Package ‘sRACIPE’

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Type Package

Title Systems biology tool to simulate gene regulatory circuits

Version 1.20.0

Description sRACIPE implements a randomization-based method for gene circuit modeling. It allows us to study the effect of both the gene expression noise and the parametric variation on any gene regulatory circuit (GRC) using only its topology, and simulates an ensemble of models with random kinetic parameters at multiple noise levels. Statistical analysis of the generated gene expressions reveals the basin of attraction and stability of various phenotypic states and their changes associated with intrinsic and extrinsic noises. sRACIPE provides a holistic picture to evaluate the effects of both the stochastic nature of cellular processes and the parametric variation.

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**Description**

The network file should contain three columns with headers, "Source" "Target" "Type". Here "Source" and "Target" are the names of the genes and "Type" refers to the regulation, "1" if source activates target and "2" if source inhibits target.

**Usage**

```r
.loadNetworkFile(networkFile = "inputs/test.net")
```

**Arguments**

- `networkFile` Network file name

**Value**

Network as a dataframe

---

**Description**

A utility function.

**Usage**

```r
.ModelPvalue(
    dataSimulation,
    dataReference,
    clusterCut,
    permutations,
    refClusterVar,
    corMethod,
    simulatedClusterVar
)
```
Arguments

dataSimulation Simulation data to be compared.
dataReference Reference data with which to compare.
clusterCut The original cluster assignments.
permutations The number of permutations.
refClusterVar SD of the clusters.
corMethod Correlation method to be used.
simulatedClusterVar Variance of simulated clusters

Value

An array of dimension n.models by nClusters by permutations.

---

.NthMin

Find nth minimum value from a vector

Description

A utility function to find the nth minimum

Usage

.NthMin(x, index)

Arguments

x the given unsorted vector
index N.

Value

the nth minimum element of the vector
.PermutedVar  

_find variance of permutations_

_description_

A utility function to generate permutations

_usage_

PermutedVar(simulated.refCor, clusterCut, permutations, refClusterVar)

_args_

simulated.refCor  
Correlation matrix of simulated and reference data

clusterCut  
The original cluster assignments

permutations  
The number of permutations

refClusterVar  
Reference Cluster Variance

_value_

An array of dimension n.models by nClusters by permutations

_simulatedPValueAbs_

_finds the variance corresponding to a given value._

_description_

A utility function to calculate the absolute p values.

_usage_

SimulatedPValueAbs(permutedVar, simulatedClusterVar)

_args_

permutedVar  
An array containing the distance of clusters for each model for every permutation.

simulatedClusterVar  
Variance of simulated clusters

_value_

p-values for each model.
.SimulatedVarPValue  Finds the variance corresponding to a given value.

Description
A utility function for calculating the p values.

Usage
.SimulatedVarPValue(permutedVar, pValue)

Arguments

permutedVar  An array containing the distance of clusters for each model for every permutation.
pValue  Cut off p value.

Value
p-values for each model.

annotation,RacipeSE-method  A method to get the annotation

Description
A method to get the annotation

Usage
## S4 method for signature 'RacipeSE'
annotation(object, ...)

Arguments

object  RacipeSE object
...  Additional arguments, for use in specific methods.

Value
character
Examples

data("demoCircuit")
rSet <- sRACIPE::sracipeSimulate(circuit = demoCircuit, numModels = 100)
ann <- annotation(rSet)
annotation(rSet) <- ann

Description

A method to set the circuit name or annotation

Usage

```r
## S4 replacement method for signature 'RacipeSE,ANY'
annotation(object, ...) <- value
```

Arguments

- `object`  
  RacipeSE object
- `...`  
  Additional arguments, for use in specific methods.
- `value`  
  annotation character

Value

A RacipeSE object

Examples

data("demoCircuit")
rSet <- sRACIPE::sracipeSimulate(circuit = demoCircuit, numModels = 100)
ann <- annotation(rSet)
annotation(rSet) <- ann
Description

It contains simulation parameters like integration method (stepper) and other lists or vectors like simParams, stochParams, hyperParams, options, thresholds etc. The list simParams contains values for parameters like the number of models (numModels), simulation time (simulationTime), step size for simulations (integrateStepSize), when to start recording the gene expressions (printStart), time interval between recordings (printInterval), number of initial conditions (nIC), output precision (outputPrecision), tolerance for adaptive runge kutta method (rkTolerance), parametric variation (paramRange). The list stochParams contains the parameters for stochastic simulations like the number of noise levels to be simulated (nNoise), the ratio of subsequent noise levels (noiseScalingFactor), maximum noise (initialNoise), whether to use same noise for all genes or to scale it as per the median expression of the genes (scaledNoise), ratio of shot noise to additive noise (shotNoise). The list hyperParams contains the parameters like the minimum and maximum production and degradation of the genes, fold change, hill coefficient etc. The list options includes logical values like annealing (anneal), scaling of noise (scaledNoise), generation of new initial conditions (genIC), parameters (genParams) and whether to integrate or not (integrate). The user modifiable simulation options can be specified as other arguments. This list should be used if one wants to modify many settings for multiple simulations.

