eeglib Documentation

Release 0.4.1

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Jul 13, 2022

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This module is a library with some tools and functions for EEG signal analysis.

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This reference manual contains the documentation about the modules, classes and functions included in eeglib. For learning how to use this library, use the Quickstart Guide. Next, there are the submodules API.

CHAPTER

ONE

DOCUMENTATION OF EEGLIB.EEG MODULE

This module define the basic data structure that are used in this library

class eeglib.eeg.**EEG**(*windowSize*, *sampleRate*, *channelNumber*, *names=None*)

Bases: object

This class apply sginal analysis functions over the data stored in its attribute window.

Attributes

windowSize: int
The maximun samples the window will store.

sampleRate: int
The number of samples per second

channelNumber: int
The number of channels of samples the window will handle.

window: SampleWindow
It stores the data.

Methods

CCC([channels, allPermutations])	Computes the Cross Correlation Coeficient between the data in c1 and the data in c2.
DFA([i])	Applies Detrended Fluctuation Analysis algorithm to the given data.
DFT([i, windowFunction, output, ...])	Returns the Discrete Fourier Transform of the data at a given index of the window.
DTW([channels, allPermutations, normalize, ...])	Computes the Dynamic Time Warping algortihm between the data of the given channels.
HFD([i, kMax])	Returns the Higuchi Fractal Dimension at the given index of the window.
LZC([i])	Returns the Lempel-Ziv Complexity at the given channel/s.
PFD([i])	Returns the Petrosian Fractal Dimension at the given index of the window.
PSD([i, windowFunction, nperseg, retFrequencies])	Returns the Power Spectral Density of the data at a given index of the window using the Welch method.
bandPower([i, bands, spectrumFrom, ...])	Returns the power of each band at the given index.
engagementLevel()	Returns the engagament level, which is calculated with this formula: beta/(alpha+theta), where alpha, beta and theta are the average of the average band values between al the channels.
getBoundsForBand(bandBounds)	Returns the bounds of each band depending of the sample rate and the window size.
getChannel([i])	Returns the raw data stored at the given index of the windows.
getSignalAtBands([i, bands])	Rebuilds the signal from a component i but only in the specified frequency bands.
hjorthActivity([i])	Returns the Hjorth Activity at the given channel
hjorthComplexity([i])	Returns the Hjorth Complexity at the given channel
hjorthMobility([i])	Returns the Hjorth Mobility at the given channel
sampEn([i])	Returns Multiscale Sample Entropy at the given channel/s.
set(samples[, columnMode])	Sets multiple samples at a time into the window.
synchronizationLikelihood([channels, ...])	Returns the Synchronization Likelihood value applied over the i1 and i2 channels by calling `synchronizationLikelihood()`.

CCC(*channels=None*, *allPermutations=False*)

Computes the Cross Correlation Coeficient between the data in c1 and the data in c2.

Parameters

channels: Variable type, optional
In order to understand how this parameter works go to the doc of `eeglib.eeg.EEG._applyFunctionTo2C()`

allPermutations: bool, optional

In order to understand how this parameter works go to the doc of

`eeglib.eeg.EEG._applyFunctionTo2C()`

Returns

float or dict
If a tuple is passed the it returns the result of applying the function to the channels specified in the tuple. If another valid value is passed, the method returns a dictionary, being the key the two channels used and the value the result of applying the function to those channels.

DFA(*i=None*, **args*, ***kargs*)

Applies Detrended Fluctuation Analysis algorithm to the given data.

Parameters

i: Variable type, optional

- int: the index of the channel.
- str: the name of the channel.
- list of strings and integers: a list of channels that will be used.
- slice: a slice selecting the range of channels that will be used.
- None: all the channels will be used

fit_degree: int, optional
Degree of the polynomial used to model de local trends. Default: 1.

min_window_size: int, optional
Size of the smallest window that will be used. Default: signalSize//2.

fskip: float, optional
Fraction of the window that will be skiped in each iteration for each window size. Default: 1.

Returns

float or array
The resulting value. If more than one channe was selected the return object will be a 1D array containing the result of the procesing.

DFT(*i=None*, *windowFunction=None*, *output='complex'*, *onlyPositiveFrequencies=False*)

Returns the Discrete Fourier Transform of the data at a given index of the window.

