mlpy Documentation

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CONTENTS

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`mlpy` is a high-performance Python package for predictive modeling. It makes extensive use of NumPy (http://scipy.org) to provide fast N-dimensional array manipulation and easy integration of C code. `mlpy` provides high level procedures that support, with few lines of code, the design of rich Data Analysis Protocols (DAPs) for preprocessing, clustering, predictive classification and feature selection. Methods are available for feature weighting and ranking, data resampling, error evaluation and experiment landscaping. The package includes tools to measure stability in sets of ranked feature lists.

`mlpy` is a project of the MPBA Research Unit at FBK, the Bruno Kessler Foundation in Trento, Italy (http://mpba.fbk.eu).

TUTORIAL

1.1 A Simple Example

In this example the performance of SVM classifier is evaluated in a stratified k-fold resampling schema.

First, import NumPy and mlpy modules:

```
>>> import numpy as np
>>> import mlpy
```

Then, load a data file (*data.dat*) containing 30 samples described by 100 features (*x*) and labels (*y*):

```
>>> x, y = mlpy.data_fromfile('data.dat') # import data file
>>> x.shape
(30, 100)
```

Initialize SVM classifier, specifying kernel type (*linear*) and regularization parameter (*C*):

```
>>> classifier = mlpy.Svm(kernel = 'linear', C = 1.0)   # initialize the svm classifier
```

Define a stratified 10-fold resampling schema, where *idx* contains the sample indexes (list of train/test pairs):

```
>>> idx = mlpy.kfoldS(cl = y, sets = 10)
```

Actually build train and test data. Train the model on *xtr* and test it on *xts*. The performance is evaluated computing the average prediction error:

```
>>> pred_err = 0.0
>>> for idxtr, idxts in idx:
...     xtr, xts = x[idxtr], x[idxts]       # build training data
...     ytr, yts = y[idxtr], y[idxts]       # build test data
...     ret = classifier.compute(xtr, ytr)  # compute the model
...     pred = classifier.predict(xts)      # test the model on test data
...     pred_err += mlpy.err(yts, pred)         # compute the prediction error
>>> av_pred_err = pred_err / len(idx)       # compute the average prediction error
>>> av_pred_err
0.17499999999999999
```

WAVELET TRANSFORM

2.1 Extend data

This function should be used in `dwt()` and `uwt()` to extend the length of data to power of two. `cwt()` use it as internal function.

`mlpy.`**`extend`**(*x*, *method='reflection'*, *length='powerof2'*)
Extend the 1D numpy array x beyond its original length.

> **Parameters**
>
>> **x** [1d ndarray] data
>>
>> **method** [string ('reflection', 'periodic', 'zeros')] indicates which extension method to use
>>
>> **length** [string ('powerof2', 'double')] indicates how to determinate the length of the extended data
>
> **Returns**
>
>> **xext** [1d ndarray] extended version of x

Example:

```
>>> import numpy as np
>>> import mlpy
>>> a = np.array([1,2,3,4,5])
>>> mlpy.extend(a, method='periodic', length='powerof2')
array([1, 2, 3, 4, 5, 1, 2, 3])
```

New in version 2.0.6.

2.2 Discrete Wavelet Transform

Discrete Wavelet Transform based on the GSL DWT [Gsldwt].

`mlpy.`**`dwt`**(*x*, *wf*, *k*)
Discrete Wavelet Tranform

> **Parameters**
>
>> **x** [1d ndarray float (the length is restricted to powers of two)] data
>>
>> **wf** [string ('d': daubechies, 'h': haar, 'b': bspline)] wavelet type
>>
>> **k** [integer] member of the wavelet family

- daubechies : k = 4, 6, ..., 20 with k even

- haar : the only valid choice of k is k = 2

- bspline : k = 103, 105, 202, 204, 206, 208, 301, 303, 305 307, 309

> **Returns**
>
>> **X** [1d ndarray float] discrete wavelet transformed data

Example:

```
>>> import numpy as np
>>> import mlpy
>>> x = np.array([1,2,3,4,3,2,1,0])
>>> mlpy.dwt(x=x, wf='d', k=6)
array([ 5.65685425,  3.41458985,  0.29185347, -0.29185347, -0.28310081,
        -0.07045258,  0.28310081,  0.07045258])
```

mlpy.**idwt**(*X*, *wf*, *k*)

> Inverse Discrete Wavelet Tranform
>
> **Parameters**
>
>> **X** [1d ndarray float] discrete wavelet transformed data
>>
>> **wf** [string ('d': daubechies, 'h': haar, 'b': bspline)] wavelet type
>>
>> **k** [integer] member of the wavelet family
>>
>> - daubechies : k = 4, 6, ..., 20 with k even
>>
>> - haar : the only valid choice of k is k = 2
>>
>> - bspline : k = 103, 105, 202, 204, 206, 208, 301, 303, 305 307, 309
>
> **Returns**
>
>> **x** [1d ndarray float] data

Example:

```
>>> import numpy as np
>>> import mlpy
>>> X = np.array([ 5.65685425,  3.41458985,  0.29185347, -0.29185347, -0.28310081,
...                -0.07045258,  0.28310081,  0.07045258])
>>> mlpy.idwt(X=X, wf='d', k=6)
array([  1.00000000e+00,   2.00000000e+00,   3.00000000e+00,
         4.00000000e+00,   3.00000000e+00,   2.00000000e+00,
         1.00000000e+00,  -3.53954610e-09])
```

2.3 Undecimated Wavelet Transform

Undecimated Wavelet Transform based on the "wavelets" R package.

mlpy.**uwt**(*x*, *wf*, *k*, *levels=0*)

> Undecimated Wavelet Tranform
>
> **Parameters**
>
>> **x** [1d ndarray float (the length is restricted to powers of two)] data
>>
>> **wf** [string ('d': daubechies, 'h': haar, 'b': bspline)] wavelet type

k [integer] member of the wavelet family

- daubechies : k = 4, 6, ..., 20 with k even

- haar : the only valid choice of k is k = 2

- bspline : k = 103, 105, 202, 204, 206, 208, 301, 303, 305 307, 309

levels [integer] level of the decomposition (J). If levels = 0 this is the value J such that the length of X is at least as great as the length of the level J wavelet filter, but less than the length of the level J+1 wavelet filter. Thus, $j <= \log\_2((n-1)/(l-1)+1)$, where n is the length of x.

Returns

X [2d ndarray float (2J x len(x))] undecimated wavelet transformed data

Data:

```
[[wavelet coefficients W_1]
 [wavelet coefficients W_2]
               :
 [wavelet coefficients W_J]
 [scaling coefficients V_1]
 [scaling coefficients V_2]
               :
 [scaling coefficients V_J]]
```

Example:

```
>>> import numpy as np
>>> import mlpy
>>> x = np.array([1,2,3,4,3,2,1,0])
>>> mlpy.uwt(x=x, wf='d', k=6, levels=0)
array([[ 0.0498175 ,  0.22046721,  0.2001825 , -0.47046721, -0.0498175 ,
        -0.22046721, -0.2001825 ,  0.47046721],
       [ 0.28786838,  0.8994525 ,  2.16140162,  3.23241633,  3.71213162,
         3.1005475 ,  1.83859838,  0.76758367]])
```

mlpy.**iuwt**(*X*, *wf*, *k*)

Inverse Undecimated Wavelet Tranform

Parameters

X [2d ndarray float] undecimated wavelet transformed data

wf [string ('d': daubechies, 'h': haar, 'b': bspline)] wavelet type

k [integer] member of the wavelet family

- daubechies : k = 4, 6, ..., 20 with k even

- haar : the only valid choice of k is k = 2

- bspline : k = 103, 105, 202, 204, 206, 208, 301, 303, 305 307, 309

Returns

x [1d ndarray float] data

Example:

```
>>> import numpy as np
>>> import mlpy
>>> X = np.array([[ 0.0498175 ,  0.22046721,  0.2001825 , -0.47046721, -0.0498175,
...                -0.22046721, -0.2001825 ,  0.47046721],
...               [ 0.28786838,  0.8994525 ,  2.16140162,  3.23241633,  3.71213162,
...                 3.1005475 ,  1.83859838,  0.76758367]])
>>> mlpy.iuwt(X=X, wf='d', k=6)
array([ 1.00000000e+00,  2.00000000e+00,  3.00000000e+00,
        4.00000000e+00,  3.00000000e+00,  2.00000000e+00,
        1.00000000e+00,  2.29246158e-09])
```

New in version 2.0.2.

2.4 Continuous Wavelet Transform

Continuous Wavelet Transform based on [Torrence98].

mlpy.**cwt**(*x*, *dt*, *dj*, *wf='dog'*, *p=2*, *extmethod='none'*, *extlength='powerof2'*)
    Continuous Wavelet Tranform.

> **Parameters**

> > **x** [1d ndarray float] data

> > **dt** [float] time step

> > **dj** [float] scale resolution (smaller values of dj give finer resolution)

> > **wf** [string ('morlet', 'paul', 'dog')] wavelet function

> > **p** [float] wavelet function parameter

> > **extmethod** [string ('none', 'reflection', 'periodic', 'zeros')] indicates which extension method
> > > to use

> > **extlength** [string ('powerof2', 'double')] indicates how to determinate the length of the ex-
> > > tended data

> **Returns**

> > **(X, scales)** [(2d ndarray complex, 1d ndarray float)] transformed data, scales

Example:

```
>>> import numpy as np
>>> import mlpy
>>> x = np.array([1,2,3,4,3,2,1,0])
>>> mlpy.cwt(x=x, dt=1, dj=2, wf='dog', p=2)
(array([[ -4.66713159e-02 -6.66133815e-16j,
         -3.05311332e-16 +2.77555756e-16j,
          4.66713159e-02 +1.38777878e-16j,
          6.94959463e-01 -8.60422844e-16j,
          4.66713159e-02 +6.66133815e-16j,
          3.05311332e-16 -2.77555756e-16j,
         -4.66713159e-02 -1.38777878e-16j,
         -6.94959463e-01 +8.60422844e-16j],
       [ -2.66685280e+00 +2.44249065e-15j,
         -1.77635684e-15 -4.44089210e-16j,
          2.66685280e+00 -3.10862447e-15j,
          3.77202823e+00 -8.88178420e-16j,
```

```
                         2.66685280e+00 -2.44249065e-15j,
                          1.77635684e-15 +4.44089210e-16j,
                         -2.66685280e+00 +3.10862447e-15j,
                         -3.77202823e+00 +8.88178420e-16j]]), array([ 0.50329212,  2.01316848]))
```

mlpy.**icwt**(*X*, *dt*, *dj*, *wf='dog'*, *p=2*, *recf=True*)
    Inverse Continuous Wavelet Tranform.

