motifcluster

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A Python package for motif-based spectral clustering of weighted directed networks.

CHAPTER

ONE

INTRODUCTION

The **motifcluster** package provides implementations of motif-based spectral clustering of weighted directed networks in Python. These provide the capability for:

- Building motif adjacency matrices
- Sampling random weighted directed networks
- Spectral embedding with motif adjacency matrices
- Motif-based spectral clustering

The methods are all designed to run quickly on large sparse networks, and are easy to install and use. These methods are based on those described in [Underwood, Elliott and Cucuringu, 2020], which is available at arxiv:2004.01293.

CHAPTER

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INSTALLATION

```
pip install motifcluster
```

CHAPTER

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DEPENDENCIES

- Networkx
- Numpy
- Scipy
- Scikit-learn

CHAPTER

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DOCUMENTATION

Documentation for the **motifcluster** package is available on Read the Docs, and also on GitHub in the doc directory.

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TUTORIAL

A tutorial for the **motifcluster** package is available on Github in the tutorial directory.

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LINKS

- Source code repository on GitHub
- Package index page on PyPI
- Documentation on Read the Docs

CHAPTER

EIGHT

CONTENTS

8.1 Clustering methods

Functions for spectral clustering are in *motifcluster.clustering*.

cluster_spectrum(*spectrum*, *num_clusts*)

Get cluster assignments from spectrum using k-means++.

Get a list of cluster assignments from a spectrum, using k-means++ and *num_clusts* clusters.

Parameters

- **spectrum** (*dict*) – A dictionary containing *"vects"*: the matrix of eigenvectors to pass to k-means++.
- **num_clusts** (*int*) – The number of clusters to find.

Returns **cluster_assigns** – A list of integers from *1* to *num_clusts*, representing cluster assignments.

Return type list of int

run_motif_clustering(*adj_mat*, *motif_name*, *motif_type='struc'*, *mam_weight_type='unweighted'*, *mam_method='sparse'*, *num_eigs=2*, *type_lap='comb'*, *num_clusts=2*, *restrict=True*, *gr_method='sparse'*)

Run motif-based clustering.

Run motif-based clustering on the adjacency matrix of a (weighted directed) network, using a specified motif, motif type, weighting scheme, embedding dimension, number of clusters and Laplacian type. Optionally restrict to the largest connected component before clustering.

Parameters

- **adj_mat** (*matrix*) – Adjacency matrix to be embedded.
- **motif_name** (*str*) – Motif used for the motif adjacency matrix.
- **motif_type** (*str*) – Type of motif adjacency matrix to use. One of *"func"* or *"struc"*.
- **mam_weight_type** (*str*) – Weighting scheme for the motif adjacency matrix. One of *"unweighted"*, *"mean"* or *"product"*.
- **mam_method** (*str*) – The method to use for building the motif adjacency matrix. One of *"sparse"* or *"dense"*.
- **num_eigs** (*int*) – Number of eigenvalues and eigenvectors for the embedding.
- **type_lap** (*str*) – Type of Laplacian for the embedding. One of *"comb"* or *"rw"*.
- **num_clusts** (*int*) – The number of clusters to find.

- **restrict** (*bool*) – Whether or not to restrict the motif adjacency matrix to its largest connected component before embedding.
- **gr_method** (*str*) – Format to use for getting largest component. One of *"sparse"* or *"dense"*.

Returns

- **adj_mat** (*sparse matrix*) – The original adjacency matrix.
- **motif_adj_mat** (*sparse matrix*) – The motif adjacency matrix.
- **comps** (*list*) – The indices of the largest connected component of the motif adjacency matrix (if restrict=True).
- **adj_mat_comps** (*matrix*) – The original adjacency matrix restricted to the largest connected component of the motif adjacency matrix (if restrict=True).
- **motif_adj_mat_comps** (*matrix*) – The motif adjacency matrix restricted to its largest connected component (if restrict=True).
- **vals** (*list*) – A length-*num_eigs* list containing the eigenvalues associated with the Laplace embedding of the (restricted) motif adjacency matrix.
- **vects** (*matrix*) – A matrix containing the eigenvectors associated with the Laplace embedding of the (restricted) motif adjacency matrix.
- *clusts* – A vector containing integers representing the cluster assignment of each vertex in the (restricted) graph.

