# Package ‘ibelief’

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**Type** Package

**Title** Belief Function Implementation

**Version** 1.3.1

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**Description** Some basic functions to implement belief functions including: transformation between belief functions using the method introduced by Philippe Smets <arXiv:1304.1122>, evidence combination, evidence discounting, decision-making, and constructing masses. Currently, thirteen combination rules and six decision rules are supported. It can also be used to generate different types of random masses when working on belief combination and conflict management.

**LazyData** FALSE

**Depends** R (>= 3.2.1)

**Imports** stats



**NeedsCompilation** no

**Repository** CRAN

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**RoxygenNote** 6.1.1

## R topics documented:

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ConflictTable *Computing the conflict table*

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## Description

Computing the table of conflict for $nbexperts$ masses and $natoms = round(\log 2(lm))$ classes. This function gives the conflict focal set combinations for the $nbexperts$ masses. The focal sets are labeled in natural order, e.g, number 2 denotes $\omega_1$, and number 4 donoets $\{\omega_1, \omega_2\}$ if the discernment frame is $\{\omega_1, \omega_2, \ldots, \omega_n\}$. Note that only one case of conflict is given. For example, if expert 1 says 3, and expert 2 says 2 the function returns `matrix(c(2,3),,1)` and if expert 1 says 2, and expert 2 says 3 the function also returns `matrix(c(2,3),,1)`.

## Usage

```
ConflictTable(lm, nbexperts)
```

## Arguments

| | |
|---|---|
| `lm` | The length of the power set of the discernment frame, i.e., $2^{natoms}$ |
| `nbexperts` | The number of experts (masses) |

## Value

Matrix with $nbexperts$ rows and number of conflict focal set combinations columns.

## See Also

PCR6, decisionDST

## Examples

```
## The conflict table for two experts in a discernment frame with three elements
 ConflictTable(2^3,2)
##The conflict table for three experts in a discernment frame with four elements
 ConflictTable(2^4,3)
```

decisionDST *Decision Rules*

## Description

Different rules for making decisions in the framework of belief functions

## Usage

```
decisionDST(mass, criterion, r = 0.5, sDec = 1:nrow(mass),
  D = Dcalculus(nrow(mass)))
```

## Arguments

| | |
|---|---|
| `mass` | The matrix containing the masses. Each column represents a piece of mass. |
| `criterion` | The decision baseline:<br>criterion=1 maximum of the plausibility<br>criterion=2 maximum of the credibility<br>criterion=3 maximum of the credibility with rejection<br>criterion=4 maximum of the pignistic probability<br>criterion=5 Appriou criterion (decision onto $2^\Theta$)<br>criterion=6 Distance criterion (decision onto a given subset (sDec) of $2^\Theta$) |
| `r` | The parameter in BayesianMass function. If criterion 5 is used, it should be given. Otherwise it will be set to the default value 0.5. |
| `sDec` | The parameter for the set on which we want to decide. It should be a subset of $\{1,2,3,...,2^n\}$, where $n$ is the number of elements in $\Theta$. If criterion 6 is used, it should be given; Otherwise it will be set as the default value $2^\Theta$. |
| `D` | The parameter for the used matrix in Jousselme distance. If criterion 6 is used, it should be given. Otherwise it will be set as default Otherwise it will be calculated. |

## Value

The decision vector. E.g., in classification problem, class labels.

## Examples

```
m1=c(0,0.4, 0.1, 0.2, 0.2, 0, 0, 0.1);
m2=c(0,0.2, 0.3, 0.1, 0.1, 0, 0.2, 0.1);
m3=c(0.1,0.2, 0, 0.1, 0.1, 0.1, 0, 0.3);

m3d=discounting(m3,0.95);

M_comb_Smets=DST(cbind(m1,m2,m3d),1);
M_comb_PCR6=DST(cbind(m1,m2),8);
```

```
class_fusion=decisionDST(M_comb_Smets,1)
class_fusion=decisionDST(M_comb_PCR6,1)
class_fusion=decisionDST(M_comb_Smets,5,0.5)
class_fusion=decisionDST(cbind(M_comb_Smets,M_comb_PCR6),1)
sDec<-c(2,3,4)
class_fusion=decisionDST(M_comb_Smets,6, sDec = sDec)
```

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`discounting` *Discounting masses*

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## Description

Discount masses using given factors

## Usage

```
discounting(MassIn, alpha)
```

## Arguments

| | |
|---|---|
| `MassIn` | Matrix with $nb$ columns and $2^n$ rows. Parameter $n$ is the number of elements in the discernment frame and $nb$ is the number of experts. Each column is a bba. If there is only one bba, the input could be a vector with length $2^n$. |
| `alpha` | Discounting factor. A number or a vector with length of `ncol(MassIn)`. If it is a number, all the bbas will be discounted using the same factor. If it is a vector with length `ncol{MassIn}`, the bbas will be discounted using the corresponding factor. |

## Value

Mass matrix with the same dimension as MassIn. The discounted masses, each column is a piece of mass. If the input is a vector, the output is also a vector.

