

# Package ‘CellNOptR’

October 18, 2022

**Type** Package

**Title** Training of boolean logic models of signalling networks using prior knowledge networks and perturbation data

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**Enhances** doParallel, foreach

**VignetteBuilder** knitr

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**Description** This package does optimisation of boolean logic networks of signalling pathways based on a previous knowledge network and a set of data upon perturbation of the nodes in the network.

**License** GPL-3

**LazyLoad** yes

**SystemRequirements** Graphviz version >= 2.2

**RoxygenNote** 7.1.2

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## R topics documented:

|                                     |    |
|-------------------------------------|----|
| CellNOptR-package . . . . .         | 4  |
| build_sif_table_from_rule . . . . . | 5  |
| checkSignals . . . . .              | 6  |
| CNOdata . . . . .                   | 7  |
| CNOlist-class . . . . .             | 7  |
| CNOlist-methods . . . . .           | 8  |
| CNOlistDREAM . . . . .              | 10 |
| CNOlistToy . . . . .                | 11 |
| CNOlistToy2 . . . . .               | 11 |
| CNORbool . . . . .                  | 12 |
| CNORwrap . . . . .                  | 13 |
| compressModel . . . . .             | 15 |
| computeScoreT1 . . . . .            | 16 |
| computeScoreTN . . . . .            | 17 |
| createAndRunILP . . . . .           | 18 |
| createILPBitstringAll . . . . .     | 20 |
| create_binaries . . . . .           | 20 |
| crossInhibitedData . . . . .        | 21 |
| crossvalidateBoolean . . . . .      | 22 |
| cutAndPlot . . . . .                | 24 |
| cutAndPlotResultsT1 . . . . .       | 25 |
| cutAndPlotResultsTN . . . . .       | 26 |
| cutCNOlist . . . . .                | 28 |
| cutModel . . . . .                  | 29 |
| cutNONC . . . . .                   | 30 |
| cutSimList . . . . .                | 31 |
| defaultParameters . . . . .         | 31 |
| exhaustive . . . . .                | 32 |
| expandGates . . . . .               | 33 |
| findNONC . . . . .                  | 35 |
| gaBinaryT1 . . . . .                | 36 |
| gaBinaryTN . . . . .                | 38 |
| getFit . . . . .                    | 40 |
| graph2sif . . . . .                 | 42 |
| ilpBinaryT1 . . . . .               | 43 |
| ilpBinaryT2 . . . . .               | 45 |
| ilpBinaryTN . . . . .               | 47 |
| indexFinder . . . . .               | 49 |
| internals . . . . .                 | 50 |
| invokeCPLEX . . . . .               | 50 |
| LiverDREAM . . . . .                | 51 |

|                                  |     |
|----------------------------------|-----|
| makeCNOList . . . . .            | 52  |
| mapBack . . . . .                | 53  |
| model2igraph . . . . .           | 54  |
| model2sif . . . . .              | 55  |
| normaliseCNOList . . . . .       | 56  |
| pknmodel . . . . .               | 58  |
| plot-method . . . . .            | 59  |
| plotCNOList . . . . .            | 60  |
| plotCNOList2 . . . . .           | 61  |
| plotCNOListLarge . . . . .       | 62  |
| plotCNOListLargePDF . . . . .    | 63  |
| plotCNOListPDF . . . . .         | 64  |
| plotFit . . . . .                | 64  |
| plotModel . . . . .              | 65  |
| plotOptimResults . . . . .       | 67  |
| plotOptimResultsPan . . . . .    | 69  |
| plotOptimResultsPDF . . . . .    | 71  |
| prep4sim . . . . .               | 73  |
| preprocessing . . . . .          | 74  |
| randomizeCNOList . . . . .       | 75  |
| readBND . . . . .                | 76  |
| readBNET . . . . .               | 77  |
| readMIDAS . . . . .              | 77  |
| readSBMLQual . . . . .           | 78  |
| readSIF . . . . .                | 79  |
| residualError . . . . .          | 81  |
| sif2graph . . . . .              | 82  |
| simulateTN . . . . .             | 83  |
| simulatorT0 . . . . .            | 84  |
| simulatorT1 . . . . .            | 85  |
| simulatorTN . . . . .            | 87  |
| toSBML . . . . .                 | 88  |
| ToyModel . . . . .               | 89  |
| ToyModel2 . . . . .              | 90  |
| writeDot . . . . .               | 90  |
| writeFile . . . . .              | 92  |
| writeMIDAS . . . . .             | 93  |
| writeNetwork . . . . .           | 94  |
| writeObjectiveFunction . . . . . | 96  |
| writeReport . . . . .            | 97  |
| writeScaffold . . . . .          | 99  |
| writeSIF . . . . .               | 101 |
| write_bounds . . . . .           | 102 |
| write_constraints . . . . .      | 102 |

---

CellNOptR-package      *R version of CellNOptR, boolean features*

---

## Description

This package does optimisation of boolean logic networks of signalling pathways based on a previous knowledge network and a set of data collected upon perturbation of some of the nodes in the network.

## Details

|           |            |
|-----------|------------|
| Package:  | CellNOptR  |
| Type:     | Package    |
| Version:  | 1.25.1     |
| Date:     | 2018-01-10 |
| License:  | GPLv3      |
| LazyLoad: | yes        |

## Author(s)

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## References

J. Saez-Rodriguez, L. G. Alexopoulos, J. Epperlein, R. Samaga, D. A. Lauffenburger, S. Klamt and P. K. Sorger. Discrete logic modeling as a means to link protein signaling networks with functional analysis of mammalian signal transduction, *Molecular Systems Biology*, 5:331, 2009.

## Examples

```
# quick 1 time point optimisation of a Prior Knowledge Network to MIDAS data.
data(CNolistToy,package="CellNOptR")
data(ToyModel,package="CellNOptR")

pknmodel = ToyModel
cnolist = CNolist(CNolistToy)
model = preprocessing(cnolist, pknmodel)
results = gaBinaryT1(cnolist, model, verbose=FALSE)
plotFit(results)
cutAndPlot(cnolist, model, list(results$bString))

# Same as above and HTML report
CNORwrap(name="Toy",
```

```
namesData=list(CN0list="ToyData",model="ToyModel"),
data=CN0listToy, model=pknmodel)
```

---

```
build_sif_table_from_rule
```

*Build a SIF table from a logic rule written in a string*

---

## Description

Build a SIF table from a logic rule written in a string

## Usage

```
build_sif_table_from_rule(rule_str, target, last_and_num = 0)
```

## Arguments

|              |   |
|--------------|---|
| rule_str     | String containing the rule to be parsed   |
| target       | Name of the node affected by the rule   |
| last_and_num | If the rule contains ‘and’ gates, their numeration will start after the number provided here (default is 0) |

## Value

data.frame with the network structure derived from the rule. The column ‘sif\_str’ contains the string that can be written to a file and then read with ‘readSIF()’ in order to load a CellNOpt compatible network.

## Examples

```
CellNOptR:::build_sif_table_from_rule("B & (C | D)", "A", last_and_num=2)

test_rule <- list()
test_rule[[1]] <- "AMP_ATP | (ATM & ATR) | HIF1 | !(EGFR | FGFR3)"
test_rule[[2]] <- "A & ((B | C) & !(D & E))"
test_rule[[3]] <- "A & B | C"
test_rule[[4]] <- "A & B & C"
test_rule[[5]] <- "A & (B | C)"
test_rule[[6]] <- "(A | B) & (C | D)"
test_rule[[7]] <- "!(C & D) | (E & F)"
test_rule[[8]] <- "(A | B) & (C | !D) & (E | F)"
parsed_rule <- list()
for (i in c(1:length(test_rule))) {
  parsed_rule[[i]] <- CellNOptR:::build_sif_table_from_rule(test_rule[[i]], "T")
}
```

---

`checkSignals`*Check the CNOList and model matching*

---

### Description

This function checks that all the signals in a CNOList match to species in the model. It also checks that the CNOList and Model lists have the right format and contain the right fields. It is called by the [preprocessing](#) function so there is no need to call it directly anymore if you use the [preprocessing](#) function.

In version 1.3.20, check of inhibitors and stimuli is also performed.

### Usage

```
checkSignals(CNOList, model)
```

### Arguments

|         |  |
|---------|--|
| CNOList | A CNOList structure, as created by <a href="#">makeCNOList</a> . |
| model   | A model structure, as created by <a href="#">readSIF</a> .       |

### Details

If the formats are wrong, this function produces an error. If the signals/inhibitors/stimuli do not match the species, this function produces a warning that explains which signals does no match any species.

### Author(s)

C. Terfve, T. Cokelaer

### See Also

[makeCNOList](#), [readSIF](#), [preprocessing](#)

### Examples

```
data(CNOListToy, package="CellNOptR")
data(ToyModel, package="CellNOptR")
checkSignals(CNOListToy, ToyModel)
```

---

|         |   |
|---------|---|
| CNodata | <i>Get data from a CellNOpt data repository</i> |
|---------|---|

---

**Description**

This function fetch a file from the URL provided (default is [http://www.ebi.ac.uk/~cokelaer/cellnopt/data/\\_downloads](http://www.ebi.ac.uk/~cokelaer/cellnopt/data/_downloads)) and save it into a temporary file.

You will need Rcurl package to use this function.

**Usage**

```
CNodata(filename, verbose=FALSE, url=NULL)
```

**Arguments**

|          |   |
|----------|---|
| filename | a valid filename that can be found in the url   |
| verbose  | FALSE by default, it prints the path of the temporary file where data has been copied.  |
| url      | You can overwrite the default URL ( <a href="http://www.ebi.ac.uk/~cokelaer/cellnopt/data/_downloads">http://www.ebi.ac.uk/~cokelaer/cellnopt/data/_downloads</a> ) with this argument. |

**Value**

the path of the temporary file where data has been copied.

**Author(s)**

T. Cokelaer

**Examples**

```
## Not run: readSIF(CNodata("PKN-ToyMMB.sif"))
```

---

|               |                        |
|---------------|------------------------|
| CNolist-class | <i>Class "CNolist"</i> |
|---------------|------------------------|

---

**Description**

This function takes as input the filename of a MIDAS file (or the list returned by [makeCNolist](#)) and returns an instance of CNolist class. It provides an object oriented approach to manipulate CNolist. This function calls [readMIDAS](#) and [makeCNolist](#).

**Objects from the Class**

Objects can be created by calls of the form `new("CNolist", ...)`.

**Slots**

cues: Object of class "matrix"  
inhibitors: Object of class "matrix"  
stimuli: Object of class "matrix"  
signals: Object of class "list"  
variances: Object of class "list"  
timepoints: Object of class "vector" timepoints contained in the signals matrix.  
See [CNOList-methods](#) for details

**Methods**

Available methods are plot, compatCNOList, randomize, length. See [CNOList-methods](#) for details.

**Author(s)**

T. Cokelaer

**See Also**

[randomizeCNOList](#), [plotCNOList](#), [plotCNOList2](#)

**Examples**

```
showClass("CNOList")

files<-dir(system.file("ToyModel",package="CellNOptR"),full=TRUE)
cnolist = CNOList(files[[1]])
# getters:
getCues(cnolist)
getInhibitors(cnolist)
getSignals(cnolist)
getVariances(cnolist)
getTimepoints(cnolist)
getStimuli(cnolist)
# In version 1.3.30 and above, use the plot method instead of former plotCNOList function.
plot(cnolist)
new_cnolist = randomize(cnolist)
length(cnolist)
```

**Description**

CNOList is a class with a set of methods described here below.



**Usage**

signature(x="CNOList")

**Getters**

**getCues** Returns the cues (matrix) found in the CNOList

**getSignals** Returns the signals (list of matrices) found in the CNOList

**getStimuli** Returns the cues found in the CNOList

**getInhibitors** Returns the inhibitors found in the CNOList

**getTimepoints** Returns the timepoints found in the CNOList

**getVariances** Returns the Variances (list of matrices) found in the CNOList. Will be different from zero only if replicates were found in the MIDAS data. See `makeCNOList`

**Setters**

**setSignals** Set the signals. No sanity check!

**Other methods**

**compatCNOList** convert the instance CNOList into the old-style returned by `makeCNOList` that is a list. Used in the ODE package.

**length** returns length of CNOList (number of time points)

**randomize** randomizes the signals matrix in a CNOList. See `randomizeCNOList` for details

**show** prints summary information

**plot** plot the CNOList instance using the `plotCNOList` function.

**plot** signature(x="CNOList", y="CNOList"): Please see the page of `plotCNOList2` for more details.

**readErrors** signature(object="CNOList", filename="MIDAS-file"): reads measurement error corresponding to the data from the MIDAS file and updates the CNOList object

**writeErrors** signature(object="CNOList", filename="string", overwrite=F): writes measurement error corresponding to the data from the CNOList to a MIDAS file

**Author(s)**

T.Cokelaer

**See Also**

[CNOList-class](#), [randomizeCNOList](#) [makeCNOList](#)

## Examples

```
showClass("CNolist")

data(CNolistToyMMB, package="CellNOptR")
cnolist = CNolistToyMMB

# In version 1.3.30 and above, use the plot method instead of former plotCNolist function.
plot(cnolist)
# In version 1.5.14 and above, use getters instead of the @ operator
getCues(cnolist)

# others:
new_cnolist = randomize(cnolist)
```

---

CNolistDREAM

*Data used for the DREAM3 challenge*

---

## Description

This data object contains the DREAM data used in the package vignette, already loaded and formatted as a CNolist object. This is to be used with the model "DreamModel". This is a data collected on HepG2 cells cultivated with or without stimulation of tgfa, ilk, mek12, pi3k and p38, in combination with inhibition of igf1 and/or il1a. Seven phosphoproteins are measured using Luminex xMAP assays: akt, erk12, ikb, jnk12, p38, hsp27 and mek12.

## Usage

```
data(CNolistDREAM)
```

## Format

CNolistDREAM is a list with the fields "namesCues" (character vector), "namesStimuli" (character vector), "namesInhibitors" (character vector), "namesSignals" (character vector), "timeSignals" (numerical vector), "valueCues" (numerical matrix), "valueInhibitors" (numerical matrix), "valueStimuli" (numerical matrix), "valueSignals" (numerical matrix).

## Source

This data and model is extracted from the Matlab version of CellNOpt1.0 (<http://www.ebi.ac.uk/saezrodriguez/software.html#CellNetOptimizer>).

## References

1. J. Saez-Rodriguez, L. G. Alexopoulos, J. Epperlein, R. Samaga, D. A. Lauffenburger, S. Klamt and P. K. Sorger. Discrete logic modeling as a means to link protein signaling networks with functional analysis of mammalian signal transduction, *Molecular Systems Biology*, 5:331, 2009.

- Prill RJ, Marbach D, Saez-Rodriguez J, Sorger PK, Alexopoulos LG, Xue X, Clarke ND, Altan-Bonnet G, and Stolovitzky G. Towards a rigorous assessment of systems biology models: the DREAM3 challenges. PLoS One, 5(2):e9202, 2010.

---

CNolistToy

*Toy data*

---

### Description

This data object contains the data associated with the Toy Model example from the package vignette, already loaded and formatted as a CNolist object.

### Usage

```
data(CNolistToy)
```

### Format

CNolistToy is a list with the fields "namesCues" (character vector), "namesStimuli" (character vector), "namesInhibitors" (character vector), "namesSignals" (character vector), "timeSignals" (numerical vector), "valueCues" (numerical matrix), "valueInhibitors" (numerical matrix), "valueStimuli" (numerical matrix), "valueSignals" (numerical matrix).

### Source

This data and model is extracted from the Matlab version of CellNOpt1.0 (<http://www.ebi.ac.uk/saezrodriguez/software.html#CellNetOptimizer>).

### References

J. Saez-Rodriguez, L. G. Alexopoulos, J. Epperlein, R. Samaga, D. A. Lauffenburger, S. Klamt and P. K. Sorger. Discrete logic modeling as a means to link protein signaling networks with functional analysis of mammalian signal transduction, Molecular Systems Biology, 5:331, 2009.

---

CNolistToy2

*Toy data with 2 time points*

---

### Description

This data object contains the data associated with the Toy Model example from the package vignette, already loaded and formatted as a CNolist object, and modified to contain 2 time points. The second time point is such a way that all of the signals stay as in time 1, except for cJun and Jnk which go to zero.

### Usage

```
data(CNolistToy)
```

**Format**

CNOListToy is a list with the fields "namesCues" (character vector), "namesStimuli" (character vector), "namesInhibitors" (character vector), "namesSignals" (character vector), "timeSignals" (numerical vector), "valueCues" (numerical matrix), "valueInhibitors" (numerical matrix), "valueStimuli" (numerical matrix), "valueSignals" (numerical matrix).

**Source**

This data and model is extracted from the Matlab version of CellNOpt1.0 (<http://www.ebi.ac.uk/saezrodriguez/software.html#CellNetOptimizer>).

**References**

J. Saez-Rodriguez, L. G. Alexopoulos, J. Epperlein, R. Samaga, D. A. Lauffenburger, S. Klamt and P. K. Sorger. Discrete logic modeling as a means to link protein signaling networks with functional analysis of mammalian signal transduction, *Molecular Systems Biology*, 5:331, 2009.

---

 CNORbool

*Simple Boolean analysis standalone*


---

**Description**

This function performs the optimisation of a PKN model to a CNOList data set. It optimises each time point found in the data and returns the processed model as well as a list of optimised bitstring corresponding to each time points that has been optimised.

This function does not create any plots or reports unlike [CNORwrap](#).

**Usage**

```
CNORbool(CNOList, model, paramsList=defaultParameters(),
         compression=TRUE, expansion=TRUE, cutNONC=TRUE, verbose=FALSE,
         timeIndices = NULL)
```

**Arguments**

|             |  |
|-------------|--|
| CNOList     | a CNOList structure, as created by <a href="#">makeCNOList</a> or a MIDAS filename   |
| model       | a model structure, as created by <a href="#">readSIF</a> or a SIF filename.  |
| paramsList  | Parameters of the genetic algorithm. If not provided, it is populated with the <a href="#">defaultParameters</a> function.                                     |
| compression | compress the model (default TRUE)  |
| expansion   | expand the gates (default TRUE)  |
| cutNONC     | cut the NONC nodes off the model by (default TRUE)   |
| verbose     | FALSE  |
| timeIndices | by default, optimise T1 and T2 assuming there are the 2 first time points. However, with this argument you can change that behaviour to arbitrary time points. |

**Value**

This function returns 2 components. The first one is the processed model used in the optimisation. The second is a list of optimised bitstrings found for each time points available in the MIDAS data set.

**Author(s)**

T.Cokelaer, S.Schrier

**Examples**

```
data(CNOListToy, package="CellNOptR")
data(ToyModel, package="CellNOptR")
res = CNORbool(CNOList=CNOListToy, model=ToyModel)
```

---

CNORwrap

*CNOR analysis wrapper*

---

**Description**

This function is a wrapper around the whole CNOR analysis, it performs the following steps:

1. Plot the CNOList;
2. Checks data to model compatibility;
3. Call the preprocessing function (Cut the nonc off the model, compress the model and expand the gates);
4. Compute the residual error;
5. Prepare for simulation;
6. Optimisation T1 and T2 (optional);
7. Plot simulated and experimental results;
8. Plot the evolution of fit;
9. Write the scaffold and PKN;
10. Write the report

**Usage**

```
CNORwrap(paramsList=NA, data=NA, model=NA, name, namesData=NA, time=1,
compression=TRUE, expansion=TRUE, cutNONC=TRUE)
```

## Arguments

|             |  |
|-------------|--|
| paramsList  | <p>A list of parameters related to the Genetic Algorithm parameters:</p> <ol style="list-style-type: none"> <li>1. sizeFac: default to 1e-04;</li> <li>2. NAFac: default to 1;popSize: default to 50;</li> <li>3. pMutation: default to 0.5;</li> <li>4. maxTime: default to 60;</li> <li>5. maxGens: default to 500;</li> <li>6. stallGenMax: default to 100;</li> <li>7. selPress: default to 1.2;</li> <li>8. elitism: default to 5;</li> <li>9. relTol: default to 0.1;</li> <li>10. verbose: default to FALSE (default to true in the functions used by CNORwrap but CNORwrap sets them to false by default).</li> </ol> <p>and the Data and Model structure.</p> <p>If paramsList is not provided (NA), it is filled internally with the <a href="#">defaultParameters</a> function.</p> <p>If Data and Model are not provided in paramList, the function looks for Data and Model arguments.</p> <p>If Data and Model are provided, the function overwrites the field data and model in paramsList.</p> |
| data        | a CNOList structure, as created by <a href="#">makeCNOList</a>   |
| model       | a model structure, as created by <a href="#">readSIF</a> .   |
| name        | a string that will be used to name the project and all graphs produced   |
| namesData   | a list with two elements:CNOList and Model, each containing a string that is a reference for the user to know which model/data set was used (it will be included in the report). If not provided, the list is built automatically using the name arguments.  |
| time        | either 1 or 2: Do you want to perform a one time point steady state optimisation or a 2 time points pseudo steady state optimisation. By default this is set to 1.   |
| compression | compress the model (default TRUE)  |
| expansion   | expand the gates (default TRUE)  |
| cutNONC     | cut the NONC nodes off the model by (default TRUE)   |

## Details

If you do not provide a parameters list, you can provide only essential elements, and all other parameters will be set to their default values. In this case, you should set paramsList=NA, and provide the following fields: data, model, name, time.