Examples

```
>>> adj_mat = np.array(range(1, 10)).reshape((3, 3))
>>> run_motif_clustering(adj_mat, "M1")
```

8.2 Adjacency and indicator matrices

Functions for building adjacency and indicator matrices are in *motifcluster.indicators*.

_build_G(*adj_mat*)

Build sparse adjacency matrix.

Build the sparse adjacency matrix *G* from a graph adjacency matrix.

Parameters **adj_mat** (*matrix*) – The original adjacency matrix.

Returns **G** – The adjacency matrix in sparse form.

Return type sparse matrix

_build_Gd(*adj_mat*)

Build double-edge adjacency matrix.

Build the sparse double-edge adjacency matrix *Gd* from a graph adjacency matrix.

Parameters **adj_mat** (*matrix*) – The original adjacency matrix.

Returns **Gd** – A double-edge adjacency matrix in sparse form.

Return type sparse matrix

_build_Gp(*adj_mat*)
Build product matrix.

Build the sparse product matrix *Gp* from a graph adjacency matrix.

Parameters **adj_mat** (*matrix*) – The original adjacency matrix.

Returns **Gp** – A product matrix in sparse form.

Return type sparse matrix

_build_Gs(*adj_mat*)
Build single-edge indicator matrix.

Build the sparse single-edge adjacency matrix *Gs* from a graph adjacency matrix.

Parameters **adj_mat** (*matrix*) – The original adjacency matrix.

Returns **Gs** – A single-edge adjacency matrix in sparse form.

Return type sparse matrix

_build_Id(*adj_mat*)
Build identity matrix.

Build the sparse identity matrix *Id* from a graph adjacency matrix.

Parameters **adj_mat** (*matrix*) – The original adjacency matrix.

Returns **Id** – An identity matrix in sparse form.

Return type sparse matrix

_build_J(*adj_mat*)
Build directed indicator matrix.

Build the sparse directed indicator matrix *J* from a graph adjacency matrix.

Parameters **adj_mat** (*matrix*) – The original adjacency matrix.

Returns **J** – A directed indicator matrix in sparse form.

Return type sparse matrix

_build_J0(*adj_mat*)
Build missing-edge indicator matrix.

Build the missing-edge indicator matrix *J0* from a graph adjacency matrix.

Parameters **adj_mat** (*matrix*) – The original adjacency matrix.

Returns **J0** – A missing-edge indicator matrix.

Return type sparse matrix

_build_Jd(*adj_mat*)
Build double-edge indicator matrix.

Build the sparse double-edge indicator matrix *Jd* from a graph adjacency matrix.

Parameters **adj_mat** (*matrix*) – The original adjacency matrix.

Returns **Jd** – A double-edge indicator matrix in sparse form.

Return type sparse matrix

_build_Je(*adj_mat*)
Build edge-and-diagonal matrix.

Build the sparse edge-and-diagonal matrix *Ie* from a graph adjacency matrix.

Parameters **adj_mat** (*matrix*) – The original adjacency matrix.

Returns **Ie** – An edge-and-diagonal matrix in sparse form.

Return type sparse matrix

_build_Jn(*adj_mat*)
Build vertex-distinct indicator matrix.

Build the vertex-distinct indicator matrix *Jn* from a graph adjacency matrix.

Parameters **adj_mat** (*matrix*) – The original adjacency matrix.

Returns **Jn** – A vertex-distinct indicator matrix.

Return type sparse matrix

_build_Js(*adj_mat*)
Build single-edge indicator matrix.

Build the sparse single-edge indicator matrix *Js* from a graph adjacency matrix.

Parameters **adj_mat** (*matrix*) – The original adjacency matrix.

Returns **Js** – A single-edge indicator matrix in sparse form.

Return type sparse matrix

8.3 Motif adjacency matrices

Functions for building motif adjacency matrices are in *motifcluster.motifadjacency*.

build_motif_adjacency_matrix(*adj_mat*, *motif_name*, *motif_type='struc'*, *mam_weight_type='unweighted'*, *mam_method='sparse'*)
Build a motif adjacency matrix.

Build a motif adjacency matrix from an adjacency matrix. Entry (*i, j*) of a motif adjacency matrix is the sum of the weights of all motifs containing both nodes *i* and *j*.

