Package ‘FuzzyMCDM’

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Description Implementation of several MCDM methods for fuzzy data (triangular fuzzy numbers) for decision making problems. The methods that are implemented in this package are Fuzzy TOPSIS (with two normalization procedures), Fuzzy VIKOR, Fuzzy Multi-MOORA and Fuzzy WASPAS. In addition, function MetaRanking() calculates a new ranking from the sum of the rankings calculated, as well as an aggregated ranking.

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FuzzyMMOORA *Implementation of Fuzzy MULTIMOORA Method for Multi-Criteria Decision Making Problems.*

Description

The FuzzyMMOORA function implements both the Fuzzy Multi-Objetive Optimization by Ration Analysis (MOORA) and the Fuzzy "Full Multiplicative Form" (Fuzzy MULTIMOORA).

Usage

```
FuzzyMMOORA(decision, weights, cb)
```

Arguments

decision	The decision matrix (*m* x (*n**3)) with the values of the *m* alternatives, for the *n* criteria, and multiplied by 3 since they are triangular fuzzy numbers.
weights	A vector of length *n**3, containing the fuzzy weights for the criteria.
cb	A vector of length *n*. Each component is either `cb(i)='max'` if the *i-th* criterion is benefit or `cb(i)='min'` if the *i-th* criterion is a cost.

Value

FuzzyMMOORA returns a data frame which contains the scores and the four rankings calculated (Ratio System, Reference Point, Multiplicative Form and Multi-MOORA ranking).

References

Balezentis, T. and Balezentis, A. A Survey on Development and Applications of the Multi-criteria Decision Making Method MULTIMOORA. Journal of Multi-Criteria Decision Analysis, 21(3-4), 209-222, 2014.

Examples

```
d <- matrix(c(0.63,0.42,0.63,0.67,0.8,0.59,0.8,0.84,0.92,0.75,0.92,0.92,0.29,0.71,0.75,
0.42,0.46,0.88,0.92,0.59,0.63,1,1,0.71,0.75,0.59,0.42,0.42,0.92,0.75,0.58,0.59,1,0.88,
0.76,0.75,0.59,0.71,0.42,0.33,0.75,0.88,0.58,0.51,0.88,0.96,0.71,0.67,0.5,0.67,0.67,
0.67,0.67,0.84,0.84,0.84,0.84,0.92,0.96,0.96,0.67,0.54,0.54,0.25,0.84,0.71,0.71,0.42,
0.96,0.88,0.88,0.59,0.67,0.71,0.42,0.25,0.84,0.88,0.59,0.42,0.96,0.96,0.75,0.58,0.54,
0.625,0.625,0.295,0.705,0.79,0.795,0.46,0.88,0.92,0.875,0.62),nrow=4,ncol=24)
w <- c(1/24,1/24,1/24,1/24,1/24,1/24,1/24,1/24,1/24,1/24,1/24,1/24,1/24,1/24,1/24,1/24,
1/24,1/24,1/24,1/24,1/24,1/24,1/24,1/24)
cb <- c('max','max','max','max','max','max','max','max')
FuzzyMMOORA(d,w,cb)
```

`FuzzyTOPSISLinear` *Implementation of Fuzzy TOPSIS Method for Multi-Criteria Decision Making Problems.*

Description

The `FuzzyTOPSISLinear` function implements the Fuzzy Technique for Order of Preference by Similarity to Ideal Solution (Fuzzy TOPSIS) Method with de linear transformation (maximum) as normalization method.

Usage

```
FuzzyTOPSISLinear(decision, weights, cb)
```

Arguments

`decision`	The decision matrix (*m* x (*n**3)) with the values of the *m* alternatives, for the *n* criteria, and multiplied by 3 since they are triangular fuzzy numbers.
`weights`	A vector of length *n**3, containing the fuzzy weights for the criteria.
`cb`	A vector of length *n*. Each component is either `cb(i)='max'` if the *i-th* criterion is benefit or `cb(i)='min'` if the *i-th* criterion is a cost.

Value

`FuzzyTOPSISLinear` returns a data frame which contains the score of the R index and the ranking of the alternatives.

References

Chen, C.T. Extensions of the TOPSIS for group decision-manking under fuzzy environment. Fuzzy Sets and Systems, 114, 1-9, 2000.