>   **Parameters**

>>   **X** [2d ndarray complex] transformed data

>>   **dt** [float] time step

>>   **dj** [float] scale resolution (smaller values of dj give finer resolution)

>>   **wf** [string ('morlet', 'paul', 'dog')] wavelet function

>>   **p** [float] wavelet function parameter

>>   - morlet : 2, 4, 6

>>   - paul : 2, 4, 6

>>   - dog : 2, 6, 10

>>   **recf** [bool] use the reconstruction factor ($C_\delta \Psi_0(0)$)

>   **Returns**

>>   **x** [1d ndarray float] data

>   Example:

```
>>> import numpy as np
>>> import mlpy
>>> X = np.array([[ -4.66713159e-02 -6.66133815e-16j,
...                 -3.05311332e-16 +2.77555756e-16j,
...                  4.66713159e-02 +1.38777878e-16j,
...                  6.94959463e-01 -8.60422844e-16j,
...                  4.66713159e-02 +6.66133815e-16j,
...                  3.05311332e-16 -2.77555756e-16j,
...                 -4.66713159e-02 -1.38777878e-16j,
...                 -6.94959463e-01 +8.60422844e-16j],
...               [ -2.66685280e+00 +2.44249065e-15j,
...                 -1.77635684e-15 -4.44089210e-16j,
...                  2.66685280e+00 -3.10862447e-15j,
...                  3.77202823e+00 -8.88178420e-16j,
...                  2.66685280e+00 -2.44249065e-15j,
...                  1.77635684e-15 +4.44089210e-16j,
...                 -2.66685280e+00 +3.10862447e-15j,
...                 -3.77202823e+00 +8.88178420e-16j]])
>>> mlpy.icwt(X=X, dt=1, dj=2, wf='dog', p=2)
array([ -1.24078928e+00,  -1.07301771e-15,   1.24078928e+00,
         2.32044753e+00,   1.24078928e+00,   1.07301771e-15,
        -1.24078928e+00,  -2.32044753e+00])
```

2.4.1 Other functions

See [Torrence98].

mlpy.**angularfreq**(*N*, *dt*)
> Compute angular frequencies.
>
> Input
>
> > •*N* - [integer] number of data samples
> >
> > •*dt* - [float] time step
>
> Output
>
> > •*angular frequencies* - [1D numpy array float]

mlpy.**scales**(*N*, *dj*, *dt*, *s0*)
> Compute scales.
>
> Input
>
> > •*N* - [integer] number of data samples
> >
> > •*dj* - [float] scale resolution
> >
> > •*dt* - [float] time step
>
> Output
>
> > •*scales* - [1D numpy array float]

mlpy.**compute_s0**(*dt*, *p*, *wf*)
> Compute s0.
>
> Input
>
> > •*dt* - [float] time step
> >
> > •*p* - [float] omega0 ('morlet') or order ('paul', 'dog')
> >
> > •*wf* - [string] wavelet function ('morlet', 'paul', 'dog')
>
> Output
>
> > •*s0* - [float]

IMPUTING

3.1 Purify

`mlpy.`**`purify`**(*x*, *th0=0.1*, *th1=0.1*)

Return the matrix x without rows and cols containing respectively more than th0 * x.shape[1] and th1 * x.shape[0] NaNs.

> **Returns**
>
> > **(xout, v0, v1)** [(2d ndarray, 1d ndarray int, 1d ndarray int)] v0 are the valid index at dimension 0 and v1 are the valid index at dimension 1

Example:

```
>>> import numpy as np
>>> import mlpy
>>> x = np.array([[1,      4,      4     ],
...               [2,      9,      np.NaN],
...               [2,      5,      8     ],
...               [8,      np.NaN, np.NaN],
...               [np.NaN, 4,      4     ]])
>>> y = np.array([1, -1, 1, -1, -1])
>>> x, v0, v1 = mlpy.purify(x, 0.4, 0.4)
>>> x
array([[  1.,    4.,    4.],
       [  2.,    9.,   NaN],
       [  2.,    5.,    8.],
       [ NaN,    4.,    4.]])
>>> v0
array([0, 1, 2, 4])
>>> v1
array([0, 1, 2])
```

New in version 2.0.4.

3.2 KNN imputing

`mlpy.`**`knn_imputing`**(*x*, *k*, *dist='e'*, *method='mean'*, *y=None*, *ldep=False*)

Knn imputing

> **Parameters**
>
> > **x** [2d ndarray float (samples x feats)] data to impute

> **k** [integer] number of nearest neighbor
>
> **dist** [string ('se' = SQUARED EUCLIDEAN, 'e' = EUCLIDEAN)] adopted distance
>
> **method** [string ('mean', 'median')] method to compute the missing values
>
> **y** [1d ndarray] labels
>
> **ldep** [bool] label depended (if y != None)

Returns

> **xout** [2d ndarray float (samples x feats)] data imputed

```
>>> import numpy as np
>>> import mlpy
>>> x = np.array([[1,       4,       4     ],
...               [2,       9,       np.NaN],
...               [2,       5,       8     ],
...               [8,       np.NaN, np.NaN],
...               [np.NaN, 4,       4     ]])
>>> y = np.array([1, -1, 1, -1, -1])
>>> x, v0, v1 = mlpy.purify(x, 0.4, 0.4)
>>> x
array([[ 1.,   4.,   4.],
       [ 2.,   9.,   NaN],
       [ 2.,   5.,   8.],
       [ NaN,  4.,   4.]])
>>> v0
array([0, 1, 2, 4])
>>> v1
array([0, 1, 2])
>>> y = y[v0]
>>> x = mlpy.knn_imputing(x, 2, dist='e', method='median')
>>> x
array([[ 1. ,  4. ,  4. ],
       [ 2. ,  9. ,  6. ],
       [ 2. ,  5. ,  8. ],
       [ 1.5,  4. ,  4. ]])
```

New in version 2.0.4.

DISTANCE COMPUTATIONS

4.1 Dynamic Time Warping

Features:

- Naive and Derivative [Keogh01] DTW

- Symmetric, Asymmetric, Quasi-Symmetric implementation with Slope Constraint Condition P=0 [Sakoe78]

- Sakoe-Chiba window condition [Sakoe78] option

- Linear space-complexity implementation option

class mlpy.**Dtw**(*derivative=False*, *startbc=True*, *steppattern='symmetric0'*, *wincond='nowindow'*, *r=0.0*, *onlydist=True*)

    Dynamic Time Warping.

    Example:

```
>>> import numpy as np
>>> import mlpy
>>> x = np.array([1,1,2,2,3,3,4,4,4,4,3,3,2,2,1,1])
>>> y = np.array([1,1,1,1,1,1,1,1,1,1,2,2,3,3,4,3,2,2,1,2,3,4])
>>> mydtw = mlpy.Dtw(onlydist=False)
>>> mydtw.compute(x, y)
0.36842105263157893
>>> mydtw.px
array([ 0,  0,  0,  0,  0,  0,  0,  0,  0,  1,  2,  3,  4,  5,  6,  7,  8,
        9, 10, 11, 12, 12, 12, 13, 14, 15], dtype=int32)
>>> mydtw.py
array([ 0,  1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11, 12, 13, 14, 14, 14,
       14, 15, 15, 16, 17, 18, 19, 20, 21], dtype=int32)
```

      Parameters

          derivative [bool] derivative DTW (DDTW)

          startbc [bool] forces x=0 and y=0 boundary condition

          steppattern [string ('symmetric', 'asymmetric', 'quasisymmetric')] step pattern

          wincond [string ('nowindow', 'sakoechiba')] window condition

          r [float] sakoe-chiba window length

          onlydist [bool] linear space-complexity implementation. Only the current and previous columns are kept in memory.

New in version 2.0.7.

compute (*x*, *y*)

> **Parameters**
>
> > **x** [1d ndarray or list] first time series
> >
> > **y** [1d ndarray or list] second time series
>
> **Returns**
>
> > **d** [float] normalized distance
>
> **Attributes**
>
> > **Dtw.px** [1d ndarray int32] optimal warping path (for x time series) (if onlydist=False)
> >
> > **Dtw.py** [1d ndarray int32] optimal warping path (for y time series) (if onlydist=False)
> >
> > **Dtw.cost** [2dndarray float] cost matrix (if onlydist=False)

