupid)
>>> print(ub.urepr(keys, with_dtype=False))
>>> print(ub.urepr(groupxs, with_dtype=False))
[
    ('a', 'b'),
    ('d', 'b'),
]
[
    np.array([0, 2, 3]),
    np.array([1]),
]
```

kwarray.util_groups.**apply_grouping**(*items*, *groupxs*, *axis=0*)

Applies grouping from group_indicies.

Typically used in conjunction with *group_indices()*.

Parameters

- **items** (*NDArray*) – items to group
- **groupxs** (*List[NDArray[None, Int]]*) – groups of indices
- **axis** (*None|int, default=0*)

Returns

grouped items

Return type

List[NDArray]

Example

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> idx_to_groupid = np.array([2, 1, 2, 1, 2, 1, 2, 3, 3, 3, 3])
>>> items          = np.array([1, 8, 5, 5, 8, 6, 7, 5, 3, 0, 9])
>>> (keys, groupxs) = group_indices(idx_to_groupid)
>>> grouped_items = apply_grouping(items, groupxs)
>>> result = str(grouped_items)
>>> print(result)
[array([8, 5, 6]), array([1, 5, 8, 7]), array([5, 3, 0, 9])]
```

kwarray.util_groups.**group_consecutive**(*arr*, *offset=1*)

Returns lists of consecutive values. Implementation inspired by[3].

Parameters

- **arr** (*NDArray*) – array of ordered values
- **offset** (*float, default=1*) – any two values separated by this offset are grouped. In the default case, when offset=1, this groups increasing values like: 0, 1, 2. When offset is 0 it groups consecutive values thta are the same, e.g.: 4, 4, 4.

Returns
a list of arrays that are the groups from the input

Return type
List[NDArray]

Note: This is equivalent (and faster) to using: apply_grouping(data, group_consecutive_indices(data))

References

Example

```
>>> arr = np.array([1, 2, 3, 5, 6, 7, 8, 9, 10, 15, 99, 100, 101])
>>> groups = group_consecutive(arr)
>>> print('groups = {}'.format(list(map(list, groups))))
groups = [[1, 2, 3], [5, 6, 7, 8, 9, 10], [15], [99, 100, 101]]
>>> arr = np.array([0, 0, 3, 0, 0, 7, 2, 3, 4, 4, 4, 1, 1])
>>> groups = group_consecutive(arr, offset=1)
>>> print('groups = {}'.format(list(map(list, groups))))
groups = [[0], [0], [3], [0], [0], [7], [2, 3, 4], [4], [4], [1], [1]]
>>> groups = group_consecutive(arr, offset=0)
>>> print('groups = {}'.format(list(map(list, groups))))
groups = [[0, 0], [3], [0, 0], [7], [2], [3], [4, 4, 4], [1, 1]]
```

kwarray.util_groups.**group_consecutive_indices**(*arr*, *offset=1*)

Returns lists of indices pointing to consecutive values

Parameters

- **arr** (*NDArray*) – array of ordered values
- **offset** (*float, default=1*) – any two values separated by this offset are grouped.

Returns
groupxs: a list of indices

Return type
List[NDArray]

SeeAlso:

group_consecutive()

apply_grouping()

[3] http://stackoverflow.com/questions/7352684/groups-consecutive-elements

Example

```
>>> arr = np.array([1, 2, 3, 5, 6, 7, 8, 9, 10, 15, 99, 100, 101])
>>> groupxs = group_consecutive_indices(arr)
>>> print('groupxs = {}'.format(list(map(list, groupxs))))
groupxs = [[0, 1, 2], [3, 4, 5, 6, 7, 8], [9], [10, 11, 12]]
>>> assert all(np.array_equal(a, b) for a, b in zip(group_consecutive(arr, 1),␣
↪apply_grouping(arr, groupxs)))
>>> arr = np.array([0, 0, 3, 0, 0, 7, 2, 3, 4, 4, 4, 1, 1])
>>> groupxs = group_consecutive_indices(arr, offset=1)
>>> print('groupxs = {}'.format(list(map(list, groupxs))))
groupxs = [[0], [1], [2], [3], [4], [5], [6, 7, 8], [9], [10], [11], [12]]
>>> assert all(np.array_equal(a, b) for a, b in zip(group_consecutive(arr, 1),␣
↪apply_grouping(arr, groupxs)))
>>> groupxs = group_consecutive_indices(arr, offset=0)
>>> print('groupxs = {}'.format(list(map(list, groupxs))))
groupxs = [[0, 1], [2], [3, 4], [5], [6], [7], [8, 9, 10], [11, 12]]
>>> assert all(np.array_equal(a, b) for a, b in zip(group_consecutive(arr, 0),␣
↪apply_grouping(arr, groupxs)))
```

kwarray.util_misc module

Misc tools that should find a better home

class kwarray.util_misc.**FlatIndexer**(*lens*)

Bases: NiceRepr

Creates a flat "view" of a jagged nested indexable object. Only supports one offset level.

Parameters
lens (*List[int]*) – a list of the lengths of the nested objects.

Doctest

```
>>> self = FlatIndexer([1, 2, 3])
>>> len(self)
>>> self.unravel(4)
>>> self.ravel(2, 1)
```

classmethod fromlist(*items*)

Convenience method to create a *FlatIndexer* from the list of items itself instead of the array of lengths.

Parameters
items (*List[list]*) – a list of the lists you want to flat index over

Returns
FlatIndexer

unravel(*index*)

Parameters
index (*int | List[int]*) – raveled index

Returns
outer and inner indices

Return type
Tuple[int, int]

Example

```
>>> import kwarray
>>> rng = kwarray.ensure_rng(0)
>>> items = [rng.rand(rng.randint(0, 10)) for _ in range(10)]
>>> self = kwarray.FlatIndexer.fromlist(items)
>>> index = np.arange(0, len(self))
>>> outer, inner = self.unravel(index)
>>> recon = self.ravel(outer, inner)
>>> # This check is only possible because index is an arange
>>> check1 = np.hstack(list(map(sorted, kwarray.group_indices(outer)[1])))
>>> check2 = np.hstack(kwarray.group_consecutive_indices(inner))
>>> assert np.all(check1 == index)
>>> assert np.all(check2 == index)
>>> assert np.all(index == recon)
```

ravel(*outer*, *inner*)

Parameters

- **outer** – index into outer list
- **inner** – index into the list referenced by outer

Returns
the raveled index

Return type
List[int]

kwarray.util_numpy module

Numpy specific extensions

kwarray.util_numpy.**boolmask**(*indices*, *shape=None*)

Constructs an array of booleans where an item is True if its position is in `indices` otherwise it is False. This can be viewed as the inverse of `numpy.where()`.

Parameters

- **indices** (*NDArray*) – list of integer indices
- **shape** (*int | tuple*) – length of the returned list. If not specified the minimal possible shape to incoporate all the indices is used. In general, it is best practice to always specify this argument.

Returns
mask - mask[idx] is True if idx in indices

Return type
NDArray[Any, Int]

Example

```
>>> indices = [0, 1, 4]
>>> mask = boolmask(indices, shape=6)
>>> assert np.all(mask == [True, True, False, False, True, False])
>>> mask = boolmask(indices)
>>> assert np.all(mask == [True, True, False, False, True])
```

Example

```
>>> import kwarray
>>> import ubelt as ub  # NOQA
>>> indices = np.array([(0, 0), (1, 1), (2, 1)])
>>> shape = (3, 3)
>>> mask = kwarray.boolmask(indices, shape)
>>> result = ub.urepr(mask, with_dtype=0)
>>> print(result)
np.array([[ True, False, False],
          [False,  True, False],
          [False,  True, False]])
```

kwarray.util_numpy.**iter_reduce_ufunc**(*ufunc*, *arrs*, *out=None*, *default=None*)

constant memory iteration and reduction

Applys ufunc from left to right over the input arrays

Parameters

- **ufunc** (*Callable*) – called on each pair of consecutive ndarrays
- **arrs** (*Iterator[NDArray]*) – iterator of ndarrays
- **default** (*object*) – return value when iterator is empty

Returns

if len(arrs) == 0, returns `default` if len(arrs) == 1, returns arrs[0], if len(arrs) >= 2, returns ufunc(...ufunc(ufunc(arrs[0], arrs[1]), arrs[2]),...arrs[n-1])

Return type

NDArray

Example

```
>>> arr_list = [
...     np.array([0, 1, 2, 3, 8, 9]),
...     np.array([4, 1, 2, 3, 4, 5]),
...     np.array([0, 5, 2, 3, 4, 5]),
...     np.array([1, 1, 6, 3, 4, 5]),
...     np.array([0, 1, 2, 7, 4, 5])
... ]
>>> memory = np.array([9, 9, 9, 9, 9, 9])
>>> gen_memory = memory.copy()
>>> def arr_gen(arr_list, gen_memory):
...     for arr in arr_list:
```

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```
...         gen_memory[:] = arr
...         yield gen_memory
>>> print('memory = %r' % (memory,))
>>> print('gen_memory = %r' % (gen_memory,))
>>> ufunc = np.maximum
>>> res1 = iter_reduce_ufunc(ufunc, iter(arr_list), out=None)
>>> res2 = iter_reduce_ufunc(ufunc, iter(arr_list), out=memory)
>>> res3 = iter_reduce_ufunc(ufunc, arr_gen(arr_list, gen_memory), out=memory)
>>> print('res1       = %r' % (res1,))
>>> print('res2       = %r' % (res2,))
>>> print('res3       = %r' % (res3,))
>>> print('memory     = %r' % (memory,))
>>> print('gen_memory = %r' % (gen_memory,))
>>> assert np.all(res1 == res2)
>>> assert np.all(res2 == res3)
```

kwarray.util_numpy.**isect_flags**(*arr*, *other*)

Check which items in an array intersect with another set of items

Parameters

- **arr** (*NDArray*) – items to check
- **other** (*Iterable*) – items to check if they exist in arr

Returns

booleans corresponding to arr indicating if any item in other
is also contained in other.

Return type
NDArray

Example

```
>>> arr = np.array([
>>>     [1, 2, 3, 4],
>>>     [5, 6, 3, 4],
>>>     [1, 1, 3, 4],
>>> ])
>>> other = np.array([1, 4, 6])
>>> mask = isect_flags(arr, other)
>>> print(mask)
[[ True False False  True]
 [False  True False  True]
 [ True  True False  True]]
```

kwarray.util_numpy.**atleast_nd**(*arr*, *n*, *front=False*)

View inputs as arrays with at least n dimensions.

Parameters

- **arr** (*ArrayLike*) – An array-like object. Non-array inputs are converted to arrays. Arrays that already have n or more dimensions are preserved.
- **n** (*int*) – number of dimensions to ensure

- **front** (*bool*) – if True new dimensions are added to the front of the array. otherwise they are added to the back. Defaults to False.

Returns

An array with `a.ndim >= n`. Copies are avoided where possible, and views with three or more dimensions are returned. For example, a 1-D array of shape `(N,)` becomes a view of shape `(1, N, 1)`, and a 2-D array of shape `(M, N)` becomes a view of shape `(M, N, 1)`.

Return type

NDArray

See also:

numpy.atleast_1d, numpy.atleast_2d, numpy.atleast_3d

Example

```
>>> n = 2
>>> arr = np.array([1, 1, 1])
>>> arr_ = atleast_nd(arr, n)
>>> import ubelt as ub  # NOQA
>>> result = ub.urepr(arr_.tolist(), nl=0)
>>> print(result)
[[1], [1], [1]]
```

Example

```
>>> n = 4
>>> arr1 = [1, 1, 1]
>>> arr2 = np.array(0)
>>> arr3 = np.array([[[[[1]]]]])
>>> arr1_ = atleast_nd(arr1, n)
>>> arr2_ = atleast_nd(arr2, n)
>>> arr3_ = atleast_nd(arr3, n)
>>> import ubelt as ub  # NOQA
>>> result1 = ub.urepr(arr1_.tolist(), nl=0)
>>> result2 = ub.urepr(arr2_.tolist(), nl=0)
>>> result3 = ub.urepr(arr3_.tolist(), nl=0)
>>> result = '\n'.join([result1, result2, result3])
>>> print(result)
[[[[1]]], [[[1]]], [[[1]]]]
[[[[0]]]]
[[[[[1]]]]]
```

Note: Extensive benchmarks are in kwarray/dev/bench_atleast_nd.py

These demonstrate that this function is statistically faster than the numpy variants, although the difference is small. On average this function takes 480ns versus numpy which takes 790ns.

---

kwarray.util_numpy.**argmaxima**(*arr*, *num*, *axis=None*, *ordered=True*)

Returns the top `num` maximum indicies.

This can be significantly faster than using argsort.

Parameters

- **arr** (*NDArray*) – input array
- **num** (*int*) – number of maximum indices to return
- **axis** (*int | None*) – axis to find maxima over. If None this is equivalent to using arr.ravel().
- **ordered** (*bool*) – if False, returns the maximum elements in an arbitrary order, otherwise they are in decending order. (Setting this to false is a bit faster).

Todo:

- [ ] if num is None, return arg for all values equal to the maximum

---

Returns

NDArray

Example

```
>>> # Test cases with axis=None
>>> arr = (np.random.rand(100) * 100).astype(int)
>>> for num in range(0, len(arr) + 1):
>>>     idxs = argmaxima(arr, num)
>>>     idxs2 = argmaxima(arr, num, ordered=False)
>>>     assert np.all(arr[idxs] == np.array(sorted(arr)[::-1][:len(idxs)])),
↪'ordered=True must return in order'
>>>     assert sorted(idxs2) == sorted(idxs), 'ordered=False must return the right␣
↪idxs, but in any order'
```

Example

```
>>> # Test cases with axis
>>> arr = (np.random.rand(3, 5, 7) * 100).astype(int)
>>> for axis in range(len(arr.shape)):
>>>     for num in range(0, len(arr) + 1):
>>>         idxs = argmaxima(arr, num, axis=axis)
>>>         idxs2 = argmaxima(arr, num, ordered=False, axis=axis)
>>>         assert idxs.shape[axis] == num
>>>         assert idxs2.shape[axis] == num
```

kwarray.util_numpy.**argminima**(*arr*, *num*, *axis=None*, *ordered=True*)

Returns the top num minimum indicies.

This can be significantly faster than using argsort.

Parameters

- **arr** (*NDArray*) – input array
- **num** (*int*) – number of minimum indices to return
- **axis** (*int|None*) – axis to find minima over. If None this is equivalent to using arr.ravel().

- **ordered** (*bool*) – if False, returns the minimum elements in an arbitrary order, otherwise they are in ascending order. (Setting this to false is a bit faster).

Example

```
>>> arr = (np.random.rand(100) * 100).astype(int)
>>> for num in range(0, len(arr) + 1):
>>>     idxs = argminima(arr, num)
>>>     assert np.all(arr[idxs] == np.array(sorted(arr)[:len(idxs)])),
↪'ordered=True must return in order'
>>>     idxs2 = argminima(arr, num, ordered=False)
>>>     assert sorted(idxs2) == sorted(idxs), 'ordered=False must return the right␣
↪idxs, but in any order'
```

Example

```
>>> # Test cases with axis
>>> from kwarray.util_numpy import *  # NOQA
>>> arr = (np.random.rand(3, 5, 7) * 100).astype(int)
>>> # make a unique array so we can check argmax consistency
>>> arr = np.arange(3 * 5 * 7)
>>> np.random.shuffle(arr)
>>> arr = arr.reshape(3, 5, 7)
>>> for axis in range(len(arr.shape)):
>>>     for num in range(0, len(arr) + 1):
>>>         idxs = argminima(arr, num, axis=axis)
>>>         idxs2 = argminima(arr, num, ordered=False, axis=axis)
>>>         print('idxs = {!r}'.format(idxs))
>>>         print('idxs2 = {!r}'.format(idxs2))
>>>         assert idxs.shape[axis] == num
>>>         assert idxs2.shape[axis] == num
>>>         # Check if argmin argrees with -argmax
>>>         idxs3 = argmaxima(-arr, num, axis=axis)
>>>         assert np.all(idxs3 == idxs)
```

Example

```
>>> arr = np.arange(20).reshape(4, 5) % 6
>>> argminima(arr, axis=1, num=2, ordered=False)
>>> argminima(arr, axis=1, num=2, ordered=True)
>>> argmaxima(-arr, axis=1, num=2, ordered=True)
>>> argmaxima(-arr, axis=1, num=2, ordered=False)
```

kwarray.util_numpy.**unique_rows**(*arr*, *ordered=False*, *return_index=False*)

Like unique, but works on rows

Parameters

- **arr** (*NDArray*) – must be a contiguous C style array
- **ordered** (*bool*) – if true, keeps relative ordering

References

https://stackoverflow.com/questions/16970982/find-unique-rows-in-numpy-array

Example

```
>>> import kwarray
>>> from kwarray.util_numpy import *  # NOQA
>>> rng = kwarray.ensure_rng(0)
>>> arr = rng.randint(0, 2, size=(22, 3))
>>> arr_unique = unique_rows(arr)
>>> print('arr_unique = {!r}'.format(arr_unique))
>>> arr_unique, idxs = unique_rows(arr, return_index=True, ordered=True)
>>> assert np.all(arr[idxs] == arr_unique)
>>> print('arr_unique = {!r}'.format(arr_unique))
>>> print('idxs = {!r}'.format(idxs))
>>> arr_unique, idxs = unique_rows(arr, return_index=True, ordered=False)
>>> assert np.all(arr[idxs] == arr_unique)
>>> print('arr_unique = {!r}'.format(arr_unique))
>>> print('idxs = {!r}'.format(idxs))
```

kwarray.util_numpy.**arglexmax**(*keys*, *multi=False*)

Find the index of the maximum element in a sequence of keys.

Parameters

- **keys** (*tuple*) – a k-tuple of k N-dimensional arrays. Like np.lexsort the last key in the sequence is used for the primary sort order, the second-to-last key for the secondary sort order, and so on.
- **multi** (*bool*) – if True, returns all indices that share the max value

Returns

either the index or list of indices

Return type

int | NDArray[Any, Int]

Example

```
>>> k, N = 100, 100
>>> rng = np.random.RandomState(0)
>>> keys = [(rng.rand(N) * N).astype(int) for _ in range(k)]
>>> multi_idx = arglexmax(keys, multi=True)
>>> idxs = np.lexsort(keys)
>>> assert sorted(idxs[::-1][:len(multi_idx)]) == sorted(multi_idx)
```

Benchark:

```
>>> import ubelt as ub
>>> k, N = 100, 100
>>> rng = np.random
>>> keys = [(rng.rand(N) * N).astype(int) for _ in range(k)]
```

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```
>>> for timer in ub.Timerit(100, bestof=10, label='arglexmax'):
>>>     with timer:
>>>         arglexmax(keys)
>>> for timer in ub.Timerit(100, bestof=10, label='lexsort'):
>>>     with timer:
>>>         np.lexsort(keys)[-1]
```

kwarray.util_numpy.**generalized_logistic**(*x*, *floor=0*, *capacity=1*, *C=1*, *y_intercept=None*, *Q=None*, *growth=1*, *v=1*)

A generalization of the logistic / sigmoid functions that allows for flexible specification of S-shaped curve.

This is also known as a "Richards curve" [WikiRichardsCurve].

Parameters

- **x** (*NDArray*) – input x coordinates
- **floor** (*float*) – the lower (left) asymptote. (Also called `A` in some texts). Defaults to 0.
- **capacity** (*float*) – the carrying capacity. When C=1, this is the upper (right) asymptote. (Also called `K` in some texts). Defaults to 1.
- **C** (*float*) – Has influence on the upper asymptote. Defaults to 1. This is typically not modified.
- **y_intercept** (*float | None*) – specify where the the y intercept is at x=0. Mutually exclusive with `Q`.
- **Q** (*float | None*) – related to the value of the function at x=0. Mutually exclusive with `y_intercept`. Defaults to 1.
- **growth** (*float*) – the growth rate (also calle `B` in some texts). Defaults to 1.
- **v** (*float*) – Positive number that influences near which asymptote the growth occurs. Defaults to 1.

Returns
the values for each input

Return type
NDArray

References

Example

```
>>> from kwarray.util_numpy import *  # NOQA
>>> # xdoctest: +REQUIRES(module:pandas)
>>> import pandas as pd
>>> import ubelt as ub
>>> x = np.linspace(-3, 3, 30)
>>> basis = {
>>>     # 'y_intercept': [0.1, 0.5, 0.8, -1],
>>>     # 'y_intercept': [0.1, 0.5, 0.8],
>>>     'v': [0.5, 1.0, 2.0],
>>>     'growth': [-1, 0, 2],
```

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```
>>> }
>>> grid = list(ub.named_product(basis))
>>> datas = []
>>> for params in grid:
>>>     y = generalized_logistic(x, **params)
>>>     data = pd.DataFrame({'x': x, 'y': y})
>>>     key = ub.urepr(params, compact=1)
>>>     data['key'] = key
>>>     for k, v in params.items():
>>>         data[k] = v
>>>     datas.append(data)
>>> all_data = pd.concat(datas).reset_index()
>>> # xdoctest: +REQUIRES(--show)
>>> # xdoctest: +REQUIRES(module:kwplot)
>>> import kwplot
>>> plt = kwplot.autoplt()
>>> sns = kwplot.autosns()
>>> plt.gca().cla()
>>> sns.lineplot(data=all_data, x='x', y='y', hue='growth', size='v')
```

kwarray.util_numpy.**equal_with_nan**(*a1*, *a2*)

Numpy has array_equal with equal_nan=True, but this is elementwise

Parameters

- **a1** (*ArrayLike*) – input array
- **a2** (*ArrayLike*) – input array

Example

```
>>> import kwarray
>>> a1 = np.array([
>>>     [np.nan, 0, np.nan],
>>>     [np.nan, 0, 0],
>>>     [np.nan, 1, 0],
>>>     [np.nan, 1, np.nan],
>>> ])
>>> a2 = np.array([np.nan, 0, np.nan])
>>> flags = kwarray.equal_with_nan(a1, a2)
>>> assert np.array_equal(flags, np.array([
>>>     [ True, False,  True],
>>>     [ True, False, False],
>>>     [ True,  True, False],
>>>     [ True,  True,  True]
>>> ]))
```

kwarray.util_random module

Handle and interchange between different random number generators (numpy, python, torch, ...). Also defines useful random iterator functions and *ensure_rng()*.

Random Number Generator Patterns

If you need a seeded random number generator kwarray.ensure_rng is helpful with that: *kwarray.util_random.ensure_rng()*

If the input is a number it returns a seeded random number generator. If it is None is returns whatever the system level RNG is. If the input is an existing RNG it returns it without changing it. It also has the ability to switch between Python's random module RNG and numpys np.random RNG (it can translate the internal state between the two).

When I write randomized functions / class, a coding pattern I like is to have a default keyword argument `rng=None`. Then kwarray.ensure_rng coerces whatever the input is into a `random.Random()` or `numpy.random.RandomState()` object.

```
def some_random_function(*args, rng=None):
    rng = kwarray.ensure_rng(rng)
```

Then if this random function calls any other random function, it passes the coerced rng to all other subfunctions. This ensures that seeing the RNG at the top level produces a completely determenistic process.

For a more involved example

```
import pandas as pd
import numpy
import kwarray

def random_subfunc1(rng=None):
    rng = kwarray.ensure_rng(rng, api='python')
    value: float = rng.betavariate(3, 2.3)
    return value


def random_subfunc2(rng=None):
    rng = kwarray.ensure_rng(rng, api='numpy')
    arr: np.ndarray = rng.choice([1, 2, 3, 4], size=3, replace=0)
    return arr


def random_method(rng=None):
    value = random_subfunc1(rng=rng)
    arr = random_subfunc2(rng=rng)
    final = (arr * value).sum()
    return final

def demo():
    results = []
    num = 10
    for _ in range(num):
        rng = np.random.RandomState(3)
        row = {}
```

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```
        row['system'] = random_method(None)
        row['seeded'] = random_method(0)
        row['exiting'] = random_method(rng)
        results.append(row)

    df = pd.DataFrame(results)
    print(df)
```

This results in:

```
     system    seeded   exiting
0  3.642700  6.902354  4.869275
1  3.127890  6.902354  4.869275
2  4.317397  6.902354  4.869275
3  3.382259  6.902354  4.869275
4  1.999498  6.902354  4.869275
5  5.293688  6.902354  4.869275
6  2.984741  6.902354  4.869275
7  6.455160  6.902354  4.869275
8  5.161900  6.902354  4.869275
9  2.810358  6.902354  4.869275
```

kwarray.util_random.**seed_global**(*seed*, *offset=0*)

Seeds the python, numpy, and torch global random states

Parameters

- **seed** (*int*) – seed to use
- **offset** (*int*) – if specified, uses a different seed for each global random state separated by this offset. Defaults to 0.

kwarray.util_random.**shuffle**(*items*, *rng=None*)

Shuffles a list inplace and then returns it for convinience

Parameters

- **items** (*list | ndarray*) – data to shuffle
- **rng** (*int | float | None | numpy.random.RandomState | random.Random*) – seed or random number gen

Returns

this is the input, but returned for convinience

Return type

list

Example

```
>>> list1 = [1, 2, 3, 4, 5, 6]
>>> list2 = shuffle(list(list1), rng=1)
>>> assert list1 != list2
>>> result = str(list2)
>>> print(result)
[3, 2, 5, 1, 4, 6]
```

kwarray.util_random.**random_combinations**(*items*, *size*, *num=None*, *rng=None*)

Yields num combinations of length size from items in random order

Parameters

- **items** (*List*) – pool of items to choose from
- **size** (*int*) – Number of items in each combination
- **num** (*int | None*) – Number of combinations to generate. If None, generate them all.
- **rng** (*int | float | None | numpy.random.RandomState | random.Random*) – seed or random number generator. Defaults to the global state of the python random module.

