

pyEDM Version 1.15.3 November 31, 2023

[pyEDM](#) is a Python package interface to the [cppEDM](#) C++ library of empirical dynamic modeling (EDM) algorithms. It returns Pandas DataFrame objects, or Python dictionaries of Pandas DataFrames. pyEDM is hosted on the Python Package Index (PyPI) at [pypi/pyEDM](#). A Jupyter notebook GUI is available at [jpyEDM](#).

Table of Contents

Introduction.....	2
Installation.....	3
Python Package Index (PyPI).....	3
Manual Compilation.....	3
OSX and Linux.....	3
Windows.....	3
Usage.....	4
Parameters.....	5
Application Programming Interface (API).....	6
Embed.....	6
Simplex.....	7
SMap.....	9
CCM.....	12
Multiview.....	14
EmbedDimension.....	16
PredictInterval.....	17
PredictNonlinear.....	18
ComputeError.....	19
SurrogateData.....	20
Application Notes.....	21
Examples.....	22
References.....	23

University of California at San Diego
Scripps Institution of Oceanography
Sugihara Lab

Joseph Park, Cameron Smith

Introduction

[pyEDM](#) is a Python interface to the C++ library [cppEDM](#). Input and output objects are based on Pandas DataFrame objects. Core algorithms are listed in Table 1.

Algorithm	API Interface	Reference
Simplex projection	<code>Simplex()</code>	Sugihara and May (1990)
Sequential Locally Weighted Global Linear Maps (S-map)	<code>SMap()</code>	Sugihara (1994)
Predictions from multivariate embeddings	<code>Simplex()</code> , <code>SMap()</code>	Dixon et. al. (1999)
Convergent cross mapping	<code>CCM()</code>	Sugihara et. al. (2012)
Multiview embedding	<code>Multiview()</code>	Ye and Sugihara (2016)

Convenience functions to prepare and evaluate data are listed in Table 2.

Function	Purpose	Parameter Range
<code>Embed()</code>	Timeseries delay dimensional embedding	User defined
<code>MakeBlock()</code>	Timeseries delay dimensional embedding	User defined
<code>EmbedDimension()</code>	Evaluate prediction skill vs. embedding dimension	$E = [1, 10]$
<code>PredictInterval()</code>	Evaluate prediction skill vs. forecast interval	$T_p = [1, 10]$
<code>PredictNonlinear()</code>	Evaluate prediction skill vs. SMap nonlinear localisation	$\theta = 0.01, 0.1, 0.3, 0.5, 0.75, 1, 1.5, 2, 3, 4, 5, 6, 7, 8, 9$
<code>ComputeError()</code>	Pearson ρ , RMSE, MAE	
<code>Examples()</code>	Example function calls and plots	

Installation

There are two methods to install pyEDM:

- 1) Python Package Index and pip, which is only supported for certain OSX and Windows platforms
- 2) Download, build and install package.

Python Package Index (PyPI)

Certain Mac OSX and Windows platforms are supported with prebuilt binary distributions and can be installed using the Python pip module. The module is located at pypi.org/project/pyEDM/.

Installation can be executed as:

```
python -m pip install pyEDM --trusted-host pypi.org --trusted-host
files.pythonhosted.org pyEDM
```

Manual Compilation

Unfortunately, we do not have the resources to provide pre-built binary distributions for all computer platforms. In this case the user is required to first build the cppEDM library on their machine, and then install the Python package using pip. On OSX and Linux this requires gcc and the LAPACK library. On Windows, mingw from MSYS2 can be used.

OSX and Linux

1) Download pyEDM: `git clone https://github.com/SugiharaLab/pyEDM`

2) Build cppEDM library:
`cd pyEDM/cppEDM/src`
`make`

3) Build and install package:
`cd ../../`
`python -m pip install . --user --trusted-host pypi.org`

Windows

We do not have resources to maintain windows build support. These suggestions may be useful.

Requires mingw installation. MSYS2 provides a mingw package.