Parameters

i: Variable type, optional

- int: the index of the channel.
- str: the name of the channel.
- list of strings and integers: a list of channels that will be used.
- slice: a slice selecting the range of channels that will be used.
- None: all the channels will be used.

windowFunction: str, tuple or numpy.ndarray, optional
This can be a string with the name of the function, a tuple with a str with the name of the funcion in the first position and the parameters of the funcion in the nexts or a numpy array with a size equals to the window size. In the first case an array with the size of windowSize will be created. The created array will be multiplied by the data in the window before FFT is used.

output: str, optional

- "complex": default output of the FFT, x+yi

- "magnitude": computes the magnitude of the FFT, sqrt(x^2+y^2)
- "phase": computes the phase of the FFT, atan2(yi,x)

Returns

numpy.ndarray
An array with the result of the Fourier Transform. If more than one channel was selected the array will be of 2 Dimensions.

DTW(*channels=None*, *allPermutations=False*, *normalize=False*, *returnOnlyDistances=True*, **args*, ***kargs*)

Computes the Dynamic Time Warping algortihm between the data of the given channels. It uses the FastDTW implementation given by the library fastdtw.

Parameters

channels: Variable type, optional
In order to understand how this parameter works go to the doc of `eeglib.eeg.EEG._applyFunctionTo2C()`

allPermutations: bool, optional

In order to understand how this parameter works go to the doc of

`eeglib.eeg.EEG._applyFunctionTo2C()`

normalize: bool optional
If True the result of the algorithm is divided by the window size. Default: True.

returnOnlyDistances: bool, optional
If True, the result of the function will include only the distances after applying the DTW algorithm. If False it will return also the path. Default: True.

radius
[int, optional] size of neighborhood when expanding the path. A higher value will increase the accuracy of the calculation but also increase time and memory consumption. A radius equal to the size of x and y will yield an exact dynamic time warping calculation.

dist
[function or int, optional] The method for calculating the distance between x[i] and y[j]. If dist is an int of value p > 0, then the p-norm will be used. If dist is a function then dist(x[i], y[j]) will be used. If dist is None then abs(x[i] - y[j]) will be used.

Returns

tuple, float, dict of floats or dict of tuples
If a tuple is passed the it returns the result of applying the function to the channels specified in the tuple. If another valid value is passed, the method returns a dictionary, being the key the two channels used and the value the result of applying the function to those channels.

HFD(*i=None*, *kMax=None*)

Returns the Higuchi Fractal Dimension at the given index of the window.

Parameters

i: Variable type, optional

- int: the index of the channel.
- str: the name of the channel.
- list of strings and integers: a list of channels that will be used.
- slice: a slice selecting the range of channels that will be used.

- None: all the channels will be used.

kmax: int, optional
By default it will be windowSize//2.

Returns

float or array
The resulting value. If more than one channe was selected the return object will be a 1D array containing the result of the procesing.

LZC(*i=None*, **args*, ***kargs*)

Returns the Lempel-Ziv Complexity at the given channel/s.

Parameters

i: Variable type, optional

- int: the index of the channel.
- str: the name of the channel.
- list of strings and integers: a list of channels that will be used.
- slice: a slice selecting the range of channels that will be used.
- None: all the channels will be used

theshold: numeric, optional
A number use to binarize the signal. The values of the signal above threshold will be converted to 1 and the rest to 0. By default, the median of the data.

normalize: bool
If True the resulting value will be between 0 and 1, being 0 the minimal posible complexity of a sequence that has the same lenght of data and 1 the maximal posible complexity. By default, False.

Returns

float or array
The resulting value. If more than one channe was selected the return object will be a 1D array containing the result of the procesing.

PFD(*i=None*)

Returns the Petrosian Fractal Dimension at the given index of the window.

Parameters

i: Variable type, optional

- int: the index of the channel.
- str: the name of the channel.
- list of strings and integers: a list of channels that will be used.
- slice: a slice selecting the range of channels that will be used.
- None: all the channels will be used.

Returns

float or array
The resulting value. If more than one channe was selected the return object will be a 1D array containing the result of the procesing.

PSD(*i=None*, *windowFunction='hann'*, *nperseg=None*, *retFrequencies=False*)

Returns the Power Spectral Density of the data at a given index of the window using the Welch method.

Parameters

i: Variable type, optional

- int: the index of the channel.
- str: the name of the channel.
- list of strings and integers: a list of channels that will be used.
- slice: a slice selecting the range of channels that will be used.
- None: all the channels will be used.

windowFunction: str or tuple or array_like, optional
Desired window to use. If window is a string or tuple, it is passed to get_window to generate the window values, which are DFT-even by default. See get_window for a list of windows and required parameters. If window is array_like it will be used directly as the window and its length must be nperseg. Defaults to a Hann window.

nperseg: int, optional
Length of each segment. Defaults to None, but if window is str or tuple, is set to 256, and if window is array_like, is set to the length of the window.

retFrequencies: bool, optional
If True two arrays will be raturned for each channel, one with the frequencies and another with the spectral density of those frequencies.

