

Package ‘MCDA’

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Title Support for the Multicriteria Decision Aiding Process

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Description

Support for the analyst in a Multicriteria Decision Aiding (MCDA) process with algorithms, preference elicitation and data visualisation functions. Sébastien Bigaret, Richard Hodgett, Patrick Meyer, Tatyana Mironova, Alexandru Olteanu (2017) Supporting the multi-criteria decision aiding process : R and the MCDA package, Euro Journal On Decision Processes, Volume 5, Issue 1 - 4, pages 169 - 194 <doi:10.1007/s40070-017-0064-1>.

Imports Rglpk, glpkAPI, methods, RColorBrewer, combinat, triangle, plyr, ggplot2

Suggests Rgraphviz, cplexAPI

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URL <https://github.com/paterijk/MCDA>

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 additiveValueFunctionElicitation

Elicitation of a general additive value function.

Description

Elicits a general additive value function from a ranking of alternatives.

Usage

```
additiveValueFunctionElicitation(performanceTable,
                                criteriaMinMax, epsilon,
                                alternativesRanks = NULL,
                                alternativesPreferences = NULL,
                                alternativesIndifferences = NULL,
                                alternativesIDs = NULL,
                                criteriaIDs = NULL)
```

Arguments

performanceTable	Matrix or data frame containing the performance table. Each row corresponds to an alternative, and each column to a criterion. Rows (resp. columns) must be named according to the IDs of the alternatives (resp. criteria).
criteriaMinMax	Vector containing the preference direction on each of the criteria. "min" (resp. "max") indicates that the criterion has to be minimized (maximized). The elements are named according to the IDs of the criteria.
epsilon	Numeric value containing the minimal difference in value between two consecutive alternatives in the final ranking.
alternativesRanks	Optional vector containing the ranks of the alternatives. The elements are named according to the IDs of the alternatives. If not present, then at least one of alternativesPreferences or alternativesIndifferences should be given.
alternativesPreferences	Optional matrix containing the preference constraints on the alternatives. Each line of the matrix corresponds to a constraint of the type alternative a is strictly preferred to alternative b. If not present, then either alternativesRanks or alternativesIndifferences should be given.
alternativesIndifferences	Optional matrix containing the indifference constraints on the alternatives. Each line of the matrix corresponds to a constraint of the type alternative a is indifferent to alternative b. If not present, then either alternativesRanks or alternativesPreferences should be given.
alternativesIDs	Vector containing IDs of alternatives, according to which the data should be filtered.
criteriaIDs	Vector containing IDs of criteria, according to which the data should be filtered.

Value

The function returns a list structured as follows :

optimum	The value of the objective function.
valueFunctions	A list containing the value functions which have been determined. Each value function is defined by a matrix of breakpoints, where the first row corresponds to the abscissa (row labelled "x") and where the second row corresponds to the ordinate (row labelled "y").
overallValues	A vector containing the overall values of the input alternatives.
ranks	A vector containing the ranks of the alternatives obtained via the elicited value functions. Ties method = "min".
Kendall	Kendall's tau between the input ranking and the one obtained via the elicited value functions.
errors	The errors (sigma) which have to be added to the overall values of the alternatives in order to respect the input ranking.

References

Based on the UTA algorithm (E. Jacquet-Lagrange, J. Siskos, Assessing a set of additive utility functions for multicriteria decision-making, the UTA method, European Journal of Operational Research, Volume 10, Issue 2, 151–164, June 1982) except that the breakpoints of the value functions are the actual performances of the alternatives on the criteria.

Examples

```
# -----
# ranking some cars (from original article on UTA by Siskos and Lagreze, 1982)

# the separation threshold

epsilon <-0.01

# the performance table

performanceTable <- rbind(
  c(173, 11.4, 10.01, 10, 7.88, 49500),
  c(176, 12.3, 10.48, 11, 7.96, 46700),
  c(142, 8.2, 7.30, 5, 5.65, 32100),
  c(148, 10.5, 9.61, 7, 6.15, 39150),
  c(178, 14.5, 11.05, 13, 8.06, 64700),
  c(180, 13.6, 10.40, 13, 8.47, 75700),
  c(182, 12.7, 12.26, 11, 7.81, 68593),
  c(145, 14.3, 12.95, 11, 8.38, 55000),
  c(161, 8.6, 8.42, 7, 5.11, 35200),
  c(117, 7.2, 6.75, 3, 5.81, 24800)
)

rownames(performanceTable) <- c(
```

```

    "Peugeot 505 GR",
    "Opel Record 2000 LS",
    "Citroen Visa Super E",
    "VW Golf 1300 GLS",
    "Citroen CX 2400 Pallas",
    "Mercedes 230",
    "BMW 520",
    "Volvo 244 DL",
    "Peugeot 104 ZS",
    "Citroen Dyane")

colnames(performanceTable) <- c(
  "MaximalSpeed",
  "ConsumptionTown",
  "Consumption120kmh",
  "HP",
  "Space",
  "Price")

# ranks of the alternatives

alternativesRanks <- c(1,2,3,4,5,6,7,8,9,10)

names(alternativesRanks) <- row.names(performanceTable)

# criteria to minimize or maximize

criteriaMinMax <- c("max", "min", "min", "max", "max", "min")

names(criteriaMinMax) <- colnames(performanceTable)

x<-additiveValueFunctionElicitation(performanceTable,
                                   criteriaMinMax, epsilon,
                                   alternativesRanks = alternativesRanks)

```

AHP

Analytic Hierarchy Process (AHP) method

Description

AHP is a multi-criteria decision analysis method which was originally developed by Thomas L. Saaty in 1970s.

Usage

```
AHP(criteriaWeightsPairwiseComparisons, alternativesPairwiseComparisonsList)
```

Arguments

`criteriaWeightsPairwiseComparisons`

Matrix or data frame containing the pairwise comparison matrix for the criteria weights. Lines and columns are named according to the IDs of the criteria.

`alternativesPairwiseComparisonsList`

A list containing a matrix or data frame of pairwise comparisons (comparing alternatives) for each criterion. The elements of the list are named according to the IDs of the criteria. In each matrix, the lines and the columns are named according to the IDs of the alternatives.

Value

The function returns a vector containing the AHP score for each alternative.

References

The Analytic Hierarchy Process: Planning, Priority Setting (1980), ISBN 0-07-054371-2, McGraw-Hill

Examples

```
style <- t(matrix(c(1,0.25,4,1/6,4,1,4,0.25,0.25,0.25,1,0.2,6,4,5,1),
                 nrow=4,ncol=4))

colnames(style) = c("Corsa","Clio","Fiesta","Sandero")
rownames(style) = c("Corsa","Clio","Fiesta","Sandero")

reliability <- t(matrix(c(1,2,5,1,0.5,1,3,2,0.2,1/3,1,0.25,1,0.5,4,1),
                       nrow=4,ncol=4))

colnames(reliability) = c("Corsa","Clio","Fiesta","Sandero")
rownames(reliability) = c("Corsa","Clio","Fiesta","Sandero")

fuel <- t(matrix(c(1,2,4,1,0.5,1,3,2,0.25,1/3,1,0.2,1,0.5,5,1),nrow=4,ncol=4))

colnames(fuel) = c("Corsa","Clio","Fiesta","Sandero")
rownames(fuel) = c("Corsa","Clio","Fiesta","Sandero")

alternativesPairwiseComparisonsList <- list(style=style,
                                             reliability=reliability,
                                             fuel=fuel)

criteriaWeightsPairwiseComparisons <- t(matrix(c(1,0.5,3,2,1,4,1/3,0.25,1),
                                               nrow=3,ncol=3))
colnames(criteriaWeightsPairwiseComparisons) = c("style","reliability","fuel")
rownames(criteriaWeightsPairwiseComparisons) = c("style","reliability","fuel")

overall1 <- AHP(criteriaWeightsPairwiseComparisons,
               alternativesPairwiseComparisonsList)
```

```
applyPiecewiseLinearValueFunctionsOnPerformanceTable
```

Applies value functions on a performance table.

Description

Transforms a performance table via given piecewise linear value functions.

Usage

```
applyPiecewiseLinearValueFunctionsOnPerformanceTable(valueFunctions,
                                                    performanceTable,
                                                    alternativesIDs = NULL,
                                                    criteriaIDs = NULL)
```

Arguments

valueFunctions A list containing, for each criterion, the piecewise linear value functions defined by the coordinates of the break points. Each value function is defined by a matrix of breakpoints, where the first row corresponds to the abscissa (row labelled "x") and where the second row corresponds to the ordinate (row labelled "y").

performanceTable Matrix or data frame containing the performance table. Each row corresponds to an alternative, and each column to a criterion. Rows (resp. columns) must be named according to the IDs of the alternatives (resp. criteria).

alternativesIDs Vector containing IDs of alternatives, according to which the data should be filtered.

criteriaIDs Vector containing IDs of criteria, according to which the data should be filtered.

Value

The function returns a performance table which has been transformed through the given value functions.

Examples

```
# the value functions

v<-list(
  Price = array(c(30, 0, 16, 0, 2, 0.0875),
               dim=c(2,3), dimnames = list(c("x", "y"), NULL)),
  Time = array(c(40, 0, 30, 0, 20, 0.025, 10, 0.9),
               dim = c(2, 4), dimnames = list(c("x", "y"), NULL)),
  Comfort = array(c(0, 0, 1, 0, 2, 0.0125, 3, 0.0125),
                  dim = c(2, 4), dimnames = list(c("x", "y"), NULL)))
```

```

# the performance table

performanceTable <- rbind(
  c(3,10,1),
  c(4,20,2),
  c(2,20,0),
  c(6,40,0),
  c(30,30,3))

rownames(performanceTable) <- c("RER", "METRO1", "METRO2", "BUS", "TAXI")

colnames(performanceTable) <- c("Price", "Time", "Comfort")

# the transformed performance table

applyPiecewiseLinearValueFunctionsOnPerformanceTable(v, performanceTable)

```

```
assignAlternativesToCategoriesByThresholds
```

Assign alternatives to categories according to thresholds.

Description

Assign alternatives to categories according to thresholds representing the lower bounds of the categories.

Usage

```
assignAlternativesToCategoriesByThresholds(alternativesScores,
  categoriesLowerBounds,
  alternativesIDs = NULL,
  categoriesIDs = NULL)
```

Arguments

`alternativesScores`

Vector representing the overall scores of the alternatives. The elements are named according to the IDs of the alternatives.

`categoriesLowerBounds`

Vector containing the lower bounds of the categories. An alternative is assigned to a category if its score is higher or equal to the lower bound of the category, and strictly lower to the lower bound of the category above.

`alternativesIDs`

Vector containing IDs of alternatives, according to which the data should be filtered.

`categoriesIDs`

Vector containing IDs of categories, according to which the data should be filtered.


```

scores <- weightedSum(npt, c(1,1,1))

# add a lower bound for the "bad" category

lbs <- c(x$categoriesLBs,0)

names(lbs) <- c(names(x$categoriesLBs),"bad")

assignments<-assignAlternativesToCategoriesByThresholds(scores,lbs)

```

ELECTREIIIDistillation

ELECTRE III ranking

Description

This function computes the two ELECTRE III distillations, or rankings.

Usage

```

ELECTREIIIDistillation(performanceTable,
                        criteriaWeights,
                        minMaxcriteria,
                        preferenceThresholds,
                        indifferenceThresholds,
                        vetoThresholds)

```

Arguments

performanceTable

Matrix or data frame containing the performance table. Each row corresponds to an alternative, and each column to a criterion. Rows (resp. columns) must be named according to the IDs of the alternatives (resp. criteria).

criteriaWeights

Vector containing the weights of the criteria. The elements are named according to the IDs of the criteria.

minMaxcriteria Vector containing the preference direction on each of the criteria. "min" (resp. "max") indicates that the criterion has to be minimized (maximized). The elements are named according to the IDs of the criteria.

preferenceThresholds

Vector containing preference thresholds for each criterion.

indifferenceThresholds

Vector containing indifference thresholds for each criterion.

vetoThresholds

Vector containing veto thresholds for each criterion.

Value

The function returns two lists, one for each distillation.

Examples

```
performanceTable <- rbind(
  c(10,20,5,10,16),
  c(0,5,5,16,10),
  c(0,10,0,16,7),
  c(20,5,10,10,13),
  c(20,10,15,10,13),
  c(20,10,20,13,13))
rownames(performanceTable) <-c("P1", "P2", "P3", "P4", "P5", "P6")
colnames(performanceTable) <-c("CRIT1", "CRIT2", "CRIT3", "CRIT4", "CRIT5")
## vector indicating the direction of the criteria evaluation .
minMaxcriteria <-c("max", "max", "max", "max", "max")
names(minMaxcriteria) <- colnames(performanceTable)
## criteriaWeights vector
criteriaWeights <- c(3,2,3,1,1)
names(criteriaWeights) <- colnames(performanceTable)

indifferenceThresholds<-c(3,3,3,3,3)
names(indifferenceThresholds) <- colnames(performanceTable)
preferenceThresholds<-c(5,5,5,5,5)
names(preferenceThresholds) <- colnames(performanceTable)
vetoThresholds<-c(11,11,11,11,11)
names(vetoThresholds) <- colnames(performanceTable)

ELECTREIIIDistillation(performanceTable,criteriaWeights,minMaxcriteria,
  preferenceThresholds,indifferenceThresholds,
  vetoThresholds)
```

 LPDMRSort

MRSort that takes into account large performance differences.