- 1) Download pyEDM: `git clone https://github.com/SugiharaLab/pyEDM`
- 2) Build cppEDM library: `cd pyEDM\cppEDM\src; make`
- 3) Build and install package in pyEDM\ : `python -m pip install . --user`

Usage

```
>>> import pyEDM
>>> pyEDM.Examples()
```

See the Examples section below.

All data input files are assumed to be in .csv format or Pandas DataFrame.

The files are required to have a single line header with column names.

It is expected the first column is a vector of times or time indices. This can be disabled with the `noTime = True` parameter.

Parameters

API parameter names and purpose are listed in Table 3.

Parameter	Type	Default	Purpose
pathIn	string	"./"	Input data file path
dataFile	string	""	Data file name
dataFrame	Pandas DataFrame	None	Input DataFrame
pathOut	string	"./"	Output file path
predictFile	string	""	Prediction output file
smapCoefFile	string	""	SMap coefficient output file
smapSVFile	string	""	SMap singular values output file
lib	string	""	library start : stop row indices
pred	string	""	prediction start : stop row indices
D	int	0	Multiview state-space dimension
E	int	0	Embedding dimension
Tp	int	0 or 1	Prediction interval
knn	int	0	Number nearest neighbors
tau	int	-1	Embedding delay
theta	float	0	SMap localisation
exclusionRadius	int	0	Prediction vector exclusion radius
columns	string	"" or []	Column names or indices for library
target	string	""	Target library column name or index
embedded	bool	False	Is data an embedding?
const_pred	bool	False	Include non projected forecast data
ignoreNan	bool	True	SMap detect and remove nan from lib
verbose	bool	False	Echo messages
validLib	[bool]	[]	Conditional Embedding (CE)
noTime	bool	False	Do not require first column to be time
generateSteps	int	0	Simplex, SMap feedback prediction
generateLibrary	bool	False	Increment EDM library with feedback
parameterList	bool	False	Return Parameters map
smapFile	string	""	SMap coefficient output file
solver	sklearn.linear_model	None	SMap solver
multiview	int	0	Number of ensembles, 0 = sqrt(N)
trainLib	bool	True	Multiview use lib as training library
excludeTarget	bool	True	Multiview exclude target from combos
libSizes	string or [int]	""	CCM library sizes
sample	int	0	CCM number of random samples
random	bool	True	CCM use random samples?
replacement	bool	False	CCM sample with replacement?
includeData	bool	False	CCM include all projections in return
seed	unsigned	0	CCM RNG seed, 0 = random seed
method	string	"ebisusaki"	SurrogateData method
alpha	float	range / 5	SurrogateData seasonal noise std dev
smooth	float	0.8	SurrogateData seasonal spline smooth

Application Programming Interface (API)

Embed

Create a data block of Takens (1981) time-delay embedding from each of the columns in the csv file or dataframe. The columns parameter can be a list of column names, or a list of column indices. If columns is a list of indices, then column names are created as V1, V2...

Note: The returned DataFrame will have $\tau \cdot (E - 1)$ fewer rows than the input data from the removal of partial vectors as a result of the embedding.

Note: The returned DataFrame will not have the time column.

```
//-----  
//  
//-----  
DataFrame Embed ( path      = "./",  
                  dataFile  = "",  
                  dataframe = None,  
                  E         = 0,  
                  tau       = -1,  
                  columns   = "",  
                  verbose   = False )  
  
//-----  
//  
//-----  
DataFrame MakeBlock ( dataframe,  
                     E         = 0,  
                     tau       = -1,  
                     columnNames = "",  
                     deletePartial = False )
```

Simplex

Simplex projection of the input data file or DataFrame. If `parameterList = False`, (default) the returned object is a DataFrame with 3 columns : "Time", "Observations", "Predictions". nan values are inserted where there is no observation or prediction. If `parameterList = True`, a dictionary with keys: `predictions`, `parameters` is returned with the respective dictionary values the predictions DataFrame and parameter dictionary.

See the Parameters table for parameter definitions.

Parameters

`lib` and `pred` specify [start stop] row indices of the input data for the library and predictions.

If `embedded` is `False` the data columns are embedded to dimension `E` with delay `tau`. If `embedded` is `True` the data columns are assumed to be a multivariable data block.