Returns

numpy.ndarray
An array with the result of the Fourier Transform. If more than one channel was selected the array will be of 2 Dimensions.

__init__(*windowSize*, *sampleRate*, *channelNumber*, *names=None*)

Parameters

windowSize: int
The maximun samples the window will store.

sampleRate: int
The number of samples per second

channelNumber: int
The number of channels of samples the window will handle.

names: list of strings, optional
The optional names that can be used to refer to each channel.

bandPower(*i=None*, *bands={'alpha': (8, 12), 'beta': (12, 30), 'delta': (1, 4), 'theta': (4, 7)}*, *spectrumFrom='DFT'*, *windowFunction='hann'*, *nperseg=None*, *normalize=False*)

Returns the power of each band at the given index.

Parameters

i: Variable type, optional

- int: the index of the channel.
- str: the name of the channel.

- list of strings and integers: a list of channels that will be used.
- slice: a slice selecting the range of channels that will be used.
- None: all the channels will be used.

bands: dict, optional
This parameter is used to indicate the bands that are going to be used. It is a dict with the name of each band as key and a tuple with the lower and upper bounds as value.

spectrumFrom: str, optional

- "DFT": uses the spectrum from the DFT of the signal.
- "PSD": uses the spectrum from the PSD of the signal.

windowFunction: str or tuple or array_like, optional
Desired window to use. If window is a string or tuple, it is passed to get_window to generate the window values, which are DFT-even by default. See get_window for a list of windows and required parameters. If window is array_like it will be used directly as the window and its length must be nperseg. Defaults to a Hann window.

nperseg: int, optional
This parameter is only relevant when powerFrom is "PSD", else it is ignored. Length of each segment. Defaults to None, but if window is str or tuple, is set to 256, and if window is array_like, is set to the length of the window.

normalize: bool, optional
If True the each band power is divided by the total power of the spectrum. Default False.

Returns

dict or list of dict
The keys are the name of each band and the values are the mean of the magnitudes. If more than one channel was selected the return object will be a list containing the dict for each channel selected

`engagementLevel`()

Returns the engagament level, which is calculated with this formula: beta/(alpha+theta), where alpha, beta and theta are the average of the average band values between al the channels.

Returns

float
The engagement level.

`getBoundsForBand`(*bandBounds*)

Returns the bounds of each band depending of the sample rate and the window size.

Parameters

bandbounds: tuple
A tuple containig the lower and upper bounds of a frequency band.

Returns

tuple
A tuple containig the the new bounds of the given band.

`getChannel`(*i=None*)

Returns the raw data stored at the given index of the windows.

Parameters

i: Variable type, optional

- int: the index of the channel.
- str: the name of the channel.
- list of strings and integers: a list of channels that will be returned as a 2D ndarray.
- slice: a slice selecting the range of channels that wll be returned as a 2D ndarray.
- None: all the data returned as a 2D ndarray

Returns

list
The list of values of a specific channel.

`getSignalAtBands`(*i=None*, *bands={'alpha': (8, 12), 'beta': (12, 30), 'delta': (1, 4), 'theta': (4, 7)}*)

Rebuilds the signal from a component i but only in the specified frequency bands.

Parameters

i: Variable type, optional

- int: the index of the channel.
- str: the name of the channel.
- list of strings and integers: a list of channels that will be used.
- slice: a slice selecting the range of channels that will be used.
- None: all the channels will be used.

bands: dict, optional
This parameter is used to indicate the bands that are going to be used. It is a dict with the name of each band as key and a tuple with the lower and upper bounds as value.

Returns

dict of numpy.ndarray (1D or 2D)
The keys are the same keys the bands dictionary is using. The values are the signal filtered in every band at the given index of the window. If more than one channel is selected the return object will be a dict containing 2D arrays in which each row is a signal filtered at the corresponding channel.

`hjorthActivity`(*i=None*)

Returns the Hjorth Activity at the given channel

Parameters

i: int or string, optional
Index or name of the channel.

Returns

float or array
The resulting value. If more than one channe was selected the return object will be a 1D array containing the result of the procesing.

`hjorthComplexity`(*i=None*)

Returns the Hjorth Complexity at the given channel

Parameters

i: Variable type, optional

- int: the index of the channel.
- str: the name of the channel.
- list of strings and integers: a list of channels that will be used.
- slice: a slice selecting the range of channels that will be used.
- None: all the channels will be used.

Returns

float or array
The resulting value. If more than one channe was selected the return object will be a 1D array containing the result of the procesing.

`hjorthMobility`(*i=None*)

Returns the Hjorth Mobility at the given channel

Parameters

i: Variable type, optional

- int: the index of the channel.
- str: the name of the channel.
- list of strings and integers: a list of channels that will be used.
- slice: a slice selecting the range of channels that will be used.
- None: all the channels will be used.