## Value

This function does not return anything, it does the analysis, produces all the plots and puts them in a folder that is in your working directory, and is called "Name".

**Author(s)**

C. Terfve

**Examples**

```
#version with paramslist

data(CNolistToy,package="CellNOptR")
data(ToyModel,package="CellNOptR")

pList = defaultParameters(CNolistToy, ToyModel)
pList$maxGens = 5
pList$popSize = 5

CNORwrap(paramsList=pList, name="Toy",
          namesData=list(CNolist="ToyData", model="ToyModel"))

## Not run:
#version with default parameters

data(CNolistToy,package="CellNOptR")
data(ToyModel,package="CellNOptR")

CNORwrap(name="Toy",
          namesData=list(CNolist="ToyData", model="ToyModel"),
          data=CNolistToy, model=ToyModel)

## End(Not run)
```

---

`compressModel`*Compress a model*

---

**Description**

This function compresses a model by compressing species that are not signals/inhibited/stimulated and that are not dead ends/in complex logic (i.e. only species with either one input or one output are compressed)/in self loops.

You can also use [preprocessing](#) function instead that calls [compressModel](#) and other preprocessing functions.

**Usage**

```
compressModel(model, indexes)
```

**Arguments**

|                      |  |
|----------------------|--|
| <code>model</code>   | a model structure as produced by <a href="#">readSIF</a> .   |
| <code>indexes</code> | list of indexes of the species stimulated/inhibited/measured in the model, as created by <a href="#">indexFinder</a> . |

**Details**

Be aware that in the multiple inputs/one output case, if one of the outputs is an '&' gate this function handles it fine as long as it is an '&' with 2 inputs and no more.

**Value**

a compressed model list, with an additional field called 'speciesCompressed' that contains the names of the species that have been compressed

**Note**

No need to call this function directly since version 0.99.24. Use [preprocessing](#) instead.

**Author(s)**

C. Terfve

**See Also**

[indexFinder](#), [readSIF](#), [preprocessing](#)

**Examples**

```
#load data

data(CN0listToy,package="CellNOptR")
data(ToyModel,package="CellNOptR")

indicesToy<-indexFinder(CN0listToy,ToyModel,verbose=FALSE)
toyComp<-compressModel(ToyModel,indicesToy)
```

---

|                |  |
|----------------|--|
| computeScoreT1 | <i>Compute the score of a model/data set using a bitString to cut the model.</i> |
|----------------|--|

---

**Description**

The bitString made of 0 and 1 allows to select a submodel from the model provided. Then, the simulator function are called to compute the objective function. The sizeFac and NAFac are penalties added to the final score as described in gaBinaryT1. The indexList and simList arguments can be provided to speed up the code otherwise, they are recomputed from the CN0list and model.

**Usage**

```
computeScoreT1(CN0list, model, bString, simList=NULL, indexList=NULL,
  sizeFac=0.0001, NAFac=1, timeIndex=2)
```



**Arguments**

|           |  |
|-----------|--|
| CNOlist   | a CNOlist structure, as created by makeCNOlist.  |
| model     | a model structure, as created by codereadSIF, normally pre-processed but that is not a requirement of this function.   |
| bString   | a bitstring of the same size as the number of reactions in the model above   |
| simList   | If provided, simList should be created by prep4sim, that has also already been cut to contain only the reactions to be evaluated.                            |
| indexList | If provided, indexList should contain a list of indexes of the species stimulated/inhibited/measured in the model, as created by indexFinder.                |
| sizeFac   | the scaling factor for the size term in the objective function, default to 0.0001  |
| NAFac     | the scaling factor for the NA term in the objective function, default to 1   |
| timeIndex | the index of the time point to optimize. Must be greater or equal to 2 (1 corresponds to time=0). Must be less than the number of time points. Default is 2. |

**Value**

|       |                            |
|-------|----------------------------|
| score | See gaBinaryT1 for details |
|-------|----------------------------|

**Author(s)**

T. Cokelaer

**Examples**

```
data(CNOlistToy, package="CellNOptR")
data(ToyModel, package="CellNOptR")
model <- preprocessing(CNOlistToy, ToyModel)
score = computeScoreT1(CNOlist(CNOlistToy), model, bString=rep(1,16))
```

---

|                |  |
|----------------|--|
| computeScoreTN | <i>Compute the score at TN of a model/data set using a bitString to cut the model.</i> |
|----------------|--|

---

**Description**

The bitString made of 0 and 1 allows to select a submodel from the model provided. Then, the simulator function are called to compute the objective function. The sizeFac and NAFac are penalties added to the final score as described in gaBinaryTN.

**Usage**

```
computeScoreTN(CNOlist, model, simList=NULL, indexList=NULL, simResPrev=NULL,
  bStringPrev=NULL, bStringNext=NULL, timeIndex=NULL, sizeFac=0.0001, NAFac=1, bStrings=NULL)
```

**Arguments**

|             |  |
|-------------|--|
| CNOlist     | a CNOlist structure, as created by makeCNOlist.  |
| model       | a model structure, as created by codereadSIF, normally pre-processed but that is not a requirement of this function.   |
| simList     | a simList as created by prep4sim, that has also already been cut to contain only the reactions to be evaluated. If not provided, it is recomputed automatically. |
| indexList   | a list of indexes of the species stimulated/inhibited/measured in the model, as created by indexFinder. If not provided, it is recomputed automatically.         |
| simResPrev  | Results of Previous simulation at time TN-1 step.  |
| bStringPrev | the best bitString at time TN-1  |
| bStringNext | the bitString to use to compute the score at time TN   |
| timeIndex   | Future feature will allow timeIndex to provide the exact list of indices to cut and plot. For now, it is based on the bitStrings provided.                       |
| sizeFac     | the scaling factor for the size term in the objective function, default to 0.0001  |
| NAFac       | the scaling factor for the NA term in the objective function, default to 1   |
| bStrings    | list of optimised bitstrings found at the previous time points   |

**Value**

|       |                            |
|-------|----------------------------|
| score | See gaBinaryTN for details |
|-------|----------------------------|

**Author(s)**

T. Cokelaer, S.Schrier

**Examples**

```
data(CNOlistToy2,package="CellNOptR")
data(ToyModel2,package="CellNOptR")
model <- preprocessing(CNOlistToy2, ToyModel2)
bStringT1 = c(0,0,1,1,1,1,1,1,1,0,0,1,1,1,1,1)
simT1<-simulateTN(CNOlist=CNOlistToy2, model=model, bStrings=list(bStringT1))

score1 = computeScoreTN(CNOlistToy2, model, bStrings=list(bStringT1,c(1,0,1,0)))
```

---

createAndRunILP

*Creating and running the ILP problem.*

---

**Description**

This function takes as an input the cno inputs (model + data) together with CPLEX parameters and then solves the ILP problem.

**Usage**

```
createAndRunILP(model = model,  
                midas = midas,  
                cnolist = cnolist,  
                accountForModelSize = accountForModelSize,  
                sizeFac = sizeFac,  
                source_path = source_path,  
                mipGap = mipGap,  
                relGap = relGap,  
                timelimit = timelimit,  
                cplexPath = cplexPath,  
                method = method,  
                numSolutions = numSolutions,  
                limitPop = limitPop,  
                poolIntensity = poolIntensity,  
                poolReplace = poolReplace)
```

**Arguments**

|                     |   |
|---------------------|---|
| model               | the model   |
| midas               | the midas table   |
| cnolist             | the cnolist object                                      |
| accountForModelSize | the verbose parameter whether to account for model size |
| sizeFac             | the size penalty factor                                 |
| source_path         | the source path   |
| mipGap              | the mipgap  |
| relGap              | the relGap  |
| timelimit           | the timelimit   |
| cplexPath           | the cplex solver path                                   |
| method              | the optimization method (quadratic/linear)              |
| numSolutions        | the number of desired solutions                         |
| limitPop            | the limitPop  |
| poolIntensity       | the poolIntensity                                       |
| poolReplace         | the poolReplace   |

**Author(s)**

E Gjerga, H Koch

---

createILPBitstringAll *Reading the optimal solutions as bitstrings.*

---

### Description

This function takes as the cplex optimization results and the variables assigned to each interaction in the ILP formulation in order to read the optimal bitstring.

### Usage

```
createILPBitstringAll(cplexSolutionFileName,  
                     y_vector,  
                     binary_variables)
```

### Arguments

cplexSolutionFileName  
the file name where the cplex results are stored

y\_vector  
the variables for each interaction in the PKN

binary\_variables  
the binary variables of the ILP formulation

### Author(s)

E Gjerga, H Koch

---

create\_binaries *Defining the set of binary variables for the ILP implementation of CellNOptR.*

---

### Description

This function takes as input the model and data in a CNOList object in order to define the set of binary variablese.

### Usage

```
create_binaries(model,  
               midas,  
               numberOfExperiments,  
               y_vector)
```

**Arguments**

model            the model  
 midas            the midas table  
 numberOfExperiments  
                   the number of experimental conditions  
 y\_vector        the variables for each interaction in the PKN

**Author(s)**

E Gjerga, H Koch

**References**

Alexander Mitsos, Ioannis N. Melas, Paraskeuas Siminelakis, Aikaterini D. Chairakaki, Julio Saez-Rodriguez, and Leonidas G. Alexopoulos. Identifying Drug Effects via Pathway Alterations using an Integer Linear Programming Optimization Formulation on Phosphoproteomic Data. PLoS Comput Biol. 2009 Dec; 5(12): e1000591.

---

crossInhibitedData    *If an inhibitor is also a measured species, replace the data with NA (when inhibited)*

---

**Description**

If an inhibitor is also a measured species, replace the data with NA (when inhibited)

**Usage**

```
crossInhibitedData(object)
```

**Arguments**

object            the CNOList that contains the data

**Value**

the new cnolist

**Author(s)**

T. Cokelaer

**Examples**

```

data(ToyModel,package="CellNOptR")
data(CNOLISTToy,package="CellNOptR")
cnolist = crossInhibitedData(CNOLIST(CNOLISTToy))

```

---

crossvalidateBoolean *k-fold crossvalidation for Boolean model.*

---

### Description

Cross-validation analysis for the boolean case.

### Usage

```
crossvalidateBoolean(CNolist,model,nfolds=10,foldid=NULL,
                    type=c('datapoint','experiment','observable'),timeIndex = 2,parallel=FALSE,...)
```

### Arguments

|           |  |
|-----------|--|
| CNolist   | a CNolist on which the score is based (based on valueSignals[[2]], i.e. data at time 1).   |
| model     | a model structure, as created by readSIF, normally pre-processed but that is not a requirement of this function.   |
| nfolds    | number of folds - default is 10. Although nfolds can be as large as the sample size (leave-one-out CV), it is not recommended for large datasets.  |
| foldid    | an optional vector of values between '1' and 'nfold' identifying what fold each observation is in. If supplied, 'nfold' can be missing.  |
| type      | define the way to do the crossvalidation. The default is type="datapoint", which assigns the data randomly into folds. The option 'type="experiment"' uses whole experiments for crossvalidation (all data corresponding to a cue combination). The 'type=observable' uses the subset of nodes across all experiments for crossvalidation. |
| timeIndex | the index of the time point to optimize. Must be greater or equal to 2 (1 corresponds to time=0). Must be less than the number of time points. Default is 2.   |
| parallel  | verbose parameter, indicating wheter to parallelize the cross-validation procedure or not (default set to FALSE).  |
| ...       | further arguments are passed to gaBinaryT1   |

### Details

Does a k-fold cross-validation for Boolean CellNOpt models. In k-iterations a fraction of the data is eliminated from the CNolist. The model is trained on the remaining data and then the model predicts the held-out data. Then the prediction accuracy is reported for each iteration.

### Value

This function returns a list with elements:

cvScores            cross-validation scores

|                    |  |
|--------------------|--|
| fitScores          | fitting scores                           |
| bStrings           | the optimal bit-string list for each run |
| crossvalidate.call | echo of the function which was called    |
| foldid             | the fold id's                            |

**Author(s)**

A. Gabor, E. Gjerga

**Examples**

```

data("ToyModel", package="CellNOptR")
data("CNolistToy", package="CellNOptR")
pknmodel = ToyModel
cnodata = CNolist(CNolistToy)

# original and preprocessed network
plotModel(pknmodel,cnodata)
model = preprocessing(data = cnodata,
model = pknmodel,
compression = TRUE,
expansion = TRUE)
plotModel(model,cnodata)

# original CNolist contains many timepoints, we use only a subset
plot(cnodata)
selectedTime = c(0,10)
cnodata_prep = cutCNolist(cnodata,
model = model,
cutTimeIndices = which(!getTimepoints(cnodata) %in% selectedTime))

plot(cnodata_prep)

# optimise and show results
opt = gaBinaryT1(CNolist = cnodata_prep,model = model,verbose = FALSE)

# 10-fold crossvalidation using T1 data
# We use only T1 data for crossvalidation, because data in the T0 matrix is not independent.
# All rows of data in T0 describes the basal condition.

# Crossvalidation produce some text in the command window:
## Not run:
library(doParallel)
registerDoParallel(cores=3)
R=crossvalidateBoolean(CNolist = cnodata_prep,
model = model,
type = "datapoint",
nfolds = 10,
parallel = TRUE)

```

```
## End(Not run)
```

---

cutAndPlot                      *Interface to cutAndPlotResults functions.*

---

### Description

This function takes a model and cnolist as well as a list of optimised bitstring at different time points. It calls the appropriate cutAndPlotResultsTX function.

### Usage

```
cutAndPlot(CNolist, model, bStrings, plotPDF=FALSE, tag=NULL,
plotParams = list(maxrow = 10))
```

### Arguments

|            |   |
|------------|---|
| CNolist    | a CNolist, corresponding to the optimisation one  |
| model      | a model (the full one that was used for optimisation)   |
| bStrings   | a bitstring for T1 as output by gaBinaryT1 (i.e. a vector of 1s and 0s)   |
| plotPDF    | TRUE or FALSE; tells whether you want a pdf to be produced or not   |
| tag        | NULL or string; tells whether you want to prefix filenames with a tag (replaces the default behaviour).   |
| plotParams | a list of option related to the PDF and plotting outputs. (1) maxrow is the maximum number of row used to plot the results. See <a href="#">plotOptimResultsPan</a> for other fields. |

### Value

This function returns nothing. It plots a graph in your graphic window and sqve it in a file if asked

### Author(s)

T. Cokelaer

### See Also

[cutAndPlotResultsT1](#)



**Examples**

```
#load data

data(CNolistToy,package="CellNOptR")
data(ToyModel,package="CellNOptR")

#pre-process model
model = preprocessing(CNolistToy, ToyModel)

cutAndPlot(CNolistToy, model,
           bStrings=list(rep(1,length(model$reacID))),plotPDF=FALSE)
```

---

```
cutAndPlotResultsT1 Plot the results of an optimisation at t1
```

---

**Description**

This function takes a model and an optimised bitstring, it cuts the model according to the bitstring and plots the results of the simulation along with the experimental data.

**Usage**

```
cutAndPlotResultsT1(model, bString, simList=NULL, CNolist, indexList=NULL, plotPDF =
FALSE, tag = NULL, tPt=CNolist@timepoints[2], plotParams = list(maxrow=10))
```

**Arguments**

|            |   |
|------------|---|
| model      | a model (the full one that was used for optimisation)   |
| bString    | a bitstring for T1 as output by <code>gaBinaryT1</code> (i.e. a vector of 1s and 0s)  |
| simList    | deprecated argument kept for back compatibility. a simlist corresponding to the model, as output by <code>prep4sim</code>   |
| CNolist    | a CNolist, corresponding to the optimisation one  |
| indexList  | deprecated argument kept for back compatibility. an indexList, produced by <code>indexFinder</code> ran on the model and the CNolist above  |
| plotPDF    | TRUE or FALSE; tells whether you want a pdf to be produced or not   |
| tag        | NULL or string; tells whether you want to prefix filenames with a tag (replaces the default behaviour).   |
| tPt        | The number of time points in the data.  |
| plotParams | a list of option related to the PDF and plotting outputs. (1) maxrow is the maximum number of row used to plot the results. See <a href="#">plotOptimResultsPan</a> for other fields. |

**Value**

This function returns plotted MSEs and list of filenames generated (if any)

**Author(s)**

C.Terfve, T. Cokelaer, A. MacNamara

**See Also**

[gaBinaryT1](#)

**Examples**

```
#load data

data(CN0listToy, package="CellNOptR")
data(ToyModel, package="CellNOptR")

#pre-process model
model = preprocessing(CN0listToy, ToyModel)

#optimise
ToyT1opt<-gaBinaryT1(
  CN0list=CN0listToy,
  model=model,
  maxGens=20,
  popSize = 10,
  verbose=FALSE)

#plotting
cutAndPlotResultsT1(
  model=model,
  CN0list=CN0listToy,
  bString=ToyT1opt$bString,
  plotPDF=FALSE)
```

---

cutAndPlotResultsTN *Plot the results of an optimisation at tN*

---

**Description**

This function takes a model and an optimised bitstring, it cuts the model according to the bitstring and plots the results of the simulation along with the experimental data. This function is designed to work on results of a 2 step optimisation.

**Usage**

```
cutAndPlotResultsTN(CN0list, model, bStrings, plotPDF = FALSE, tag=NULL,
  plotParams = list(maxrow = 10))
```

**Arguments**

|            |   |
|------------|---|
| CN0list    | a CN0list, corresponding to the optimisation one  |
| model      | a model (the full one that was used for optimisation)   |
| bStrings   | a list of bitstring at different time points  |
| plotPDF    | TRUE or FALSE, tells whether you want a pdf to be produced or not   |
| tag        | NULL or string; tells whether you want to prefix filenames with a tag (replaces the default behaviour).   |
| maxrow     | maximum number of row in the plot.  |
| plotParams | a list of option related to the PDF and plotting outputs. (1) maxrow is the maximum number of row used to plot the results. See <a href="#">plotOptimResultsPan</a> for other fields. |

**Value**

This function returns plotted MSEs

**Note**

New in version 1.3.28

**Author(s)**

T. Cokelaer, A. MacNamara, Sarah Schrier, C. Terfve based on [cutAndPlotResultsT1](#)

**See Also**

[gaBinaryT1](#), [prep4sim](#), [cutAndPlotResultsT1](#)

**Examples**

```
#load data

data(CN0listToy2,package="CellNOptR")
data(ToyModel2,package="CellNOptR")

#pre-process model
model = preprocessing(CN0listToy2, ToyModel2)

#optimise t1
ToyT1<-gaBinaryT1(
  CN0list=CN0listToy2,
  model=model,
  maxGens=20,
  popSize = 10,
  verbose=FALSE)

#Optimise T2
ToyT2<-gaBinaryTN(
  CN0list=CN0listToy2,
```

```

model=model,
bStrings=list(ToyT1$bString),
maxGens=20,
popSize = 10,
verbose=FALSE)

cutAndPlotResultsTN(
CNOList=CNOListToy2,
model=model,
bStrings=list(ToyT1$bString, bStringT2=ToyT2$bString),
plotPDF=FALSE)

```

---

cutCNOList

*Cut a CNOList structure according to a model*


---

### Description

The MIDAS file may contain species that are not contained in the model. If you want to remove cues and signals from your CNOList that are not contained in the model, you can use this function by using the parameter model. It can also be used to remove some time points by using the parameter cutTimeIndices. Both parameters can be used at the same time and at least one of them must be provided.

