

# Package ‘ibelief’

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**Type** Package

**Title** Belief Function Implementation

**Version** 1.2

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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 [cs.AI]), evidence combination, evidence discounting, decision-making, and constructing masses. Currently, thirteen combination rules and five 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

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**Imports** stats

**License** GPL (>= 2)

**NeedsCompilation** no

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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 denotes  $\{\omega_1, \omega_2\}$  if the discernment frame is  $\{\omega_1, \omega_2, \dots, \omega_n\}$ . 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)
```

**Arguments**

mass	The matrix containing the masses. Each column represents a piece of mass.
criterion	The decision baseline: criterion=1 maximum of the plausibility criterion=2 maximum of the credibility criterion=3 maximum of the credibility with rejection criterion=4 maximum of the pignistic probability criterion=5 Appriou criterion (decision onto $2^\Theta$ )
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.

**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)

```

---

discounting

*Discounting masses*


---

**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 $ncol(\text{MassIn})$ . If it is a number, all the bbas will be discounted using the same factor. If it is a vector with length $ncol\{\text{MassIn}\}$ , 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: criterion=1 Smets criterion (conjunctive combination rule) criterion=2 Dempster-Shafer criterion (normalized) criterion=3 Yager criterion criterion=4 Disjunctive combination criterion criterion=5 Dubois criterion (normalized and disjunctive combination) criterion=6 Dubois and Prade criterion (mixt combination), only for Bayesian masses whose focal elements are singletons

	<p>criterion=7 Florea criterion</p> <p>criterion=8 PCR6</p> <p>criterion=9 Cautious Denoeux Min for functions non-dogmatics</p> <p>criterion=10 Cautious Denoeux Max for separable masses</p> <p>criterion=11 Hard Denoeux for functions sub-normal</p> <p>criterion=12 Mean of the bbas</p> <p>criterion=13 LNS rule, for separable masses</p> <p>criterion=131 LNSa rule, for separable masses</p>
TypeSSF	<p>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 <math>\Theta</math> as a focal element.</p>

### 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)

```

**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=mtog(mass)
mass=qtom(qvec)
```

---

LCPrinciple

*Least-Committed Principle for creating bbas*

---

**Description**

Least-Committed Principle for creating bbas

**Usage**

```
LCPrinciple(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);
```

```
LCPrinciple(pro1)
LCPrinciple(pro2)
LCPrinciple(pro3)
```

---

PCR6

*PCR6 rule*

---

### 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 singleton 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 singleton and $\Theta$ . If parameter singleton is set to 0, the defined singleton 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 <i>Theta.Size</i> 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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