

# Package ‘MOMA’

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**Title** Multi Omic Master Regulator Analysis

**Version** 1.10.0

**Description** This package implements the inference of candidate master regulator proteins from multi-omics' data (MOMA) algorithm, as well as ancillary analysis and visualization functions.

**Depends** R (>= 4.0)

**License** GPL-3

**Encoding** UTF-8

**LazyData** true

**BugReports** <https://github.com/califano-lab/MOMA/issues>

**RoxygenNote** 7.1.0

**biocViews** Software, NetworkEnrichment, NetworkInference, Network, FeatureExtraction, Clustering, FunctionalGenomics, Transcriptomics, SystemsBiology

**Imports** circlize, cluster, ComplexHeatmap, dplyr, ggplot2, graphics, grid, grDevices, magrittr, methods, MKmisc, MultiAssayExperiment, parallel, qvalue, RColorBrewer, readr, reshape2, rlang, stats, stringr, tibble, tidyr, utils

**Suggests** BiocStyle, knitr, rmarkdown, testthat, viper

**VignetteBuilder** knitr

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**Author** Evan Paull [aut],  
Sunny Jones [aut, cre],  
Mariano Alvarez [aut]

**Maintainer** Sunny Jones <sunnyjjones@gmail.com>

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cnvScoreStouffer	<i>Integrate CNV scores</i>
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### Description

Integrate CNV scores

### Usage

```
cnvScoreStouffer(
  mapping,
  diggit.interactions,
  cytoband = TRUE,
  from.p = FALSE,
  pos.nes.only = TRUE
)
```

### Arguments

mapping	a named vector of genomic locations/cytoband IDs. names are the gene names for each–i.e. a many to one mapping from HUGO or entrez IDs to cytoband location
diggit.interactions	list indexed by MR/TF name in Entrez Space each points to a named vector of NES / z-scores associated with entrez IDs for each interacting event.
cytoband	Boolean to use cytoband locations for computing final integrated score
from.p	Boolean, set TRUE if diggit.interaction values are p-values instead of z-scores
pos.nes.only	Boolean, only consider positive DIGGIT association scores when ranking candidate MRs (default=TRUE)

**Value**

A vector of z-scores, named by the Master Regulators in 'diggit.interactions'

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example.gbm.mae	<i>Glioblastoma (GBM) Example Dataset</i>
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**Description**

MultiAssayExperiment Object containing all the genomic assays needed to run the example code for MOMA

**Usage**

example.gbm.mae

**Format**

An MultiAssayExperiment object with 4 different sets of GBM assays

**viper** matrix of viper scores with samples in columns and regulators across the rows

**mut** matrix of samples and genes with potential mutations. 0 for no mutation, 1 for presence of some non-silent mutation

**cnv** matrix of samples and genes with copy number variant scores

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gbm.pathways	<i>Glioblastoma (GBM) Pathways</i>
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**Description**

Object containing information about the biological pathways that will be used in the analysis

**Usage**

gbm.pathways

**Format**

A list of lists named "cindy" and "preppi" respectively

**cindy** list of regulators, each with a set of modulators and p values representing their CINDY inferred association

**preppi** list of regulators, each with a set of potential binding partners and PREPPI inferred p values for probability of binding

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`gene.map`*Gene Location Mapping*

---

**Description**

Table used for converting between different forms of gene information. Downloaded from HGNC's custom download portal using the "Approved Symbol", "NCBI Gene ID", "Chromosome" and "Ensembl Gene ID" curated data options and only those with "Approved" status. Updated December 2019.

**Usage**`gene.map`**Format**

A Data frame with 4 columns

**Gene.Symbol** Approved Symbol gene name

**Entrez.IDs** NCBI Gene ID

**Cytoband** Chromosome location

**Ensembl** Ensembl gene ID

@source <https://www.genenames.org/download/custom/>

---

`makeSaturationPlots`*Main function to generate the summary plots of the analysis*

---

**Description**

Main function to generate the summary plots of the analysis

**Usage**

```
makeSaturationPlots(  
  momaObj,  
  clustering.solution = NULL,  
  important.genes = NULL,  
  fCNV = NULL,  
  max.events = 30  
)
```