Description

MRSort is a simplified ElectreTRI method that uses the pessimistic assignment rule, without indifference or preference thresholds attached to criteria. LPDMRSort considers both a binary discordance and a binary concordance conditions including several interactions between them.

Usage

```
LPDMRSort(performanceTable, categoriesLowerProfiles, categoriesRanks,
  criteriaWeights, criteriaMinMax, majorityThreshold,
  criteriaVetos = NULL, criteriaDictators = NULL,
  majorityRule = "M", alternativesIDs = NULL,
  criteriaIDs = NULL, categoriesIDs = NULL)
```

Arguments

performanceTable	Matrix or data frame containing the performance table. Each row corresponds to an alternative, and each column to a criterion. Rows (resp. columns) must be named according to the IDs of the alternatives (resp. criteria).
categoriesLowerProfiles	Matrix containing, in each row, the lower profiles of the categories. The columns are named according to the criteria, and the rows are named according to the categories. The index of the row in the matrix corresponds to the rank of the category.
categoriesRanks	A vector containing the ranks of the categories (1 for the best, with higher values for increasingly less preferred categories). The vector needs to be named with the categories names, whereas the ranks need to be a range of values from 1 to the number of categories.
criteriaWeights	Vector containing the weights of the criteria. The elements are named according to the IDs of the criteria.
criteriaMinMax	Vector containing the preference direction on each of the criteria. "min" (resp. "max") indicates that the criterion has to be minimized (maximized). The elements are named according to the IDs of the criteria.
majorityThreshold	The cut threshold for the concordance condition. Should be at least half of the sum of the weights.
criteriaVetos	Matrix containing in each row a vector defining the veto values for the lower profile of the category. NA values mean that no veto is defined. A veto threshold for criterion <i>i</i> and category <i>k</i> represents the performance below which an alternative is forbidden to outrank the lower profile of category <i>k</i> , and thus is forbidden to be assigned to the category <i>k</i> . The rows are named according to the categories, whereas the columns are named according to the criteria.
criteriaDictators	Matrix containing in each row a vector defining the dictator values for the lower profile of the category. NA values mean that no veto is defined. A dictator threshold for criterion <i>i</i> and category <i>k</i> represents the performance above which an alternative is guaranteed to outrank the lower profile of category <i>k</i> , and thus may no be assigned below category <i>k</i> . The rows are named according to the categories, whereas the columns are named according to the criteria.
majorityRule	String denoting how the vetoes and dictators are combined in order to form the assignment rule. The values to choose from are "M", "V", "D", "v", "d", "dV", "Dv", "dv". "M" corresponds to using only the majority rule without vetoes or dictators, "V" considers only the vetoes, "D" only the dictators, "v" is like "V" only that a dictator may invalidate a veto, "d" is like "D" only that a veto may invalidate a dictator, "dV" is like "V" only that if there is no veto we may then consider the dictator, "Dv" is like "D" only that when there is no dictator we may consider the vetoes, while finally "dv" is identical to using both dictator and vetoes only that when both are active they invalidate each other, so the majority rule is considered in that case.

alternativesIDs	Vector containing IDs of alternatives, according to which the data should be filtered.
criteriaIDs	Vector containing IDs of criteria, according to which the data should be filtered.
categoriesIDs	Vector containing IDs of categories, according to which the data should be filtered.

Value

The function returns a vector containing the assignments of the alternatives to the categories.

References

Bouyssou, D. and Marchant, T. An axiomatic approach to noncompensatory sorting methods in MCDM, II: more than two categories. *European Journal of Operational Research*, 178(1): 246–276, 2007.

Meyer, P. and Olteanu, A-L. Integrating large positive and negative performance differences in majority-rule sorting models. *European Journal of Operational Research*, submitted, 2015.

Examples

```
# the performance table

performanceTable <- rbind(c(10,10,9), c(10,9,10), c(9,10,10), c(9,9,10),
                          c(9,10,9), c(10,9,9), c(10,10,7), c(10,7,10),
                          c(7,10,10), c(9,9,17), c(9,17,9), c(17,9,9),
                          c(7,10,17), c(10,17,7), c(17,7,10), c(7,17,10),
                          c(17,10,7), c(10,7,17), c(7,9,17), c(9,17,7),
                          c(17,7,9), c(7,17,9), c(17,9,7), c(9,7,17))

profilesPerformances <- rbind(c(10,10,10),c(0,0,0))

vetoPerformances <- rbind(c(7,7,7),c(0,0,0))

dictatorPerformances <- rbind(c(17,17,17),c(0,0,0))

rownames(performanceTable) <- c("a1", "a2", "a3", "a4", "a5", "a6", "a7",
                                "a8", "a9", "a10", "a11", "a12", "a13",
                                "a14", "a15", "a16", "a17", "a18", "a19",
                                "a20", "a21", "a22", "a23", "a24")

rownames(profilesPerformances) <- c("P","F")

rownames(vetoPerformances) <- c("P","F")

rownames(dictatorPerformances) <- c("P","F")

colnames(performanceTable) <- c("c1", "c2", "c3")

colnames(profilesPerformances) <- c("c1", "c2", "c3")
```

```

colnames(vetoPerformances) <- c("c1","c2","c3")

colnames(dictatorPerformances) <- c("c1","c2","c3")

lambda <- 0.5

weights <- c(1/3,1/3,1/3)

names(weights) <- c("c1","c2","c3")

categoriesRanks <-c(1,2)

names(categoriesRanks) <- c("P","F")

criteriaMinMax <- c("max","max","max")

names(criteriaMinMax) <- colnames(performanceTable)

assignments <-rbind(c("P","P","P","F","F","F","F","F","F","F","F","F",
  "F","F","F","F","F","F","F","F","F","F","F"),
  c("P","P","P","F","F","F","P","P","P","P","P","P",
  "P","P","P","P","P","P","P","P","P","P","P"),
  c("P","P","P","F","F","F","F","F","F","F","F","F",
  "P","P","P","P","P","P","F","F","F","F","F"),
  c("P","P","P","F","F","F","P","P","P","P","P","P",
  "P","P","P","P","P","P","F","F","F","F","F"),
  c("P","P","P","F","F","F","F","F","F","P","P","P",
  "F","F","F","F","F","F","F","F","F","F","F"),
  c("P","P","P","F","F","F","F","F","F","P","P","P",
  "P","P","P","P","P","P","P","P","P","P","P"),
  c("P","P","P","F","F","F","F","F","F","P","P","P",
  "P","P","P","P","P","P","F","F","F","F","F"))

colnames(assignments) <- rownames(performanceTable)

majorityRules <- c("V","D","v","d","dV","Dv","dv")

for(i in 1:7)
{
  ElectreAssignments<-LPDMRSort(performanceTable, profilesPerformances,
    categoriesRanks,
    weights, criteriaMinMax, lambda,
    criteriaVetos=vetoPerformances,
    criteriaDictators=dictatorPerformances,
    majorityRule = majorityRules[i])

  print(all(ElectreAssignments == assignments[i,]))
}

```

LPDMRSortIdentifyIncompatibleAssignments

Identifies all sets of assignment examples which are incompatible with the MRSort sorting method extended to handle large performance differences.

Description

MRSort is a simplified ElectreTRI method that uses the pessimistic assignment rule, without indifference or preference thresholds attached to criteria. LPDMRSort considers both a binary discordance and a binary concordance conditions including several interactions between them. This function outputs all (or a fixed number of) sets of incompatible assignment examples ranging in size from the minimal size and up to a given threshold. The retrieved sets are also not contained in each other.

Usage

```
LPDMRSortIdentifyIncompatibleAssignments(performanceTable,
                                         assignments,
                                         categoriesRanks,
                                         criteriaMinMax,
                                         majorityRule = "M",
                                         incompatibleSetsLimit = 100,
                                         largerIncompatibleSetsMargin = 0,
                                         alternativesIDs = NULL,
                                         criteriaIDs = NULL,
                                         solver="glpk",
                                         cplexIntegralityTolerance = NULL,
                                         cplexThreads = NULL)
```

Arguments

performanceTable	Matrix or data frame containing the performance table. Each row corresponds to an alternative, and each column to a criterion. Rows (resp. columns) must be named according to the IDs of the alternatives (resp. criteria).
assignments	Vector containing the assignments (IDs of the categories) of the alternatives to the categories. The elements are named according to the alternatives.
categoriesRanks	Vector containing the ranks of the categories. The elements are named according to the IDs of the categories.
criteriaMinMax	Vector containing the preference direction on each of the criteria. "min" (resp. "max") indicates that the criterion has to be minimized (maximized). The elements are named according to the IDs of the criteria.
majorityRule	String denoting how the vetoes and dictators are combined in order to form the assignment rule. The values to choose from are "M", "V", "D", "v", "d", "dV", "Dv", "dv". "M" corresponds to using only the majority rule without vetoes

or dictators, "V" considers only the vetoes, "D" only the dictators, "v" is like "V" only that a dictator may invalidate a veto, "d" is like "D" only that a veto may invalidate a dictator, "dV" is like "V" only that if there is no veto we may then consider the dictator, "Dv" is like "D" only that when there is no dictator we may consider the vetoes, while finally "dv" is identical to using both dictator and vetoes only that when both are active they invalidate each other, so the majority rule is considered in that case.

`incompatibleSetsLimit`

Positive integer denoting the upper limit of the number of sets to be retrieved.

`largerIncompatibleSetsMargin`

Positive integer denoting whether sets larger than the minimal size should be retrieved, and by what margin. For example, if this is 0 then only sets of the minimal size will be retrieved, if this is 1 then sets also larger by 1 element will be retrieved.

`alternativesIDs`

Vector containing IDs of alternatives, according to which the data should be filtered.

`criteriaIDs`

Vector containing IDs of criteria, according to which the data should be filtered.

`solver`

String specifying if the glpk solver (glpk) should be used, or the cplex (cplex) solver. By default glpk. The cplex solver requires to install the cplex binary and the cplex C API, as well as the cplexAPI R package.

`cplexIntegralityTolerance`

If the cplex solver is used, allows to fix a tolerance for integrality. By default NULL (which corresponds to the default value of cplex).

`cplexThreads`

If the cplex solver is used, allows to the number of threads for the calculation. By default NULL (which corresponds to the default value of cplex).

Value

The function returns NULL if there is a problem, or a list containing a list of incompatible sets of alternatives as vectors and the status of the execution.

References

Bouyssou, D. and Marchant, T. An axiomatic approach to noncompensatory sorting methods in MCDM, II: more than two categories. *European Journal of Operational Research*, 178(1): 246–276, 2007.

Meyer, P. and Olteanu, A-L. Integrating large positive and negative performance differences in majority-rule sorting models. *European Journal of Operational Research*, submitted, 2015.

Examples

```
# the performance table
```

```
performanceTable <- rbind(c(10,10,9), c(10,9,10), c(9,10,10), c(9,9,10),
                          c(9,10,9), c(10,9,9), c(10,10,7), c(10,7,10),
                          c(7,10,10), c(9,9,17), c(9,17,9), c(17,9,9),
                          c(7,10,17), c(10,17,7), c(17,7,10), c(7,17,10),
```



```

c(17,10,7), c(10,7,17), c(7,9,17), c(9,17,7),
c(17,7,9), c(7,17,9), c(17,9,7), c(9,7,17),
c(7,7,7))

rownames(performanceTable) <- c("a1", "a2", "a3", "a4", "a5", "a6", "a7",
"a8", "a9", "a10", "a11", "a12", "a13",
"a14", "a15", "a16", "a17", "a18", "a19",
"a20", "a21", "a22", "a23", "a24", "a25")

colnames(performanceTable) <- c("c1", "c2", "c3")

assignments <- rbind(c("P", "P", "P", "F", "F", "F", "F", "F", "F", "F", "F", "F", "F",
"F", "F", "F", "F", "F", "F", "F", "F", "F", "F", "F", "F", "F", "P"),
c("P", "P", "P", "F", "F", "F", "P", "P", "P", "P", "P", "P", "P", "P",
"P", "P", "P", "P", "P", "P", "P", "P", "P", "P", "P", "P", "P", "P"),
c("P", "P", "P", "F", "F", "F", "F", "F", "F", "F", "F", "F", "F", "F",
"P", "P", "P", "P", "P", "P", "F", "F", "F", "F", "F", "F", "F", "P"),
c("P", "P", "P", "F", "F", "F", "P", "P", "P", "P", "P", "P", "P", "P",
"P", "P", "P", "P", "P", "P", "F", "F", "F", "F", "F", "F", "F", "P"),
c("P", "P", "P", "F", "F", "F", "F", "F", "F", "F", "F", "F", "F", "F",
"F", "F", "F", "F", "F", "F", "F", "F", "F", "F", "F", "F", "F", "P"),
c("P", "P", "P", "F", "F", "F", "F", "F", "F", "F", "F", "F", "F", "P", "P",
"P", "P", "P", "P", "P", "P", "P", "P", "P", "P", "P", "P", "P", "P"),
c("P", "P", "P", "F", "F", "F", "F", "F", "F", "F", "F", "F", "F", "P", "P",
"P", "P", "P", "P", "P", "P", "F", "F", "F", "F", "F", "F", "F", "P")),

colnames(assignments) <- rownames(performanceTable)

categoriesRanks <- c(1,2)

names(categoriesRanks) <- c("P", "F")

criteriaMinMax <- c("max", "max", "max")

names(criteriaMinMax) <- colnames(performanceTable)

majorityRules <- c("V", "D", "v", "d", "dV", "Dv", "dv")

for(i in 1:1)# change to 7 in order to perform all tests
{
  incompatibleAssignmentsSets <- LPDMRSortIdentifyIncompatibleAssignments(
    performanceTable, assignments[i,],
    categoriesRanks, criteriaMinMax,
    majorityRule = majorityRules[i])

  filteredAlternativesIDs <- setdiff(rownames(performanceTable),
    incompatibleAssignmentsSets[[1]][1])

  x <- LPDMRSortInferenceExact(performanceTable, assignments[i,],
    categoriesRanks, criteriaMinMax,
    majorityRule = majorityRules[i],
    readableWeights = TRUE,
    readableProfiles = TRUE,

```

```

        minmaxLPD = TRUE,
        alternativesIDs = filteredAlternativesIDs)

ElectreAssignments<-LPDMRSort(performanceTable, x$profilesPerformances,
                              categoriesRanks,
                              x$weights, criteriaMinMax, x$lambda,
                              criteriaVetos=x$vetoPerformances,
                              criteriaDictators=x$dictatorPerformances,
                              majorityRule = majorityRules[i],
                              alternativesIDs = filteredAlternativesIDs)

print(all(ElectreAssignments == assignments[i,filteredAlternativesIDs]))
}

```

LPDMRSortIdentifyUsedDictatorProfiles

Identify dictator profiles evaluations that have an impact on the final assignments of MRSort with large performance differences

Description

MRSort is a simplified ELECTRE-TRI approach which assigns alternatives to a set of ordered categories using delimiting profiles evaluations. In this case, we also take into account large performance differences. This method is used to identify which dictator profiles evaluations have an impact on the final assignment of at least one of the input alternatives.