Extended example (requires matplotlib module):

```
>>> import numpy as np
>>> import matplotlib.pyplot as plt
>>> import mlpy
>>> x = np.array([1,1,2,2,3,3,4,4,4,4,3,3,2,2,1,1])
>>> y = np.array([1,1,1,1,1,1,1,1,1,1,2,2,3,3,4,3,2,2,1,2,3,4])
>>> plt.figure(1)
>>> plt.subplot(211)
>>> plt.plot(x)
>>> plt.subplot(212)
>>> plt.plot(y)
>>> plt.show()
```
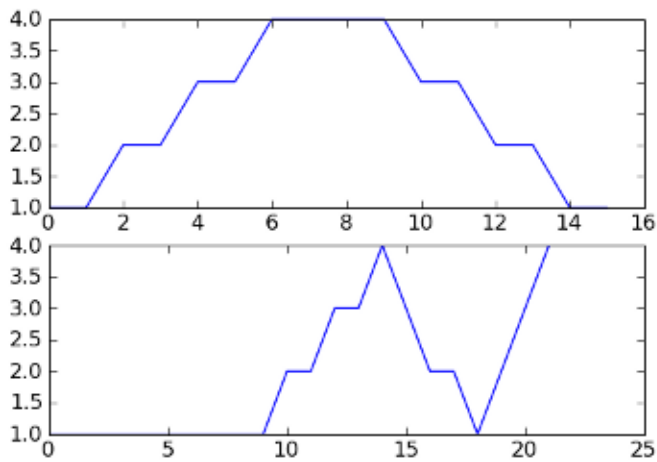


```
>>> mydtw = mlpy.Dtw()
>>> d = mydtw.compute(x, y)
>>> plt.figure(2)
>>> plt.imshow(mydtw.cost.T, interpolation='nearest', origin='lower')
>>> plt.plot(mydtw.px, mydtw.py, 'r')
>>> plt.show()
```
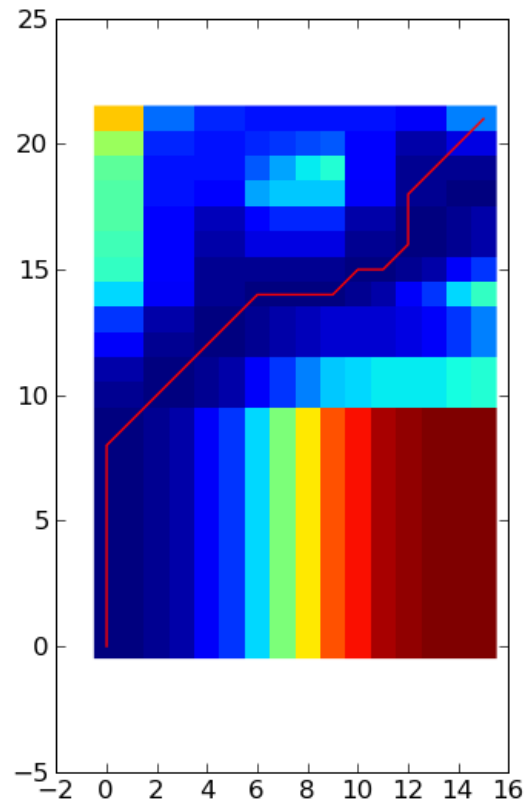
4.2 Minkowski Distance

class `mlpy.**Minkowski**`(p)

> Computes the Minkowski distance between two vectors `x` and `y`.

$$||x - y||_p = (\sum |x_i - y_i|^p)^{1/p}.$$

> Initialize Minkowski class.

> ### Parameters

> > **p** [float] The norm of the difference $||x - y||_p$

> New in version 2.0.8.

> `**compute**`(x, y)

> > Compute Minkowski distance

> > ### Parameters

> > > **x** [ndarray] An 1-dimensional vector.

> > > **y** [ndarray] An 1-dimensional vector.

> > ### Returns

> > > **d** [float] The Minkowski distance between vectors `x` and `y`

CLUSTERING

5.1 Hierarchical Clustering

Hierarchical Clustering algorithm derived from the R package 'amap' [Amap].

class `mlpy.`**`HCluster`**(*method='euclidean', link='complete'*)
Hierarchical Cluster.

Initialize Hierarchical Cluster.

> **Parameters**
>
> > **method** [string ('euclidean')] the distance measure to be used
> >
> > **link** [string ('single', 'complete', 'mcquitty', 'median')] the agglomeration method to be used

Example:

```
>>> import numpy as np
>>> import mlpy
>>> x = np.array([[ 1. ,  1.5],
...               [ 1.1,  1.8],
...               [ 2. ,  2.8],
...               [ 3.2,  3.1],
...               [ 3.4,  3.2]])
>>> hc = mlpy.HCluster()
>>> hc.compute(x)
>>> hc.ia
array([-4, -1, -3,  2])
>>> hc.ib
array([-5, -2,  1,  3])
>>> hc.heights
array([ 0.2236068 ,  0.31622776,  1.4560219 ,  2.94108844])
>>> hc.cut(0.5)
array([0, 0, 1, 2, 2])
```

`compute`(*x*)
Compute Hierarchical Cluster.

> **Parameters**
>
> > **x** [ndarray] An 2-dimensional vector (sample x features).
>
> **Returns**
>
> > **self.ia** [ndarray (1-dimensional vector)] merge

self.ib [ndarray (1-dimensional vector)] merge

self.heights [ndarray (1-dimensional vector)] a set of n-1 non-decreasing real values. The clustering height: that is, the value of the criterion associated with the clustering method for the particular agglomeration.

Element i of merge describes the merging of clusters at step i of the clustering. If an element j is negative, then observation -j was merged at this stage. If j is positive then the merge was with the cluster formed at the (earlier) stage j of the algorithm. Thus negative entries in merge indicate agglomerations of singletons, and positive entries indicate agglomerations of non-singletons.

cut (*ht*)

Cuts the tree into several groups by specifying the cut height.

Parameters

ht [float] height where the tree should be cut

Returns

cl [ndarray (1-dimensional vector)] group memberships. Groups are in 0, ..., N-1

5.2 k-means

class `mlpy.`**`Kmeans`** (*k*, *init='std'*, *seed=0*)

k-means algorithm.

Initialization.

Parameters

k [int (>1)] number of clusters

init [string ('std', 'plus')]

initialization algorithm

- 'std' : randomly selected

- 'plus' : k-means++ algorithm

seed [int (>=0)] random seed

Example:

```
>>> import numpy as np
>>> import mlpy
>>> x = np.array([[ 1. ,   1.5],
...               [ 1.1,   1.8],
...               [ 2. ,   2.8],
...               [ 3.2,   3.1],
...               [ 3.4,   3.2]])
>>> kmeans = mlpy.Kmeans(k=3, init="plus", seed=0)
>>> kmeans.compute(x)
array([1, 1, 2, 0, 0], dtype=int32)
>>> kmeans.means
array([[ 3.3 ,   3.15],
[ 1.05,   1.65],
[ 2.  ,   2.8 ]])
>>> kmeans.steps
2
```

New in version 2.2.0.

compute(*x*)

Compute Kmeans.

> **Parameters**
>
>> **x** [ndarray] an 2-dimensional vector (number of points x dimensions)
>
> **Returns**
>
>> **cls** [ndarray (1-dimensional vector)] cluster membership. Clusters are in 0, ..., k-1
>
> **Attributes**
>
>> **Kmeans.means** [2d ndarray float (k x dim)] means
>>
>> **Kmeans.steps** [int] number of steps

5.3 k-medoids

class `mlpy.`**`Kmedoids`**(*k*, *dist*, *maxloops=100*, *rs=0*)

k-medoids algorithm.

Initialize Kmedoids.

> **Parameters**
>
>> **k** [int] Number of clusters/medoids
>>
>> **dist** [class] class with a .compute(x, y) method which returns a distance
>>
>> **maxloops** [int] maximum number of loops
>>
>> **rs** [int] random seed

Example:

```
>>> import numpy as np
>>> import mlpy
>>> x = np.array([[ 1. ,   1.5],
...               [ 1.1,   1.8],
...               [ 2. ,   2.8],
...               [ 3.2,   3.1],
...               [ 3.4,   3.2]])
>>> dtw = mlpy.Dtw(onlydist=True)
>>> km = mlpy.Kmedoids(k=3, dist=dtw)
>>> km.compute(x)
(array([4, 0, 2]), array([3, 1]), array([0, 1]), 0.072499999999999981)
```

Samples 4, 0, 2 are medoids and represent cluster 0, 1, 2 respectively.

> • cluster 0: samples 4 (medoid) and 3
>
> • cluster 1: samples 0 (medoid) and 1
>
> • cluster 2: sample 2 (medoid)

New in version 2.0.8.

compute(*x*)

Compute Kmedoids.

> **Parameters**

x [ndarray] An 2-dimensional vector (sample x features).

Returns

m [ndarray (1-dimensional vector)] medoids indexes

n [ndarray (1-dimensional vector)] non-medoids indexes

cl [ndarray 1-dimensional vector)] cluster membership for non-medoids. Groups are in 0, ..., k-1

co [double] total cost of configuration

KERNELS

Methods:

.matrix(*x*)

Return the kernel matrix $K_{ij} = k(x_i, x_j)$.

.vector(*a*, *x*)

Return the kernel vector $K_i = k(x_i, a)$.

6.1 Linear Kernel

class mlpy.**KernelLinear**

Linear Kernel

$$K(x, x') = x \cdot x'$$

6.2 Gaussian Kernel

class mlpy.**KernelGaussian**(*sigma*)

Gaussian Kernel

$$K(x, x') = e^{-\frac{\|x - x'\|}{2\sigma^2}}$$

6.3 Polynomial Kernel

class mlpy.**KernelPolynomial**(*d*)

Polynomial Kernel

$$K(x, x') = (x \cdot x' + 1)^d$$

SUPERVISED CLASSIFICATION

Every classifier must be initialized with a specific set of parameters. Two distinct methods are deployed for the *training* (`compute()`) and the *testing* (`predict()`) phases. Whenever possible, the real valued prediction is stored in the *realpred* variable.

7.1 Support Vector Machines (SVMs)

class `mlpy.`**Svm**(*kernel='linear'*, *kp=0.1*, *C=1.0*, *tol=0.001*, *eps=0.001*, *maxloops=1000*, *cost=0.0*, *alpha_tversky=1.0*, *beta_tversky=1.0*, *opt_offset=True*)
    Support Vector Machines (SVM).

