

# Package ‘mSigAct’

July 29, 2020

**Title** mutational Signature Activity analysis ('mSigAct')

**Version** 2.0.0.9900

**Author** Steve Rozen, Alvin Wei Tian Ng, Arnoud Boot

**Maintainer** Steve Rozen <steverozen@gmail.com>

**Description** Analyze the “activities” of mutational signatures in one or more mutational spectra. 'mSigAct' stands for mutational Signature Activity. mSigAct can estimate (conservatively) whether there is evidence that a particular set of mutational signatures is present in a spectrum. It can also determine a \*minimal\* subset of signatures needed to plausibly reconstruct an observed spectrum. This sparse assign signatures functionality is \*deliberately biased\* toward using as few signatures as possible. This package does not provide all-purpose estimation for signature attribution.

**License** GPL-3

**URL** <https://github.com/steverozen/mSigAct>

**BugReports** <https://github.com/steverozen/mSigAct/issues>

**Encoding** UTF-8

**LazyData** true

**Language** en-US

**Remotes** github::steverozen/PCAWG7,  
github::steverozen/ICAMS@master,  
github::steverozen/mSigBG

**Depends** R (>= 3.5),

**RoxyenNote** 7.1.0

**VignetteBuilder** knitr

**biocViews**

**Imports** ICAMS,  
nloptr,  
stats,  
lsa,  
sets,  
mSigBG

**Suggests** devtools,  
testthat (>= 2.1.0),  
usethis,  
utils,

```
knitr,
BSgenome.Hsapiens.1000genomes.hs37d5,
rmarkdown,
PCAWG7
```

## R topics documented:

AnySigSubsetPresent . . . . .	2
cossim . . . . .	3
DefaultManyOpts . . . . .	4
ObjFnBinomMaxLHMustRound . . . . .	4
ObjFnBinomMaxLHNoRoundOK . . . . .	5
OptimizeExposure . . . . .	5
SignaturePresenceTest . . . . .	6
SparseAssignActivity . . . . .	6
<b>Index</b>	<b>8</b>

---

AnySigSubsetPresent	<i>For each combination of several signatures, determine if the combination is plausibly needed to reconstruct a spectrum.</i>
---------------------	--

---

## Description

Please see **Details**.

## Usage

```
AnySigSubsetPresent(
  spect,
  all.sigs,
  Ha.sigs.indices,
  eval_f = mSigAct::ObjFnBinomMaxLHNoRoundOK,
  m.opts,
  max.mc.cores = NULL
)
```

## Arguments

spect	The spectrum to be reconstructed, as single column matrix or <a href="#">ICAMS</a> catalog.
all.sigs	The matrix or catalog of all signatures of possible interest, which consist of the signatures for $H_0$ and for the alternative hypotheses.
Ha.sigs.indices	An integer vector of the indices of the signatures that are in the various $H_a$ 's.
eval_f	Usually one of <a href="#">ObjFnBinomMaxLHNoRoundOK</a> or <a href="#">ObjFnBinomMaxLHMustRound</a> . For background see <a href="#">nloptr</a> .
m.opts	Controls the numerical search for maximum likelihood reconstructions of spect plus some additional flags; see <a href="#">DefaultManyOpts</a> .
max.mc.cores	The maximum number of cores to use. If NULL defaults to $2^{n_a} - 1$ , where $n_a$ is the length of Ha.sigs.indices – except on MS Windows machines, where it defaults to 1.

## Details

Let  $H_0$  be the likelihood that the signatures specified by `all.sigs[, -Ha.sigs.indicies, drop = FALSE]` generated the observed spectrum, `spect`. For each non-empty subset,  $S$ , of `Ha.sigs.indices` let  $H_a$  be the likelihood that all the signatures in  $H_0$  plus the signatures specified by  $S$  generated `spect`. Return a list with the results of likelihood ratio tests of all  $H_a$ 's against  $H_0$ .

## Value

A list with two elements:

`H0.info` contains the sub-elements

`loglh` The log likelihood associated with  $H_0$ .