Returns

float or array
The resulting value. If more than one channe was selected the return object will be a 1D array containing the result of the procesing.

`sampEn`(*i=None*, **args*, ***kargs*)

Returns Multiscale Sample Entropy at the given channel/s.

Parameters

i: Variable type, optional

- int: the index of the channel.
- str: the name of the channel.
- list of strings and integers: a list of channels that will be used.
- slice: a slice selecting the range of channels that will be used.
- None: all the channels will be used

m: int, optional
Size of the embedded vectors. By default 2.

l: int, optional
Lag beetwen elements of embedded vectors. By default 1.

r: float, optional
Tolerance. By default fr*std(data)

fr: float, optional
Fraction of std(data) used as tolerance. If r is passed, this parameter is ignored. By default, 0.2.

Returns

float or array
The resulting value. If more than one channe was selected the return object will be a 1D array containing the result of the procesing.

`set`(*samples*, *columnMode=False*)

Sets multiple samples at a time into the window. The sample number must be the same as the window size.

Parameters

samples: array_like of 2 dimensions
Samples of data with a size equals to window.

columnMode: boolean, optional
By default it is assummed that the shape of the data given is nSamples X nchannels. If the given data is the inverse, columnMode should be True.

`synchronizationLikelihood`(*channels=None*, *allPermutations=False*, *m=None*, *l=None*, *w1=None*, *w2=None*, *pRef=0.05*, ***kargs*)

Returns the Synchronization Likelihood value applied over the i1 and i2 channels by calling `synchronizationLikelihood()`.

Parameters

channels: Variable type, optional
In order to understand how this parameter works go to the doc of `eeglib.eeg.EEG._applyFunctionTo2C()`

allPermutations: bool, optional

In order to understand how this parameter works go to the doc of

`eeglib.eeg.EEG._applyFunctionTo2C()`

m: int, optional
Numbers of elements of the embedded vectors.

l: int, optional
Separation between elements of the embedded vectors.

w1: int, optional
Theiler correction for autocorrelation effects

w2: int, optional
A window that sharpens the time resolution of the Synchronization measure

pRef: float, optional
The p Ref param of the synchronizationLikelihood. Default 0.05

epsilonIterations: int,optional
Number of iterations used to determine the value of epsilon

Returns

float or dict
If a tuple is passed the it returns the result of applying the function to the channels specified in the tuple. If another valid value is passed, the method returns a dictionary, being the key the two channels used and the value the result of applying the function to those channels.

class eeglib.eeg.**SampleWindow**(*windowSize*, *channelNumber*, *names=None*)

Bases: object

This class is a data structure that stores the signal data and works like a sliding window.

Attributes

windowSize: int
The maximun samples the window will store.

channelNumber: int
The number of channels of samples the window will handle.

window: list of lists
It stores the data.

Methods

getChannel([i])	Returns an array containing the data of the the selected channel/s.
getIndicesList(i)	Returns a list of numeric indices from a combined type of indices.
getPairOfChannels([channels, allPermutations])	Applies a function that uses two signals by selecting the channels to use.
getPairsIndicesList(i[, allPermutations])	Returns a list of tuples of numeric indices from a combined type of indices.
set(samples[, columnMode])	Sets multiple samples at a time.

__init__(*windowSize*, *channelNumber*, *names=None*)

Creates a SampleWindow wich stores the value of windowSize as the number of samples and the value of channelNumber as the number of channels.

Parameters

windowSize: int
The size of the sliding window.

channelNumber: int
The number of channels recording simultaneously.

names: list of strings, optional
The optional names that can be used to refer to each channel.

getChannel(*i=None*)

Returns an array containing the data of the the selected channel/s.

Parameters

i: Variable type, optional

- int: the index of the channel.
- str: the name of the channel.
- list of strings and integers: a list of channels that will be returned as a 2D ndarray.
- slice: a slice selecting the range of channels that wll be returned as a 2D ndarray.
- None: all the data returned as a 2D ndarray

Returns

numpy.ndarray
Can be a one or a two dimension matrix, depending of the parameters.

`getIndicesList`(*i*)

Returns a list of numeric indices from a combined type of indices.

`getPairOfChannels`(*channels=None*, *allPermutations=False*)

Applies a function that uses two signals by selecting the channels to use. It will apply the function to different channels depending on the parameters. Note: a single channel can be selected by using an int or a string if a name for the channel was specified.