- The motif is specified by name and the type of motif instance can be one of:
  - Functional: motifs should appear as subgraphs.
  - Structural: motifs should appear as induced subgraphs.
- The weighting scheme can be one of:
  - Unweighted: the weight of any motif instance is one.
  - Mean: the weight of any motif instance is the mean of its edge weights.
  - Product: the weight of any motif instance is the product of its edge weights.

Parameters

- **adj_mat** (*matrix*) – Adjacency matrix from which to build the motif adjacency matrix.
- **motif_name** (*str*) – Motif used for the motif adjacency matrix.
- **motif_type** (*str*) – Type of motif adjacency matrix to build. One of *"func"* or *"struc"*.

- **mam_weight_type** (*str*) – The weighting scheme to use. One of *"unweighted"*, *"mean"* or *"product"*.
- **mam_method** (*str*) – Which formulation to use. One of *"dense"* or *"sparse"*. The sparse formulation avoids generating large dense matrices so tends to be faster for large sparse graphs.

Returns A motif adjacency matrix.

Return type sparse matrix

Examples

```
>>> adj_mat = np.array(range(1, 10)).reshape((3, 3))
>>> build_motif_adjacency_matrix(adj_mat, "M1", "func", "mean")
```

mam_M1 (*adj_mat*, *motif_type*, *mam_weight_type*)
Perform the motif adjacency matrix calculations for motif M1.

Parameters

- **adj_mat** (*matrix*) – Adjacency matrix from which to build the motif adjacency matrix.
- **motif_type** (*str*) – Type of motif adjacency matrix to build.
- **mam_weight_type** (*str*) – The weighting scheme to use. One of *"unweighted"*, *"mean"* or *"product"*.

Returns A motif adjacency matrix.

Return type sparse matrix

mam_M10 (*adj_mat*, *motif_type*, *mam_weight_type*, *mam_method*)
Perform the motif adjacency matrix calculations for motif M10.

Parameters

- **adj_mat** (*matrix*) – Adjacency matrix from which to build the motif adjacency matrix.
- **motif_type** (*str*) – Type of motif adjacency matrix to build.
- **mam_weight_type** (*str*) – The weighting scheme to use. One of *"unweighted"*, *"mean"* or *"product"*.
- **mam_method** (*str*) – Which formulation to use. One of *"dense"* or *"sparse"*.

Returns A motif adjacency matrix.

Return type sparse matrix

mam_M11 (*adj_mat*, *motif_type*, *mam_weight_type*, *mam_method*)
Perform the motif adjacency matrix calculations for motif M11.

Parameters

- **adj_mat** (*matrix*) – Adjacency matrix from which to build the motif adjacency matrix.
- **motif_type** (*str*) – Type of motif adjacency matrix to build.
- **mam_weight_type** (*str*) – The weighting scheme to use. One of *"unweighted"*, *"mean"* or *"product"*.
- **mam_method** (*str*) – Which formulation to use. One of *"dense"* or *"sparse"*.

Returns A motif adjacency matrix.

Return type sparse matrix

mam_M12 (*adj_mat*, *motif_type*, *mam_weight_type*, *mam_method*)
Perform the motif adjacency matrix calculations for motif M12.

Parameters

- **adj_mat** (*matrix*) – Adjacency matrix from which to build the motif adjacency matrix.
- **motif_type** (*str*) – Type of motif adjacency matrix to build.
- **mam_weight_type** (*str*) – The weighting scheme to use. One of *"unweighted"*, *"mean"* or *"product"*.
- **mam_method** (*str*) – Which formulation to use. One of *"dense"* or *"sparse"*.

Returns A motif adjacency matrix.

Return type sparse matrix

mam_M13 (*adj_mat*, *motif_type*, *mam_weight_type*, *mam_method*)
Perform the motif adjacency matrix calculations for motif M13.

Parameters

- **adj_mat** (*matrix*) – Adjacency matrix from which to build the motif adjacency matrix.
- **motif_type** (*str*) – Type of motif adjacency matrix to build.
- **mam_weight_type** (*str*) – The weighting scheme to use. One of *"unweighted"*, *"mean"* or *"product"*.
- **mam_method** (*str*) – Which formulation to use. One of *"dense"* or *"sparse"*.

Returns A motif adjacency matrix.

Return type sparse matrix

mam_M2 (*adj_mat*, *motif_type*, *mam_weight_type*)
Perform the motif adjacency matrix calculations for motif M2.