### Usage

```
cutCNOList(cnolist, model, cutTimeIndices, verbose=FALSE)
```

### Arguments

|                |   |
|----------------|---|
| cnolist        | the CNOList structure   |
| model          | the model   |
| cutTimeIndices | the time indices to remove  |
| verbose        | Set it to True to get the signals and cues not found in the model |

### Value

|            |                        |
|------------|------------------------|
| cutCNOList | the new CNOList object |
|------------|------------------------|

### Note

added in version 1.5.10

### Author(s)

T. Cokelaer

### See Also

[CNOList-class](#)

**Examples**

```
data(CNolistToy, package="CellNOptR")
data(ToyModel, package="CellNOptR")

cno_prep = cutCNolist(cnolist = CNolistToy, model = ToyModel, verbose = FALSE)
```

---

`cutModel`*Cut a model structure according to a bitstring*

---

**Description**

This function is for developers only.

**Usage**

```
cutModel(model, bString)
```

**Arguments**

|                      |   |
|----------------------|---|
| <code>model</code>   | the model object to cut.                          |
| <code>bString</code> | the bitString to be used to cut the model object. |

**Value**

|                       |                      |
|-----------------------|----------------------|
| <code>cutModel</code> | the new model object |
|-----------------------|----------------------|

**Note**

added in version 1.3.16

**Author(s)**

T. Cokelaer

**Examples**

```
data(ToyModel, package="CellNOptR")

bString = rep(1, length(ToyModel$reacID))
# remove some reactions by setting them to 0.
bString[c(2,5,6)] <- 0

prepModel = cutModel(model = ToyModel, bString = bString )
```

---

`cutNONC`*Cuts the non-observable/non-controllable species from the model*

---

**Description**

This function cuts the non-observable and/or non-controllable species from the model, and returns a cut model.

**Usage**

```
cutNONC(model, NONCindexes)
```

**Arguments**

|                          |  |
|--------------------------|--|
| <code>model</code>       | a model structure, as produced by <code>readSIF</code>   |
| <code>NONCindexes</code> | a vector of indices of species to remove in that model, as produced for example by <code>findNONC</code> |

**Details**

This function takes in a model and a vector of indices of species to remove in that model and it removes those species and any reaction involving them (be aware, if you have  $x=y=z$  and  $x$  is to be removed, then the function produces  $y=z$ , because it works by removing entire rows of the model matrices and then removes the columns that do not have either an input or an output). This function could actually be used to cut any species, not only NONC species.

**Value**

a model

**Note**

No need to call this function directly since version 0.99.24. Use [preprocessing](#) instead.

**Author(s)**

C.Terfve

**See Also**

[findNONC](#), [readSIF](#)

**Examples**

```
data(CN0listToy, package="CellNOptR")
data(ToyModel, package="CellNOptR")
indicesToy<-indexFinder(CN0listToy, ToyModel, verbose=FALSE)
ToyNCN0indices<-findNONC(ToyModel, indicesToy, verbose=FALSE)
ToyNCN0cut<-cutNONC(ToyModel, ToyNCN0indices)
```

---

|            |   |
|------------|---|
| cutSimList | <i>Cut a simList structure according to a bitstring</i> |
|------------|---|

---

**Description**

This function is for developers only.

**Usage**

```
cutSimList(simList, bString)
```

**Arguments**

|         |   |
|---------|---|
| simList | the simList object to cut.                          |
| bString | the bitString to be used to cut the simList object. |

**Value**

|            |                        |
|------------|------------------------|
| cutSimList | the new simList object |
|------------|------------------------|

**Author(s)**

T. Cokelaer

---

|                   |  |
|-------------------|--|
| defaultParameters | <i>Create a list of default parameters</i> |
|-------------------|--|

---

**Description**

This function provides a list of default parameters including the Genetic Algorithm parameters.

**Usage**

```
defaultParameters(data=NA, model=NA)
```

**Arguments**

|       |   |
|-------|---|
| data  | a CNOList structure, as created by makeCNOList  |
| model | a model structure, as created by readSIF, normally pre-processed but that is not a requirement of this function |

**Details**

The list contains the Genetic Algorithm parameter, a verbose option and can be used to store the Data and Model.

**Value**

params a list with the fields: data, model, verbose and all default parameters of [gaBinaryT1](#)

**Author(s)**

T. Cokelaer

**Examples**

```
data(ToyModel, package="CellNOptR")
data(CNolistToy, package="CellNOptR")
params = defaultParameters(CNolistToy, ToyModel)
```

---

|            |  |
|------------|--|
| exhaustive | <i>Exhaustive search over the optimisation of a PKN model on MIDAS data.</i> |
|------------|--|

---

**Description**

This function performs an exhaustive search of the parameter space trying all the solutions. It is used internally by the genetic algorithm when a small model has to be optimised and the number of solutions to try is smaller than the number of iterations that the Genetic Algorithm will perform.

**Usage**

```
exhaustive(CNolist, model, shuffle=FALSE, Nmax=NULL, verbose=TRUE, sizeFac =
0.0001, NAFac = 1, relTol=0.1, timeIndex=2)
```

**Arguments**

|           |  |
|-----------|--|
| CNolist   | a CNolist on which the score is based (based on valueSignals[[2]], i.e. data at time 1)  |
| model     | a model structure, as created by readSIF, normally pre-processed but that is not a requirement of this function  |
| shuffle   | The list of bitstrings is set up arbitrarily. You may want to shuffle it.  |
| Nmax      | The total number of computation will be 2 to the power N, where N is the size of the model (ReacID field). The total number of computation can be large. You may want to set a maximum number of computation using Nmax. |
| sizeFac   | the scaling factor for the size term in the objective function, default to 0.0001  |
| NAFac     | the scaling factor for the NA term in the objective function, default to 1   |
| relTol    | the relative tolerance for the best bitstring reported by the genetic algorithm, i.e., how different from the best solution, default set to 0.1 Not yet implemented.   |
| verbose   | logical (default to TRUE) do you want the statistics of each generation to be printed on the screen?   |
| timeIndex | the index of the time point to optimize. Must be greater or equal to 2 (1 corresponds to time=0). Must be less than the number of time points. Default is 2.   |



**Value**

This function returns a list with elements:

|                  |   |
|------------------|---|
| bString          | the best bitstring  |
| bScore           | the best score  |
| all_scores       | all scores that have been computed  |
| results          | a matrix with columns "Generation", "Best_score", "Best_bitString", "Stall_Generation", "Avg_Score_Gen" |
| stringsTol       | the bitstrings whose scores are within the tolerance  |
| stringsTolScores | the scores of the above-mentioned strings   |

Note that the field results, is not yet populated but maybe in the future.

**Author(s)**

T. Cokelaer

**See Also**

[gaBinaryT1](#)

**Examples**

```
data(CN0listToy,package="CellNOptR")
data(ToyModel,package="CellNOptR")

#pre-process model

model = preprocessing(CN0listToy, ToyModel)

#optimise

results <-exhaustive(
  CN0list=CN0listToy,
  model=model,
  shuffle=TRUE,
  Nmax=1000,
  verbose=FALSE)
```

---

expandGates

*Expand the gates of a model*

---

**Description**

This function takes in a model and (1) splits all AND gates into ORs. In addition, (2) wherever there are more than one, it creates all possible ANDs combinations of them, but considering only ANDs with 2, 3 or 4 inputs according to the user argument (default is 2)

**Usage**

```
expandGates(model, ignoreList=NA, maxInputsPerGate=2)
```

**Arguments**

|                  |  |
|------------------|--|
| model            | a model structure  |
| ignoreList       | an index vector of states to ignore incoming edges during step (1), i.e. at the time of splitting up AND gates |
| maxInputsPerGate | maximum number of input per gates (Default is 2; up to 4)  |

**Details**

This function returns a model with additional fields that help keep track of the processing done on the network. I would advice not to overwrite on the initial model but rather to assign the result of this function to a variable with a different name.

**Value**

returns a model, with additional fields:

|           |   |
|-----------|---|
| SplitANDs | list that contains a named element for each AND reac that has been split, and each element contains a vector with the names of the of the reactions that result from the split if nothing was split, this element has the default value \$initialReac [1] "split1" "split2" |
| newANDs   | list that contains an element for each new '&' gate, named by the name of this new and reac, and containing a vector of the names of the reactions from which it was created (contains all the reacts in that pool, not the particular ones, this could be improved)        |

**Note**

No need to call this function directly since version 0.99.24. Use [preprocessing](#) instead.

**Author(s)**

C.Terfve, T. Cokelaer, A.MacNamara, Martin-Franz-Xaver Pirkl

**Examples**

```
#load data

data(CN0listToy,package="CellNOptR")
data(ToyModel,package="CellNOptR")

#pre-process the model

indicesToy<-indexFinder(CN0listToy,ToyModel,verbose=TRUE)
ToyNCNOindices<-findNONC(ToyModel,indicesToy,verbose=TRUE)
ToyNCNOcut<-cutNONC(ToyModel,ToyNCNOindices)
```

```
indicesToyNCNOcut<-indexFinder(CNOlistToy,ToyNCNOcut)
ToyNCNOcutComp<-compressModel(ToyNCNOcut,indicesToyNCNOcut)
indicesToyNCNOcutComp<-indexFinder(CNOlistToy,ToyNCNOcutComp)
ToyNCNOcutCompExp<-expandGates(ToyNCNOcutComp, maxInputsPerGate=4)
```

---

findNONC

*Find the indexes of the non-observable and non controllable species*

---

## Description

This function finds the indexes of the non-observable and non controllable species and returns the indices, in the model, of the species to remove

## Usage

```
findNONC(model, indexes, verbose=FALSE)
```

## Arguments

|         |   |
|---------|---|
| model   | a model structure, as created by <a href="#">readSIF</a>  |
| indexes | a list of indexes of the species stimulated/inhibited/measured, as created by <a href="#">indexFinder</a> from a model. |
| verbose | verbose option (default to FALSE)   |

## Details

This function uses the function `floyd.warshall.all.pairs.sp` from the package `RBGL`. Non observable nodes are those that do not have a path to any measured species in the model, whereas non controllable nodes are those that do not receive any information from a species that is perturbed in the data.

## Value

a vector of indices of species to remove

## Note

No need to call this function directly since version 0.99.24. Use [preprocessing](#) instead.

## Author(s)

C. Terfve

## See Also

[cutNONC](#), [indexFinder](#), [readSIF](#)

**Examples**

```

data(CNolistToy, package="CellNOptR")
data(ToyModel, package="CellNOptR")
checkSignals(CNolistToy, ToyModel)
indicesToy <- indexFinder(CNolistToy, ToyModel)
ToyNCNOindices <- findNONC(ToyModel, indicesToy)

```

gaBinaryT1

*Genetic algorithm used to optimise a model***Description**

This function is the genetic algorithm to be used to optimise a model by fitting to data containing one time point.

**Usage**

```

gaBinaryT1(CNolist, model, initBstring=NULL, sizeFac = 1e-04,
  NAFac = 1, popSize = 50, pMutation = 0.5, maxTime = 60, maxGens = 500,
  stallGenMax = 100, selPress = 1.2, elitism = 5, relTol = 0.1, verbose=TRUE,
  priorBitString=NULL, timeIndex=2)

```

**Arguments**

|             |   |
|-------------|---|
| CNolist     | a CNolist on which the score is based (based on valueSignals[[2]], i.e. data at time 1)   |
| model       | a model structure, as created by readSIF, normally pre-processed but that is not a requirement of this function                                   |
| initBstring | an initial bitstring to be tested, should be of the same size as the number of reactions in the model above (model\$reacID). Default is all ones. |
| sizeFac     | the scaling factor for the size term in the objective function, default to 0.0001   |
| NAFac       | the scaling factor for the NA term in the objective function, default to 1  |
| popSize     | the population size for the genetic algorithm, default set to 50  |
| pMutation   | the mutation probability for the genetic algorithm, default set to 0.5  |
| maxTime     | the maximum optimisation time in seconds, default set to 60   |
| maxGens     | the maximum number of generations in the genetic algorithm, default set to 500  |
| stallGenMax | the maximum number of stall generations in the genetic algorithm, default to 100  |
| selPress    | the selective pressure in the genetic algorithm, default set to 1.2   |
| elitism     | the number of best individuals that are propagated to the next generation in the genetic algorithm, default set to 5                              |
| relTol      | the relative tolerance for the best bitstring reported by the genetic algorithm, i.e., how different from the best solution, default set to 0.1   |

|                |  |
|----------------|--|
| verbose        | logical (default to TRUE) do you want the statistics of each generation to be printed on the screen?   |
| priorBitString | At each generation, the GA algorithm creates a population of bitstrings that will be used to perform the optimisation. If the user knows the values of some bits, they can be used to overwrite bit values proposed by the GA algorithm. If provided, the priorBitString must have the same length as the initial bitstring and be made of 0, 1 or NA (by default, this bitstring is set to NULL, which is equivalent to setting all bits to NA). Bits that are set to 0 or 1 are used to replace the bits created by the GA itself (see example). |
| timeIndex      | the index of the time point to optimize. Must be greater or equal to 2 (1 corresponds to time=0). Must be less than the number of time points. Default is 2.   |

### Details

The whole procedure is described in details in Saez-Rodriguez et al. (2009). The basic principle is that at each generation, the algorithm evaluates a population of models based on excluding or including some gates in the initial pre-processed model (this is encoded in a bitstring with contains 0/1 entries for each gate). The population is then evolved based on the results of the evaluation of these networks, where the evaluation is obtained by simulating the model (to steady state) under the various conditions present in the data, and then computing the squared deviation from the data, to which a penalty is added for size of the model and for species in the model that do not reach steady state.

### Value

This function returns a list with elements:

|                  |   |
|------------------|---|
| bString          | the best bitstring  |
| bScore           | the best score  |
| results          | a matrix with columns "Generation", "Best_score", "Best_bitString", "Stall_Generation", "Avg_Score_Gen" |
| stringsTol       | the bitstrings whose scores are within the tolerance  |
| stringsTolScores | the scores of the above-mentioned strings   |

### Author(s)

C. Terfve. T. Cokelaer

### References

J. Saez-Rodriguez, L. G. Alexopoulos, J. Epperlein, R. Samaga, D. A. Lauffenburger, S. Klamt and P. K. Sorger. Discrete logic modeling as a means to link protein signaling networks with functional analysis of mammalian signal transduction, *Molecular Systems Biology*, 5:331, 2009.

### See Also

[gaBinaryTN](#), [simulatorT1](#)

**Examples**

```

data(CN0listToy,package="CellNOptR")
data(ToyModel,package="CellNOptR")

#pre-process model

model = preprocessing(CN0listToy, ToyModel)

#optimise

initBstring<-rep(1,length(model$reacID))
ToyT1opt<-gaBinaryT1(
CN0list=CN0listToy,
model=model,
initBstring=initBstring,
maxGens=100, popSize=10, verbose=FALSE)

# During the optimisation, some bits can be overwritten by your prior knowledge
# First, you need to create a priorBitString made of NA where known bit values
# are replaced by 0 or 1
priorBitString = rep(NA, length(model$reacID))
priorBitString[1] = 0
priorBitString[2] = 1

# Second, you call the gaBinaryT1 function by providing the priorBitString
# argument:
ToyT1opt<-gaBinaryT1(CN0list=CN0listToy, model=model,
  initBstring=initBstring,maxGens=10, popSize=10, verbose=FALSE,
  priorBitString=priorBitString)

```

---

gaBinaryTN

*Genetic algorithm for time point N*


---

**Description**

This is the genetic algorithm for time point N, that should follow optimisation based on time point 1.

Replaced gaBinaryT2.

**Usage**

```

gaBinaryTN(CN0list, model, bStrings, sizeFac = 1e-04, NAFac = 1,
popSize = 50, pMutation = 0.5, maxTime = 60, maxGens = 500,
stallGenMax = 100, selPress = 1.2, elitism = 5, relTol = 0.1, verbose=TRUE,
priorBitString=NULL, timeIndex = NULL)

```

**Arguments**

|                |  |
|----------------|--|
| CNOlist        | a CNOlist on which the score is based (based on valueSignals[[3]], i.e. data at t2)  |
| model          | a model structure, as created by readSIF, normally pre-processed but that is not a requirement of this function  |
| bStrings       | the optimal bitstring from optimisation at time 1 (i.e. a vector of 0s and 1s)   |
| sizeFac        | the scaling factor for the size term in the objective function, default to 0.0001  |
| NAFac          | the scaling factor for the NA term in the objective function, default to 1   |
| popSize        | the population size for the genetic algorithm, default set to 50   |
| pMutation      | the mutation probability for the genetic algorithm, default set to 0.5   |
| maxTime        | the maximum optimisation time in seconds, default set to 60  |
| maxGens        | the maximum number of generations in the genetic algorithm, default set to 500   |
| stallGenMax    | the maximum number of stall generations in the genetic algorithm, default to 100   |
| selPress       | the selective pressure in the genetic algorithm, default set to 1.2  |
| elitism        | the number of best individuals that are propagated to the next generation in the gen. al. default set to 5   |
| relTol         | the relative tolerance for the best bitstring reported by the genetic algorithm, i.e. how different from the best solution can solutions be to be reported as well, default set to 0.1   |
| verbose        | logical (default to TRUE) do you want the statistics of each generation to be printed on the screen  |
| priorBitString | A bitString of same length at the initial bitstring made of 0, 1 or NA. By default, this bitstring is set to NULL (equivalent to setting all bits to NA). If provided, all bitstring in a population will be changed to be in agreement with the prior-BitString list. |
| timeIndex      | todo   |

**Details**

This function takes in the same input as the T1 ga, but in addition it takes in the bitstring optimised for T1, and does not take an initial bitstring. Be aware that the bitString that this function returns is one that only includes the bits that it actually looks at, i.e. the bits that were 0 in the bStringT1

**Value**

This function returns a list with elements:

|                  |   |
|------------------|---|
| bString          | the best bitstring  |
| results          | a matrix with columns "Generation", "Best_score", "Best_bitString", "Stall_Generation", "Avg_Score_Gen" |
| stringsTol       | the bitstrings whose scores are within the tolerance  |
| stringsTolScores | the scores of the above-mentioned strings   |

**Author(s)**

C.Terfve, T. Cokelaer

**See Also**

[getFit](#), [simulatorT1](#), [simulatorT2](#)

**Examples**

```
#load data

data(CN0listToy2,package="CellNOptR")
data(ToyModel2,package="CellNOptR")

#pre-process model

checkSignals(CN0listToy2,ToyModel2)
model = preprocessing(CN0listToy2, ToyModel2)

#optimise t1
ToyT1<-gaBinaryT1(
CN0list=CN0listToy2,
model=model,
maxGens=10,
popSize = 10,
verbose=FALSE)

#Optimise T2

ToyT2<-gaBinaryTN(
CN0list=CN0listToy2,
model=model,
bStrings=list(ToyT1$bString),
maxGens=10,
popSize = 10,
verbose=FALSE)
```

---

getFit

*Compute the score of a model*

---

**Description**

This function computes the value of the objective function for a model and an associated data set, as a sum of a term that computes the fit of model to data, a term that penalises the NA values produced by the model, and a term that penalises increasing size of the model.

**Usage**

```
getFit(simResults, CN0list, model, indexList=NULL, timePoint=c("t1", "t2"),
sizeFac=1e-04, NAFac=1, nInTot, simResultsT0=NULL)
```



**Arguments**

|              |  |
|--------------|--|
| simResults   | matrix of simulated results (the full one as output by the simulator)  |
| CNOlist      | a CNOlist to compare the simulated results with  |
| model        | a model that has already been cut to contain only the reactions in the optimal bitstring   |
| indexList    | list of indexes as produced by indexFinder. User should not use this parameter that is kept for back compatibility with previous version of the simulator written in R. The new simulator (C code) does not necessitate the usage of the indexList parameter in this function anymore. |
| timePoint    | "t1" or "t2" tells which time point we are looking at. If timePoint=t1 then we will compare the simResults to the results stored in CNOlist\$valueSignals[[2]]. If timePoint=t2 then we will compare the simResults to the results stored in CNOlist\$valueSignals[[1]].               |
| sizeFac      | weights the penalty for the size of the model, default=0.0001  |
| NAFac        | weights the penalty for the number of NAs  |
| nInTot       | the number of inputs in the model prior to cutting, used to normalised the size penalty  |
| simResultsT0 | Results of the time 0 simulator (internal usage of gaBinaryT1)   |

**Details**

BE AWARE: contrary to what is done in the Matlab version of CellNOpt, here the simulation results are computed beforehand and the model that is input into this function is a model that has already been cut i.e. that only contains the reactions present in the optimised model (i.e. should be the same model as the one that you input into the simulator). Also, the simResults matrix is the full one as output by the simulator, i.e. it contains results for all species in the model, not only the signals

**Value**

This function returns a single number, the value of the objective function.