Parameters

channels: Variable type, optional

- tuple of lenght 2 containing channel indexes: applies the function to the two channels specified by the tuple.
- list of tuples(same restrictions than the above): applies the function to every tuple in the list.
- list of index: creates combinations of channels specifies in the list depending of the allPermutations parameter.
- None: Are channels are used in the same way than in the list above. This is the default value.

allPermutations: bool, optional
Only used when channels is a list of index or None. If True all permutations of the channels in every order are used; if False only combinations of different channels are used. Example: with the list [0, 2, 4] and allPermutations = True, the channels used will be (0,2), (0,4), (2,0), (2,4), (4,0), (4,2); meanwhile, with allPermutations = False, the channels used will be: (0,2), (0,4), (2,4). Default: False.

Returns

If a tuple is passed the it returns the result of applying the function to the channels specified in the tuple. If another valid value is passed, the method returns a dictionary, being the key the two channels used and the value the result of applying the function to those channels.

`getPairsIndicesList`(*i*, *allPermutations=False*)

Returns a list of tuples of numeric indices from a combined type of indices.

`set`(*samples*, *columnMode=False*)

Sets multiple samples at a time. The sample number must be the same as the window size.

Parameters

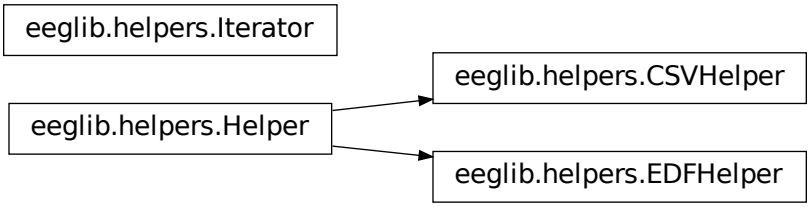
samples: array_like of 2 dimensions
Samples of data with a size equals to window.

columnMode: boolean, optional
By default it is assummed that the shape of the data given is nSamples X nchannels. If the given data is the inverse, columnMode should be True.

CHAPTER

TWO

DOCUMENTATION OF EEGLIB.HELPERS MODULE



This module contains helper classes that are useful to iterating over a EEG data stream. Currently there is support only for CSV files.

class eeglib.helpers.**CSVHelper**(*path*, **args*, ***kargs*)

Bases: *Helper*

This class is for applying diferents operations using the EEG class over a csv file.

Methods

getNames([indexes])	Returns the names of the specified indexes of channels.
moveEEGWindow(position)	Moves the window to start at position.
prepareEEG(windowSize)	Prepares and creates the EEG object that the iteration will use with the same parameters that an EEG objects is initialized.
prepareIterator([step, startPoint, endPoint])	Prepares the iterator of the helper.
selectSignals(selectedSignals)	**Parameters**

__init__(*path*, **args*, ***kargs*)

The rest of parameters can be seen at *Helper.__init__()*

Parameters

path: str
The path to the csv file

`getNames`(*indexes=None*)

Returns the names of the specified indexes of channels.

Parameters

indexes: Iterable of int, optional.
The indexes of the channels desired. If None it will return all the channels' names. Default: None.

`moveEEGWindow`(*position*)

Moves the window to start at position. Also it returns the inner eeg object.

Parameters

position: int, str or datetime.timedelta

- int: position of the sample
- str with format hh:mm:ss.ss: temporal position
- timedelta: temporal position

Returns

EEG

`prepareEEG`(*windowSize*)

Prepares and creates the EEG object that the iteration will use with the same parameters that an EEG objects is initialized. Also it returns the inner eeg object.

Parameters

windowSize: int
The maximun samples the window will store.

Returns

EEG

`prepareIterator`(*step=None*, *startPoint=0*, *endPoint=None*)

Prepares the iterator of the helper.

Parameters

step: int,optional
Number of samples to be skipped in each iteration.

startPoint: int, optional
The index of first sample from where the iteration will start. By default 0.

endPoint: int, optional
The index of the last sample + 1 until where the iteration will go. By default the size of the data.

`selectSignals`(*selectedSignals*)

Parameters

selectedSignals
[iterable of str and/or int] The indexes of the desired selected signals. It must be an iterable type containing either str or int.

Returns

None.

class eeglib.helpers.**EDFHelper**(*path*, **args*, *sampleRate=None*, ***kargs*)

Bases: *Helper*

This class is for applying diferents operations using the EEG class over an edf file.

Methods

getNames([indexes])	Returns the names of the specified indexes of channels.
moveEEGWindow(position)	Moves the window to start at position.
prepareEEG(windowSize)	Prepares and creates the EEG object that the iteration will use with the same parameters that an EEG objects is initialized.
prepareIterator([step, startPoint, endPoint])	Prepares the iterator of the helper.
selectSignals(selectedSignals)	

Parameters

__init__(*path*, **args*, *sampleRate=None*, ***kargs*)

The rest of parameters can be seen at *Helper.__init__()*

Parameters

path: str
The path to the edf file

getNames(*indexes=None*)

Returns the names of the specified indexes of channels.