Usage

configData

Format

list

CoupledToggleSwitchSA Five coupled toggle switches

Description

This data contains the topology of a circuit with ten genes A1...A5 and B1...B5. Genes with different alphabet inhibit each other whereas genes from different groups activate the other. For further details, see Kohar, V. and Lu, M., Role of noise and parametric variation in the dynamics of gene regulatory circuits, npj Systems Biology and Applications 4, Article number: 40 (2018)

Usage

CoupledToggleSwitchSA

Format

A data frame with 18 rows and 3 variables
**demoCircuit**

*demoCircuit*  
*A toggle switch circuit for demonstrations*

**Description**
This data contains the topology of a circuit with two genes A and B both of which inhibit each other and have self activations. For further details, see Kohar, V. and Lu, M., Role of noise and parametric variation in the dynamics of gene regulatory circuits, npj Systems Biology and Applications 4, Article number: 40 (2018)

**Usage**
demoCircuit

**Format**
A data frame with 4 rows and 3 variables

---

**densityPlot**  
*Density Plot*

**Description**
Plot the density of points as an image alongwith histograms on the sides.

**Usage**
densityPlot(plotData, binCount = 40, plotColor = NULL, ...)

**Arguments**
- `plotData`: Dataframe containing the data.
- `binCount`: (optional) Integer. Default 40. The number of bins to be used for dividing the data along an axis.
- `plotColor`: (optional) The color palette.
- `...`: any additional arguments

**Value**
plot

**Related Functions**
sraceSimulate, sracipeKnockDown, sracipeOverExp, sracipePlotData, sracipeHeatmapSimilarity
Description

This data contains the topology of a circuit with sixteen genes involved in EMT. For further details, see Kohar, V. and Lu, M., Role of noise and parametric variation in the dynamics of gene regulatory circuits, npj Systems Biology and Applications 4, Article number: 40 (2018).

Usage

EMT1

Format

A data frame with 59 rows and 3 variables

Description

This data contains the topology of a circuit with twenty two nodes including micro RNAs involved in EMT. For further details, see Huang et al., Interrogating the topological robustness of gene regulatory circuits by randomization, PLoS computational biology 13 (3), e1005456.

Usage

EMT2

Format

A data frame with 82 rows and 3 variables
**RacipeSE**

**RacipeSE constructor**

**Description**

Create an RacipeSE object. RacipeSE is an S4 class for Random Circuit Perturbation (RACIPE) simulations of networks in which a large number of models with randomized parameters are used for simulation of the circuit. Each model can be considered as a sample. It extends the `SummarizedExperiment` class to store and access the circuit, simulated gene expressions, parameters, initial conditions and other meta information. SummarizedExperiment slot assays is used for storing simulated gene expressions. The rows of these matrix-like elements correspond to various genes in the circuit and columns correspond to models. The first element is used for unperturbed deterministic simulations. The subsequent elements are used for stochastic simulations at different noise levels and/or knockout simulations. SummarizedExperiment slot rowData stores the circuit topology. It is a square matrix with dimension equal to the number of genes in the circuit. The values of the matrix represent the type of interaction in the gene pair given by row and column. 1 represents activation, 2 inhibition and 0 no interaction. This should not be set directly and `sracipeCircuit` accessor should be used instead. SummarizedExperiment slot colData contains the parameters and initial conditions for each model. Each gene in the circuit has two parameters, namely, its production rate and its degradation rate. Each interaction in the has three parameters, namely, threshold of activation, the hill coefficient, and the fold change. Each gene has one or more initial gene expression values as specified by nIC. This should not be modified directly and `sracipeParams` and `sracipeIC` accessors should be used instead. SummarizedExperiment slot metadata Contains metadata information especially the config list (containing the simulation settings), annotation, nInteraction (number of interactions in the circuit), normalized (whether the data is normalized or not), data analysis lists like pca, umap, cluster assignment of the models etc. The config list includes simulation parameters like integration method (stepper) and other lists or vectors like simParams, stochParams, hyperParams, options, thresholds etc. The list simParams contains values for parameters like the number of models (numModels), simulation time (simulationTime), step size for simulations (integrateStepSize), when to start recording the gene expressions (printStart), time interval between recordings (printInterval), number of initial conditions (nIC), output precision (outputPrecision), tolerance for adaptive runge kutta method (rkTolerance), parametric variation (paramRange). The list stochParams contains the parameters for stochastic simulations like the number of noise levels to be simulated (nNoise), the ratio of subsequent noise levels (noiseScalingFactor), maximum noise (initialNoise), whether to use same noise for all genes or to scale it as per the median expression of the genes (scaledNoise), ratio of shot noise to additive noise (shotNoise). The list hyperParams contains the parameters like the minimum and maximum production and degradation of the genes, fold change, hill coefficient etc. The list options includes logical values like annealing (anneal), scaling of noise (scaledNoise), generation of new initial conditions (genIC), parameters (genParams) and whether to integrate or not (integrate). The user modifiable simulation options can be specified as arguments to `sracipeSimulate` function.