**Arguments**

momaObj : momaObj that has already run the saturationCalculation function  
clustering.solution : clustering vector with sample names and cluster designations  
important.genes : vector of gene names to prioritize when plotting. Can be general genes of interest, oncogenes, tumor suppressors etc  
fCNV : vector of confirmed functional CNVs if calculated. Will filter for only those CNVs  
max.events : maximum number of events to plot for the oncoplots

**Value**

object with both types of summary plot for each subtype

**Examples**

```
## Not run:  
makeSaturationPlots(momaObj, max.events = 20)  
  
## End(Not run)
```

---

mapEntrez *Convert from entrez ids to hugo gene names*

---

**Description**

Convert from entrez ids to hugo gene names

**Usage**

```
mapEntrez(entrez.ids)
```

**Arguments**

entrez.ids : vector of entrez ids requires hugo2entrez to be loaded

**Value**

: vector of hugo gene names

**See Also**

[mapHugo](#)

**Examples**

```
mapEntrez(c("29974", "5728"))
```

mapHugo

*Convert from hugo gene names to entrez ids*

---

**Description**

Convert from hugo gene names to entrez ids

**Usage**

```
mapHugo(hugo.ids)
```

**Arguments**

hugo.ids : vector of hugo gene names, requires hugo2entrez to be loaded

**Value**

: vector of entrez ids

**See Also**

[mapEntrez](#)

**Examples**

```
mapHugo(c("A1CF", "PTEN"))
```

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mapScoresCnvBand*Map scores to cytoband location*

---

**Description**

Map scores to cytoband location

**Usage**

```
mapScoresCnvBand(  
  mapping,  
  diggit.interactions,  
  from.p = FALSE,  
  pos.nes.only = TRUE  
)
```

**Arguments**

mapping	a named vector of genomic locations/cytoband IDs. names are the gene names for each–i.e. a many to one mapping from HUGO or entrez IDs to cytoband location
diggit.interactions	list indexed by MR/TF name in Entrez Space
from.p	DIGGIT interactions are in p-value format instead of z-score (default=FALSE)
pos.nes.only	Only consider positive associations with NES scores (default=TRUE) each points to a named vector of NES / z-scores associated with entrez IDs for each interacting event.

**Value**

A list of input scores, now named by cytoband location

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Moma-class

*MOMA Object*


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**Description**

Main class encapsulating the input data and logic of the MOMA algorithm

**Fields**

viper	matrix of inferred activity score inferred by viper
mut	binary mutation matrix 1 for presence of mutation, 0 for not, NA if not determined
cnv	matrix of cnv values. Can be binary or a range.
fusions	binary matrix of fusion events if applicable
pathways	list of pathways/connections to consider as extra evidence in the analysis
gene.blacklist	character vector of genes to not include because of high mutation frequency
output.folder	character vector of location to save files if desired
gene.loc.mapping	data frame of gene names, entrez ids and cytoband locations
nes	field for saving Normalized Enrichment Matrices from the associate events step
interactions	field for saving the MR-interactions list
clustering.results	results from clustering are saved here
ranks	results field for ranking of MRs based on event association analysis
hypotheses	results field for saving events that have enough occurrences to be considered
genomic.saturation	results field for genomic saturation analysis
coverage.summaryStats	results field for genomic saturation analysis
checkpoints	results field with the MRs determined to be the checkpoint for each cluster
sample.clustering	field to save sample clustering vector. Numbers are cluster assignments, names are sample ids

## Methods

```
Cluster(clus.eval = c("reliability", "silhouette"), use.parallel = FALSE, cores = 1)
```

Cluster the samples after applying the MOMA weights to the VIPER scores

```
makeInteractions(genomic.event.types = c("amp", "del", "mut", "fus"), cindy.only = FALSE)
```

Make interaction web for significant MRs based on their associated events

```
Rank(use.cindy = TRUE, genomic.event.types = c("amp", "del", "mut", "fus"), use.parallel = FALSE, cores = )
```

Rank MRs based on DIGGIT scores and number of associated events

```
runDIGGIT(fCNV = NULL, cnvthr = 0.5, min.events = 4, verbose = FALSE) Run DIGGIT asso-  
ciation function to get associations for driver genomic events
```

```
saturationCalculation(clustering.solution = NULL, cov.fraction = 0.85, topN = 100, verbose = FALSE)
```