If `knn` is not specified, and `embedded` is `False`, it is set equal to `E+1`. If `embedded` is `True`, `knn` is set equal to the number of columns + 1.

`exclusionRadius` defines the number of library rows excluded from the state-space library with respect to a temporal "radius" from the prediction state. If `exclusionRadius = 1`, library state-space points from observation time series that are within ± 1 sequential observation row of the prediction state are not included in the library. Note that units of the radius are time series rows, not time values.

`validLib` implements conditional embedding (CE). It is a boolean vector the same length as the number of time series rows. A `False` entry means that the state-space vector derived from the corresponding time series row will not be included in the state-space library.

If `columns` is a string and column names have whitespace, delimit the columns with “,” or, place the column names in a list.

If `parameterList = True`, then `parameters` is populated and returned in a dictionary.

If `generateSteps > 0`, then `Simplex` operates in feedback generative mode. The values of `pred` are over-riden to start at the end of the data. At each step one prediction is made, added to the `columns` data, a new time-delay embedded is created, and the cycle repeated for `generateSteps`. Feedback generation only operates on a univariate time series that is time-delay embedded. The `columns` and target variables must be the same. If `generateLibrary` is `false` the state-space library is not expanded as predictions are generated, it is static. If `generateLibrary` is `true` the state-space library has the generated prediction added to the library at each step.

If `noTime = False`, the first column of the input DataFrame or .csv file must be an index or time column. If `noTime = True` an index or time column is not required.

```
//-----
//
//-----
DataFrame Simplex( pathIn      = "./",
                   dataFile    = "",
                   dataframe    = None,
                   pathOut     = "./",
                   predictFile  = "",
                   lib          = "",
                   pred         = "",
                   E            = 0,
                   Tp          = 1,
                   knn          = 0,
                   tau          = -1,
                   exclusionRadius = 0,
                   columns      = "",
                   target       = "",
                   embedded     = False,
                   verbose      = False,
                   const_pred   = False,
                   showPlot     = False,
                   validLib     = [],
                   generateSteps = 0,
                   generateLibrary = False,
                   parameterList = False,
                   noTime       = False )
```


SMap

SMap projection of the input data file or DataFrame. See the Parameters table for parameter definitions.

SMap() returns a dict with three DataFrames:

```
dict { predictions      : DataFrame,  
      coefficients     : DataFrame,  
      singularValues   : DataFrame  
}
```

The predictions DataFrame has 3 columns "Time", "Observations", "Predictions". nan values are inserted where there is no observation or prediction. If predictFile is provided the predictions will be written to it in csv format.

The coefficients DataFrame will have E+2 columns. The first column is the "Time" vector, the remaining E+1 columns are the SMap SVD fit coefficients. The first column "C0" is the bias term, following coefficients are $\partial \text{target} / \partial \text{columns}[i]$.

The singularValues DataFrame holds SVD singular values if the default LAPACK solver, or scikit.learn LinearRegression solver is used. The scikit.learn LinearRegression does not return a singular value for the intercept (bias) term.

If parameterList = True, a dictionary with parameters is added to the returned object.

Parameters

lib and pred specify [start, stop] row indices of the input data for the library and predictions.

If embedded is False the data columns are embedded to dimension E with delay tau. If embedded is True the data columns are assumed to be a multivariable data block. If smapFile is provided the coefficients will be written to it in csv format.

If columns is a string and column names have whitespace, delimit the columns with “,” or, place the column names in a list.

If parameterList = True, a dictionary with parameters is added to the returned object.

If a multivariate data set is used (number of columns > 1) it must use embedded = true with E equal to the number of columns. This prevents the function from internally time-delay embedding the multiple columns to dimension E. If the internal time-delay embedding is performed, then state-space columns will not correspond to the intended dimensions in the matrix inversion, coefficient assignment, and prediction. In the multivariate case, the user should first prepare the embedding (using Embed() for time-delay embedding if desired), then pass this embedding to SMap with appropriately specified columns, E, and embedded = true.