Yields

Tuple – a random combination of items of length size.

Example

```
>>> # xdoctest: +REQUIRES(module:scipy)
>>> import ubelt as ub
>>> items = list(range(10))
>>> size = 3
>>> num = 5
>>> rng = 0
>>> # xdoctest: +IGNORE_WANT
>>> combos = list(random_combinations(items, size, num, rng))
>>> print('combos = {}'.format(ub.urepr(combos, nl=1)))
combos = [
    (0, 6, 9),
    (4, 7, 8),
    (4, 6, 7),
    (2, 3, 5),
    (1, 2, 4),
]
```

Example

```
>>> # xdoctest: +REQUIRES(module:scipy)
>>> import ubelt as ub
>>> items = list(zip(range(10), range(10)))
>>> # xdoctest: +IGNORE_WANT
>>> combos = list(random_combinations(items, 3, num=5, rng=0))
>>> print('combos = {}'.format(ub.urepr(combos, nl=1)))
combos = [
    ((0, 0), (6, 6), (9, 9)),
    ((4, 4), (7, 7), (8, 8)),
    ((4, 4), (6, 6), (7, 7)),
    ((2, 2), (3, 3), (5, 5)),
    ((1, 1), (2, 2), (4, 4)),
]
```

kwarray.util_random.**random_product**(*items*, *num=None*, *rng=None*)

Yields num items from the cartesian product of items in a random order.

Parameters

- **items** (*List[Sequence]*) – items to get caresian product of packed in a list or tuple. (note this deviates from api of `itertools.product()`)
- **num** (*int | None*) – maximum number of items to generate. If None generat them all
- **rng** (*int | float | None | numpy.random.RandomState | random.Random*) – Seed or random number generator. Defaults to the global state of the python random module.

Yields

Tuple – a random item in the cartesian product

Example

```
>>> import ubelt as ub
>>> items = [(1, 2, 3), (4, 5, 6, 7)]
>>> rng = 0
>>> # xdoctest: +IGNORE_WANT
>>> products = list(random_product(items, rng=0))
>>> print(ub.urepr(products, nl=0))
[(3, 4), (1, 7), (3, 6), (2, 7),... (1, 6), (2, 5), (2, 4)]
>>> products = list(random_product(items, num=3, rng=0))
>>> print(ub.urepr(products, nl=0))
[(3, 4), (1, 7), (3, 6)]
```

Example

```
>>> # xdoctest: +REQUIRES(--profile)
>>> rng = ensure_rng(0)
>>> items = [np.array([15, 14]), np.array([27, 26]),
>>>          np.array([21, 22]), np.array([32, 31])]
>>> num = 2
>>> for _ in range(100):
>>>     list(random_product(items, num=num, rng=rng))
```

kwarray.util_random.**_npstate_to_pystate**(*npstate*)

Convert state of a NumPy RandomState object to a state that can be used by Python's Random. Derived from [SO44313620].

References

Example

```
>>> py_rng = random.Random(0)
>>> np_rng = np.random.RandomState(seed=0)
>>> npstate = np_rng.get_state()
>>> pystate = _npstate_to_pystate(npstate)
>>> py_rng.setstate(pystate)
>>> assert np_rng.rand() == py_rng.random()
```

kwarray.util_random.**_pystate_to_npstate**(*pystate*)

Convert state of a Python Random object to state usable by NumPy RandomState. Derived from [SO44313620].

References

Example

```
>>> py_rng = random.Random(0)
>>> np_rng = np.random.RandomState(seed=0)
>>> pystate = py_rng.getstate()
>>> npstate = _pystate_to_npstate(pystate)
>>> np_rng.set_state(npstate)
>>> assert np_rng.rand() == py_rng.random()
```

kwarray.util_random.**_coerce_rng_type**(*rng*)

Internal method that transforms input seeds into an integer form.

kwarray.util_random.**ensure_rng**(*rng=None*, *api='numpy'*)

Coerces input into a random number generator.

This function is useful for ensuring that your code uses a controlled internal random state that is independent of other modules.

If the input is None, then a global random state is returned.

If the input is a numeric value, then that is used as a seed to construct a random state.

If the input is a random number generator, then another random number generator with the same state is returned. Depending on the api, this random state is either return as-is, or used to construct an equivalent random state with the requested api.

Parameters

- **rng** (*int | float | None | numpy.random.RandomState | random.Random*) – if None, then defaults to the global rng. Otherwise this can be an integer or a RandomState class. Defaults to the global random.
- **api** (*str*) – specify the type of random number generator to use. This can either be 'numpy' for a `numpy.random.RandomState` object or 'python' for a `random.Random` object. Defaults to numpy.

Returns

rng - either a numpy or python random number generator, depending on the setting of `api`.

Return type

(numpy.random.RandomState | random.Random)

Example

```
>>> rng = ensure_rng(None)
>>> ensure_rng(0).randint(0, 1000)
684
>>> ensure_rng(np.random.RandomState(1)).randint(0, 1000)
37
```

Example

```
>>> num = 4
>>> print('--- Python as PYTHON ---')
>>> py_rng = random.Random(0)
>>> pp_nums = [py_rng.random() for _ in range(num)]
>>> print(pp_nums)
>>> print('--- Numpy as PYTHON ---')
>>> np_rng = ensure_rng(random.Random(0), api='numpy')
>>> np_nums = [np_rng.rand() for _ in range(num)]
>>> print(np_nums)
>>> print('--- Numpy as NUMPY---')
>>> np_rng = np.random.RandomState(seed=0)
>>> nn_nums = [np_rng.rand() for _ in range(num)]
>>> print(nn_nums)
>>> print('--- Python as NUMPY---')
>>> py_rng = ensure_rng(np.random.RandomState(seed=0), api='python')
>>> pn_nums = [py_rng.random() for _ in range(num)]
>>> print(pn_nums)
>>> assert np_nums == pp_nums
>>> assert pn_nums == nn_nums
```

Example

```
>>> # Test that random modules can be coerced
>>> import random
>>> import numpy as np
>>> ensure_rng(random, api='python')
>>> ensure_rng(random, api='numpy')
>>> ensure_rng(np.random, api='python')
>>> ensure_rng(np.random, api='numpy')
```

kwarray.util_robust module

Functions relating to robust statistical methods for normalizing data.

kwarray.util_robust.**find_robust_normalizers**(*data*, *params='auto'*)

Finds robust normalization statistics a set of scalar observations.

The idea is to estimate "fense" parameters: minimum and maximum values where anything under / above these values are likely outliers. For non-linear normalizaiton schemes we can also estimate an likely middle and extent of the data.

Parameters

- **data** (*ndarray*) – a 1D numpy array where invalid data has already been removed
- **params** (*str | dict*) – normalization params.

  When passed as a dictionary valid params are:

  scaling (str):
  This is the "mode" that will be used in the final normalization. Currently has no impact on the Defaults to 'linear'. Can also be 'sigmoid'.

  extrema (str):
  The method for determening what the extrama are. Can be "quantile" for strict quantile clipping Can be "adaptive-quantile" for an IQR-like adjusted quantile method. Can be "tukey" or "IQR" for an exact IQR method.

  low (float): This is the low quantile for likely inliers.

  mid (float): This is the middle quantlie for likely inliers.

  high (float): This is the high quantile for likely inliers.

  Can be specified as a concise string.

  The string "auto" defaults to:
  `dict(extrema='adaptive-quantile', scaling='linear', low=0.01, mid=0.5, high=0.9)`.

  The string "tukey" defaults to:
  `dict(extrema='tukey', scaling='linear')`.

Returns

normalization parameters that can be passed to *kwarray.normalize()* containing the keys:

type (str): which is always 'normalize'

mode (str): the value of `params['scaling']`

min_val (float): the determined "robust" minimum inlier value.

max_val (float): the determined "robust" maximum inlier value.

beta (float): the determined "robust" middle value for use in non-linear normalizers.

alpha (float): the determined "robust" extent value for use in non-linear normalizers.

Return type
Dict[str, str | float]

Note: The defaults and methods of this function are subject to change.

Todo:

- [ ] No (or minimal) Magic Numbers! Use first principles to deterimine defaults.
- [ ] Probably a lot of literature on the subject.
- [ ] https://arxiv.org/pdf/1707.09752.pdf
- [ ] https://www.tandfonline.com/doi/full/10.1080/02664763.2019.1671961
- [ ] https://www.rips-irsp.com/articles/10.5334/irsp.289/
- **[ ] This function is not possible to get right in every case** (probably can prove this with a NFL theroem), might be useful to allow the user to specify a "model" which is specific to some domain.

Example

```
>>> from kwarray.util_robust 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.urepr(norm_params1, nl=1)))
>>> print('norm_params2 = {}'.format(ub.urepr(norm_params2, nl=1)))
>>> print('norm_params3 = {}'.format(ub.urepr(norm_params3, nl=1)))
```

Example

```
>>> # xdoctest: +REQUIRES(module:scipy)
>>> from kwarray.util_robust import *  # NOQA
>>> from kwarray.distributions import Mixture
>>> import ubelt as ub
>>> # A random mixture distribution for testing
>>> data = Mixture.random(6).sample(3000)
```

kwarray.util_robust.**_tukey_quantile_fence**(*data*, *clip=False*)

One might wonder where the 1.5 in the above interval comes from – Paul Velleman, a statistician at Cornell University, was a student of John Tukey, who invented this test for outliers. He wondered the same thing. When he asked Tukey, "Why 1.5?", Tukey answered, "Because 1 is too small and 2 is too large." [OxfordShapeSpread].

References

kwarray.util_robust.**_quantile_extreme_estimator**(*data*, *params*)

kwarray.util_robust.**_custom_quantile_extreme_estimator**(*data*, *params*)

kwarray.util_robust.**robust_normalize**(*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:

- [x] 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 mid, scaling, extrema e.g. {'low': 0.1, 'mid': 0.8, 'high': 0.9, 'scaling': 'sigmoid'} See documentation in *find_robust_normalizers()*.
- **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. Note this is the opposite of a masked array.

Returns

a floating point array with values between 0 and 1. if return_info is specified, also returns extra data

Return type

ndarray | Tuple[ndarray, Any]

Note: This is effectively a combination of *find_robust_normalizers()* and *normalize()*.

Example

```
>>> # xdoctest: +REQUIRES(module:scipy)
>>> from kwarray.util_robust import *  # NOQA
>>> from kwarray.distributions import Mixture
>>> import ubelt as ub
>>> # A random mixture distribution for testing
>>> data = Mixture.random(6).sample(3000)
>>> param_basis = {
>>>     'scaling': ['linear', 'sigmoid'],
>>>     'high': [0.6, 0.8, 0.9, 1.0],
>>> }
>>> param_grid = list(ub.named_product(param_basis))
>>> param_grid += ['auto']
>>> param_grid += ['tukey']
>>> rows = []
>>> rows.append({'key': 'orig', 'result': data})
>>> for params in param_grid:
>>>     key = ub.urepr(params, compact=1)
>>>     result, info = robust_normalize(data, return_info=True, params=params)
>>>     print('key = {}'.format(key))
>>>     print('info = {}'.format(ub.urepr(info, nl=1)))
>>>     rows.append({'key': key, 'info': info, 'result': result})
>>> # xdoctest: +REQUIRES(--show)
>>> import seaborn as sns
>>> import kwplot
>>> kwplot.autompl()
>>> pnum_ = kwplot.PlotNums(nSubplots=len(rows))
>>> for row in rows:
>>>     ax = kwplot.figure(fnum=1, pnum=pnum_()).gca()
>>>     sns.histplot(data=row['result'], kde=True, bins=128, ax=ax, stat='density')
>>>     ax.set_title(row['key'])
```

Example

```
>>> # xdoctest: +REQUIRES(module:kwimage)
>>> from kwarray.util_robust 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)
```

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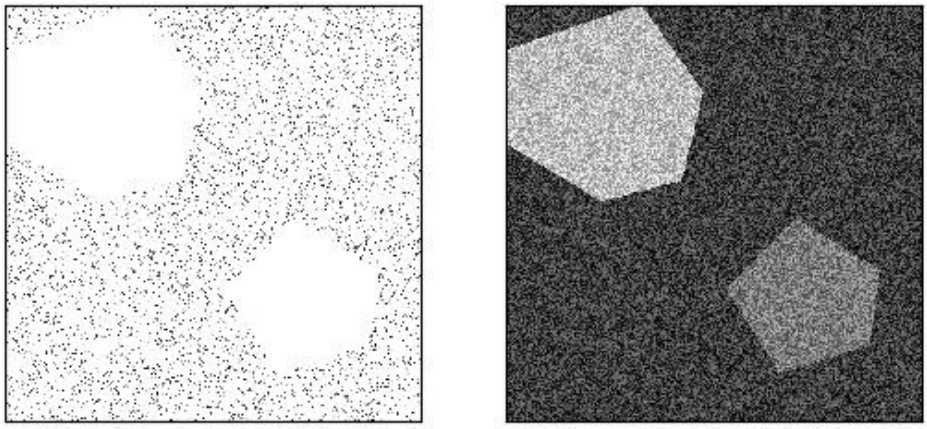
```
>>> forground = poly2.fill(forground, value=122)
>>> forground = (kwimage.ensure_float01(forground) * max_val).astype(dtype)
>>> imdata = background + forground
>>> normed, info = kwarray.robust_normalize(imdata, return_info=True)
>>> print('info = {}'.format(ub.urepr(info, nl=1)))
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(imdata, pnum=(1, 2, 1), fnum=1)
>>> kwplot.imshow(normed, pnum=(1, 2, 2), fnum=1)
```



kwarray.util_robust.**_apply_robust_normalizer**(*normalizer*, *imdata*, *imdata_valid*, *mask*, *dtype*, *copy=True*)

Todo: abstract into a scikit-learn-style Normalizer class which can fit/predict different types of normalizers.

kwarray.util_robust.**normalize**(*arr*, *mode='linear'*, *alpha=None*, *beta=None*, *out=None*, *min_val=None*, *max_val=None*)

Normalizes input values based on a specified scheme.

The default behavior is a linear normalization between 0.0 and 1.0 based on the min/max values of the input. Parameters can be specified to achieve more general constrat stretching or signal rebalancing. Implements the linear and sigmoid normalization methods described in [WikiNorm].

Parameters

- **arr** (*NDArray*) – array to normalize, usually an image
- **out** (*NDArray | None*) – output array. Note, that we will create an internal floating point copy for integer computations.
- **mode** (*str*) – either linear or sigmoid.
- **alpha** (*float*) – Only used if mode=sigmoid. Division factor (pre-sigmoid). If unspecified computed as: `max(abs(old_min - beta), abs(old_max - beta)) / 6.212606`. Note this parameter is sensitive to if the input is a float or uint8 image.
- **beta** (*float*) – subtractive factor (pre-sigmoid). This should be the intensity of the most interesting bits of the image, i.e. bring them to the center (0) of the distribution. Defaults to `(max - min) / 2`. Note this parameter is sensitive to if the input is a float or uint8 image.
- **min_val** – inputs lower than this minimum value are clipped
- **max_val** – inputs higher than this maximum value are clipped.

SeeAlso:

find_robust_normalizers() **- determine robust parameters for** normalize to mitigate the effect of outliers.

robust_normalize() **- finds and applies robust normalization** parameters

References

Example

```
>>> raw_f = np.random.rand(8, 8)
>>> norm_f = normalize(raw_f)
```

```
>>> raw_f = np.random.rand(8, 8) * 100
>>> norm_f = normalize(raw_f)
>>> assert isclose(norm_f.min(), 0)
>>> assert isclose(norm_f.max(), 1)
```

```
>>> raw_u = (np.random.rand(8, 8) * 255).astype(np.uint8)
>>> norm_u = normalize(raw_u)
```

Example

```
>>> # xdoctest: +REQUIRES(module:kwimage)
>>> import kwimage
>>> arr = kwimage.grab_test_image('lowcontrast')
>>> arr = kwimage.ensure_float01(arr)
>>> norms = {}
>>> norms['arr'] = arr.copy()
>>> norms['linear'] = normalize(arr, mode='linear')
>>> # xdoctest: +REQUIRES(module:scipy)
```

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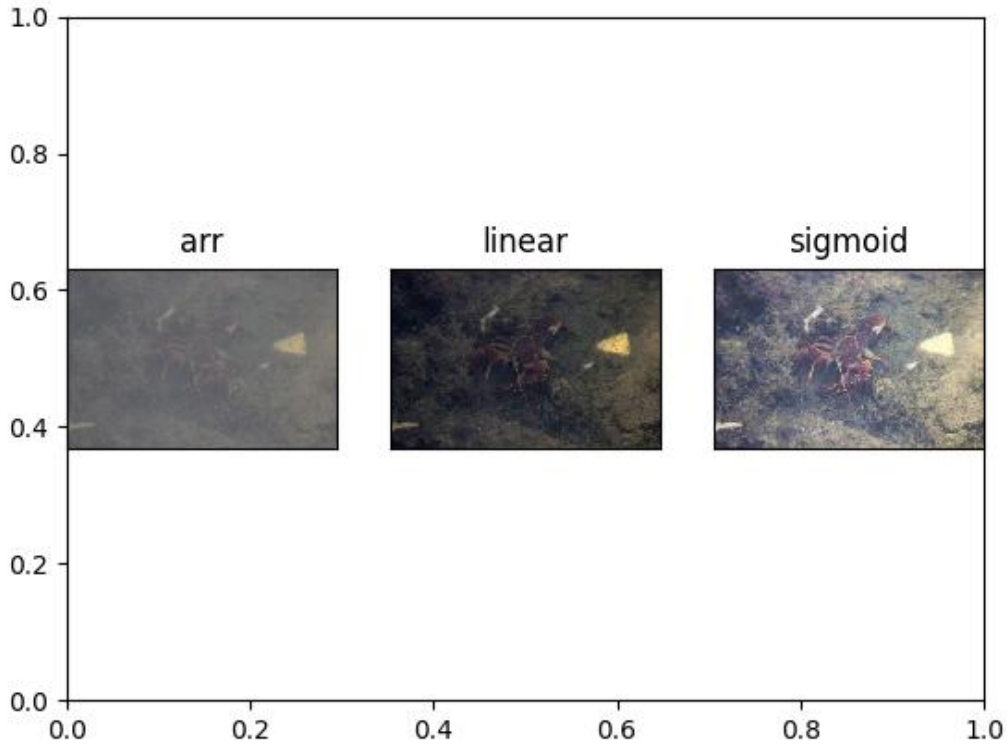
```
>>> norms['sigmoid'] = normalize(arr, mode='sigmoid')
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.figure(fnum=1, doclf=True)
>>> pnum_ = kwplot.PlotNums(nSubplots=len(norms))
>>> for key, img in norms.items():
>>>     kwplot.imshow(img, pnum=pnum_(), title=key)
```



Example

```
>>> # xdoctest: +REQUIRES(module:kwimage)
>>> arr = np.array([np.inf])
>>> normalize(arr, mode='linear')
>>> # xdoctest: +REQUIRES(module:scipy)
>>> normalize(arr, mode='sigmoid')
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.figure(fnum=1, doclf=True)
>>> pnum_ = kwplot.PlotNums(nSubplots=len(norms))
>>> for key, img in norms.items():
```

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```
>>>     kwplot.imshow(img, pnum=pnum_(), title=key)
```

Benchmark

```
>>> # Our method is faster than standard in-line implementations for
>>> # uint8 and competative with in-line float32, in addition to being
>>> # more concise and configurable. In 3.11 all inplace variants are
>>> # faster.
>>> # xdoctest: +REQUIRES(module:kwimage)
>>> import timerit
>>> import kwimage
>>> import kwarray
>>> ti = timerit.Timerit(1000, bestof=10, verbose=2, unit='ms')
>>> arr = kwimage.grab_test_image('lowcontrast', dsize=(512, 512))
>>> #
>>> arr = kwimage.ensure_float01(arr)
>>> out = arr.copy()
>>> for timer in ti.reset('inline_naive(float)'):
>>>     with timer:
>>>         (arr - arr.min()) / (arr.max() - arr.min())
>>> #
>>> for timer in ti.reset('inline_faster(float)'):
>>>     with timer:
>>>         max_ = arr.max()
>>>         min_ = arr.min()
>>>         result = (arr - min_) / (max_ - min_)
>>> #
>>> for timer in ti.reset('kwarray.normalize(float)'):
>>>     with timer:
>>>         kwarray.normalize(arr)
>>> #
>>> for timer in ti.reset('kwarray.normalize(float, inplace)'):
>>>     with timer:
>>>         kwarray.normalize(arr, out=out)
>>> #
>>> arr = kwimage.ensure_uint255(arr)
>>> out = arr.copy()
>>> for timer in ti.reset('inline_naive(uint8)'):
>>>     with timer:
>>>         (arr - arr.min()) / (arr.max() - arr.min())
>>> #
>>> for timer in ti.reset('inline_faster(uint8)'):
>>>     with timer:
>>>         max_ = arr.max()
>>>         min_ = arr.min()
>>>         result = (arr - min_) / (max_ - min_)
>>> #
>>> for timer in ti.reset('kwarray.normalize(uint8)'):
>>>     with timer:
>>>         kwarray.normalize(arr)
```

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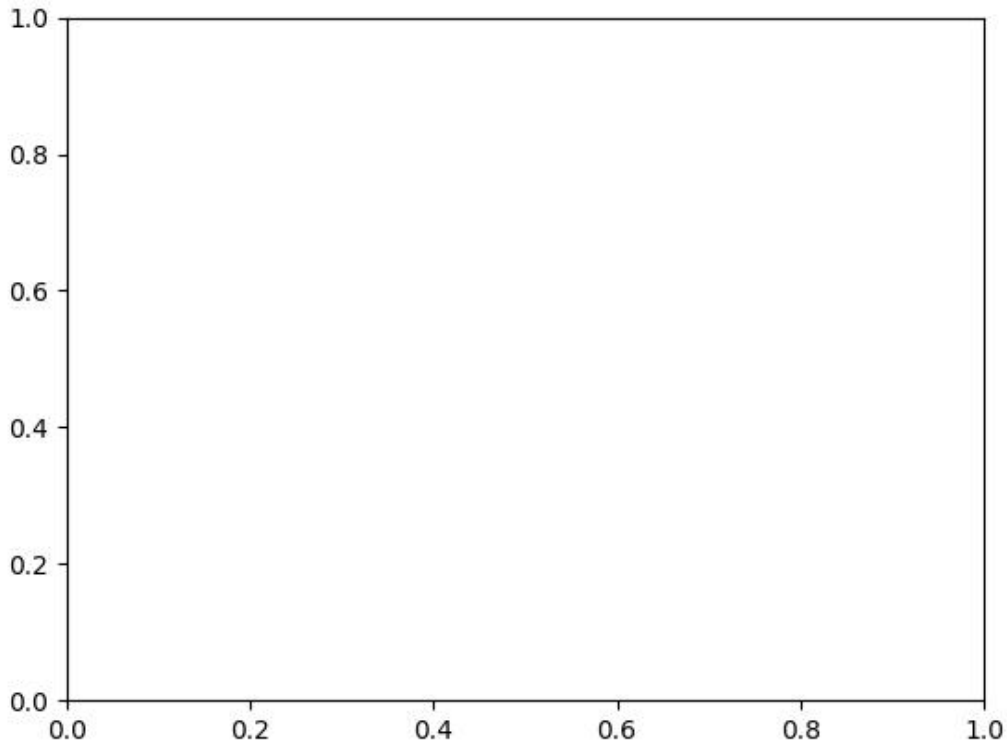
```
>>> #
>>> for timer in ti.reset('kwarray.normalize(uint8, inplace)'):
>>>     with timer:
>>>         kwarray.normalize(arr, out=out)
>>> print('ti.rankings = {}'.format(ub.urepr(
>>>     ti.rankings, nl=2, align=':', precision=5)))
```



kwarray.util_slices module

Utilities related to slicing

References

https://stackoverflow.com/questions/41153803/zero-padding-slice-past-end-of-array-in-numpy

---

Todo:

- **[ ] Could have a kwarray function to expose this inverse slice**
  functionality. Also having a top-level call to apply an embedded slice would be good.

---

kwarray.util_slices.**padded_slice**(*data*, *slices*, *pad=None*, *padkw=None*, *return_info=False*)

Allows slices with out-of-bound coordinates. Any out of bounds coordinate will be sampled via padding.

Parameters

- **data** (*Sliceable*) – data to slice into. Any channels must be the last dimension.
- **slices** (*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, default=False*) – if True, return extra information about the transform.

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.

SeeAlso:
embed_slice - finds the embedded slice and padding

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

```
>>> import kwarray
>>> data = np.arange(5)
>>> slices = [slice(-2, 7)]
```

```
>>> data_sliced = kwarray.padded_slice(data, slices)
>>> print(ub.urepr(data_sliced, with_dtype=False))
np.array([0, 0, 0, 1, 2, 3, 4, 0, 0])
```

```
>>> data_sliced = kwarray.padded_slice(data, slices, pad=[(3, 3)])
>>> print(ub.urepr(data_sliced, with_dtype=False))
np.array([0, 0, 0, 0, 0, 0, 1, 2, 3, 4, 0, 0, 0, 0, 0])
```

```
>>> data_sliced = kwarray.padded_slice(data, slice(3, 4), pad=[(1, 0)])
>>> print(ub.urepr(data_sliced, with_dtype=False))
np.array([2, 3])
```

kwarray.util_slices.**apply_embedded_slice**(*data*, *data_slice*, *extra_padding*, ***padkw*)

Apply a precomputed embedded slice.

This is used as a subroutine in padded_slice.

Parameters

- **data** (*ndarray*) – data to slice
- **data_slice** (*Tuple[slice]*)
- **extra_padding** (*Tuple[slice]*)

Returns

ndarray

kwarray.util_slices.**_apply_padding**(*array*, *pad_width*, ***padkw*)

Alternative to numpy pad with different short-cut semantics for the "pad_width" argument.

Unlike numpy pad, you must specify a (start, stop) tuple for each dimension. The shortcut is that you only need to specify this for the leading dimensions. Any unspecified trailing dimension will get an implicit (0, 0) padding.

TODO: does this get exposed as a public function?

kwarray.util_slices.**embed_slice**(*slices*, *data_dims*, *pad=None*)

Embeds a "padded-slice" inside known data dimension.

Returns the valid data portion of the slice with extra padding for regions outside of the available dimension.

Given a slices for each dimension, image dimensions, and a padding get the corresponding slice from the image and any extra padding needed to achieve the requested window size.

Todo:

- [ ] Add the option to return the inverse slice

Parameters

- **slices** (*Tuple[slice, ...]*) – a tuple of slices for to apply to data data dimension.
- **data_dims** (*Tuple[int, ...]*) – n-dimension data sizes (e.g. 2d height, width)
- **pad** (*int | List[int | Tuple[int, int]]*) – extra pad applied to (start / end) / (both) sides of each slice dim

Returns

data_slice - Tuple[slice] a slice that can be applied to an array
with with shape *data_dims*. This slice will not correspond to the full window size if the requested slice is out of bounds.

extra_padding - extra padding needed after slicing to achieve
the requested window size.

Return type
Tuple

Example

```
>>> # Case where slice is inside the data dims on left edge
>>> import kwarray
>>> slices = (slice(0, 10), slice(0, 10))
>>> data_dims  = [300, 300]
>>> pad        = [10, 5]
>>> a, b = kwarray.embed_slice(slices, data_dims, pad)
>>> print('data_slice = {!r}'.format(a))
>>> print('extra_padding = {!r}'.format(b))
data_slice = (slice(0, 20, None), slice(0, 15, None))
extra_padding = [(10, 0), (5, 0)]
```

Example

```
>>> # Case where slice is bigger than the image
>>> import kwarray
>>> slices = (slice(-10, 400), slice(-10, 400))
>>> data_dims  = [300, 300]
>>> pad        = [10, 5]
>>> a, b = kwarray.embed_slice(slices, data_dims, pad)
>>> print('data_slice = {!r}'.format(a))
>>> print('extra_padding = {!r}'.format(b))
data_slice = (slice(0, 300, None), slice(0, 300, None))
extra_padding = [(20, 110), (15, 105)]
```

Example

```
>>> # Case where slice is inside than the image
>>> import kwarray
>>> slices = (slice(10, 40), slice(10, 40))
>>> data_dims  = [300, 300]
>>> pad        = None
>>> a, b = kwarray.embed_slice(slices, data_dims, pad)
>>> print('data_slice = {!r}'.format(a))
>>> print('extra_padding = {!r}'.format(b))
data_slice = (slice(10, 40, None), slice(10, 40, None))
extra_padding = [(0, 0), (0, 0)]
```

Example

```
>>> # Test error cases
>>> import kwarray
>>> import pytest
>>> slices = (slice(0, 40), slice(10, 40))
>>> data_dims  = [300, 300]
>>> with pytest.raises(ValueError):
>>>     kwarray.embed_slice(slices, data_dims[0:1])
```

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```
>>> with pytest.raises(ValueError):
>>>     kwarray.embed_slice(slices[0:1], data_dims)
>>> with pytest.raises(ValueError):
>>>     kwarray.embed_slice(slices, data_dims, pad=[(1, 1)])
>>> with pytest.raises(ValueError):
>>>     kwarray.embed_slice(slices, data_dims, pad=[1])
```

kwarray.util_slices.**_coerce_pad**(*pad*, *ndims*)

kwarray.util_slider module

Defines the *SlidingWindow* and Sticher classes.