Examples

```
d <- matrix(c(5.7,6.3,6.3,7.7,8.3,8,9.3,9.7,9,5,9,7,7,10,9,9,10,10,5.7,8.3,7,7.7,9.7,9,
9,10,10,8.33,9,7,9.67,10,9,10,10,10,3,7,6.3,5,9,8.3,7,10,9.7),nrow=3,ncol=15)
w <- c(0.7,0.9,1,0.9,1,1,0.77,0.93,1,0.9,1,1,0.43,0.63,0.83)
cb <- c('max','max','max','max','max')
FuzzyTOPSISLinear(d,w,cb)
```

FuzzyTOPSISVector — *Implementation of Fuzzy TOPSIS Method for Multi-Criteria Decision Making Problems.*

Description

The FuzzyTOPSISVector function implements the Fuzzy Technique for Order of Preference by Similarity to Ideal Solution (Fuzzy TOPSIS) Method with the vector normalization procedure.

Usage

```
FuzzyTOPSISVector(decision, weights, cb)
```

Arguments

decision	The decision matrix (*m* x (*n**3)) with the values of the *m* alternatives, for the *n* criteria, and multiplied by 3 since they are triangular fuzzy numbers.
weights	A vector of length *n**3, containing the fuzzy weights for the criteria.
cb	A vector of length *n*. Each component is either cb(i)='max' if the *i-th* criterion is benefit or cb(i)='min' if the *i-th* criterion is a cost.

Value

FuzzyTOPSISVector returns a data frame which contains the score of the R index and the ranking of the alternatives.

References

Garcia-Cascales, M. S.; Lamata, M. T. and Sanchez-Lozano, J. M. Evaluation of photovoltaic cells in a multi-criteria decision making process. Annals of Operations Research, 199(1), 373-391, 2012.

Examples

```
d <- matrix(c(0.68,0.4,0.6,0.2,0.4,1.44,0.67,0.9,0.45,0.6,2.2,0.95,1.2,0.7,0.8,18,8,8,
25,6,21,11.5,11.5,32.5,9,24,15,15,40,12,9,0.66,0.66,0,0,10,2.33,2.33,0.66,0.33,10,4.33,
4.33,2.33,1.66,5,1.33,1.33,5.66,1,7,3,3,7.66,2,8.66,5,5,9.33,3.66,2.33,0.66,0.33,1.33,
1.66,4.33,2,1.33,3,2.66,6.33,3.66,3,5,4.33),nrow=5,ncol=15)
w <- c(0.189,0.214,0.243,0.397,0.432,0.462,0.065,0.078,0.096,0.068,0.084,0.106,0.174,
0.190,0.207)
cb <- c('min','max','max','min','min')
FuzzyTOPSISVector(d,w,cb)
```

FuzzyVIKOR *Implementation of Fuzzy VIKOR Method for Multi-Criteria Decision Making Problems.*

Description

The FuzzyVIKOR function implements the Fuzzy "VIseKriterijumska Optimizacija I Kompromisno Resenje" (Fuzzy VIKOR) Method.

Usage

```
FuzzyVIKOR(decision, weights, cb, v)
```

Arguments

decision	The decision matrix (*m* x (*n**3)) with the values of the *m* alternatives, for the *n* criteria, and multiplied by 3 since they are triangular fuzzy numbers.
weights	A vector of length *n**3, containing the fuzzy weights for the criteria.
cb	A vector of length *n*. Each component is either `cb(i)='max'` if the *i-th* criterion is benefit or `cb(i)='min'` if the *i-th* criterion is a cost.
v	A value in [0,1]. It is used in the calculation of the Q index.

Value

FuzzyVIKOR returns a data frame which contains the score of the S, R and Q indixes and the ranking of the alternatives according to Q index.

References

Opricovic, S. Fuzzy VIKOR with an application to water resources planning. Expert Systems with Applications, 38(10), 12983-12990, 2011.

Examples

```
d <- matrix(c(38,20,24.58,44.54,33.33,33.86,40.01,21.06,25.87,46.89,33.33,33.86,48,24,
29.75,56.27,43.33,42.32,3.26,2.57,2.82,2.46,2.25,2.47,4.08,2.87,2.97,2.73,2.5,2.74,4.08,
2.87,2.97,2.73,2.62,2.85,43,6,38,60,6,6,47,6,42,62,6,6,48,6,50,68,6,6,10,10,1,0,2,3,10,
10,1,0,2,3,10,10,1,0,2,3),nrow=6,ncol=12)
w <- c(1/12,1/12,1/12,1/12,1/12,1/12,1/12,1/12,1/12,1/12,1/12,1/12)
cb <- c('min','max','min','min')
v <- 0.625
FuzzyVIKOR(d,w,cb,v)
```

FuzzyWASPAS — *Implementation of Fuzzy WASPAS Method for Multi-Criteria Decision Making Problems.*

Description

The FuzzyWASPAS function implements the Fuzzy Weighted Aggregated Sum Product ASsessment (Fuzzy WASPAS) Method.