    Example

```
>>> import numpy as np
>>> import mlpy
>>> xtr = np.array([[1.0, 2.0, 3.0, 1.0],    # first sample
...                 [1.0, 2.0, 3.0, 2.0],    # second sample
...                 [1.0, 2.0, 3.0, 1.0]])   # third sample
>>> ytr = np.array([1, -1, 1])               # classes
>>> mysvm = mlpy.Svm()                        # initialize Svm class
>>> mysvm.compute(xtr, ytr)                   # compute SVM
1
>>> mysvm.predict(xtr)                         # predict SVM model on training data
array([ 1, -1,  1])
>>> xts = np.array([4.0, 5.0, 6.0, 7.0])      # test point
>>> mysvm.predict(xts)                          # predict SVM model on test point
-1
>>> mysvm.realpred                              # real-valued prediction
-5.5
>>> mysvm.weights(xtr, ytr)                     # compute weights on training data
array([ 0.,  0.,  0.,  1.])
```

    Initialize the Svm class

        Parameters

            kernel [string ['linear', 'gaussian', 'polynomial', 'tr', 'tversky']] kernel

            kp [float] kernel parameter (two sigma squared) for gaussian and polynomial kernel

            C [float] regularization parameter

            tol [float] tolerance for testing KKT conditions

            eps [float] convergence parameter

> **maxloops** [integer] maximum number of optimization loops
>
> **cost** [float [-1.0, ..., 1.0]] for cost-sensitive classification
>
> **alpha_tversky** [float] positive multiplicative parameter for the norm of the first vector
>
> **beta_tversky** [float] positive multiplicative parameter for the norm of the second vector
>
> **opt_offset** [bool] compute the optimal offset

compute(*x*, *y*)

> Compute SVM model
>
> > **Parameters**
> >
> > > **x** [2d ndarray float (samples x feats)] training data
> > >
> > > **y** [1d ndarray integer (-1 or 1)] classes
> >
> > **Returns**
> >
> > > **conv** [integer] svm convergence (0: false, 1: true)

predict(*p*)

> Predict svm model on a test point(s)
>
> > **Parameters**
> >
> > > **p** [1d or 2d ndarray float (samples x feats)] test point(s)training dataInput
> >
> > **Returns**
> >
> > > **cl** [integer or 1d ndarray integer] class(es) predicted
> >
> > **Attributes**
> >
> > > **Svm.realpred** [float or 1d ndarray float] real valued prediction

weights(*x*, *y*)

> Return feature weights
>
> > **Parameters**
> >
> > > **x** [2d ndarray float (samples x feats)] training data
> > >
> > > **y** [1d ndarray integer (-1 or 1)] classes
> >
> > **Returns**
> >
> > > **fw** [1d ndarray float] feature weights

Note: For *tr* kernel (Terminated Ramp Kernel) see [Merler06].

7.2 K Nearest Neighbor (KNN)

class mlpy.**Knn**(*k*, *dist='se'*)

> k-Nearest Neighbor (KNN).
>
> Example:

```python
>>> import numpy as np
>>> import mlpy
>>> xtr = np.array([[1.0, 2.0, 3.1, 1.0],   # first sample
...                 [1.0, 2.0, 3.0, 2.0],   # second sample
...                 [1.0, 2.0, 3.1, 1.0]])  # third sample
>>> ytr = np.array([1, -1, 1])             # classes
>>> myknn = mlpy.Knn(k = 1)                 # initialize knn class
>>> myknn.compute(xtr, ytr)                 # compute knn
1
>>> myknn.predict(xtr)                      # predict knn model on training data
array([ 1, -1,  1])
>>> xts = np.array([4.0, 5.0, 6.0, 7.0])   # test point
>>> myknn.predict(xts)                      # predict knn model on test point
-1
>>> myknn.realpred                          # real-valued prediction
0.0
```

Initialize the Knn class.

> **Parameters**
>
> > **k** [int (odd > = 1)] number of NN
> >
> > **dist** [string ('se' = SQUARED EUCLIDEAN, 'e' = EUCLIDEAN)] adopted distance

compute(*x*, *y*)
> Store x and y data.
>
> > **Parameters**
> >
> > > **x** [2d ndarray float (samples x feats)] training data
> > >
> > > **y** [1d ndarray integer (-1 or 1 for binary classification)] : 1d ndarray integer (1, ..., nclasses for multiclass classificatio) classes
> >
> > **Returns** 1
> >
> > **Raises**
> >
> > > **ValueError** if not (1 <= k <= #samples)
> > >
> > > **ValueError** if there aren'e at least 2 classes
> > >
> > > **ValueError** if, in case of 2-classes problems, the lables are not 1 and -1
> > >
> > > **ValueError** if, in case of n-classes problems, the lables are not int from 1 to n

predict(*p*)
> Predict knn model on a test point(s).
>
> > **Parameters**
> >
> > > **p** [1d or 2d ndarray float (sample(s) x feats)] test sample(s)
> >
> > **Returns** the predicted value(s) on success: integer or 1d numpy array integer (-1 or 1) for binary classification integer or 1d numpy array integer (1, ..., nclasses) for multiclass classification 0 on succes with non unique classification -2 otherwise
> >
> > **Raises**
> >
> > > **StandardError** if no Knn method computed

7.3 Fisher Discriminant Analysis (FDA)

Described in [Mika01].

class mlpy.**Fda**(*C=1*)

Fisher Discriminant Analysis.

Example:

```
>>> import numpy as np
>>> import mlpy
>>> xtr = np.array([[1.0, 2.0, 3.1, 1.0],   # first sample
...                  [1.0, 2.0, 3.0, 2.0],   # second sample
...                  [1.0, 2.0, 3.1, 1.0]])  # third sample
>>> ytr = np.array([1, -1, 1])              # classes
>>> myfda = mlpy.Fda()                       # initialize fda class
>>> myfda.compute(xtr, ytr)                  # compute fda
1
>>> myfda.predict(xtr)                       # predict fda model on training data
array([ 1, -1,  1])
>>> xts = np.array([4.0, 5.0, 6.0, 7.0])     # test point
>>> myfda.predict(xts)                        # predict fda model on test point
-1
>>> myfda.realpred                            # real-valued prediction
-42.51475717037367
>>> myfda.weights(xtr, ytr)                   # compute weights on training data
array([ 9.60629896,   9.77148463,   9.82027615,  11.58765243])
```

Initialize Fda class.

> **Parameters**
>
> > **C** [float] regularization parameter

compute(*x*, *y*)

Compute fda model.

> **Parameters**
>
> > **x** [2d numpy array float (sample x feature)] training data
> >
> > **y** [1d numpy array integer (two classes, 1 or -1)] classes
>
> **Returns** 1

predict(*p*)

Predict fda model on test point(s).

> **Parameters**
>
> > **p** [1d or 2d ndarray float (sample(s) x feats)] test sample(s)
>
> **Returns**
>
> > **cl** [integer or 1d numpy array integer] class(es) predicted
>
> **Attributes**
>
> > **self.realpred** [float or 1d numpy array float] real valued prediction

weights(*x*, *y*)

Return feature weights.

> **Parameters**

> **x** [2d ndarray float (samples x feats)] training data

> **y** [1d ndarray integer (-1 or 1)] classes

> **Returns**

> > **fw** [1d ndarray float] feature weights

7.4 Spectral Regression Discriminant Analysis (SRDA)

Described in [Cai08].

class `mlpy.`**`Srda`**(*alpha=1.0*)
> Spectral Regression Discriminant Analysis (SRDA).

> Example:

```
>>> import numpy as np
>>> import mlpy
>>> xtr = np.array([[1.0, 2.0, 3.1, 1.0],   # first sample
...                 [1.0, 2.0, 3.0, 2.0],   # second sample
...                 [1.0, 2.0, 3.1, 1.0]])  # third sample
>>> ytr = np.array([1, -1, 1])             # classes
>>> mysrda = mlpy.Srda()                   # initialize srda class
>>> mysrda.compute(xtr, ytr)               # compute srda
1
>>> mysrda.predict(xtr)                     # predict srda model on training data
array([ 1, -1,  1])
>>> xts = np.array([4.0, 5.0, 6.0, 7.0])   # test point
>>> mysrda.predict(xts)                     # predict srda model on test point
-1
>>> mysrda.realpred                         # real-valued prediction
-6.8283034257748758
>>> mysrda.weights(xtr, ytr)               # compute weights on training data
array([ 0.10766721,  0.21533442,  0.51386623,  1.69331158])
```

> Initialize the Srda class.

> > **Parameters**

> > > **alpha** [float(>=0.0)] regularization parameter

> **`compute`**(*x*, *y*)

> > **Compute Srda model.** Initialize array of alphas a.

> > > **Parameters**

> > > > **x** [2d ndarray float (samples x feats)] training data

> > > > **y** [1d ndarray integer (-1 or 1)] classes

> > > **Returns** 1

> > > **Raises**

> > > > **LinAlgError** if x is singular matrix in __PenRegrModel

> **`predict`**(*p*)
> > Predict Srda model on test point(s).

> > > **Parameters**

> **p** [1d or 2d ndarray float (sample(s) x feats)] test sample(s)

> **Returns**

>> **cl** [integer or 1d numpy array integer] class(es) predicted

> **Attributes**

>> **self.realpred** [float or 1d numpy array float] real valued prediction

weights(*x*, *y*)
> Return feature weights.

>> **Parameters**

>>> **x** [2d ndarray float (samples x feats)] training data

>>> **y** [1d ndarray integer (-1 or 1)] classes

>> **Returns**

>>> **fw** [1d ndarray float] feature weights

7.5 Penalized Discriminant Analysis (PDA)

Described in [Ghosh03].

class mlpy.**Pda**(*Nreg=3*)
> Penalized Discriminant Analysis (PDA).

> Example:

```
>>> import numpy as np
>>> import mlpy
>>> xtr = np.array([[1.0, 2.0, 3.1, 1.0],   # first sample
...                 [1.0, 2.0, 3.0, 2.0],   # second sample
...                 [1.0, 2.0, 3.1, 1.0]])  # third sample
>>> ytr = np.array([1, -1, 1])              # classes
>>> mypda = mlpy.Pda()                       # initialize pda class
>>> mypda.compute(xtr, ytr)                  # compute pda
1
>>> mypda.predict(xtr)                        # predict pda model on training data
array([ 1, -1,  1])
>>> xts = np.array([4.0, 5.0, 6.0, 7.0])     # test point
>>> mypda.predict(xts)                        # predict pda model on test point
-1
>>> mypda.realpred                            # real-valued prediction
-7.6106885609535624
>>> mypda.weights(xtr, ytr)                   # compute weights on training data
array([  4.0468174 ,   8.0936348 ,  18.79228266,  58.42466988])
```

> Initialize Pda class.

>> **Parameters**

>>> **Nreg** [int] number of regressions

compute(*x*, *y*)
> Compute Pda model.