Usage

```

LPDMRSortIdentifyUsedDictatorProfiles(performanceTable, assignments,
                                       categoriesRanks, criteriaMinMax,
                                       majorityThreshold,
                                       criteriaWeights,
                                       profilesPerformances,
                                       dictatorPerformances,
                                       vetoPerformances = NULL,
                                       majorityRule = "D",
                                       alternativesIDs = NULL,
                                       criteriaIDs = NULL)

```

Arguments

performanceTable	Matrix or data frame containing the performance table. Each row corresponds to an alternative, and each column to a criterion. Rows (resp. columns) must be named according to the IDs of the alternatives (resp. criteria).
assignments	A vector containing the category to which each alternative is assigned. The vector needs to be named using the alternatives IDs.

categoriesRanks	A vector containing the ranks of the categories (1 for the best, with higher values for increasingly less preferred categories). The vector needs to be named with the categories names, whereas the ranks need to be a range of values from 1 to the number of categories.
criteriaMinMax	Vector containing the preference direction on each of the criteria. "min" (resp. "max") indicates that the criterion has to be minimized (maximized). The elements are named according to the IDs of the criteria.
majorityThreshold	The majority threshold needed to determine when a coalition of criteria is sufficient in order to validate an outranking relation.
criteriaWeights	Vector containing the weights of the criteria. The elements are named according to the IDs of the criteria.
profilesPerformances	Matrix containing, in each row, the lower profiles of the categories. The columns are named according to the criteria, and the rows are named according to the categories. The index of the row in the matrix corresponds to the rank of the category.
dictatorPerformances	Matrix containing in each row a vector defining the dictator values for the lower profile of the category. NA values mean that no dictator is defined. A dictator threshold for criterion <i>i</i> and category <i>k</i> represents the performance above which an alternative outranks the lower profile of category <i>k</i> regardless of the size of the coalition of criteria in favor of this statement. The rows are named according to the categories, whereas the columns are named according to the criteria.
vetoPerformances	Matrix containing in each row a vector defining the veto values for the lower profile of the category. NA values mean that no veto is defined. A veto threshold for criterion <i>i</i> and category <i>k</i> represents the performance below which an alternative is forbidden to outrank the lower profile of category <i>k</i> , and thus is forbidden to be assigned to the category <i>k</i> . The rows are named according to the categories, whereas the columns are named according to the criteria. By default no veto profiles are needed.
majorityRule	String denoting how the vetoes and dictators are combined in order to form the assignment rule. The values to choose from are "D", "v", "d", "dV", "Dv", "dv". "D" considers only the dictators, "v" is like "V" only that a dictator may invalidate a veto, "d" is like "D" only that a veto may invalidate a dictator, "dV" is like "V" only that if there is no veto we may then consider the dictator, "Dv" is like "D" only that when there is no dictator we may consider the vetoes, while finally "dv" is identical to using both dictator and vetoes only that when both are active they invalidate each other, so the majority rule is considered in that case.
alternativesIDs	Vector containing IDs of alternatives, according to which the data should be filtered.
criteriaIDs	Vector containing IDs of criteria, according to which the data should be filtered.

Value

The function returns a matrix containing TRUE/FALSE indicators for each evaluation of the veto profiles.

Examples

```
# the performance table

performanceTable <- rbind(
  c(1,27,1),
  c(6,20,1),
  c(2,20,0),
  c(6,40,0),
  c(30,10,3))

rownames(performanceTable) <- c("RER","METRO1","METRO2","BUS","TAXI")

colnames(performanceTable) <- c("Price","Time","Comfort")

# lower profiles of the categories (best category in the first position of the list)

categoriesLowerProfiles <- rbind(c(3, 11, 3),c(7, 25, 2),c(NA,NA,NA))

colnames(categoriesLowerProfiles) <- colnames(performanceTable)

rownames(categoriesLowerProfiles)<-c("Good","Medium","Bad")

# the order of the categories, 1 being the best

categoriesRanks <-c(1,2,3)

names(categoriesRanks) <- c("Good","Medium","Bad")

# criteria to minimize or maximize

criteriaMinMax <- c("min","min","max")

names(criteriaMinMax) <- colnames(performanceTable)

# dictators

criteriaDictators <- rbind(c(1, 1, -1),c(1, 20, 0),c(NA,NA,NA))

colnames(criteriaDictators) <- colnames(performanceTable)
rownames(criteriaDictators) <- c("Good","Medium","Bad")

# vetos

criteriaVetos <- rbind(c(9, 50, 5),c(50, 50, 5),c(NA,NA,NA))

colnames(criteriaVetos) <- colnames(performanceTable)
rownames(criteriaVetos) <- c("Good","Medium","Bad")
```


Arguments

performanceTable	Matrix or data frame containing the performance table. Each row corresponds to an alternative, and each column to a criterion. Rows (resp. columns) must be named according to the IDs of the alternatives (resp. criteria).
assignments	A vector containing the category to which each alternative is assigned. The vector needs to be named using the alternatives IDs.
categoriesRanks	A vector containing the ranks of the categories (1 for the best, with higher values for increasingly less preferred categories). The vector needs to be named with the categories names, whereas the ranks need to be a range of values from 1 to the number of categories.
criteriaMinMax	Vector containing the preference direction on each of the criteria. "min" (resp. "max") indicates that the criterion has to be minimized (maximized). The elements are named according to the IDs of the criteria.
majorityThreshold	The majority threshold needed to determine when a coalition of criteria is sufficient in order to validate an outranking relation.
criteriaWeights	Vector containing the weights of the criteria. The elements are named according to the IDs of the criteria.
profilesPerformances	Matrix containing, in each row, the lower profiles of the categories. The columns are named according to the criteria, and the rows are named according to the categories. The index of the row in the matrix corresponds to the rank of the category.
vetoPerformances	Matrix containing in each row a vector defining the veto values for the lower profile of the category. NA values mean that no veto is defined. A veto threshold for criterion <i>i</i> and category <i>k</i> represents the performance below which an alternative is forbidden to outrank the lower profile of category <i>k</i> , and thus is forbidden to be assigned to the category <i>k</i> . The rows are named according to the categories, whereas the columns are named according to the criteria.
dictatorPerformances	Matrix containing in each row a vector defining the dictator values for the lower profile of the category. NA values mean that no dictator is defined. A dictator threshold for criterion <i>i</i> and category <i>k</i> represents the performance above which an alternative outranks the lower profile of category <i>k</i> regardless of the size of the coalition of criteria in favor of this statement. The rows are named according to the categories, whereas the columns are named according to the criteria. By default no dictator profiles are needed for this method.
majorityRule	String denoting how the vetoes and dictators are combined in order to form the assignment rule. The values to choose from are "V", "v", "d", "dV", "Dv", "dv". "V" considers only the vetoes, "v" is like "V" only that a dictator may invalidate a veto, "d" is like "D" only that a veto may invalidate a dictator, "dV" is like "V" only that if there is no veto we may then consider the dictator, "Dv" is like

"D" only that when there is no dictator we may consider the vetoes, while finally "dv" is identical to using both dictator and vetoes only that when both are active they invalidate each other, so the majority rule is considered in that case.

`alternativesIDs` Vector containing IDs of alternatives, according to which the data should be filtered.

`criteriaIDs` Vector containing IDs of criteria, according to which the data should be filtered.

Value

The function returns a matrix containing TRUE/FALSE indicators for each evaluation of the veto profiles.

Examples

```
# the performance table

performanceTable <- rbind(
  c(1,27,1),
  c(6,20,1),
  c(2,20,0),
  c(6,40,0),
  c(30,10,3))

rownames(performanceTable) <- c("RER", "METRO1", "METRO2", "BUS", "TAXI")

colnames(performanceTable) <- c("Price", "Time", "Comfort")

# lower profiles of the categories (best category in the first position of the list)

categoriesLowerProfiles <- rbind(c(3, 11, 3), c(7, 25, 2), c(NA, NA, NA))

colnames(categoriesLowerProfiles) <- colnames(performanceTable)

rownames(categoriesLowerProfiles) <- c("Good", "Medium", "Bad")

# the order of the categories, 1 being the best

categoriesRanks <- c(1,2,3)

names(categoriesRanks) <- c("Good", "Medium", "Bad")

# criteria to minimize or maximize

criteriaMinMax <- c("min", "min", "max")

names(criteriaMinMax) <- colnames(performanceTable)

# dictators

criteriaDictators <- rbind(c(1, 1, -1), c(1, 20, 0), c(NA, NA, NA))
```

```

colnames(criteriaDictators) <- colnames(performanceTable)
rownames(criteriaDictators) <- c("Good", "Medium", "Bad")

# vetos

criteriaVetos <- rbind(c(9, 50, 5), c(50, 50, 5), c(NA, NA, NA))

colnames(criteriaVetos) <- colnames(performanceTable)
rownames(criteriaVetos) <- c("Good", "Medium", "Bad")

# weights

criteriaWeights <- c(1/6, 3/6, 2/6)

names(criteriaWeights) <- colnames(performanceTable)

# assignments

assignments <- c("Good", "Medium", "Bad", "Bad", "Bad")

# LPDMRSortIdentifyUsedVetoProfiles

used<-LPDMRSortIdentifyUsedVetoProfiles(performanceTable, assignments,
                                         categoriesRanks, criteriaMinMax,
                                         0.5, criteriaWeights,
                                         categoriesLowerProfiles,
                                         criteriaVetos,
                                         criteriaDictators,
                                         "dv")

```

LPDMRSortInferenceApprox

Identification of profiles, weights, majority threshold, veto and dictator thresholds for LPDMRSort using a genetic algorithm.

Description

MRSort is a simplified ElectreTRI method that uses the pessimistic assignment rule, without indifference or preference thresholds attached to criteria. LPDMRSort considers both a binary discordance and a binary concordance conditions including several interactions between them. The identification of the profiles, weights, majority threshold and veto thresholds is done by taking into account assignment examples.

Usage

```

LPDMRSortInferenceApprox(performanceTable, criteriaMinMax, categoriesRanks, assignments,
                          majorityRules = c("M", "V", "D", "v", "d", "dV", "Dv", "dv"),
                          alternativesIDs = NULL, criteriaIDs = NULL,
                          timeLimit = 60, populationSize = 20, mutationProb = 0.1)

```


Arguments

performanceTable	Matrix or data frame containing the performance table. Each row corresponds to an alternative, and each column to a criterion. Rows (resp. columns) must be named according to the IDs of the alternatives (resp. criteria).
assignments	Vector containing the assignments (IDs of the categories) of the alternatives to the categories. The elements are named according to the alternatives.
categoriesRanks	Vector containing the ranks of the categories. The elements are named according to the IDs of the categories.
criteriaMinMax	Vector containing the preference direction on each of the criteria. "min" (resp. "max") indicates that the criterion has to be minimized (maximized). The elements are named according to the IDs of the criteria.
majorityRules	A vector containing the different type of majority rules to be considered ("M", "V", "D", "v", "d", "dV", "Dv", "dv"). "M" corresponds to using only the majority rule without vetoes or dictators, "V" considers only the vetoes, "D" only the dictators, "v" is like "V" only that a dictator may invalidate a veto, "d" is like "D" only that a veto may invalidate a dictator, "dV" is like "V" only that if there is no veto we may then consider the dictator, "Dv" is like "D" only that when there is no dictator we may consider the vetoes, while finally "dv" is identical to using both dictator and vetoes only that when both are active they invalidate each other, so the majority rule is considered in that case.
alternativesIDs	Vector containing IDs of alternatives, according to which the data should be filtered.
criteriaIDs	Vector containing IDs of criteria, according to which the data should be filtered.
timeLimit	Allows to fix a time limit of the execution, in seconds (default 60).
populationSize	Allows to change the size of the population used by the genetic algorithm (default 20).
mutationProb	Allows to change the mutation probability used by the genetic algorithm (default 0.1).