The *SlidingWindow* generates a grid of slices over an numpy.ndarray(), which can then be used to compute on subsets of the data. The *Stitcher* can then take these results and recombine them into a final result that matches the larger array.

class kwarray.util_slider.**SlidingWindow**(*shape*, *window*, *overlap=None*, *stride=None*, *keepbound=False*, *allow_overshoot=False*)

Bases: NiceRepr

Slide a window of a certain shape over an array with a larger shape.

This can be used for iterating over a grid of sub-regions of 2d-images, 3d-volumes, or any n-dimensional array.

Yields slices of shape *window* that can be used to index into an array with shape *shape* via numpy / torch fancy indexing. This allows for fast fast iteration over subregions of a larger image. Because we generate a grid-basis using only shapes, the larger image does not need to be in memory as long as its width/height/depth/etc...

Parameters

- **shape** (*Tuple[int, ...]*) – shape of source array to slide across.
- **window** (*Tuple[int, ...]*) – shape of window that will be slid over the larger image.
- **overlap** (*float, default=0*) – a number between 0 and 1 indicating the fraction of overlap that parts will have. Specifying this is mutually exclusive with *stride*. Must be *0 <= overlap < 1*.
- **stride** (*int, default=None*) – the number of cells (pixels) moved on each step of the window. Mutually exclusive with overlap.
- **keepbound** (*bool, default=False*) – if True, a non-uniform stride will be taken to ensure that the right / bottom of the image is returned as a slice if needed. Such a slice will not obey the overlap constraints. (Defaults to False)
- **allow_overshoot** (*bool, default=False*) – if False, we will raise an error if the window doesn't slide perfectly over the input shape.

Variables

- **strides** (*basis_shape - shape of the grid corresponding to the number of*) – the sliding window will take.
- **dimension** (*basis_slices - slices that will be taken in every*) –

Yields

Tuple[slice, ...] –

slices used for numpy indexing, the number of slices
in the tuple

Note: For each dimension, we generate a basis (which defines a grid), and we slide over that basis.

Todo:

- **[ ] have an option that is allowed to go outside of the window bounds**
  on the right and bottom when the slider overshoots.

Example

```
>>> from kwarray.util_slider import *  # NOQA
>>> shape = (10, 10)
>>> window = (5, 5)
>>> self = SlidingWindow(shape, window)
>>> for i, index in enumerate(self):
>>>     print('i={}, index={}'.format(i, index))
i=0, index=(slice(0, 5, None), slice(0, 5, None))
i=1, index=(slice(0, 5, None), slice(5, 10, None))
i=2, index=(slice(5, 10, None), slice(0, 5, None))
i=3, index=(slice(5, 10, None), slice(5, 10, None))
```

Example

```
>>> from kwarray.util_slider import *  # NOQA
>>> shape = (16, 16)
>>> window = (4, 4)
>>> self = SlidingWindow(shape, window, overlap=(.5, .25))
>>> print('self.stride = {!r}'.format(self.stride))
self.stride = [2, 3]
>>> list(ub.chunks(self.grid, 5))
[[(0, 0), (0, 1), (0, 2), (0, 3), (0, 4)],
 [(1, 0), (1, 1), (1, 2), (1, 3), (1, 4)],
 [(2, 0), (2, 1), (2, 2), (2, 3), (2, 4)],
 [(3, 0), (3, 1), (3, 2), (3, 3), (3, 4)],
 [(4, 0), (4, 1), (4, 2), (4, 3), (4, 4)],
 [(5, 0), (5, 1), (5, 2), (5, 3), (5, 4)],
 [(6, 0), (6, 1), (6, 2), (6, 3), (6, 4)]]
```

Example

```
>>> # Test shapes that dont fit
>>> # When the window is bigger than the shape, the left-aligned slices
>>> # are returend.
>>> self = SlidingWindow((3, 3), (12, 12), allow_overshoot=True, keepbound=True)
>>> print(list(self))
[(slice(0, 12, None), slice(0, 12, None))]
>>> print(list(SlidingWindow((3, 3), None, allow_overshoot=True, keepbound=True)))
[(slice(0, 3, None), slice(0, 3, None))]
>>> print(list(SlidingWindow((3, 3), (None, 2), allow_overshoot=True,␣
↪keepbound=True)))
[(slice(0, 3, None), slice(0, 2, None)), (slice(0, 3, None), slice(1, 3, None))]
```

_compute_stride(*overlap*, *stride*, *shape*, *window*)

Ensures that stride hasoverlap the correct shape. If stride is not provided, compute stride from desired overlap.

_iter_basis_frac()

property grid

Generate indices into the "basis" slice for each dimension. This enumerates the nd indices of the grid.

Yields
Tuple[int, ...]

property slices

Generate slices for each window (equivalent to iter(self))

Example

```
>>> shape = (220, 220)
>>> window = (10, 10)
>>> self = SlidingWindow(shape, window, stride=5)
>>> list(self)[41:45]
[(slice(0, 10, None), slice(205, 215, None)),
 (slice(0, 10, None), slice(210, 220, None)),
 (slice(5, 15, None), slice(0, 10, None)),
 (slice(5, 15, None), slice(5, 15, None))]
>>> print('self.overlap = {!r}'.format(self.overlap))
self.overlap = [0.5, 0.5]
```

property centers

Generate centers of each window

Yields
Tuple[float, ...] – the center coordinate of the slice

Example

```
>>> shape = (4, 4)
>>> window = (3, 3)
>>> self = SlidingWindow(shape, window, stride=1)
>>> list(zip(self.centers, self.slices))
[((1.0, 1.0), (slice(0, 3, None), slice(0, 3, None))),
 ((1.0, 2.0), (slice(0, 3, None), slice(1, 4, None))),
 ((2.0, 1.0), (slice(1, 4, None), slice(0, 3, None))),
 ((2.0, 2.0), (slice(1, 4, None), slice(1, 4, None)))]
>>> shape = (3, 3)
>>> window = (2, 2)
>>> self = SlidingWindow(shape, window, stride=1)
>>> list(zip(self.centers, self.slices))
[((0.5, 0.5), (slice(0, 2, None), slice(0, 2, None))),
 ((0.5, 1.5), (slice(0, 2, None), slice(1, 3, None))),
 ((1.5, 0.5), (slice(1, 3, None), slice(0, 2, None))),
 ((1.5, 1.5), (slice(1, 3, None), slice(1, 3, None)))]
```

class kwarray.util_slider.**Stitcher**(*shape*, *device='numpy'*, *dtype='float32'*, *nan_policy='propogate'*)

Bases: NiceRepr

Stitches multiple possibly overlapping slices into a larger array.

This is used to invert the SlidingWindow. For semenatic segmentation the patches are probability chips. Overlapping chips are averaged together.

SeeAlso:

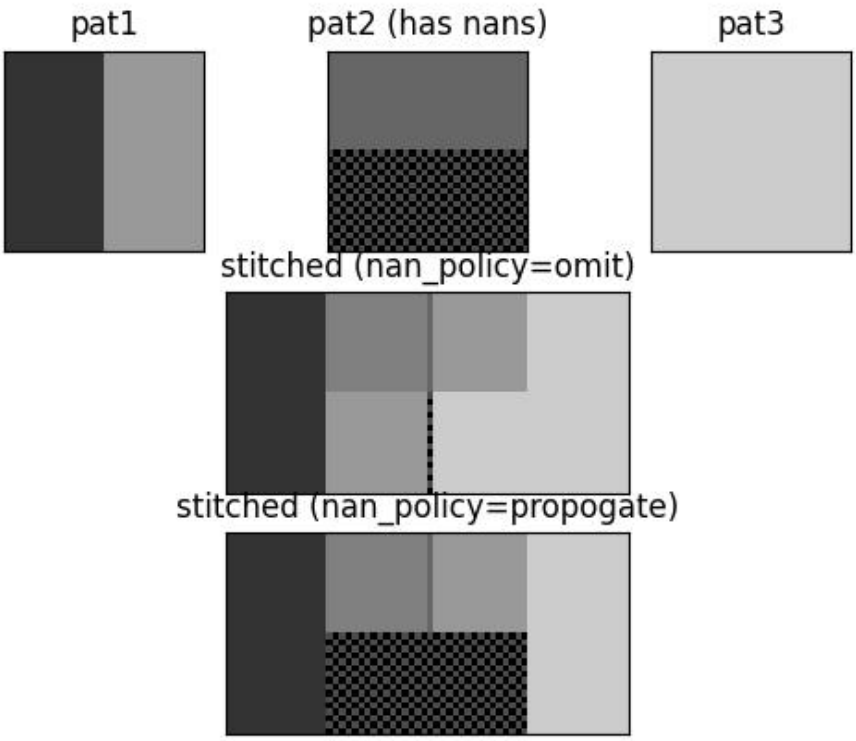
kwarray.RunningStats **- similarly performs running means, but** can also track other statistics.

Example

```
>>> from kwarray.util_slider import *  # NOQA
>>> import sys
>>> # Build a high resolution image and slice it into chips
>>> highres = np.random.rand(5, 200, 200).astype(np.float32)
>>> target_shape = (1, 50, 50)
>>> slider = SlidingWindow(highres.shape, target_shape, overlap=(0, .5, .5))
>>> # Show how Sticher can be used to reconstruct the original image
>>> stitcher = Stitcher(slider.input_shape)
>>> for sl in list(slider):
...     chip = highres[sl]
...     stitcher.add(sl, chip)
>>> assert stitcher.weights.max() == 4, 'some parts should be processed 4 times'
>>> recon = stitcher.finalize()
```

Example

```
>>> from kwarray.util_slider import *  # NOQA
>>> import sys
>>> # Demo stitching 3 patterns where one has nans
>>> pat1 = np.full((32, 32), fill_value=0.2)
>>> pat2 = np.full((32, 32), fill_value=0.4)
>>> pat3 = np.full((32, 32), fill_value=0.8)
>>> pat1[:, 16:] = 0.6
>>> pat2[16:, :] = np.nan
>>> # Test with nan_policy=omit
>>> stitcher = Stitcher(shape=(32, 64), nan_policy='omit')
>>> stitcher[0:32, 0:32](pat1)
>>> stitcher[0:32, 16:48](pat2)
>>> stitcher[0:32, 33:64](pat3[:, 1:])
>>> final1 = stitcher.finalize()
>>> # Test without nan_policy=propogate
>>> stitcher = Stitcher(shape=(32, 64), nan_policy='propogate')
>>> stitcher[0:32, 0:32](pat1)
>>> stitcher[0:32, 16:48](pat2)
>>> stitcher[0:32, 33:64](pat3[:, 1:])
>>> final2 = stitcher.finalize()
>>> # Checks
>>> assert np.isnan(final1).sum() == 16, 'only should contain nan where no data was␣
↪stiched'
>>> assert np.isnan(final2).sum() == 512, 'should contain nan wherever a nan was␣
↪stitched'
>>> # xdoctest: +REQUIRES(--show)
>>> # xdoctest: +REQUIRES(module:kwplot)
>>> import kwplot
>>> import kwimage
>>> kwplot.autompl()
>>> kwplot.imshow(pat1, title='pat1', pnum=(3, 3, 1))
>>> kwplot.imshow(kwimage.nodata_checkerboard(pat2, square_shape=1), title='pat2␣
↪(has nans)', pnum=(3, 3, 2))
>>> kwplot.imshow(pat3, title='pat3', pnum=(3, 3, 3))
>>> kwplot.imshow(kwimage.nodata_checkerboard(final1, square_shape=1), title=
↪'stitched (nan_policy=omit)', pnum=(3, 1, 2))
>>> kwplot.imshow(kwimage.nodata_checkerboard(final2, square_shape=1), title=
↪'stitched (nan_policy=propogate)', pnum=(3, 1, 3))
```



Example

```
>>> # Example of weighted stitching
>>> # xdoctest: +REQUIRES(module:kwimage)
>>> from kwarray.util_slider import *  # NOQA
>>> import kwimage
>>> import kwarray
>>> import sys
>>> data = kwimage.Mask.demo().data.astype(np.float32)
>>> data_dims = data.shape
>>> window_dims = (8, 8)
>>> # We are going to slide a window over the data, do some processing
>>> # and then stitch it all back together. There are a few ways we
>>> # can do it. Lets demo the params.
>>> basis = {
>>>     # Vary the overlap of the slider
>>>     'overlap': (0, 0.5, .9),
>>>     # Vary if we are using weighted stitching or not
>>>     'weighted': ['none', 'gauss'],
>>>     'keepbound': [True, False]
>>> }
>>> results = []
>>> gauss_weights = kwimage.gaussian_patch(window_dims)
```

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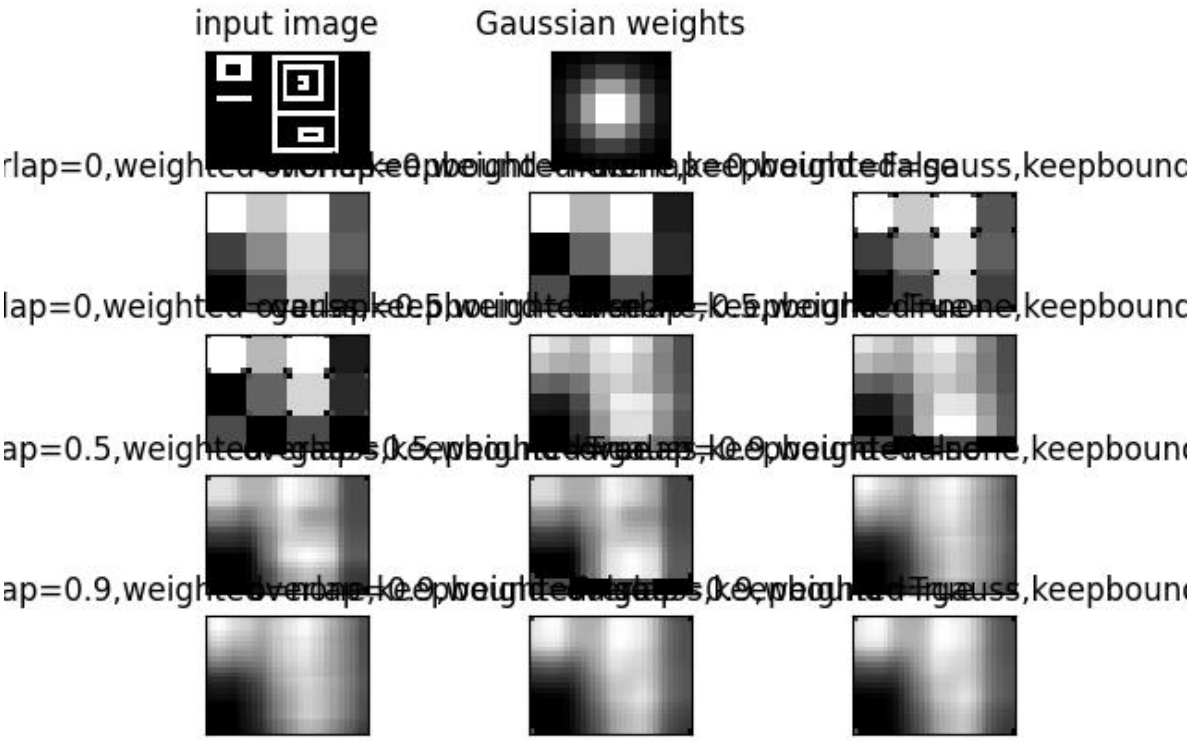
```
>>> gauss_weights = kwimage.normalize(gauss_weights)
>>> for params in ub.named_product(basis):
>>>     if params['weighted'] == 'none':
>>>         weights = None
>>>     elif params['weighted'] == 'gauss':
>>>         weights = gauss_weights
>>>     # Build the slider and stitcher
>>>     slider = kwarray.SlidingWindow(
>>>         data_dims, window_dims, overlap=params['overlap'],
>>>         allow_overshoot=True,
>>>         keepbound=params['keepbound'])
>>>     stitcher = kwarray.Stitcher(data_dims)
>>>     # Loop over the regions
>>>     for sl in list(slider):
>>>          chip = data[sl]
>>>          # This is our dummy function for thie example.
>>>          predicted = np.ones_like(chip) * chip.sum() / chip.size
>>>          stitcher.add(sl, predicted, weight=weights)
>>>     final = stitcher.finalize()
>>>     results.append({
>>>         'final': final,
>>>         'params': params,
>>>     })
>>> # xdoctest: +REQUIRES(--show)
>>> # xdoctest: +REQUIRES(module:kwplot)
>>> import kwplot
>>> kwplot.autompl()
>>> pnum_ = kwplot.PlotNums(nCols=3, nSubplots=len(results) + 2)
>>> kwplot.imshow(data, pnum=pnum_(), title='input image')
>>> kwplot.imshow(gauss_weights, pnum=pnum_(), title='Gaussian weights')
>>> pnum_()
>>> for result in results:
>>>     param_key = ub.urepr(result['params'], compact=1)
>>>     final = result['final']
>>>     canvas = kwarray.normalize(final)
>>>     canvas = kwimage.fill_nans_with_checkers(canvas)
>>>     kwplot.imshow(canvas, pnum=pnum_(), title=param_key)
```



Parameters

- **shape** (*tuple*) – dimensions of the large image that will be created from the smaller pixels or patches.
- **device** (*str | int | torch.device*) – default is 'numpy', but if given as a torch device, then underlying operations will be done with torch tensors instead.
- **dtype** (*str*) – the datatype to use in the underlying accumulator.
- **nan_policy** (*str*) – if omit, check for nans and convert any to zero weight items in stitching.

`add`(*indices*, *patch*, *weight=None*)

Incorporate a new (possibly overlapping) patch or pixel using a weighted sum.

Parameters

- **indices** (*slice | tuple | None*) – typically a Tuple[slice] of pixels or a single pixel, but this can be any numpy fancy index.
- **patch** (*ndarray*) – data to patch into the bigger image.
- **weight** (*float | ndarray*) – weight of this patch (default to 1.0)

`average`()

Averages out contributions from overlapping adds using weighted average

Returns

out - the stitched image

Return type
ndarray

finalize(*indices=None*)

Averages out contributions from overlapping adds

Parameters
indices (*None | slice | tuple*) – if None, finalize the entire block, otherwise only finalize a subregion.

Returns
final - the stitched image

Return type
ndarray

kwarray.util_slider.**_slices1d**(*margin*, *stop*, *step=None*, *start=0*, *keepbound=False*, *check=True*)

Helper to generates slices in a single dimension.

Parameters

- **margin** (*int*) – the length of the slice (window)
- **stop** (*int*) – the length of the image dimension
- **step** (*int, default=None*) – the length of each step / distance between slices
- **start** (*int, default=0*) – starting point (in most cases set this to 0)
- **keepbound** (*bool*) – if True, a non-uniform step will be taken to ensure that the right / bottom of the image is returned as a slice if needed. Such a slice will not obey the overlap constraints. (Defaults to False)
- **check** (*bool*) – if True an error will be raised if the window does not cover the entire extent from start to stop, even if keepbound is True.

Yields
slice – slice in one dimension of size (margin)

Example

```
>>> stop, margin, step = 2000, 360, 360
>>> keepbound = True
>>> strides = list(_slices1d(margin, stop, step, keepbound, check=False))
>>> assert all([(s.stop - s.start) == margin for s in strides])
```

Example

```
>>> stop, margin, step = 200, 46, 7
>>> keepbound = True
>>> strides = list(_slices1d(margin, stop, step, keepbound=False, check=True))
>>> starts = np.array([s.start for s in strides])
>>> stops = np.array([s.stop for s in strides])
>>> widths = stops - starts
>>> assert np.all(np.diff(starts) == step)
>>> assert np.all(widths == margin)
```

Example

```
>>> import pytest
>>> stop, margin, step = 200, 36, 7
>>> with pytest.raises(ValueError):
...     list(_slices1d(margin, stop, step))
```

kwarray.util_torch module

Torch specific extensions

kwarray.util_torch.**_is_in_onnx_export**()

kwarray.util_torch.**one_hot_embedding**(*labels*, *num_classes*, *dim=1*)

Embedding labels to one-hot form.

Parameters

- **labels** – (LongTensor) class labels, sized [N,].
- **num_classes** – (int) number of classes.
- **dim** (*int*) – dimension which will be created, if negative

Returns

encoded labels, sized [N,#classes].

Return type

Tensor

References

https://discuss.pytorch.org/t/convert-int-into-one-hot-format/507/4

Example

```
>>> # each element in target has to have 0 <= value < C
>>> # xdoctest: +REQUIRES(module:torch)
>>> import torch
>>> labels = torch.LongTensor([0, 0, 1, 4, 2, 3])
>>> num_classes = max(labels) + 1
>>> t = one_hot_embedding(labels, num_classes)
>>> assert all(row[y] == 1 for row, y in zip(t.numpy(), labels.numpy()))
>>> import ubelt as ub
>>> print(ub.urepr(t.numpy().tolist()))
[
    [1.0, 0.0, 0.0, 0.0, 0.0],
    [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, 1.0],
    [0.0, 0.0, 1.0, 0.0, 0.0],
    [0.0, 0.0, 0.0, 1.0, 0.0],
]
```

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```
>>> t2 = one_hot_embedding(labels.numpy(), num_classes)
>>> assert np.all(t2 == t.numpy())
>>> from kwarray.util_torch import _torch_available_devices
>>> devices = _torch_available_devices()
>>> if devices:
>>>     device = devices[0]
>>>     try:
>>>         t3 = one_hot_embedding(labels.to(device), num_classes)
>>>     except RuntimeError:
>>>         pass
>>>     assert np.all(t3.cpu().numpy() == t.numpy())
```

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> import torch
>>> nC = num_classes = 3
>>> labels = (torch.rand(10, 11, 12) * nC).long()
>>> assert one_hot_embedding(labels, nC, dim=0).shape == (3, 10, 11, 12)
>>> assert one_hot_embedding(labels, nC, dim=1).shape == (10, 3, 11, 12)
>>> assert one_hot_embedding(labels, nC, dim=2).shape == (10, 11, 3, 12)
>>> assert one_hot_embedding(labels, nC, dim=3).shape == (10, 11, 12, 3)
>>> labels = (torch.rand(10, 11) * nC).long()
>>> assert one_hot_embedding(labels, nC, dim=0).shape == (3, 10, 11)
>>> assert one_hot_embedding(labels, nC, dim=1).shape == (10, 3, 11)
>>> labels = (torch.rand(10) * nC).long()
>>> assert one_hot_embedding(labels, nC, dim=0).shape == (3, 10)
>>> assert one_hot_embedding(labels, nC, dim=1).shape == (10, 3)
```

kwarray.util_torch.**one_hot_lookup**(*data*, *indices*)

Return value of a particular column for each row in data.