>> **Parameters**

>>> **x** [2d ndarray float (samples x feats)] training data

> > **y** [1d ndarray integer (-1 or 1)] classes
>
> > **Returns** 1
>
> > **Raises**
>
> > > **LinAlgError** if x is singular matrix in __PenRegrModel

predict(*p*)
> Predict Pda model on test point(s).
>
> > **Parameters**
>
> > > **p** [1d or 2d ndarray float (sample(s) x feats)] test sample(s)
>
> > **Returns**
>
> > > **cl** [integer or 1d numpy array integer] class(es) predicted
>
> > **Attributes**
>
> > > **self.realpred** [float or 1d numpy array float] real valued prediction

weights(*x*, *y*)
> Compute feature weights.
>
> > **Parameters**
>
> > > **x** [2d ndarray float (samples x feats)] training data
>
> > > **y** [1d ndarray integer (-1 or 1)] classes
>
> > **Returns**
>
> > > **fw** [1d ndarray float] feature weights

7.6 Diagonal Linear Discriminant Analysis (DLDA)

class `mlpy.`**Dlda**(*nf=0*, *tol=10*, *overview=False*, *bal=False*)
> Diagonal Linear Discriminant Analysis.

Example:

```
>>> from numpy import *
>>> from mlpy import *
>>> xtr = array([[1.1, 2.4, 3.1, 1.0],   # first sample
...              [1.2, 2.3, 3.0, 2.0],   # second sample
...              [1.3, 2.2, 3.5, 1.0],   # third sample
...              [1.4, 2.1, 3.2, 2.0]])  # fourth sample
>>> ytr = array([1, -1, 1, -1])          # classes
>>> mydlda = Dlda(nf = 2)                        # initialize dlda class
>>> mydlda.compute(xtr, ytr)        # compute dlda
1
>>> mydlda.predict(xtr)                  # predict dlda model on training data
array([ 1, -1,  1, -1])
>>> xts = array([4.0, 5.0, 6.0, 7.0])    # test point
>>> mydlda.predict(xts)                          # predict dlda model on test point
-1
>>> mydlda.realpred                              # real-valued prediction
-21.999999999999954
>>> mydlda.weights(xtr, ytr)        # compute weights on training data
array([  2.13162821e-14,   0.00000000e+00,   0.00000000e+00,   4.00000000e+00])
```

Initialize Dlda class.

> **Parameters**
>
>> **nf** [int (1 <= nf >= #features)] the number of the best features that you want to use in the model. If nf = 0 the system stops at a number of features corresponding to a peak of accuracy
>>
>> **tol** [int] in case of nf = 0 it's the number of steps of classification to be calculated after the peak to avoid a local maximum
>>
>> **overview** [bool] set True to print informations about the accuracy of the classifier at every step of the compute
>>
>> **bal** [bool] set True if it's reasonable to consider the unbalancement of the test set similar to the one of the training set

compute (*x*, *y*, *mf=0*)

> Compute Dlda model.
>
>> **Parameters**
>>
>>> **x** [2d ndarray float (samples x feats)] training data
>>>
>>> **y** [1d ndarray integer (-1 or 1)] classes
>>>
>>> **mf** [int] number of classification steps to be calculated more on a model already computed
>>
>> **Returns** 1
>>
>> **Raises**
>>
>>> **LinAlgError** if x is singular matrix

predict (*p*)

> Predict Dlda model on test point(s).
>
>> **Parameters**
>>
>>> **p** [1d or 2d ndarray float (sample(s) x feats)] test sample(s)
>>
>> **Returns**
>>
>>> **cl** [integer or 1d numpy array integer] class(es) predicted
>>
>> **Attributes**
>>
>>> **self.realpred** [float or 1d numpy array float] real valued prediction

weights (*x*, *y*)

> Return feature weights.
>
>> **Parameters**
>>
>>> **x** [2d ndarray float (samples x feats)] training data
>>>
>>> **y** [1d ndarray integer (-1 or 1)] classes
>>
>> **Returns**
>>
>>> **fw** [1d ndarray float] feature weights, they are going to be > 0 for the features chosen for the classification and = 0 for all the others

REGRESSION

8.1 Ordinary Least Squares and Ridge Regression

class `mlpy.`**`RidgeRegression`**(*alpha=0.0*)

  Ridge Regression and Ordinary Least Squares (OLS).

  Initialization.

  > **Parameters**
  >
  > > **alpha** [float (>= 0.0)] regularization (0.0: OLS)

  New in version 2.2.0.

  `beta`()
  > Return b_1, ..., b_p.

  `beta0`()
  > Return b_0.

  `learn`(*x, y*)
  > Compute the regression coefficients.
  >
  > > **Parameters**
  > >
  > > > **x** [numpy 2d array (n x p)] matrix of regressors
  > > >
  > > > **y** [numpy 1d array (n)] response

  `pred`(*x*)
  > Compute the predicted response.
  >
  > > **Parameters**
  > >
  > > > **x** [numpy 2d array (nxp)] matrix of regressors
  > >
  > > **Returns**
  > >
  > > > **yp** [1d ndarray] predicted response

  `selected`()
  > Returns the regressors ranking.

Note: The predicted response is computed as:

$$\hat{y} = \beta_0 + X\boldsymbol{\beta}$$

Example (requires matplotlib module):

```python
>>> import numpy as np
>>> import mlpy
>>> import matplotlib.pyplot as plt
>>> x = np.array([[1], [2], [3], [4], [5], [6]]) # p = 1
>>> y = np.array([0.13, 0.19, 0.31, 0.38, 0.49, 0.64])
>>> rr = mlpy.RidgeRegression(alpha=0.0) # OLS
>>> rr.learn(x, y)
>>> y_hat = rr.pred(x)
>>> plt.figure(1)
>>> plt.plot(x[:, 0], y, 'o') # show y
>>> plt.plot(x[:, 0], y_hat) # show y_hat
>>> plt.show()
```
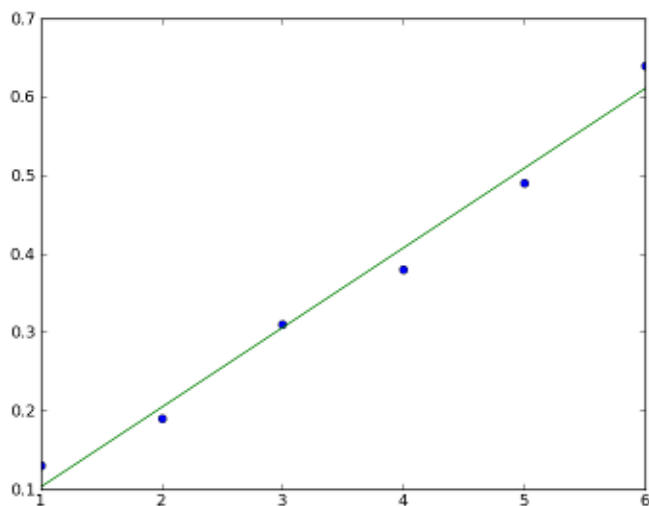


```python
>>> rr.beta0()
0.0046666666666667078
>>> rr.beta()
array([ 0.10057143])
```

8.2 Kernel Ridge Regression

class `mlpy.`**`KernelRidgeRegression`**(*kernel*, *alpha*)

　　Ridge Regression and Ordinary Least Squares (OLS).

　　Initialization.

　　　　　Parameters　alpha : float (> 0.0)

　　New in version 2.2.0.

　　`learn`(*x*, *y*)

　　　　Compute the regression coefficients.

　　　　　　Parameters

> **x** [numpy 2d array (n x p)] matrix of regressors
>
> **y** [numpy 1d array (n)] response

pred(*x*)

Compute the predicted response.

> **Parameters**
>
> > **x** [numpy 2d array (n x p)] matrix of regressors
>
> **Returns**
>
> > **yp** [1d ndarray] predicted response

Example (requires matplotlib module):

```python
>>> import numpy as np
>>> import mlpy
>>> import matplotlib.pyplot as plt
>>> x = np.array([[1], [2], [3], [4], [5], [6]]) # p = 1
>>> y = np.array([0.13, 0.19, 0.31, 0.38, 0.49, 0.64])
>>> kernel = mlpy.KernelGaussian(sigma=0.01)
>>> krr = mlpy.KernelRidgeRegression(kernel=kernel, alpha=0.01)
>>> krr.learn(x,y)
>>> y_hat = krr.pred(x)
>>> plt.figure(1)
>>> plt.plot(x[:, 0], y, 'o') # show y
>>> plt.plot(x[:, 0], y_hat) # show y_hat
>>> plt.show()
```
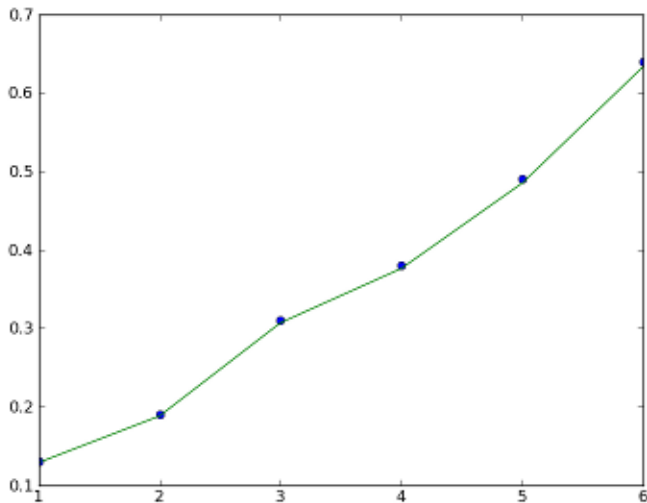

8.3 Least Angle Regression (LAR)

Least Angle Regression is described in [Efron04].

Covariates should be standardized to have mean 0 and unit length, and the response should have mean 0:

$$\sum_{i=1}^{n} x_{ij} = 0, \qquad \sum_{i=1}^{n} x_{ij}^2 = 1, \qquad \sum_{i=1}^{n} y_i = 0 \qquad \text{for } j = 1, 2, \ldots, p.$$

class mlpy.**Lar**(*m=None*)

LAR.

Initialization.

> **Parameters**
>
>> **m** [int (> 0)] max number of steps (= number of features selected). If m=None -> m=x.shape[1] in .learn(x, y)

New in version 2.2.0.

beta()

Return b_1, ..., b_p.

learn(*x*, *y*)

Compute the regression coefficients.

> **Parameters**
>
>> **x** [numpy 2d array (nxp)] matrix of regressors
>>
>> **y** [numpy 1d array (n)] response

pred(*x*)

Compute the predicted response.