Parameters

- **adj_mat** (*matrix*) – Adjacency matrix from which to build the motif adjacency matrix.
- **motif_type** (*str*) – Type of motif adjacency matrix to build.
- **mam_weight_type** (*str*) – The weighting scheme to use. One of *"unweighted"*, *"mean"* or *"product"*.

Returns A motif adjacency matrix.

Return type sparse matrix

mam_M3 (*adj_mat*, *motif_type*, *mam_weight_type*)
Perform the motif adjacency matrix calculations for motif M3.

Parameters

- **adj_mat** (*matrix*) – Adjacency matrix from which to build the motif adjacency matrix.
- **motif_type** (*str*) – Type of motif adjacency matrix to build.
- **mam_weight_type** (*str*) – The weighting scheme to use. One of *"unweighted"*, *"mean"* or *"product"*.

Returns A motif adjacency matrix.

Return type sparse matrix

mam_M4 (*adj_mat*, *mam_weight_type*)
Perform the motif adjacency matrix calculations for motif M4.

Parameters

- **adj_mat** (*matrix*) – Adjacency matrix from which to build the motif adjacency matrix.
- **mam_weight_type** (*str*) – The weighting scheme to use. One of *"unweighted"*, *"mean"* or *"product"*.

Returns A motif adjacency matrix.

Return type sparse matrix

mam_M5 (*adj_mat*, *motif_type*, *mam_weight_type*)
Perform the motif adjacency matrix calculations for motif M5.

Parameters

- **adj_mat** (*matrix*) – Adjacency matrix from which to build the motif adjacency matrix.
- **motif_type** (*str*) – Type of motif adjacency matrix to build.
- **mam_weight_type** (*str*) – The weighting scheme to use. One of *"unweighted"*, *"mean"* or *"product"*.

Returns A motif adjacency matrix.

Return type sparse matrix

mam_M6 (*adj_mat*, *motif_type*, *mam_weight_type*)
Perform the motif adjacency matrix calculations for motif M6.

Parameters

- **adj_mat** (*matrix*) – Adjacency matrix from which to build the motif adjacency matrix.
- **motif_type** (*str*) – Type of motif adjacency matrix to build.
- **mam_weight_type** (*str*) – The weighting scheme to use. One of *"unweighted"*, *"mean"* or *"product"*.

Returns A motif adjacency matrix.

Return type sparse matrix

mam_M7 (*adj_mat*, *motif_type*, *mam_weight_type*)
Perform the motif adjacency matrix calculations for motif M7.

Parameters

- **adj_mat** (*matrix*) – Adjacency matrix from which to build the motif adjacency matrix.
- **motif_type** (*str*) – Type of motif adjacency matrix to build.
- **mam_weight_type** (*str*) – The weighting scheme to use. One of *"unweighted"*, *"mean"* or *"product"*.

Returns A motif adjacency matrix.

Return type sparse matrix

mam_M8 (*adj_mat*, *motif_type*, *mam_weight_type*, *mam_method*)
Perform the motif adjacency matrix calculations for motif M8.

Parameters

- **adj_mat** (*matrix*) – Adjacency matrix from which to build the motif adjacency matrix.

- **motif_type** (*str*) – Type of motif adjacency matrix to build.
- **mam_weight_type** (*str*) – The weighting scheme to use. One of *"unweighted"*, *"mean"* or *"product"*.
- **mam_method** (*str*) – Which formulation to use. One of *"dense"* or *"sparse"*.

Returns A motif adjacency matrix.

Return type sparse matrix

mam_M9(*adj_mat*, *motif_type*, *mam_weight_type*, *mam_method*)
Perform the motif adjacency matrix calculations for motif M9.

Parameters

- **adj_mat** (*matrix*) – Adjacency matrix from which to build the motif adjacency matrix.
- **motif_type** (*str*) – Type of motif adjacency matrix to build.
- **mam_weight_type** (*str*) – The weighting scheme to use. One of *"unweighted"*, *"mean"* or *"product"*.
- **mam_method** (*str*) – Which formulation to use. One of *"dense"* or *"sparse"*.

Returns A motif adjacency matrix.

Return type sparse matrix

mam_Mcoll(*adj_mat*, *motif_type*, *mam_weight_type*, *mam_method*)
Perform the motif adjacency matrix calculations for motif Mcoll.