**Author(s)**

C. Terfve

**References**

J. Saez-Rodriguez, L. G. Alexopoulos, J. Epperlein, R. Samaga, D. A. Lauffenburger, S. Klamt and P. K. Sorger. Discrete logic modeling as a means to link protein signaling networks with functional analysis of mammalian signal transduction, *Molecular Systems Biology*, 5:331, 2009.

**See Also**

[gaBinaryT1](#), [simulatorT1](#)

**Examples**

```
#Here we will evaluate the fit of the full initial model,
#without pre-processing or any optimisation

data(CN0listToy,package="CellNOptR")
data(ToyModel,package="CellNOptR")

indicesToy<-indexFinder(CN0listToy,ToyModel,verbose=FALSE)
ToyFields4Sim<-prep4sim(ToyModel)
simResults<-simulatorT1(
  CN0list=CN0listToy,
  model=ToyModel,
  simList=ToyFields4Sim,
  indexList=indicesToy)
simResults = simResults[, indicesToy$signals]
Score<-getFit(
  simResults=simResults,
  CN0list=CN0listToy,
  model=ToyModel,
  timePoint="t1",
  nInTot=length(which(ToyModel$interMat == -1))
)
```

---

graph2sif

---

*Convert graph to SIF*


---

**Description**

This function converts a network from graph format to SIF format. The resulting table can also be saved in a SIF file.

**Usage**

```
graph2sif(graph, writeSif=FALSE, filename="Graph")
```

**Arguments**

|          |  |
|----------|--|
| graph    | a graph, as generated using <a href="#">sif2graph</a>                                |
| writeSif | if writeSif=FALSE (default) the SIF file is not saved. If writeSif=TRUE it is saved. |
| filename | the name of the SIF file saved if writeSif=TRUE. Default is Model.sif.               |

**Details**

The sign of link is supposed to be encoded in the graph as the weight of the edge (-1 negative regulation, +1 positive regulation).

**Value**

sifFile            a table with all the links in the model in the format sourceNode-tab-sign-tab-targetNode

**Author(s)**

F. Eduati

**See Also**

[model2sif](#), [sif2graph](#), [readSIF](#),

**Examples**

```
data(ToyModel,package="CellNOptR")
sif_file = tempfile(fileext = ".sif")
writeSIF(model = ToyModel,filename = sif_file)
g = sif2graph(sif_file)

graph2sif(graph = g,writeSif = FALSE)
```

---

ilpBinaryT1

*ILP method used to optimise a model*

---

**Description**

This function is the ilp method to be used to optimise a model by fitting to data containing one time point.

**Usage**

```
ilpBinaryT1(cnolist,
            model,
            cplexPath,
            sizeFac = 0.0001,
            mipGap = 0,
            relGap = 0,
            timelimit = 3600,
            method = "quadratic",
            numSolutions = 100,
            limitPop = 500,
            poolIntensity = 0,
            poolReplace = 2)
```

**Arguments**

|                            |  |
|----------------------------|--|
| <code>cnolist</code>       | a CNOList on which the score is based (based on <code>valueSignals[[2]]</code> , i.e. data at time 1)  |
| <code>model</code>         | a model structure, as created by <code>readSIF</code> , normally pre-processed but that is not a requirement of this function  |
| <code>sizeFac</code>       | the scaling factor for the size term in the objective function, default to 0.0001  |
| <code>mipGap</code>        | the absolute tolerance on the gap between the best integer objective and the objective of the best node remaining. When this difference falls below the value of this parameter, the linear integer optimization is stopped. Default set to 0  |
| <code>relGap</code>        | the relative tolerance on the objective value for the solutions in the solution pool. Solutions that are worse (either greater in the case of a minimization, or less in the case of a maximization) than the incumbent solution by this measure are not kept in the solution pool. Default set to 0 |
| <code>timelimit</code>     | the maximum optimisation time in seconds, default set to 3600  |
| <code>cplexPath</code>     | the path where the cplex solver is stored (mandatory).   |
| <code>method</code>        | the method of writing the objective function (quadratic/linear). Default set to "quadratic"  |
| <code>numSolutions</code>  | the number of solutions to save  |
| <code>limitPop</code>      | the number of solutions to be generated. Default set to 500  |
| <code>poolIntensity</code> | the Intensity of solution searching. Default set to 4  |
| <code>poolReplace</code>   | Pool replacement strategy  |

**Value**

This function returns a list with elements:

|                               |   |
|-------------------------------|---|
| <code>bitstringILPAll</code>  | the list of all optimal bitstrings identified   |
| <code>bScore</code>           | the best score for each set of bitstrings   |
| <code>time_cplex_only</code>  | the time it took for cplex to solve the problem   |
| <code>total_time</code>       | the total time for the pipeline to run (writing problem + solving problem + retrieving solutions) |
| <code>stringsToIScores</code> | the scores of the above-mentioned strings   |

**Author(s)**

E Gjerga, H Koch

**References**

Alexander Mitsos, Ioannis N. Melas, Paraskeuas Siminelakis, Aikaterini D. Chairakaki, Julio Saez-Rodriguez, and Leonidas G. Alexopoulos. Identifying Drug Effects via Pathway Alterations using an Integer Linear Programming Optimization Formulation on Phosphoproteomic Data. *PLoS Comput Biol.* 2009 Dec; 5(12): e1000591.

**Examples**

```

# Toy Example
data("ToyModel", package="CellNOptR")
data("CNolistToy", package="CellNOptR")
pknmodel = ToyModel
cnolist = CNolist(CNolistToy)
model = preprocessing(data = cnolist, model = pknmodel, compression = TRUE, expansion = TRUE)
plotModel(model = model, CNolist = cnolist)

# Training to data - ILP
## Not run:
resILP = ilpBinaryT1(cnolist = cnolist, model = model)

## End(Not run)

```

---

ilpBinaryT2

*ILP method used to optimise a model*


---

**Description**

This function is the ilp method to be used to optimise a model by fitting to data for time point 2, that should follow optimisation based on time point 1.

**Usage**

```

ilpBinaryT2(cnolist,
            model,
            sizeFac = 0.0001,
            mipGap = 0,
            relGap = 0,
            timelimit = 3600,
            cplexPath,
            method = "quadratic",
            numSolutions = 100,
            limitPop = 500,
            poolIntensity = 0,
            poolReplace = 2)

```

**Arguments**

|         |   |
|---------|---|
| cnolist | a CNolist on which the score is based (based on valueSignals[[2]], i.e. data at time 1)                         |
| model   | a model structure, as created by readSIF, normally pre-processed but that is not a requirement of this function |
| sizeFac | the scaling factor for the size term in the objective function, default to 0.0001                               |

|               |  |
|---------------|--|
| mipGap        | the absolute tolerance on the gap between the best integer objective and the objective of the best node remaining. When this difference falls below the value of this parameter, the linear integer optimization is stopped. Default set to 0  |
| relGap        | the relative tolerance on the objective value for the solutions in the solution pool. Solutions that are worse (either greater in the case of a minimization, or less in the case of a maximization) than the incumbent solution by this measure are not kept in the solution pool. Default set to 0 |
| timelimit     | the maximum optimisation time in seconds, default set to 3600  |
| cplexPath     | the path where the cplex solver is stored. Default set to "~/Documents/cplex"  |
| method        | the method of writing the objective function (quadratic/linear). Default set to "quadratic"  |
| numSolutions  | the number of solutions to save  |
| limitPop      | the number of solutions to be generated. Default set to 500  |
| poolIntensity | the Intensity of solution searching. Default set to 4  |
| poolReplace   | pool replacement strategy, consult CPLEX manual for details.   |

### Value

This function returns a list with elements:

|                  |   |
|------------------|---|
| bitstringILPAll  | the list of all optimal bitstrings identified   |
| bScore           | the best score for each set of bitstrings   |
| time_cplex_only  | the time it took for cplex to solve the problem   |
| total_time       | the total time for the pipeline to run (writing problem + solving problem + retrieving solutions) |
| stringsToIScores | the scores of the above-mentioned strings   |

### Author(s)

E Gjerga, H Koch

### References

Alexander Mitsos, Ioannis N. Melas, Paraskeuas Siminelakis, Aikaterini D. Chairakaki, Julio Saez-Rodriguez, and Leonidas G. Alexopoulos. Identifying Drug Effects via Pathway Alterations using an Integer Linear Programming Optimization Formulation on Phosphoproteomic Data. PLoS Comput Biol. 2009 Dec; 5(12): e1000591.

### Examples

```
# Toy Example
data("ToyModel", package="CellNOptR")
data("CNolistToy", package="CellNOptR")
pknmodel = ToyModel
```

```

cnolist = CNolist(CNolistToy)
model = preprocessing(data = cnolist, model = pknmodel, compression = TRUE, expansion = TRUE)
plotModel(model = model, CNolist = cnolist)

# Training to data - ILP
## Not run:
resILP = ilpBinaryT2(cnolist = cnolist, model = model)

## End(Not run)

```

---

ilpBinaryTN

*ILP method used to optimise a model*


---

### Description

This function is the ilp method to be used to optimise a model by fitting to data for time point 2, that should follow optimisation based on time point 1.

### Usage

```

ilpBinaryTN(cnolist,
            model,
            sizeFac = 0.0001,
            mipGap = 0,
            relGap = 0,
            timelimit = 3600,
            cplexPath,
            method = "quadratic",
            numSolutions = 100,
            limitPop = 500,
            poolIntensity = 0,
            poolReplace = 2,
            timeIndices = c(1, 2))

```

### Arguments

|         |  |
|---------|--|
| cnolist | a CNolist on which the score is based (based on valueSignals[[2]], i.e. data at time 1)  |
| model   | a model structure, as created by readSIF, normally pre-processed but that is not a requirement of this function  |
| sizeFac | the scaling factor for the size term in the objective function, default to 0.0001  |
| mipGap  | the absolute tolerance on the gap between the best integer objective and the objective of the best node remaining. When this difference falls below the value of this parameter, the linear integer optimization is stopped. Default set to 0  |
| relGap  | the relative tolerance on the objective value for the solutions in the solution pool. Solutions that are worse (either greater in the case of a minimization, or less in the case of a maximization) than the incumbent solution by this measure are not kept in the solution pool. Default set to 0 |

|               |   |
|---------------|---|
| timelimit     | the maximum optimisation time in seconds, default set to 3600                               |
| cplexPath     | the path where the cplex solver is stored. Default set to "~/Documents/cplex"               |
| method        | the method of writing the objective function (quadratic/linear). Default set to "quadratic" |
| numSolutions  | the number of solutions to save   |
| limitPop      | the number of solutions to be generated. Default set to 500                                 |
| poolIntensity | the Intensity of solution searching. Default set to 4                                       |
| timeIndices   | the time indeces to optimize. Default set to timeIndices=c(1, 2)                            |
| poolReplace   | pool replacement strategy, consult CPLEX manual for details.                                |

**Value**

This function returns a list with elements:

|                  |   |
|------------------|---|
| bitstringILPAll  | the list of all optimal bitstrings identified   |
| bScore           | the best score for each set of bitstrings   |
| time_cplex_only  | the time it took for cplex to solve the problem   |
| total_time       | the total time for the pipeline to run (writing problem + solving problem + retrieving solutions) |
| stringsToIScores | the scores of the above-mentioned strings   |

**Author(s)**

E Gjerga, H Koch

**References**

Alexander Mitsos, Ioannis N. Melas, Paraskeuas Siminelakis, Aikaterini D. Chairakaki, Julio Saez-Rodriguez, and Leonidas G. Alexopoulos. Identifying Drug Effects via Pathway Alterations using an Integer Linear Programming Optimization Formulation on Phosphoproteomic Data. *PLoS Comput Biol.* 2009 Dec; 5(12): e1000591.

**Examples**

```
# Toy Example
data("ToyModel", package="CellNOptR")
data("CNOLISTToy", package="CellNOptR")
pknmodel = ToyModel
cnolist = CNOLIST(CNOLISTToy)
model = preprocessing(data = cnolist, model = pknmodel, compression = TRUE, expansion = TRUE)
plotModel(model = model, CNOLIST = cnolist)

# Training to data - ILP
## Not run:
```



```
resILP = ilpBinaryTN(cnolist = cnolist, model = model)

## End(Not run)
```

---

|             |  |
|-------------|--|
| indexFinder | <i>Finds the indices, in the model fields, of the species that are measured/inhibited/stimulated</i> |
|-------------|--|

---

### Description

This function finds the indices, in the model fields, of the species that are measured/inhibited/stimulated. It looks for their position in model\$namesSpecies which has the same order as the rows of interMat and notMat, and therefore these indexes can be used there as well.

### Usage

```
indexFinder(CNOlist, model, verbose=FALSE)
```

### Arguments

|         |   |
|---------|---|
| CNOlist | a CNOlist structure, as produced by makeCNOlist   |
| model   | a model structure, as produced by readSIF   |
| verbose | do you want information about the cues and signals identities printed on the screen? Default if false but we would advise to set it to true when the function is called for the first time. |

### Value

a list with fields:

|            |   |
|------------|---|
| signals    | vector of indices of the measured species   |
| stimulated | vector of indices of the stimulated species |
| inhibited  | vector of indices of the inhibited species  |

### Note

For internal usage since version 1.3.28

### Author(s)

C. Terfve

### See Also

[makeCNOlist](#), [readSIF](#)

**Examples**

```
data(CN0listToy,package="CellNOptR")
data(ToyModel,package="CellNOptR")
indicesToy<-indexFinder(CN0listToy,ToyModel,verbose=TRUE)
```

---

internals

*List of CellNOptR internal functions.*


---

**Description**

This is a list of functions that are part of CellNOptR but are not exposed to the end-user. It may be of interest for developers. They may have a manual associated to it. If so, you can get the documentation in a R console as usual by typing preceding the name of the function with question tag.

**Details**

| Function:       | deprecated since        | manual |
|-----------------|-------------------------|--------|
| cSimulator:     | internal usage          | yes    |
| buildBitString: | internal usage          | yes    |
| simulateT1:     | 1.3.28 (use simulateTN) | yes    |

**Author(s)**

T.Cokelaer

---

invokeCPLEX

*Solving the ILP problem with CPLEX.*


---

**Description**

This function takes as an input the file name where we write the ILP formulation together with CPLEX parameters and then solves the ILP problem.

**Usage**

```
invokeCPLEX(inputFileName,
            outputFileName,
            mipGap=mipGap,
            relGap = relGap,
```

```
timelimit=timelimit,  
cplexPath = cplexPath,  
numSolutions = numSolutions,  
limitPop = limitPop,  
poolIntensity = poolIntensity,  
poolReplace = poolReplace)
```

### Arguments

|                |   |
|----------------|---|
| inputFileName  | the file name where the cplex ilp problem is stored |
| outputFileName | the file name where to store the cplex result       |
| mipGap         | the mipgap  |
| relGap         | the relGap  |
| timelimit      | the timelimit                                       |
| cplexPath      | the cplex solver path                               |
| numSolutions   | the number of desired solutions                     |
| limitPop       | the limitPop  |
| poolIntensity  | the poolIntensity                                   |
| poolReplace    | the poolReplace                                     |

### Author(s)

E Gjerga, H Koch

---

LiverDREAM

*Model used for the DREAM3 challenge*

---

### Description

This data object contains the model used in the package vignette, already loaded and formatted as a Model object. This is to be used with the data in "CNOListDREAM"

### Usage

```
data(DreamModel)
```

### Format

DreamModel is a list with fields "reacID" (character vector), "namesSpecies" (character vector), "interMat" (numerical matrix), "notMat"(numerical matrix).

### Source

This data and model is extracted from the Matlab version of CellNOpt1.0 (<http://www.ebi.ac.uk/saezrodriguez/software.html#CellNetOptimizer>).

## References

1. J. Saez-Rodriguez, L. G. Alexopoulos, J. Epperlein, R. Samaga, D. A. Lauffenburger, S. Klamt and P. K. Sorger. Discrete logic modeling as a means to link protein signaling networks with functional analysis of mammalian signal transduction, *Molecular Systems Biology*, 5:331, 2009.
2. Prill RJ, Marbach D, Saez-Rodriguez J, Sorger PK, Alexopoulos LG, Xue X, Clarke ND, Altan-Bonnet G, and Stolovitzky G. Towards a rigorous assessment of systems biology models: the DREAM3 challenges. *PLoS One*, 5(2):e9202, 2010.

---

makeCNOList

*Make a CNOList structure*

---

## Description

This function takes as input the output of readMIDAS and extracts the elements that are needed in a CNO project. Instead, please use the CNOList class to read a MIDAS file that will be converted to a CNOList.

## Usage

```
makeCNOList(dataset, subfield, verbose=TRUE)
```

## Arguments

|          |   |
|----------|---|
| dataset  | output of readMIDAS   |
| subfield | TRUE or FALSE, specifies if the column headers contain subfields or not i.e. if I should look for TR:sthg:sthg or just TR:sthg. |
| verbose  | logical (default to TRUE) print information on the screen.  |

## Details

Be aware that most of the functions in this package, including this one, expect the data to contain measurements at time 0, but these should all be equal to zero according to the normalisation procedure that should be used. Therefore, if you have one time point, the files valueSignals contains two matrices, one for t0 and one for t1.

If there are replicate rows in the MIDAS file (i.e., identical cues and identical time), this function averages the values of the measurements for these replicates.

Columns with the following tags are ignored: NOINHIB, NO-INHIB, NO-LIG, NOCYTO.

## Value

a CNOList with fields

|              |                              |
|--------------|------------------------------|
| namesCues    | a vector of names of cues    |
| namesStimuli | a vector of names of stimuli |

|                 |   |
|-----------------|---|
| namesInhibitors | a vector of names of inhibitors   |
| namesSignals    | a vector of names of signals  |
| timeSignals     | a vector of times   |
| valueCues       | a matrix of dimensions nConditions x nCues, with 0 or 1 if the cue is present or absent in the particular condition   |
| valueInhibitors | a matrix of dimensions nConditions x nInhibitors, with 0 or 1 if the inhibitor is present or absent in the particular condition                                 |
| valueStimuli    | of dimensions nConditions x nStimuli, with 0 or 1 if the stimuli is present or absent in the particular condition   |
| valueSignals    | a list of the same length as timeSignals, each element containing a matrix of dimensions nConditions x nsignals, with the measurements.                         |
| valueVariances  | a list of the same length as timeSignals, each element containing a matrix of dimensions nConditions x nsignals, with the standard deviation of the replicates. |

**Author(s)**

C. Terfve, T. Cokelaer

**References**

J. Saez-Rodriguez, L. G. Alexopoulos, J. Epperlein, R. Samaga, D. A. Lauffenburger, S. Klamt and P. K. Sorger. Discrete logic modeling as a means to link protein signaling networks with functional analysis of mammalian signal transduction, *Molecular Systems Biology*, 5:331, 2009.

**See Also**

[readMIDAS](#), [CNolist-class](#)

**Examples**

```
cpfile<-dir(system.file("ToyModel",package="CellNOptR"),full=TRUE)
file.copy(from=cpfile,to=getwd(),overwrite=TRUE)
dataToy<-readMIDAS(MIDASfile='ToyDataMMB.csv')
CNolistToy<-makeCNolist(dataset=dataToy,subfield=FALSE)
```

---

mapBack

*Map an optimised model back onto the PKN model.*

---

**Description**

Map an optimised model back onto the PKN model.

**Usage**

```
mapBack(model, PKN, bString)
```

**Arguments**

|         |                             |
|---------|-----------------------------|
| model   | the optimised model         |
| PKN     | the Prior Knowledge network |
| bString | the optimised bitString     |

**Value**

|            |  |
|------------|--|
| bStringPKN | the corresponding bitstring corresponding to the original PKN. |
|------------|--|

**Author(s)**

F.Eduati

**See Also**

[graph2sif](#), [sif2graph](#), [readSIF](#),

---

|              |  |
|--------------|--|
| model2igraph | <i>Convert a model object to a igraph object</i> |
|--------------|--|

---

**Description**

This function receives as input a model object and converts it to a graph object made by igraph. igraph provides lots of utilities especially to write the file in different format such as GML.