**Usage**

```r
RacipeSE(
  .object = NULL,
  assays = SimpleList(),
)```
rowData = NULL,
colData = DataFrame(),
metadata = list(),
...)

Arguments
.object (optional) Another RacipeSE object.
assays (optional) assay object for initialization
rowData (optional) rowData for initialization
colData (optional) colData for initialization
metadata (optional) metadata for initialization
... Arguments passed to SummarizedExperiment

Value
RacipeSE object

Examples
rSet <- RacipeSE()

---

RacipeSE-class  RacipeSE

Description
An S4 class for Random Circuit Perturbation (RACIPE) simulations of networks. Extends the SummarizedExperiment class. RACIPE can simulate a gene regulatory circuit using the circuit and a large ensemble of parameters.

---

sRACIPE  sRACIPE: A package for stochastic random circuit perturbation.

Description
sRACIPE is a systems biology tool to study the role of noise and parameter variation in gene regulatory circuits. It implements a randomization-based method for gene circuit modeling. It allows us to study the effect of both the gene expression noise and the parametric variation on any gene regulatory circuit (GRC) using only its topology, and simulates an ensemble of models with random kinetic parameters at multiple noise levels. Statistical analysis of the generated gene expressions reveals the basin of attraction and stability of various phenotypic states and their changes associated with intrinsic and extrinsic noises. sRACIPE provides a holistic picture to evaluate the effects of both the stochastic nature of cellular processes and the parametric variation.
sRACIPE functions

sracipeSimulate Primary function to simulate a circuit. Contains options for plotting as well.
sracipeKnockDown In-silico knockdown analysis of the circuit. Plots the relative changes in different cluster proportions.
sracipeOverExp In-silico over expression analysis of the circuit. Plots the relative changes in different cluster proportions.
sracipePlotData Plot the simulated data. Includes options to plot the hierarchichal clustering analysis, principal components, and uniform manifold approximation and projection. Can plot the stochastic as well as the knockout simulations.
sracipeSimulate, sracipeKnockDown, sracipeOverExp, sracipePlotData

sracipeCircuit Method to get the circuit

Description

The circuit file should contain three columns with headers, "Source" "Target" "Type" Here "Source" and "Target" are the names of the genes and "Type" refers to the regulation, "1" if source activates target and "2" if source inhibits target.

Usage

sracipeCircuit(.object)

# S4 method for signature 'RacipeSE'
sracipeCircuit(.object)

Arguments

.object RacipeSE object

Value

A dataframe

Examples

rs <- RacipeSE()
data("demoCircuit")
sracipeCircuit(rs) <- demoCircuit
circuitDataFrame <- sracipeCircuit(rs)
rm(rs, demoCircuit, circuitDataFrame)
sracipeCircuit<-  

Initialize the circuit

Description

Initialize the circuit from a topology file or a data.frame. A typical topology file looks like

<table>
<thead>
<tr>
<th>Source</th>
<th>Target</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>geneA</td>
<td>geneB</td>
<td>2</td>
</tr>
<tr>
<td>geneB</td>
<td>geneC</td>
<td>1</td>
</tr>
<tr>
<td>geneB</td>
<td>geneA</td>
<td>2</td>
</tr>
</tbody>
</table>

Here the regulation type is specified by number - activation: 1, inhibition: 2

Usage

sracipeCircuit(.object) <- value

## S4 replacement method for signature 'RacipeSE'
sracipeCircuit(.object) <- value

Arguments

.object  
RacipeSE object

value  
data.frame containing the circuit information

Value

data.frame

Related Functions

sracipeSimulate, sracipeKnockDown, sracipeOverExp, sracipePlotData

Examples

RacipeSet <- RacipeSE()
data("demoCircuit")
sracipeCircuit(RacipeSet) <- demoCircuit
sracipeCircuit(RacipeSet)
rm(RacipeSet, demoCircuit)
sracipeConfig

Description

The hyperparameters like number of models, range from which parameters are to be sampled, simulation time etc.

Usage

