

# Package ‘SpectralTAD’

December 10, 2025

**Title** SpectralTAD: Hierarchical TAD detection using spectral clustering

**Version** 1.27.0

**Description** SpectralTAD is an R package designed to identify Topologically Associated Domains (TADs) from Hi-C contact matrices. It uses a modified version of spectral clustering that uses a sliding window to quickly detect TADs. The function works on a range of different formats of contact matrices and returns a bed file of TAD coordinates. The method does not require users to adjust any parameters to work and gives them control over the number of hierarchical levels to be returned.

**License** MIT + file LICENSE

**Encoding** UTF-8

**RoxygenNote** 7.2.3

**Imports** dplyr, PRIMME, cluster, Matrix, parallel, BiocParallel, magrittr, HiCcompare, GenomicRanges, utils

**Suggests** BiocCheck, BiocManager, BiocStyle, knitr, rmarkdown, microbenchmark, testthat, covr

**Depends** R (>= 3.6)

**VignetteBuilder** knitr

**biocViews** Software, HiC, Sequencing, FeatureExtraction, Clustering

**BugReports** <https://github.com/dozmorovlab/SpectralTAD/issues>

**URL** <https://github.com/dozmorovlab/SpectralTAD>

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|                  |                                                                     |
|------------------|---------------------------------------------------------------------|
| rao_chr20_25_rep | <i>Contact matrix from Rao 2014, chromosome 20, 25kb resolution</i> |
|------------------|---------------------------------------------------------------------|

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**Description**

A sparse 3-column contact matrix

**Usage**

data(rao\_chr20\_25\_rep)

**Format**

- A data.frame with 3 columns and 2125980 rows:
- V1** The genomic loci corresponding to a given row of the contact matrix
  - V2** The genomic loci corresponding to a given column of the contact matrix
  - V3** Number of contacts between Loci1 and Loci2

**Value**

A data.frame

**Source**

Data from Rao SS, Huntley MH, Durand NC, Stamenova EK et al. A 3D map of the human genome at kilobase resolution reveals principles of chromatin looping. Cell 2014 Dec 18;159(7):1665-80. PMID: 25497547. Available at <https://www.ncbi.nlm.nih.gov/geo/query/acc.cgi?acc=GSE63525>

SpectralTAD

*Hierarchical Spectral Clustering of TADs***Description**

Hierarchical Spectral Clustering of TADs

**Usage**

```

SpectralTAD(
  cont_mat,
  chr,
  levels = 1,
  qual_filter = FALSE,
  z_clust = FALSE,
  eigenvalues = 2,
  min_size = 5,
  window_size = 25,
  resolution = "auto",
  gap_threshold = 1,
  grange = FALSE,
  out_format = "none",
  out_path = chr
)

```

**Arguments**

|             |                                                                                                                                                                                                                                                                                                                                                                                        |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| cont_mat    | Contact matrix in either sparse 3 column, n x n or n x (n+3) form where the first three columns are coordinates in BED format. If an x n matrix is used, the column names must correspond to the start point of the corresponding bin. If large mode is selected, then this matrix must be a tab-separated n x n or n x (n+3) and it should be the path to a contact matrix. Required. |
| chr         | The chromosome of the contact matrix being analyzed. Required.                                                                                                                                                                                                                                                                                                                         |
| levels      | The number of levels of the TAD hierarchy to be calculated. The default setting is 1.                                                                                                                                                                                                                                                                                                  |
| qual_filter | Option to turn on quality filtering which removes TADs with negative silhouette scores (poorly organized TADs). Default is FALSE.                                                                                                                                                                                                                                                      |
| z_clust     | Option to filter sub-TADs based on the z-score of their eigenvector gaps. Default is TRUE.                                                                                                                                                                                                                                                                                             |
| eigenvalues | The number of eigenvectors to be calculated. The default and suggested setting is 2.                                                                                                                                                                                                                                                                                                   |
| min_size    | The minimum allowable TAD size measured in bins. Default is 5.                                                                                                                                                                                                                                                                                                                         |
| window_size | The size of the sliding window for calculating TADs. Smaller window sizes correspond to less noise from long-range contacts but limit the possible size of TADs                                                                                                                                                                                                                        |

|               |                                                                                                                                                                                                                                                       |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| resolution    | The resolution of the contact matrix. If none selected, the resolution is estimated by taking the most common distance between bins. For $n \times (n+3)$ contact matrices, this value is automatically calculated from the first three columns.      |
| gap_threshold | Corresponds to the percentage of zeros allowed before a column/row is removed from the analysis. 1=100%, .7 = 70%, etc. Default is 1.                                                                                                                 |
| grange        | Parameter to determine whether the result should be a GRangeList object. Defaults to FALSE                                                                                                                                                            |
| out_format    | Specifies the format of the file which SpectralTAD outputs. If "none", no file is output. "juicebox" or "bedpe" returns a bedpe file compatible with juicebox. "hicexplorer" or "bed" returns a bed file compatible with hicexplorer. Default is none |
| out_path      | Path of output file. Default is the chromosome                                                                                                                                                                                                        |