## Examples

```
## The conflict table for two experts in a discernment frame with three elements
m1=c(0,0.4, 0.1, 0.2, 0.2, 0, 0, 0.1);
m2=c(0,0.2, 0.3, 0.1, 0.1, 0, 0.2, 0.1);
discounting(m1,0.95)
# if only one factor is given, all the masses are discounted using the same factor
discounting(cbind(m1,m2),0.95)
# if the factor vector is given, the masses are discounted using the corresponding factor
discounting(cbind(m1,m2),c(0.95,0.9))
```

DST *Combination rules*

## Description

Different rules to combine masses

## Usage

```
DST(MassIn, criterion, TypeSSF = 0)
```

## Arguments

| | |
|---|---|
| `MassIn` | The matrix containing the masses. Each column represents a piece of mass. |
| `criterion` | The combination criterion:<br>criterion=1 Smets criterion (conjunctive combination rule)<br>criterion=2 Dempster-Shafer criterion (normalized)<br>criterion=3 Yager criterion<br>criterion=4 Disjunctive combination criterion<br>criterion=5 Dubois criterion (normalized and disjunctive combination)<br>criterion=6 Dubois and Prade criterion (mixt combination), only for Bayesian masses whose focal elements are singletons<br>criterion=7 Florea criterion<br>criterion=8 PCR6<br>criterion=9 Cautious Denoeux Min for functions non-dogmatics<br>criterion=10 Cautious Denoeux Max for separable masses<br>criterion=11 Hard Denoeux for functions sub-normal<br>criterion=12 Mean of the bbas<br>criterion=13 LNS rule, for separable masses<br>criterion=131 LNSa rule, for separable masses |
| `TypeSSF` | The parameter of LNS rule (criterion = 13) and LNSa rule (criterion = 131). If TypeSSF = 0, it is not a SSF, the general case. If TypeSSF = 1, a SSF with a singleton as a focal element. If TypeSSF = 2, a SSF with any subset of $\Theta$ as a focal element. |

## Value

The combined mass vector. One column.

## Examples

```
m1=c(0,0.4, 0.1, 0.2, 0.2, 0, 0, 0.1);
m2=c(0,0.2, 0.3, 0.1, 0.1, 0, 0.2, 0.1);
m3=c(0.1,0.2, 0, 0.1, 0.1, 0.1, 0, 0.3);
```

```
m3d=discounting(m3,0.95);

M_comb_Smets=DST(cbind(m1,m2,m3d),1);
M_comb_Smets
M_comb_PCR6=DST(cbind(m1,m2),8);
M_comb_PCR6
M_comb_LNS = DST(cbind(m1,m2),13);
M_comb_LNS
M_comb_LNSa = DST(cbind(m1,m2),131);
M_comb_LNSa

n1 = 5
ThetaSize = 3
mass_mat = matrix(0, 2^ThetaSize, n1 + 1);
mass_mat[2, 1 : n1] = c(0.12, 0.16, 0.15, 0.11, 0.14)
mass_mat[3, n1 + 1] = 0.95;
mass_mat[8, ] = 1 - colSums(mass_mat)
mass_ssf_mat = mass_mat[c(2^(1:ThetaSize-1)+1, 8), ]
# the following three functions could produce the same results
DST(mass_mat, 13)
DST(mass_mat, 13, TypeSSF = 2)
DST(mass_ssf_mat, 13, TypeSSF = 1)
```

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`FMTfunctions` *Fast Mobius Transform*

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## Description

Use the Fast Mobius Transformation to convert one measure to another one

## Usage

```
beltob(InputVec)
beltom(InputVec)
beltopl(InputVec)
beltoq(InputVec)
btobel (InputVec)
btom(InputVec)
btopl (InputVec)
btoq (InputVec)
btov(InputVec)
mtob (InputVec)
mtobel(InputVec)
mtobetp(InputVec)
mtonm(InputVec)
mtopl(InputVec)
mtoq (InputVec)
mtov (InputVec)
```

```
mtow (InputVec)
pltob(InputVec)
pltobel(InputVec)
pltom(InputVec)
pltoq (InputVec)
qtom (InputVec)
qtow(InputVec)
vtob(InputVec)
vtom (InputVec)
wtom (InputVec)
wtoq(InputVec)
```

## Arguments

| | |
|---|---|
| InputVec | the measure to transform, e.g., mass, bel function, plausibility function, etc. |

## Value

The associated converted new measure

## Examples

```
Mass=RandomMass(nbFocalElement=3, ThetaSize=3, nbMass=4, Type=1)
mass=mtobel(Mass)
qvec=mtoq(mass)
mass=qtom(qvec)
```

---

# LCPrincple *Least-Committed Principle for creating bbas*

---

## Description

Least-Committed Principle for creating bbas

## Usage

```
LCPrincple(Mat)
```

## Arguments

| | |
|---|---|
| Mat | matrix, $m \times k$, $m$ is the number of sources, $k$ is the length of probability vectors. If the number of sources is 1, the input probability could be a vector. |

## Value

mass_bba matrix, $m \times 2^k$, each column is a bba. If there is only one source, the output is a bba vector.