If `knn` is not specified, it is set equal to the library size. If `knn` is specified, it must be greater than $E+1$.

`exclusionRadius` defines the number of library rows excluded from the state-space library with respect to a temporal "radius" from the prediction state. If `exclusionRadius = 1`, library state-space points from observation time series that are within ± 1 sequential observation row of the prediction state are not included in the library. Note that units of the radius are time series rows, not time values.

If `noTime = False`, the first column of the input DataFrame or .csv file must be an index or time column. If `noTime = True` an index or time column is not required.

`ignoreNan` automatically redefines the library to avoid nan observations and associated state vectors. If `ignoreNan` is false the library is not changed. The user can manually specify library row segments to ignore nan values.

`validLib` implements conditional embedding (CE). It is a boolean vector the same length as the number of time series rows. A false entry means that the state-space vector derived from the corresponding time series row will not be included in the state-space library.

If `generateSteps > 0`, then SMap operates in feedback generative mode. The values of `pred` are overridden to start at the end of the data. At each step one prediction is made, added to the columns data, a new time-delay embedded is created, and the cycle repeated for `generateSteps`. Feedback generation only operates on a univariate time series that is time-delay embedded. The columns and target variables must be the same. If `generateLibrary` is false the state-space library is not expanded as predictions are generated, it is static. If `generateLibrary` is true the state-space library has the generated prediction added to the library at each step.

The default solver for the SMap coefficient matrix is the LAPACK SVD function `dgelss()`. If the default solver is used, SMap singular values are returned. This can be replaced with a user-instantiated class object from the python `sklearn.linear_model`: Linear Models. Supported solvers include: `LinearRegression`, `Ridge`, `Lasso`, `ElasticNet`, `RidgeCV`, `LassoCV`, `ElasticNetCV`. See the `pyEDM/tests/smapSolverTest.py` script for examples.

```

//-----
//
//-----
dict SMap( pathIn      = "./",
           dataFile    = "",
           dataFrame   = None,
           pathOut     = "./",
           predictFile  = "",
           lib         = "",
           pred        = "",
           E           = 0,
           Tp          = 1,
           knn         = 0,
           tau         = -1,
           theta       = 0,
           exclusionRadius = 0,
           columns     = "",
           target      = "",
           smapCoefFile = "",
           smapSVFile  = "",
           solver      = None,
           embedded    = False,
           verbose     = False,
           const_pred  = False,
           showPlot    = False,
           validLib    = [],
           ignoreNan   = True,
           generateSteps = 0,
           generateLibrary = False,
           parameterList = False,
           noTime      = False )

```

CCM

Convergent cross mapping of columns against target via Simplex. Normally, one column and one target are specified. The column time series is time-delay embedded to dimension E, cross mapped with the target time series. The target time series is then embedded to E and cross mapped against the column as the "target" time series, not an embedding.

If there are multiple columns and embedded is false, each column is time-delay embedded to dimension E creating an N-columns * E dimensional "mixed" embedding. If embedded is true, no time-delay embedding is done, creating a multivariate embedding of the specified columns. The same logic applies if multiple target are specified for the "reverse" mapping. If embedded is false, each target is time-delay embedded to dimension E creating an N-target * E dimensional "mixed" embedding cross mapped to the first column as the cross map target. If embedded is true, no time-delay embedding is done, creating a multivariate embedding of the specified target(s).

Cross mappings are performed between column : target, and, target : column in separate threads. If multiprocessing is applied, halve the number of processors.

See the Parameters table for parameter definitions.

If includeData is False, the returned DataFrame has 3 columns. The first column is "LibSize", the second and third columns are Pearson correlation coefficients for "column : target" and "target : column" cross mapping. If includeData is True, a dict is returned with the LibMeans DataFrame, and a DataFrames of prediction statistics for all predictions in the ensembles. If includeData is True, and parameterList = True, then parameters dictionary is added to the return object.

Parameters

The libSizes parameter is a string of whitespace or comma separated library sizes. If the string has 3 values, and, if the third value is less than the second value, then the three values are interpreted as a sequence generator specifying "start stop increment" row values, i.e. "10 80 10" will evaluate library sizes from 10 to 80 in increments of 10.