**Usage**

```
model2igraph(model)
```

**Arguments**

|       |  |
|-------|--|
| model | the model as generated using <a href="#">readSIF</a> |
|-------|--|

**Value**

|   |                 |
|---|-----------------|
| g | a igraph object |
|---|-----------------|

**Author(s)**

T. Cokelaer

**See Also**

[graph2sif](#), [sif2graph](#)

**Examples**

```
data(ToyModel,package="CellNOptR")
model2igraph(model=ToyModel)
```

---

|           |   |
|-----------|---|
| model2sif | <i>Convert a model object in sif format</i> |
|-----------|---|

---

**Description**

This function receives as input a model object and converts it to the cytoscape sif format. It can be used to convert either the whole model (before or after pre-processing) or the optimized one (if the corresponding bitString is provided). The resulting table can also be saved in a sif file.

**Usage**

```
model2sif(model,optimRes=NA,writeSif=FALSE, filename="Model")
```

**Arguments**

|          |  |
|----------|--|
| model    | the model as generated using <a href="#">readSIF</a>   |
| optimRes | the output of the optimisation (as obtained using <a href="#">gaBinaryT1</a> ), default set to NA the whole model in converted |
| writeSif | if writeSif=FALSE (default) the sif file is not saved. If writeSif=TRUE it is saved.   |
| filename | the name of the sif file saved if writeSif=TRUE. Default is Model.sif.   |

**Details**

All links in the model are converted in sif format that is sourceNode-tab-sign-tab-targetNode. If there are ANDs, they are converted using dummy nodes called and# (e.g. A+B=C will be A-tab-1-tab-and1; B-tab-1-tab-and1; and1-tab-1-tab-C).

**Value**

|         |  |
|---------|--|
| sifFile | a table with all the links in the model in the format sourceNode-tab-sign-tab-targetNode |
|---------|--|

**Author(s)**

F.Eduati

**See Also**

[graph2sif](#), [sif2graph](#), [readSIF](#),

**Examples**

```
data(ToyModel,package="CellNOptR")
model2sif(model=ToyModel,writeSif = FALSE)
```

---

|                  |   |
|------------------|---|
| normaliseCNOList | <i>Normalisation for boolean modelling.</i> |
|------------------|---|

---

**Description**

This function takes in a CNOList and does the normalisation of the data between 0 and 1, according to two different procedures (see details).

**Usage**

```
normaliseCNOList(CNOList, EC50Data=0.5, HillCoef=2, EC50Noise=0., detection=0,
  saturation=Inf, changeTh=0, norm2TorCtrl=NULL, mode="time",
  options=list(rescale_negative = TRUE), verbose=FALSE)
```

**Arguments**

|              |   |
|--------------|---|
| CNOList      | a CNOList   |
| EC50Data     | parameter for the scaling of the data between 0 and 1, default=0.5  |
| HillCoef     | Hill coefficient for the scaling of the data, default to 2  |
| EC50Noise    | parameter for the computation of a penalty for data comparatively smaller than other time points or conditions. No effect if set to zero (default).   |
| detection    | minimum detection level of the instrument, everything smaller will be treated as noise (NA), default to 0   |
| saturation   | saturation level of the instrument, everything over this will be treated as NA, default to Inf.   |
| changeTh     | threshold for relative change considered significant, default to 0  |
| norm2TorCtrl | deprecated since 1.5.0. Use the mode argument instead.  |
| mode         | "time" or "ctrl" or "raw" (experimental): choice of a normalisation method: "ctrl" computes the relative change compared to the control at the same time. "time" computes the relative change compared to the same condition and measurement at time 0. "raw" does not take into account time zero data; data are relative to time 0 so can be positive or negative values. |
| options      | rescale column with negative values to be in 0-1 range (experimental)   |
| verbose      | prints some information if True (default is False)  |



## Details

The normalisation procedure works as follows:

1. every value that is out of the dynamic range of the equipment (as specified by the parameters detection and saturation are set to NA,
2. values are transformed to fold changes relative to the same condition at t0 (if mode="time") or the control condition (i.e. same inhibitors, no stimuli) at the same time (if mode="ctrl"),
3. the fold changes are transformed with a Hill function  $\frac{x^{HillCoef}}{((EC50Data^{HillCoef})+(x^{HillCoef}))}$
4. a penalty for "noisiness" is computed for each measurement as the value divided by the maximum value for that readout across all conditions and times (excluding values out of the dynamic range)
5. the noise penalty is transformed by a saturation function (for each measurement  $\frac{x}{(EC50Noise+x)}$  where  $x = \frac{x}{\max x}$ ),
6. the noise penalty and Hilled fold changes are multiplied,
7. if the fold change is negative and bigger than ChangeTh, the resulting product is multiplied by -1, if the fold change is smaller than ChangeTh (either positive or negative), it is set to 0.

The normalisation procedure applied here is explained in details in saez-Rodriguez et al. (2009).

As the normalisation procedure works by computing a fold change relative to the same condition at time 0 or the control condition, if the aforementioned conditions have a value of zero (which is not expected with any common biochemical technique), then the fold change calculation will return a "NaN" value. If this is a problem for your particular case then we would suggest putting a dummy, very low value, instead of the zero, or setting that measurement to "NA" in the MIDAS file.

## Value

a normalised CNOList

## Author(s)

C. Terfve

## References

J. Saez-Rodriguez, L. G. Alexopoulos, J. Epperlein, R. Samaga, D. A. Lauffenburger, S. Klamt and P. K. Sorger. Discrete logic modeling as a means to link protein signaling networks with functional analysis of mammalian signal transduction, *Molecular Systems Biology*, 5:331, 2009.

## See Also

[makeCNOList](#)

**Examples**

```

#Load a CN0list

data(CN0listToy,package="CellNOptR")

#Replace the values in the list by random values
#(for demonstration purposes, when actually using this function you would simply load a non-normalised CN0list)

CN0listToy$valueSignals$t0<-matrix(
data=runif(n=(dim(CN0listToy$valueSignals$t0)[1]*dim(CN0listToy$valueSignals$t0)[2]),min=0,max=400),
nrow=dim(CN0listToy$valueSignals$t0)[1],
ncol=dim(CN0listToy$valueSignals$t0)[2])
CN0listToy$valueSignals[[2]]<-CN0listToy$valueSignals[[1]]+matrix(
data=runif(n=(dim(CN0listToy$valueSignals$t0)[1]*dim(CN0listToy$valueSignals$t0)[2]),min=0,max=100),
nrow=dim(CN0listToy$valueSignals$t0)[1],
ncol=dim(CN0listToy$valueSignals$t0)[2])

CN0listToyN<-normaliseCN0list(
CN0listToy,
EC50Data = 0.5,
HillCoef = 2,
EC50Noise = 0.1,
detection = 0,
saturation = Inf,
changeTh = 0,
mode = "time")

```

---

*pknmodel*

*pknmodel*

---

**Description**

Small in-silico case study used for demonstration. Use with CN0list\_ToyPB data.

**Usage**

```
data(PKN_ToyPB)
```

**Format**

An object of class `list` of length 4.

---

plot-method

*plot a "CN0list" object - methods*

---

## Description

A plot method for CN0list.

## Usage

signature(x="CN0list"): Please see the help page for the plot.CN0list method in the CellNOptR package

## arguments

**x** The CN0list object to plot

## Author(s)

T.Cokelaer

## See Also

[readMIDAS](#), [makeCN0list](#)

## Examples

```
showClass("CN0list")

files<-dir(system.file("ToyModel",package="CellNOptR"),full=TRUE)
cnolist = CN0list(files[[1]])
# accessors:
getCues(cnolist)
getInhibitors(cnolist)
getSignals(cnolist)
getTimepoints(cnolist)
getStimuli(cnolist)
# In version 1.3.30 and above, use the plot method instead of former plotCN0list function.
plot(cnolist)
```

---

|             |                                   |
|-------------|-----------------------------------|
| plotCNOList | <i>Plot the data in a CNOList</i> |
|-------------|-----------------------------------|

---

### Description

This function plots the data in a CNOList as a matrix of plots with a row for each condition and a column for each signal, and an extra plot for each row that specifies which cues are present..

### Usage

```
plotCNOList(CNOList)
```

### Arguments

CNOList      a CNOList

### Details

This function can plot the normalised values or the un-normalised ones, it just needs a CNOList.

### Value

This function just produces a plot on your graphics window

### Author(s)

C. Terfve

### See Also

plotCNOListPDF, plotCNOListLarge, plotCNOListLargePDF

### Examples

```
data(CNOListToy, package="CellNOptR")  
plotCNOList(CNOListToy)
```

---

|              |   |
|--------------|---|
| plotCNOList2 | <i>Another version of plotCNOList that allows to plot 2 cnolist in the same layout to compare them. This function uses ggplot2 library. It is recommended for small data sets (about 15 species).</i> |
|--------------|---|

---

### Description

This function plots the data in a CNOList as a matrix of plots with a row for each condition and a column for each signal, Cues are simply represented by a number.

### Usage

```
plotCNOList2(cnolist, simulated_cnolist=NULL, ymin=0,ymax=1)
```

### Arguments

|                   |   |
|-------------------|---|
| cnolist           | a CNOList                               |
| simulated_cnolist | another cnolist                         |
| ymin              | Change the lower y-limit (default is 0) |
| ymax              | Change the lower y-limit (default is 1) |

### Details

This function can plot either a single CNOList, or 2 on top of each other.

### Author(s)

T. Cokelaer

### See Also

plotCNOListPDF, plotCNOListLarge, plotCNOListLargePDF, plotCNOList

### Examples

```
# this data set is not an object so we need to convert it
data(CNOListToy,package="CellNOptR")
cnolist = CNOList(CNOListToy)
plotCNOList2(cnolist)
```

---

plotCNOListLarge      *Plot the data in a CNOList, for lists with many conditions.*

---

### Description

This function plots the data in a CNOList as a matrix of plots with a row for each condition and a column for each signal, and an extra plot for each row that specifies which cues are present.

### Usage

```
plotCNOListLarge(CNOList, nsplit=4, newDevice=FALSE)
```

### Arguments

|           |   |
|-----------|---|
| CNOList   | a CNOList   |
| nsplit    | the number of splits in the condition dimension (one new plot window will be produced for each split, i.e. if you have 80 conditions and specify 4 splits you will get 4 plots with 20 conditions each).  |
| newDevice | nsplit plots are created within the same device. In principle, most of the R Graphical User Interface will allow the user to navigate between the different plots. However, if scripting only the last plot will be seen. If you want to create new device for each different plot, then set this option to TRUE. |

### Details

This function can plot normalised values or the un-normalised ones, it just needs a CNOList. This function makes plots of CNOLists that are more readable when many conditions are present in the data. In addition to plotting the conditions divided into multiple plots, this function also plots the cues divided in two columns, one for inhibitors and one for stimuli.

### Value

This function just produces plots on your graphics window.

### Author(s)

C. Terfve

### See Also

[plotCNOList](#), [plotCNOListPDF](#), [plotCNOListLargePDF](#)

### Examples

```
data(CNOListDREAM, package="CellNOptR")
plotCNOListLarge(CNOListDREAM, nsplit=2)
```

---

plotCNOListLargePDF *Plots a CNOList into a pdf file, for lists with many conditions.*

---

### Description

This function is a wrapper for plotCNOListLarge, that plots the output directly in a pdf file.

### Usage

```
plotCNOListLargePDF(CNOList, filename, nsplit, width=14, height=7)
```

### Arguments

|          |   |
|----------|---|
| CNOList  | a CNOList   |
| filename | a name for your pdf file, eg. "plot.pdf"                                  |
| nsplit   | the number of splits along the condition dimension (see plotCNOListLarge) |
| width    | set the width of the PDF document.  |
| height   | set the height of the PDF document.                                       |

### Details

This function makes plots of CNOLists that are more readable when many conditions are present in the data. In addition to plotting the conditions divided into multiple plots, this function also plots the cues divided in two columns, one for inhibitors and one for stimuli.

### Value

This function doesn't return anything, it just produces a pdf file with your plots, in your current working directory.

### Author(s)

C. Terfve

### See Also

[plotCNOListLarge](#), [plotCNOList](#), [plotCNOListPDF](#)

### Examples

```
data(CNOListDREAM, package="CellNOptR")
plotCNOListLargePDF(CNOListDREAM, filename="dreamData.pdf", nsplit=2)
```

---

plotCNOListPDF            *Plots a CNOList into a pdf file.*

---

**Description**

This function is a wrapper for plotCNOList, that plots the output directly in a pdf file.

**Usage**

```
plotCNOListPDF(CNOList, filename)
```

**Arguments**

|          |  |
|----------|--|
| CNOList  | a CNOList                                |
| filename | a name for your pdf file, eg. "plot.pdf" |

**Value**

This function doesn't return anything, it just produces a pdf file containing your plot, in your working directory.

**Author(s)**

C. Terfve

**See Also**

[plotCNOList](#), [plotCNOListLarge](#), [plotCNOListLargePDF](#)

**Examples**

```
data(CNOListToy, package="CellNOptR")  
plotCNOListPDF(CNOList=CNOListToy, filename="ToyModelGraph.pdf")
```

---

plotFit                    *Plot the evolution of an optimisation*

---

**Description**

This function takes in the results of an optimisation by gaBinaryT1 and plots the evolution of best fit and average fit against generations.

**Usage**

```
plotFit(optRes, filename = NULL)
```



**Arguments**

optRes            an object created by the optimisation engine (gaBinaryT1)  
filename        NULL or string: if provided, the plot is save in PDF format in the filename.

**Value**

This function doesn't return anything, it just produces a plot in your graphics window.

**Author(s)**

C. Terfve

**See Also**

[gaBinaryT1](#)

**Examples**

```
data(CN0listToy,package="CellNOptR")
data(ToyModel,package="CellNOptR")

#process the model
model = preprocessing(CN0listToy,ToyModel)

#optimise

ToyT1opt<-gaBinaryT1(
  CN0list=CN0listToy,
  model=model,
  maxGens=10,
  popSize=10,
  verbose=FALSE)

plotFit(optRes=ToyT1opt)
```

---

plotModel

*Plot a model*

---

**Description**

This function can be used to plot a prior model network before any pre-processing step. However, additional information can be provided such as a CN0list (see makeCN0list and readMIDAS) or information related to the pre-processing steps (compression, NONC nodes, expansion gates). It can also be used to plot optimised model given the optimisation bitstring.

**Usage**

```
plotModel(model, CN0list=NULL, bString=NULL, indexIntegr=NULL, signals=NULL,
  stimuli=NULL, inhibitors=NULL, NCNO=NULL, compressed=NULL, output="STDOUT",
  filename=NULL, graphvizParams=list(), show=TRUE, remove_dot=TRUE, removeEmptyAnds=TRUE)
```

**Arguments**

|                 |  |
|-----------------|--|
| model           | a model as returned by readSIF. Alternatively, the filename can also be provided.  |
| CNOList         | output of makeCNOList  |
| bString         | a sequence made of numbers between 0 and 1 of same length as the one returned by the Genetic Algorithm (GA). This is a generalisation of the bitString returned by the GA function: several bit strings can be averaged and used.  |
| indexIntegr     | additional indices to highlight some edge (optional).  |
| signals         | a list of nodes belonging to the signals class   |
| stimuli         | a list of nodes belonging to the stimuli class   |
| inhibitors      | a list of nodes belonging to the inhibitors class  |
| NCNO            | a list of NCNO nodes.  |
| compressed      | a list of compressed nodes   |
| filename        | the filename (without extension) used to write the dot file  |
| output          | the type of output (PNG, PDF, SVG accepted)  |
| graphvizParams  | a list of optional arguments dedicated to Rgraphviz to tune the layout: <ul style="list-style-type: none"> <li>• arrowsize default is 2</li> <li>• sizea string for the size of the dot output; default is "15,15"</li> <li>• fontsize default is 22</li> <li>• edgecolor default is "black"</li> <li>• nodeLabels overwrite node label with a list of proper length.</li> <li>• nodeWidth default is 2</li> <li>• nodeHeight default is 1</li> <li>• viewEmptyEdges default is TRUE</li> <li>• mode can be 'classic' or 'sbgn' (default). The difference appears in the and gate.</li> <li>• andWidth = 0.2 in 'classic' mode and 0.5 in 'sbgn' mode</li> <li>• andHeight = 0.2 in 'classic' mode and 0.5 in 'sbgn' mode</li> </ul> |
| show            | show the plot (default is True)  |
| remove_dot      | remove the dot file that has been created. Default is False  |
| removeEmptyAnds | removes AND gates from plotted graph if the corresponding bit is 0 to give a compact view. Default is TRUE.  |

**Details**

This function plots the model and also saves it in a dot file that can be processed later on. However, you can also save the plot in PNG or PDF or SVG format (one at a time).

The CNOList argument contains the signals/stimuli/inhibitors so if you provide a CNOList there is no need to use these arguments. If you decide to use them they will overwrite the contents of the CNOList argument.

optimRes is the output of gaBinary. One of its field is called bString and contains a list of 0 and 1 (the optimisation is performed with a binary procedure). This list of 0 and 1 is then used to plot or not the edges of the model. However, you can provide a bitString made of floats (e.g., average of several bitStrings). In such case, edges will appear in gray light or dark according to the bistring value (between 0 and 1).

### Value

a graph representation of the model

```
graph$g      A graph representation of the model
graph$attrs  graph attributes
graph$nodeAttrs nodes attributes
graph$edgeAttrs edges attributes
graph$clusters clusters of nodes
```

### Note

This function depends on the Rgraphviz package.

### Author(s)

T. Cokelaer

### See Also

[readMIDAS](#), [readSIF](#), [makeCNOList](#), [writeNetwork](#), [writeDot](#), [gaBinaryT1](#)

### Examples

```
data(CNOListToy, package="CellNOptR")
data(ToyModel, package="CellNOptR")
res<-plotModel(ToyModel, CNOList=CNOListToy, compressed=c("TRAF6", "p38"),
  graphvizParams=list(mode="classic", fontsize=30))
```

---

plotOptimResults

*Plot the data and simulated values*

---

### Description

This function is the equivalent of CNOPlotFits, it plots the data and the simulated values, along with an image plot that tells which cues were present. The plots are coloured according to the fit between data and simulated data.

**Usage**

```
plotOptimResults(simResults, expResults, times, namesCues, namesSignals,
valueCues, formalism="new")
```

**Arguments**

|              |  |
|--------------|--|
| simResults   | a list with a field for each time point, each containing a matrix of dimensions (number of conditions) * (number of signals), with the first field being t0. Typically produced by simulating a model and then extracting the columns that correspond to signals |
| expResults   | same as above, but contains the experimental results, ie this is CN0list\$valueSignals   |
| times        | a vector of times, its length should be the same as the number of fields in simResults and ExpResults  |
| namesCues    | a vector of names, typically CN0list\$namesCues  |
| namesSignals | a vector of names, typically CN0list\$namesSignals   |
| valueCues    | a matrix of dimensions (number of conditions) * (number of cues), typically CN0list\$valueCues   |
| formalism    | New convention is to take the time=0 data set into account to compute the MSE. you can use the previous convection by setting this argument to something different from the default value.   |

**Details**

The colouring of the background is done as follows: the mean absolute difference between observed and simulated values are computed, and colours are chosen based on this value: red (above 0.9), indianred1 (between 0.8 and 0.9), lightpink2 (between 0.7 and 0.8), lightpink (between 0.6 and 0.7), mistyrose (between 0.5 and 0.6), palegoldenrod (between 0.4 and 0.5), palegreen (between 0.3 and 0.4), darkolivegreen3 (between 0.2 and 0.3), chartreuse3 (between 0.1 and 0.2), forestgreen (between 0 and 0.1). This function is used inside cutAndPlotResultsT1.

**Value**

This function doesn't return anything, it just produces a plot in your graphics window.

**Author(s)**

C. Terfve

**References**

J. Saez-Rodriguez, L. G. Alexopoulos, J. Epperlein, R. Samaga, D. A. Lauffenburger, S. Klamt and P. K. Sorger. Discrete logic modeling as a means to link protein signaling networks with functional analysis of mammalian signal transduction, *Molecular Systems Biology*, 5:331, 2009.