> **Parameters**
>
>> **x** [numpy 2d array (nxp)] matrix of regressors
>
> **Returns**
>
>> **yp** [1d ndarray] predicted response

selected()

Returns the regressors ranking.

steps()

Return the number of steps really performed.

8.4 LASSO (LARS implementation)

It implements simple modifications of the LARS algorithm that produces Lasso estimates. See [Efron04] and [Tibshirani96].

Covariates should be standardized to have mean 0 and unit length, and the response should have mean 0:

$$\sum_{i=1}^{n} x_{ij} = 0, \qquad \sum_{i=1}^{n} x_{ij}^2 = 1, \qquad \sum_{i=1}^{n} y_i = 0 \qquad \text{for } j = 1, 2, \ldots, p.$$

class mlpy.**Lasso**(*m*)

LASSO computed with LARS algoritm.

Initialization.

Parameters

> **m** [int (> 0)] max number of steps.

New in version 2.2.0.

beta()
> Return b_1, ..., b_p.

learn(*x*, *y*)
> Compute the regression coefficients.

> > **Parameters**

> > > **x** [numpy 2d array (nxp)] matrix of regressors

> > > **y** [numpy 1d array (n)] response

pred(*x*)
> Compute the predicted response.

> > **Parameters**

> > > **x** [numpy 2d array (nxp)] matrix of regressors

> > **Returns**

> > > **yp** [1d ndarray] predicted response

selected()
> Returns the regressors ranking.

steps()
> Return the number of steps really performed.

8.5 Gradient Descent

class mlpy.**GradientDescent**(*kernel*, *t*, *stepsize*)
> Gradient Descent Method

> Initialization.

> > **Parameters**

> > > **kernel: kernel object** kernel

> > > **t** [int (> 0)] number of iterations

> > > **stepsize: float** step size

> New in version 2.2.0.

learn(*x*, *y*)
> Compute the regression coefficients.

> > **Parameters**

> > > **x** [numpy 2d array (n x p)] matrix of regressors

> > > **y** [numpy 1d array (n)] response

pred(*x*)
> Compute the predicted response.

> > **Parameters**

    x [numpy 2d array (n x p)] matrix of regressors

Returns

    yp [1d ndarray] predicted response

FEATURE WEIGHTING

Algorithms for assessing the quality of features.

9.1 Classifier-derived methods

See classification.

9.2 Iterative RELIEF (I-RELIEF)

class `mlpy.`**`Irelief`**(*T=1000*, *sigma=1.0*, *theta=0.001*)

Iterative RELIEF for Feature Weighting.

Example:

```
>>> from numpy import *
>>> from mlpy import *
>>> x = array([[1.1, 2.1, 3.1, -1.0],   # first sample
...            [1.2, 2.2, 3.2, 1.0],    # second sample
...            [1.3, 2.3, 3.3, -1.0]])  # third sample
>>> y = array([1, 2, 1])                # classes
>>> myir = Irelief()                    # initialize ireslief class
>>> myir.weights(x, y)                  # compute feature weights
array([ 0.,  0.,  0.,  1.])
```

Initialize the Irelief class.

Input

- *T* - [integer] (>0) max loops

- *sigma* - [float] (>0.0) kernel width

- *theta* - [float] (>0.0) convergence parameter

`weights` (*x*, *y*)

Return feature weights.

Input

- *x* - [2D numpy array float] (sample x feature) training data

- *y* - [1D numpy array integer] (two classes) classes

Output

•*fw* - [1D numpy array float] feature weights

exception `mlpy.`**`SigmaError`**

Sigma Error

Sigma parameter is too small.

9.3 Feature Weighting/Selection Yijun Sun08

A feature weighting/selection algorithm described in [Sun08].

class `mlpy.`**`FSSun`**(*T=1000*, *sigma=1.0*, *theta=0.001*, *lmbd=1.0*, *eps=0.001*, *alpha0=1.0*, *c=0.01*, *rho=0.5*, *debug=False*)

Sun Algorithm for feature weighting/selection

Initialize the FSSun class

Parameters

T [int (> 0)] max loops

sigma [float (> 0.0)] kernel width

theta [float (> 0.0)] convergence parameter

lmbd [float] regularization parameter

eps [float (0 < eps << 1)] termination tolerance for steepest descent method

alpha0 [float (> 0.0)] initial step length (usually 1.0) for line search

c [float (0 < c < 1/2)] costant for line search

rho [flaot (0 < rho < 1)] alpha coefficient for line search

New in version 2.1.0.

`weights`(*x*, *y*)

Compute the feature weights

Parameters

x [2d ndarray float (samples x feats)] training data

y [1d ndarray integer (-1 or 1)] classes

Returns

fw [1d ndarray float] feature weights

Attributes

FSSun.loops [int] number of loops

Raises

ValueError if classes are not -1 or 1

SigmaError if sigma parameter is too small

9.4 Discrete Wavelet Transform based (DWT)

class `mlpy.`**`Dwt`**(*specdiff='rpv'*)

Discrete Wavelet Transform (DWT).

Example:

```
>>> import numpy as np
>>> import mlpy
>>> xtr = np.array([[1.0, 2.0, 3.1, 1.0],   # first sample
...                 [1.0, 2.0, 3.0, 2.0],   # second sample
...                 [1.0, 2.0, 3.1, 1.0]])  # third sample
>>> ytr = np.array([1, -1, 1])              # classes
>>> mydwt = mlpy.Dwt()                       # initialize dwt class
>>> mydwt.weights(xtr, ytr)                  # compute weights on training data
array([ -2.22044605e-14,  -2.22044605e-14,   6.34755463e+00,  -3.00000000e+02])
```

Initialize the Dwt class.

Input

- *specdiff* - [string] spectral difference method ('rpv', 'arpv', 'crpv')

`weights`(*x*, *y*)

Return ABSOLUTE feature weights.

Parameters

x [2d ndarray float (samples x feats)] training data

y [1d ndarray integer (-1 or 1)] classes

Returns

fw [1d ndarray float] feature weights

FEATURE RANKING (WRAPPER METHODS)

The feature weights are used for selecting and ranking purposes inside one of the implemented schemes:

- *Recursive Feature Elimination family* [Guyon02]: RFE, ERFE [Furlanello03], BISRFE, SQRTRFE

- *Recursive Forward Selection* family [Louw06]: RFS

- *One-step*

class mlpy.**Ranking**(*method='rfe'*, *lastsinglesteps=0*)
    Ranking class based on Recursive Feature Elimination (RFE) and Recursive Forward Selection (RFS) methods.

    Example:

```
>>> from numpy import *
>>> from mlpy import *
>>> x = array([[1.1, 2.1, 3.1, -1.0],   # first sample
...            [1.2, 2.2, 3.2, 1.0],    # second sample
...            [1.3, 2.3, 3.3, -1.0]])  # third sample
>>> y = array([1, -1, 1])               # classes
>>> myrank = Ranking()                  # initialize ranking class
>>> mysvm = Svm()                       # initialize svm class
>>> myrank.compute(x, y, mysvm)         # compute feature ranking
array([3, 1, 2, 0])
```

    Initialize Ranking class.

    Input

        •*method* - [string] method ('onestep', 'rfe', 'bisrfe', 'sqrtrfe', 'erfe', 'rfs')

        •*lastsinglesteps* - [integer] last single steps with 'rfe'

compute(*x*, *y*, *w*, *debug=False*)
    Compute the feature ranking.

    Input

        •*x* - [2D numpy array float] (sample x feature) training data

        •*y* - [1D numpy array integer] (1 or -1) classes

        •*w* - object (e.g. classifier) with weights() method

        •*debug* - [bool] show remaining number of feature at each step (True or False)

    Output

•*feature ranking* - [1D numpy array integer] ranked feature indexes

RESAMPLING METHODS

11.1 k-fold

`mlpy.`**`kfold`**(*nsamples*, *sets*, *rseed=0*, *indexes=None*)

    K-fold Resampling Method.

    Input

        •*nsamples* - [integer] number of samples

        •*sets* - [integer] number of subsets (= number of tr/ts pairs)

        •*rseed* - [integer] random seed

        •*indexes* - [list integer] source indexes (None for [0, nsamples-1])

    Output

        •*idx* - list of *sets* tuples: ([training indexes], [test indexes])

`mlpy.`**`kfoldS`**(*cl*, *sets*, *rseed=0*, *indexes=None*)

    Stratified K-fold Resampling Method.

    Input

        •*cl* - [list (1 or -1)] class label

        •*sets* - [integer] number of subsets (= number of tr/ts pairs)

        •*rseed* - [integer] random seed

        •*indexes* - [list integer] source indexes (None for [0, nsamples-1])

    Output

        •*idx* - list of *sets* tuples: ([training indexes], [test indexes])

11.2 Monte Carlo

`mlpy.`**`montecarlo`**(*nsamples*, *pairs*, *sets*, *rseed=0*, *indexes=None*)

    Monte Carlo Resampling Method.

    Input

        •*nsamples* - [integer] number of samples

        •*pairs* - [integer] number of tr/ts pairs

> •*sets* - [integer] 1/(fraction of data in test sets)
>
> •*rseed* - [integer] random seed
>
> •*indexes* - [list integer] source indexes (None for [0, nsamples-1])

Output

> •*idx* - list of *pairs* tuples: ([training indexes], [test indexes])

mlpy.**montecarloS**(*cl*, *pairs*, *sets*, *rseed=0*, *indexes=None*)
   Stratified Monte Carlo Resampling Method.

Input

> •*cl* - [list (1 or -1)] class label
>
> •*pairs* - [integer] number of tr/ts pairs
>
> •*sets* - [integer] 1/(fraction of data in test sets)
>
> •*rseed* - [integer] random seed
>
> •*indexes* - [list integer] source indexes (None for [0, nsamples-1])

Output

> •*idx* - list of *pairs* tuples: ([training indexes], [test indexes])

11.3 Leave-one-out

mlpy.**leaveoneout**(*nsamples*, *indexes=None*)
   Leave-one-out Resampling Method.

Input

> •*nsamples* - [integer] number of samples
>
> •*indexes* - [list integer] source indexes (None for [0, nsamples-1])

Output

> •*idx* - list of *nsamples* tuples: ([training indexes], [test indexes])

11.4 All Combinations

mlpy.**allcombinations**(*cl*, *sets*, *indexes=None*)
   All Combinations Resampling Method.