If random is true, sample observations are randomly selected from the subset of each library size. If seed=0, then a random seed is generated for the random number generator. Otherwise, seed is used to initialise the random number generator.

If random is false, sample is ignored and contiguous library rows up to the current library size are used.

If noTime = False, the first column of the input DataFrame or .csv file must be an index or time column. If noTime = True an index or time column is not required.

Note: Cross mappings are performed between column : target, and target : column. The default is to do this in separate threads. Threading can be disabled in the makefile by removing -DCCM_THREADED.

Note: The entire prediction vector is used in the Simplex prediction at each library subset size.

```

//-----
//
//-----
DataFrame or dict CCM( pathIn      = "./",
                      dataFile    = "",
                      dataframe   = None,
                      pathOut     = "./",
                      predictFile = "",
                      E           = 0,
                      Tp          = 0,
                      knn         = 0,
                      tau         = -1,
                      exclusionRadius = 0,
                      columns     = "",
                      target      = "",
                      libSizes    = "",
                      sample      = 0,
                      random      = True,
                      replacement = False,
                      seed        = 0, // seed=0: use RNG
                      embedded    = False,
                      includeData = False,
                      parameterList = False,
                      verbose     = False,
                      showPlot    = False,
                      noTime      = False );

```

Multiview

Multiview embedding and forecasting of the input data file or DataFrame. See the Parameters table for parameter definitions.

Multiview() returns a dict:

```
dict { View      : DataFrame,
      Predictions : DataFrame,
      [ parameters : dict ]
}
```

The Predictions DataFrame has 3 columns "Time", "Observations", "Predictions". nan values are inserted where there is no observation or prediction. If predictFile is provided the Predictions will be written to it in csv format.

The View DataFrame will have $2*D+3$ columns. The first D columns are the the column indices in the input data DataFrame that are embedded and applied to Simplex prediction. The following three columns are "rho", "MAE", "RMSE" corresponding to the prediction Pearson correlation, maximum absolute error and root mean square error. The final D columns are the column names of the input embedding.

Parameters

D represents the number of variables to combine for each assessment, if not specified, it is the number of columns.

E is the embedding dimension of each variable. If $E = 1$, no time delay embedding is done.

multiview is the number of top-ranked D -dimensional predictions to "average" for the final prediction. Corresponds to parameter k in Ye & Sugihara with default $k = \sqrt{C}$ where C is the number of combinations $C(n,D)$ available from the embedding columns taken D at-a-time.

trainLib specifies whether projections used to rank the column combinations are done in-sample (pred = lib, the default), or, using the lib and pred specified as input options (trainLib false).

lib and pred specify [start, stop] row indices of the input data for the library and predictions.

If knn is not specified, it is set equal to $D+1$.

If columns is a string and column names have whitespace, delimit the columns with “,” or, place the column names in a list.

If parameterList = True, a dictionary with parameters is added to the returned object.

numThreads defines the number of worker threads.

If noTime = False, the first column of the input DataFrame or .csv file must be an index or time column. If noTime = True an index or time column is not required.

```

//-----
//
//-----
dict Multiview( pathIn      = "./",
                dataFile    = "",
                dataFrame    = None,
                pathOut      = "./",
                predictFile   = "",
                lib           = "",
                pred         = "",
                D             = 0,
                E             = 1,
                Tp            = 1,
                knn           = 0,
                tau           = -1,
                columns       = "",
                target        = "",
                multiview     = 0,
                exclusionRadius = 0,
                trainLib      = True,
                excludeTarget = False,
                parameterList = False,
                verbose       = False,
                numThreads    = 4,
                showPlot      = False,
                noTime        = True )

```

EmbedDimension

Evaluate Simplex prediction skill for embedding dimensions from 1 to 10. The returned `DataFrame` has columns "E" and "rho". See the Parameters table for parameter definitions.

Note: `numThreads` defines the number of worker threads for the 10 embeddings. The maximum number of threads is 10.

If `noTime = False`, the first column of the input `DataFrame` or `.csv` file must be an index or time column. If `noTime = True` an index or time column is not required.