Parameters

indexes: Iterable of int, optional.
The indexes of the channels desired. If None it will return all the channels' names. Default: None.

moveEEGWindow(*position*)

Moves the window to start at position. Also it returns the inner eeg object.

Parameters

position: int, str or datetime.timedelta

- int: position of the sample
- str with format hh:mm:ss.ss: temporal position
- timedelta: temporal position

Returns

EEG

prepareEEG(*windowSize*)

Prepares and creates the EEG object that the iteration will use with the same parameters that an EEG objects is initialized. Also it returns the inner eeg object.

Parameters

windowSize: int
The maximun samples the window will store.

Returns

EEG

prepareIterator(*step=None*, *startPoint=0*, *endPoint=None*)

Prepares the iterator of the helper.

Parameters

step: int,optional
Number of samples to be skipped in each iteration.

startPoint: int, optional
The index of first sample from where the iteration will start. By default 0.

endPoint: int, optional
The index of the last sample + 1 until where the iteration will go. By default the size of the data.

selectSignals(*selectedSignals*)

Parameters

selectedSignals
[iterable of str and/or int] The indexes of the desired selected signals. It must be an iterable type containing either str or int.

Returns

None.

class eeglib.helpers.**Helper**(*data*, *sampleRate=None*, *windowSize=None*, *names=None*, *highpass=None*, *lowpass=None*, *normalize=False*, *ICA=False*, *selectedSignals=None*)

Bases: object

This is an abstract class that defines the way every helper works.

Methods

getNames([indexes])	Returns the names of the specified indexes of channels.
moveEEGWindow(position)	Moves the window to start at position.
prepareEEG(windowSize)	Prepares and creates the EEG object that the iteration will use with the same parameters that an EEG objects is initialized.
prepareIterator([step, startPoint, endPoint])	Prepares the iterator of the helper.
selectSignals(selectedSignals)	**Parameters**

__init__(*data*, *sampleRate=None*, *windowSize=None*, *names=None*, *highpass=None*, *lowpass=None*, *normalize=False*, *ICA=False*, *selectedSignals=None*)

Parameters

data: 2D matrix
The signals data in the shape (nChannels, nSamples).

sampleRate: numeric, optional
The frequency at which the data was recorded. By default its value is the lenght of the data.

windowSize: int, optional
The size of the window in which the calculations will be done. By default its value is the lenght of one second of the data.

names: list of strings
A list containing the names of each channel in the same positions than data channels.

highpass: numeric, optional
The signal will be filtered above this value.

lowpass: numeric, optional
The signal will be filtered bellow this value.

normalize: boolean, optional
If True, the data will be normalizing using z-scores. Default = False.

ICA: boolean, optional
If True, Independent Component Analysis will be applied to the data . It is applied always after normalization if normalize = True. Default: False.

selectedSignals: list of strings or ints
If the data file has names asociated to each columns, those columns can be selected through the name or the index of the column. If the data file hasn't names in the columns, they can be selected just by the index.

`getNames`(*indexes=None*)

Returns the names of the specified indexes of channels.

Parameters

indexes: Iterable of int, optional.
The indexes of the channels desired. If None it will return all the channels' names. Default: None.

`moveEEGWindow`(*position*)

Moves the window to start at position. Also it returns the inner eeg object.

Parameters

position: int, str or datetime.timedelta

- int: position of the sample
- str with format hh:mm:ss.ss: temporal position
- timedelta: temporal position

Returns

EEG

`prepareEEG`(*windowSize*)

Prepares and creates the EEG object that the iteration will use with the same parameters that an EEG objects is initialized. Also it returns the inner eeg object.

Parameters

windowSize: int
The maximun samples the window will store.

Returns

EEG

`prepareIterator`(*step=None*, *startPoint=0*, *endPoint=None*)

Prepares the iterator of the helper.

Parameters

step: int,optional
Number of samples to be skipped in each iteration.

startPoint: int, optional
The index of first sample from where the iteration will start. By default 0.

endPoint: int, optional
The index of the last sample + 1 until where the iteration will go. By default the size of the data.

`selectSignals`(*selectedSignals*)

Parameters

selectedSignals
[iterable of str and/or int] The indexes of the desired selected signals. It must be an iterable type containing either str or int.

Returns

None.