Value

The function returns a list containing:

majorityThreshold	The inferred majority threshold (single numeric value).
criteriaWeights	The inferred criteria weights (a vector named with the criteria IDs).
majorityRule	A string corresponding to the inferred majority rule (one of "M", "V", "D", "v", "d", "dV", "Dv", "dv").
profilesPerformances	The inferred category limits (a matrix with the column names given by the criteria IDs and the rownames given by the upper categories each profile delimits).

vetoPerformances	The inferred vetoes (a matrix with the column names given by the criteria IDs and the rownames given by the categories to which each profile applies).
dictatorPerformances	The inferred dictators (a matrix with the column names given by the criteria IDs and the rownames given by the categories to which each profile applies).
fitness	The classification accuracy of the inferred model (from 0 to 1).

References

Bouyssou, D. and Marchant, T. An axiomatic approach to noncompensatory sorting methods in MCDM, II: more than two categories. *European Journal of Operational Research*, 178(1): 246–276, 2007.

no reference yet for the algorithmic approach; one should become available in 2018

Examples

```
performanceTable <- rbind(c(10,10,9),c(10,9,10),c(9,10,10),c(9,9,10),c(9,10,9),c(10,9,9),
  c(10,10,7),c(10,7,10),c(7,10,10),c(9,9,17),c(9,17,9),c(17,9,9),
  c(7,10,17),c(10,17,7),c(17,7,10),c(7,17,10),c(17,10,7),c(10,7,17),
  c(7,9,17),c(9,17,7),c(17,7,9),c(7,17,9),c(17,9,7),c(9,7,17))

rownames(performanceTable) <- c("a1", "a2", "a3", "a4", "a5", "a6", "a7", "a8", "a9", "a10", "a11",
  "a12", "a13", "a14", "a15", "a16", "a17", "a18", "a19", "a20",
  "a21", "a22", "a23", "a24")

colnames(performanceTable) <- c("c1", "c2", "c3")

assignments <- c("P", "P", "P", "F", "F", "F", "F", "F", "F", "P", "P", "P", "P", "P", "P", "P", "P", "P", "F", "F",
  "F", "F", "F", "F")

names(assignments) <- rownames(performanceTable)

categoriesRanks <- c(1,2)

names(categoriesRanks) <- c("P", "F")

criteriaMinMax <- c("max", "max", "max")

names(criteriaMinMax) <- colnames(performanceTable)

set.seed(1)

x<-LPDMRSortInferenceApprox(performanceTable, criteriaMinMax, categoriesRanks, assignments,
  majorityRules = c("dv", "Dv", "dv"),
  timeLimit = 180, populationSize = 30,
  alternativesIDs = c("a1", "a2", "a3", "a4", "a5", "a6", "a7"))
```

 LPDMRSortInferenceExact

Identification of profiles, weights, majority threshold and veto and dictator thresholds for the MRSort sorting approach extended to handle large performance differences.

Description

MRSort is a simplified ElectreTRI method that uses the pessimistic assignment rule, without indifference or preference thresholds attached to criteria. LPDMRSort considers both a binary discordance and a binary concordance conditions including several interactions between them. The identification of the profiles, weights, majority threshold and veto and dictator thresholds are done by taking into account assignment examples.

Usage

```
LPDMRSortInferenceExact(performanceTable, assignments,
                        categoriesRanks, criteriaMinMax,
                        majorityRule = "M", readableWeights = FALSE,
                        readableProfiles = FALSE, minmaxLPD = FALSE,
                        alternativesIDs = NULL, criteriaIDs = NULL,
                        solver="glpk", cplexTimeLimit = NULL,
                        cplexIntegralityTolerance = NULL, cplexThreads = NULL)
```

Arguments

performanceTable	Matrix or data frame containing the performance table. Each row corresponds to an alternative, and each column to a criterion. Rows (resp. columns) must be named according to the IDs of the alternatives (resp. criteria).
assignments	Vector containing the assignments (IDs of the categories) of the alternatives to the categories. The elements are named according to the alternatives.
categoriesRanks	Vector containing the ranks of the categories. The elements are named according to the IDs of the categories.
criteriaMinMax	Vector containing the preference direction on each of the criteria. "min" (resp. "max") indicates that the criterion has to be minimized (maximized). The elements are named according to the IDs of the criteria.
majorityRule	String denoting how the vetoes and dictators are combined in order to form the assignment rule. The values to choose from are "M", "V", "D", "v", "d", "dV", "Dv", "dv". "M" corresponds to using only the majority rule without vetoes or dictators, "V" considers only the vetoes, "D" only the dictators, "v" is like "V" only that a dictator may invalidate a veto, "d" is like "D" only that a veto may invalidate a dictator, "dV" is like "V" only that if there is no veto we may then consider the dictator, "Dv" is like "D" only that when there is no dictator we may consider the vetoes, while finally "dv" is identical to using both dictator and

vetoed only that when both are active they invalidate each other, so the majority rule is considered in that case.

readableWeights	Boolean parameter indicating whether the weights are to be spaced more evenly or not.
readableProfiles	Boolean parameter indicating whether the profiles are to be spaced more evenly or not.
minmaxLPD	Boolean parameter indicating whether the veto thresholds are to be minimized (or maximized if lower criteria values are preferred) while the dictator thresholds are to be maximized (or minimized if lower criteria values are preferred).
alternativesIDs	Vector containing IDs of alternatives, according to which the data should be filtered.
criteriaIDs	Vector containing IDs of criteria, according to which the data should be filtered.
solver	String specifying if the glpk solver (glpk) should be used, or the cplex (cplex) solver. By default glpk. The cplex solver requires to install the cplex binary and the cplex C API, as well as the cplexAPI R package.
cplexTimeLimit	If the cplex solver is used, allows to fix a time limit of the execution, in seconds. By default NULL (which corresponds to the default value of cplex).
cplexIntegrityTolerance	If the cplex solver is used, allows to fix a tolerance for integrality. By default NULL (which corresponds to the default value of cplex).
cplexThreads	If the cplex solver is used, allows to the number of threads for the calculation. By default NULL (which corresponds to the default value of cplex).

Value

The function returns a list structured as follows :

lambda	The majority threshold.
weights	A vector containing the weights of the criteria. The elements are named according to the criteria IDs.
profilesPerformances	A matrix containing the lower profiles of the categories. The columns are named according to the criteria, whereas the rows are named according to the categories. The lower profile of the lower category can be considered as a dummy profile.
vetoPerformances	A matrix containing the veto profiles of the categories. The columns are named according to the criteria, whereas the rows are named according to the categories. The veto profile of the lower category can be considered as a dummy profile.
solverStatus	The solver status as given by glpk or cplex.

References

Bouyssou, D. and Marchant, T. An axiomatic approach to noncompensatory sorting methods in MCDM, II: more than two categories. *European Journal of Operational Research*, 178(1): 246–276, 2007.

Meyer, P. and Olteanu, A-L. Integrating large positive and negative performance differences in majority-rule sorting models. *European Journal of Operational Research*, submitted, 2015.

Examples

```
# the performance table

performanceTable <- rbind(c(10,10,9), c(10,9,10), c(9,10,10), c(9,9,10),
                          c(9,10,9), c(10,9,9), c(10,10,7), c(10,7,10),
                          c(7,10,10), c(9,9,17), c(9,17,9), c(17,9,9),
                          c(7,10,17), c(10,17,7), c(17,7,10), c(7,17,10),
                          c(17,10,7), c(10,7,17), c(7,9,17), c(9,17,7),
                          c(17,7,9), c(7,17,9), c(17,9,7), c(9,7,17))

rownames(performanceTable) <- c("a1", "a2", "a3", "a4", "a5", "a6", "a7",
                                "a8", "a9", "a10", "a11", "a12", "a13",
                                "a14", "a15", "a16", "a17", "a18", "a19",
                                "a20", "a21", "a22", "a23", "a24")

colnames(performanceTable) <- c("c1", "c2", "c3")

categoriesRanks <-c(1,2)

names(categoriesRanks) <- c("P", "F")

criteriaMinMax <- c("max", "max", "max")

names(criteriaMinMax) <- colnames(performanceTable)

assignments <-rbind(c("P", "P", "P", "F", "F", "F", "F", "F", "F", "F", "F", "F",
                    "F", "F", "F", "F", "F", "F", "F", "F", "F", "F", "F", "F",
                    "F", "F", "F", "F", "F", "F", "F", "F", "F", "F", "F", "F",
                    c("P", "P", "P", "F", "F", "F", "P", "P", "P", "P", "P", "P",
                    "P", "P", "P", "P", "P", "P", "P", "P", "P", "P", "P", "P",
                    "P", "P", "P", "F", "F", "F", "F", "F", "F", "F", "F", "F",
                    "P", "P", "P", "P", "P", "P", "F", "F", "F", "F", "F", "F",
                    c("P", "P", "P", "F", "F", "F", "F", "F", "F", "F", "F", "F",
                    "P", "P", "P", "P", "P", "P", "P", "P", "P", "P", "P", "P",
                    "P", "P", "P", "P", "P", "P", "P", "P", "P", "P", "P", "P",
                    c("P", "P", "P", "F", "F", "F", "F", "F", "F", "F", "F", "P",
                    "P", "P", "P", "P", "P", "P", "P", "P", "P", "P", "P", "P",
                    "P", "P", "P", "P", "P", "P", "F", "F", "F", "F", "F", "F"))

colnames(assignments) <- rownames(performanceTable)

majorityRules <- c("V", "D", "v", "d", "dV", "Dv", "dv")
```

```

for(i in 1:1)# change to 7 in order to perform all tests
{
  x<-LPDMRSortInferenceExact(performanceTable, assignments[i,],
                             categoriesRanks, criteriaMinMax,
                             majorityRule = majorityRules[i],
                             readableWeights = TRUE,
                             readableProfiles = TRUE,
                             minmaxLPD = TRUE)

  ElectreAssignments<-LPDMRSort(performanceTable, x$profilesPerformances,
                                categoriesRanks,
                                x$weights, criteriaMinMax, x$lambda,
                                criteriaVetos=x$vetoPerformances,
                                criteriaDictators=x$dictatorPerformances,
                                majorityRule = majorityRules[i])

  print(x)

  print(all(ElectreAssignments == assignments[i,]))
}

```

MARE

Multi-Attribute Range Evaluations (MARE)

Description

MARE is a multi-criteria decision analysis method which was originally developed by Hodgett et al. in 2014.

Usage

```

MARE(performanceTableMin,
     performanceTable,
     performanceTableMax,
     criteriaWeights,
     criteriaMinMax,
     alternativesIDs = NULL,
     criteriaIDs = NULL)

```

Arguments

performanceTableMin

Matrix or data frame containing the minimum performance table. Each column corresponds to an alternative, and each row to a criterion. Columns (resp. rows) must be named according to the IDs of the alternatives (resp. criteria).

performanceTable

Matrix or data frame containing the most likely performance table. Each column corresponds to an alternative, and each row to a criterion. Columns (resp. rows) must be named according to the IDs of the alternatives (resp. criteria).

performanceTableMax	Matrix or data frame containing the maximum performance table. Each column corresponds to an alternative, and each row to a criterion. Columns (resp. rows) must be named according to the IDs of the alternatives (resp. criteria).
criteriaWeights	Vector containing the weights of the criteria. The elements are named according to the IDs of the criteria.
criteriaMinMax	Vector containing the preference direction on each of the criteria. "min" (resp. "max") indicates that the criterion has to be minimized (maximized). The elements are named according to the IDs of the criteria.
alternativesIDs	Vector containing IDs of alternatives, according to which the data should be filtered.
criteriaIDs	Vector containing IDs of criteria, according to which the data should be filtered.

Value

The function returns an element of type `mare` which contains the MARE scores for each alternative.

References

Richard E. Hodgett, Elaine B. Martin, Gary Montague, Mark Talford (2014). Handling uncertain decisions in whole process design. *Production Planning & Control*, Volume 25, Issue 12, 1028-1038.

Examples

```
performanceTableMin <- t(matrix(c(78,87,79,19,8,68,74,8,90,89,74.5,9,20,81,30),
                               nrow=3,ncol=5, byrow=TRUE))
performanceTable <- t(matrix(c(80,87,86,19,8,70,74,10,90,89,75,9,33,82,30),
                              nrow=3,ncol=5, byrow=TRUE))
performanceTableMax <- t(matrix(c(81,87,95,19,8,72,74,15,90,89,75.5,9,36,84,30),
                                nrow=3,ncol=5, byrow=TRUE))

row.names(performanceTable) <- c("Yield","Toxicity","Cost","Separation","Odour")
colnames(performanceTable) <- c("Route One","Route Two","Route Three")
row.names(performanceTableMin) <- row.names(performanceTable)
colnames(performanceTableMin) <- colnames(performanceTable)
row.names(performanceTableMax) <- row.names(performanceTable)
colnames(performanceTableMax) <- colnames(performanceTable)

weights <- c(0.339,0.077,0.434,0.127,0.023)
names(weights) <- row.names(performanceTable)

criteriaMinMax <- c("max", "max", "max", "max", "max")
names(criteriaMinMax) <- row.names(performanceTable)

overall1 <- MARE(performanceTableMin,
                 performanceTable,
                 performanceTableMax,
```

```

weights,
criteriaMinMax)

overall12 <- MARE(performanceTableMin,
                 performanceTable,
                 performanceTableMax,
                 weights,
                 criteriaMinMax,
                 alternativesIDs = c("Route Two", "Route Three"),
                 criteriaIDs = c("Yield", "Toxicity", "Cost", "Separation"))

```

MRSort *Electre TRI-like sorting method axiomatized by Bouyssou and Marchant.*

Description

This simplification of the Electre TRI method uses the pessimistic assignment rule, without indifference or preference thresholds attached to criteria. Only a binary discordance condition is considered, i.e. a veto forbids an outranking in any possible concordance situation, or not.