```r
sracipeConfig(.object)
```

## S4 method for signature 'RacipeSE'
```
sracipeConfig(.object)
```

Arguments

- `.object` RacipeSE object

Value

list

Examples

```r
RacipeSet <- RacipeSE()
data("demoCircuit")
sracipeCircuit(RacipeSet) <- demoCircuit
sracipeConfig(RacipeSet)
rm(RacipeSet)
```

sracipeConfig<-

Description

The hyperparameters like number of models, range from which parameters are to be sampled, simulation time etc.

Usage

```r
sracipeConfig(.object) <- value
```

## S4 replacement method for signature 'RacipeSE'
```
sracipeConfig(.object) <- value
```
**Arguments**

<table>
<thead>
<tr>
<th>.object</th>
<th>RacipeSE object</th>
</tr>
</thead>
<tbody>
<tr>
<td>value</td>
<td>list. Configuration as a list</td>
</tr>
</tbody>
</table>

**Value**

RacipeSE object

**Examples**

```r
rSet <- RacipeSE()
tmpConfig <- sracipeConfig(rSet)
sracipeConfig(rSet) <- tmpConfig
rm(rSet, tmpConfig)
```

---

**sracipeGenParamNames**  Generate parameter names for a circuit

**Description**

Generate parameter names for a circuit

**Usage**

```
sracipeGenParamNames(circuit = "inputs/test.tpo")
```

**Arguments**

| circuit | RacipeSE object or topology as data.frame or filename |

**Value**

list

**Examples**