Parameters

- **adj_mat** (*matrix*) – Adjacency matrix from which to build the motif adjacency matrix.
- **motif_type** (*str*) – Type of motif adjacency matrix to build.
- **mam_weight_type** (*str*) – The weighting scheme to use. One of *"unweighted"*, *"mean"* or *"product"*.
- **mam_method** (*str*) – Which formulation to use. One of *"dense"* or *"sparse"*.

Returns A motif adjacency matrix.

Return type sparse matrix

mam_Md(*adj_mat*, *mam_weight_type*)
Perform the motif adjacency matrix calculations for motif Md.

Parameters

- **adj_mat** (*matrix*) – Adjacency matrix from which to build the motif adjacency matrix.
- **mam_weight_type** (*str*) – The weighting scheme to use. One of *"unweighted"*, *"mean"* or *"product"*.

Returns A motif adjacency matrix.

Return type sparse matrix

mam_Mexpa(*adj_mat*, *motif_type*, *mam_weight_type*, *mam_method*)
Perform the motif adjacency matrix calculations for motif Mexpa.

Parameters

- **adj_mat** (*matrix*) – Adjacency matrix from which to build the motif adjacency matrix.
- **motif_type** (*str*) – Type of motif adjacency matrix to build.

- **mam_weight_type** (*str*) – The weighting scheme to use. One of *"unweighted"*, *"mean"* or *"product"*.
- **mam_method** (*str*) – Which formulation to use. One of *"dense"* or *"sparse"*.

Returns A motif adjacency matrix.

Return type sparse matrix

mam_Ms(*adj_mat*, *motif_type*, *mam_weight_type*)

Perform the motif adjacency matrix calculations for motif Ms.

Parameters

- **adj_mat** (*matrix*) – Adjacency matrix from which to build the motif adjacency matrix.
- **motif_type** (*str*) – Type of motif adjacency matrix to build.
- **mam_weight_type** (*str*) – The weighting scheme to use. One of *"unweighted"*, *"mean"* or *"product"*.

Returns A motif adjacency matrix.

Return type sparse matrix

8.4 Network sampling

Functions for random sampling of weighted directed networks are in *motifcluster.sampling*.

demonstration_graph()

Generate a small graph for demonstrations.

Generate the sparse and dense adjacency matrices of a small weighted directed graph, for demonstrating methods and running tests.

Returns

- **adj_mat_dense** (*matrix*) – the adjacency matrix in dense form.
- **adj_mat_sparse** (*sparse matrix*) – the adjacency matrix in sparse form.

sample_bsbm(*source_block_sizes*, *dest_block_sizes*, *bipartite_connection_matrix*, *bipartite_weight_matrix=None*, *sample_weight_type='unweighted'*)

Sample a bipartite stochastic block model (BSBM).

Sample the (weighted) adjacency matrix of a (weighted) bipartite stochastic block model (BSBM) with specified parameters.

Parameters

- **source_block_sizes** (*list of int*) – A list containing the size of each block of source vertices.
- **dest_block_sizes** (*list of int*) – A list containing the size of each block of destination vertices.
- **bipartite_connection_matrix** (*matrix*) – A matrix containing the source block to destination block connection probabilities.
- **sample_weight_type** (*str*) – The type of weighting scheme. One of *"unweighted"*, *"constant"* or *"poisson"*.
- **weight_matrix** (*matrix*) – A matrix containing the source block to destination block weight parameters. Unused for *sample_weight_type = "constant"*. Defaults to *None*.

Returns **adj_mat** – A randomly sampled (weighted) adjacency matrix of a BSBM.

Return type sparse matrix

Examples

```
>>> source_block_sizes = [10, 10]
>>> dest_block_sizes = [10, 10, 10]
>>> bipartite_connection_matrix = np.array([0.8, 0.5, 0.1, 0.1, 0.5, 0.8]).
↪reshape((2, 3))
>>> bipartite_weight_matrix = np.array([20, 10, 2, 2, 10, 20]).reshape((2, 3))
>>> sample_bsbm(block_sizes, bipartite_connection_matrix,
...   bipartite_weight_matrix, "poisson")
```

sample_dsbm(*block_sizes*, *connection_matrix*, *weight_matrix=None*, *sample_weight_type='unweighted'*)
Sample a directed stochastic block model (DSBM).

Sample the (weighted) adjacency matrix of a (weighted) directed stochastic block model (DSBM) with specified parameters.