**See Also**

cutAndPlotResultsT1

**Examples**

```

#We will plot the fit of the full initial model compared to the data, without any optimisation
#This is normally not done on a stand alone basis, but if you have a model and would like to visualise its output comp

#load and prepare data

data(CN0listToy,package="CellNOptR")
data(ToyModel,package="CellNOptR")
indicesToy<-indexFinder(CN0listToy,ToyModel,verbose=TRUE)
ToyFields4Sim<-prep4sim(ToyModel)

#simulate model

simRes<-simulatorT1(CN0list=CN0listToy,model=ToyModel, simList=ToyFields4Sim, indexList=indicesToy)

#format data and results

simResults<-list(t0=matrix(data=0,nrow=dim(simRes)[1],ncol=dim(simRes)[2]),t1=simRes)
expResults<-list(t0=CN0listToy$valueSignals[[1]],t1=CN0listToy$valueSignals[[2]])

#plot

plotOptimResults(
  simResults=simResults,
  expResults=expResults,
  times=CN0listToy$timeSignals[1:2],
  namesCues=CN0listToy$namesCues,
  namesSignals=CN0listToy$namesSignals,
  valueCues=CN0listToy$valueCues)

```

---

plotOptimResultsPan     *Plots the data and simulated values from any CellNOptR formalism*

---

**Description**

This function plots the data and simulated values according to each experiment in CN0list. The data is shown as black triangles and the simulation by a blue dashed line. The combination of cues is given by a panel where black denotes the presence and white the absence of the cue. The goodness-of-fit between model and data is color-coded on a continuous scale from white to red.

**Usage**

```

plotOptimResultsPan(simResults, yInterpol=NULL, xCoords=NULL,
  CN0list=CN0list, formalism=c("ss1","ss2","ssN","dt","ode"), pdf=FALSE,
  pdfFileName="", tPt=NULL,
  plotParams = list(margin = 0.1, width=15, height=12, cmap_scale=1, cex=1.6,
  ymin=NULL, Fac=1, rotation=0))

```

**Arguments**

|             |   |
|-------------|---|
| simResults  | A list with a field for each time point, each containing a matrix of dimensions (number of conditions) * (number of signals), with the first field being t0. Typically produced by simulating a model and then extracting the columns that correspond to signals.   |
| yInterpol   | If using CNORdt, these are the interpolated experimental results from getFitTimeScale() that are needed to compare against the Boolean simulation.  |
| xCoords     | These are the x-coordinates obtained from the optimized scaling factor in CNORdt that allow for comparison between time course experimental data and a Boolean model.   |
| CNOlist     | A CNOlist.  |
| formalism   | An abbreviation of the CellNOptR formalism being used.  |
| pdf         | A Boolean argument denoting whether to print the figure produced by this function to file.  |
| pdfFileName | If printing to file, the filename to be used.   |
| tPt         | The number of time points in the data.  |
| plotParams  | a list of option related to the PDF and plotting outputs. Currently, the following attributes are used: (1) margin of the boxes, (2) width and heigth used while creating the PDF, (3) cmap_scale a value that scales the colors towards small errors (<1) or large errors (>1); default is 1 (linear colormap) (4) cex is the fontsize used in the header (5) ymin sets the minimum y axis limit; by default it is the minimum value found over all data points and therefore can be negative. |

**Details**

Depending on the logic formalism, this function is generally called from cutAndPlotResults\*(). As shown in the example below however, it can plot the fit of any data and corresponding compatible model. The color denotes the goodness-of-fit, where white shows no difference between simulation and data and red is the maximum error from all conditions and readouts.

**Value**

This function does not return a value.

**Author(s)**

A. MacNamara

**References**

J. Saez-Rodriguez, L. G. Alexopoulos, J. Epperlein, R. Samaga, D. A. Lauffenburger, S. Klamt and P. K. Sorger. Discrete logic modeling as a means to link protein signaling networks with functional analysis of mammalian signal transduction, *Molecular Systems Biology*, 5:331, 2009.

**See Also**

cutAndPlotResultsT1

**Examples**

```

data(CNolistToy,package="CellNOptR")
data(ToyModel,package="CellNOptR")
indicesToy <- indexFinder(CNolistToy, ToyModel, verbose=TRUE)
ToyFields4Sim <- prep4sim(ToyModel)

# simulate model
simRes <- simulatorT1(CNolist=CNolistToy, model=ToyModel, simList=ToyFields4Sim, indexList=indicesToy)
simRes = simRes[, indicesToy$signals]

# format data and results

simResults <- list(t0=matrix(data=0, nrow=dim(simRes)[1], ncol=dim(simRes)[2]), t1=simRes)
# plot
plotOptimResultsPan(simResults,
  CNolist=CNolistToy,
  formalism="ss1",
  pdf=FALSE,
  tPt=10
)

```

---

plotOptimResultsPDF *Plot the data and simulated values in a pdf file*

---

**Description**

This is a wrapper for plotOptimResults

**Usage**

```

plotOptimResultsPDF(simResults, expResults, times, namesCues, namesSignals,
valueCues, filename, formalism="new")

```

**Arguments**

|              |  |
|--------------|--|
| simResults   | a list with a field for each time point, each containing a matrix of dimensions number of conditions * number of signals, with the first field being t0. Typically produced by simulating a model and then extracting the columns that correspond to signals |
| expResults   | same as above, but contains the experimental results, ie this is CNolist\$valueSignals   |
| times        | a vector of times, its length should be the same as the number of fields in simResults and ExpResults  |
| namesCues    | a vector of names, typically CNolist\$namesCues  |
| namesSignals | a vector of names, typically CNolist\$namesSignals   |
| valueCues    | a matrix of dimensions (number of conditions) * (number of cues), typically CNolist\$valueCues   |

|           |  |
|-----------|--|
| filename  | a name for your file, eg. "plot.pdf"   |
| formalism | New convention is to take the time=0 data set into account to compute the MSE. you can use the previous convention by setting this argument to something different from the default value. |

### Details

The coloring of the background is done as follows: the mean absolute difference between observed and simulated values are computed, and colours are chosen based on this value: red (above 0.9), indianred1 (between 0.8 and 0.9), lightpink2 (between 0.7 and 0.8), lightpink (between 0.6 and 0.7), mistyrose (between 0.5 and 0.6), palegoldenrod (between 0.4 and 0.5), palegreen (between 0.3 and 0.4), darkolivegreen3 (between 0.2 and 0.3), chartreuse3 (between 0.1 and 0.2), forestgreen (between 0 and 0.1). This function is used inside cutAndPlotResultsT1.

### Value

This function doesn't return anything, it just produces a plot in a pdf document in your working directory.

### Author(s)

C. Terfve

### See Also

plotOptimResults, cutAndPlotResultsT1

### Examples

```
#We will plot the fit of the full initial model compared to the data, without any optimisation
#This is normally not done on a stand alone basis, but if you have a model and would like to visualise
#its output compared to your data, then this is what you should do

#load and prepare data

data(CN0listToy,package="CellNOptR")
data(ToyModel,package="CellNOptR")
indicesToy<-indexFinder(CN0listToy,ToyModel,verbose=TRUE)
ToyFields4Sim<-prep4sim(ToyModel)

#simulate the model

simRes<-simulatorT1(CN0list=CN0listToy,model=ToyModel,simList=ToyFields4Sim,indexList=indicesToy)

#format the results and data as expected by plotOptimResults

simResults<-list(t0=matrix(data=0,nrow=dim(simRes)[1],ncol=dim(simRes)[2]),t1=simRes)
expResults<-list(t0=CN0listToy$valueSignals[[1]],t1=CN0listToy$valueSignals[[2]])

#plot
```



```
plotOptimResultsPDF(
  simResults=simResults,
  expResults=expResults,
  times=CNolistToy$timeSignals[1:2],
  namesCues=CNolistToy$namesCues,
  namesSignals=CNolistToy$namesSignals,
  valueCues=CNolistToy$valueCues,
  filename="Toyfull.pdf")
```

---

 prep4sim

*Prepare a model for simulation*


---

### Description

Adds to the model some fields that are used by the simulation engine

### Usage

```
prep4sim(model)
```

### Arguments

|       |   |
|-------|---|
| model | a model list, as output by readSIF, normally pre-processed but that is not a requirement of this function |
|-------|---|

### Details

This adds fields that are necessary for the simulation engine in a version that is extensible for constrained Fuzzy logic extension of the methods applied here (in development).

### Value

this function returns a list with fields:

|            |   |
|------------|---|
| finalCube  | stores, for each reac(row) the location of its inputs (col)   |
| ixNeg      | stores, for each reac(row) and each input (col) whether it is a negative input                          |
| ignoreCube | logical matrix of the same size as the 2 above, that tells whether the particular cell is filled or not |
| maxIx      | row vector that stores, for each reac, the location of its output                                       |
| modelName  | stores the name of the model from which these fields were derived                                       |
| maxInput   | stores the max number of inputs observed in the model for a single reaction                             |

### Note

For internal usage since version 1.3.28

**Author(s)**

C. Terfve, T. Cokelaer

**See Also**

[simulatorT1](#)

**Examples**

```
data(ToyModel,package="CellNOptR")
ToyFields4Sim<-prep4sim(ToyModel)
```

---

|               |  |
|---------------|--|
| preprocessing | <i>Performs the pre-processing steps</i> |
|---------------|--|

---

**Description**

This function performs any of the following preprocessing steps:

1. removes Non-Controllable and Non-Observables nodes
2. compress the model
3. and-gates expansion

**Usage**

```
preprocessing(data, model, cutNONC=TRUE, compression=TRUE,
  expansion=TRUE, ignoreList=NA, maxInputsPerGate=2, verbose=TRUE)
```

**Arguments**

|                  |  |
|------------------|--|
| data             | the CNOList that contains the data that you will use   |
| model            | the model object as returned by <a href="#">readSIF</a>  |
| cutNONC          | Removes the NONC nodes using <a href="#">cutNONC</a> and <a href="#">findNONC</a> (Default is TRUE). |
| compression      | Compress the model using <a href="#">compressModel</a> (Default is TRUE).                            |
| expansion        | Add and gates using <a href="#">expandGates</a> (Default is TRUE).                                   |
| ignoreList       | an index vector of states to ignore incoming edges in <a href="#">expandGates</a> .                  |
| maxInputsPerGate | used by the <a href="#">expandGates</a> function to set maximum inputs per and gates.                |
| verbose          | verbose option (Default is TRUE).  |

**Details**

The function can apply any or none of the pre-processing steps. It returns the new model and the indices returned by [indexFinder](#).

**Value**

the new model

**Author(s)**

T. Cokelaer

**See Also**

[readSIF](#), [readMIDAS](#), [cutNONC](#), [findNONC](#), [compressModel](#), [expandGates](#).

**Examples**

```
data(ToyModel,package="CellNOptR")
data(CNOListToy,package="CellNOptR")
model = preprocessing(CNOListToy, ToyModel, cutNONC=FALSE)
```

---

randomizeCNOList      *add noise to the data contained in a CNOList.*

---

**Description**

This function takes in a CNOList and does the normalisation of the data between 0 and 1, according to two different procedures (see details).

**Usage**

```
randomizeCNOList(cnolist, sd=0.1, minValue=0, maxValue=1, mode="gaussian")
```

**Arguments**

|          |   |
|----------|---|
| cnolist  | a CNOList   |
| sd       | standard deviation to be used when adding gaussian noise. Not used if mode is uniform.  |
| minValue | When adding Gaussian noise, the result may be below the minValue(default 0). If so, the value is set to minValue.   |
| maxValue | When adding Gaussian noise, the result may be above the maxValue(default 1). If so, the value is set to maxValue.   |
| mode     | The mode can be either 'gaussian', 'shuffle' or uniform'. In gaussian mode, a gaussian noise is added to the data. The mean parameter is the data and the standard deviation is defined by the sd parameter. In uniform mode, the data is simply replaced by values taken from a uniform distribution between 0 and 1. In 'shuffle' mode all rows and columns are shuffled. |

**Value**

a noisy CNOList

**Author(s)**

T. Cokelaer

**Examples**

```
data(CNolistToyMMB, package="CellNOptR")
cnolist = CNolistToyMMB
cnolist2 = randomizeCNolist(cnolist, mode="uniform")

# a method called randomize is available in the CNolist class so you could type:
cnolist2 = randomize(cnolist, mode="uniform")
```

---

readBND

*Read network from BND file*

---

**Description**

BND is a file format used by MaBoSS to store the boolean network definition. The reader works if the logic for the activation of the node is stated withing the parameter 'logic' of the node. An example file can be found in '<https://maboss.curie.fr/pub/example.bnd>'.

**Usage**

```
readBND(filename)
```

**Arguments**

filename      BND file.

**Value**

CellNOpt network

**Author(s)**

Luis Tobalina

**Examples**

```
## Not run:
model = readBND("https://maboss.curie.fr/pub/example.bnd")

## End(Not run)
```

---

|          |                                    |
|----------|------------------------------------|
| readBNET | <i>Read network from BNET file</i> |
|----------|------------------------------------|

---

**Description**

Read network from BNET file

**Usage**

```
readBNET(filename)
```

**Arguments**

|          |  |
|----------|--|
| filename | BNET file. The file is a tab delimited file with two columns, 'targets' and 'factors'. 'factors' contains the logic rule and 'targets' the node activated by the logic rule. |
|----------|--|

**Value**

CellNOpt network

**Author(s)**

Luis Tobalina

---

|           |                                  |
|-----------|----------------------------------|
| readMIDAS | <i>Reads in a CSV MIDAS file</i> |
|-----------|----------------------------------|

---

**Description**

This function takes in a single argument, the name of a CSV MIDAS file containing the data, and returns a list that contains all the elements to build a CNOList. The output of this function should be used as input for [makeCNOList](#).

**Usage**

```
readMIDAS(MIDASfile, verbose=TRUE)
```

**Arguments**

|           |                                |
|-----------|--------------------------------|
| MIDASfile | a CSV MIDAS file (see details) |
| verbose   | logical (default to TRUE).     |

**Details**

This function does not return a CNOList, but the output of this function can be used directly into makeCNOList to create one. The MIDAS file format is described in Saez-Rodriguez et al. (2008).

If you have all of the readouts measured at the same series of time points, you can specify a unique DA: column which must have the format "DA:ALL".

**Value**

this function returns a list with fields:

|            |  |
|------------|--|
| dataMatrix | matrix containing the data in the MIDAS file                             |
| TRcol      | indexes of the columns that contain the treatments (excluding cell line) |
| DAcol      | indexes of the columns that contain the data time points                 |
| DVcol      | indexes of the columns that contain the actual values (measurements)     |

**Author(s)**

C.Terfve

**References**

J. Saez-Rodriguez, A. Goldsipe, J. Muhlich, L. Alexopoulos, B. Millard, D. A. Lauffenburger, P. K. Sorger *Flexible Informatics for Linking Experimental Data to Mathematical Models via DataRail*. *Bioinformatics*, 24:6, 840-847 (2008).

**See Also**

[makeCNOList](#)

**Examples**

```
cpfile<-dir(system.file("ToyModel",package="CellNOptR"),full=TRUE)
file.copy(from=cpfile,to=getwd(),overwrite=TRUE)
dataToy<-readMIDAS(MIDASfile='ToyDataMMB.csv')
CNOListToy<-makeCNOList(dataset=dataToy,subfield=FALSE)
```

---

|              |   |
|--------------|---|
| readSBMLQual | <i>Read a SBMLQual document and returns a SIF object (as returned by readSIG)</i> |
|--------------|---|

---

**Description**

This function reads a SBMLQual XML file where a model is stored. The XML is scanned and saved in SIF format in a temporary file. This file is read by readSIF. The returned object is therefore the output of readSIF.

**Usage**

```
readSBMLQual(filename)
```

**Arguments**

filename            The name of a SBMLQual file.

**Value**

a model list with fields:

|              |   |
|--------------|---|
| interMat     | contains a matrix with column for each reaction and a row for each species, with a -1 where the species is the source node and a +1 where the species is a target node, and 0 otherwise |
| notMat       | has the same format as interMat but just contains a 1 if the source node enters the reac with a negative effect, and 0 otherwise  |
| namesSpecies | vector that contains the names of the species in the same order as the rows of the interMat and notMat matrices   |
| reacID       | vector that holds character strings specifying the reaction in full letters, in the same order as the columns of interMat and notMat  |

**Author(s)**

T. Cokelaer

**References**

SBMLQual: qualitative models. See SBML.org for details.

**Examples**

```
## Not run:  
sif = readSBMLQual("test.xml")  
  
## End(Not run)
```

---

readSIF

*Read a SIF file and create a model object*

---

**Description**

This function reads in a cytoscape SIF file and creates a model object that can be used in the CellNOptR procedure.

**Usage**

```
readSIF(sifFile)
```

**Arguments**

sifFile            The name of a SIF file (Cytoscape format). See details for the accepted format.

**Details**

The input argument is the name of a SIF file that contains a prior knowledge network. The SIF format (See [http://wiki.cytoscape.org/Cytoscape\\_User\\_Manual/Network\\_Formats/](http://wiki.cytoscape.org/Cytoscape_User_Manual/Network_Formats/)) can be of the form:

```
nodeA typeA node2
```

or

```
node2 typeB node3 node4
```

with space or tabulations in between types and nodes. Spaces and tabulations have different meaning in the original cytoscape format. However, we do not differentiate them. Therefore names of the nodes cannot have white space inside them.

The accepted values for the types are -1 (inhibitor) or 1 (normal relation).

If there are ANDs they should be introduced as dummy nodes called "and#" (don't forget the number after "and" otherwise this won't be recognised). Please be aware that "and" nodes are not expected to be negated, i.e. there are not supposed to be !and1=xyz because that amounts to inverting the sign of all inputs of and1, which is more simply done at the inputs level.

The SIF format can also include unconnected node that is a row with a single name:

```
nodeA
```

Although there would be no error, these type of rows are ignored.

**Value**

a model list with fields:

|              |   |
|--------------|---|
| interMat     | contains a matrix with column for each reaction and a row for each species, with a -1 where the species is the source node and a +1 where the species is a target node, and 0 otherwise |
| notMat       | has the same format as interMat but just contains a 1 if the source node enters the reac with a negative effect, and 0 otherwise  |
| namesSpecies | vector that contains the names of the species in the same order as the rows of the interMat and notMat matrices   |
| reacID       | vector that holds character strings specifying the reaction in full letters, in the same order as the columns of interMat and notMat  |

**Author(s)**

C. Terfve

**References**

Shannon P, Markiel A, Ozier O, Baliga NS, Wang JT, Ramage D, Amin N, Schwikowski B, Ideker T. Cytoscape: a software environment for integrated models of biomolecular interaction networks. *Genome Research* 2003 Nov; 13(11):2498-504.



**Examples**

```
cpfile<-dir(system.file("ToyModel",package="CellNOptR"),full=TRUE)
file.copy(from=cpfile,to=getwd(),overwrite=TRUE)
ToyModel<-readSIF(sifFile="ToyPKNMMB.sif")
```

---

|               |   |
|---------------|---|
| residualError | <i>Compute the residual error for a dataset</i> |
|---------------|---|

---

**Description**

This function takes in a CNOList and computes the residual error, which is the minimum error between the scaled continuous data and a binary boolean approximation of this data.

**Usage**

```
residualError(CNOList)
```

**Arguments**

CNOList            a CNOList

**Details**

Be aware that it is expected that \$valueSignals[[1]] holds t0 (all signals=0) and \$valueSignals[[2]] holds t1, \$valueSignals[[3]] holds t2 and so on. The output is a list of residual errors at each time greater than 2. In addition, the total error is stored. For back compatibility, an additional field called t1andt2 is stored (NA is only t1 provided).

**Value**

a vector with named entries t1, t2, ...tn, t1andt2 and total. If only t1 is provided, t1andt2 is set to NA. The field t1andt2 may be removed in the future. Use the field called total instead.

**Author(s)**

C. Terfve, T. Cokelaer

**See Also**

[makeCNOList](#), [normaliseCNOList](#), [getFit](#)

**Examples**

```
data(CNOListToy,package="CellNOptR")
resECNOListToy<-residualError(CNOListToy)
```

---

`sif2graph`*Convert sif to graph*

---

**Description**

This function receives as input a network in form sif format and converts it to graph format.