Usage

```

MRSort(performanceTable, categoriesLowerProfiles,
       categoriesRanks, criteriaWeights, criteriaMinMax,
       majorityThreshold, criteriaVetos = NULL,
       alternativesIDs = NULL, criteriaIDs = NULL,
       categoriesIDs = NULL)

```

Arguments

performanceTable
Matrix or data frame containing the performance table. Each row corresponds to an alternative, and each column to a criterion. Rows (resp. columns) must be named according to the IDs of the alternatives (resp. criteria).

categoriesLowerProfiles
Matrix containing, in each row, the lower profiles of the categories. The columns are named according to the criteria, and the rows are named according to the categories. The index of the row in the matrix corresponds to the rank of the category.

categoriesRanks
A vector containing the ranks of the categories (1 for the best, with higher values for increasingly less preferred categories). The vector needs to be named with the categories names, whereas the ranks need to be a range of values from 1 to the number of categories.

criteriaWeights
Vector containing the weights of the criteria. The elements are named according to the IDs of the criteria.

<code>criteriaMinMax</code>	Vector containing the preference direction on each of the criteria. "min" (resp. "max") indicates that the criterion has to be minimized (maximized). The elements are named according to the IDs of the criteria.
<code>majorityThreshold</code>	The cut threshold for the concordance condition. Should be at least half of the sum of the weights.
<code>criteriaVetos</code>	Matrix containing in each row a vector defining the veto values for the lower profile of the category. NA values mean that no veto is defined. A veto threshold for criterion <i>i</i> and category <i>k</i> represents the performance below which an alternative is forbidden to outrank the lower profile of category <i>k</i> , and thus is forbidden to be assigned to the category <i>k</i> . The rows are named according to the categories, whereas the columns are named according to the criteria.
<code>alternativesIDs</code>	Vector containing IDs of alternatives, according to which the data should be filtered.
<code>criteriaIDs</code>	Vector containing IDs of criteria, according to which the data should be filtered.
<code>categoriesIDs</code>	Vector containing IDs of categories, according to which the data should be filtered.

Value

The function returns a vector containing the assignments of the alternatives to the categories.

References

Bouyssou, D. and Marchant, T. An axiomatic approach to noncompensatory sorting methods in MCDM, II: more than two categories. *European Journal of Operational Research*, 178(1): 246–276, 2007.

Examples

```
# the performance table

performanceTable <- rbind(
  c(1,10,1),
  c(4,20,2),
  c(2,20,0),
  c(6,40,0),
  c(30,30,3))

rownames(performanceTable) <- c("RER", "METRO1", "METRO2", "BUS", "TAXI")

colnames(performanceTable) <- c("Price", "Time", "Comfort")

# lower profiles of the categories
# (best category in the first position of the list)

categoriesLowerProfiles <- rbind(c(3, 11, 3), c(7, 25, 2), c(NA, NA, NA))
```

```

colnames(categoriesLowerProfiles) <- colnames(performanceTable)
rownames(categoriesLowerProfiles)<-c("Good", "Medium", "Bad")

# the order of the categories, 1 being the best
categoriesRanks <-c(1,2,3)

names(categoriesRanks) <- c("Good", "Medium", "Bad")

# criteria to minimize or maximize
criteriaMinMax <- c("min", "min", "max")

names(criteriaMinMax) <- colnames(performanceTable)

# vetos
criteriaVetos <- rbind(c(10, NA, NA),c(NA, NA, 1),c(NA,NA,NA))

colnames(criteriaVetos) <- colnames(performanceTable)
rownames(criteriaVetos) <- c("Good", "Medium", "Bad")

# weights
criteriaWeights <- c(1,3,2)

names(criteriaWeights) <- colnames(performanceTable)

# MRSort
assignments<-MRSort(performanceTable, categoriesLowerProfiles,
                    categoriesRanks,criteriaWeights,
                    criteriaMinMax, 3,
                    criteriaVetos = criteriaVetos)

print(assignments)

# un peu de filtrage
assignments<-MRSort(performanceTable, categoriesLowerProfiles,
                    categoriesRanks, criteriaWeights,
                    criteriaMinMax, 2,
                    categoriesIDs = c("Medium", "Bad"),
                    criteriaIDs = c("Price", "Time"),
                    alternativesIDs = c("RER", "BUS"))

print(assignments)

```

MRSortIdentifyIncompatibleAssignments

Identifies all sets of assignment examples which are incompatible with the MRSort method.

Description

This MRSort method, which is a simplification of the Electre TRI method, uses the pessimistic assignment rule, without indifference or preference thresholds attached to criteria. Only a binary discordance condition is considered, i.e. a veto forbids an outranking in any possible concordance situation, or not. This function outputs for all (or a fixed number of) sets of incompatible assignment examples ranging in size from the minimal size and up to a given threshold. The retrieved sets are also not contained in each other.

Usage

```
MRSortIdentifyIncompatibleAssignments(performanceTable,
                                       assignments,
                                       categoriesRanks,
                                       criteriaMinMax, veto = FALSE,
                                       incompatibleSetsLimit = 100,
                                       largerIncompatibleSetsMargin = 0,
                                       alternativesIDs = NULL,
                                       criteriaIDs = NULL,
                                       solver="glpk",
                                       cplexIntegralityTolerance = NULL,
                                       cplexThreads = NULL)
```

Arguments

performanceTable	Matrix or data frame containing the performance table. Each row corresponds to an alternative, and each column to a criterion. Rows (resp. columns) must be named according to the IDs of the alternatives (resp. criteria).
assignments	Vector containing the assignments (IDs of the categories) of the alternatives to the categories. The elements are named according to the alternatives.
categoriesRanks	Vector containing the ranks of the categories. The elements are named according to the IDs of the categories.
criteriaMinMax	Vector containing the preference direction on each of the criteria. "min" (resp. "max") indicates that the criterion has to be minimized (maximized). The elements are named according to the IDs of the criteria.
veto	Boolean parameter indicating whether veto profiles are being used by the model or not.
incompatibleSetsLimit	Positive integer denoting the upper limit of the number of sets to be retrieved.

largerIncompatibleSetsMargin	Positive integer denoting whether sets larger than the minimal size should be retrieved, and by what margin. For example, if this is 0 then only sets of the minimal size will be retrieved, if this is 1 then sets also larger by 1 element will be retrieved.
alternativesIDs	Vector containing IDs of alternatives, according to which the data should be filtered.
criteriaIDs	Vector containing IDs of criteria, according to which the data should be filtered.
solver	String specifying if the glpk solver (glpk) should be used, or the cplex (cplex) solver. By default glpk. The cplex solver requires to install the cplex binary and the cplex C API, as well as the cplexAPI R package.
cplexIntegrityTolerance	If the cplex solver is used, allows to fix a tolerance for integrality. By default NULL (which corresponds to the default value of cplex).
cplexThreads	If the cplex solver is used, allows to the number of threads for the calculation. By default NULL (which corresponds to the default value of cplex).

Value

The function returns NULL if there is a problem, or a list containing a list of incompatible sets of alternatives as vectors and the status of the execution.

References

Bouyssou, D. and Marchant, T. An axiomatic approach to noncompensatory sorting methods in MCDM, II: more than two categories. *European Journal of Operational Research*, 178(1): 246–276, 2007.

Examples

```
performanceTable <- rbind(c(10,10,9), c(10,9,10), c(9,10,10), c(9,9,10),
  c(9,10,9), c(10,9,9), c(10,10,7), c(10,7,10),
  c(7,10,10), c(9,9,17), c(9,17,9), c(17,9,9),
  c(7,10,17), c(10,17,7), c(17,7,10), c(7,17,10),
  c(17,10,7), c(10,7,17), c(7,9,17), c(9,17,7),
  c(17,7,9), c(7,17,9), c(17,9,7), c(9,7,17))

rownames(performanceTable) <- c("a1", "a2", "a3", "a4", "a5", "a6", "a7",
  "a8", "a9", "a10", "a11", "a12", "a13",
  "a14", "a15", "a16", "a17", "a18", "a19",
  "a20", "a21", "a22", "a23", "a24")

colnames(performanceTable) <- c("c1", "c2", "c3")

assignments <- c("P", "P", "P", "F", "F", "F", "F", "F", "F", "P", "F",
  "F", "F", "F", "F", "F", "F", "F", "F", "F", "F", "F",
  "F", "F")
```

```

names(assignments) <- rownames(performanceTable)

categoriesRanks <-c(1,2)

names(categoriesRanks) <- c("P", "F")

criteriaMinMax <- c("max", "max", "max")

names(criteriaMinMax) <- colnames(performanceTable)

incompatibleAssignmentsSets<-MRSortIdentifyIncompatibleAssignments(
    performanceTable, assignments,
    categoriesRanks, criteriaMinMax,
    veto = TRUE,
    alternativesIDs = c("a1", "a2", "a3", "a4",
    "a5", "a6", "a7", "a8", "a9", "a10"))

print(incompatibleAssignmentsSets)

filteredAlternativesIDs <- setdiff(c("a1", "a2", "a3", "a4", "a5", "a6", "a7", "a8", "a9"),
    incompatibleAssignmentsSets[[1]][1])

print(filteredAlternativesIDs)

x<-MRSortInferenceExact(performanceTable, assignments, categoriesRanks,
    criteriaMinMax, veto = TRUE,
    readableWeights = TRUE, readableProfiles = TRUE,
    alternativesIDs = filteredAlternativesIDs)

ElectreAssignments<-MRSort(performanceTable, x$profilesPerformances,
    categoriesRanks, x$weights,
    criteriaMinMax, x$lambda,
    criteriaVetos=x$vetoPerformances,
    alternativesIDs = filteredAlternativesIDs)

```

MRSortIdentifyUsedVetoProfiles

Identify veto profiles evaluations that have an impact on the final assignments of MRSort

Description

MRSort is a simplified ELECTRE-TRI approach which assigns alternatives to a set of ordered categories using delimiting profiles evaluations. In addition, veto profiles may also be used in order to circumvent a sufficient majority coalition in favor of an alternative being assigned to a certain category. This method is used to identify which veto profiles evaluations have an impact on the final assignment of at least one of the input alternatives.

Usage

```
MRSortIdentifyUsedVetoProfiles(performanceTable, assignments,
                                categoriesRanks, criteriaMinMax,
                                majorityThreshold,
                                criteriaWeights,
                                profilesPerformances,
                                vetoPerformances,
                                alternativesIDs = NULL,
                                criteriaIDs = NULL)
```

Arguments

- performanceTable**
Matrix or data frame containing the performance table. Each row corresponds to an alternative, and each column to a criterion. Rows (resp. columns) must be named according to the IDs of the alternatives (resp. criteria).
- assignments**
A vector containing the category to which each alternative is assigned. The vector needs to be named using the alternatives IDs.
- categoriesRanks**
A vector containing the ranks of the categories (1 for the best, with higher values for increasingly less preferred categories). The vector needs to be named with the categories names, whereas the ranks need to be a range of values from 1 to the number of categories.
- criteriaMinMax**
Vector containing the preference direction on each of the criteria. "min" (resp. "max") indicates that the criterion has to be minimized (maximized). The elements are named according to the IDs of the criteria.
- majorityThreshold**
The majority threshold needed to determine when a coalition of criteria is sufficient in order to validate an outranking relation.
- criteriaWeights**
Vector containing the weights of the criteria. The elements are named according to the IDs of the criteria.
- profilesPerformances**
Matrix containing, in each row, the lower profiles of the categories. The columns are named according to the criteria, and the rows are named according to the categories. The index of the row in the matrix corresponds to the rank of the category.
- vetoPerformances**
Matrix containing in each row a vector defining the veto values for the lower profile of the category. NA values mean that no veto is defined. A veto threshold for criterion *i* and category *k* represents the performance below which an alternative is forbidden to outrank the lower profile of category *k*, and thus is forbidden to be assigned to the category *k*. The rows are named according to the categories, whereas the columns are named according to the criteria.
- alternativesIDs**
Vector containing IDs of alternatives, according to which the data should be filtered.

`criteriaIDs` Vector containing IDs of criteria, according to which the data should be filtered.

Value

The function returns a matrix containing TRUE/FALSE indicators for each evaluation of the veto profiles.