`exposure` The signature attributions (exposures) corresponding to the  $H_0$  log likelihood.

`everything.else` A sub-list with information on the output of the numerical optimization that provided `loglh`.

`all.Ha.info` A list with one sub-element for each non-empty subset of `Ha.sigs.indices`. Each sub-element is a list with elements that include

`sigs.added` The identifiers of the (additional) signatures tested.

`p` The  $p$  value for the likelihood-ratio test. This  $p$  value can be NaN when the likelihoods of ( $H_0$  and  $H_a$ ) are both  $-\text{Inf}$ . This can occur if there are mutation classes in the spectra that are  $> 0$  but that have 0 probability in all the available input signatures. This is unlikely to occur, since most spectra have non-0 (albeit very small) probabilities for most mutation classes. This is not an error is using `eval_f = ObjFnBinomMaxLHNoRoundOK`. However, if `p == NaN` when using `eval_f = ObjFnBinomMaxLHMustRound`, switch to `ObjFnBinomMaxLHNoRoundOK`.

`df` The degrees of freedom of the likelihood-ratio test (equal to the number of signatures in `sigs.added`).

WARNING: tests all non-empty subsets of `Ha.sigs.indices`, so will get very slow for large numbers of `Ha.sigs.indices`.

---

cossim

*Cosine similarity with useful argument types..*


---

## Description

Calls `cosine`.

## Usage

```
cossim(v1, v2)
```

## Arguments

`v1` A vector or single-column matrix

`v2` A vector or single-column matrix

---

DefaultManyOpts	<i>Set default options for many functions, especially <a href="#">nloptr</a>.</i>
-----------------	---

---

### Description

Set default options for many functions, especially [nloptr](#).

### Usage

```
DefaultManyOpts()
```

### Value

A list with the following elements

**global.opts** Options for [nloptr](#), q.v., for the global optimization phase.

**local.opts** Options for [nloptr](#), q.v., for the local optimization phase.

**nbinom.size** The dispersion parameter for the negative binomial distribution; smaller is more dispersed. See [NegBinomial](#).

**trace** If > 0 print progress messages.

---

ObjFnBinomMaxLHMustRound	<i>A deprecated negative binomial maximum likelihood objective function.</i>
--------------------------	--

---

### Description

Use [ObjFnBinomMaxLHNoRoundOK](#) instead.

### Usage

```
ObjFnBinomMaxLHMustRound(exp, spectrum, sigs, nbinom.size)
```

### Arguments

exp	The matrix of exposures ("activities").
spectrum	The spectrum to assess.
sigs	The matrix of signatures.
nbinom.size	The dispersion parameter for the negative binomial distribution; smaller is more dispersed. See <a href="#">NegBinomial</a> .

### Details

This function will lead to errors in some situations when the rounded reconstructed signature contains 0s for mutations classes for which the target spectrum is > 0.

---

ObjFnBinomMaxLHNoRoundOK

*The preferred negative binomial maximum likelihood objective function.*


---

### Description

Can be used as the objective function for [SparseAssignActivity](#), [SparseAssignActivity1](#), and [SignaturePresenceTest1](#). (Internally used by [nloptr](#).)

### Usage

```
ObjFnBinomMaxLHNoRoundOK(exp, spectrum, sigs, nbinom.size)
```

### Arguments

exp	The matrix of exposures ("activities").
spectrum	The spectrum to assess.
sigs	The matrix of signatures.
nbinom.size	The dispersion parameter for the negative binomial distribution; smaller is more dispersed. See <a href="#">NegBinomial</a> .

### Value

$-1 * \log(\text{likelihood}(\text{spectrum} \mid \text{reconstruction}))$

[nloptr](#) minimizes the objective function, so the lower the objective function, the better.

---

OptimizeExposure

*Optimize the reconstruction of a spectrum from a set of signatures.*


---

### Description

Optimize the reconstruction of a spectrum from a set of signatures.