`class eeglib.helpers.Iterator`(*helper*, *step*, *auxPoint*, *endPoint*)

Bases: `object`

`__init__`(*helper*, *step*, *auxPoint*, *endPoint*)

CHAPTER

THREE

DOCUMENTATION OF EEGLIB.WRAPPER MODULE

This module contains the Wrapper class that wraps around a Helper and computes every feature in each window configured. It also allows specifying labels for the whole signal or for specific segments.

class eeglib.wrapper.**Wrapper**(*helper*, *flat=True*, *flatSeparator='_'*, *store=True*, *label=None*, *segmentation=None*, *onlySegments=False*, *showProgress=False*)

This class wraps around a helper and allows getting multiple features at once. The main usage of this class if for generating features to use with machine learning techniques.

Methods

addCustomFeature(function[, channels, ...])	Adds a custom feature that will be included in the dataset.
addFeatures(features)	**Parameters**
featuresNames()	Returns the names of the specified features.
getAllFeatures()	Iterates over all the windows in the helper and returns all the values.
getFeatures()	Returns the features in the current window of the helper iterator.
getStoredFeatures()	Returns the stored features if store was set to True, else it returns None.
reset()	Resets the

__init__(*helper*, *flat=True*, *flatSeparator='_'*, *store=True*, *label=None*, *segmentation=None*, *onlySegments=False*, *showProgress=False*)

Parameters

helper:
[py:class:*eeglib.helpers.Helper*] The helper object that will be used to get the data and the iteration settings.

flat: Bool
If True the result of calling getFeatures() will be a one dimensional sequence of data. If False, the return value will be a list containing the result of each feature, that can be a float, a dict or an array. Default: True.

separator: str
It is used to separate the features names when flatten.

store: Bool
If True, the data will be stored in a self.storedFeatures. Default: True.

label: object, optional
This value will be added as a field in the data except if it is None. Default: None.

segmentation: dict of tuples, optional
Parameter format [((begin, end),label),]; begin is the begin of the segment, end is the end of the segment and label the label realed to that segment. Begin and end can be either an int, a str or a datetime.timedelta, being the same that the parameter of *eeglib.helpers.Helper.moveEEGWindow()*. The label of the unlabelled segments will be 0. If None, no segmentation will be added. Default: None.

onlySegments: bool, optional
If True, only windows between segments will be computed. Only used if a segmentation argument is used.

showProgress: bool, optional
If True, it will shown the progress when computing all the features.

`addCustomFeature`(*function*, *channels=None*, *twoChannels=False*, *name=None*, *customArgs=[]*, *customKwargs={}*)

Adds a custom feature that will be included in the dataset.

Parameters

function: function
The function to apply. It must take an array-like as first parameter if twoChannels parameter is False or two array-like for each of the first two parameters if twoChannels is True.

channels: Variable type, optional
The channels over which the function will be applied. * int: the index of the channel. * str: the name of the channel. * list of strings and integers: a list of channels. * slice: a slice selecting the range of channels. * None: all the channels. The function to apply to the data to obtain the feature.

twoChannels: bool
If function receives two channels of data this parameter should be True. Default: False.

name: str
A custom name for the feature that will be visible in the df.

customArgs: list
A list of fixed arguments for the function.

customKwargs: dict
A dict of keyword arguments, where the key is the argument name and the value is the argument content.

Returns

None

`addFeatures`(*features*)

Parameters

features: list(tuple(str,list, dict))
A list containing tuples that represent the parameters needed to add a single feature.

`featuresNames()`

Returns the names of the specified features.

`getAllFeatures()`

Iterates over all the windows in the helper and returns all the values.

Returns

pandas.DataFrame

`getFeatures()`

Returns the features in the current window of the helper iterator.

Returns

pandas.Series

`getStoredFeatures()`

Returns the stored features if store was set to True, else it returns None.

`reset()`

Resets the

Returns

None.

CHAPTER

FOUR

DOCUMENTATION OF EEGLIB.FEATURES MODULE

This module define the functions of the features for EEG analysis

eeglib.features.**DFA**(*data*, *fit_degree=1*, *min_window_size=4*, *max_window_size=None*, *fskip=1*, *max_n_windows_sizes=None*)

Applies Detrended Fluctuation Analysis algorithm to the given data.

Parameters

data: array_like
The signal.

fit_degree: int, optional
Degree of the polynomial used to model de local trends. Default: 1.

min_window_size: int, optional
Size of the smallest window that will be used. Default: 4.

max_window_size: int, optional
Size of the biggest window that will be used. Default: signalSize//4

fskip: float, optional
Fraction of the window that will be skiped in each iteration for each window size. Default: 1

max_n_windows_sizes: int, optional
Maximum number of window sizes that will be used. The final number can be smaller once the repeated values are removed Default: log2(size)

Returns

float
The resulting value

eeglib.features.**HFD**(*data*, *kMax=None*)

Returns the Higuchi Fractal Dimension of the signal given data.