Each item in labels corresonds to a row in `data`. Returns the index specified at each row.

Parameters

- **data** (*ArrayLike*) – N x C float array of values
- **indices** (*ArrayLike*) – N integer array between 0 and C. This is an column index for each row in `data`.

Returns

the selected probability for each row

Return type

ArrayLike

Note: This is functionally equivalent to `[row[c] for row, c in zip(data, indices)]` except that it is works with pure matrix operations.

Todo:

- **[ ] Allow the user to specify which dimension indices should be** zipped over. By default it should be dim=0
- **[ ] Allow the user to specify which dimension indices should select** from. By default it should be dim=1.

Example

```
>>> from kwarray.util_torch import *  # NOQA
>>> data = np.array([
>>>     [0, 1, 2],
>>>     [3, 4, 5],
>>>     [6, 7, 8],
>>>     [9, 10, 11],
>>> ])
>>> indices = np.array([0, 1, 2, 1])
>>> res = one_hot_lookup(data, indices)
>>> print('res = {!r}'.format(res))
res = array([ 0,  4,  8, 10])
>>> alt = np.array([row[c] for row, c in zip(data, indices)])
>>> assert np.all(alt == res)
```

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> import torch
>>> data = torch.from_numpy(np.array([
>>>     [0, 1, 2],
>>>     [3, 4, 5],
>>>     [6, 7, 8],
>>>     [9, 10, 11],
>>> ]))
>>> indices = torch.from_numpy(np.array([0, 1, 2, 1])).long()
>>> res = one_hot_lookup(data, indices)
>>> print('res = {!r}'.format(res))
res = tensor([ 0,  4,  8, 10]...)
>>> alt = torch.LongTensor([row[c] for row, c in zip(data, indices)])
>>> assert torch.all(alt == res)
```

kwarray.util_torch.**_torch_available_devices**()

An attempt to determine what devices this version of torch can use

Try and check that cuda is availble AND we have a good kernel image

1.1.2 Module contents

The kwarray module implements a small set of pure-python extensions to numpy and torch along with a few select algorithms. Each module contains module level docstring that gives a rough idea of the utilities in each module, and each function or class itself contains a docstring with more details and examples.

KWarray is part of Kitware's computer vision Python suite:

https://gitlab.kitware.com/computer-vision

class kwarray.**ArrayAPI**

Bases: object

Compatability API between torch and numpy.

The API defines classmethods that work on both Tensors and ndarrays. As such the user can simply use kwarray.ArrayAPI.<funcname> and it will return the expected result for both Tensor and ndarray types.

However, this is inefficient because it requires us to check the type of the input for every API call. Therefore it is recommended that you use the *ArrayAPI.coerce()* function, which takes as input the data you want to operate on. It performs the type check once, and then returns another object that defines with an identical API, but specific to the given data type. This means that we can ignore type checks on future calls of the specific implementation. See examples for more details.

Example

```
>>> # Use the easy-to-use, but inefficient array api
>>> # xdoctest: +REQUIRES(module:torch)
>>> import kwarray
>>> import torch
>>> take = kwarray.ArrayAPI.take
>>> np_data = np.arange(0, 143).reshape(11, 13)
>>> pt_data = torch.LongTensor(np_data)
>>> indices = [1, 3, 5, 7, 11, 13, 17, 21]
>>> idxs0 = [1, 3, 5, 7]
>>> idxs1 = [1, 3, 5, 7, 11]
>>> assert np.allclose(take(np_data, indices), take(pt_data, indices))
>>> assert np.allclose(take(np_data, idxs0, 0), take(pt_data, idxs0, 0))
>>> assert np.allclose(take(np_data, idxs1, 1), take(pt_data, idxs1, 1))
```

Example

```
>>> # Use the easy-to-use, but inefficient array api
>>> # xdoctest: +REQUIRES(module:torch)
>>> import kwarray
>>> import torch
>>> compress = kwarray.ArrayAPI.compress
>>> np_data = np.arange(0, 143).reshape(11, 13)
>>> pt_data = torch.LongTensor(np_data)
>>> flags = (np_data % 2 == 0).ravel()
>>> f0 = (np_data % 2 == 0)[:, 0]
>>> f1 = (np_data % 2 == 0)[0, :]
>>> assert np.allclose(compress(np_data, flags), compress(pt_data, flags))
```

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```
>>> assert np.allclose(compress(np_data, f0, 0), compress(pt_data, f0, 0))
>>> assert np.allclose(compress(np_data, f1, 1), compress(pt_data, f1, 1))
```

Example

```
>>> # Use ArrayAPI to coerce an identical API that doesnt do type checks
>>> # xdoctest: +REQUIRES(module:torch)
>>> import kwarray
>>> import torch
>>> np_data = np.arange(0, 15).reshape(3, 5)
>>> pt_data = torch.LongTensor(np_data)
>>> # The new ``impl`` object has the same API as ArrayAPI, but works
>>> # specifically on torch Tensors.
>>> impl = kwarray.ArrayAPI.coerce(pt_data)
>>> flat_data = impl.view(pt_data, -1)
>>> print('flat_data = {!r}'.format(flat_data))
flat_data = tensor([ 0,  1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11, 12, 13, 14])
>>> # The new ``impl`` object has the same API as ArrayAPI, but works
>>> # specifically on numpy ndarrays.
>>> impl = kwarray.ArrayAPI.coerce(np_data)
>>> flat_data = impl.view(np_data, -1)
>>> print('flat_data = {!r}'.format(flat_data))
flat_data = array([ 0,  1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11, 12, 13, 14])
```

_torch

alias of *TorchImpls*

_numpy

alias of *NumpyImpls*

static impl(*data*)

Returns a namespace suitable for operating on the input data type

Parameters

data (*ndarray | Tensor*) – data to be operated on

static coerce(*data*)

Coerces some form of inputs into an array api (either numpy or torch).

static result_type(**arrays_and_dtypes*)

Return type from promotion rules

Example

```
>>> import kwarray
>>> kwarray.ArrayAPI.result_type(float, np.uint8, np.float32, np.float16)
>>> # xdoctest: +REQUIRES(module:torch)
>>> import torch
>>> kwarray.ArrayAPI.result_type(torch.int32, torch.int64)
```

static cat(*datas*, **args*, ***kwargs*)

static **hstack**(*datas*, **args*, ***kwargs*)

static **vstack**(*datas*, **args*, ***kwargs*)

static **take**(*data*, **args*, ***kwargs*)

static **compress**(*data*, **args*, ***kwargs*)

static **repeat**(*data*, **args*, ***kwargs*)

static **tile**(*data*, **args*, ***kwargs*)

static **view**(*data*, **args*, ***kwargs*)

static **numel**(*data*, **args*, ***kwargs*)

static **atleast_nd**(*data*, **args*, ***kwargs*)

static **full_like**(*data*, **args*, ***kwargs*)

static **ones_like**(*data*, **args*, ***kwargs*)

static **zeros_like**(*data*, **args*, ***kwargs*)

static **empty_like**(*data*, **args*, ***kwargs*)

static **sum**(*data*, **args*, ***kwargs*)

static **argsort**(*data*, **args*, ***kwargs*)

static **argmax**(*data*, **args*, ***kwargs*)

static **argmin**(*data*, **args*, ***kwargs*)

static **max**(*data*, **args*, ***kwargs*)

static **min**(*data*, **args*, ***kwargs*)

static **max_argmax**(*data*, **args*, ***kwargs*)

static **min_argmin**(*data*, **args*, ***kwargs*)

static **maximum**(*data*, **args*, ***kwargs*)

static **minimum**(*data*, **args*, ***kwargs*)

static **matmul**(*data*, **args*, ***kwargs*)

static **astype**(*data*, **args*, ***kwargs*)

static **nonzero**(*data*, **args*, ***kwargs*)

static **nan_to_num**(*data*, **args*, ***kwargs*)

static **tensor**(*data*, **args*, ***kwargs*)

static **numpy**(*data*, **args*, ***kwargs*)

static **tolist**(*data*, **args*, ***kwargs*)

static **asarray**(*data*, **args*, ***kwargs*)

static **T**(*data*, **args*, ***kwargs*)

static **transpose**(*data*, **args*, ***kwargs*)

static **contiguous**(*data*, **args*, ***kwargs*)

static **pad**(*data*, **args*, ***kwargs*)

static **dtype_kind**(*data*, **args*, ***kwargs*)

static **any**(*data*, **args*, ***kwargs*)

static **all**(*data*, **args*, ***kwargs*)

static **array_equal**(*data*, **args*, ***kwargs*)

static **log2**(*data*, **args*, ***kwargs*)

static **log**(*data*, **args*, ***kwargs*)

static **copy**(*data*, **args*, ***kwargs*)

static **iceil**(*data*, **args*, ***kwargs*)

static **ifloor**(*data*, **args*, ***kwargs*)

static **floor**(*data*, **args*, ***kwargs*)

static **ceil**(*data*, **args*, ***kwargs*)

static **round**(*data*, **args*, ***kwargs*)

static **iround**(*data*, **args*, ***kwargs*)

static **clip**(*data*, **args*, ***kwargs*)

static **softmax**(*data*, **args*, ***kwargs*)

class kwarray.**DataFrameArray**(*data=None*, *columns=None*)

Bases: *DataFrameLight*

DataFrameLight assumes the backend is a Dict[list] DataFrameArray assumes the backend is a Dict[ndarray]

Take and compress are much faster, but extend and union are slower

extend(*other*)

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

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

class kwarray.**DataFrameLight**(*data=None*, *columns=None*)

Bases: NiceRepr

Implements a subset of the pandas.DataFrame API

The API is restricted to facilitate speed tradeoffs

Note: Assumes underlying data is Dict[list|ndarray]. If the data is known to be a Dict[ndarray] use DataFrameArray instead, which has faster implementations for some operations.

Note: pandas.DataFrame is slow. DataFrameLight is faster. It is a tad more restrictive though.

Example

```
>>> self = DataFrameLight({})
>>> print('self = {!r}'.format(self))
>>> self = DataFrameLight({'a': [0, 1, 2], 'b': [2, 3, 4]})
>>> print('self = {!r}'.format(self))
>>> item = self.iloc[0]
>>> print('item = {!r}'.format(item))
```

Benchmark

```
>>> # BENCHMARK
>>> # xdoc: +REQUIRES(--bench)
>>> from kwarray.dataframe_light import *  # NOQA
>>> import ubelt as ub
>>> NUM = 1000
>>> print('NUM = {!r}'.format(NUM))
>>> # to_dict conversions
>>> print('===============')
>>> print('====== to_dict conversions =====')
>>> _keys = ['list', 'dict', 'series', 'split', 'records', 'index']
>>> results = []
>>> df = DataFrameLight._demodata(num=NUM).pandas()
>>> ti = ub.Timerit(verbose=False, unit='ms')
>>> for key in _keys:
>>>     result = ti.reset(key).call(lambda: df.to_dict(orient=key))
>>>     results.append((result.mean(), result.report()))
>>> key = 'series+numpy'
>>> result = ti.reset(key).call(lambda: {k: v.values for k, v in df.to_dict(orient=
↪'series').items()})
>>> results.append((result.mean(), result.report()))
>>> print('\n'.join([t[1] for t in sorted(results)]))
>>> print('===============')
>>> print('====== DFLight Conversions =======')
>>> ti = ub.Timerit(verbose=True, unit='ms')
>>> key = 'self.pandas'
>>> self = DataFrameLight(df)
>>> ti.reset(key).call(lambda: self.pandas())
>>> key = 'light-from-pandas'
>>> ti.reset(key).call(lambda: DataFrameLight(df))
>>> key = 'light-from-dict'
>>> ti.reset(key).call(lambda: DataFrameLight(self._data))
>>> print('===============')
>>> print('====== BENCHMARK: .LOC[] =======')
>>> ti = ub.Timerit(num=20, bestof=4, verbose=True, unit='ms')
>>> df_light = DataFrameLight._demodata(num=NUM)
>>> # xdoctest: +REQUIRES(module:pandas)
```

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```
>>> df_heavy = df_light.pandas()
>>> series_data = df_heavy.to_dict(orient='series')
>>> list_data = df_heavy.to_dict(orient='list')
>>> np_data = {k: v.values for k, v in df_heavy.to_dict(orient='series').items()}
>>> for timer in ti.reset('DF-heavy.iloc'):
>>>     with timer:
>>>         for i in range(NUM):
>>>             df_heavy.iloc[i]
>>> for timer in ti.reset('DF-heavy.loc'):
>>>     with timer:
>>>         for i in range(NUM):
>>>             df_heavy.iloc[i]
>>> for timer in ti.reset('dict[SERIES].loc'):
>>>     with timer:
>>>         for i in range(NUM):
>>>             {key: series_data[key].loc[i] for key in series_data.keys()}
>>> for timer in ti.reset('dict[SERIES].iloc'):
>>>     with timer:
>>>         for i in range(NUM):
>>>             {key: series_data[key].iloc[i] for key in series_data.keys()}
>>> for timer in ti.reset('dict[SERIES][]'):
>>>     with timer:
>>>         for i in range(NUM):
>>>             {key: series_data[key][i] for key in series_data.keys()}
>>> for timer in ti.reset('dict[NDARRAY][]'):
>>>     with timer:
>>>         for i in range(NUM):
>>>             {key: np_data[key][i] for key in np_data.keys()}
>>> for timer in ti.reset('dict[list][]'):
>>>     with timer:
>>>         for i in range(NUM):
>>>             {key: list_data[key][i] for key in np_data.keys()}
>>> for timer in ti.reset('DF-Light.iloc/loc'):
>>>     with timer:
>>>         for i in range(NUM):
>>>             df_light.iloc[i]
>>> for timer in ti.reset('DF-Light._getrow'):
>>>     with timer:
>>>         for i in range(NUM):
>>>             df_light._getrow(i)
NUM = 1000
==============
====== to_dict conversions =====
Timed best=0.022 ms, mean=0.022 ± 0.0 ms for series
Timed best=0.059 ms, mean=0.059 ± 0.0 ms for series+numpy
Timed best=0.315 ms, mean=0.315 ± 0.0 ms for list
Timed best=0.895 ms, mean=0.895 ± 0.0 ms for dict
Timed best=2.705 ms, mean=2.705 ± 0.0 ms for split
Timed best=5.474 ms, mean=5.474 ± 0.0 ms for records
Timed best=7.320 ms, mean=7.320 ± 0.0 ms for index
==============
====== DFLight Conversions =======
```

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```
Timed best=1.798 ms, mean=1.798 ± 0.0 ms for self.pandas
Timed best=0.064 ms, mean=0.064 ± 0.0 ms for light-from-pandas
Timed best=0.010 ms, mean=0.010 ± 0.0 ms for light-from-dict
==============
====== BENCHMARK: .LOC[] =======
Timed best=101.365 ms, mean=101.564 ± 0.2 ms for DF-heavy.iloc
Timed best=102.038 ms, mean=102.273 ± 0.2 ms for DF-heavy.loc
Timed best=29.357 ms, mean=29.449 ± 0.1 ms for dict[SERIES].loc
Timed best=21.701 ms, mean=22.014 ± 0.3 ms for dict[SERIES].iloc
Timed best=11.469 ms, mean=11.566 ± 0.1 ms for dict[SERIES][]
Timed best=0.807 ms, mean=0.826 ± 0.0 ms for dict[NDARRAY][]
Timed best=0.478 ms, mean=0.492 ± 0.0 ms for dict[list][]
Timed best=0.969 ms, mean=0.994 ± 0.0 ms for DF-Light.iloc/loc
Timed best=0.760 ms, mean=0.776 ± 0.0 ms for DF-Light._getrow
```

property iloc

property values

property loc

to_string(**args*, ***kwargs*)

Return type
str

to_dict(*orient='dict'*, *into=<class 'dict'>*)

Convert the data frame into a dictionary.

Parameters

- **orient** (*str*) – Currently naitively suports orient in {'dict', 'list'}, otherwise we fallback to pandas conversion and call its to_dict method.
- **into** (*type*) – type of dictionary to transform into

Returns
dict

Example

```
>>> from kwarray.dataframe_light import *  # NOQA
>>> self = DataFrameLight._demodata(num=7)
>>> print(self.to_dict(orient='dict'))
>>> print(self.to_dict(orient='list'))
```

pandas()

Convert back to pandas if you need the full API

Return type
pd.DataFrame

Example

```
>>> # xdoctest: +REQUIRES(module:pandas)
>>> df_light = DataFrameLight._demodata(num=7)
>>> df_heavy = df_light.pandas()
>>> got = DataFrameLight(df_heavy)
>>> assert got._data == df_light._data
```

_pandas()

Deprecated, use self.pandas instead

classmethod _demodata(*num=7*)

Example

```
>>> self = DataFrameLight._demodata(num=7)
>>> print('self = {!r}'.format(self))
>>> other = DataFrameLight._demodata(num=11)
>>> print('other = {!r}'.format(other))
>>> both = self.union(other)
>>> print('both = {!r}'.format(both))
>>> assert both is not self
>>> assert other is not self
```

property columns

sort_values(*key*, *inplace=False*, *ascending=True*)

keys()

_getrow(*index*)

_getcol(*key*)

_getcols(*keys*)

get(*key*, *default=None*)

Get item for given key. Returns default value if not found.

clear()

Removes all rows inplace

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

NOTE: NOT A PART OF THE PANDAS API

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

Return the elements in the given *positional* indices along an axis.

Parameters

inplace (*bool*) – NOT PART OF PANDAS API

Note: assumes axis=0

Example

```
>>> df_light = DataFrameLight._demodata(num=7)
>>> indices = [0, 2, 3]
>>> sub1 = df_light.take(indices)
>>> # xdoctest: +REQUIRES(module:pandas)
>>> df_heavy = df_light.pandas()
>>> sub2 = df_heavy.take(indices)
>>> assert np.all(sub1 == sub2)
```

copy()

extend(*other*)

Extend `self` inplace using another dataframe array

Parameters

other (*DataFrameLight | dict[str, Sequence]*) – values to concat to end of this object

Note: Not part of the pandas API

Example

```
>>> self = DataFrameLight(columns=['foo', 'bar'])
>>> other = {'foo': [0], 'bar': [1]}
>>> self.extend(other)
>>> assert len(self) == 1
```

union(**others*)

Note: Note part of the pandas API

classmethod concat(*others*)

classmethod from_pandas(*df*)

classmethod from_dict(*records*)

reset_index(*drop=False*)

noop for compatability, the light version doesnt store an index

groupby(*by=None*, **args*, ***kwargs*)

Group rows by the value of a column. Unlike pandas this simply returns a zip object. To ensure compatiability call list on the result of groupby.

Parameters

- **by** (*str*) – column name to group by
- ***args** – if specified, the dataframe is coerced to pandas
- ***kwargs** – if specified, the dataframe is coerced to pandas

Example

```
>>> df_light = DataFrameLight._demodata(num=7)
>>> res1 = list(df_light.groupby('bar'))
>>> # xdoctest: +REQUIRES(module:pandas)
>>> df_heavy = df_light.pandas()
>>> res2 = list(df_heavy.groupby('bar'))
>>> assert len(res1) == len(res2)
>>> assert all([np.all(a[1] == b[1]) for a, b in zip(res1, res2)])
```

rename(*mapper=None*, *columns=None*, *axis=None*, *inplace=False*)

Rename the columns (index renaming is not supported)

Example

```
>>> df_light = DataFrameLight._demodata(num=7)
>>> mapper = {'foo': 'fi'}
>>> res1 = df_light.rename(columns=mapper)
>>> res3 = df_light.rename(mapper, axis=1)
>>> # xdoctest: +REQUIRES(module:pandas)
>>> df_heavy = df_light.pandas()
>>> res2 = df_heavy.rename(columns=mapper)
>>> res4 = df_heavy.rename(mapper, axis=1)
>>> assert np.all(res1 == res2)
>>> assert np.all(res3 == res2)
>>> assert np.all(res3 == res4)
```

iterrows()

Iterate over rows as (index, Dict) pairs.

Yields

Tuple[int, Dict] – the index and a dictionary representing a row

Example

```
>>> from kwarray.dataframe_light import *  # NOQA
>>> self = DataFrameLight._demodata(num=3)
>>> print(ub.urepr(list(self.iterrows()), sort=1))
[
    (0, {'bar': 0, 'baz': 2.73, 'foo': 0}),
    (1, {'bar': 1, 'baz': 2.73, 'foo': 0}),
    (2, {'bar': 2, 'baz': 2.73, 'foo': 0}),
]
```

Benchmark

```
>>> # xdoc: +REQUIRES(--bench)
>>> from kwarray.dataframe_light import *  # NOQA
>>> import ubelt as ub
>>> df_light = DataFrameLight._demodata(num=1000)
>>> df_heavy = df_light.pandas()
>>> ti = ub.Timerit(21, bestof=3, verbose=2, unit='ms')
>>> ti.reset('light').call(lambda: list(df_light.iterrows()))
>>> ti.reset('heavy').call(lambda: list(df_heavy.iterrows()))
>>> # xdoctest: +IGNORE_WANT
Timed light for: 21 loops, best of 3
    time per loop: best=0.834 ms, mean=0.850 ± 0.0 ms
Timed heavy for: 21 loops, best of 3
    time per loop: best=45.007 ms, mean=45.633 ± 0.5 ms
```

class kwarray.**FlatIndexer**(*lens*)

Bases: NiceRepr

Creates a flat "view" of a jagged nested indexable object. Only supports one offset level.

Parameters
lens (*List[int]*) – a list of the lengths of the nested objects.

Doctest

```
>>> self = FlatIndexer([1, 2, 3])
>>> len(self)
>>> self.unravel(4)
>>> self.ravel(2, 1)
```

classmethod fromlist(*items*)

Convenience method to create a *FlatIndexer* from the list of items itself instead of the array of lengths.

Parameters
items (*List[list]*) – a list of the lists you want to flat index over

Returns
FlatIndexer

unravel(*index*)

Parameters
index (*int | List[int]*) – raveled index

Returns
outer and inner indices

Return type
Tuple[int, int]

Example

```
>>> import kwarray
>>> rng = kwarray.ensure_rng(0)
>>> items = [rng.rand(rng.randint(0, 10)) for _ in range(10)]
>>> self = kwarray.FlatIndexer.fromlist(items)
>>> index = np.arange(0, len(self))
>>> outer, inner = self.unravel(index)
>>> recon = self.ravel(outer, inner)
>>> # This check is only possible because index is an arange
>>> check1 = np.hstack(list(map(sorted, kwarray.group_indices(outer)[1])))
>>> check2 = np.hstack(kwarray.group_consecutive_indices(inner))
>>> assert np.all(check1 == index)
>>> assert np.all(check2 == index)
>>> assert np.all(index == recon)
```

ravel(*outer*, *inner*)

Parameters

- **outer** – index into outer list
- **inner** – index into the list referenced by outer

Returns
the raveled index

Return type
List[int]

class kwarray.**LocLight**(*parent*)

Bases: object

exception kwarray.**NoSupportError**

Bases: RuntimeError

class kwarray.**RunningStats**(*nan_policy='omit'*, *check_weights=True*, ***kwargs*)

Bases: NiceRepr

Track mean, std, min, and max values over time with constant memory.

Dynamically records per-element array statistics and can summarized them per-element, across channels, or globally.