```r
rSet <- RacipeSE()
data("demoCircuit")
sracipeCircuit(rSet) <- demoCircuit
paramNames <- sRACIPE::sracipeGenParamNames(rSet)
```
sracipeGetTS

A method to extract the time series

Description

If timeSeries option is used in sracipeSimulate function, this method will return the simulated time series.

Usage

sracipeGetTS(.object)

## S4 method for signature 'RacipeSE'
sracipeGetTS(.object)

Arguments

.object RacipeSE object

Value

List

Examples

data("demoCircuit")
RacipeSet <- RacipeSE()
sracipeCircuit(RacipeSet) <- demoCircuit
RacipeSet <- sracipeSimulate(demoCircuit, timeSeries = TRUE, simulationTime = 2)
trajectories <- sracipeGetTS(RacipeSet)
rm(RacipeSet)

sracipeHeatmapSimilarity

Calculates the similarity between two gene expression data.

Description

Comparison is done across columns, i.e., how similar are the columns in the two dataset. For gene expression data, format data so that gene names are in rows and samples in columns.
sracieHeatmapSimilarity

Usage

sracieHeatmapSimilarity(
  dataReference,
  dataSimulation,
  clusterCut = NULL,
  nClusters = 3,
  pValue = 0.05,
  permutedVar,
  permutations = 1000,
  corMethod = "spearman",
  clusterMethod = "ward.D2",
  method = "pvalue",
  buffer = 0.001,
  permutMethod = "simulation",
  returnData = FALSE
)

Arguments

dataReference - Matrix. The reference data matrix, for example, the experimental gene expression values.
dataSimulation - Matrix. The data matrix to be compared.
clusterCut (optional) - Integer vector. Cluster numbers assigned to reference data. If clusterCut is missing, hierarchical clustering using hclust with method = ward.D2 and distance = 1 - cor(x, method = "spearman")/2 will be used to cluster the reference data.
nClusters (optional) - Integer. The number of clusters in which the reference data should be clustered for comparison. Not needed if clusterCut is provided.
pValue (optional) - Numeric. p-value to consider two gene expression sets as belonging to same cluster. Ward’s method with spearman correlation is used to determine if a model belongs to a specific cluster.
permutedVar (optional) - Similarity scores computed after permutations.
permutations (optional) - Integer. Default 1000. Number of gene permutations to generate the null distribution.
corMethod (optional) - Correlation method. Default method is "spearman". For single cell data, use "kendall".
clusterMethod (optional) - Character - default ward.D2, other options include complete. Clustering method to be used to cluster the experimental data. hclust for other options.
method (optional) - character. Method to compare the gene expressions. Default pvalue. One can use variance as well which assigns clusters based on the cluster whose samples have minimum variance with the simulated sample.
buffer (optional) - Numeric. Default 0.001. The fraction of models to be assigned to clusters to which no samples could be assigned. For example, a minimum of 1 ghost sample in reference is assigned to NULL cluster.
permutMethod - "sample" or "reference"
sracipeIC

returnData  (optional) Logical. Default FALSE. Whether to return the sorted and clustered data.

Value

A list containing the KL distance of new cluster distribution from reference data and the probability of each cluster in the reference and simulated data.

Related Functions

sracipeSimulate, sracipeKnockDown, sracipeOverExp, sracipePlotData, sracipeHeatmapSimilarity

sracipeIC  A method to get the initial conditions used for simulations

Description

The initial conditions of each of the models.

Usage

sracipeIC(.object)

## S4 method for signature 'RacipeSE'
sracipeIC(.object)

Arguments

.object  RacipeSE object

Value

DataFrame

Examples

data("demoCircuit")
rSet <- sRACIPE::sracipeSimulate(circuit = demoCircuit, numModels = 20, integrate=FALSE)
ics <- sracipeIC(rSet)
rm(rSet,ics)
sracipeIC<-  

A method to set the initial conditions

Description

Set the initial conditions

Usage

sracipeIC(.object) <- value

## S4 replacement method for signature 'RacipeSE'

sracipeIC(.object) <- value

Arguments

.object  RacipeSE object
value  DataFrame containing the initial conditions

Value

A RacipeSE object

Examples

data("demoCircuit")
rSet <- sRACIPE::sracipeSimulate(circuit = demoCircuit, numModels = 10, integrate=FALSE)
ics <- sracipeIC(rSet)
sracipeIC(rSet) <- ics
rm(rSet, ics)

sracipeKnockDown  

Perform in-silico knockdown analysis

Description

Calculate the fraction of models in different clusters with full parameter range and on a subset of models with low production rate of a specific gene representing the knockdown of the specific gene.
sracipeKnockDown

Usage

sracipeKnockDown(
  .object,
  reduceProduction = 10,
  nClusters = 2,
  clusterOfInterest = 2,
  plotFilename = NULL,
  plotHeatmap = TRUE,
  plotBarPlot = TRUE,
  clusterCut = NULL,
  plotToFile = FALSE
)

## S4 method for signature 'RacipeSE'
sracipeKnockDown(
  .object,
  reduceProduction = 10,
  nClusters = 2,
  clusterOfInterest = 2,
  plotFilename = NULL,
  plotHeatmap = TRUE,
  plotBarPlot = TRUE,
  clusterCut = NULL,
  plotToFile = FALSE
)

Arguments

.object          RacipeSE object generated by sracipeSimulate function.
reduceProduction (optional) Percentage to which production rate decreases on knockdown. Uses
                   a default value of 10 percent.
nClusters        (optional) Number of clusters in the data. Uses a default value of 2.
clusterOfInterest (optional) cluster number (integer) to be used for arranging the transcription
                   factors
plotFilename     (optional) Name of the output file.
plotHeatmap      logical. Default TRUE. Whether to plot the heatmap or not.
plotBarPlot      logical. Default TRUE. Whether to plot the barplot.
clusterCut       integer or character. The cluster assignments.
plotToFile       logical. Default FALSE.

Value

List containing fraction of models in different clusters in the original simulations and after knowck-
ing down different genes. Additionally, it generates two pdf files in the results folder. First is barplot
showing the percentage of different clusters in the original simulations and after knocking down each gene. The second pdf contains the heatmap of clusters after marking the models with cluster assignments.

Related Functions

sracipeSimulate, sracipeKnockDown, sracipeOverExp, sracipePlotData

Examples

data("demoCircuit")
## Not run:
    rSet <- sRACIPE::sracipeSimulate(circuit = demoCircuit, numModels = 100,
    plots=FALSE, plotToFile = FALSE)
    rSet <- sRACIPE::sracipeNormalize(rSet)
    rSet <- sRACIPE::sracipeKnockDown(rSet, plotToFile = FALSE,
    plotBarPlot = TRUE, plotHeatmap = FALSE, reduceProduction = 50)
## End(Not run)

sracipeNormalize Normalize the simulated gene expression

Description

Normalize the simulated gene expression including gene expressions for stochastic and knockout simulations

Usage

sracipeNormalize(.object)

## S4 method for signature 'RacipeSE'
sracipeNormalize(.object)

Arguments

.object RacipeSE object

Value

A RacipeSE object

Related Functions

sracipeSimulate, sracipeKnockDown, sracipeOverExp, sracipePlotData,
sracipeOverExp

Examples

data("demoCircuit")
rSet <- sRACIPE::sracipeSimulate(circuit = demoCircuit, numModels = 20,
integrateStepSize = 0.1, simulationTime = 30)
rSet <- sracipeNormalize(rSet)

sracipeOverExp

Perform in-silico over expression analysis

Description

Calculates the fraction of models in different clusters with full parameter range and on a subset of
models with high production rate of a specific gene representing the over expression of the specific
gene.

Usage

sracipeOverExp(
  .object,
  overProduction = 10,
  nClusters = 2,
  clusterOfInterest = 2,
  plotFilename = NULL,
  plotHeatmap = TRUE,
  plotBarPlot = TRUE,
  clusterCut = NULL,
  plotToFile = FALSE
)

## S4 method for signature 'RacipeSE'
sracipeOverExp(
  .object,
  overProduction = 10,
  nClusters = 2,
  clusterOfInterest = 2,
  plotFilename = NULL,
  plotHeatmap = TRUE,
  plotBarPlot = TRUE,
  clusterCut = NULL,
  plotToFile = FALSE
)

Arguments

.object RacipeSE object generated by `sracipeSimulate` function.
overProduction (optional) Percentage to which production rate decreases on knockdown. Uses
a default value of 10 percent.
sracipeParams

**Description**

The parameters for each model.

**Usage**

sracipeParams(.object)

# S4 method for signature 'RecipeSE'
sracipeParams(.object)
sracipeParams<-  A method to set the simulation parameters

Description
Set the parameters

Usage
sracipeParams(.object) <- value

## S4 replacement method for signature 'RacipeSE'
sracipeParams(.object) <- value

Arguments
.object RacipeSE object
value DataFrame containing the parameteres

Value
A RacipeSE object

Examples

data("demoCircuit")
rSet <- sRACIPE::sracipeSimulate(circuit = demoCircuit, numModels = 20, integrate = FALSE)
parameters <- sracipeParams(rSet)
sracipeParams(rSet) <- parameters
rm(parameters, rSet)
**sracipePlotCircuit**

Plot Gene Regulatory Circuit

**Description**

Plot Gene Regulatory Circuit to a file or output device.

**Usage**