Parameters

data: array_like
signal

kMax: int, optional
By default it will be windowSize//4.

Returns

float
The resulting value

eeglib.features.**LZC**(*data*, *threshold=None*)

Returns the Lempel-Ziv Complexity (LZ76) of the given data.

Parameters

data: array_like
The signal.

theshold: numeric, optional
A number use to binarize the signal. The values of the signal above threshold will be converted to 1 and the rest to 0. By default, the median of the data.

References

[1]

eeglib.features.**PFD**(*data*)

Returns the Petrosian Fractal Dimension of the signal given in data.

Parameters

data: array_like
Signal

Returns

float
The resulting value

eeglib.features.**bandPower**(*spectrum*, *bandsLimits*, *freqRes*, *normalize=False*)

Returns the power of each band at the given index.

Parameters

spectrum: 1D arraylike
An array containing the spectrum of a signal

bandsLimits: dict
This parameter is used to indicate the bands that are going to be used. It is a dict with the name of each band as key and a tuple with the lower and upper bounds as value.

freqRes: float
Minimum resolution for the frequency.

normalize: bool, optional
If True the each band power is divided by the total power of the spectrum. Default False.

Returns

dict
The keys are the name of each band and the values are their power.

eeglib.features.**countSignChanges**(*data*)

Returns the number of sign changes of a 1D array

Parameters

data: array_like
The data from which the sign changes will be counted

Returns

int
Number of sign changes in the data

eeglib.features.**hjorthActivity**(*data*)

Returns the Hjorth Activity of the given data

Parameters

data: array_like

Returns

float
The resulting value

eeglib.features.**hjorthComplexity**(*data*)

Returns the Hjorth Complexity of the given data

Parameters

data: array_like

Returns

float
The resulting value

eeglib.features.**hjorthMobility**(*data*)

Returns the Hjorth Mobility of the given data

Parameters

data: array_like

Returns

float
The resulting value

eeglib.features.**sampEn**(*data*, *m=2*, *l=1*, *r=None*, *fr=0.2*, *eps=1e-10*)

Returns Sample Entropy of the given data.

Parameters

data: array_like
The signal

m: int, optional
Size of the embedded vectors. By default 2.

l: int, optional
Lag beetwen elements of embedded vectors. By default 1.

r: float, optional
Tolerance. By default fr*std(data)

fr: float, optional
Fraction of std(data) used as tolerance. If r is passed, this parameter is ignored. By default, 0.2.

eps: float, optional
Small number added to avoid infinite results. If 0 infinite results can appear. Default: 1e-10.

Returns

float
The resulting value

eeglib.features.**synchronizationLikelihood**(*c1*, *c2*, *m*, *l*, *w1*, *w2*, *pRef=0.05*, *epsilonIterations=20*)

Returns the Synchronization Likelihood between c1 and c2. This is a modified version of the original algorithm.

Parameters

c1: array_like
First signal

c2: array_like
second signal

m: int
Numbers of elements of the embedded vectors.

l: int
Separation between elements of the embedded vectors.

w1: int
Theiler correction for autocorrelation effects

w2: int
A window that sharpens the time resolution of the Synchronization measure

pRef: float, optional
The pRef param of the synchronizationLikelihood. Default 0.05

epsilonIterations: int,optional
Number of iterations used to determine the value of epsilon. Default:20

Returns

float
A value between 0 and 1. 0 means that the signal are not synchronized at all and 1 means that they are totally synchronized.

CHAPTER

FIVE

DOCUMENTATION OF EEGLIB.PREPROCESSING MODULE

This module define the functions for preprocessing the signal data

eeglib.preprocessing.**bandPassFilter**(*data*, *sampleRate=None*, *highpass=None*, *lowpass=None*, *order=2*)

Return the signal filtered between highpass and lowpass. Note that neither highpass or lowpass should be above sampleRate/2.

Parameters

data: numpy.ndarray
The signal

sampleRate: numeric, optional
The frequency at which the signal was recorded. By default it is the same as the number of samples of the signal.

highpass: numeric, optional
The signal will be filtered above this value.

lowpass: numeric, optional
The signal will be filtered bellow this value.

order: int, optional
Butterworth

Returns

numpy.ndarray
The signal filtered betwen the highpass and the lowpass

CHAPTER

SIX

INDICES AND TABLES

Here there are diferents indices of the documentation and a search utility.

- genindex
- modindex
- search

BIBLIOGRAPHY

[1] M. Aboy, R. Hornero, D. Abasolo and D. Alvarez, “Interpretation of the Lempel-Ziv Complexity Measure in the Context of Biomedical Signal Analysis,” in IEEE Transactions on Biomedical Engineering, vol. 53, no.11, pp. 2282-2288, Nov. 2006.

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