Todo:

- [ ] This may need a few API tweaks and good documentation

Example

```
>>> import kwarray
>>> run = kwarray.RunningStats()
>>> ch1 = np.array([[0, 1], [3, 4]])
>>> ch2 = np.zeros((2, 2))
>>> img = np.dstack([ch1, ch2])
>>> run.update(np.dstack([ch1, ch2]))
>>> run.update(np.dstack([ch1 + 1, ch2]))
>>> run.update(np.dstack([ch1 + 2, ch2]))
>>> # No marginalization
>>> print('current-ave = ' + ub.urepr(run.summarize(axis=ub.NoParam), nl=2,␣
↪precision=3))
>>> # Average over channels (keeps spatial dims separate)
>>> print('chann-ave(k=1) = ' + ub.urepr(run.summarize(axis=0), nl=2, precision=3))
>>> print('chann-ave(k=0) = ' + ub.urepr(run.summarize(axis=0, keepdims=0), nl=2,␣
↪precision=3))
>>> # Average over spatial dims (keeps channels separate)
>>> print('spatial-ave(k=1) = ' + ub.urepr(run.summarize(axis=(1, 2)), nl=2,␣
↪precision=3))
>>> print('spatial-ave(k=0) = ' + ub.urepr(run.summarize(axis=(1, 2), keepdims=0),␣
↪nl=2, precision=3))
>>> # Average over all dims
>>> print('alldim-ave(k=1) = ' + ub.urepr(run.summarize(axis=None), nl=2,␣
↪precision=3))
>>> print('alldim-ave(k=0) = ' + ub.urepr(run.summarize(axis=None, keepdims=0),␣
↪nl=2, precision=3))
```

Parameters

nan_policy (*str*) – indicates how we will handle nan values

- if “omit” - set weights of nan items to zero.
- if “propogate” - propogate nans.
- if “raise” - then raise a ValueError if nans are given.

check_weights (bool):
if True, we check the weights for zeros (which can also implicitly occur when data has nans). Disabling this check will result in faster computation, but it is your responsibility to ensure all data passed to update is valid.

property shape

_update_from_other(*other*)

Combine this runner with another one.

update_many(*data*, *weights=1*)

Assumes first data axis represents multiple observations

Example

```
>>> import kwarray
>>> rng = kwarray.ensure_rng(0)
>>> run = kwarray.RunningStats()
>>> data = rng.randn(1, 2, 3)
>>> run.update_many(data)
>>> print(run.current())
>>> data = rng.randn(2, 2, 3)
>>> run.update_many(data)
>>> print(run.current())
>>> data = rng.randn(3, 2, 3)
>>> run.update_many(data)
>>> print(run.current())
>>> run.update_many(1000)
>>> print(run.current())
>>> assert np.all(run.current()['n'] == 7)
```

Example

```
>>> import kwarray
>>> rng = kwarray.ensure_rng(0)
>>> run = kwarray.RunningStats()
>>> data = rng.randn(1, 2, 3)
>>> run.update_many(data.ravel())
>>> print(run.current())
>>> data = rng.randn(2, 2, 3)
>>> run.update_many(data.ravel())
>>> print(run.current())
>>> data = rng.randn(3, 2, 3)
>>> run.update_many(data.ravel())
>>> print(run.current())
>>> run.update_many(1000)
>>> print(run.current())
>>> assert np.all(run.current()['n'] == 37)
```

update(*data*, *weights=1*)

Updates statistics across all data dimensions on a per-element basis

Example

```
>>> import kwarray
>>> data = np.full((7, 5), fill_value=1.3)
>>> weights = np.ones((7, 5), dtype=np.float32)
>>> run = kwarray.RunningStats()
>>> run.update(data, weights=1)
>>> run.update(data, weights=weights)
>>> rng = np.random
>>> weights[rng.rand(*weights.shape) > 0.5] = 0
>>> run.update(data, weights=weights)
```

Example

```
>>> import kwarray
>>> run = kwarray.RunningStats()
>>> data = np.array([[1, np.nan, np.nan], [0, np.nan, 1.]])
>>> run.update(data)
>>> print('current = {}'.format(ub.urepr(run.current(), nl=1)))
>>> print('summary(axis=None) = {}'.format(ub.urepr(run.summarize(), nl=1)))
>>> print('summary(axis=1) = {}'.format(ub.urepr(run.summarize(axis=1), nl=1)))
>>> print('summary(axis=0) = {}'.format(ub.urepr(run.summarize(axis=0), nl=1)))
>>> data = np.array([[2, 0, 1], [0, 1, np.nan]])
>>> run.update(data)
>>> data = np.array([[3, 1, 1], [0, 1, np.nan]])
>>> run.update(data)
>>> data = np.array([[4, 1, 1], [0, 1, 1.]])
>>> run.update(data)
>>> print('----')
>>> print('current = {}'.format(ub.urepr(run.current(), nl=1)))
>>> print('summary(axis=None) = {}'.format(ub.urepr(run.summarize(), nl=1)))
>>> print('summary(axis=1) = {}'.format(ub.urepr(run.summarize(axis=1), nl=1)))
>>> print('summary(axis=0) = {}'.format(ub.urepr(run.summarize(axis=0), nl=1)))
```

_sumsq_std(*total*, *squares*, *n*)

Sum of squares method to compute standard deviation

summarize(*axis=None*, *keepdims=True*)

Compute summary statistics across a one or more dimension

Parameters

- **axis** (*int | List[int] | None | NoParamType*) – axis or axes to summarize over, if None, all axes are summarized. if ub.NoParam, no axes are summarized the current result is returned.
- **keepdims** (*bool, default=True*) – if False removes the dimensions that are summarized over

Returns

containing minimum, maximum, mean, std, etc..

Return type

Dict

Raises

NoSupportError – if update was never called with valid data

Example

```
>>> # Test to make sure summarize works across different shapes
>>> base = np.array([1, 1, 1, 1, 0, 0, 0, 1])
>>> run0 = RunningStats()
>>> for _ in range(3):
>>>     run0.update(base.reshape(8, 1))
>>> run1 = RunningStats()
>>> for _ in range(3):
```

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```
>>>     run1.update(base.reshape(4, 2))
>>> run2 = RunningStats()
>>> for _ in range(3):
>>>     run2.update(base.reshape(2, 2, 2))
>>> #
>>> # Summarizing over everything should be exactly the same
>>> s0N = run0.summarize(axis=None, keepdims=0)
>>> s1N = run1.summarize(axis=None, keepdims=0)
>>> s2N = run2.summarize(axis=None, keepdims=0)
>>> #assert ub.util_indexable.indexable_allclose(s0N, s1N, rel_tol=0.0, abs_
↪tol=0.0)
>>> #assert ub.util_indexable.indexable_allclose(s1N, s2N, rel_tol=0.0, abs_
↪tol=0.0)
>>> assert s0N['mean'] == 0.625
```

current()

Returns current staticis on a per-element basis (not summarized over any axis)

class kwarray.**SlidingWindow**(*shape*, *window*, *overlap=None*, *stride=None*, *keepbound=False*, *allow_overshoot=False*)

Bases: NiceRepr

Slide a window of a certain shape over an array with a larger shape.

This can be used for iterating over a grid of sub-regions of 2d-images, 3d-volumes, or any n-dimensional array.

Yields slices of shape *window* that can be used to index into an array with shape *shape* via numpy / torch fancy indexing. This allows for fast fast iteration over subregions of a larger image. Because we generate a grid-basis using only shapes, the larger image does not need to be in memory as long as its width/height/depth/etc...

Parameters

- **shape** (*Tuple[int, ...]*) – shape of source array to slide across.
- **window** (*Tuple[int, ...]*) – shape of window that will be slid over the larger image.
- **overlap** (*float, default=0*) – a number between 0 and 1 indicating the fraction of overlap that parts will have. Specifying this is mutually exclusive with *stride*. Must be *0 <= overlap < 1*.
- **stride** (*int, default=None*) – the number of cells (pixels) moved on each step of the window. Mutually exclusive with overlap.
- **keepbound** (*bool, default=False*) – if True, a non-uniform stride will be taken to ensure that the right / bottom of the image is returned as a slice if needed. Such a slice will not obey the overlap constraints. (Defaults to False)
- **allow_overshoot** (*bool, default=False*) – if False, we will raise an error if the window doesn't slide perfectly over the input shape.

Variables

- **strides** (*basis_shape - shape of the grid corresponding to the number of*) – the sliding window will take.
- **dimension** (*basis_slices - slices that will be taken in every*) –

Yields

Tuple[slice, ...] –

slices used for numpy indexing, the number of slices
in the tuple

Note: For each dimension, we generate a basis (which defines a grid), and we slide over that basis.

Todo:

- **[ ] have an option that is allowed to go outside of the window bounds**
  on the right and bottom when the slider overshoots.

Example

```
>>> from kwarray.util_slider import *  # NOQA
>>> shape = (10, 10)
>>> window = (5, 5)
>>> self = SlidingWindow(shape, window)
>>> for i, index in enumerate(self):
>>>     print('i={}, index={}'.format(i, index))
i=0, index=(slice(0, 5, None), slice(0, 5, None))
i=1, index=(slice(0, 5, None), slice(5, 10, None))
i=2, index=(slice(5, 10, None), slice(0, 5, None))
i=3, index=(slice(5, 10, None), slice(5, 10, None))
```

Example

```
>>> from kwarray.util_slider import *  # NOQA
>>> shape = (16, 16)
>>> window = (4, 4)
>>> self = SlidingWindow(shape, window, overlap=(.5, .25))
>>> print('self.stride = {!r}'.format(self.stride))
self.stride = [2, 3]
>>> list(ub.chunks(self.grid, 5))
[[(0, 0), (0, 1), (0, 2), (0, 3), (0, 4)],
 [(1, 0), (1, 1), (1, 2), (1, 3), (1, 4)],
 [(2, 0), (2, 1), (2, 2), (2, 3), (2, 4)],
 [(3, 0), (3, 1), (3, 2), (3, 3), (3, 4)],
 [(4, 0), (4, 1), (4, 2), (4, 3), (4, 4)],
 [(5, 0), (5, 1), (5, 2), (5, 3), (5, 4)],
 [(6, 0), (6, 1), (6, 2), (6, 3), (6, 4)]]
```

Example

```
>>> # Test shapes that dont fit
>>> # When the window is bigger than the shape, the left-aligned slices
>>> # are returend.
>>> self = SlidingWindow((3, 3), (12, 12), allow_overshoot=True, keepbound=True)
>>> print(list(self))
[(slice(0, 12, None), slice(0, 12, None))]
>>> print(list(SlidingWindow((3, 3), None, allow_overshoot=True, keepbound=True)))
[(slice(0, 3, None), slice(0, 3, None))]
>>> print(list(SlidingWindow((3, 3), (None, 2), allow_overshoot=True,␣
↪keepbound=True)))
[(slice(0, 3, None), slice(0, 2, None)), (slice(0, 3, None), slice(1, 3, None))]
```

_compute_stride(*overlap*, *stride*, *shape*, *window*)

Ensures that stride hasoverlap the correct shape. If stride is not provided, compute stride from desired overlap.

_iter_basis_frac()

property grid

Generate indices into the "basis" slice for each dimension. This enumerates the nd indices of the grid.

Yields
Tuple[int, ...]

property slices

Generate slices for each window (equivalent to iter(self))

Example

```
>>> shape = (220, 220)
>>> window = (10, 10)
>>> self = SlidingWindow(shape, window, stride=5)
>>> list(self)[41:45]
[(slice(0, 10, None), slice(205, 215, None)),
 (slice(0, 10, None), slice(210, 220, None)),
 (slice(5, 15, None), slice(0, 10, None)),
 (slice(5, 15, None), slice(5, 15, None))]
>>> print('self.overlap = {!r}'.format(self.overlap))
self.overlap = [0.5, 0.5]
```

property centers

Generate centers of each window

Yields
Tuple[float, ...] – the center coordinate of the slice

Example

```
>>> shape = (4, 4)
>>> window = (3, 3)
>>> self = SlidingWindow(shape, window, stride=1)
>>> list(zip(self.centers, self.slices))
[((1.0, 1.0), (slice(0, 3, None), slice(0, 3, None))),
 ((1.0, 2.0), (slice(0, 3, None), slice(1, 4, None))),
 ((2.0, 1.0), (slice(1, 4, None), slice(0, 3, None))),
 ((2.0, 2.0), (slice(1, 4, None), slice(1, 4, None)))]
>>> shape = (3, 3)
>>> window = (2, 2)
>>> self = SlidingWindow(shape, window, stride=1)
>>> list(zip(self.centers, self.slices))
[((0.5, 0.5), (slice(0, 2, None), slice(0, 2, None))),
 ((0.5, 1.5), (slice(0, 2, None), slice(1, 3, None))),
 ((1.5, 0.5), (slice(1, 3, None), slice(0, 2, None))),
 ((1.5, 1.5), (slice(1, 3, None), slice(1, 3, None)))]
```

class kwarray.**Stitcher**(*shape*, *device='numpy'*, *dtype='float32'*, *nan_policy='propogate'*)

Bases: NiceRepr

Stitches multiple possibly overlapping slices into a larger array.

This is used to invert the SlidingWindow. For semenatic segmentation the patches are probability chips. Overlapping chips are averaged together.

SeeAlso:

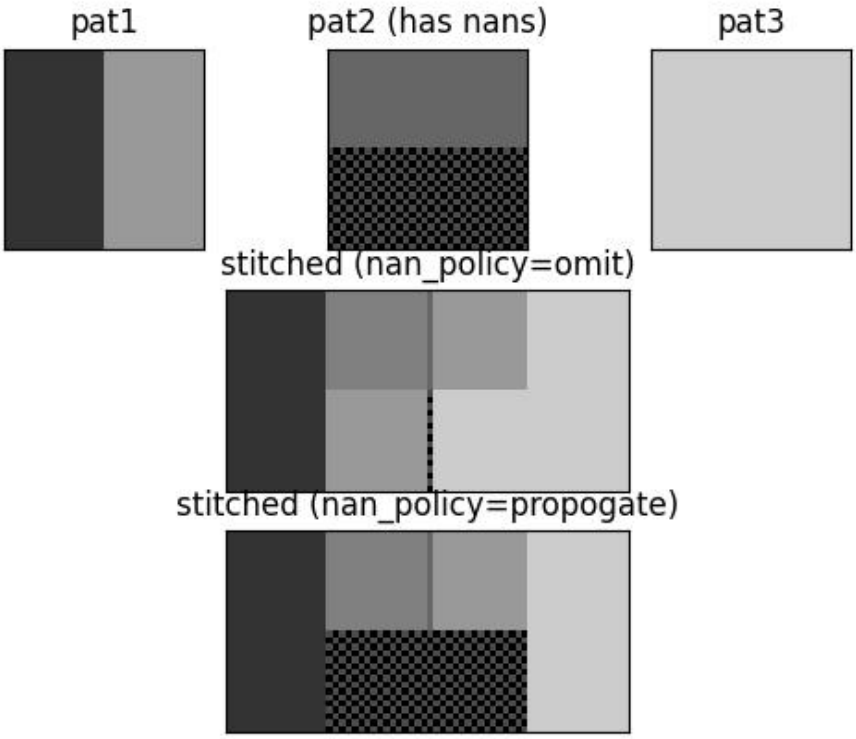
kwarray.RunningStats **- similarly performs running means, but** can also track other statistics.

Example

```
>>> from kwarray.util_slider import *  # NOQA
>>> import sys
>>> # Build a high resolution image and slice it into chips
>>> highres = np.random.rand(5, 200, 200).astype(np.float32)
>>> target_shape = (1, 50, 50)
>>> slider = SlidingWindow(highres.shape, target_shape, overlap=(0, .5, .5))
>>> # Show how Sticher can be used to reconstruct the original image
>>> stitcher = Stitcher(slider.input_shape)
>>> for sl in list(slider):
...     chip = highres[sl]
...     stitcher.add(sl, chip)
>>> assert stitcher.weights.max() == 4, 'some parts should be processed 4 times'
>>> recon = stitcher.finalize()
```

Example

```
>>> from kwarray.util_slider import *  # NOQA
>>> import sys
>>> # Demo stitching 3 patterns where one has nans
>>> pat1 = np.full((32, 32), fill_value=0.2)
>>> pat2 = np.full((32, 32), fill_value=0.4)
>>> pat3 = np.full((32, 32), fill_value=0.8)
>>> pat1[:, 16:] = 0.6
>>> pat2[16:, :] = np.nan
>>> # Test with nan_policy=omit
>>> stitcher = Stitcher(shape=(32, 64), nan_policy='omit')
>>> stitcher[0:32, 0:32](pat1)
>>> stitcher[0:32, 16:48](pat2)
>>> stitcher[0:32, 33:64](pat3[:, 1:])
>>> final1 = stitcher.finalize()
>>> # Test without nan_policy=propogate
>>> stitcher = Stitcher(shape=(32, 64), nan_policy='propogate')
>>> stitcher[0:32, 0:32](pat1)
>>> stitcher[0:32, 16:48](pat2)
>>> stitcher[0:32, 33:64](pat3[:, 1:])
>>> final2 = stitcher.finalize()
>>> # Checks
>>> assert np.isnan(final1).sum() == 16, 'only should contain nan where no data was␣
↪stiched'
>>> assert np.isnan(final2).sum() == 512, 'should contain nan wherever a nan was␣
↪stitched'
>>> # xdoctest: +REQUIRES(--show)
>>> # xdoctest: +REQUIRES(module:kwplot)
>>> import kwplot
>>> import kwimage
>>> kwplot.autompl()
>>> kwplot.imshow(pat1, title='pat1', pnum=(3, 3, 1))
>>> kwplot.imshow(kwimage.nodata_checkerboard(pat2, square_shape=1), title='pat2␣
↪(has nans)', pnum=(3, 3, 2))
>>> kwplot.imshow(pat3, title='pat3', pnum=(3, 3, 3))
>>> kwplot.imshow(kwimage.nodata_checkerboard(final1, square_shape=1), title=
↪'stitched (nan_policy=omit)', pnum=(3, 1, 2))
>>> kwplot.imshow(kwimage.nodata_checkerboard(final2, square_shape=1), title=
↪'stitched (nan_policy=propogate)', pnum=(3, 1, 3))
```



Example

```
>>> # Example of weighted stitching
>>> # xdoctest: +REQUIRES(module:kwimage)
>>> from kwarray.util_slider import *  # NOQA
>>> import kwimage
>>> import kwarray
>>> import sys
>>> data = kwimage.Mask.demo().data.astype(np.float32)
>>> data_dims = data.shape
>>> window_dims = (8, 8)
>>> # We are going to slide a window over the data, do some processing
>>> # and then stitch it all back together. There are a few ways we
>>> # can do it. Lets demo the params.
>>> basis = {
>>>     # Vary the overlap of the slider
>>>     'overlap': (0, 0.5, .9),
>>>     # Vary if we are using weighted stitching or not
>>>     'weighted': ['none', 'gauss'],
>>>     'keepbound': [True, False]
>>> }
>>> results = []
>>> gauss_weights = kwimage.gaussian_patch(window_dims)
```

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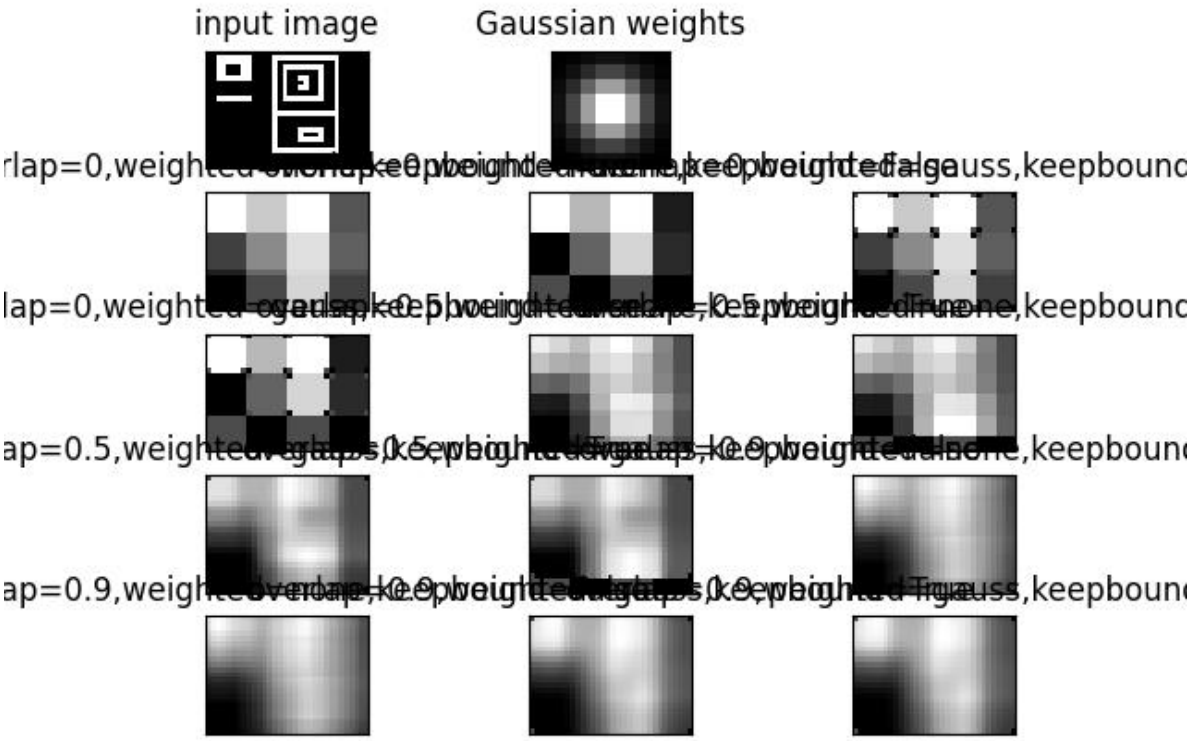
```
>>> gauss_weights = kwimage.normalize(gauss_weights)
>>> for params in ub.named_product(basis):
>>>     if params['weighted'] == 'none':
>>>         weights = None
>>>     elif params['weighted'] == 'gauss':
>>>         weights = gauss_weights
>>>     # Build the slider and stitcher
>>>     slider = kwarray.SlidingWindow(
>>>         data_dims, window_dims, overlap=params['overlap'],
>>>         allow_overshoot=True,
>>>         keepbound=params['keepbound'])
>>>     stitcher = kwarray.Stitcher(data_dims)
>>>     # Loop over the regions
>>>     for sl in list(slider):
>>>          chip = data[sl]
>>>          # This is our dummy function for thie example.
>>>          predicted = np.ones_like(chip) * chip.sum() / chip.size
>>>          stitcher.add(sl, predicted, weight=weights)
>>>     final = stitcher.finalize()
>>>     results.append({
>>>         'final': final,
>>>         'params': params,
>>>     })
>>> # xdoctest: +REQUIRES(--show)
>>> # xdoctest: +REQUIRES(module:kwplot)
>>> import kwplot
>>> kwplot.autompl()
>>> pnum_ = kwplot.PlotNums(nCols=3, nSubplots=len(results) + 2)
>>> kwplot.imshow(data, pnum=pnum_(), title='input image')
>>> kwplot.imshow(gauss_weights, pnum=pnum_(), title='Gaussian weights')
>>> pnum_()
>>> for result in results:
>>>     param_key = ub.urepr(result['params'], compact=1)
>>>     final = result['final']
>>>     canvas = kwarray.normalize(final)
>>>     canvas = kwimage.fill_nans_with_checkers(canvas)
>>>     kwplot.imshow(canvas, pnum=pnum_(), title=param_key)
```



Parameters

- **shape** (*tuple*) – dimensions of the large image that will be created from the smaller pixels or patches.
- **device** (*str | int | torch.device*) – default is 'numpy', but if given as a torch device, then underlying operations will be done with torch tensors instead.
- **dtype** (*str*) – the datatype to use in the underlying accumulator.
- **nan_policy** (*str*) – if omit, check for nans and convert any to zero weight items in stitching.

`add`(*indices*, *patch*, *weight=None*)

Incorporate a new (possibly overlapping) patch or pixel using a weighted sum.

Parameters

- **indices** (*slice | tuple | None*) – typically a Tuple[slice] of pixels or a single pixel, but this can be any numpy fancy index.
- **patch** (*ndarray*) – data to patch into the bigger image.
- **weight** (*float | ndarray*) – weight of this patch (default to 1.0)

`average`()

Averages out contributions from overlapping adds using weighted average

Returns

out - the stitched image

Return type
ndarray

finalize(*indices=None*)

Averages out contributions from overlapping adds

Parameters
indices (*None | slice | tuple*) – if None, finalize the entire block, otherwise only finalize a subregion.

Returns
final - the stitched image

Return type
ndarray

kwarray.**apply_embedded_slice**(*data*, *data_slice*, *extra_padding*, ***padkw*)

Apply a precomputed embedded slice.

This is used as a subroutine in padded_slice.

Parameters

- **data** (*ndarray*) – data to slice
- **data_slice** (*Tuple[slice]*)
- **extra_padding** (*Tuple[slice]*)

Returns
ndarray

kwarray.**apply_grouping**(*items*, *groupxs*, *axis=0*)

Applies grouping from group_indicies.

Typically used in conjunction with *group_indices()*.

Parameters

- **items** (*NDArray*) – items to group
- **groupxs** (*List[NDArray[None, Int]]*) – groups of indices
- **axis** (*None|int, default=0*)

Returns
grouped items

Return type
List[NDArray]

Example

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> idx_to_groupid = np.array([2, 1, 2, 1, 2, 1, 2, 3, 3, 3, 3])
>>> items          = np.array([1, 8, 5, 5, 8, 6, 7, 5, 3, 0, 9])
>>> (keys, groupxs) = group_indices(idx_to_groupid)
>>> grouped_items = apply_grouping(items, groupxs)
>>> result = str(grouped_items)
>>> print(result)
[array([8, 5, 6]), array([1, 5, 8, 7]), array([5, 3, 0, 9])]
```

kwarray.**arglexmax**(*keys*, *multi=False*)

Find the index of the maximum element in a sequence of keys.

Parameters

- **keys** (*tuple*) – a k-tuple of k N-dimensional arrays. Like np.lexsort the last key in the sequence is used for the primary sort order, the second-to-last key for the secondary sort order, and so on.
- **multi** (*bool*) – if True, returns all indices that share the max value

Returns
either the index or list of indices

Return type
int | NDArray[Any, Int]

Example

```
>>> k, N = 100, 100
>>> rng = np.random.RandomState(0)
>>> keys = [(rng.rand(N) * N).astype(int) for _ in range(k)]
>>> multi_idx = arglexmax(keys, multi=True)
>>> idxs = np.lexsort(keys)
>>> assert sorted(idxs[::-1][:len(multi_idx)]) == sorted(multi_idx)
```

Benchark:

```
>>> import ubelt as ub
>>> k, N = 100, 100
>>> rng = np.random
>>> keys = [(rng.rand(N) * N).astype(int) for _ in range(k)]
>>> for timer in ub.Timerit(100, bestof=10, label='arglexmax'):
>>>     with timer:
>>>         arglexmax(keys)
>>> for timer in ub.Timerit(100, bestof=10, label='lexsort'):
>>>     with timer:
>>>         np.lexsort(keys)[-1]
```

kwarray.**argmaxima**(*arr*, *num*, *axis=None*, *ordered=True*)

Returns the top num maximum indicies.

This can be significantly faster than using argsort.

Parameters

- **arr** (*NDArray*) – input array
- **num** (*int*) – number of maximum indices to return
- **axis** (*int | None*) – axis to find maxima over. If None this is equivalent to using arr.ravel().
- **ordered** (*bool*) – if False, returns the maximum elements in an arbitrary order, otherwise they are in decending order. (Setting this to false is a bit faster).