### Usage

```
OptimizeExposure(spectrum, sigs, m.opts, eval_f, ...)
```

### Arguments

spectrum	The spectrum to be reconstructed.
sigs	The available signatures.
m.opts	Options that govern the numerical optimization. For documentation see <a href="#">DefaultManyOpts</a> .
eval_f	The objective function for <a href="#">nloptr</a> . We have only tested <a href="#">ObjFnBinomMaxLHNoRoundOK</a> and <a href="#">ObjFnBinomMaxLHMustRound</a> .
...	Additional arguments for eval_f.
	Returns a list with elements

`loglh` The log likelihood of the best solution (set of exposures) found. For a more general objective function this might be NULL.

`exposure` The vector of exposures that generate `loglh`, i.e. the number of mutations ascribed to each signature.

`obj.fn.value` The objective function value associated with exposure.

`everything.else` Everything returned by the function [Nloptr1Tumor](#).

---

`SignaturePresenceTest` *Test whether a given signature is plausibly present in a catalog*

---

## Description

Test whether a given signature is plausibly present in a catalog

## Usage

```
SignaturePresenceTest(
  spectra,
  sigs,
  target.sig.index,
  m.opts = NULL,
  eval_f,
  mc.cores = 10
)
```

## Arguments

<code>spectra</code>	The catalog (matrix) to analyze. This could be an <a href="#">ICAMS</a> catalog or a numerical matrix.
<code>sigs</code>	A catalog of signatures from which to choose. This could be an <a href="#">ICAMS</a> catalog or a numerical matrix.
<code>target.sig.index</code>	The index of the signature the presence of which we want to test.
<code>m.opts</code>	If NULL use the return from calling <a href="#">DefaultManyOpts</a> . For documentation see <a href="#">DefaultManyOpts</a> .
<code>eval_f</code>	See <a href="#">nloptr</a> .
<code>mc.cores</code>	Number of cores to use. Always silently changed to 1 on Microsoft Windows.

---

`SparseAssignActivity` *Find known signatures that can most sparsely reconstruct each spectrum in a catalog.*

---

## Description

Find known signatures that can most sparsely reconstruct each spectrum in a catalog.

**Usage**

```
SparseAssignActivity(  
  spectra,  
  sigs,  
  max.level = 5,  
  p.thresh = 0.05,  
  eval_f = ObjFnBinomMaxLHNoRoundOK,  
  m.opts = NULL,  
  num.parallel.samples = 5,  
  mc.cores.per.sample = NULL  
)
```

**Arguments**

spectra	The spectra (multiple spectra) to be reconstructed.
sigs	The known signatures to use in reconstruction.
max.level	The largest number of signatures to consider discarding in the reconstruction.
p.thresh	The maximum p value based on which it is decided to retain a signature in a reconstruction.
eval_f	The objective function for <a href="#">nloptr</a> .
m.opts	For documentation see <a href="#">DefaultManyOpts</a> .
num.parallel.samples	The (maximum) number of samples to run in parallel; each sample in turn can require multiple cores, as governed by <code>mc.cores.per.sample</code> .
mc.cores.per.sample	The maximum number of cores to use for each sample. If NULL defaults to $2^{\text{max.level}}$ – except on MS Windows machines, where it defaults to 1.

**Value**

A list with the inferred exposure matrix as element exposure.

# Index

AnySigSubsetPresent, [2](#)

cosine, [3](#)

coessim, [3](#)

DefaultManyOpts, [2](#), [4](#), [5–7](#)

ICAMS, [2](#), [6](#)

NegBinomial, [4](#), [5](#)

nloptr, [2](#), [4–7](#)

Nloptr1Tumor, [6](#)

ObjFnBinomMaxLHMustRound, [2](#), [4](#), [5](#)

ObjFnBinomMaxLHNoRoundOK, [2](#), [4](#), [5](#), [5](#)

OptimizeExposure, [5](#)

SignaturePresenceTest, [6](#)

SignaturePresenceTest1, [5](#)

SparseAssignActivity, [5](#), [6](#)

SparseAssignActivity1, [5](#)