Calculate the number of MRs it takes to represent the desired coverage fraction of events

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MomaConstructor

*MOMA Constructor Function*

---

## Description

Create MOMA Object from either a MultiAssayExperiment object or a list of assays. See vignette for more information on how to set up and run the MOMA object

## Usage

```
MomaConstructor(  
  x,  
  pathways,  
  gene.blacklist = NA_character_,  
  output.folder = NA_character_,  
  gene.loc.mapping = gene.map,  
  viperAssay = "viper",  
  mutMat = "mut",  
  cnvMat = "cnv",  
  fusionMat = "fusion"  
)
```

## Arguments

**x** A MultiAssayExperiment object or list object with the following assays: (note: by default assays must have these exact names. Otherwise they can be changed using the viperAssay, mutMat, cnvMat and fusionMat parameters.)

**viper** VIPER protein activity matrix with samples as columns and rows as protein IDs

**mut** An indicator matrix (0/1) of mutation events with samples as columns and genes as rows

**cnv** A matrix of CNV scores (typically SNP6 array scores from TCGA) with samples as columns and genes as rows



	<b>fusion</b>	An indicator matrix (0/1) of fusion events with samples as columns and genes as rows
pathways		A named list of lists. Each named list represents interactions between proteins (keys) and their associated partners
gene.blacklist		A vector of genes to exclude from the analysis
output.folder		Location to store output and intermediate results
gene.loc.mapping		A data.frame of band locations and Entrez IDs
viperAssay		name associated with the viper assay in the assay object
mutMat		name associated with the mutation matrix in the assay object
cnvMat		name associated with the cnv matrix in the assay object
fusionMat		name associated with the fusion matrix in the assay object

**Value**

an instance of class Moma

**Examples**

```
momaObj <- MomaConstructor(example.gbm.mae, gbm.pathways)
```

---

mutSig	<i>MutSig Blacklisted genes</i>
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---

**Description**

List of genes to not include in the DIGGIT mutation inference because they have been found to be mutated more often than expected by chance given background mutation processes.

**Usage**

```
mutSig
```

**Format**

A character vector of Entrez Gene IDs

**Source**

<https://software.broadinstitute.org/cancer/cga/mutsig>

---

sampleNameFilter      *Retain TCGA sample ids without the final letter designation ('A/B/C')*

---

**Description**

Retain TCGA sample ids without the final letter designation ('A/B/C')

**Usage**

```
sampleNameFilter(input, desired.len = 15)
```

**Arguments**

input                  Matrix of expression or protein activity scores. Columns are sample names, rows are genes. Input can also just be an input vector of sample names.

desired.len          length to reduce strings to. Default is 15 because of TCGA naming conventions

**Value**

An identical matrix with new (shorter) column names, or a vector with the shortened names.

**Examples**

```
sample.names <- c("TCGA-14-1825-01A", "TCGA-76-4931-01B", "TCGA-06-5418-01A")
sampleNameFilter(sample.names)
```

---

stoufferIntegrate      *dispatch method for either CNV location corrected or SNV*

---

**Description**

dispatch method for either CNV location corrected or SNV

**Usage**

```
stoufferIntegrate(interactions, cytoband.map = NULL)
```

**Arguments**

interactions        List of MR - Genomic Event interactions, inferred by DIGGIT

cytoband.map        Data.frame mapping Entrez.IDs to cytoband locations

**Value**

Z-scores for each MR

---

stoufferIntegrateDiggIt

*Use Stouffer's method to combine z-scores of DIGGIT interactions for each cMR protein.*

---

### Description

This function combines only positively associated DIGGIT scores by default to create a cumulative DIGGIT score for each cMR.

### Usage

```
stoufferIntegrateDiggIt(interactions, from.p = FALSE, pos.nes.only = TRUE)
```

### Arguments

interactions	A list indexed by TF, includes z-scores or p-values for each interacting event
from.p	Integrate p-values or z-scores (default z-scores; from.p = FALSE)
pos.nes.only	Use only positive NES scores to rank proteins (default TRUE)

### Value

A list indexed by TF, a stouffer integrated z-score

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