Parameters

- **block_sizes** (*list of int*) – A list containing the size of each block of vertices.
- **connection_matrix** (*matrix*) – A matrix containing the block-to-block connection probabilities.
- **sample_weight_type** (*str*) – The type of weighting scheme. One of *"unweighted"*, *"constant"* or *"poisson"*.
- **weight_matrix** (*matrix*) – A matrix containing the block-to-block weight parameters. Unused for *sample_weight_type = "constant"*. Defaults to *None*.

Returns **adj_mat** – A randomly sampled (weighted) adjacency matrix of a DSBM.

Return type sparse matrix

Examples

```
>>> block_sizes = [10, 10]
>>> connection_matrix = np.array([0.8, 0.1, 0.1, 0.8]).reshape((2, 2))
>>> weight_matrix = np.array([10, 3, 3, 10]).reshape((2, 2))
>>> sample_dsbm(block_sizes, connection_matrix, weight_matrix, "poisson")
```

8.5 Spectral methods

Functions relating to spectral methods are in *motifcluster.spectral*.

_get_first_eigs(*some_mat*, *num_eigs*)
Compute first few eigenvalues and eigenvectors of a matrix.

Compute the first few eigenvalues (by magnitude) and associated eigenvectors of a matrix.

Parameters

- **some_mat** (*matrix*) – Matrix for which eigenvalues and eigenvectors are to be calculated.
- **num_eigs** (*int*) – Number of eigenvalues and eigenvectors to calculate.

Returns

- **vals** (*list*) – A length-*num_eigs* list of the first few eigenvalues.
- **vects** (*matrix*) – A *some_mat.shape[0]* by *num_eigs* matrix of the associated eigenvectors.

build_laplacian(*adj_mat*, *type_lap='rw'*)

Build a Laplacian matrix.

Build a Laplacian matrix (combinatorial Laplacian or random-walk Laplacian) from a symmetric (weighted) graph adjacency matrix.

Parameters

- **adj_mat** (*matrix*) – Symmetric adjacency matrix from which to build the Laplacian.
- **type_lap** (*str*) – Type of Laplacian to build. One of *"comb"* (combinatorial) or *"rw"* (random-walk).

Returns The specified Laplacian matrix.

Return type sparse matrix

Examples

```
>>> adj_mat = np.array(range(1, 10)).reshape((3, 3))
>>> build_laplacian(adj_mat, "rw")
```

run_laplace_embedding(*adj_mat*, *num_eigs*, *type_lap='rw'*)

Run Laplace embedding.

Run Laplace embedding on a symmetric (weighted) adjacency matrix with a specified number of eigenvalues and eigenvectors.

Parameters

- **adj_mat** (*matrix*) – Symmetric adjacency matrix to be embedded.
- **num_eigs** (*int*) – Number of eigenvalues and eigenvectors for the embedding.
- **type_lap** (*str*) – Type of Laplacian for the embedding. One of *"comb"* (combinatorial) or *"rw"* (random-walk).

Returns

- **vals** (*list*) – The length-*num_eigs* list of the first few eigenvalues of the Laplacian.
- **vects** (*matrix*) – An *adj_mat.shape[0]* by *num_eigs* matrix of the associated eigenvectors.

Examples

```
>>> adj_mat = np.array(range(1, 10)).reshape((3, 3))
>>> run_laplace_embedding(adj_mat, 2, "rw")
```

run_motif_embedding(*adj_mat*, *motif_name*, *motif_type='struc'*, *mam_weight_type='unweighted'*, *mam_method='sparse'*, *num_eigs=2*, *type_lap='rw'*, *restrict=True*, *gr_method='sparse'*)

Run motif embedding.

Calculate a motif adjacency matrix for a given motif and motif type, optionally restrict it to its largest connected component, and then run Laplace embedding with specified Laplacian type and number of eigenvalues and eigenvectors.

Parameters

- **adj_mat** (*matrix*) – Adjacency matrix to be embedded.
- **motif_name** (*str*) – Motif used for the motif adjacency matrix.
- **motif_type** (*str*) – Type of motif adjacency matrix to use. One of *"func"* or *"struc"*.
- **mam_weight_type** (*str*) – Weighting scheme for the motif adjacency matrix. One of *"unweighted"*, *"mean"* or *"product"*.
- **mam_method** (*str*) – The method to use for building the motif adjacency matrix. One of *"sparse"* or *"dense"*.
- **num_eigs** (*int*) – Number of eigenvalues and eigenvectors for the embedding.
- **type_lap** (*str*) – Type of Laplacian for the embedding. One of *"comb"* or *"rw"*.
- **restrict** (*bool*) – Whether or not to restrict the motif adjacency matrix to its largest connected component before embedding.
- **gr_method** (*str*) – Format to use for getting largest component. One of *"sparse"* or *"dense"*.