If `columns` is a string and column names have whitespace, delimit the columns with “,” or, place the column names in a list.

```
//-----  
//  
//-----  
DataFrame EmbedDimension( pathIn      = "./",  
                           dataFile    = "",  
                           dataframe    = None,  
                           pathOut     = "./",  
                           predictFile  = "",  
                           lib          = "",  
                           pred         = "",  
                           maxE         = 10,  
                           Tp           = 1,  
                           tau          = -1,  
                           exclusionRadius = 0,  
                           columns      = "",  
                           target       = "",  
                           embedded     = False,  
                           verbose      = False,  
                           validLib     = [],  
                           numThreads   = 4,  
                           showPlot     = True,  
                           noTime       = False )
```


PredictInterval

Evaluate Simplex prediction skill for forecast intervals from 1 to 10. The returned DataFrame has columns "Tp" and "rho". See the Parameters table for parameter definitions.

Note: numThreads defines the number of worker threads for the 10 prediction interval forecasts. The maximum number of threads is 10.

If noTime = False, the first column of the input DataFrame or .csv file must be an index or time column. If noTime = True an index or time column is not required.

If columns is a string and column names have whitespace, delimit the columns with “,” or, place the column names in a list.

```
//-----  
// Overload 1: Explicit data file path/name  
//-----  
DataFrame PredictInterval( pathIn      = "./",  
                           dataFile    = "",  
                           dataframe    = None,  
                           pathOut     = "./",  
                           predictFile = "",  
                           lib         = "",  
                           pred        = "",  
                           maxTp       = 10,  
                           E           = 0,  
                           tau         = -1,  
                           exclusionRadius = 0,  
                           columns     = "",  
                           target      = "",  
                           embedded    = False,  
                           verbose     = False,  
                           validLib    = [],  
                           numThreads  = 4,  
                           showPlot    = True,  
                           noTime      = False );
```

PredictNonlinear

Evaluate SMap prediction skill for localisation parameter θ (default from 0.01 to 9). The returned DataFrame has columns "theta" and "rho". See the Parameters table for parameter definitions.

If knn is not specified, it is set equal to the library size. If knn is specified, it must be greater than E.

Note: numThreads defines the number of worker threads for the θ value forecasts.

If noTime = False, the first column of the input DataFrame or .csv file must be an index or time column. If noTime = True an index or time column is not required.

If columns is a string and column names have whitespace, delimit the columns with “,” or, place the column names in a list.

```
//-----  
//  
//-----  
DataFrame PredictNonlinear( pathIn      = "./",  
                             dataFile    = "",  
                             dataframe    = None,  
                             pathOut     = "./",  
                             predictFile  = "",  
                             lib          = "",  
                             pred         = "",  
                             theta        = "",  
                             E            = 0,  
                             knn          = 0,  
                             Tp           = 1,  
                             tau          = -1,  
                             exclusionRadius = 0,  
                             columns      = "",  
                             target       = "",  
                             embedded     = False,  
                             verbose      = False,  
                             validLib     = [],  
                             ignoreNan    = true,  
                             numThreads   = 4,  
                             showPlot     = True,  
                             noTime       = False );
```

ComputeError

Compute Pearson correlation coefficient, maximum absolute error (MAE) and root mean square error (RMSE) between two vectors.

`ComputeError()` returns a dict:

```
dict { rho  : double,  
        RMSE : double,  
        MAE  : double  
}
```

```
//-----  
//-----  
dict ComputeError( obsIn, predIn )
```

SurrogateData

Generate surrogate data using one of three methods.

1) random_shuffle :

Sample the data with a uniform distribution.

2) ebisuzaki :

Journal of Climate. A Method to Estimate the Statistical Significance of a Correlation When the Data Are Serially Correlated.

[https://doi.org/10.1175/1520-0442\(1997\)010<2147:AMTETS>2.0.CO;2](https://doi.org/10.1175/1520-0442(1997)010<2147:AMTETS>2.0.CO;2)

Presumes data are serially correlated with low pass coherence. It is: "resampling in the frequency domain. This procedure will not preserve the distribution of values but rather the power spectrum (periodogram). The advantage of preserving the power spectrum is that resampled series retains the same autocorrelation as the original series."