Examples

```
# the performance table

performanceTable <- rbind(
  c(1,10,1),
  c(4,20,2),
  c(2,20,0),
  c(6,40,0),
  c(30,10,3))

rownames(performanceTable) <- c("RER", "METRO1", "METRO2", "BUS", "TAXI")
colnames(performanceTable) <- c("Price", "Time", "Comfort")

# lower profiles of the categories (best category in the first position of the list)
categoriesLowerProfiles <- rbind(c(3, 11, 3), c(7, 25, 2), c(NA, NA, NA))
colnames(categoriesLowerProfiles) <- colnames(performanceTable)
rownames(categoriesLowerProfiles) <- c("Good", "Medium", "Bad")

# the order of the categories, 1 being the best
categoriesRanks <- c(1, 2, 3)
names(categoriesRanks) <- c("Good", "Medium", "Bad")

# criteria to minimize or maximize
criteriaMinMax <- c("min", "min", "max")
names(criteriaMinMax) <- colnames(performanceTable)

# vetos
criteriaVetos <- rbind(c(9, 50, -1), c(50, 50, 0), c(NA, NA, NA))
colnames(criteriaVetos) <- colnames(performanceTable)
rownames(criteriaVetos) <- c("Good", "Medium", "Bad")

# weights
criteriaWeights <- c(1/6, 3/6, 2/6)
```

```

names(criteriaWeights) <- colnames(performanceTable)

# assignments

assignments <- c("Good", "Medium", "Bad", "Bad", "Bad")

# MRSortIdentifyUsedVetoProfiles

used<-MRSortIdentifyUsedVetoProfiles(performanceTable, assignments,
                                     categoriesRanks, criteriaMinMax,
                                     0.5, criteriaWeights,
                                     categoriesLowerProfiles,
                                     criteriaVetos)

```

MRSortInferenceApprox *Identification of profiles, weights, majority threshold and veto thresholds for MRSort using a genetic algorithm.*

Description

MRSort is a simplification of the Electre TRI method that uses the pessimistic assignment rule, without indifference or preference thresholds attached to criteria. Only a binary discordance condition is considered, i.e. a veto forbids an outranking in any possible concordance situation, or not. The identification of the profiles, weights, majority threshold and veto thresholds are done by taking into account assignment examples.

Usage

```

MRSortInferenceApprox(performanceTable, assignments, categoriesRanks, criteriaMinMax,
                      veto = FALSE, alternativesIDs = NULL, criteriaIDs = NULL,
                      timeLimit = 60, populationSize = 20, mutationProb = 0.1)

```

Arguments

performanceTable	Matrix or data frame containing the performance table. Each row corresponds to an alternative, and each column to a criterion. Rows (resp. columns) must be named according to the IDs of the alternatives (resp. criteria).
assignments	Vector containing the assignments (IDs of the categories) of the alternatives to the categories. The elements are named according to the alternatives.
categoriesRanks	Vector containing the ranks of the categories. The elements are named according to the IDs of the categories.
criteriaMinMax	Vector containing the preference direction on each of the criteria. "min" (resp. "max") indicates that the criterion has to be minimized (maximized). The elements are named according to the IDs of the criteria.
veto	Boolean parameter indicating whether veto profiles are to be used or not.


```

      "F", "F", "F", "F", "F", "F", "F")

names(assignments) <- rownames(performanceTable)

categoriesRanks <- c(1,2)

names(categoriesRanks) <- c("P","F")

criteriaMinMax <- c("max","max","max")

names(criteriaMinMax) <- colnames(performanceTable)

set.seed(1)

x<-MRSortInferenceApprox(performanceTable, assignments, categoriesRanks,
                          criteriaMinMax, veto = TRUE,
                          alternativesIDs = c("a1","a2","a3","a4","a5","a6","a7"))

```

MRSortInferenceExact *Identification of profiles, weights and majority threshold for the MR-Sort sorting method using an exact approach.*

Description

The MRSort method, a simplification of the Electre TRI method, uses the pessimistic assignment rule, without indifference or preference thresholds attached to criteria. Only a binary discordance condition is considered, i.e. a veto forbids an outranking in any possible concordance situation, or not. The identification of the profiles, weights and majority threshold are done by taking into account assignment examples.

Usage

```

MRSortInferenceExact(performanceTable, assignments,
                      categoriesRanks, criteriaMinMax,
                      veto = FALSE, readableWeights = FALSE,
                      readableProfiles = FALSE,
                      alternativesIDs = NULL, criteriaIDs = NULL,
                      solver = "glpk",
                      cplexTimeLimit = NULL, cplexIntegralityTolerance = NULL, cplexThreads = NULL)

```

Arguments

performanceTable	Matrix or data frame containing the performance table. Each row corresponds to an alternative, and each column to a criterion. Rows (resp. columns) must be named according to the IDs of the alternatives (resp. criteria).
assignments	Vector containing the assignments (IDs of the categories) of the alternatives to the categories. The elements are named according to the alternatives.

categoriesRanks	Vector containing the ranks of the categories. The elements are named according to the IDs of the categories.
criteriaMinMax	Vector containing the preference direction on each of the criteria. "min" (resp. "max") indicates that the criterion has to be minimized (maximized). The elements are named according to the IDs of the criteria.
veto	Boolean parameter indicating whether veto profiles are being used or not.
readableWeights	Boolean parameter indicating whether the weights are to be spaced more evenly or not.
readableProfiles	Boolean parameter indicating whether the profiles are to be spaced more evenly or not.
alternativesIDs	Vector containing IDs of alternatives, according to which the data should be filtered.
criteriaIDs	Vector containing IDs of criteria, according to which the data should be filtered.
solver	String specifying if the glpk solver (glpk) should be used, or the cplex (cplex) solver. By default glpk. The cplex solver requires to install the cplex binary and the cplex C API, as well as the cplexAPI R package.
cplexTimeLimit	If the cplex solver is used, allows to fix a time limit of the execution, in seconds. By default NULL (which corresponds to the default value of cplex).
cplexIntegralityTolerance	If the cplex solver is used, allows to fix a tolerance for integrality. By default NULL (which corresponds to the default value of cplex).
cplexThreads	If the cplex solver is used, allows to the number of threads for the calculation. By default NULL (which corresponds to the default value of cplex).

Value

The function returns a list structured as follows :

lambda	The majority threshold.
weights	A vector containing the weights of the criteria. The elements are named according to the criteria IDs.
profilesPerformances	A matrix containing the lower profiles of the categories. The columns are named according to the criteria, whereas the rows are named according to the categories. The lower profile of the lower category can be considered as a dummy profile.
vetoPerformances	A matrix containing the veto profiles of the categories. The columns are named according to the criteria, whereas the rows are named according to the categories. The veto profile of the lower category can be considered as a dummy profile.
solverStatus	The solver status as given by glpk or cplex.

References

Bouyssou, D. and Marchant, T. An axiomatic approach to noncompensatory sorting methods in MCDM, II: more than two categories. *European Journal of Operational Research*, 178(1): 246–276, 2007.

Examples

```
performanceTable <- rbind(c(10,10,9), c(10,9,10), c(9,10,10), c(9,9,10),
  c(9,10,9), c(10,9,9), c(10,10,7), c(10,7,10),
  c(7,10,10), c(9,9,17), c(9,17,9), c(17,9,9),
  c(7,10,17), c(10,17,7), c(17,7,10), c(7,17,10),
  c(17,10,7), c(10,7,17), c(7,9,17), c(9,17,7),
  c(17,7,9), c(7,17,9), c(17,9,7), c(9,7,17))

rownames(performanceTable) <- c("a1", "a2", "a3", "a4", "a5", "a6", "a7",
  "a8", "a9", "a10", "a11", "a12", "a13",
  "a14", "a15", "a16", "a17", "a18", "a19",
  "a20", "a21", "a22", "a23", "a24")

colnames(performanceTable) <- c("c1", "c2", "c3")

assignments <- c("P", "P", "P", "F", "F", "F", "F", "F", "F", "F", "F", "F", "F",
  "F", "F", "F", "F", "F", "F", "F", "F", "F", "F", "F", "F")

names(assignments) <- rownames(performanceTable)

categoriesRanks <- c(1,2)

names(categoriesRanks) <- c("P", "F")

criteriaMinMax <- c("max", "max", "max")

names(criteriaMinMax) <- colnames(performanceTable)

x<-MRSortInferenceExact(performanceTable, assignments, categoriesRanks,
  criteriaMinMax, veto = TRUE, readableWeights = TRUE,
  readableProfiles = TRUE,
  alternativesIDs = c("a1", "a2", "a3", "a4", "a5", "a6", "a7"))

ElectreAssignments<-MRSort(performanceTable, x$profilesPerformances,
  categoriesRanks,
  x$weights, criteriaMinMax, x$lambda,
  criteriaVetos=x$vetoPerformances,
  alternativesIDs = c("a1", "a2", "a3", "a4", "a5", "a6", "a7"))
```

Description

This method is an extension of the classical MRSort, that allows the handling of problems where the decision alternatives contain imprecise or even missing evaluations. Unlike MRSort, where an alternative is assigned to one category, MRSortInterval offers the possibility of assigning an alternative to one or more neighboring categories.

Usage

```
MRSortInterval(performanceTable, categoriesLowerProfiles,
               categoriesRanks, criteriaWeights, criteriaMinMax,
               majorityThresholdPes, majorityThresholdOpt)
```

Arguments

- `performanceTable`
Two-dimensional list containing the performance table. Each row corresponds to an alternative, and each column to a criterion. Rows (resp. columns) must be named according to the IDs of the alternatives (resp. criteria). This list may contain imprecise performances of alternatives on the criteria, represented by interval evaluations, as well as missing performances.
- `categoriesLowerProfiles`
Matrix containing, in each row, the lower profiles of the categories. The columns are named according to the criteria, and the rows are named according to the categories except of the last one.
- `categoriesRanks`
A vector containing the ranks of the categories (1 for the best, with higher values for increasingly less preferred categories). The vector needs to be named with the categories names, whereas the ranks need to be a range of values from 1 to the number of categories.
- `criteriaWeights`
Vector containing the weights of the criteria. The elements are named according to the IDs of the criteria.
- `criteriaMinMax` Vector containing the preference direction on each of the criteria. "min" (resp. "max") indicates that the criterion has to be minimized (maximized).
- `majorityThresholdPes`
The cut threshold for the pessimistic concordance relation.
- `majorityThresholdOpt`
The cut threshold for the optimistic concordance relation.

Value

The function returns a list containing the assignments of the alternatives to all possible categories.

Examples

```
# the performance table
performanceTable <- as.list(numeric(6*5))
```

```

dim(performanceTable)=c(6,5)
performanceTable[[1,1]]<-0
performanceTable[[1,2]]<-0
performanceTable[[1,3]]<-0
performanceTable[[1,4]]<-0
performanceTable[[1,5]]<-0
performanceTable[[2,1]]<-0
performanceTable[[2,2]]<-0
performanceTable[[2,3]]<-1
performanceTable[[2,4]]<-0
performanceTable[[2,5]]<-0
performanceTable[[3,1]]<-0
performanceTable[[3,2]]<-0
performanceTable[[3,3]]<-2
performanceTable[[3,4]]<-0
performanceTable[[3,5]]<-0
performanceTable[[4,1]]<-0
performanceTable[[4,2]]<-0
performanceTable[[4,3]]<-0:1
performanceTable[[4,4]]<-0
performanceTable[[4,5]]<-0
performanceTable[[5,1]]<-0
performanceTable[[5,2]]<-0
performanceTable[[5,3]]<-NA
performanceTable[[5,4]]<-0
performanceTable[[5,5]]<-0
performanceTable[[6,1]]<-0
performanceTable[[6,2]]<-0
performanceTable[[6,3]]<-0
performanceTable[[6,4]]<-0
performanceTable[[6,5]]<-NA

rownames(performanceTable)<-c("a1","a2","a3","a4","a5","a6")
colnames(performanceTable)<-c("c1","c2","c3","c4","c5")

# lower profiles of the categories (best category in the first position of the list)

categoriesLowerProfiles <- rbind(c(1,1,1,1,1),c(0,0,0,2,2))
colnames(categoriesLowerProfiles) <- colnames(performanceTable)

rownames(categoriesLowerProfiles)<-c("Medium","Good")

categoriesRanks <-c(1,2,3)

names(categoriesRanks) <- c("Good","Medium","Bad")

# weights

criteriaWeights <- c(1/5,1/5,1/5,1/5,1/5)
names(criteriaWeights) <- colnames(performanceTable)

#pessimistic and optimistic majority thresholds
majorityThresholdPes=majorityThresholdOpt=3/5

```

```
# criteria to minimize or maximize

criteriaMinMax <- c("min", "min", "min", "max", "max")
names(criteriaMinMax) <- colnames(performanceTable)

#MRSortInterval

assignments<-MRSortInterval(performanceTable, categoriesLowerProfiles,
                             categoriesRanks, criteriaWeights,
                             criteriaMinMax, majorityThresholdPes,
                             majorityThresholdOpt)
```

```
normalizePerformanceTable
```

Function to normalize (or rescale) the columns (or criteria) of a performance table.

Description

Standardizes the range of the criteria according to a few methods : percentage of max, scale between 0 and 1, scale to 0 mean and 1 standard deviation, scale to euclidian unit length.

Usage

```
normalizePerformanceTable(performanceTable,
                          normalizationTypes,
                          alternativesIDs = NULL,
                          criteriaIDs = NULL)
```

Arguments

`performanceTable`

A matrix containing the performance table to be plotted. The columns are labelled according to the criteria IDs, and the rows according to the alternatives IDs.

`normalizationTypes`

Vector indicating the type of normalization that should be applied to each of the criteria. Possible values : "percentageOfMax", "rescaling" (minimum becomes 0, maximum becomes 1), "standardization" (rescale to a mean of 0 and a standard deviation of 1), "scaleToUnitLength" (scale the criteria values such that the column has euclidian length 1). Any other value (like "none") will result in no data transformation. The elements are named according to the IDs of the criteria.

`alternativesIDs`

Vector containing IDs of alternatives, according to which the data should be filtered.

`criteriaIDs`

Vector containing IDs of criteria, according to which the data should be filtered.