**Usage**

```
sif2graph(sif)
```

**Arguments**

`sif` the name of a sif file or the equivalent table

**Details**

This function takes a network in sif format (tabel or file), i.e. sourceNode-tab-sign-tab-targetNode. If there are ANDs they should be introduced as dummy nodes called and# (don't forget the number after "and" otherwise this won't be recognised). Please be aware that "and" nodes are not expected to be negated, i.e. there are not supposed to be !and1=xyz because that amounts to inverting the sign of all inputs of and1, which is more simply done at the inputs level.

In the resulting graph, the sign of each link is encodes as the weigth of the edge (-1 negative regulation, +1 positive regulation).

**Value**

`g` the corresponding graph

**Author(s)**

F.Eduati

**See Also**

[graph2sif](#), [model2sif](#), [readSIF](#),

**Examples**

```
data(ToyModel,package="CellNOptR")
sif_file = tempfile(fileext = ".sif")
writeSIF(model = ToyModel,filename = sif_file)
g = sif2graph(sif_file)
```

---

`simulateTN`*Cut and simulation of a boolean model at t1*

---

**Description**

This function cuts a model according to a bitstring optimised at T1, and simulates the model accordingly.

**Usage**

```
simulateTN(CNolist, model, bStrings)
```

**Arguments**

|                       |  |
|-----------------------|--|
| <code>CNolist</code>  | a CNolist object   |
| <code>model</code>    | a full model   |
| <code>bStrings</code> | a bitstring to cut the model, as output by <code>gaBinaryT1</code> (i.e. a vector of 1s and 0s, of length equal to the number of reactions in the model) |

**Details**

This function is a wrapper around the family of functions called `simulatorT1`, `T2` and `TN`.

**Value**

a matrix of simulated values, including all species in the model, i.e. to be used as input of `gaBinaryTN`.

**Author(s)**

T.Cokelaer, S.Schrier based on `simulatorT1` (C.Terfve)

**See Also**

[cutAndPlotResultsT1](#), [simulatorT1](#)

**Examples**

```
# This will compute the output of a random model obtained by randomly selecting  
# which gates of the initial models are included.
```

```
data(CNolistToy,package="CellNOptR")  
data(ToyModel,package="CellNOptR")
```

```
simRes<-simulateTN(  
  CNolist=CNolistToy,  
  model=ToyModel,  
  bStrings=list(round(runif(length(ToyModel$reacID))))))
```

---

|             |                                      |
|-------------|--------------------------------------|
| simulatorT0 | <i>Simulation of a boolean model</i> |
|-------------|--------------------------------------|

---

### Description

This is the simulator, inspired from BoolSimEngMKM in the Matlab CellNOpt, to be used on one time point simulations

### Usage

```
simulatorT0(CNOlist, model, simList, indexList)
```

### Arguments

|           |  |
|-----------|--|
| CNOlist   | a CNOlist  |
| model     | a model that only contains the reactions to be evaluated   |
| simList   | a simList as created by prep4sim, that has also already been cut to contain only the reactions to be evaluated |
| indexList | an indexList as created by indexFinder   |

### Details

Differences from the BoolSimEngMKM simulator include: the valueInhibitors has not been previously flipped; the function outputs the values across all conditions for all species in the model, instead of only for the signal species. This is because then the output of this function can be used as initial values for the version of the simulator that works on time point 2 (not implemented in this version).

If you would like to compute the output of a model that contains some of the gates in the model but not all, we suggest that you use the function SimulateT1 and specify in the bStringT1 argument which gates you want to be included. Indeed, SimulateT1 is a wrapper around simulatorT1 that takes care of cutting the model for you before simulating it.

### Value

This function outputs a single matrix of format similar to valueSignals in the CNOlist but that contains an output for each species in the model. This matrix is the simulated equivalent of valueSignals at time 1, if you consider only the columns given by indexSignals.

### Author(s)

T. Cokelaer

## References

1. J. Saez-Rodriguez, L. G. Alexopoulos, J. Epperlein, R. Samaga, D. A. Lauffenburger, S. Klamt and P. K. Sorger. Discrete logic modeling as a means to link protein signaling networks with functional analysis of mammalian signal transduction, *Molecular Systems Biology*, 5:331, 2009.
2. M. K. Morris, J. Saez-Rodriguez, D. Clarke, P. K. Sorger, D. A. Lauffenburger. Training Signaling Pathway Maps to Biochemical Data with Constrained Fuzzy Logic: Quantitative Analysis of Liver Cell Responses to Inflammatory Stimuli, *PLoS Comp. Biol.*, 7(3): e1001099, 2011.

## See Also

[simulateTN](#), [cutAndPlotResultsT1](#)

## Examples

#This computes the output of the full model, which is normally not done on a stand alone basis, but if you have a model

```
data(CN0listToy,package="CellNOptR")
data(ToyModel,package="CellNOptR")

indicesToy<-indexFinder(CN0listToy,ToyModel,verbose=TRUE)
ToyFields4Sim<-prep4sim(ToyModel)

Sim<-simulatorT0(
  CN0list=CN0listToy,
  model=ToyModel,
  simList=ToyFields4Sim,
  indexList=indicesToy)
```

---

simulatorT1

*Simulation of a boolean model*

---

## Description

This is the simulator, inspired from BoolSimEngMKM in the Matlab CellNOpt, to be used on one time point simulations

## Usage

```
simulatorT1(CN0list, model, simList, indexList, mode=1)
```

## Arguments

|         |  |
|---------|--|
| CN0list | a CN0list  |
| model   | a model that only contains the reactions to be evaluated   |
| simList | a simList as created by prep4sim, that has also already been cut to contain only the reactions to be evaluated |

indexList      an indexList as created by indexFinder  
 mode            switch to use the cSimualor for time 0 or 1

### Details

Differences from the BoolSimEngMKM simulator include: the valueInhibitors has not been previously flipped; the function outputs the values across all conditions for all species in the model, instead of only for the signal species. This is because then the output of this function can be used as initial values for the version of the simulator that works on time point 2 (not implemented in this version).

If you would like to compute the output of a model that contains some of the gates in the model but not all, we suggest that you use the function SimulateT1 and specify in the bStringT1 argument which gates you want to be included. Indeed, SimulateT1 is a wrapper around simulatorT1 that takes care of cutting the model for you before simulating it.

### Value

This function outputs a single matrix of format similar to valueSignals in the CNOList but that contains an output for each species in the model. This matrix is the simulated equivalent of valueSignals at time 1, if you consider only the columns given by indexSignals.

### Author(s)

C. Terfve

### References

1. J. Saez-Rodriguez, L. G. Alexopoulos, J. Epperlein, R. Samaga, D. A. Lauffenburger, S. Klamt and P. K. Sorger. Discrete logic modeling as a means to link protein signaling networks with functional analysis of mammalian signal transduction, *Molecular Systems Biology*, 5:331, 2009.
2. M. K. Morris, J. Saez-Rodriguez, D. Clarke, P. K. Sorger, D. A. Lauffenburger. Training Signaling Pathway Maps to Biochemical Data with Constrained Fuzzy Logic: Quantitative Analysis of Liver Cell Responses to Inflammatory Stimuli, *PLoS Comp. Biol.*, 7(3): e1001099, 2011.

### See Also

[simulateTN](#), [cutAndPlotResultsT1](#)

### Examples

#This computes the output of the full model, which is normally not done on a stand alone basis, but if you have a model

```
data(CNOListToy,package="CellNOptR")
data(ToyModel,package="CellNOptR")
```

```
indicesToy<-indexFinder(CNOListToy,ToyModel,verbose=TRUE)
ToyFields4Sim<-prep4sim(ToyModel)
```

```

Sim<-simulatorT1(
  CN0list=CN0listToy,
  model=ToyModel,
  simList=ToyFields4Sim,
  indexList=indicesToy)

```

---

|             |  |
|-------------|--|
| simulatorTN | <i>Simulation of a boolean model at any time points dependent on a previous one.</i> |
|-------------|--|

---

### Description

This is a the simulator at TN using a C implementation. The computation relies on the time TN-1. T1 is a special case that is solved by using [simulatorT2](#).

### Usage

```
simulatorTN(simResultsPrev, CN0list, model, simList, indexList, timeIndex=3)
```

### Arguments

|                |  |
|----------------|--|
| simResultsPrev | a matrix that is the output of simulatorTN (i.e. one row per condition and one column per species IN THE MODEL)          |
| CN0list        | a CN0list  |
| model          | a model that only contains the reactions to be evaluated   |
| simList        | a simList as created by prep4sim, that has also already been cut to contain only the reactions to be evaluated           |
| indexList      | an indexList as created by indexFinder   |
| timeIndex      | 3 by default to behave like deprecated function simulatorT2. This is the timeIndex at which the simulation is requested. |

### Details

Differences from the BoolSimEngMKM simulator include: the valueInhibitors has not been previously flipped; the function outputs the values across all conditions for all species in the model, instead of only for the signal species. This is because then the output of this function can be used as initial values for the version of the simulator that works on time point 2 (not implemented in this version).

If you would like to compute the output of a model that contains some of the gates in the model but not all, we suggest that you use the function SimulateT1 and specify in the bStringT1 argument which gates you want to be included. Indeed, SimulateT1 is a wrapper around simulatorT1 that takes care of cutting the model for you before simulating it.

### Value

This function outputs a single matrix of format similar to valueSignals in the CN0list but that contains an output for each species in the model. This matrix is the simulated equivalent of valueSignals at time 1, if you consider only the columns given by indexSignals.

**Author(s)**

T. Cokelaer, based on [cSimulator](#) (A. MacNamara)

**References**

1. J. Saez-Rodriguez, L. G. Alexopoulos, J. Epperlein, R. Samaga, D. A. Lauffenburger, S. Klant and P. K. Sorger. Discrete logic modeling as a means to link protein signaling networks with functional analysis of mammalian signal transduction, *Molecular Systems Biology*, 5:331, 2009.
2. M. K. Morris, J. Saez-Rodriguez, D. Clarke, P. K. Sorger, D. A. Lauffenburger. Training Signaling Pathway Maps to Biochemical Data with Constrained Fuzzy Logic: Quantitative Analysis of Liver Cell Responses to Inflammatory Stimuli, *PLoS Comp. Biol.*, 7(3): e1001099, 2011.

**See Also**

[simulateTN](#), [cutAndPlotResultsT1](#)

**Examples**

#This computes the output of the full model, which is normally not done on a stand alone basis, but if you have a model

```
data(CN0listToy,package="CellNOptR")
data(ToyModel,package="CellNOptR")

indicesToy<-indexFinder(CN0listToy,ToyModel,verbose=TRUE)
ToyFields4Sim<-prep4sim(ToyModel)

#Sim<-simulatorTN(
# CN0list=CN0listToy,
# model=ToyModel,
# simList=ToyFields4Sim,
# indexList=indicesToy)
```

---

toSBML

*Export the network to SBML-qual format*

---

**Description**

Export a Boolean network <network> to an sbml-qual file <fileName>. This file can then be read in using other software that supports SBMLqual standards.

The function also takes a bit string as input. It cuts the model according to the values in bitstrings and write the new model object to SBMLqual.

**Usage**

```
toSBML(network, file, bitString = c(rep(1,length(network$reacID))),version=c("standard","cellnopt"))
```



**Arguments**

|           |  |
|-----------|--|
| network   | a valid CellNOptR network model created by e.g. readSIF()  |
| file      | a valid filename to save the SBMLqual model  |
| bitString | optional vector of binary values (for example the resulted bitString from optimisation) to cut the unnecessary interactions from the network before exporting. |
| version   | defines the format of SBMLqual file, read details.   |

**Details**

version = "standard" exports one transition block for each node of the network. This format is the SBMLqual standard, that can be imported then with other softwares

version = "cellnopt" the exported file follows a simplified syntax, where each edge of the network is transformed to a transition block in the SBMLqual file. Can be later imported to CellNOptR again.

**Author(s)**

Francesco Ceccarelli

**Examples**

```
data(ToyModel, package="CellNOptR")
toSBML(ToyModel, file = tempfile())
```

---

ToyModel

*Toy model*

---

**Description**

This data object contains the Toy model from the package vignette, already loaded and formatted as a Model object.

**Usage**

```
data(ToyModel)
```

**Format**

ToyModel is a list with fields "reacID" (character vector), "namesSpecies" (character vector), "interMat" (numerical matrix), "notMat"(numerical matrix).

**Source**

This data and model is extracted from the Matlab version of CellNOpt1.0 (<http://www.ebi.ac.uk/saezrodriguez/software.html#CellNetOptimizer>).

**References**

J. Saez-Rodriguez, L. G. Alexopoulos, J. Epperlein, R. Samaga, D. A. Lauffenburger, S. Klamt and P. K. Sorger. Discrete logic modeling as a means to link protein signaling networks with functional analysis of mammalian signal transduction, *Molecular Systems Biology*, 5:331, 2009.

---

|           |                  |
|-----------|------------------|
| ToyModel2 | <i>Toy model</i> |
|-----------|------------------|

---

**Description**

This data object contains the Toy model from the package vignette, already loaded and formatted as a Model object, and modified for the 2 time points version (a negative feedback between cJun and Jnk (!cJun=Jnk) is added).

**Usage**

```
data(ToyModel)
```

**Format**

ToyModel is a list with fields "reacID" (character vector), "namesSpecies" (character vector), "interMat" (numerical matrix), "notMat"(numerical matrix).

**Source**

This data and model is extracted from the Matlab version of CellNOpt1.0 (<http://www.ebi.ac.uk/saezrodriguez/software.html#CellNetOptimizer>).

**References**

J. Saez-Rodriguez, L. G. Alexopoulos, J. Epperlein, R. Samaga, D. A. Lauffenburger, S. Klamt and P. K. Sorger. Discrete logic modeling as a means to link protein signaling networks with functional analysis of mammalian signal transduction, *Molecular Systems Biology*, 5:331, 2009.

---

|          |  |
|----------|--|
| writeDot | <i>Write a model, and attached features, to a dot file</i> |
|----------|--|

---

**Description**

This function writes a model to a Graphviz dot file with encoded features such as edge weight and nodes status (see details).

**Usage**

```
writeDot(dotNodes, dotMatrix, model, filename)
```

**Arguments**

|           |   |
|-----------|---|
| dotNodes  | internal variables created by writeNetwork or writeScaffold; dotNodes is a matrix with 2 columns: the first has the node names, and the second the attributes (signal, stimulated, inhibited, compressed, nano). A node can appear twice in this matrix if it belongs to more of one of the above categories; a node could also not appear here if it is none of these categories   |
| dotMatrix | internal variables created by writeNetwork or writeScaffold; dotMatrix is a matrix with 4 or 5 columns, and a row for each reaction: the first column holds the name of the input node, the second column holds the sign of the reaction (-1 if negative, 1 if positive), the third column holds the name of the output node, the fourth column holds the time stamp (0,1,2), an optional 5th column holds the weights of the edges |
| model     | A model to be plotted, if used inside writeNetwork then this should be the previous knowledge network (modelOriginal), if inside writeScaffold then this should be the scaffold (modelComprExpanded)  |
| filename  | a name for the file   |

**Details**

This function is not to be used on its own, it should be used internally to writeNetwork or writeScaffold. For the colouring of the nodes, nodes that are both stimulated and inhibited or any other combination, only one colour per category is used, and the following order of priority for the colours is used: signals prime over inhibited nodes which primes over stimulated nodes which primes over non-controllable/non-observable nodes, which primes over compressed. Nodes that are neither of those have a black contour, stimulated nodes are green, inhibited are red, measure are blue, compressed and non-controllable/non-observable nodes are black and dashed. Edges are coloured according to time stamp in the optimal model (green=t1, blue=t1 and/or t2, grey=neither); on the scaffold, the strokes of the edges reflects the weights in the models within reltol (i.e. for each edge, the weight is the frequency with which it appeared among the models within the relative tolerance boundaries around the best solution).

**Value**

This function does not have any output, it just writes a dot file in your working directory.

**Author(s)**

C. Terfve

**References**

Emden R. Gansner , Stephen C. North. An Open Graph Visualization System and Its Applications to Software Engineering. Software - Practice and Experience (1999)

**See Also**

[writeNetwork](#), [writeScaffold](#)

**Examples**

```

#load data

data(CN0listToy,package="CellNOptR")
data(ToyModel,package="CellNOptR")

#pre-process model

indicesToy<-indexFinder(CN0listToy,ToyModel,verbose=TRUE)
ToyNCNOindices<-findNONC(ToyModel,indicesToy,verbose=TRUE)
ToyNCNOcut<-cutNONC(ToyModel,ToyNCNOindices)
indicesToyNCNOcut<-indexFinder(CN0listToy,ToyNCNOcut)
ToyNCNOcutComp<-compressModel(ToyNCNOcut,indicesToyNCNOcut)
indicesToyNCNOcutComp<-indexFinder(CN0listToy,ToyNCNOcutComp)
ToyNCNOcutCompExp<-expandGates(ToyNCNOcutComp)

#optimise

ToyFields4Sim<-prep4sim(ToyNCNOcutCompExp)
initBstring<-rep(1,length(ToyNCNOcutCompExp$reacID))
ToyT1opt<-gaBinaryT1(
  CN0list=CN0listToy,
  model=ToyNCNOcutCompExp,
  initBstring=initBstring,
  maxGens=2,
  popSize=5,
  verbose=TRUE)

#write network

writeNetwork(
  modelOriginal=ToyModel,
  modelComprExpanded=ToyNCNOcutCompExp,
  optimResT1=ToyT1opt,
  optimResT2=NA,
  CN0list=CN0listToy)

```

---

writeFile

*Writing the ILP problem.*


---

**Description**

This function takes as input the objective function, constraints, bounds and the solver path in order to generate a file containing the ILP problem.

**Usage**

```

writeFile(objectiveFunction,
          constraints,
          bounds,
          binaries)

```

**Arguments**

|                   |   |
|-------------------|---|
| objectiveFunction | the objective function of the ILP problem   |
| constraints       | the set of constraints of the ILP problem   |
| bounds            | the set of bounds for each integer variable |
| binaries          | the set of binary variables                 |

**Author(s)**

E Gjerga, H Koch

---

writeMIDAS

*Write a CNOList structure into a MIDAS file*

---

**Description**

This function takes a CNOList structure (output of makeCNOList and readMIDAS) and save it a MIDAS format.

**Usage**

```
writeMIDAS(CNOList, filename, timeIndices=NULL, overwrite=FALSE)
```

**Arguments**

|             |  |
|-------------|--|
| CNOList     | a CNOList structure  |
| filename    | a filename. Not overwritten if it exists already                             |
| timeIndices | select subset of the times to be saved. Works with indices (not time values) |
| overwrite   | overwrite the file if it exists already (Default is FALSE)                   |

**Author(s)**

T. Cokelaer

**See Also**

[makeCNOList](#), [readMIDAS](#), [CNOList-class](#)

**Examples**

```
data(CNOListToy)
writeMIDAS(CNOListToy, 'test.csv')
readMIDAS('test.csv')
writeMIDAS(CNOListToy, 'test.csv', timeIndices=c(1,2), overwrite=TRUE)
```

---

|              |   |
|--------------|---|
| writeNetwork | <i>Write a previous knowledge network model to a sif file (with attribute files), as well as a dot file</i> |
|--------------|---|

---

### Description

This function writes the original previous knowledge network (the model that you loaded in the beginning of your analysis) in a sif file, with a nodes attribute file that specifies if each node was stimulated/inhibited/signal/compressed/non-controllable-non-observable and an edge attribute file that specifies if the edge was absent in the optimal model (0) present in the optimal model at t1 (1) or present in the optimal model at t2 (2).

This function also writes a Graphviz dot file that contains the same information (see writeDot for more information about the dot file conventions).

### Usage

```
writeNetwork(modelOriginal, modelComprExpanded, optimResT1, optimResT2, CNOList,
tag = NULL, verbose=FALSE)
```

### Arguments

|                    |  |
|--------------------|--|
| modelOriginal      | The PKN model  |
| modelComprExpanded | The scaffold model (i.e. compressed and expanded)  |
| optimResT1         | The results of the optimisation process at t1  |
| optimResT2         | The results of the optimisation process at t2 (set this to NA if you have performed a one time point optimisation).          |
| CNOList            | The CNOList on which the optimisation is based   |
| tag                | NULL or string; tells whether you want to prefix filenames with a tag (replaces the default behaviour).                      |
| verbose            | If verbose=TRUE, the function prints a message every time an edge in the scaffold network couldn't be mapped back to the PKN |

### Details

The weights of the edges are computed as the mean across models within the relative tolerance limits, as output in the results from the optimisation \$stringsTol. Strings that are in \$stringsTol are the ones that are within the relative tolerance limits around the best solution in the population across all generations of the optimisation.