3) seasonal :

Presume a smoothing spline represents the seasonal trend. The smooth parameter can range from 0 to 1. See [scipy.interpolate.UnivariateSpline](#) parameter s.

Each surrogate is a summation of the trend, resampled residuals, and possibly additive Gaussian noise. Default noise has a standard deviation (alpha) that is the data range / 5.

Note: It is presumed the first column of the dataframe is a time vector. It is set as the first column of the returned DataFrame.

```
//-----  
//  
//-----  
DataFrame SurrogateData( dataframe    = None,  
                           column      = None,  
                           method      = 'ebisuzaki',  
                           numSurrogates = 10,  
                           alpha       = None,  
                           smooth      = 0.8,  
                           outputFile   = None )
```

Application Notes

All data input files are assumed to be in .csv format, or Pandas DataFrame.

The files are required to have a single line header with column names.

It is expected the first column be a vector of times or time indices. This can be disabled by setting the parameter `noTime = True`.

`SMap()` should be called with `DataFrame` that have columns explicitly corresponding to dimensions E . This means that if a multivariate data set is used, it should Not be called with an embedding from `Embed()` since `Embed()` will add lagged coordinates for each variable. These extra columns will then not correspond to the intended dimensions in the matrix inversion and prediction reconstruction. In this case, use the `embedded` parameter set to `true` so that the columns selected correspond to the proper dimension.

Examples

```
from pyEDM import *

df = EmbedDimension( dataFrame = sampleData["TentMap"],
                    lib = "1 100", pred = "201 500",
                    columns = "TentMap", showPlot = True )

df = PredictInterval( dataFrame = sampleData["TentMap"],
                    lib = "1 100", pred = "201 500", E = 2,
                    columns = "TentMap", showPlot = True )

df = PredictNonlinear( dataFrame = sampleData["TentMapNoise"],
                    lib = "1 100", pred = "201 500", E = 2,
                    columns = "TentMap", showPlot = True )

df = Simplex( dataFrame = sampleData["block_3sp"],
             lib = "1 99", pred = "100 198", E = 3,
             columns = "x_t y_t z_t", target = "x_t",
             embedded = True, showPlot = True )

df = Simplex( dataFrame = sampleData["block_3sp"],
             lib = "1 99", pred = "100 195", E = 3,
             columns = "x_t", target = "x_t", showPlot = True )

M = Multiview( dataFrame = sampleData["block_3sp"],
             lib = "1 100", pred = "101 198", E = 3,
             columns = "x_t y_t z_t", target = "x_t", showPlot = True )

S = SMap( dataFrame = sampleData["circle"],
         lib = "1 100", pred = "101 198", E = 2, theta = 4,
         columns = "x y", target = "x", embedded = True, showPlot = True )

df = CCM( dataFrame = sampleData["sardine_anchovy_sst"],
         E = 3, Tp = 0, columns = "anchovy", target = "np_sst",
         libSizes = "5 75 5", sample = 100, showPlot = True )
```

References

Dixon, P. A., M. Milicich, and G. Sugihara, 1999. Episodic fluctuations in larval supply. *Science* 283:1528–1530.

Sugihara G. and May R. 1990. Nonlinear forecasting as a way of distinguishing chaos from measurement error in time series. *Nature*, 344:734–741.

Sugihara G. 1994. Nonlinear forecasting for the classification of natural time series. *Philosophical Transactions: Physical Sciences and Engineering*, 348 (1688) : 477–495.

Sugihara G., May R., Ye H., Hsieh C., Deyle E., Fogarty M., Munch S., 2012. Detecting Causality in Complex Ecosystems. *Science* 338:496-500.

Takens, F. Detecting strange attractors in turbulence. *Lect. Notes Math.* 898, 366–381 (1981).

Ye H., and G. Sugihara, 2016. Information leverage in interconnected ecosystems: Overcoming the curse of dimensionality. *Science* 353:922–925.