Input

> •*cl* - [list (1 or -1)] class label
>
> •*sets* - [integer] number of subset
>
> •*indexes* - [list integer] source indexes (None for [0, nsamples-1])

Output

> •*idx* - list of tuples: ([training indexes], [test indexes])

11.5 Manual Resampling

mlpy.**manresampling**(*cl*, *pairs*, *trp*, *trn*, *tsp*, *tsn*, *rseed=0*)
Manual Resampling.

Input

- *cl* - [list (1 or -1)] class label

- *pairs* - [integer] number of tr/ts pairs

- *trp* - [integer] number of positive samples in training

- *trn* - [integer] number of negative samples in training

- *tsp* - [integer] number of positive samples in test

- *tsn* - [integer] number of negative samples in test

Output

- *idx* - list of *pairs* tuples: ([training indexes], [test indexes])

11.6 Resampling File

mlpy.**resamplingfile**(*nsamples*, *file*, *sep='\t'*)
Resampling file from file.

Returns a list of tuples: ([training indexes],[test indexes])

Read a file in the form:

```
[test indexes 'sep'-separated for the first  replicate]
[test indexes 'sep'-separated for the second replicate]
                         .
                         .
                         .
[test indexes 'sep'-separated for the last   replicate]
```

where indexes must be integers in [0, nsamples-1].

Input

- *file* - [string] test indexes file

- *nsamples* - [integer] number of samples

Output

- *idx* - list of tuples: ([training indexes],[test indexes])

METRIC FUNCTIONS

Compute metrics for assessing the performance of classification/regression models.

The Confusion Matrix:

Total Samples (ts)	Actual Positives (ap)	Actual Negatives (an)
Predicted Positives (pp)	True Positives (tp)	False Positives (fp)
Predicted Negatives (pn)	False Negatives (fn)	True Negatives (tn)

mlpy.**err**(y, p)

> Compute the Error.
>
> error = (fp + fn) / ts
>
> Input
>
>> •*y* - classes (two classes) [1D numpy array integer]
>>
>> •*p* - prediction (two classes) [1D numpy array integer]
>
> Output
>
>> •error

mlpy.**errp**(y, p)

> Compute the Error for positive samples.
>
> errp = fp / ap
>
> Input
>
>> •*y* - classes (two classes +1 and -1) [1D numpy array integer]
>>
>> •*p* - prediction (two classes +1 and -1) [1D numpy array integer]
>
> Output
>
>> •error for positive samples

mlpy.**errn**(y, p)

> Compute the Error for negative samples.
>
> errn = fn / an
>
> Input
>
>> •*y* - classes (two classes +1 and -1) [1D numpy array integer]
>>
>> •*p* - prediction (two classes +1 and -1) [1D numpy array integer]
>
> Output
>
>> •error for negative samples

`mlpy.``acc``(`*y*`, `*p*`)`

> Compute the Accuracy.
>
> accuracy = (tp + tn) / ts
>
> Input
>
>> • *y* - classes (two classes) [1D numpy array integer]
>>
>> • *p* - prediction (two classes) [1D numpy array integer]
>
> Output
>
>> • accuracy

`mlpy.``sens``(`*y*`, `*p*`)`

> Compute the Sensitivity.
>
> sensitivity = tp / ap
>
> Input
>
>> • *y* - classes (two classes +1 and -1) [1D numpy array integer]
>>
>> • *p* - prediction (two classes +1 and -1) [1D numpy array integer]
>
> Output
>
>> • sensitivity

`mlpy.``spec``(`*y*`, `*p*`)`

> Compute the Specificity.
>
> specificity = tn / an
>
> Input
>
>> • *y* - classes (two classes +1 and -1) [1D numpy array integer]
>>
>> • *p* - prediction (two classes +1 and -1) [1D numpy array integer]
>
> Output
>
>> • specificity

`mlpy.``single_auc``(`*y*`, `*p*`)`

> Compute the single AUC.
>
> Input
>
>> • *y* - classes (two classes +1 and -1) [1D numpy array integer]
>>
>> • *p* - prediction (two classes +1 and -1) [1D numpy array integer]
>
> Output
>
>> • singleAUC

`mlpy.``wmw_auc``(`*y*`, `*r*`)`

> Compute the AUC by using the Wilcoxon-Mann-Whitney formula.
>
> Input
>
>> • *y* - classes (two classes +1 and -1) [1D numpy array integer]
>>
>> • *r* - real-valued prediction [1D numpy array float]
>
> Output
>
>> • wmwAUC

`mlpy.`**`ppv`**(*y*, *p*)

> Compute the Positive Predictive Value (PPV).
>
> PPV = tp / pp
>
> Input
>
>> •*y* - classes (two classes +1 and -1) [1D numpy array integer]
>>
>> •*p* - prediction (two classes +1 and -1) [1D numpy array integer]
>
> Output
>
>> •PPV

`mlpy.`**`npv`**(*y*, *p*)

> Compute the Negative Predictive Value (NPV).
>
> NPV = tn / pn
>
> Input
>
>> •*y* - classes (two classes +1 and -1) [1D numpy array integer]
>>
>> •*p* - prediction (two classes +1 and -1) [1D numpy array integer]
>
> Output
>
>> •NPV

`mlpy.`**`mcc`**(*y*, *p*)

> Compute the Matthews Correlation Coefficient (MCC).
>
> MCC = ((tp*tn)-(fp*fn)) / sqrt((tp+fn)*(tp+fp)*(tn+fn)*(tn+fp))
>
> Input
>
>> •*y* - classes (two classes +1 and -1) [1D numpy array integer]
>>
>> •*p* - prediction (two classes +1 and -1) [1D numpy array integer]
>
> Output
>
>> •MCC

`mlpy.`**`mse`**(*y*, *p*)

> Mean Squared Error

`mlpy.`**`r2`**(*y*, *p*)

> Coefficient of determination (R^2)
>
> R^2 is computed as square of the correlation coefficient.

FEATURE LIST ANALYSIS

13.1 Canberra Indicator

Canberra stability indicator on top-k positions [Jurman08]

mlpy.**canberra**(*lists*, *k*, *dist=False*, *modules=None*)
   Compute mean Canberra distance indicator on top-k sublists.

   Input

> •*lists* - [2D numpy array integer] position lists Positions must be in [0, #elems-1]
>
> •*k* - [integer] top-k sublists
>
> •*modules* - [list] modules (list of group indicies)
>
> •*dist* - [bool] return partial distances (True or False)

   Output

> •*cd* - [float] canberra distance
>
> •*i1* - [1D numpy array integer] index 1 (if dist == True)
>
> •*i2* - [1D numpy array integer] index 2 (if dist == True)
>
> •*pd* - [1D numpy array float] partial distances for index1 and index2 (if dist == True)

```
>>> from numpy import *
>>> from mlpy import *
>>> lists = array([[2,4,1,3,0],   # first positions list
...                [3,4,1,2,0],   # second positions list
...                [2,4,3,0,1],   # third positions list
...                [0,1,4,2,3]])  # fourth positions list
>>> canberra(lists, 3)
1.0861983059292479
```

mlpy.**canberraq**(*lists*, *complete=True*, *normalize=False*, *dist=False*)
   Compute mean Canberra distance indicator on generic lists.

   Input

> •*lists* - [2D numpy array integer] position lists Positions must be in [-1, #elems-1], where -1 indicates features not present in the list
>
> •*complete* - [bool] complete
>
> •*normalize* - [bool] normalize

•*dist* - [bool] return partial distances (True or False)

Output

•*cd* - [float] canberra distance

•*i1* - [1D numpy array integer] index 1 (if dist == True)

•*i2* - [1D numpy array integer] index 2 (if dist == True)

•*pd* - [1D numpy array float] partial distances for index1 and index2 (if dist == True)

```
>>> from numpy import *
>>> from mlpy import *
>>> lists = array([[2,-1,1,-1,0],   # first positions list
...                [3,4,1,2,0],     # second positions list
...                [2,-1,3,0,1],    # third positions list
...                [0,1,4,2,3]])    # fourth positions list
>>> canberraq(lists)
1.0628570368721744
```

mlpy.**normalizer**(*lists*)

Compute the average length of the partial lists (nm) and the corresponding normalizing factor (nf) given by 1 - a / b where a is the exact value computed on the average length and b is the exact value computed on the whole set of features.

Inputs

•*lists* - [2D numpy array integer] position lists Positions must be in [-1, #elems-1], where -1 indicates features not present in the list

Output

•*(nm, nf)* - (float, float)

13.2 Borda Count, Extraction Indicator, Mean Position Indicator

Borda Count [Borda1781]

mlpy.**borda**(*lists*, *k*, *modules=None*)

Compute the number of extractions on top-k sublists and the mean position on lists for each element. Sort the element ids with decreasing number of extractions, AND element ids with equal number of extractions should be sorted with increasing mean positions.

Input

•*lists* - [2D numpy array integer] ranked feature-id lists. Feature-id must be in [0, #elems-1].

•*k* - [integer] on top-k sublists

•*modules* - [list] modules (list of group indicies)

Output

•*borda* - (feature-id, number of extractions, mean positions)

Example:

```
>>> from numpy import *
>>> from mlpy import *
>>> lists = array([[2,4,1,3,0],   # first ranked feature-id list
...                [3,4,1,2,0],   # second ranked feature-id list
...                [2,4,3,0,1],   # third ranked feature-id list
```

```
...                   [0,1,4,2,3]]) # fourth ranked feature-id list
>>> borda(lists, 3)
(array([4, 1, 2, 3, 0]), array([4, 3, 2, 2, 1]), array([ 1.25      ,  1.66666667,  0.        ,
```

- Element 4 is in the first position with 4 extractions and mean position 1.25.

- Element 1 is in the first position with 3 extractions and mean position 1.67.

- Element 2 is in the first position with 2 extractions and mean position 0.00.

- Element 3 is in the first position with 2 extractions and mean position 1.00.

- Element 0 is in the first position with 1 extractions and mean position 0.00.

mlpy.**borda_weighted**(*lists*, *w*, *decimals=2*)

Compute the mean position on lists for each element. Sort the element ids with increasing mean weighted positions.