Examples

```

library(MCDA)

performanceTable <- matrix(runif(5*9), ncol=5)

row.names(performanceTable) <- c("x1", "x2", "x3", "x4", "x5", "x6", "x7", "x8", "x9")

colnames(performanceTable) <- c("g1", "g2", "g3", "g4", "g5")

normalizationTypes <- c("percentageOfMax", "rescaling",
                       "standardization", "scaleToUnitLength", "none")

names(normalizationTypes) <- c("g1", "g2", "g3", "g4", "g5")

normalizedPerformanceTable <- normalizePerformanceTable(performanceTable,
                                                         normalizationTypes)

```

pairwiseConsistencyMeasures

Consistency Measures for Pairwise Comparison Matrices

Description

This function calculates four pairwise consistency checks: Consistency Ratio (CR) from Saaty (1980), Koczkodaj's Measure from Koczkodaj (1993) and Congruence / Dissonance Measures from Siraj et al. (2015).

Usage

```
pairwiseConsistencyMeasures(matrix)
```

Arguments

`matrix` A reciprocal matrix containing pairwise judgements

Value

The function returns a list of outputs for the four pairwise consistency checks

References

Thomas Saaty (1980). The Analytic Hierarchy Process: Planning, Priority Setting, ISBN 0-07-054371-2, McGraw-Hill.

W.W. Koczkodaj (1993). A new definition of consistency of pairwise comparisons. Mathematical and Computer Modelling. 18 (7).

Sajid Siraj, Ludmil Mikhailov & John A. Keane (2015). Contribution of individual judgments toward inconsistency in pairwise comparisons. European Journal of Operational Research. 242(2).

plotMARE

*Plot Multi-Attribute Range Evaluations (MARE)***Description**

Plots the output of function MARE()

Usage

```
plotMARE(x)
```

Arguments

x Output from function MARE()

Examples

```
performanceTableMin <- t(matrix(c(78,87,79,19,8,68,74,8,90,89,74.5,9,20,81,30),
                                nrow=3,ncol=5, byrow=TRUE))
performanceTable <- t(matrix(c(80,87,86,19,8,70,74,10,90,89,75,9,33,82,30),
                              nrow=3,ncol=5, byrow=TRUE))
performanceTableMax <- t(matrix(c(81,87,95,19,8,72,74,15,90,89,75.5,9,36,84,30),
                                nrow=3,ncol=5, byrow=TRUE))

row.names(performanceTable) <- c("Yield","Toxicity","Cost","Separation","Odour")
colnames(performanceTable) <- c("Route One","Route Two","Route Three")
row.names(performanceTableMin) <- row.names(performanceTable)
colnames(performanceTableMin) <- colnames(performanceTable)
row.names(performanceTableMax) <- row.names(performanceTable)
colnames(performanceTableMax) <- colnames(performanceTable)

weights <- c(0.339,0.077,0.434,0.127,0.023)
names(weights) <- row.names(performanceTable)

criteriaMinMax <- c("max", "max", "max", "max", "max")
names(criteriaMinMax) <- row.names(performanceTable)

overall1 <- MARE(performanceTableMin, performanceTable, performanceTableMax,
                weights, criteriaMinMax)
plotMARE(overall1)

overall2 <- MARE(performanceTableMin,
                performanceTable,
                performanceTableMax,
                weights,
                criteriaMinMax,
                alternativesIDs = c("Route Two","Route Three"),
                criteriaIDs = c("Yield","Toxicity","Cost","Separation"))
plotMARE(overall2)
```

plotMRSortSortingProblem

Plot the categories and assignments of an Electre TRI-like sorting problem (via separation profiles).

Description

The profiles shown are the separation profiles between the classes. They are stored as the lower profiles of the categories.

Usage

```
plotMRSortSortingProblem(performanceTable, categoriesLowerProfiles,
                          categoriesRanks, assignments, criteriaMinMax,
                          criteriaUBs, criteriaLBs,
                          categoriesDictators = NULL, categoriesVetoes = NULL,
                          majorityRule = NULL, criteriaWeights = NULL,
                          majorityThreshold = NULL, alternativesIDs = NULL,
                          criteriaIDs = NULL, legendRatio = 0.2)
```

Arguments

performanceTable

Matrix or data frame containing the performance table. Each row corresponds to an alternative, and each column to a criterion. Rows (resp. columns) must be named according to the IDs of the alternatives (resp. criteria).

categoriesLowerProfiles

Matrix containing, in each row, the lower profiles of the categories (the separation profiles in fact). The columns are named according to the criteria, and the rows are named according to the categories. The index of the row in the matrix corresponds to the rank of the category.

categoriesRanks

A vector containing the ranks of the categories (1 for the best, with higher values for increasingly less preferred categories). The vector needs to be named with the categories names, whereas the ranks need to be a range of values from 1 to the number of categories.

assignments

Vector containing the assignments (IDs of the categories) of the alternatives to the categories. The elements are named according to the alternatives.

criteriaMinMax

Vector containing the preference direction on each of the criteria. "min" (resp. "max") indicates that the criterion has to be minimized (maximized). The elements are named according to the IDs of the criteria.

criteriaLBs

Vector containing the lower bounds of the criteria to be considered for the plotting. The elements are named according to the IDs of the criteria.

criteriaUBs

Vector containing the upper bounds of the criteria to be considered for the plotting. The elements are named according to the IDs of the criteria.

<code>categoriesDictators</code>	Matrix containing, in each row, the lower dictator profiles of the categories. The columns are named according to the criteria, and the rows are named according to the categories. The index of the row in the matrix corresponds to the rank of the category.
<code>categoriesVetoes</code>	Matrix containing, in each row, the lower veto profiles of the categories. The columns are named according to the criteria, and the rows are named according to the categories. The index of the row in the matrix corresponds to the rank of the category.
<code>majorityRule</code>	A string containing one of the following values: 'V', 'D', 'v', 'd', 'dV', 'Dv', 'dv'. This indicates the type of majority rule that will be used by the MRSort model. 'V' stands for MRSort with vetoes, 'D' stands for MRSort with dictators, 'v' stands for MRSort with vetoes weakened by dictators, 'd' stands for MRSort with dictators weakened by vetoes, 'dV' stands for MRSort with vetoes dominating dictators, 'Dv' stands for MRSort with dictators dominating vetoes, while 'dv' stands for MRSort with conflicting vetoes and dictators.
<code>criteriaWeights</code>	Vector containing the criteria weights. The elements are named according to the IDs of the criteria.
<code>majorityThreshold</code>	A value corresponding to the majority threshold. Along with the criteria weights, this value is used to determine when a coalition of criteria is sufficient in order to assert that an alternative is at least as good as a category profile.
<code>alternativesIDs</code>	Vector containing IDs of alternatives, according to which the data should be filtered.
<code>criteriaIDs</code>	Vector containing IDs of criteria, according to which the data should be filtered.
<code>legendRatio</code>	The ratio between the legend and plot heights. By default 0.2.

Examples

```
# the performance table

performanceTable <- rbind(
  c(1,10,1),
  c(4,20,2),
  c(2,20,0),
  c(6,40,0),
  c(30,30,3))

rownames(performanceTable) <- c("RER", "METRO1", "METRO2", "BUS", "TAXI")

colnames(performanceTable) <- c("Price", "Time", "Comfort")

# lower profiles of the categories
# (best category in the first position of the list)

categoriesLowerProfiles <- rbind(c(3, 11, 3), c(7, 25, 2), c(30,30,0))
```

```
colnames(categoriesLowerProfiles) <- colnames(performanceTable)

rownames(categoriesLowerProfiles) <- c("Good", "Medium", "Bad")

categoriesRanks <- c(1,2,3)

names(categoriesRanks) <- c("Good", "Medium", "Bad")

# criteria to minimize or maximize

criteriaMinMax <- c("min", "min", "max")

names(criteriaMinMax) <- colnames(performanceTable)

# lower bounds of the criteria for the determination of value functions

criteriaLBs = c(0,5,0)

names(criteriaLBs) <- colnames(performanceTable)

# upper bounds of the criteria for the determination of value functions

criteriaUBs = c(50,50,4)

names(criteriaUBs) <- colnames(performanceTable)

# weights

criteriaWeights <- c(1,3,2)

names(criteriaWeights) <- colnames(performanceTable)

assignments <- assignments <- MRSort(performanceTable,
                                   categoriesLowerProfiles,
                                   categoriesRanks,
                                   criteriaWeights,
                                   criteriaMinMax, 3)

names(assignments) <- rownames(performanceTable)

plotMRSortSortingProblem(performanceTable, categoriesLowerProfiles,
                         categoriesRanks, assignments, criteriaMinMax,
                         criteriaUBs, criteriaLBs)
```

plotPiecewiseLinearValueFunctions

Function to plot piecewise linear value functions.

Description

Plots piecewise linear value function.

Usage

```
plotPiecewiseLinearValueFunctions(valueFunctions,
                                  criteriaIDs = NULL)
```

Arguments

valueFunctions A list containing, for each criterion, the piecewise linear value functions defined by the coordinates of the break points. Each value function is defined by a matrix of breakpoints, where the first row corresponds to the abscissa (row labelled "x") and where the second row corresponds to the ordinate (row labelled "y").

criteriaIDs Vector containing IDs of criteria, according to which the data should be filtered.

Examples

```
v<-list(
  Price = array(c(30, 0, 16, 0, 2, 0.0875),
               dim=c(2,3), dimnames = list(c("x", "y"), NULL)),
  Time = array(c(40, 0, 30, 0, 20, 0.025, 10, 0.9),
               dim = c(2, 4), dimnames = list(c("x", "y"), NULL)),
  Comfort = array(c(0, 0, 1, 0, 2, 0.0125, 3, 0.0125),
                  dim = c(2, 4), dimnames = list(c("x", "y"), NULL))

# plot the value functions

plotPiecewiseLinearValueFunctions(v)
```

plotRadarPerformanceTable

Function to plot radar plots of alternatives of a performance table.

Description

Plots radar plots of alternatives contained in a performance table, either in one radar plot, or on multiple radar plots. For a given alternative, the plot shows how far above/below average (the thick black line) each of the criteria performances values are (average taken w.r.t. to the filtered performance table).

Usage

```
plotRadarPerformanceTable(performanceTable,
                           criteriaMinMax=NULL,
                           alternativesIDs = NULL,
                           criteriaIDs = NULL,
```

```
overlay=FALSE,
bw=FALSE,
lwd=2)
```

Arguments

performanceTable	A matrix containing the performance table to be plotted. The columns are labelled according to the criteria IDs, and the rows according to the alternatives IDs.
criteriaMinMax	Vector indicating whether criteria should be minimized or maximized. If it is given, a "higher" value in the radar plot corresponds to a more preferred value according to the decision maker. "min" (resp. "max") indicates that the criterion has to be minimized (maximized). The elements are named according to the IDs of the criteria.
alternativesIDs	Vector containing IDs of alternatives, according to which the data should be filtered.
criteriaIDs	Vector containing IDs of criteria, according to which the data should be filtered.
overlay	Boolean value indicating if the plots should be overlaid on one plot (TRUE), or not (FALSE)
bw	Boolean value indicating if the plots should be in black/white (TRUE) or color (FALSE)
lwd	Value indicating the line width of the plot.

Examples

```
library(MCDA)

performanceTable <- matrix(runif(6*9), ncol=6)

row.names(performanceTable) <- c("x1", "x2", "x3", "x4", "x5", "x6", "x7", "x8", "x9")

colnames(performanceTable) <- c("g1", "g2", "g3", "g4", "g5", "g6")

criteriaMinMax <- c("min", "max", "min", "max", "min", "max")

names(criteriaMinMax) <- c("g1", "g2", "g3", "g4", "g5", "g6")

# plotRadarPerformanceTable(performanceTable, criteriaMinMax, overlay=TRUE)

plotRadarPerformanceTable(performanceTable, criteriaMinMax,
                           alternativesIDs = c("x1", "x2", "x3", "x4"),
                           criteriaIDs = c("g1", "g3", "g4", "g5", "g6"),
                           overlay=FALSE, bw=FALSE)

# plotRadarPerformanceTable(performanceTable, criteriaMinMax,
#                             # alternativesIDs = c("x1", "x2"),
#                             # criteriaIDs = c("g1", "g3", "g4", "g5", "g6"),
```

```
# overlay=FALSE)
```

```
plotSURE          Plot SURE kernel density plots.
```

Description

Plots the output of function SURE()

Usage

```
plotSURE(SURE,
         greyScale = FALSE,
         separate = FALSE)
```

Arguments

SURE	Output from function SURE().
greyScale	TRUE/FALSE indicating if you want the plot to be in greyscale.
separate	TRUE/FALSE indicating if you want the density plots to be separated.

Examples

```
performanceTableMin <- t(matrix(c(78,87,79,19,8,68,74,8,90,89,74.5,9,20,81,30),
                               nrow=3,ncol=5, byrow=TRUE))
performanceTable <- t(matrix(c(80,87,86,19,8,70,74,10,90,89,75,9,33,82,30),
                              nrow=3,ncol=5, byrow=TRUE))
performanceTableMax <- t(matrix(c(81,87,95,19,8,72,74,15,90,89,75.5,9,36,84,30),
                                nrow=3,ncol=5, byrow=TRUE))

row.names(performanceTable) <- c("Yield","Toxicity","Cost","Separation","Odour")
colnames(performanceTable) <- c("Route One","Route Two","Route Three")
row.names(performanceTableMin) <- row.names(performanceTable)
colnames(performanceTableMin) <- colnames(performanceTable)
row.names(performanceTableMax) <- row.names(performanceTable)
colnames(performanceTableMax) <- colnames(performanceTable)

criteriaWeights <- c(0.339,0.077,0.434,0.127,0.023)
names(criteriaWeights) <- row.names(performanceTable)

criteriaMinMax <- c("max", "max", "max", "max", "max")
names(criteriaMinMax) <- row.names(performanceTable)

test1 <- SURE(performanceTableMin,
             performanceTable,
             performanceTableMax,
             criteriaWeights,
             criteriaMinMax,
```



```

                                NoOfSimulations = 101)

summary(test1)
plotSURE(test1)
plotSURE(test1, greyScale = TRUE, separate = TRUE)

```

PROMETHEE I

PROMETHEE I

Description

The PROMETHEE I constructs preference indices from the criteria evaluations of alternatives and outputs three preference relations (P - preference, I - indifference, R - incomparability) based on the outranking flows between the alternatives.