```
sracipePlotCircuit(.object, plotToFile = FALSE)
```

```
## S4 method for signature 'RacipeSE'
sracipePlotCircuit(.object, plotToFile = TRUE)
```

**Arguments**

- `.object` RacipeSE object A list returned by `sracipeSimulate` function
- `plotToFile` (optional) logical. Default FALSE. Whether to save plots to a file.

**Value**

circuit plot

**Related Functions**

- `sracipeSimulate`, `sracipeKnockDown`, `sracipeOverExp`, `sracipePlotData`

**Examples**

```
data("demoCircuit")
## Not run:
rSet <- sRACIPE::sracipeSimulate(circuit = demoCircuit, numModels = 20,
                                 integrateStepSize = 0.1, simulationTime = 30)
sracipePlotCircuit(rSet, plotToFile = FALSE)
rm(rSet)
## End(Not run)
```
**sracipePlotData**

**Plot sRACIPE data**

**Description**

Plots heatmap, pca, umap of the data simulated using sRACIPE

**Usage**

```r
sracipePlotData(
  .object,
  plotToFile = FALSE,
  nClusters = 2,
  heatmapPlot = TRUE,
  pcaPlot = TRUE,
  umapPlot = TRUE,
  networkPlot = TRUE,
  clustMethod = "ward.D2",
  col = col,
  distType = "euclidean",
  assignedClusters = NULL,
  corMethod = "spearman",
  ...
)
```

## S4 method for signature 'RacipeSE'