Input

- *lists* - [2D numpy array integer] ranked feature-id lists. Feature-id must be in [0, #elems-1].

- *w* - [1D numpy array float] weights

- *decimals* - [integer >=0] decimals

Output

- *borda* - (feature-id, mean positions)

DATA MANAGEMENT

14.1 Importing and exporting data

mlpy.**data_fromfile**(*file*, *ytype=<type 'int'>*)

Read data file in the form:

```
x11 [TAB] x12 [TAB] ... x1n [TAB] y1
x21 [TAB] x22 [TAB] ... x2n [TAB] y2
  .         .         .   .        .
  .         .             .  .     .
  .         .             .  .     .
xm1 [TAB] xm2 [TAB] ... xmn [TAB] ym
```

where xij are float and yi are of type 'ytype' (numpy.int or numpy.float).

Input

> •*file* - data file name
>
> •*ytype* - numpy datatype for labels (numpy.int or numpy.float)

Output

> •*x* - data [2D numpy array float]
>
> •*y* - classes [1D numpy array int or float]

Example:

```
>>> from numpy import *
>>> from mlpy import *
>>> x, y = data_fromfile('data_example.dat')
>>> x
array([[ 1.1,  2. ,  5.3,  3.1],
...     [ 3.7,  1.4,  2.3,  4.5],
...     [ 1.4,  5.4,  3.1,  1.4]])
>>> y
array([ 1, -1,  1])
```

mlpy.**data_fromfile_wl**(*file*)

Read data file in the form:

```
x11 [TAB] x12 [TAB] ... x1n [TAB]
x21 [TAB] x22 [TAB] ... x2n [TAB]
  .         .         .   .
  .         .             .  .
```

```
    .        .        .   .
xm1 [TAB] xm2 [TAB] ... xmn [TAB]
```

where xij are float.

Input

> •*file* - data file name

Output

> •*x* - data [2D numpy array float]

Example:

```python
>>> from numpy import *
>>> from mlpy import *
>>> x, y = data_fromfile('data_example.dat')
>>> x
array([[ 1.1,  2. ,  5.3,  3.1],
...    [ 3.7,  1.4,  2.3,  4.5],
...    [ 1.4,  5.4,  3.1,  1.4]])
```

mlpy.**data_tofile**(*file*, *x*, *y*, *sep*='\t')

> Write data file in the form:

```
x11 [sep] x12 [sep] ... x1n [sep] y1
x21 [sep] x22 [sep] ... x2n [sep] y2
    .        .        .   .        .
    .        .        .   .        .
    .        .        .   .        .
xm1 [sep] xm2 [sep] ... xmn [sep] ym
```

where xij are float and yi are integer.

Input

> •*file* - data file name
>
> •*x* - data [2D numpy array float]
>
> •*y* - classes [1D numpy array integer]
>
> •*sep* - separator

mlpy.**data_tofile_wl**(*file*, *x*, *sep*='\t')

> Write data file in the form:

```
x11 [sep] x12 [sep] ... x1n [sep]
x21 [sep] x22 [sep] ... x2n [sep]
    .        .        .   .
    .        .        .   .
    .        .        .   .
xm1 [sep] xm2 [sep] ... xmn [sep]
```

where xij are float.

Input

> •*file* - data file name
>
> •*x* - data [2D numpy array float]
>
> •*sep* - separator

14.2 Normalization

mlpy.**data_normalize**(*x*)

Normalize numpy array (2D) x.

Input

•*x* - data [2D numpy array float]

Output

•normalized data

Example:

```
>>> from numpy import *
>>> from mlpy import *
>>> x = array([[ 1.1,  2. ,  5.3,  3.1],
...            [ 3.7,  1.4,  2.3,  4.5],
...            [ 1.4,  5.4,  3.1,  1.4]])
>>> data_normalize(x)
array([[-0.9797065 , -0.48295391,  1.33847226,  0.12418815],
...    [ 0.52197912, -1.13395464, -0.48598056,  1.09795608],
...    [-0.75217354,  1.35919078,  0.1451563 , -0.75217354]])
```

> **Warning:** Deprecated in version 2.3

mlpy.**data_standardize**(*x*, *p=None*)

Standardize numpy array (2D) x and optionally standardize p using mean and std of x.

Input

•*x* - data [2D numpy array float]

•*p* - optional data [2D numpy array float]

Output

•standardized data

Example:

```
>>> from numpy import *
>>> from mlpy import *
>>> x = array([[ 1.1,  2. ,  5.3,  3.1],
...            [ 3.7,  1.4,  2.3,  4.5],
...            [ 1.4,  5.4,  3.1,  1.4]])
>>> data_standardize(x)
array([[-0.67958381, -0.43266792,  1.1157668 ,  0.06441566],
...    [ 1.1482623 , -0.71081158, -0.81536804,  0.96623494],
...    [-0.46867849,  1.1434795 , -0.30039875, -1.0306506 ]])
```

> **Warning:** Deprecated in version 2.3. Use mlpy.standardize and mlpy.standardize_from instead

mlpy.**standardize**(*x*)

Standardize x.

x is standardized to have mean 0 and unit length by columns. Return standardized x, the mean and the standard deviation.

`mlpy.`**`center`**(*y*)
    Center y to have mean 0.

    Return centered y.

`mlpy.`**`standardize_from`**(*x*, *mean*, *std*)
    Standardize x using external mean and standard deviation.

    Return standardized x.

`mlpy.`**`center_from`**(*y*, *mean*)
    Center y using external mean.

    Return centered y.

MISCELLANEOUS

15.1 Confidence Interval

mlpy.**percentile_ci_median**(*x*, *nboot=1000*, *alpha=0.025*, *rseed=0*)

Percentile confidence interval for the median of a sample x and unknown distribution.

Input

- *x* - [1D numpy array] sample

- *nboot* - [integer] (>1) number of resamples

- *alpha* - [float] confidence level is 100*(1-2*alpha) (0.0<alpha<1.0)

- *rseed* - [integer] random seed

Output

- *ci* - (cimin, cimax) confidence interval

Example:

```
>>> from numpy import *
>>> from mlpy import *
>>> x = array([1,2,4,3,2,2,1,1,2,3,4,3,2])
>>> percentile_ci_median(x, nboot = 100)
(1.8461538461538463, 2.8461538461538463)
```

15.2 Peaks Detection

mlpy.**span_pd**(*x*, *span*)

span peaks detection.

Input

- *x* - [1D numpy array float] data

- *span* - [odd int] span

Output

- *idx* - [1D numpy array integer] peaks indexes

New in version 2.0.7.

15.3 Functions from GSL

mlpy.**gamma**(*x*)

>Gamma Function.

>Input

>>•*x* - [float] data

>Output

>>•*gx* - [float] gamma(x)

mlpy.**fact**(*x*)

>Factorial x!. The factorial is related to the gamma function by x! = gamma(x+1)

>Input

>>•*x* - [int] data

>Output

>>•*fx* - [float] factorial x!

mlpy.**quantile**(*x, f*)

>Quantile value of sorted data. The elements of the array must be in ascending numerical order. The quantile is determined by the f, a fraction between 0 and 1. The quantile is found by interpolation, using the formula: quantile = (1 - delta) x_i + delta x_{i+1} where i is floor((n - 1)f) and delta is (n-1)f - i.

>Input

>>•*x* - [1D numpy array float] sorted data

>>•*f* - [float] fraction between 0 and 1

>Output

>>•*q* - [float] quantile

mlpy.**cdf_gaussian_P**(*x, sigma*)

>Cumulative Distribution Functions (CDF) P(x) for the Gaussian distribution.

>Input

>>•*x* - [float] data

>>•*sigma* - [float] standard deviation

>Output

>>•*p* - [float]

>New in version 2.0.2.

15.4 Other

mlpy.**away**(*a, b, d*)

>Given numpy 1D array *a* and numpy 1D array *b* compute $c = \{ b_i : |b_i - a_j| > d$ for each i, j\}

>Input

>>•*a* - [1D numpy array float]

>>•*b* - [1D numpy array float]

•*d* - [double]

Output

•*c* - [1D numpy array float]

New in version 2.0.3.

mlpy.**is_power**(*n*, *b*)

Return True if 'n' is power of 'b', False otherwise. New in version 2.0.6.

mlpy.**next_power**(*n*, *b*)

Returns the smallest integer, greater than or equal to 'n' which can be obtained as power of 'b'. New in version 2.0.6.

TOOLS

16.1 Landscaping and Parameter Tuning

`mlpy` includes executable scripts to be used off-the-shelf for landscaping and parameter tuning tasks. The classification and optionally feature ranking operations are organized in a sampling procedure (k-fold or Monte Carlo cross validation).

- **svm-landscape**: landscaping and regularization parameter (*C*) tuning

- **fda-landscape**: landscaping and regularization parameter (*C*) tuning

- **srda-landscape**: landscaping and alpha parameter (*alpha*) tuning

- **pda-landscape**: landscaping and number of regressions parameter (*Nreg*) tuning

- **dlda-landscape**

- **nn-landscape**: landscaping

Error (`mlpy.err()`), Matthews Correlation Coefficient (`mlpy.mcc()`) and optionally Canberra Distance (`mlpy.canberra()`) are retrieved at each parameter step.

`mlpy` includes executable scripts to be used exclusively for parameter tuning tasks:

- **irelief-sigma**: kernel width parameter (*sigma*) tuning

In order to print help message:

```
$ command --help
```

16.2 Other Tools

borda

Compute Borda Count, Extraction Indicator, Mean Position Indicator from a text file containing feature lists.

canberra

Compute mean Canberra distance indicator on top-k sublists from a text file containing feature lists and one containing the top-k positions.

In order to print help message:

```
$ command --help
```

16.2.1 The Feature Lists File

The feature lists file is a plain text TAB-separated file where each row is a feature ranking (a feature list).

Example:

```
feat6 [TAB] feat2 [TAB] ... [TAB] feat1
feat4 [TAB] feat1 [TAB] ... [TAB] feat7
feat4 [TAB] feat9 [TAB] ... [TAB] feat3
feat2 [TAB] feat3 [TAB] ... [TAB] feat9
feat8 [TAB] feat4 [TAB] ... [TAB] feat2
```

genindex

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PYTHON MODULE INDEX

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INDEX