### Details

Given a sparse 3 column, an  $n \times n$  contact matrix, or  $n \times (n+3)$  contact matrix, SpectralTAD returns a list of TAD coordinates in BED format. SpectralTAD works by using a sliding window that moves along the diagonal of the contact matrix. By default, we use the biologically relevant maximum TAD size of 2Mb and minimum size of 5 bins to determine the size of this window. Within each window, we calculate a Laplacian matrix and determine the location of TAD boundaries based on gaps between eigenvectors calculated from this matrix. The number of TADs in a given window is calculated by finding the number that maximizes the silhouette score. A hierarchy of TADs is created by iteratively applying the function to sub-TADs. The number of levels in each hierarchy is determined by the user.

### Value

A list where each entry is in BED format corresponding to the level of the hierarchy.

### Examples

```
#Read in data
data("rao_chr20_25_rep")
#Find TADs
spec_table <- SpectralTAD(rao_chr20_25_rep, chr= 'chr20')
```

---

SpectralTAD\_Par

*Parallelized Hierarchical Spectral Clustering of TADs*

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### Description

Parallelized Hierarchical Spectral Clustering of TADs

**Usage**

```

SpectralTAD_Par(
  cont_list,
  chr,
  levels = 1,
  qual_filter = FALSE,
  z_clust = FALSE,
  eigenvalues = 2,
  min_size = 5,
  window_size = 25,
  resolution = "auto",
  grange = FALSE,
  gap_threshold = 1,
  cores = "auto",
  labels = NULL
)

```

**Arguments**

|               |                                                                                                                                                                                                                                                                                                                         |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| cont_list     | List of contact matrices where each is in either sparse 3 column, $n \times n$ or $n \times (n+3)$ form, where the first 3 columns are chromosome, start and end coordinates of the regions. If an $n \times n$ matrix is used, the column names must correspond to the start point of the corresponding bin. Required. |
| chr           | Vector of chromosomes in the same order as their corresponding contact matrices. Must be same length as cont_list. Required.                                                                                                                                                                                            |
| levels        | The number of levels of the TAD hierarchy to be calculated. The default setting is 1.                                                                                                                                                                                                                                   |
| qual_filter   | Option to turn on quality filtering which removes TADs with negative silhouette scores (poorly organized TADs). Default is FALSE.                                                                                                                                                                                       |
| z_clust       | Option to filter sub-TADs based on the z-score of their eigenvector gaps. Default is TRUE.                                                                                                                                                                                                                              |
| eigenvalues   | The number of eigenvectors to be calculated. The default and suggested setting is 2.                                                                                                                                                                                                                                    |
| min_size      | The minimum allowable TAD size measured in bins. Default is 5.                                                                                                                                                                                                                                                          |
| window_size   | The size of the sliding window for calculating TADs. Smaller window sizes correspond to less noise from long-range contacts but limit the possible size of TADs                                                                                                                                                         |
| resolution    | The resolution of the contact matrix. If none selected, the resolution is estimated by taking the most common distance between bins. For $n \times (n+3)$ contact matrices, this value is automatically calculated from the first 3 columns.                                                                            |
| grange        | Parameter to determine whether the result should be a GRangeList object. Defaults to FALSE                                                                                                                                                                                                                              |
| gap_threshold | Corresponds to the percentage of zeros allowed before a column/row is removed from analysis. $1=100\%$ , $.7 = 70\%$ , etc. Default is 1.                                                                                                                                                                               |
| cores         | Number of cores to use. Defaults to total available cores minus one.                                                                                                                                                                                                                                                    |

**labels**                      Vector of labels used to name each contact matrix. Must be same length as `cont_list`. Default is `NULL`.

### Details

This is the parallelized version of the `SpectralTAD()` function. Given a sparse 3 column, an  $n \times n$  contact matrix, or  $n \times (n+3)$  contact matrix, `SpectralTAD` returns a list of TAD coordinates in BED format. `SpectralTAD` works by using a sliding window that moves along the diagonal of the contact matrix. By default we use the biologically relevant maximum TAD size of 2Mb and minimum size of 5 bins to determine the size of this window. Within each window, we calculate a Laplacian matrix and determine the location of TAD boundaries based on gaps between eigenvectors calculated from this matrix. The number of TADs in a given window is calculated by finding the number that maximize the silhouette score. A hierarchy of TADs is created by iteratively applying the function to sub-TADs. The number of levels in each hierarchy is determined by the user.

### Value

List of lists where each entry is a list of data frames or `GRanges` in BED format corresponding to TADs separated by hierarchies

### Examples

```
#Read in data
data("rao_chr20_25_rep")
#Make a list of matrices
mat_list = list(rao_chr20_25_rep, rao_chr20_25_rep)
#Make a vector of chromosomes
chr = c("chr20", "chr20")
#Make a vector of labels
labels = c("run1", "run2")
spec_table <- SpectralTAD_Par(mat_list, chr= chr, labels = labels, cores = 2)
```

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## \* **datasets**

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