```r
sracipePlotData(
  .object,
  plotToFile = FALSE,
  nClusters = 2,
  heatmapPlot = TRUE,
  pcaPlot = TRUE,
  umapPlot = TRUE,
  networkPlot = TRUE,
  clustMethod = "ward.D2",
  col = col,
  distType = "euclidean",
  assignedClusters = NULL,
  corMethod = "spearman",
  ...
)
```

**Arguments**

- `.object` List A list returned by `sracipeSimulate` function
- `plotToFile` (optional) logical. Default FALSE. Whether to save plots to a file.
Parameter bifurcation plots

Plot the expression of the genes against parameter values to understand the effect of parameters on the gene expressions.

Value

RacipeSE object

Related Functions

sracipeSimulate, sracipeKnockDown, sracipeOverExp, sracipePlotData,

Examples

data("demoCircuit")
## Not run:
rSet <- sRACIPE::sracipeSimulate(circuit = demoCircuit, numModels = 20,
integrateStepSize = 0.1, simulationTime = 30)
rSet <- sracipePlotData(rSet)
## End(Not run)
Usage

sracipePlotParamBifur(
  .object,
  paramName,
  data = NULL,
  paramValue = NULL,
  assignedClusters = NULL,
  plotToFile = FALSE
)

## S4 method for signature 'RacipeSE'

sracipePlotParamBifur(
  .object,
  paramName,
  data = NULL,
  paramValue = NULL,
  assignedClusters = NULL,
  plotToFile = FALSE
)

Arguments

.object RacipeSE object generated by sracipeSimulate function.
paramName character. The name of the parameter to be plotted.
data (optional) dataframe. Default rSet geneExpression. The data to be plotted. For example, use rSet$stochasticSimulations$[noise] to plot the stochastic data.
paramValue (optional) Dataframe. The parameter values if rSet$params is not to be used.
assignedClusters (optional) Dataframe. The cluster assignment of data.
plotToFile (optional) logical. Default FALSE. Whether to save plots to a file.

Value

none

Examples

data("demoCircuit")

## Not run:

rSet <- sRACIPE::sracipeSimulate(circuit = demoCircuit, numModels = 100,
  plots=FALSE, plotToFile = FALSE)

rSet <- sRACIPE::sracipeNormalize(rSet)

sracipePlotParamBifur(rSet, "G_A")

## End(Not run)
sracipeSimulate

Simulate a gene regulatory circuit

Description

Simulate a gene regulatory circuit using its topology as the only input. It will generate an ensemble of random models.

Usage

sracipeSimulate(
  circuit = "inputs/test.tpo",
  config = config,
  anneal = FALSE,
  knockOut = NA_character_,
  numModels = 2000,
  paramRange = 100,
  prodRateMin = 1,
  prodRateMax = 100,
  degRateMin = 0.1,
  degRateMax = 1,
  foldChangeMin = 1,
  foldChangeMax = 100,
  hillCoeffMin = 1L,
  hillCoeffMax = 6L,
  integrateStepSize = 0.02,
  simulationTime = 50,
  nIC = 1L,
  nNoise = 0L,
  simDet = TRUE,
  initialNoise = 50,
  noiseScalingFactor = 0.5,
  shotNoise = 0,
  scaledNoise = FALSE,
  outputPrecision = 12L,
  printStart = 50,
  printInterval = 10,
  stepper = "RK4",
  thresholdModels = 5000,
  plots = FALSE,
  plotToFile = FALSE,
  genIC = TRUE,
  genParams = TRUE,
  integrate = TRUE,
  rkTolerance = 0.01,
  timeSeries = FALSE,
  nCores = 1L,
Arguments

circuit (optional) List. It contains simulation parameters like integration method (step-
per) and other lists or vectors like simParams, stochParams, hyperParams, options, thresholds etc. The list simParams contains values for parameters like the number of models (numModels), simulation time (simulationTime), step size for simulations (integrateStepSize), when to start recording the gene expressions (printStart), time interval between recordings (printInterval), number of initial conditions (nIC), output precision (outputPrecision), tolerance for adaptive runge kutta method (rkTolerance), parametric variation (paramRange). The list stochParams contains the parameters for stochastic simulations like the number of noise levels to be simulated (nNoise), the ratio of subsequent noise levels (noiseScalingFactor), maximum noise (initialNoise), whether to use same noise for all genes or to scale it as per the median expression of the genes (scaledNoise), ratio of shot noise to additive noise (shotNoise). The list hyperParams contains the parameters like the minimum and maximum production and de-

gration of the genes, fold change, hill coefficient etc. The list options includes logical values like annealing (anneal), scaling of noise (scaledNoise), generation of new initial conditions (genIC), parameters (genParams) and whether to integrate or not (integrate). The user modifiable simulation options can be spec-

anneal (optional) Logical. Default FALSE. Whether to use annealing for stochastic simulations. If TRUE, the gene expressions at higher noise are used as initial conditions for simulations at lower noise.

knockOut (optional) List of character or vector of characters. Simulation after knocking out one or more genes. To knock out all the genes in the circuit, use knockOut = "all". If it is a vector, then all the genes in the vector will be knocked out simultaneously.

numModels (optional) Integer. Default 2000. Number of random models to be simulated.