### Examples

```
pro1 = c(0.25, 0.25, 0.25, 0.25);
pro2 = c(0.3, 0.2, 0.2, 0.1);
pro3 = rbind(pro1, pro2);

LCPrincple(pro1)
LCPrincple(pro2)
LCPrincple(pro3)
```

---

## PCR6 *PCR6 rule*

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### Description

PCR6 combination rule

### Usage

```
PCR6(MassIn, TabConflict)
```

### Arguments

| | |
|---|---|
| MassIn | Matrix with $2^n$ rows and $nb$ columns. Parameter $n$ is the number of classes (or the length of discernment frame) and $nb$ is the number of experts. |
| TabConflict | The conflict table, which can be got using the function $ConflictTable$ |

### Value

Two parts:

| | |
|---|---|
| Mass | matrix with $2^n$ rows and one column, the combined mass |
| conf | a number, total conflict |

### See Also

ConflictTable, decisionDST

### Examples

```
## The conflict table for two experts in a discernment frame with three elements
TabConflict=ConflictTable(2^3,2)
m1=c(0,0.4, 0.1, 0.2, 0.2, 0, 0, 0.1);
m2=c(0,0.2, 0.3, 0.1, 0.1, 0, 0.2, 0.1);
PCR6(cbind(m1,m2),TabConflict)
```

RandomMass *Generating masses*

### Description

Different ways to generate masses

### Usage

```
RandomMass(nbFocalElement, ThetaSize, nbMass, Type, singleton, Include)
```

### Arguments

`nbFocalElement` The number of focal elements

`ThetaSize` The length of the discernment frame $\Theta$

`nbMass` The number of masses to generate

`Type` Which kind of mass to generate:

Type=1 for focal elements can be everywhere

Type=2 for focal elements can not be on the emptyset

Type=3 for no dogmatic mass : one focal element is on $\Theta$ (ignorance)

Type=4 for no dogmatic mass : one focal element is on $\Theta$ (ignorance) and no focal elements are on the emptyset

Type=5 for all the focal elements are the singletons

Type=6 for all the focal elements are the singletons and on $\Theta$ (ignorance)

Type=7 for all the focal elements are the singletons and on $\Theta$ (ignorance), but not on all the singletons

Type=8 On only one defined singleton, on $\Theta$ (ignorance), and others

Type=9 On one defined singleton, on other singletons and on $\Theta$ (ignorance)

Type=10 On one focal element contain a defined singleton, on other focal elements and on $\Theta$ (ignorance)

Type=11 On one focal element contain a defined singleton, on other focal elements (not emptyset) and on $\Theta$ (ignorance)

Type=12 For consonant bba with nested focal elements, all of them contain a defined singleton. If parameter singleton is set to 0, the defined singleton can be any one of the element in the discernment framework. Note that the defined singleton may not be one of the focal elements.

Type=13 For non-dogmatic consonant bba with nested focal elements, all of them contain a defined singleton. Different from Type 12, the mass given to $\Theta$ must be positive (non-dogmatic). If parameter singleton is set to 0, the defined sigleton can be any one of the element in the discernment framework. Note that the defined singleton is one of the focal elements.

Type=14 For non-dogmatic consonant bba with nested focal elements, all of them contain a defined singleton. The focal elements must contain the defined sigleton and $\Theta$. If parameter singleton is set to 0, the defined sigleton can be any one of the element in the discernment framework. Note that the difined singleton may not be the focal elements.

Type=15 Random SSFs with Include and $\Theta$ as focal elements. Generally, parameter Include shoud have the same length as nbMass. If the lenght of parameter Include is 1, all the random masses have the same focal elements. If Include is missing, then the focal element (except $\Theta$) could be randomly set to be any subset of $\Theta$ except the empty set and the total ignorance.

`singleton` The singleton element (with only one element) in the focal sets. It should be given a number from 1 to $ThetaSize$ if Type is from 5 to 11.

`Include` The natrual id of the focal element (not $\Theta$) of SSFs

## Value

The generated mass matrix. Each column represents a piece of mass

## Examples

```
RandomMass(nbFocalElement=3, ThetaSize=3, nbMass=4, Type=1)
RandomMass(nbFocalElement=3, ThetaSize=4, nbMass=4, Type=3)
RandomMass(nbFocalElement=4, ThetaSize=4, nbMass=4, Type=5,singleton=2)
RandomMass(nbFocalElement=4, ThetaSize=4, nbMass=4, Type=10,singleton=2)
RandomMass(nbFocalElement=4, ThetaSize=4, nbMass=4, Type=13,singleton=2)
RandomMass(nbFocalElement=2, ThetaSize=4, nbMass=4, Type=14,singleton=2)
RandomMass(ThetaSize=4, nbMass=4, Type=15, Include=2)
```

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