Todo:

- [ ] if num is None, return arg for all values equal to the maximum

Returns
NDArray

Example

```
>>> # Test cases with axis=None
>>> arr = (np.random.rand(100) * 100).astype(int)
>>> for num in range(0, len(arr) + 1):
>>>     idxs = argmaxima(arr, num)
>>>     idxs2 = argmaxima(arr, num, ordered=False)
>>>     assert np.all(arr[idxs] == np.array(sorted(arr)[::-1][:len(idxs)])),
↪'ordered=True must return in order'
>>>     assert sorted(idxs2) == sorted(idxs), 'ordered=False must return the right␣
↪idxs, but in any order'
```

Example

```
>>> # Test cases with axis
>>> arr = (np.random.rand(3, 5, 7) * 100).astype(int)
>>> for axis in range(len(arr.shape)):
>>>     for num in range(0, len(arr) + 1):
>>>         idxs = argmaxima(arr, num, axis=axis)
>>>         idxs2 = argmaxima(arr, num, ordered=False, axis=axis)
>>>         assert idxs.shape[axis] == num
>>>         assert idxs2.shape[axis] == num
```

kwarray.**argminima**(*arr*, *num*, *axis=None*, *ordered=True*)

Returns the top num minimum indicies.

This can be significantly faster than using argsort.

Parameters

- **arr** (*NDArray*) – input array
- **num** (*int*) – number of minimum indices to return
- **axis** (*int|None*) – axis to find minima over. If None this is equivalent to using arr.ravel().
- **ordered** (*bool*) – if False, returns the minimum elements in an arbitrary order, otherwise they are in ascending order. (Setting this to false is a bit faster).

Example

```
>>> arr = (np.random.rand(100) * 100).astype(int)
>>> for num in range(0, len(arr) + 1):
>>>     idxs = argminima(arr, num)
>>>     assert np.all(arr[idxs] == np.array(sorted(arr)[:len(idxs)])),
↪'ordered=True must return in order'
>>>     idxs2 = argminima(arr, num, ordered=False)
>>>     assert sorted(idxs2) == sorted(idxs), 'ordered=False must return the right␣
↪idxs, but in any order'
```

Example

```
>>> # Test cases with axis
>>> from kwarray.util_numpy import *  # NOQA
>>> arr = (np.random.rand(3, 5, 7) * 100).astype(int)
>>> # make a unique array so we can check argmax consistency
>>> arr = np.arange(3 * 5 * 7)
>>> np.random.shuffle(arr)
>>> arr = arr.reshape(3, 5, 7)
>>> for axis in range(len(arr.shape)):
>>>     for num in range(0, len(arr) + 1):
>>>         idxs = argminima(arr, num, axis=axis)
>>>         idxs2 = argminima(arr, num, ordered=False, axis=axis)
>>>         print('idxs = {!r}'.format(idxs))
>>>         print('idxs2 = {!r}'.format(idxs2))
>>>         assert idxs.shape[axis] == num
>>>         assert idxs2.shape[axis] == num
>>>         # Check if argmin argrees with -argmax
>>>         idxs3 = argmaxima(-arr, num, axis=axis)
>>>         assert np.all(idxs3 == idxs)
```

Example

```
>>> arr = np.arange(20).reshape(4, 5) % 6
>>> argminima(arr, axis=1, num=2, ordered=False)
>>> argminima(arr, axis=1, num=2, ordered=True)
>>> argmaxima(-arr, axis=1, num=2, ordered=True)
>>> argmaxima(-arr, axis=1, num=2, ordered=False)
```

kwarray.**atleast_nd**(*arr*, *n*, *front=False*)

View inputs as arrays with at least n dimensions.

Parameters

- **arr** (*ArrayLike*) – An array-like object. Non-array inputs are converted to arrays. Arrays that already have n or more dimensions are preserved.
- **n** (*int*) – number of dimensions to ensure
- **front** (*bool*) – if True new dimensions are added to the front of the array. otherwise they are added to the back. Defaults to False.

Returns

An array with `a.ndim >= n`. Copies are avoided where possible, and views with three or more dimensions are returned. For example, a 1-D array of shape `(N,)` becomes a view of shape `(1, N, 1)`, and a 2-D array of shape `(M, N)` becomes a view of shape `(M, N, 1)`.

Return type

NDArray

See also:

numpy.atleast_1d, numpy.atleast_2d, numpy.atleast_3d

Example

```
>>> n = 2
>>> arr = np.array([1, 1, 1])
>>> arr_ = atleast_nd(arr, n)
>>> import ubelt as ub  # NOQA
>>> result = ub.urepr(arr_.tolist(), nl=0)
>>> print(result)
[[1], [1], [1]]
```

Example

```
>>> n = 4
>>> arr1 = [1, 1, 1]
>>> arr2 = np.array(0)
>>> arr3 = np.array([[[[[1]]]]])
>>> arr1_ = atleast_nd(arr1, n)
>>> arr2_ = atleast_nd(arr2, n)
>>> arr3_ = atleast_nd(arr3, n)
>>> import ubelt as ub  # NOQA
>>> result1 = ub.urepr(arr1_.tolist(), nl=0)
>>> result2 = ub.urepr(arr2_.tolist(), nl=0)
>>> result3 = ub.urepr(arr3_.tolist(), nl=0)
>>> result = '\n'.join([result1, result2, result3])
>>> print(result)
[[[[1]]], [[[1]]], [[[1]]]]
[[[[0]]]]
[[[[[1]]]]]
```

Note: Extensive benchmarks are in kwarray/dev/bench_atleast_nd.py

These demonstrate that this function is statistically faster than the numpy variants, although the difference is small. On average this function takes 480ns versus numpy which takes 790ns.

---

kwarray.**boolmask**(*indices*, *shape=None*)

Constructs an array of booleans where an item is True if its position is in `indices` otherwise it is False. This can be viewed as the inverse of `numpy.where()`.

Parameters

- **indices** (*NDArray*) – list of integer indices

- **shape** (*int | tuple*) – length of the returned list. If not specified the minimal possible shape to incoporate all the indices is used. In general, it is best practice to always specify this argument.

Returns
mask - mask[idx] is True if idx in indices

Return type
NDArray[Any, Int]

Example

```
>>> indices = [0, 1, 4]
>>> mask = boolmask(indices, shape=6)
>>> assert np.all(mask == [True, True, False, False, True, False])
>>> mask = boolmask(indices)
>>> assert np.all(mask == [True, True, False, False, True])
```

Example

```
>>> import kwarray
>>> import ubelt as ub  # NOQA
>>> indices = np.array([(0, 0), (1, 1), (2, 1)])
>>> shape = (3, 3)
>>> mask = kwarray.boolmask(indices, shape)
>>> result = ub.urepr(mask, with_dtype=0)
>>> print(result)
np.array([[ True, False, False],
          [False,  True, False],
          [False,  True, False]])
```

kwarray.**dtype_info**(*dtype*)

Lookup datatype information

Parameters
dtype (*type*) – a numpy, torch, or python numeric data type

Returns
an iinfo of finfo structure depending on the input type.

Return type
numpy.iinfo | numpy.finfo | torch.iinfo | torch.finfo

References

..[DtypeNotes] https://higra.readthedocs.io/en/stable/_modules/higra/hg_utils.html#dtype_info

Example

```
>>> from kwarray.arrayapi import *  # NOQA
>>> try:
>>>     import torch
>>> except ImportError:
>>>     torch = None
>>> results = []
>>> results += [dtype_info(float)]
>>> results += [dtype_info(int)]
>>> results += [dtype_info(complex)]
>>> results += [dtype_info(np.float32)]
>>> results += [dtype_info(np.int32)]
>>> results += [dtype_info(np.uint32)]
>>> if hasattr(np, 'complex256'):
>>>     results += [dtype_info(np.complex256)]
>>> if torch is not None:
>>>     results += [dtype_info(torch.float32)]
>>>     results += [dtype_info(torch.int64)]
>>>     results += [dtype_info(torch.complex64)]
>>> for info in results:
>>>     print('info = {!r}'.format(info))
>>> for info in results:
>>>     print('info.bits = {!r}'.format(info.bits))
```

kwarray.**embed_slice**(*slices*, *data_dims*, *pad=None*)

Embeds a “padded-slice” inside known data dimension.

Returns the valid data portion of the slice with extra padding for regions outside of the available dimension.

Given a slices for each dimension, image dimensions, and a padding get the corresponding slice from the image and any extra padding needed to achieve the requested window size.

Todo:

- [ ] Add the option to return the inverse slice

Parameters

- **slices** (*Tuple[slice, ...]*) – a tuple of slices for to apply to data data dimension.
- **data_dims** (*Tuple[int, ...]*) – n-dimension data sizes (e.g. 2d height, width)
- **pad** (*int | List[int | Tuple[int, int]]*) – extra pad applied to (start / end) / (both) sides of each slice dim

Returns

data_slice - Tuple[slice] a slice that can be applied to an array
with with shape *data_dims*. This slice will not correspond to the full window size if the requested slice is out of bounds.

extra_padding - extra padding needed after slicing to achieve
the requested window size.

Return type
Tuple

Example

```
>>> # Case where slice is inside the data dims on left edge
>>> import kwarray
>>> slices = (slice(0, 10), slice(0, 10))
>>> data_dims  = [300, 300]
>>> pad        = [10, 5]
>>> a, b = kwarray.embed_slice(slices, data_dims, pad)
>>> print('data_slice = {!r}'.format(a))
>>> print('extra_padding = {!r}'.format(b))
data_slice = (slice(0, 20, None), slice(0, 15, None))
extra_padding = [(10, 0), (5, 0)]
```

Example

```
>>> # Case where slice is bigger than the image
>>> import kwarray
>>> slices = (slice(-10, 400), slice(-10, 400))
>>> data_dims  = [300, 300]
>>> pad        = [10, 5]
>>> a, b = kwarray.embed_slice(slices, data_dims, pad)
>>> print('data_slice = {!r}'.format(a))
>>> print('extra_padding = {!r}'.format(b))
data_slice = (slice(0, 300, None), slice(0, 300, None))
extra_padding = [(20, 110), (15, 105)]
```

Example

```
>>> # Case where slice is inside than the image
>>> import kwarray
>>> slices = (slice(10, 40), slice(10, 40))
>>> data_dims  = [300, 300]
>>> pad        = None
>>> a, b = kwarray.embed_slice(slices, data_dims, pad)
>>> print('data_slice = {!r}'.format(a))
>>> print('extra_padding = {!r}'.format(b))
data_slice = (slice(10, 40, None), slice(10, 40, None))
extra_padding = [(0, 0), (0, 0)]
```

Example

```
>>> # Test error cases
>>> import kwarray
>>> import pytest
>>> slices = (slice(0, 40), slice(10, 40))
>>> data_dims  = [300, 300]
>>> with pytest.raises(ValueError):
>>>     kwarray.embed_slice(slices, data_dims[0:1])
```

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```
>>> with pytest.raises(ValueError):
>>>     kwarray.embed_slice(slices[0:1], data_dims)
>>> with pytest.raises(ValueError):
>>>     kwarray.embed_slice(slices, data_dims, pad=[(1, 1)])
>>> with pytest.raises(ValueError):
>>>     kwarray.embed_slice(slices, data_dims, pad=[1])
```

kwarray.**ensure_rng**(*rng=None*, *api='numpy'*)

Coerces input into a random number generator.

This function is useful for ensuring that your code uses a controlled internal random state that is independent of other modules.

If the input is None, then a global random state is returned.

If the input is a numeric value, then that is used as a seed to construct a random state.

If the input is a random number generator, then another random number generator with the same state is returned. Depending on the api, this random state is either return as-is, or used to construct an equivalent random state with the requested api.

Parameters

- **rng** (*int | float | None | numpy.random.RandomState | random.Random*) – if None, then defaults to the global rng. Otherwise this can be an integer or a RandomState class. Defaults to the global random.
- **api** (*str*) – specify the type of random number generator to use. This can either be 'numpy' for a `numpy.random.RandomState` object or 'python' for a `random.Random` object. Defaults to numpy.

Returns

rng - either a numpy or python random number generator, depending on the setting of `api`.

Return type

(numpy.random.RandomState | random.Random)

Example

```
>>> rng = ensure_rng(None)
>>> ensure_rng(0).randint(0, 1000)
684
>>> ensure_rng(np.random.RandomState(1)).randint(0, 1000)
37
```

Example

```
>>> num = 4
>>> print('--- Python as PYTHON ---')
>>> py_rng = random.Random(0)
>>> pp_nums = [py_rng.random() for _ in range(num)]
>>> print(pp_nums)
>>> print('--- Numpy as PYTHON ---')
>>> np_rng = ensure_rng(random.Random(0), api='numpy')
```

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```
>>> np_nums = [np_rng.rand() for _ in range(num)]
>>> print(np_nums)
>>> print('--- Numpy as NUMPY---')
>>> np_rng = np.random.RandomState(seed=0)
>>> nn_nums = [np_rng.rand() for _ in range(num)]
>>> print(nn_nums)
>>> print('--- Python as NUMPY---')
>>> py_rng = ensure_rng(np.random.RandomState(seed=0), api='python')
>>> pn_nums = [py_rng.random() for _ in range(num)]
>>> print(pn_nums)
>>> assert np_nums == pp_nums
>>> assert pn_nums == nn_nums
```

Example

```
>>> # Test that random modules can be coerced
>>> import random
>>> import numpy as np
>>> ensure_rng(random, api='python')
>>> ensure_rng(random, api='numpy')
>>> ensure_rng(np.random, api='python')
>>> ensure_rng(np.random, api='numpy')
```

kwarray.**equal_with_nan**(*a1*, *a2*)

Numpy has array_equal with `equal_nan=True`, but this is elementwise

Parameters

- **a1** (*ArrayLike*) – input array
- **a2** (*ArrayLike*) – input array

Example

```
>>> import kwarray
>>> a1 = np.array([
>>>     [np.nan, 0, np.nan],
>>>     [np.nan, 0, 0],
>>>     [np.nan, 1, 0],
>>>     [np.nan, 1, np.nan],
>>> ])
>>> a2 = np.array([np.nan, 0, np.nan])
>>> flags = kwarray.equal_with_nan(a1, a2)
>>> assert np.array_equal(flags, np.array([
>>>     [ True, False,  True],
>>>     [ True, False, False],
>>>     [ True,  True, False],
>>>     [ True,  True,  True]
>>> ]))
```

kwarray.**find_robust_normalizers**(*data*, *params='auto'*)

Finds robust normalization statistics a set of scalar observations.

The idea is to estimate "fense" parameters: minimum and maximum values where anything under / above these values are likely outliers. For non-linear normalizaiton schemes we can also estimate an likely middle and extent of the data.

Parameters

- **data** (*ndarray*) – a 1D numpy array where invalid data has already been removed
- **params** (*str | dict*) – normalization params.

  When passed as a dictionary valid params are:

  scaling (str):
  This is the "mode" that will be used in the final normalization. Currently has no impact on the Defaults to 'linear'. Can also be 'sigmoid'.

  extrema (str):
  The method for determening what the extrama are. Can be "quantile" for strict quantile clipping Can be "adaptive-quantile" for an IQR-like adjusted quantile method. Can be "tukey" or "IQR" for an exact IQR method.

  low (float): This is the low quantile for likely inliers.

  mid (float): This is the middle quantlie for likely inliers.

  high (float): This is the high quantile for likely inliers.

  Can be specified as a concise string.

  The string "auto" defaults to:
  `dict(extrema='adaptive-quantile', scaling='linear', low=0.01, mid=0.5, high=0.9)`.

  The string "tukey" defaults to:
  `dict(extrema='tukey', scaling='linear')`.

Returns

normalization parameters that can be passed to *kwarray.normalize()* containing the keys:

type (str): which is always 'normalize'

mode (str): the value of `params['scaling']`

min_val (float): the determined "robust" minimum inlier value.

max_val (float): the determined "robust" maximum inlier value.

beta (float): the determined "robust" middle value for use in non-linear normalizers.

alpha (float): the determined "robust" extent value for use in non-linear normalizers.

Return type
Dict[str, str | float]

Note: The defaults and methods of this function are subject to change.

Todo:

- [ ] No (or minimal) Magic Numbers! Use first principles to deterimine defaults.
- [ ] Probably a lot of literature on the subject.
- [ ] https://arxiv.org/pdf/1707.09752.pdf
- [ ] https://www.tandfonline.com/doi/full/10.1080/02664763.2019.1671961
- [ ] https://www.rips-irsp.com/articles/10.5334/irsp.289/
- **[ ] This function is not possible to get right in every case**
  (probably can prove this with a NFL theroem), might be useful to allow the user to specify a "model" which is specific to some domain.

Example

```
>>> from kwarray.util_robust 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.urepr(norm_params1, nl=1)))
>>> print('norm_params2 = {}'.format(ub.urepr(norm_params2, nl=1)))
>>> print('norm_params3 = {}'.format(ub.urepr(norm_params3, nl=1)))
```

Example

```
>>> # xdoctest: +REQUIRES(module:scipy)
>>> from kwarray.util_robust import *  # NOQA
>>> from kwarray.distributions import Mixture
>>> import ubelt as ub
>>> # A random mixture distribution for testing
>>> data = Mixture.random(6).sample(3000)
```

kwarray.**generalized_logistic**(*x*, *floor=0*, *capacity=1*, *C=1*, *y_intercept=None*, *Q=None*, *growth=1*, *v=1*)

A generalization of the logistic / sigmoid functions that allows for flexible specification of S-shaped curve.

This is also known as a "Richards curve" [WikiRichardsCurve].

Parameters

- **x** (*NDArray*) – input x coordinates
- **floor** (*float*) – the lower (left) asymptote. (Also called `A` in some texts). Defaults to 0.
- **capacity** (*float*) – the carrying capacity. When C=1, this is the upper (right) asymptote. (Also called `K` in some texts). Defaults to 1.
- **C** (*float*) – Has influence on the upper asymptote. Defaults to 1. This is typically not modified.
- **y_intercept** (*float | None*) – specify where the the y intercept is at x=0. Mutually exclusive with `Q`.
- **Q** (*float | None*) – related to the value of the function at x=0. Mutually exclusive with `y_intercept`. Defaults to 1.

- **growth** (*float*) – the growth rate (also calle B in some texts). Defaults to 1.
- **v** (*float*) – Positive number that influences near which asymptote the growth occurs. Defaults to 1.

Returns
the values for each input

Return type
NDArray

References

Example

```
>>> from kwarray.util_numpy import *  # NOQA
>>> # xdoctest: +REQUIRES(module:pandas)
>>> import pandas as pd
>>> import ubelt as ub
>>> x = np.linspace(-3, 3, 30)
>>> basis = {
>>>     # 'y_intercept': [0.1, 0.5, 0.8, -1],
>>>     # 'y_intercept': [0.1, 0.5, 0.8],
>>>     'v': [0.5, 1.0, 2.0],
>>>     'growth': [-1, 0, 2],
>>> }
>>> grid = list(ub.named_product(basis))
>>> datas = []
>>> for params in grid:
>>>     y = generalized_logistic(x, **params)
>>>     data = pd.DataFrame({'x': x, 'y': y})
>>>     key = ub.urepr(params, compact=1)
>>>     data['key'] = key
>>>     for k, v in params.items():
>>>         data[k] = v
>>>     datas.append(data)
>>> all_data = pd.concat(datas).reset_index()
>>> # xdoctest: +REQUIRES(--show)
>>> # xdoctest: +REQUIRES(module:kwplot)
>>> import kwplot
>>> plt = kwplot.autoplt()
>>> sns = kwplot.autosns()
>>> plt.gca().cla()
>>> sns.lineplot(data=all_data, x='x', y='y', hue='growth', size='v')
```

kwarray.**group_consecutive**(*arr*, *offset=1*)

Returns lists of consecutive values. Implementation inspired by[3].

Parameters

- **arr** (*NDArray*) – array of ordered values
- **offset** (*float, default=1*) – any two values separated by this offset are grouped. In the default case, when offset=1, this groups increasing values like: 0, 1, 2. When offset is 0

[3] http://stackoverflow.com/questions/7352684/groups-consecutive-elements

it groups consecutive values thta are the same, e.g.: 4, 4, 4.

Returns
a list of arrays that are the groups from the input

Return type
List[NDArray]

Note: This is equivalent (and faster) to using: apply_grouping(data, group_consecutive_indices(data))

References

Example

```
>>> arr = np.array([1, 2, 3, 5, 6, 7, 8, 9, 10, 15, 99, 100, 101])
>>> groups = group_consecutive(arr)
>>> print('groups = {}'.format(list(map(list, groups))))
groups = [[1, 2, 3], [5, 6, 7, 8, 9, 10], [15], [99, 100, 101]]
>>> arr = np.array([0, 0, 3, 0, 0, 7, 2, 3, 4, 4, 4, 1, 1])
>>> groups = group_consecutive(arr, offset=1)
>>> print('groups = {}'.format(list(map(list, groups))))
groups = [[0], [0], [3], [0], [0], [7], [2, 3, 4], [4], [4], [1], [1]]
>>> groups = group_consecutive(arr, offset=0)
>>> print('groups = {}'.format(list(map(list, groups))))
groups = [[0, 0], [3], [0, 0], [7], [2], [3], [4, 4, 4], [1, 1]]
```

kwarray.**group_consecutive_indices**(*arr*, *offset=1*)

Returns lists of indices pointing to consecutive values

Parameters

- **arr** (*NDArray*) – array of ordered values
- **offset** (*float, default=1*) – any two values separated by this offset are grouped.

Returns
groupxs: a list of indices

Return type
List[NDArray]

SeeAlso:

group_consecutive()

apply_grouping()

Example

```
>>> arr = np.array([1, 2, 3, 5, 6, 7, 8, 9, 10, 15, 99, 100, 101])
>>> groupxs = group_consecutive_indices(arr)
>>> print('groupxs = {}'.format(list(map(list, groupxs))))
groupxs = [[0, 1, 2], [3, 4, 5, 6, 7, 8], [9], [10, 11, 12]]
>>> assert all(np.array_equal(a, b) for a, b in zip(group_consecutive(arr, 1),␣
↪apply_grouping(arr, groupxs)))
>>> arr = np.array([0, 0, 3, 0, 0, 7, 2, 3, 4, 4, 4, 1, 1])
>>> groupxs = group_consecutive_indices(arr, offset=1)
>>> print('groupxs = {}'.format(list(map(list, groupxs))))
groupxs = [[0], [1], [2], [3], [4], [5], [6, 7, 8], [9], [10], [11], [12]]
>>> assert all(np.array_equal(a, b) for a, b in zip(group_consecutive(arr, 1),␣
↪apply_grouping(arr, groupxs)))
>>> groupxs = group_consecutive_indices(arr, offset=0)
>>> print('groupxs = {}'.format(list(map(list, groupxs))))
groupxs = [[0, 1], [2], [3, 4], [5], [6], [7], [8, 9, 10], [11, 12]]
>>> assert all(np.array_equal(a, b) for a, b in zip(group_consecutive(arr, 0),␣
↪apply_grouping(arr, groupxs)))
```

kwarray.**group_indices**(*idx_to_groupid*, *assume_sorted=False*)

Find unique items and the indices at which they appear in an array.

A common use case of this function is when you have a list of objects (often numeric but sometimes not) and an array of "group-ids" corresponding to that list of objects.

Using this function will return a list of indices that can be used in conjunction with *apply_grouping()* to group the elements. This is most useful when you have many lists (think column-major data) corresponding to the group-ids.

In cases where there is only one list of objects or knowing the indices doesn't matter, then consider using func:*group_items* instead.

Parameters

- **idx_to_groupid** (*NDArray*) – The input array, where each item is interpreted as a group id. For the fastest runtime, the input array must be numeric (ideally with integer types). If the type is non-numeric then the less efficient `ubelt.group_items()` is used.
- **assume_sorted** (*bool*) – If the input array is sorted, then setting this to True will avoid an unnecessary sorting operation and improve efficiency. Defaults to False.

Returns

(keys, groupxs) -

keys (NDArray):
The unique elements of the input array in order

groupxs (List[NDArray]):
Corresponding list of indexes. The i-th item is an array indicating the indices where the item `key[i]` appeared in the input array.

Return type
Tuple[NDArray, List[NDArray]]

Example

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> import kwarray
>>> import ubelt as ub
>>> idx_to_groupid = np.array([2, 1, 2, 1, 2, 1, 2, 3, 3, 3, 3])
>>> (keys, groupxs) = kwarray.group_indices(idx_to_groupid)
>>> print('keys = ' + ub.urepr(keys, with_dtype=False))
>>> print('groupxs = ' + ub.urepr(groupxs, with_dtype=False))
keys = np.array([1, 2, 3])
groupxs = [
    np.array([1, 3, 5]),
    np.array([0, 2, 4, 6]),
    np.array([ 7,  8,  9, 10]),
]
```

Example

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> import kwarray
>>> import ubelt as ub
>>> # 2d arrays must be flattened before coming into this function so
>>> # information is on the last axis
>>> idx_to_groupid = np.array([[  24], [ 129], [ 659], [ 659], [ 24],
...       [659], [ 659], [ 822], [ 659], [ 659], [24]]).T[0]
>>> (keys, groupxs) = kwarray.group_indices(idx_to_groupid)
>>> # Different versions of numpy may produce different orderings
>>> # so normalize these to make test output consistent
>>> #[gxs.sort() for gxs in groupxs]
>>> print('keys = ' + ub.urepr(keys, with_dtype=False))
>>> print('groupxs = ' + ub.urepr(groupxs, with_dtype=False))
keys = np.array([ 24, 129, 659, 822])
groupxs = [
    np.array([ 0,  4, 10]),
    np.array([1]),
    np.array([2, 3, 5, 6, 8, 9]),
    np.array([7]),
]
```

Example

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> import kwarray
>>> import ubelt as ub
>>> idx_to_groupid = np.array([True, True, False, True, False, False, True])
>>> (keys, groupxs) = kwarray.group_indices(idx_to_groupid)
>>> print(ub.urepr(keys, with_dtype=False))
>>> print(ub.urepr(groupxs, with_dtype=False))
np.array([False,  True])
[
```

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(continued from previous page)

```
    np.array([2, 4, 5]),
    np.array([0, 1, 3, 6]),
]
```

Example

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> import ubelt as ub
>>> import kwarray
>>> idx_to_groupid = [('a', 'b'),  ('d', 'b'), ('a', 'b'), ('a', 'b')]
>>> (keys, groupxs) = kwarray.group_indices(idx_to_groupid)
>>> print(ub.urepr(keys, with_dtype=False))
>>> print(ub.urepr(groupxs, with_dtype=False))
[
    ('a', 'b'),
    ('d', 'b'),
]
[
    np.array([0, 2, 3]),
    np.array([1]),
]
```

kwarray.**group_items**(*item_list*, *groupid_list*, *assume_sorted=False*, *axis=None*)

Groups a list of items by group id.