paramRange (optional) numeric (0-100). Default 100. The relative range of parameters (pro-
duction rate, degradation rate, fold change).

prodRateMin (optional) numeric. Default 1. Minimum production rate.

prodRateMax (optional) numeric. Default 100. Maximum production rate.

degRateMin (optional) numeric. Default 0.1. Minimum degradation rate.

degRateMax (optional) numeric. Default 1. Maximum degradation rate.

foldChangeMin (optional) numeric. Default 1. Minimum fold change for interactions.

foldChangeMax (optional) numeric. Default 100. Maximum fold change for interactions.

hillCoeffMin (optional) integer. Default 1. Minimum hill coefficient.

integrateStepSize
(optional) numeric. Default 0.02. step size for integration using "EM" and "RK4" steppers.

simulationTime
(optional) numeric. Total simulation time.

nIC
(optional) integer. Default 1. Number of initial conditions to be simulated for each model.

nNoise
(optional) integer. Default 0. Number of noise levels at which simulations are to be done. Use nNoise = 1 if simulations are to be carried out at a specific noise. If nNoise > 0, simulations will be carried out at nNoise levels as well as for zero noise. "EM" stepper will be used for simulations and any argument for stepper will be ignored.

simDet
(optional) logical. Default TRUE. Whether to simulate at zero noise as well also when using nNoise > 0.

initialNoise
(optional) numeric. Default 50/sqrt(number of genes in the circuit). The initial value of noise for simulations. The noise value will decrease by a factor noiseScalingFactor at subsequent noise levels.

noiseScalingFactor
(optional) numeric (0-1) Default 0.5. The factor by which noise will be decreased when nNoise > 1.

shotNoise
(optional) numeric. Default 0. The ratio of shot noise to additive noise.

scaledNoise
(optional) logical. Default FALSE. Whether to scale the noise in each gene by its expected median expression across all models. If TRUE the noise in each gene will be proportional to its expression levels.

outputPrecision
(optional) integer. Default 12. The decimal point precision of the output.

printStart
(optional) numeric (0-simulationTime). Default simulationTime. To be used only when timeSeries is TRUE. The time from which the output should be recorded. Useful for time series analysis and studying the dynamics of a model for a particular initial condition.

printInterval
(optional) numeric (integrateStepSize-simulationTime - printStart). Default 10. The separation between two recorded time points for a given trajectory. To be used only when timeSeries is TRUE.

stepper
(optional) Character. Stepper to be used for integrating the differential equations. The options include "EM" for Euler-Maruyama O(1), "RK4" for fourth order Runge-Kutta O(4) and "DP" for adaptive stepper based Dormand-Prince algorithm. The default method is "RK4" for deterministic simulations and the method defaults to "EM" for stochastic simulations.

thresholdModels
(optional) integer. Default 5000. The number of models to be used for calculating the thresholds for genes.

plots
(optional) logical Default FALSE. Whether to plot the simulated data.

plotToFile
(optional) Default FALSE. Whether to save the plots to a file.

genIC
(optional) logical. Default TRUE. Whether to generate the initial conditions. If FALSE, the initial conditions must be supplied as a dataframe to circuit$ic.
sracipeSimulate

- **genParams**: (optional) logical. Default TRUE. Whether to generate the parameters. If FALSE, the parameters must be supplied as a dataframe to `circuit$params`.
- **integrate**: (optional) logical. Default TRUE. Whether to integrate the differential equations or not. If FALSE, the function will only generate the parameters and initial conditions. This can be used iteratively as one can first generate the parameters and initial conditions and then modify these before using these modified values for integration. For example, this can be used to knockOut genes by changing the production rate and initial condition to zero.
- **rkTolerance**: (optional) numeric. Default 0.01. Error tolerance for adaptive integration method.
- **timeSeries**: (optional) logical. Default FALSE. Whether to generate time series for a single model instead of performing RACIPE simulations.
- **nCores**: (optional) integer. Default 1. Number of cores to be used for computation. Utilizes `multiprocess` from `doFuture` package. Will not work in Rstudio.
- **...**: Other arguments

**Value**

RacipeSE object. RacipeSE class inherits `SummarizedExperiment` and contains the circuit, parameters, initial conditions, simulated gene expressions, and simulation configuration. These can be accessed using corresponding getters.

**Related Functions**

- `sracipeSimulate`, `sracipeKnockDown`, `sracipeOverExp`, `sracipePlotData`

**Examples**

```r
data("demoCircuit")
rSet <- sRACIPE::sracipeSimulate(circuit = demoCircuit)
```
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