Returns

- **adj_mat** (*sparse matrix*) – The original adjacency matrix.
- **motif_adj_mat** (*sparse matrix*) – The motif adjacency matrix.
- **comps** (*list*) – The indices of the largest connected component of the motif adjacency matrix (if restrict=True).
- **adj_mat_comps** (*matrix*) – The original adjacency matrix restricted to the largest connected component of the motif adjacency matrix (if restrict=True).
- **motif_adj_mat_comps** (*matrix*) – The motif adjacency matrix restricted to its largest connected component (if restrict=True).
- **vals** (*list*) – A length-*num_eigs* list containing the eigenvalues associated with the Laplace embedding of the (restricted) motif adjacency matrix.
- *vects* – A matrix containing the eigenvectors associated with the Laplace embedding of the (restricted) motif adjacency matrix.

Examples

adj_mat = np.array(range(1, 10)),reshape((3, 3)) run_motif_embedding(adj_mat, "M1")

8.6 Utility functions

Assorted utility functions for the motifcluster module are in *motifcluster.utils*.

_a_b_one(*a_mat*, *b_mat*)

Compute a right-multiplication with the ones matrix.

Compute *a * (b @ one_mat)* where *a*, *b*, *ones_mat* are square matrices of the same size, and *ones_mat* contains all entries equal to one. The product * is an entry-wise (Hadamard) product, while @ represents matrix multiplication. This method is more efficient than the naive approach when *a* or *b* are sparse.

Parameters **a, b** (*matrix*) – Square matrices of the same size.

Returns The sparse square matrix *a * (b @ one_mat)*.

Return type sparse matrix

_a_one_b(*a_mat*, *b_mat*)
Compute a left-multiplication with the ones matrix.

Compute *a * (one_mat @ b)* where *a*, *b*, *ones_mat* are square matrices of the same size, and *ones_mat* contains all entries equal to one. The product * is an entry-wise (Hadamard) product, while @ represents matrix multiplication. This method is more efficient than the naive approach when *a* or *b* are sparse.

Parameters **a, b** (*matrix*) – Square matrices of the same size.

Returns The sparse square matrix *a * (one_mat @ b)*.

Return type sparse matrix

_drop0_killdiag(*some_mat*)
Set diagonal entries to zero and sparsify.

Set the diagonal entries of a matrix to zero and convert it to sparse form.

Parameters **some_mat** (*matrix*) – A square matrix.

Returns **sparse_mat** – A sparse-form copy of *some_mat* with its diagonal entries set to zero.

Return type sparse matrix

_random_sparse_matrix(*m*, *n*, *p*, *sample_weight_type='constant'*, *w=1*)
Build a random sparse matrix.

Build a sparse matrix of size *m * n* with non-zero probability *p*. Edge weights can be unweighted, constant-weighted or Poisson-weighted.

Parameters

- **m, n** (*int*) – Dimension of matrix to build is *(m, n)*.
- **p** (*float*) – Probability that each entry is non-zero (before weighting).
- **sample_weight_type** (*str*) – Type of weighting scheme.
- **w** (*float*) – Weight parameter.

Returns A random sparse matrix.

Return type sparse matrix

get_largest_component(*adj_mat*, *gr_method*)
Get largest connected component.

Get the indices of the vertices in the largest connected component of a graph from its adjacency matrix.

Parameters

- **adj_mat** (*matrix*) – An adjacency matrix of a graph.
- **gr_method** (*str*) – Format to use before building the graph. One of *"sparse"* or *"dense"*.

Returns **verts_to_keep** – A list of indices corresponding to the vertices in the largest connected component.

Return type list

Examples

```
>>> adj_mat = np.array([0, 1, 0, 0, 0, 0, 0, 0, 0]).reshape((3, 3))
>>> get_largest_component(adj_mat)
```

get_motif_names()

Get common motif names.

Get the names of some common motifs as strings.

Returns **motif_names** – A list of names (strings) of common motifs.

Return type list

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