Works like `ubelt.group_items()`, but with numpy optimizations. This can be quite a bit faster than using `itertools.groupby()`[1][2].

In cases where there are many lists of items to group (think column-major data), consider using *group_indices()* and *apply_grouping()* instead.

Parameters

- **item_list** (*NDArray*) – The input array of items to group. Extended typing `NDArray[Any, VT]`
- **groupid_list** (*NDArray*) – Each item is an id corresponding to the item at the same position in `item_list`. For the fastest runtime, the input array must be numeric (ideally with integer types). This list must be 1-dimensional. Extended typing `NDArray[Any, KT]`
- **assume_sorted** (*bool*) – If the input array is sorted, then setting this to True will avoid an unnecessary sorting operation and improve efficiency. Defaults to False.
- **axis** (*int | None*) – Group along a particular axis in `items` if it is n-dimensional.

Returns

mapping from groupids to corresponding items. Extended typing `Dict[KT, NDArray[Any, VT]]`.

Return type

Dict[Any, NDArray]

[1] http://stackoverflow.com/questions/4651683/

[2] numpy-grouping-using-itertools-groupby-performance

References

Example

```
>>> from kwarray.util_groups import *  # NOQA
>>> items = np.array([0, 1, 2, 3, 4, 5, 6, 7, 1, 1])
>>> keys = np.array( [2, 2, 1, 1, 0, 1, 0, 1, 1, 1])
>>> grouped = group_items(items, keys)
>>> print('grouped = ' + ub.urepr(grouped, nl=1, with_dtype=False, sort=1))
grouped = {
    0: np.array([4, 6]),
    1: np.array([2, 3, 5, 7, 1, 1]),
    2: np.array([0, 1]),
}
```

kwarray.**isect_flags**(*arr*, *other*)

Check which items in an array intersect with another set of items

Parameters

- **arr** (*NDArray*) – items to check
- **other** (*Iterable*) – items to check if they exist in arr

Returns

booleans corresponding to arr indicating if any item in other
is also contained in other.

Return type
NDArray

Example

```
>>> arr = np.array([
>>>     [1, 2, 3, 4],
>>>     [5, 6, 3, 4],
>>>     [1, 1, 3, 4],
>>> ])
>>> other = np.array([1, 4, 6])
>>> mask = isect_flags(arr, other)
>>> print(mask)
[[ True False False  True]
 [False  True False  True]
 [ True  True False  True]]
```

kwarray.**iter_reduce_ufunc**(*ufunc*, *arrs*, *out=None*, *default=None*)

constant memory iteration and reduction

Applys ufunc from left to right over the input arrays

Parameters

- **ufunc** (*Callable*) – called on each pair of consecutive ndarrays
- **arrs** (*Iterator[NDArray]*) – iterator of ndarrays
- **default** (*object*) – return value when iterator is empty

Returns
if len(arrs) == 0, returns `default` if len(arrs) == 1, returns arrs[0], if len(arrs) >= 2, returns ufunc(...ufunc(ufunc(arrs[0], arrs[1]), arrs[2]),...arrs[n-1])

Return type
NDArray

Example

```
>>> arr_list = [
...     np.array([0, 1, 2, 3, 8, 9]),
...     np.array([4, 1, 2, 3, 4, 5]),
...     np.array([0, 5, 2, 3, 4, 5]),
...     np.array([1, 1, 6, 3, 4, 5]),
...     np.array([0, 1, 2, 7, 4, 5])
... ]
>>> memory = np.array([9, 9, 9, 9, 9, 9])
>>> gen_memory = memory.copy()
>>> def arr_gen(arr_list, gen_memory):
...     for arr in arr_list:
...         gen_memory[:] = arr
...         yield gen_memory
>>> print('memory = %r' % (memory,))
>>> print('gen_memory = %r' % (gen_memory,))
>>> ufunc = np.maximum
>>> res1 = iter_reduce_ufunc(ufunc, iter(arr_list), out=None)
>>> res2 = iter_reduce_ufunc(ufunc, iter(arr_list), out=memory)
>>> res3 = iter_reduce_ufunc(ufunc, arr_gen(arr_list, gen_memory), out=memory)
>>> print('res1       = %r' % (res1,))
>>> print('res2       = %r' % (res2,))
>>> print('res3       = %r' % (res3,))
>>> print('memory     = %r' % (memory,))
>>> print('gen_memory = %r' % (gen_memory,))
>>> assert np.all(res1 == res2)
>>> assert np.all(res2 == res3)
```

kwarray.**maxvalue_assignment**(*value*)

Finds the maximum value assignment based on a NxM value matrix. Any pair with a non-positive value will not be assigned.

Parameters
value (*ndarray*) – NxM matrix, value[i, j] is the value of matching i and j

Returns

tuple containing a list of assignment of rows
and columns, and the total value of the assignment.

Return type
Tuple[list, float]

CommandLine

```
xdoctest -m ~/code/kwarray/kwarray/algo_assignment.py maxvalue_assignment
```

Example

```
>>> # xdoctest: +REQUIRES(module:scipy)
>>> # Costs to match item i in set1 with item j in set2.
>>> value = np.array([
>>>     [9, 2, 1, 3],
>>>     [4, 1, 5, 5],
>>>     [9, 9, 2, 4],
>>>     [-1, -1, -1, -1],
>>> ])
>>> ret = maxvalue_assignment(value)
>>> # Note, depending on the scipy version the assignment might change
>>> # but the value should always be the same.
>>> print('Total value: {}'.format(ret[1]))
Total value: 23.0
>>> print('Assignment: {}'.format(ret[0]))  # xdoc: +IGNORE_WANT
Assignment: [(0, 0), (1, 3), (2, 1)]
```

```
>>> ret = maxvalue_assignment(np.array([[np.inf]]))
>>> print('Assignment: {}'.format(ret[0]))
>>> print('Total value: {}'.format(ret[1]))
Assignment: [(0, 0)]
Total value: inf
```

```
>>> ret = maxvalue_assignment(np.array([[0]]))
>>> print('Assignment: {}'.format(ret[0]))
>>> print('Total value: {}'.format(ret[1]))
Assignment: []
Total value: 0
```

kwarray.**mincost_assignment**(*cost*)

Finds the minimum cost assignment based on a NxM cost matrix, subject to the constraint that each row can match at most one column and each column can match at most one row. Any pair with a cost of infinity will not be assigned.

Parameters

cost (*ndarray*) – NxM matrix, cost[i, j] is the cost to match i and j

Returns

tuple containing a list of assignment of rows
and columns, and the total cost of the assignment.

Return type

Tuple[list, float]

CommandLine

```
xdoctest -m ~/code/kwarray/kwarray/algo_assignment.py mincost_assignment
```

Example

```
>>> # xdoctest: +REQUIRES(module:scipy)
>>> # Costs to match item i in set1 with item j in set2.
>>> cost = np.array([
>>>     [9, 2, 1, 9],
>>>     [4, 1, 5, 5],
>>>     [9, 9, 2, 4],
>>> ])
>>> ret = mincost_assignment(cost)
>>> print('Assignment: {}'.format(ret[0]))
>>> print('Total cost: {}'.format(ret[1]))
Assignment: [(0, 2), (1, 1), (2, 3)]
Total cost: 6
```

Example

```
>>> # xdoctest: +REQUIRES(module:scipy)
>>> cost = np.array([
>>>     [0, 0, 0, 0],
>>>     [4, 1, 5, -np.inf],
>>>     [9, 9, np.inf, 4],
>>>     [9, -2, np.inf, 4],
>>> ])
>>> ret = mincost_assignment(cost)
>>> print('Assignment: {}'.format(ret[0]))
>>> print('Total cost: {}'.format(ret[1]))
Assignment: [(0, 2), (1, 3), (2, 0), (3, 1)]
Total cost: -inf
```

Example

```
>>> # xdoctest: +REQUIRES(module:scipy)
>>> cost = np.array([
>>>     [0, 0, 0, 0],
>>>     [4, 1, 5, -3],
>>>     [1, 9, np.inf, 0.1],
>>>     [np.inf, np.inf, np.inf, 100],
>>> ])
>>> ret = mincost_assignment(cost)
>>> print('Assignment: {}'.format(ret[0]))
>>> print('Total cost: {}'.format(ret[1]))
Assignment: [(0, 2), (1, 1), (2, 0), (3, 3)]
Total cost: 102.0
```

kwarray.**mindist_assignment**(*vecs1*, *vecs2*, *p=2*)

Finds minimum cost assignment between two sets of D dimensional vectors.

Parameters

- **vecs1** (*np.ndarray*) – NxD array of vectors representing items in vecs1
- **vecs2** (*np.ndarray*) – MxD array of vectors representing items in vecs2
- **p** (*float*) – L-p norm to use. Default is 2 (aka Eucliedean)

Returns

tuple containing assignments of rows in vecs1 to
rows in vecs2, and the total distance between assigned pairs.

Return type
Tuple[list, float]

Note: Thin wrapper around mincost_assignment

CommandLine

```
xdoctest -m ~/code/kwarray/kwarray/algo_assignment.py mindist_assignment
```

CommandLine

```
xdoctest -m ~/code/kwarray/kwarray/algo_assignment.py mindist_assignment
```

Example

```
>>> # xdoctest: +REQUIRES(module:scipy)
>>> # Rows are detections in img1, cols are detections in img2
>>> rng = np.random.RandomState(43)
>>> vecs1 = rng.randint(0, 10, (5, 2))
>>> vecs2 = rng.randint(0, 10, (7, 2))
>>> ret = mindist_assignment(vecs1, vecs2)
>>> print('Total error: {:.4f}'.format(ret[1]))
Total error: 8.2361
>>> print('Assignment: {}'.format(ret[0]))  # xdoc: +IGNORE_WANT
Assignment: [(0, 0), (1, 3), (2, 5), (3, 2), (4, 6)]
```

kwarray.**normalize**(*arr*, *mode='linear'*, *alpha=None*, *beta=None*, *out=None*, *min_val=None*, *max_val=None*)

Normalizes input values based on a specified scheme.

The default behavior is a linear normalization between 0.0 and 1.0 based on the min/max values of the input. Parameters can be specified to achieve more general constrat stretching or signal rebalancing. Implements the linear and sigmoid normalization methods described in [WikiNorm].

Parameters

- **arr** (*NDArray*) – array to normalize, usually an image

- **out** (*NDArray | None*) – output array. Note, that we will create an internal floating point copy for integer computations.
- **mode** (*str*) – either linear or sigmoid.
- **alpha** (*float*) – Only used if mode=sigmoid. Division factor (pre-sigmoid). If unspecified computed as: `max(abs(old_min - beta), abs(old_max - beta)) / 6.212606`. Note this parameter is sensitive to if the input is a float or uint8 image.
- **beta** (*float*) – subtractive factor (pre-sigmoid). This should be the intensity of the most interesting bits of the image, i.e. bring them to the center (0) of the distribution. Defaults to `(max - min) / 2`. Note this parameter is sensitive to if the input is a float or uint8 image.
- **min_val** – inputs lower than this minimum value are clipped
- **max_val** – inputs higher than this maximum value are clipped.

SeeAlso:

find_robust_normalizers() **- determine robust parameters for** normalize to mitigate the effect of outliers.

robust_normalize() **- finds and applies robust normalization** parameters

References

Example

```
>>> raw_f = np.random.rand(8, 8)
>>> norm_f = normalize(raw_f)
```

```
>>> raw_f = np.random.rand(8, 8) * 100
>>> norm_f = normalize(raw_f)
>>> assert isclose(norm_f.min(), 0)
>>> assert isclose(norm_f.max(), 1)
```

```
>>> raw_u = (np.random.rand(8, 8) * 255).astype(np.uint8)
>>> norm_u = normalize(raw_u)
```

Example

```
>>> # xdoctest: +REQUIRES(module:kwimage)
>>> import kwimage
>>> arr = kwimage.grab_test_image('lowcontrast')
>>> arr = kwimage.ensure_float01(arr)
>>> norms = {}
>>> norms['arr'] = arr.copy()
>>> norms['linear'] = normalize(arr, mode='linear')
>>> # xdoctest: +REQUIRES(module:scipy)
>>> norms['sigmoid'] = normalize(arr, mode='sigmoid')
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
```

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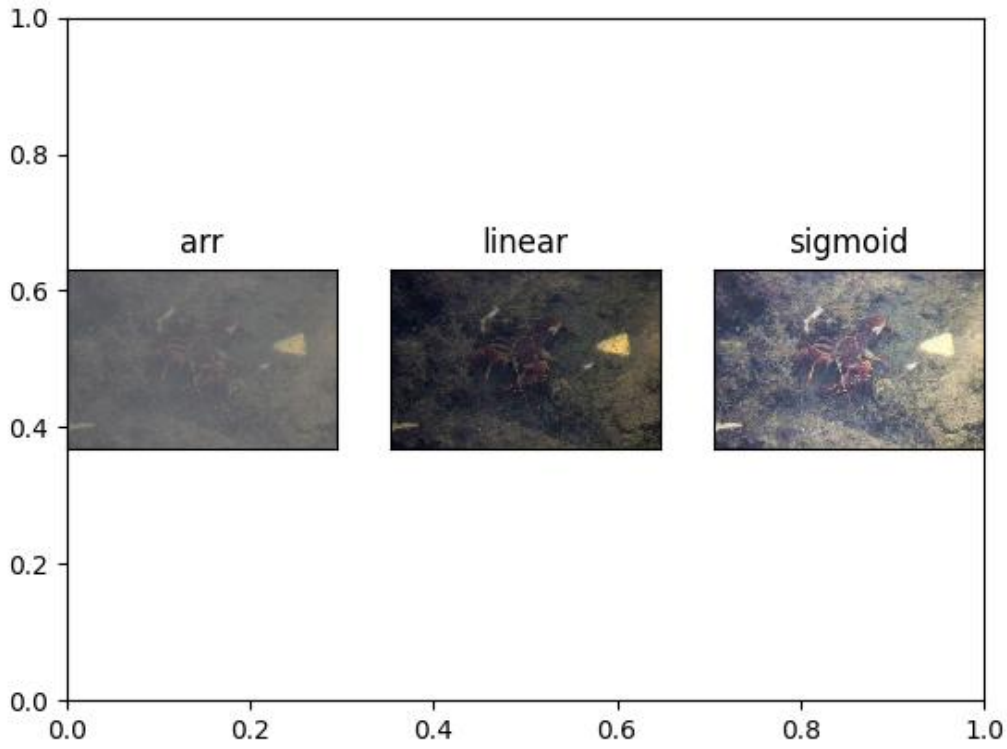
```
>>> kwplot.autompl()
>>> kwplot.figure(fnum=1, doclf=True)
>>> pnum_ = kwplot.PlotNums(nSubplots=len(norms))
>>> for key, img in norms.items():
>>>     kwplot.imshow(img, pnum=pnum_(), title=key)
```



Example

```
>>> # xdoctest: +REQUIRES(module:kwimage)
>>> arr = np.array([np.inf])
>>> normalize(arr, mode='linear')
>>> # xdoctest: +REQUIRES(module:scipy)
>>> normalize(arr, mode='sigmoid')
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.figure(fnum=1, doclf=True)
>>> pnum_ = kwplot.PlotNums(nSubplots=len(norms))
>>> for key, img in norms.items():
>>>     kwplot.imshow(img, pnum=pnum_(), title=key)
```

Benchmark

```
>>> # Our method is faster than standard in-line implementations for
>>> # uint8 and competative with in-line float32, in addition to being
>>> # more concise and configurable. In 3.11 all inplace variants are
>>> # faster.
>>> # xdoctest: +REQUIRES(module:kwimage)
>>> import timerit
>>> import kwimage
>>> import kwarray
>>> ti = timerit.Timerit(1000, bestof=10, verbose=2, unit='ms')
>>> arr = kwimage.grab_test_image('lowcontrast', dsize=(512, 512))
>>> #
>>> arr = kwimage.ensure_float01(arr)
>>> out = arr.copy()
>>> for timer in ti.reset('inline_naive(float)'):
>>>     with timer:
>>>         (arr - arr.min()) / (arr.max() - arr.min())
>>> #
>>> for timer in ti.reset('inline_faster(float)'):
>>>     with timer:
>>>         max_ = arr.max()
>>>         min_ = arr.min()
>>>         result = (arr - min_) / (max_ - min_)
>>> #
>>> for timer in ti.reset('kwarray.normalize(float)'):
>>>     with timer:
>>>         kwarray.normalize(arr)
>>> #
>>> for timer in ti.reset('kwarray.normalize(float, inplace)'):
>>>     with timer:
>>>         kwarray.normalize(arr, out=out)
>>> #
>>> arr = kwimage.ensure_uint255(arr)
>>> out = arr.copy()
>>> for timer in ti.reset('inline_naive(uint8)'):
>>>     with timer:
>>>         (arr - arr.min()) / (arr.max() - arr.min())
>>> #
>>> for timer in ti.reset('inline_faster(uint8)'):
>>>     with timer:
>>>         max_ = arr.max()
>>>         min_ = arr.min()
>>>         result = (arr - min_) / (max_ - min_)
>>> #
>>> for timer in ti.reset('kwarray.normalize(uint8)'):
>>>     with timer:
>>>         kwarray.normalize(arr)
>>> #
>>> for timer in ti.reset('kwarray.normalize(uint8, inplace)'):
>>>     with timer:
>>>         kwarray.normalize(arr, out=out)
>>> print('ti.rankings = {}'.format(ub.urepr(
```

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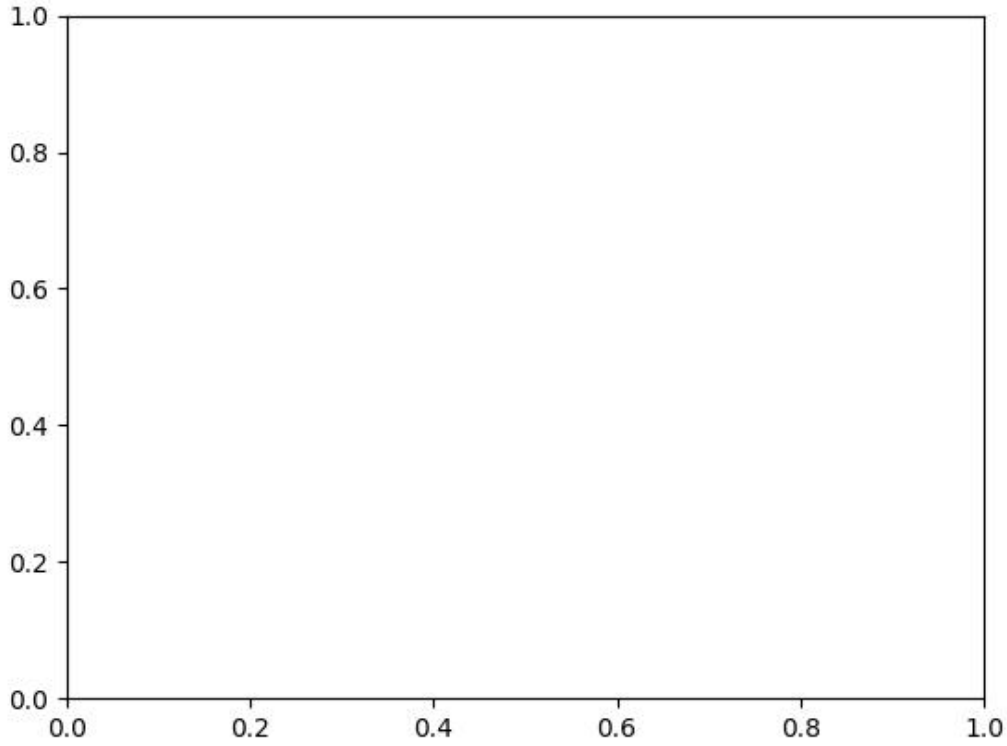
```
>>>     ti.rankings, nl=2, align=':', precision=5)))
```



kwarray.**one_hot_embedding**(*labels*, *num_classes*, *dim=1*)

Embedding labels to one-hot form.

Parameters

- **labels** – (LongTensor) class labels, sized [N,].
- **num_classes** – (int) number of classes.
- **dim** (*int*) – dimension which will be created, if negative

Returns

encoded labels, sized [N,#classes].

Return type

Tensor

References

https://discuss.pytorch.org/t/convert-int-into-one-hot-format/507/4

Example

```
>>> # each element in target has to have 0 <= value < C
>>> # xdoctest: +REQUIRES(module:torch)
>>> import torch
>>> labels = torch.LongTensor([0, 0, 1, 4, 2, 3])
>>> num_classes = max(labels) + 1
>>> t = one_hot_embedding(labels, num_classes)
>>> assert all(row[y] == 1 for row, y in zip(t.numpy(), labels.numpy()))
>>> import ubelt as ub
>>> print(ub.urepr(t.numpy().tolist()))
[
    [1.0, 0.0, 0.0, 0.0, 0.0],
    [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, 1.0],
    [0.0, 0.0, 1.0, 0.0, 0.0],
    [0.0, 0.0, 0.0, 1.0, 0.0],
]
>>> t2 = one_hot_embedding(labels.numpy(), num_classes)
>>> assert np.all(t2 == t.numpy())
>>> from kwarray.util_torch import _torch_available_devices
>>> devices = _torch_available_devices()
>>> if devices:
>>>     device = devices[0]
>>>     try:
>>>         t3 = one_hot_embedding(labels.to(device), num_classes)
>>>     except RuntimeError:
>>>         pass
>>>     assert np.all(t3.cpu().numpy() == t.numpy())
```

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> import torch
>>> nC = num_classes = 3
>>> labels = (torch.rand(10, 11, 12) * nC).long()
>>> assert one_hot_embedding(labels, nC, dim=0).shape == (3, 10, 11, 12)
>>> assert one_hot_embedding(labels, nC, dim=1).shape == (10, 3, 11, 12)
>>> assert one_hot_embedding(labels, nC, dim=2).shape == (10, 11, 3, 12)
>>> assert one_hot_embedding(labels, nC, dim=3).shape == (10, 11, 12, 3)
>>> labels = (torch.rand(10, 11) * nC).long()
>>> assert one_hot_embedding(labels, nC, dim=0).shape == (3, 10, 11)
>>> assert one_hot_embedding(labels, nC, dim=1).shape == (10, 3, 11)
>>> labels = (torch.rand(10) * nC).long()
>>> assert one_hot_embedding(labels, nC, dim=0).shape == (3, 10)
>>> assert one_hot_embedding(labels, nC, dim=1).shape == (10, 3)
```

kwarray.**one_hot_lookup**(*data*, *indices*)

Return value of a particular column for each row in data.

Each item in labels corresonds to a row in `data`. Returns the index specified at each row.

Parameters

- **data** (*ArrayLike*) – N x C float array of values
- **indices** (*ArrayLike*) – N integer array between 0 and C. This is an column index for each row in `data`.

Returns
the selected probability for each row

Return type
ArrayLike

Note: This is functionally equivalent to `[row[c] for row, c in zip(data, indices)]` except that it is works with pure matrix operations.

Todo:

- **[ ] Allow the user to specify which dimension indices should be** zipped over. By default it should be dim=0
- **[ ] Allow the user to specify which dimension indices should select** from. By default it should be dim=1.

Example

```
>>> from kwarray.util_torch import *  # NOQA
>>> data = np.array([
>>>     [0, 1, 2],
>>>     [3, 4, 5],
>>>     [6, 7, 8],
>>>     [9, 10, 11],
>>> ])
>>> indices = np.array([0, 1, 2, 1])
>>> res = one_hot_lookup(data, indices)
>>> print('res = {!r}'.format(res))
res = array([ 0,  4,  8, 10])
>>> alt = np.array([row[c] for row, c in zip(data, indices)])
>>> assert np.all(alt == res)
```

Example

```
>>> # xdoctest: +REQUIRES(module:torch)
>>> import torch
>>> data = torch.from_numpy(np.array([
>>>     [0, 1, 2],
>>>     [3, 4, 5],
>>>     [6, 7, 8],
>>>     [9, 10, 11],
>>> ]))
>>> indices = torch.from_numpy(np.array([0, 1, 2, 1])).long()
>>> res = one_hot_lookup(data, indices)
>>> print('res = {!r}'.format(res))
res = tensor([ 0,  4,  8, 10]...)
>>> alt = torch.LongTensor([row[c] for row, c in zip(data, indices)])
>>> assert torch.all(alt == res)
```

kwarray.**padded_slice**(*data*, *slices*, *pad=None*, *padkw=None*, *return_info=False*)

Allows slices with out-of-bound coordinates. Any out of bounds coordinate will be sampled via padding.

Parameters

- **data** (*Sliceable*) – data to slice into. Any channels must be the last dimension.
- **slices** (*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, default=False*) – if True, return extra information about the transform.

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.

SeeAlso:

embed_slice - finds the embedded slice and padding

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

```
>>> import kwarray
>>> data = np.arange(5)
>>> slices = [slice(-2, 7)]
```

```
>>> data_sliced = kwarray.padded_slice(data, slices)
>>> print(ub.urepr(data_sliced, with_dtype=False))
np.array([0, 0, 0, 1, 2, 3, 4, 0, 0])
```

```
>>> data_sliced = kwarray.padded_slice(data, slices, pad=[(3, 3)])
>>> print(ub.urepr(data_sliced, with_dtype=False))
np.array([0, 0, 0, 0, 0, 0, 1, 2, 3, 4, 0, 0, 0, 0, 0])
```

```
>>> data_sliced = kwarray.padded_slice(data, slice(3, 4), pad=[(1, 0)])
>>> print(ub.urepr(data_sliced, with_dtype=False))
np.array([2, 3])
```

kwarray.**random_combinations**(*items*, *size*, *num=None*, *rng=None*)

Yields `num` combinations of length `size` from items in random order

Parameters

- **items** (*List*) – pool of items to choose from
- **size** (*int*) – Number of items in each combination
- **num** (*int | None*) – Number of combinations to generate. If None, generate them all.
- **rng** (*int | float | None | numpy.random.RandomState | random.Random*) – seed or random number generator. Defaults to the global state of the python random module.

Yields
Tuple – a random combination of `items` of length `size`.

Example

```
>>> # xdoctest: +REQUIRES(module:scipy)
>>> import ubelt as ub
>>> items = list(range(10))
>>> size = 3
>>> num = 5
>>> rng = 0
>>> # xdoctest: +IGNORE_WANT
>>> combos = list(random_combinations(items, size, num, rng))
>>> print('combos = {}'.format(ub.urepr(combos, nl=1)))
combos = [
    (0, 6, 9),
    (4, 7, 8),
    (4, 6, 7),
```

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```
    (2, 3, 5),
    (1, 2, 4),
]
```

Example

```
>>> # xdoctest: +REQUIRES(module:scipy)
>>> import ubelt as ub
>>> items = list(zip(range(10), range(10)))
>>> # xdoctest: +IGNORE_WANT
>>> combos = list(random_combinations(items, 3, num=5, rng=0))
>>> print('combos = {}'.format(ub.urepr(combos, nl=1)))
combos = [
    ((0, 0), (6, 6), (9, 9)),
    ((4, 4), (7, 7), (8, 8)),
    ((4, 4), (6, 6), (7, 7)),
    ((2, 2), (3, 3), (5, 5)),
    ((1, 1), (2, 2), (4, 4)),
]
```

kwarray.**random_product**(*items*, *num=None*, *rng=None*)

Yields num items from the cartesian product of items in a random order.