Usage

```
FuzzyWASPAS(decision, weights, cb, lambda)
```

Arguments

decision	The decision matrix (*m* x (*n**3)) with the values of the *m* alternatives, for the *n* criteria, and multiplied by 3 since they are triangular fuzzy numbers.
weights	A vector of length *n**3, containing the fuzzy weights for the criteria.
cb	A vector of length *n*. Each component is either `cb(i)='max'` if the *i-th* criterion is benefit or `cb(i)='min'` if the *i-th* criterion is a cost.
lambda	A value in [0,1]. It is used in the calculation of the W index.

Value

FuzzyWASPAS returns a data frame which contains the score of the W index and the ranking of the alternatives.

References

Turskis, Z. and Zavadskas, E. K. and Antucheviciene, J. and Kosareva, N. A Hybrid Model Based on Fuzzy AHP and Fuzzy WASPAS for Construction Site Selection. International Journal of Computers Communications & Control, 10(6), 873-888, 2015.

Examples

```
d <- matrix(c(0.5,0.6,0.6,0.6,0.6,0.7,0.7,0.7,0.7,0.8,0.8,0.8,0.6,0.6,0.8,0.5,0.7,0.7,
0.9,0.6,0.8,0.8,1,0.7,0.8,0.5,0.6,0.6,0.9,0.6,0.7,0.7,1,0.7,0.8,0.8,0.5,0.6,0.5,0.4,0.6,
0.7,0.6,0.5,0.7,0.8,0.7,0.6,0.8,0.7,0.6,0.5,0.9,0.8,0.7,0.6,1,0.9,0.8,0.7,0.5,0.8,0.6,
0.8,0.6,0.9,0.7,0.9,0.7,1,0.8,1,0.4,0.5,0.8,0.7,0.5,0.6,0.9,0.8,0.6,0.7,1,0.9,0.5,0.4,
0.4,0.5,0.6,0.5,0.5,0.6,0.7,0.6,0.6,0.7),nrow=4,ncol=24)
w <- c(0.21,0.28,0.35,0.16,0.20,0.23,0.14,0.16,0.17,0.09,0.12,0.17,0.07,0.08,0.12,0.05,
0.06,0.09,0.03,0.05,0.07,0.01,0.03,0.06)
cb <- c('max','max','max','max','max','max','max','max')
lambda <- 0.49
FuzzyWASPAS(d,w,cb,lambda)
```

`MetaRanking` *Implementation of MetaRanking function for Multi-Criteria Decision Making Problems.*

Description

The `MetaRanking` function internally calls functions `FuzzyMMOORA`, `FuzzyTOPSISLinear`, `FuzzyTOPSISVector`, `FuzzyVIKOR` and `FuzzyWASPAS` and then calculates a sum of the their rankings and an aggregated ranking by applying the `RankAggreg` package.

Usage

```
MetaRanking(decision, weights, cb, lambda, v)
```

Arguments

`decision`	The decision matrix (m x n) with the values of the m alternatives, for the n criteria.
`weights`	A vector of length n, containing the weights for the criteria. The sum of the weights has to be 1.
`cb`	A vector of length n. Each component is either `cb(i)='max'` if the *i-th* criterion is benefit or `cb(i)='min'` if the *i-th* criterion is a cost.
`lambda`	A value in [0,1]. It is used in the calculation of the W index for WASPAS method.
`v`	A value in [0,1]. It is used in the calculation of the Q index for VIKOR method.

Value

`MetaRanking` returns a data frame which contains the rankings of the Fuzzy Multi-MOORA, Fuzzy TOPSIS (linear transformation and vectorial normalization), Fuzzy VIKOR, Fuzzy WASPAS Methods and the MetaRankings of the alternatives.

Examples

```
d <- matrix(c(0.68,0.4,0.6,0.2,0.4,1.44,0.67,0.9,0.45,0.6,2.2,
0.95,1.2,0.7,0.8,18,8,8,25,6,21,11.5,11.5,32.5,9,24,15,15,40,
12,9,0.66,0.66,0,0,10,2.33,2.33,0.66,0.33,10,4.33,4.33,2.33,
1.66,5,1.33,1.33,5.66,1,7,3,3,7.66,2,8.66,5,5,9.33,3.66,2.33,
0.66,0.33,1.33,1.66,4.33,2,1.33,3,2.66,6.33,3.66,3,5,4.33),
nrow=5,ncol=15)
w <- c(0.189,0.214,0.243,0.397,0.432,0.462,0.065,0.078,0.096,
0.068,0.084,0.106,0.174,0.190,0.207)
cb <- c('min','max','max','min','min')
lambda <- 0.5
v <- 0.5
MetaRanking(d,w,cb,lambda,v)
```

Index