!If there is no time 2, then the argument optimResT2 should be = NA

This function maps back the edges weights from the optimised (expanded and compressed) model to the original model. The mapping back only works if the path has length 2 at most (i.e. you have node1-comp1-comp2-node2, where comp refer to nodes that have been compressed).

**Value**

This function does not have any output, it just writes a sif file, an edge attribute file, and a node attribute file

**Note**

The mapback of this function is still an open question, even in the Matlab version. Future developments will include more robust versions of the mapping back algorithm, probably as a separate mapback function.

**Author(s)**

C. Terfve

**See Also**

writeScaffold, writeDot

**Examples**

```
#load data

data(CN0listToy,package="CellNOptR")
data(ToyModel,package="CellNOptR")

#pre-process model

indicesToy<-indexFinder(CN0listToy,ToyModel,verbose=TRUE)
ToyNCNOindices<-findNONC(ToyModel,indicesToy,verbose=TRUE)
ToyNCNOcut<-cutNONC(ToyModel,ToyNCNOindices)
indicesToyNCNOcut<-indexFinder(CN0listToy,ToyNCNOcut)
ToyNCNOcutComp<-compressModel(ToyNCNOcut,indicesToyNCNOcut)
indicesToyNCNOcutComp<-indexFinder(CN0listToy,ToyNCNOcutComp)
ToyNCNOcutCompExp<-expandGates(ToyNCNOcutComp)

#optimise

ToyFields4Sim<-prep4sim(ToyNCNOcutCompExp)
initBstring<-rep(1,length(ToyNCNOcutCompExp$reacID))
ToyT1opt<-gaBinaryT1(
  CN0list=CN0listToy,
  model=ToyNCNOcutCompExp,
  initBstring=initBstring,
  verbose=TRUE,
  maxGens=2,
  popSize=5)

#write network

writeNetwork(
  modelOriginal=ToyModel,
```

```

modelComprExpanded=ToyNCNOcutCompExp,
optimResT1=ToyT1opt,
optimResT2=NA,
CNOList=CNOListToy)

```

---

```
writeObjectiveFunction
```

*Writing the objective function for the ILP implementation of CellNOptR.*

---

### Description

This function takes as input the integer variables assigned to each of the elements in the network and data in a CNOList object in order to produce the objective function needed to be optimized by the ILP solver.

### Usage

```

writeObjectiveFunction(model,
                      midasExperimentPart,
                      y_vector=y_vector,
                      accountForModelSize = TRUE,
                      sizeFac = .000001,
                      meansOfMeasurements_at_t0,
                      method = "quadratic" )

```

### Arguments

|                           |  |
|---------------------------|--|
| model                     | the model  |
| midasExperimentPart       | the experimental part of CNOList where data is stored              |
| y_vector                  | the variables for each interaction in the PKN                      |
| accountForModelSize       | the verbose variable if we wish to apply the size penalty          |
| sizeFac                   | the size penalty factor  |
| meansOfMeasurements_at_t0 | the means of measurements at time-point 0                          |
| method                    | the method of defining the objective function ("quadratic/linear") |

### Author(s)

E Gjerga, H Koch



## References

Alexander Mitsos, Ioannis N. Melas, Paraskeuas Siminelakis, Aikaterini D. Chairakaki, Julio Saez-Rodriguez, and Leonidas G. Alexopoulos. Identifying Drug Effects via Pathway Alterations using an Integer Linear Programming Optimization Formulation on Phosphoproteomic Data. *PLoS Comput Biol.* 2009 Dec; 5(12): e1000591.

---

writeReport

*Write a report of a CellNOptR analysis*

---

## Description

This function writes a short report of a CellNOptR analysis in an html page, that is linked to the various graphs produced

## Usage

```
writeReport(modelOriginal, modelOpt, optimResT1, optimResT2, CN0list, directory,
  namesFiles = list(dataPlot = NA, evolFitT1=NA, evolFitT2=NA, simResultsT1=NA,
  simResultsT2=NA, scaffold=NA, scaffoldDot=NA, tscaffold=NA, wscaffold=NA,
  PKN=NA, PKNdot=NA, wPKN=NA, nPKN=NA), namesData = list(CN0list=NA, model=NA),
  resE=NULL)
```

## Arguments

|               |  |
|---------------|--|
| modelOriginal | the original previous knowledge network (i.e. model that you loaded) in a model list format  |
| modelOpt      | the model that was actually used for optimisation (i.e. the scaffold network, after compression and expansion) in a model list format  |
| optimResT1    | the results of the optimisation at t1, as output by gabinaryT1   |
| optimResT2    | the results of the optimisation at t2, as output by gabinaryTN. Set this to NA if you have performed a one time point optimisation.  |
| CN0list       | a CN0list  |
| directory     | the name of a new directory that will be created, where your results will be moved   |
| namesFiles    | a list of the names of the files that should have been created. Depending on whether a t2 optimisation was performed or not, all or some of the following fields are expected: dataPlot, evolFitT1, evolFitT2, simResultsT1, simResultsT2, scaffoldDot, scaffold, tscaffold, wscaffold, PKN, PKNdot, wPKN, nPKN. |
| namesData     | a list with fields \$CN0list and \$model that contain strings that are meaningful identifiers of your data and previous knowledge network (for your own record).   |
| resE          | a vector with named entries t1, t2 t1andt2, as produced by the function ResidualError, that contains the residual error associated with the discretisation of the data. Since version 1.3.29, there is no need to provide this argument. Kept for back compatibility.  |

## Details

Future versions of this function might directly write and compile a tex file.

## Value

This function produces a directory and moves all the files of namesFiles to it, then it creates an html report that contains infos about the optimisation process.

## Author(s)

C. Terfve

## See Also

[writeNetwork](#), [writeScaffold](#)

## Examples

```
#load data

data(CN0listToy,package="CellNOptR")
data(ToyModel,package="CellNOptR")

#pre-process model (partial)

indicesToy<-indexFinder(CN0listToy,ToyModel,verbose=TRUE)
ToyNCNOcutComp<-compressModel(ToyModel,indicesToy)
indicesToyNCNOcutComp<-indexFinder(CN0listToy,ToyNCNOcutComp)
ToyNCNOcutCompExp<-expandGates(ToyNCNOcutComp)

#optimise

ToyFields4Sim<-prep4sim(ToyNCNOcutCompExp)
initBstring<-rep(1,length(ToyNCNOcutCompExp$reacID))
ToyT1opt<-gaBinaryT1(
  CN0list=CN0listToy,
  model=ToyNCNOcutCompExp,
  initBstring=initBstring,
  maxGens=2,
  popSize=5,
  verbose=TRUE)

#write report

namesFilesToy<-list(
  dataPlot=NA,
  evolFitT1=NA,
  evolFitT2=NA,
  simResultsT1=NA,
  simResultsT2=NA,
  scaffold=NA,
  scaffoldDot=NA,
```

```

tscaffold=NA,
wscaffold=NA,
PKN=NA,
PKNdots=NA,
wPKN=NA,
nPKN=NA)

writeReport(
  modelOriginal=ToyModel,
  modelOpt=ToyNCNOcutCompExp,
  optimResT1=ToyT1opt,
  optimResT2=NA,
  CN0list=CN0listToy,
  directory="testToy",
  namesFiles=namesFilesToy,
  namesData=list(CN0list="Toy", model="ToyModel"),
  resE=NA)

```

---

|               |  |
|---------------|--|
| writeScaffold | <i>Writes the scaffold network to a sif file (with attributes) and to a dot file</i> |
|---------------|--|

---

### Description

This function writes a cytoscape SIF file for the scaffold network, with an associated edge attribute file that holds whether the edge is present at t1,t2 or not present at all and another associated edge attribute file that holds the weights of the edges. This function also writes a dot file that contains the same information (see writeDot for more information about the dot file conventions).

### Usage

```
writeScaffold(modelComprExpanded, optimResT1, optimResT2, modelOriginal,
  CN0list, tag=NULL)
```

### Arguments

|                    |   |
|--------------------|---|
| modelComprExpanded | The scaffold model (i.e. compressed and expanded)   |
| optimResT1         | The results of the optimisation process at t1   |
| optimResT2         | The results of the optimisation process at t2 (set this to NA if you have performed a one time point optimisation). |
| modelOriginal      | The PKN model   |
| CN0list            | The CN0list on which the optimisation is based  |
| tag                | NULL or string; tells whether you want to prefix filenames with a tag (replaces the default behaviour).             |

**Details**

By scaffold network we mean the network that is used as a basis for optimisation (i.e. a compressed and expanded network), therefore no map back of the weights is necessary here.

The weights of the edges are computed as the mean across models within the relative tolerance limits, as output in the results from the optimisation `$stringsTo1`. Strings that are in `$stringsTo1` are the ones that are within the relative tolerance limits around the best solution in the population across all generations of the optimisation.

If there is no time 2, then the argument `optimResT2` should be = NA.

**Value**

This function does not return anything, it writes a `sif` file and 2 edge attributes files, and a dot file, in your working directory.

**Author(s)**

C.Terfve

**See Also**

`writeNetwork`, `writeDot`

**Examples**

```
#load the data

data(CN0listToy,package="CellNOptR")
data(ToyModel,package="CellNOptR")

#pre-process the model (partial)

indicesToy<-indexFinder(CN0listToy,ToyModel,verbose=TRUE)
ToyNCNOcutComp<-compressModel(ToyModel,indicesToy)
indicesToyNCNOcutComp<-indexFinder(CN0listToy,ToyNCNOcutComp)
ToyNCNOcutCompExp<-expandGates(ToyNCNOcutComp)

#optimise

ToyFields4Sim<-prep4sim(ToyNCNOcutCompExp)
initBstring<-rep(1,length(ToyNCNOcutCompExp$reacID))
ToyT1opt<-gaBinaryT1(
  CN0list=CN0listToy,
  model=ToyNCNOcutCompExp,
  initBstring=initBstring,
  maxGens=3,
  popSize=5,
  verbose=TRUE)

#write the network
```

```
writeScaffold(  
  modelOriginal=ToyModel,  
  modelComprExpanded=ToyNCNOcutCompExp,  
  optimResT1=ToyT1opt,  
  optimResT2=NA,  
  CN0list=CN0listToy)
```

---

writeSIF                      *Convert a model into a SIF format and save the result in a file.*

---

### Description

This function takes as input a model (as created by e.g., read from a SIF data set with readSIF function) and save it into a file.

### Usage

```
writeSIF(model, filename, overwrite = FALSE)
```

### Arguments

|           |                                      |
|-----------|--------------------------------------|
| model     | the model                            |
| filename  | the filename                         |
| overwrite | by default, do not overwrite a file. |

### Author(s)

T Cokelaer

### Examples

```
cpfile<-dir(system.file("ToyModel",package="CellNOptR"),full=TRUE)  
file.copy(from=cpfile,to=getwd(),overwrite=TRUE)  
ToyModel<-readSIF(sifFile="ToyPKNMMB.sif")  
writeSIF(ToyModel, "ToyPKNMMB_copy.sif")
```

---

|              |   |
|--------------|---|
| write_bounds | <i>Writing the set of boundaries for each integer variable for the ILP implementation of CellNOptR.</i> |
|--------------|---|

---

### Description

This function takes as input the integer variables assigned to each of the elements in the network and data in a CNOList object in order to produce the set boundaries for each integer variable.

### Usage

```
write_bounds(model,
            midasTreatmentPart,
            y_vector,
            binary_variables)
```

### Arguments

|                    |  |
|--------------------|--|
| model              | the model  |
| midasTreatmentPart | the treatment part of CNOList where data is stored |
| y_vector           | the variables for each interaction in the PKN      |
| binary_variables   | the set of binary variables                        |

### Author(s)

E Gjerga, H Koch

### References

Alexander Mitsos, Ioannis N. Melas, Paraskeuas Siminelakis, Aikaterini D. Chairakaki, Julio Saez-Rodriguez, and Leonidas G. Alexopoulos. Identifying Drug Effects via Pathway Alterations using an Integer Linear Programming Optimization Formulation on Phosphoproteomic Data. *PLoS Comput Biol.* 2009 Dec; 5(12): e1000591.

---

|                   |  |
|-------------------|--|
| write_constraints | <i>Writing the set of constraints for the ILP implementation of CellNOptR.</i> |
|-------------------|--|

---

### Description

This function takes as input the integer variables assigned to each of the elements in the network and data in a CNOList object in order to produce the set of constraints needed to be optimized by the ILP solver.

**Usage**

```
write_constraints(model,
                 midasExperimentPart,
                 midasTreatmentPart,
                 reaction_sets,
                 y_vector,
                 midas,
                 binary_variables)
```

**Arguments**

|                     |   |
|---------------------|---|
| model               | the model   |
| midasExperimentPart | the experimental part of CNOList where data is stored |
| midasTreatmentPart  | the treatment part of CNOList where data is stored    |
| reaction_sets       | the set of reactions                                  |
| y_vector            | the variables for each interaction in the PKN         |
| midas               | the midas table                                       |
| binary_variables    | the set of binary variables                           |

**Author(s)**

E Gjerga, H Koch

**References**

Alexander Mitsos, Ioannis N. Melas, Paraskeuas Siminelakis, Aikaterini D. Chairakaki, Julio Saez-Rodriguez, and Leonidas G. Alexopoulos. Identifying Drug Effects via Pathway Alterations using an Integer Linear Programming Optimization Formulation on Phosphoproteomic Data. *PLoS Comput Biol.* 2009 Dec; 5(12): e1000591.

# Index

- \* **CNOlist**
    - CNOlist-methods, 8
    - plot-method, 59
  - \* **classes**
    - CNOlist-class, 7
  - \* **datasets**
    - CNOlistDREAM, 10
    - CNOlistToy, 11
    - CNOlistToy2, 11
    - LiverDREAM, 51
    - pknmodel, 58
    - ToyModel, 89
    - ToyModel2, 90
  - \* **methods**
    - CNOlist-methods, 8
    - plot-method, 59
  - \* **package**
    - CellNOptR-package, 4
- build\_sif\_table\_from\_rule, 5
- CellNOptR (CellNOptR-package), 4
- CellNOptR-package, 4
- checkSignals, 6
- CNOdata, 7
- cnodata (CNOdata), 7
- CNOlist (CNOlist-class), 7
- CNOlist-class, 7, 8, 28, 53, 93
- CNOlist-methods, 8, 8
- CNOlistDREAM, 10
- CNOlistToy, 11
- CNOlistToy2, 11
- CNORbool, 12
- CNORwrap, 12, 13
- compatCNOlist (CNOlist-methods), 8
- compatCNOlist, CNOlist (CNOlist-methods), 8
- compatCNOlist, CNOlist-method (CNOlist-class), 7
- compressModel, 15, 15, 74, 75
- computeScoreT1, 16
- computeScoreTN, 17
- create\_binaries, 20
- createAndRunILP, 18
- createILPBitstringAll, 20
- crossInhibitedData, 21
- crossvalidateBoolean, 22
- cSimulator, 88
- cutAndPlot, 24
- cutAndPlotResultsT1, 24, 25, 27, 83, 85, 86, 88
- cutAndPlotResultsTN, 26
- cutCNOlist, 28
- cutModel, 29
- cutNONC, 30, 35, 74, 75
- cutSimList, 31
- defaultParameters, 12, 14, 31
- DreamModel (LiverDREAM), 51
- exhaustive, 32
- expandGates, 33, 74, 75
- findNONC, 30, 35, 74, 75
- gaBinaryT1, 26, 27, 32, 33, 36, 41, 55, 65, 67
- gaBinaryTN, 37, 38
- getCues (CNOlist-methods), 8
- getCues, CNOlist (CNOlist-methods), 8
- getCues, CNOlist-method (CNOlist-class), 7
- getFit, 40, 40, 81
- getInhibitors (CNOlist-methods), 8
- getInhibitors, CNOlist (CNOlist-methods), 8
- getInhibitors, CNOlist-method (CNOlist-class), 7
- getSignals (CNOlist-methods), 8
- getSignals, CNOlist (CNOlist-methods), 8
- getSignals, CNOlist-method (CNOlist-class), 7



- getStimuli (CNolist-methods), 8
- getStimuli, CNolist (CNolist-methods), 8
- getStimuli, CNolist-method (CNolist-class), 7
- getTimepoints (CNolist-methods), 8
- getTimepoints, CNolist (CNolist-methods), 8
- getTimepoints, CNolist-method (CNolist-class), 7
- getVariances (CNolist-methods), 8
- getVariances, CNolist (CNolist-methods), 8
- getVariances, CNolist, CNolist-method (CNolist-methods), 8
- getVariances, CNolist-method (CNolist-class), 7
- graph2sif, 42, 54–56, 82
- ilpBinaryT1, 43
- ilpBinaryT2, 45
- ilpBinaryTN, 47
- indexFinder, 15, 16, 35, 49
- internals, 50
- invokeCPLEX, 50
- length (CNolist-methods), 8
- length, CNolist (CNolist-methods), 8
- length, CNolist, ANY-method (CNolist-methods), 8
- length, CNolist-method (CNolist-class), 7
- LiverDREAM, 51
- makeCNolist, 6, 7, 9, 12, 14, 49, 52, 57, 59, 67, 77, 78, 81, 93
- mapBack, 53
- model2igraph, 54
- model2sif, 43, 55, 82
- normaliseCNolist, 56, 81
- pknmodel, 58
- plot, CNolist, ANY-method (plot-method), 59
- plot, CNolist, CNolist, CNolist-method (CNolist-methods), 8
- plot, CNolist, CNolist-method (CNolist-class), 7
- plot-method, 59
- plot.CNolist (plot-method), 59
- plotCNolist, 8, 9, 60, 62–64
- plotCNolist2, 8, 9, 61
- plotCNolistLarge, 62, 63, 64
- plotCNolistLargePDF, 62, 63, 64
- plotCNolistPDF, 62, 63, 64
- plotFit, 64
- plotModel, 65
- plotOptimResults, 67
- plotOptimResultsPan, 24, 25, 27, 69
- plotOptimResultsPDF, 71
- prep4Sim (prep4sim), 73
- prep4sim, 27, 73
- preprocessing, 6, 15, 16, 30, 34, 35, 74
- randomize (CNolist-methods), 8
- randomize, CNolist (CNolist-methods), 8
- randomize, CNolist, CNolist-method (CNolist-methods), 8
- randomize, CNolist-method (CNolist-class), 7
- randomizeCNolist, 8, 9, 75
- readBND, 76
- readBNET, 77
- readErrors (CNolist-methods), 8
- readErrors, CNolist (CNolist-methods), 8
- readErrors, CNolist-method (CNolist-class), 7
- readMIDAS, 7, 53, 59, 67, 75, 77, 93
- readMidas (readMIDAS), 77
- readSBMLQual, 78
- readSIF, 6, 12, 14–16, 30, 35, 43, 49, 54–56, 67, 74, 75, 79, 82
- readSif (readSIF), 79
- residualError, 81
- setSignals<- (CNolist-methods), 8
- setSignals<- , CNolist (CNolist-methods), 8
- setSignals<- , CNolist, CNolist-method (CNolist-methods), 8
- setSignals<- , CNolist-method (CNolist-class), 7
- sif2graph, 42, 43, 54–56, 82
- simulateTN, 83, 85, 86, 88
- simulatorT0, 84
- simulatorT1, 37, 40, 41, 74, 83, 85
- simulatorT2, 40, 87
- simulatorTN, 87

toSBML, 88  
ToyModel, 89  
ToyModel2, 90  
  
write\_bounds, 102  
write\_constraints, 102  
writeDot, 67, 90  
writeErrors (CNOList-methods), 8  
writeErrors, CNOList (CNOList-methods), 8  
writeErrors, CNOList-method  
    (CNOList-class), 7  
writeFile, 92  
writeMIDAS, 93  
writeNetwork, 67, 91, 94, 98  
writeObjectiveFunction, 96  
writeReport, 97  
writeScaffold, 91, 98, 99  
writeSIF, 101  
writeSif (writeSIF), 101