Parameters

- **items** (*List[Sequence]*) – items to get caresian product of packed in a list or tuple. (note this deviates from api of `itertools.product()`)
- **num** (*int | None*) – maximum number of items to generate. If None generat them all
- **rng** (*int | float | None | numpy.random.RandomState | random.Random*) – Seed or random number generator. Defaults to the global state of the python random module.

Yields

Tuple – a random item in the cartesian product

Example

```
>>> import ubelt as ub
>>> items = [(1, 2, 3), (4, 5, 6, 7)]
>>> rng = 0
>>> # xdoctest: +IGNORE_WANT
>>> products = list(random_product(items, rng=0))
>>> print(ub.urepr(products, nl=0))
[(3, 4), (1, 7), (3, 6), (2, 7),... (1, 6), (2, 5), (2, 4)]
>>> products = list(random_product(items, num=3, rng=0))
>>> print(ub.urepr(products, nl=0))
[(3, 4), (1, 7), (3, 6)]
```

Example

```
>>> # xdoctest: +REQUIRES(--profile)
>>> rng = ensure_rng(0)
>>> items = [np.array([15, 14]), np.array([27, 26]),
>>>          np.array([21, 22]), np.array([32, 31])]
>>> num = 2
>>> for _ in range(100):
>>>     list(random_product(items, num=num, rng=rng))
```

kwarray.**robust_normalize**(*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:

- [x] 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 mid, scaling, extrema e.g. {'low': 0.1, 'mid': 0.8, 'high': 0.9, 'scaling': 'sigmoid'} See documentation in *find_robust_normalizers()*.
- **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. Note this is the opposite of a masked array.

Returns

a floating point array with values between 0 and 1. if return_info is specified, also returns extra data

Return type

ndarray | Tuple[ndarray, Any]

Note: This is effectively a combination of *find_robust_normalizers()* and *normalize()*.

Example

```
>>> # xdoctest: +REQUIRES(module:scipy)
>>> from kwarray.util_robust import *  # NOQA
>>> from kwarray.distributions import Mixture
>>> import ubelt as ub
>>> # A random mixture distribution for testing
>>> data = Mixture.random(6).sample(3000)
>>> param_basis = {
>>>     'scaling': ['linear', 'sigmoid'],
>>>     'high': [0.6, 0.8, 0.9, 1.0],
>>> }
>>> param_grid = list(ub.named_product(param_basis))
>>> param_grid += ['auto']
>>> param_grid += ['tukey']
>>> rows = []
>>> rows.append({'key': 'orig', 'result': data})
>>> for params in param_grid:
>>>     key = ub.urepr(params, compact=1)
>>>     result, info = robust_normalize(data, return_info=True, params=params)
>>>     print('key = {}'.format(key))
>>>     print('info = {}'.format(ub.urepr(info, nl=1)))
>>>     rows.append({'key': key, 'info': info, 'result': result})
>>> # xdoctest: +REQUIRES(--show)
>>> import seaborn as sns
>>> import kwplot
>>> kwplot.autompl()
>>> pnum_ = kwplot.PlotNums(nSubplots=len(rows))
>>> for row in rows:
>>>     ax = kwplot.figure(fnum=1, pnum=pnum_()).gca()
>>>     sns.histplot(data=row['result'], kde=True, bins=128, ax=ax, stat='density')
>>>     ax.set_title(row['key'])
```

Example

```
>>> # xdoctest: +REQUIRES(module:kwimage)
>>> from kwarray.util_robust 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)
```

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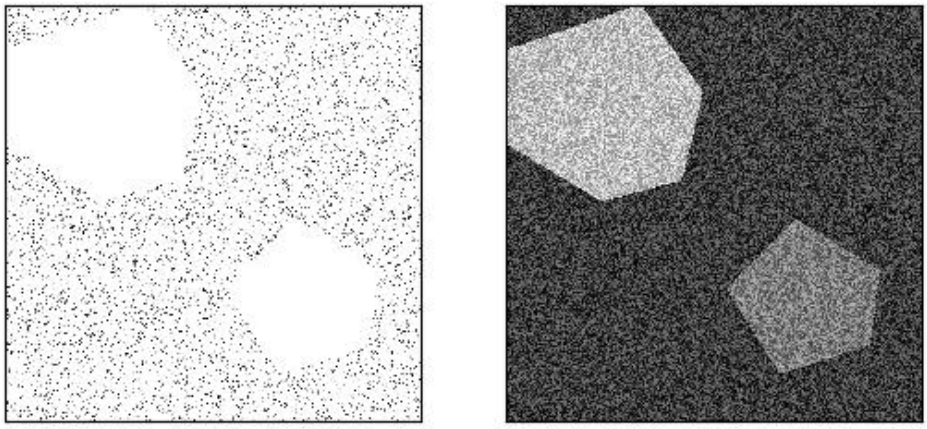
```
>>> forground = poly2.fill(forground, value=122)
>>> forground = (kwimage.ensure_float01(forground) * max_val).astype(dtype)
>>> imdata = background + forground
>>> normed, info = kwarray.robust_normalize(imdata, return_info=True)
>>> print('info = {}'.format(ub.urepr(info, nl=1)))
>>> # xdoctest: +REQUIRES(--show)
>>> import kwplot
>>> kwplot.autompl()
>>> kwplot.imshow(imdata, pnum=(1, 2, 1), fnum=1)
>>> kwplot.imshow(normed, pnum=(1, 2, 2), fnum=1)
```



kwarray.**seed_global**(*seed*, *offset=0*)

Seeds the python, numpy, and torch global random states

Parameters

- **seed** (*int*) – seed to use
- **offset** (*int*) – if specified, uses a different seed for each global random state separated by this offset. Defaults to 0.

kwarray.**setcover**(*candidate_sets_dict*, *items=None*, *set_weights=None*, *item_values=None*, *max_weight=None*, *algo='approx'*)

Finds a feasible solution to the minimum weight maximum value set cover. The quality and runtime of the solution will depend on the backend algorithm selected.

Parameters

- **candidate_sets_dict** (*Dict[KT, List[VT]]*) – a dictionary where keys are the candidate set ids and each value is a candidate cover set.
- **items** (*Optional[VT]*) – the set of all items to be covered, if not specified, it is infered from the candidate cover sets
- **set_weights** (*Optional[Dict[KT, float]]*) – maps candidate set ids to a cost for using this candidate cover in the solution. If not specified the weight of each candiate cover defaults to 1.
- **item_values** (*Optional[Dict[VT, float]]*) – maps each item to a value we get for returning this item in the solution. If not specified the value of each item defaults to 1.
- **max_weight** (*Optional[float]*) – if specified, the total cost of the returned cover is constrained to be less than this number.
- **algo** (*str*) – specifies which algorithm to use. Can either be 'approx' for the greedy solution or 'exact' for the globally optimal solution. Note the 'exact' algorithm solves an integer-linear-program, which can be very slow and requires the *pulp* package to be installed.

Returns
a subdict of candidate_sets_dict containing the chosen solution.

Return type
Dict

Example

```
>>> candidate_sets_dict = {
>>>     'a': [1, 2, 3, 8, 9, 0],
>>>     'b': [1, 2, 3, 4, 5],
>>>     'c': [4, 5, 7],
>>>     'd': [5, 6, 7],
>>>     'e': [6, 7, 8, 9, 0],
>>> }
>>> greedy_soln = setcover(candidate_sets_dict, algo='greedy')
>>> print('greedy_soln = {}'.format(ub.urepr(greedy_soln, nl=0)))
greedy_soln = {'a': [1, 2, 3, 8, 9, 0], 'c': [4, 5, 7], 'd': [5, 6, 7]}
>>> # xdoc: +REQUIRES(module:pulp)
>>> exact_soln = setcover(candidate_sets_dict, algo='exact')
>>> print('exact_soln = {}'.format(ub.urepr(exact_soln, nl=0)))
exact_soln = {'b': [1, 2, 3, 4, 5], 'e': [6, 7, 8, 9, 0]}
```

kwarray.**shuffle**(*items*, *rng=None*)

Shuffles a list inplace and then returns it for convinience

Parameters

- **items** (*list | ndarray*) – data to shuffle
- **rng** (*int | float | None | numpy.random.RandomState | random.Random*) – seed or random number gen

Returns
this is the input, but returned for convinience

Return type
list

Example

```
>>> list1 = [1, 2, 3, 4, 5, 6]
>>> list2 = shuffle(list(list1), rng=1)
>>> assert list1 != list2
>>> result = str(list2)
>>> print(result)
[3, 2, 5, 1, 4, 6]
```

kwarray.**standard_normal**(*size*, *mean=0*, *std=1*, *dtype=<class 'float'>*, *rng=<module 'numpy.random' from '/home/docs/checkouts/readthedocs.org/user_builds/kwarray/envs/release/lib/python3.11/site-packages/numpy/random/__init__.py'>*)

Draw samples from a standard Normal distribution with a specified mean and standard deviation.

Parameters

- **size** (*int | Tuple[int, ...]*) – shape of the returned ndarray
- **mean** (*float*) – mean of the normal distribution. defaults to 0
- **std** (*float*) – standard deviation of the normal distribution. defaults to 1.
- **dtype** (*type*) – either np.float32 (default) or np.float64
- **rng** (*numpy.random.RandomState*) – underlying random state

Returns
normally distributed random numbers with chosen size and dtype Extended typing `NDArray[Literal[size], Literal[dtype]]`

Return type
ndarray

Benchmark

```
>>> from timerit import Timerit
>>> import kwarray
>>> size = (300, 300, 3)
>>> for timer in Timerit(100, bestof=10, label='dtype=np.float32'):
>>>     rng = kwarray.ensure_rng(0)
>>>     with timer:
>>>         ours = standard_normal(size, rng=rng, dtype=np.float32)
>>> # Timed best=4.705 ms, mean=4.75 ± 0.085 ms for dtype=np.float32
>>> for timer in Timerit(100, bestof=10, label='dtype=np.float64'):
>>>     rng = kwarray.ensure_rng(0)
>>>     with timer:
>>>         theirs = standard_normal(size, rng=rng, dtype=np.float64)
>>> # Timed best=9.327 ms, mean=9.794 ± 0.4 ms for rng.np.float64
```

kwarray.**standard_normal32**(*size*, *mean=0*, *std=1*, *rng=<module 'numpy.random' from '/home/docs/checkouts/readthedocs.org/user_builds/kwarray/envs/release/lib/python3.11/site-packages/numpy/random/__init__.py'>*)

Fast normally distributed random variables.

Uses the Box–Muller transform [WikiBoxMuller].

The difference between this function and `numpy.random.standard_normal()` is that we use float32 arrays in the backend instead of float64. Halving the amount of bits that need to be manipulated can significantly reduce the execution time, and 32-bit precision is often good enough.

Parameters

- **size** (*int | Tuple[int, ...]*) – shape of the returned ndarray
- **mean** (*float, default=0*) – mean of the normal distribution
- **std** (*float, default=1*) – standard deviation of the normal distribution
- **rng** (*numpy.random.RandomState*) – underlying random state

Returns

normally distributed random numbers with chosen size.

Return type

ndarray[Any, Float32]

References

SeeAlso:

- *standard_normal()*
- *standard_normal64()*

Example

```
>>> # xdoctest: +REQUIRES(module:scipy)
>>> import scipy
>>> import scipy.stats
>>> pts = 1000
>>> # Our numbers are normally distributed with high probability
>>> rng = np.random.RandomState(28041990)
>>> ours_a = standard_normal32(pts, rng=rng)
>>> ours_b = standard_normal32(pts, rng=rng) + 2
>>> ours = np.concatenate((ours_a, ours_b))  # numerical stability?
>>> p = scipy.stats.normaltest(ours)[1]
>>> print('Probability our data is non-normal is: {:.4g}'.format(p))
Probability our data is non-normal is: 1.573e-14
>>> rng = np.random.RandomState(28041990)
>>> theirs_a = rng.standard_normal(pts)
>>> theirs_b = rng.standard_normal(pts) + 2
>>> theirs = np.concatenate((theirs_a, theirs_b))
>>> p = scipy.stats.normaltest(theirs)[1]
>>> print('Probability their data is non-normal is: {:.4g}'.format(p))
Probability their data is non-normal is: 3.272e-11
```

Example

```
>>> pts = 1000
>>> rng = np.random.RandomState(28041990)
>>> ours = standard_normal32(pts, mean=10, std=3, rng=rng)
>>> assert np.abs(ours.std() - 3.0) < 0.1
>>> assert np.abs(ours.mean() - 10.0) < 0.1
```

Example

```
>>> # Test an even and odd numbers of points
>>> assert standard_normal32(3).shape == (3,)
>>> assert standard_normal32(2).shape == (2,)
>>> assert standard_normal32(1).shape == (1,)
>>> assert standard_normal32(0).shape == (0,)
>>> assert standard_normal32((3, 1)).shape == (3, 1)
>>> assert standard_normal32((3, 0)).shape == (3, 0)
```

kwarray.**standard_normal64**(*size*, *mean=0*, *std=1*, *rng=<module 'numpy.random' from '/home/docs/checkouts/readthedocs.org/user_builds/kwarray/envs/release/lib/python3.11/site-packages/numpy/random/__init__.py'>*)

Simple wrapper around rng.standard_normal to make an API compatible with *standard_normal32()*.

Parameters

- **size** (*int | Tuple[int, ...]*) – shape of the returned ndarray
- **mean** (*float*) – mean of the normal distribution. defaults to 0
- **std** (*float*) – standard deviation of the normal distribution. defaults to 1.
- **rng** (*numpy.random.RandomState*) – underlying random state

Returns

normally distributed random numbers with chosen size.

Return type

ndarray[Any, Float64]

SeeAlso:

- standard_normal
- standard_normal32

Example

```
>>> pts = 1000
>>> rng = np.random.RandomState(28041994)
>>> out = standard_normal64(pts, mean=10, std=3, rng=rng)
>>> assert np.abs(out.std() - 3.0) < 0.1
>>> assert np.abs(out.mean() - 10.0) < 0.1
```

kwarray.**stats_dict**(*inputs*, *axis=None*, *nan=False*, *sum=False*, *extreme=True*, *n_extreme=False*, *median=False*, *shape=True*, *size=False*, *quantile='auto'*)

Describe statistics about an input array

Parameters

- **inputs** (*ArrayLike*) – set of values to get statistics of
- **axis** (*int*) – if `inputs` is ndarray then this specifies the axis
- **nan** (*bool*) – report number of nan items (TODO: rename to skipna)
- **sum** (*bool*) – report sum of values
- **extreme** (*bool*) – report min and max values
- **n_extreme** (*bool*) – report extreme value frequencies
- **median** (*bool*) – report median
- **size** (*bool*) – report array size
- **shape** (*bool*) – report array shape
- **quantile** (*str | bool | List[float]*) – defaults to 'auto'. Can also be a list of quantiles to compute. if truthy computes quantiles.

Returns

dictionary of common numpy statistics (min, max, mean, std, nMin, nMax, shape)

Return type

collections.OrderedDict

SeeAlso:

`scipy.stats.describe()` `pandas.DataFrame.describe()`

Example

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> from kwarray.util_averages import *  # NOQA
>>> axis = 0
>>> rng = np.random.RandomState(0)
>>> inputs = rng.rand(10, 2).astype(np.float32)
>>> stats = stats_dict(inputs, axis=axis, nan=False, median=True)
>>> import ubelt as ub  # NOQA
>>> result = str(ub.urepr(stats, nl=1, precision=4, with_dtype=True))
>>> print(result)
{
    'mean': np.array([[0.5206, 0.6425]], dtype=np.float32),
    'std': np.array([[0.2854, 0.2517]], dtype=np.float32),
    'min': np.array([[0.0202, 0.0871]], dtype=np.float32),
    'max': np.array([[0.9637, 0.9256]], dtype=np.float32),
    'q_0.25': np.array([0.4271, 0.5329], dtype=np.float64),
    'q_0.50': np.array([0.5584, 0.6805], dtype=np.float64),
    'q_0.75': np.array([0.7343, 0.8607], dtype=np.float64),
    'med': np.array([0.5584, 0.6805], dtype=np.float32),
    'shape': (10, 2),
}
```

Example

```
>>> # xdoctest: +IGNORE_WHITESPACE
>>> from kwarray.util_averages import *  # NOQA
>>> axis = 0
>>> rng = np.random.RandomState(0)
>>> inputs = rng.randint(0, 42, size=100).astype(np.float32)
>>> inputs[4] = np.nan
>>> stats = stats_dict(inputs, axis=axis, nan=True, quantile='auto')
>>> import ubelt as ub  # NOQA
>>> result = str(ub.urepr(stats, nl=0, precision=1, strkeys=True))
>>> print(result)
```

Example

```
>>> import kwarray
>>> import ubelt as ub
>>> rng = kwarray.ensure_rng(0)
>>> orig_inputs = rng.rand(1, 1, 2, 3)
>>> param_grid = ub.named_product({
>>>     #'axis': (None, 0, (0, 1), -1),
>>>     'axis': [None],
>>>     'percent_nan': [0, 0.5, 1.0],
>>>     'nan': [True, False],
>>>     'sum': [1],
>>>     'extreme': [True],
>>>     'n_extreme': [True],
>>>     'median': [1],
>>>     'size': [1],
>>>     'shape': [1],
>>>     'quantile': ['auto'],
>>> })
>>> for params in param_grid:
>>>     kwargs = params.copy()
>>>     percent_nan = kwargs.pop('percent_nan', 0)
>>>     if percent_nan:
>>>         inputs = orig_inputs.copy()
>>>         inputs[rng.rand(*inputs.shape) < percent_nan] = np.nan
>>>     else:
>>>         inputs = orig_inputs
>>>     stats = kwarray.stats_dict(inputs, **kwargs)
>>>     print('---')
>>>     print('params = {}'.format(ub.urepr(params, nl=1)))
>>>     print('stats = {}'.format(ub.urepr(stats, nl=1)))
```

kwarray.**uniform**(*low=0.0*, *high=1.0*, *size=None*, *dtype=<class 'numpy.float32'>*, *rng=<module 'numpy.random' from '/home/docs/checkouts/readthedocs.org/user_builds/kwarray/envs/release/lib/python3.11/site-packages/numpy/random/__init__.py'>*)

Draws float32 samples from a uniform distribution.

Samples are uniformly distributed over the half-open interval `[low, high)` (includes low, but excludes high).

Parameters

- **low** (*float*) – Lower boundary of the output interval. All values generated will be greater than or equal to low. Defaults to 0.
- **high** (*float*) – Upper boundary of the output interval. All values generated will be less than high. Default to 1.
- **size** (*int | Tuple[int, ...] | None*) – Output shape. If the given shape is, e.g., `(m, n, k)`, then `m * n * k` samples are drawn. If size is `None` (default), a single value is returned if `low` and `high` are both scalars. Otherwise, `np.broadcast(low, high).size` samples are drawn.
- **dtype** (*type*) – either np.float32 or np.float64. Defaults to float32
- **rng** (*numpy.random.RandomState*) – underlying random state

Returns

uniformly distributed random numbers with chosen size and dtype Extended typing `NDArray[Literal[size], Literal[dtype]]`

Return type

ndarray

Benchmark

```
>>> from timerit import Timerit
>>> import kwarray
>>> size = (300, 300, 3)
>>> for timer in Timerit(100, bestof=10, label='dtype=np.float32'):
>>>     rng = kwarray.ensure_rng(0)
>>>     with timer:
>>>         ours = standard_normal(size, rng=rng, dtype=np.float32)
>>> # Timed best=4.705 ms, mean=4.75 ± 0.085 ms for dtype=np.float32
>>> for timer in Timerit(100, bestof=10, label='dtype=np.float64'):
>>>     rng = kwarray.ensure_rng(0)
>>>     with timer:
>>>         theirs = standard_normal(size, rng=rng, dtype=np.float64)
>>> # Timed best=9.327 ms, mean=9.794 ± 0.4 ms for rng.np.float64
```

kwarray.**uniform32**(*low=0.0*, *high=1.0*, *size=None*, *rng=<module 'numpy.random' from '/home/docs/checkouts/readthedocs.org/user_builds/kwarray/envs/release/lib/python3.11/site-packages/numpy/random/__init__.py'>*)

Draws float32 samples from a uniform distribution.

Samples are uniformly distributed over the half-open interval `[low, high)` (includes low, but excludes high).

Parameters

- **low** (*float, default=0.0*) – Lower boundary of the output interval. All values generated will be greater than or equal to low.
- **high** (*float, default=1.0*) – Upper boundary of the output interval. All values generated will be less than high.
- **size** (*int | Tuple[int, ...] | None*) – Output shape. If the given shape is, e.g., `(m, n, k)`, then `m * n * k` samples are drawn. If size is `None` (default), a single value is returned if `low` and `high` are both scalars. Otherwise, `np.broadcast(low, high).size` samples are drawn.

Returns
uniformly distributed random numbers with chosen size.

Return type
ndarray[Any, Float32]

Example

```
>>> rng = np.random.RandomState(0)
>>> uniform32(low=0.0, high=1.0, size=None, rng=rng)
0.5488...
>>> uniform32(low=0.0, high=1.0, size=2000, rng=rng).sum()
1004.94...
>>> uniform32(low=-10, high=10.0, size=2000, rng=rng).sum()
202.44...
```

Benchmark

```
>>> from timerit import Timerit
>>> import kwarray
>>> size = 512 * 512
>>> for timer in Timerit(100, bestof=10, label='theirs: dtype=np.float64'):
>>>     rng = kwarray.ensure_rng(0)
>>>     with timer:
>>>         theirs = rng.uniform(size=size)
>>> for timer in Timerit(100, bestof=10, label='theirs: dtype=np.float32'):
>>>     rng = kwarray.ensure_rng(0)
>>>     with timer:
>>>         theirs = rng.rand(size).astype(np.float32)
>>> for timer in Timerit(100, bestof=10, label='ours: dtype=np.float32'):
>>>     rng = kwarray.ensure_rng(0)
>>>     with timer:
>>>         ours = uniform32(size=size)
```

kwarray.**unique_rows**(*arr*, *ordered=False*, *return_index=False*)

Like unique, but works on rows

Parameters

- **arr** (*NDArray*) – must be a contiguous C style array
- **ordered** (*bool*) – if true, keeps relative ordering

References

https://stackoverflow.com/questions/16970982/find-unique-rows-in-numpy-array

Example

```
>>> import kwarray
>>> from kwarray.util_numpy import *  # NOQA
>>> rng = kwarray.ensure_rng(0)
>>> arr = rng.randint(0, 2, size=(22, 3))
>>> arr_unique = unique_rows(arr)
>>> print('arr_unique = {!r}'.format(arr_unique))
>>> arr_unique, idxs = unique_rows(arr, return_index=True, ordered=True)
>>> assert np.all(arr[idxs] == arr_unique)
>>> print('arr_unique = {!r}'.format(arr_unique))
>>> print('idxs = {!r}'.format(idxs))
>>> arr_unique, idxs = unique_rows(arr, return_index=True, ordered=False)
>>> assert np.all(arr[idxs] == arr_unique)
>>> print('arr_unique = {!r}'.format(arr_unique))
>>> print('idxs = {!r}'.format(idxs))
```

CHAPTER

TWO

INDICES AND TABLES

- genindex
- modindex

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PYTHON MODULE INDEX

k

INDEX

Symbols

A

B

C

D

E

F

G

H

I

J

K

L

M

N

O

P

R

S

T

U

V

Z