Usage

```

PROMETHEE I(performanceTable, preferenceFunction, preferenceThreshold,
             indifferenceThreshold, gaussParameter,
             criteriaWeights, criteriaMinMax)

```

Arguments

performanceTable Matrix containing the evaluation table. Each row corresponds to an alternative, and each column to a criterion. Rows (resp. columns) must be named according to the IDs of the alternatives (resp. criteria).

preferenceFunction A vector with preference functions. `preferenceFunction` should be equal to Usual, U-shape, V-shape, Level, V-shape-Indiff or Gaussian. The elements are named according to the IDs of the criteria.

preferenceThreshold A vector containing threshold of strict preference. The elements are named according to the IDs of the criteria.

indifferenceThreshold A vector containing threshold of indifference. The elements are named according to the IDs of the criteria.

gaussParameter A vector containing parameter of the Gaussian preference function. The elements are named according to the IDs of the criteria.

criteriaWeights Vector containing the weights of the criteria. The elements are named according to the IDs of the criteria.

criteriaMinMax Vector containing the preference direction on each of the criteria. "min" (resp. "max") indicates that the criterion has to be minimized (maximized). The elements are named according to the IDs of the criteria.

Value

The function returns three matrices: The first one contains the preference relations between the alternatives, the second one contains the indifference relations between the alternatives and the third one contains the incomparability relations between the alternatives.

Examples

```
# The evaluation table

performanceTable <- rbind(
  c(1,10,1),
  c(4,20,2),
  c(2,20,0),
  c(6,40,0),
  c(30,30,3))
rownames(performanceTable) <- c("RER", "METRO1", "METRO2", "BUS", "TAXI")
colnames(performanceTable) <- c("Price", "Time", "Comfort")

# The preference functions
preferenceFunction<-c("Gaussian", "Level", "V-shape-Indiff")

#Preference threshold
preferenceThreshold<-c(5,15,3)
names(preferenceThreshold)<-colnames(performanceTable)

#Indifference threshold
indifferenceThreshold<-c(3,11,1)
names(indifferenceThreshold)<-colnames(performanceTable)

#Parameter of the Gaussian preference function
gaussParameter<-c(4,0,0)
names(gaussParameter)<-colnames(performanceTable)

#weights
criteriaWeights<-c(0.2,0.3,0.5)
names(criteriaWeights)<-colnames(performanceTable)

# criteria to minimize or maximize

criteriaMinMax<-c("min", "min", "max")
names(criteriaMinMax)<-colnames(performanceTable)

PROMETHEEII(performanceTable, preferenceFunction,preferenceThreshold,
             indifferenceThreshold,gaussParameter,criteriaWeights,criteriaMinMax)
```

Description

The PROMETHEE II constructs preference indices from the criteria evaluations of alternatives and outputs a pre-order based on the outranking flows between the alternatives.

Usage

```
PROMETHEEII(performanceTable, preferenceFunction,
             preferenceThreshold, indifferenceThreshold, gaussParameter,
             criteriaWeights, criteriaMinMax)
```

Arguments

- performanceTable** Matrix containing the evaluation table. Each row corresponds to an alternative, and each column to a criterion. Rows (resp. columns) must be named according to the IDs of the alternatives (resp. criteria).
- preferenceFunction** A vector with preference functions. `preferenceFunction` should be equal to Usual, U-shape, V-shape, Level, V-shape-Indiff or Gaussian. The elements are named according to the IDs of the criteria.
- preferenceThreshold** A vector containing threshold of strict preference. The elements are named according to the IDs of the criteria.
- indifferenceThreshold** A vector containing threshold of indifference. The elements are named according to the IDs of the criteria.
- gaussParameter** A vector containing parameter of the Gaussian preference function. The elements are named according to the IDs of the criteria.
- criteriaWeights** Vector containing the weights of the criteria. The elements are named according to the IDs of the criteria.
- criteriaMinMax** Vector containing the preference direction on each of the criteria. "min" (resp. "max") indicates that the criterion has to be minimized (maximized). The elements are named according to the IDs of the criteria.

Value

The function returns a list containing the alternatives IDs in decreasing order of preference. Each elements of the list can be a vector of alternatives IDs.

Examples

```
# The evaluation table

performanceTable <- rbind(
  c(1,10,1),
  c(4,20,2),
  c(2,20,0),
```

```

c(6,40,0),
c(30,30,3))
rownames(performanceTable) <- c("RER", "METRO1", "METRO2", "BUS", "TAXI")
colnames(performanceTable) <- c("Price", "Time", "Comfort")

# The preference functions
preferenceFunction<-c("Gaussian", "Level", "V-shape-Indiff")

#Preference threshold
preferenceThreshold<-c(5,15,3)
names(preferenceThreshold)<-colnames(performanceTable)

#Indifference threshold
indifferenceThreshold<-c(3,11,1)
names(indifferenceThreshold)<-colnames(performanceTable)

#Parameter of the Gaussian preference function
gaussParameter<-c(4,0,0)
names(gaussParameter)<-colnames(performanceTable)

#weights

criteriaWeights<-c(0.2,0.3,0.5)
names(criteriaWeights)<-colnames(performanceTable)

# criteria to minimize or maximize

criteriaMinMax<-c("min", "min", "max")
names(criteriaMinMax)<-colnames(performanceTable)

PROMETHEEII(performanceTable, preferenceFunction,preferenceThreshold,
            indifferenceThreshold,gaussParameter,criteriaWeights,
            criteriaMinMax)

```

PROMETHEEOutrankingFlows

Outranking flows for the PROMETHEE methods

Description

This function computes the positive and negative outranking flows for the PROMETHEE methods. It takes as input a performance table and converts the evaluations to preference indices based on the given function types and parameters for each criterion.

Usage

```

PROMETHEEOutrankingFlows(performanceTable, preferenceFunction,
                          preferenceThreshold, indifferenceThreshold,
                          gaussParameter, criteriaWeights, criteriaMinMax)

```

Arguments

- performanceTable**
Matrix containing the evaluation table. Each row corresponds to an alternative, and each column to a criterion. Rows (resp. columns) must be named according to the IDs of the alternatives (resp. criteria).
- preferenceFunction**
A vector with preference functions. `preferenceFunction` should be equal to Usual, U-shape, V-shape, Level, V-shape-Indiff or Gaussian. The elements are named according to the IDs of the criteria.
- preferenceThreshold**
A vector containing threshold of strict preference. The elements are named according to the IDs of the criteria.
- indifferenceThreshold**
A vector containing threshold of indifference. The elements are named according to the IDs of the criteria.
- gaussParameter** A vector containing parameter of the Gaussian preference function. The elements are named according to the IDs of the criteria.
- criteriaWeights**
Vector containing the weights of the criteria. The elements are named according to the IDs of the criteria.
- criteriaMinMax** Vector containing the preference direction on each of the criteria. "min" (resp. "max") indicates that the criterion has to be minimized (maximized). The elements are named according to the IDs of the criteria.

Value

The function returns two vectors: The first one contains the positive outranking flows and the second one contains the negative outranking flows.

Examples

```
# The evaluation table

performanceTable <- rbind(
  c(1,10,1),
  c(4,20,2),
  c(2,20,0),
  c(6,40,0),
  c(30,30,3))
rownames(performanceTable) <- c("RER", "METRO1", "METRO2", "BUS", "TAXI")
colnames(performanceTable) <- c("Price", "Time", "Comfort")

# The preference functions
preferenceFunction<-c("Gaussian", "Level", "V-shape-Indiff")

#Preference threshold
preferenceThreshold<-c(5,15,3)
names(preferenceThreshold)<-colnames(performanceTable)
```

```

#Indifference threshold
indifferenceThreshold<-c(3,11,1)
names(indifferenceThreshold)<-colnames(performanceTable)

#Parameter of the Gaussian preference function
gaussParameter<-c(4,0,0)
names(gaussParameter)<-colnames(performanceTable)

#weights

criteriaWeights<-c(0.2,0.3,0.5)
names(criteriaWeights)<-colnames(performanceTable)

# criteria to minimize or maximize

criteriaMinMax<-c("min","min","max")
names(criteriaMinMax)<-colnames(performanceTable)

# Outranking flows

outrankingFlows<-PROMETHEEOutrankingFlows(performanceTable, preferenceFunction,
                                           preferenceThreshold,indifferenceThreshold,
                                           gaussParameter,criteriaWeights,
                                           criteriaMinMax)

```

PROMETHEEPreferenceIndices

Preference indices for the PROMETHEE methods

Description

This function computes the preference indices from a performance table based on the given function types and parameters for each criterion.

Usage

```

PROMETHEEPreferenceIndices(performanceTable, preferenceFunction,
                           preferenceThreshold,indifferenceThreshold,
                           gaussParameter,criteriaWeights,criteriaMinMax)

```

Arguments

performanceTable

Matrix containing the performance table. Each row corresponds to an alternative, and each column to a criterion. Rows (resp. columns) must be named according to the IDs of the alternatives (resp. criteria).

preferenceFunction	A vector containing the names of the preference functions to be used. preferenceFunction should be equal to Usual, U-shape, V-shape, Level, V-shape-Indiff or Gaussian. The elements of the vector are named according to the IDs of the criteria.
preferenceThreshold	A vector containing thresholds of strict preference. The elements are named according to the IDs of the criteria.
indifferenceThreshold	A vector containing thresholds of indifference. The elements are named according to the IDs of the criteria.
gaussParameter	A vector containing parameters of the Gaussian preference function. The elements are named according to the IDs of the criteria.
criteriaWeights	Vector containing the weights of the criteria. The elements are named according to the IDs of the criteria.
criteriaMinMax	Vector containing the preference direction on each of the criteria. "min" (resp. "max") indicates that the criterion has to be minimized (maximized). The elements are named according to the IDs of the criteria.

Value

The function returns a matrix containing all the aggregated preference indices.

Examples

```
# The evaluation table

performanceTable <- rbind(
  c(1,10,1),
  c(4,20,2),
  c(2,20,0),
  c(6,40,0),
  c(30,30,3))
rownames(performanceTable) <- c("RER", "METRO1", "METRO2", "BUS", "TAXI")
colnames(performanceTable) <- c("Price", "Time", "Comfort")

# The preference functions
preferenceFunction<-c("Gaussian", "Level", "V-shape-Indiff")

#Preference threshold
preferenceThreshold<-c(5,15,3)
names(preferenceThreshold)<-colnames(performanceTable)

#Indifference threshold
indifferenceThreshold<-c(3,11,1)
names(indifferenceThreshold)<-colnames(performanceTable)

#Parameter of the Gaussian preference function
gaussParameter<-c(4,0,0)
```

```

names(gaussParameter)<-colnames(performanceTable)

#weights

criteriaWeights<-c(0.2,0.3,0.5)
names(criteriaWeights)<-colnames(performanceTable)

# criteria to minimize or maximize

criteriaMinMax<-c("min","min","max")
names(criteriaMinMax)<-colnames(performanceTable)

#Preference indices

preferenceTable<-PROMETHEEPreferenceIndices(performanceTable, preferenceFunction,
                                             preferenceThreshold, indifferenceThreshold,
                                             gaussParameter, criteriaWeights,
                                             criteriaMinMax)

```

SRMP

SRMP: a simple ranking method using reference profiles

Description

SRMP is a ranking method that uses dominating reference profiles, in a given lexicographic ordering, in order to output a total preorder of a set of alternatives.

Usage

```
SRMP(performanceTable, referenceProfiles, lexicographicOrder, criteriaWeights,
     criteriaMinMax, alternativesIDs = NULL, criteriaIDs = NULL)
```

Arguments

`performanceTable`

Matrix or data frame containing the performance table. Each row corresponds to an alternative, and each column to a criterion. Rows (resp. columns) must be named according to the IDs of the alternatives (resp. criteria).

`referenceProfiles`

Matrix containing, in each row, the reference profiles. The columns are named according to the criteria.

`lexicographicOrder`

A vector containing the indexes of the reference profiles in a given order. This vector needs to be of the same length as the number of rows in `referenceProfiles` and it has to contain a permutation of the indices of these rows.

<code>criteriaWeights</code>	Vector containing the weights of the criteria. The elements are named according to the IDs of the criteria.
<code>criteriaMinMax</code>	Vector containing the preference direction on each of the criteria. "min" (resp. "max") indicates that the criterion has to be minimized (maximized). The elements are named according to the IDs of the criteria.
<code>alternativesIDs</code>	Vector containing IDs of alternatives, according to which the data should be filtered.
<code>criteriaIDs</code>	Vector containing IDs of criteria, according to which the data should be filtered.

Value

The function returns a vector containing the ranks of the alternatives (the higher the better).

References

A. Rolland. Procédures d'agrégation ordinaire de préférences avec points de référence pour l'aide à la décision. PhD thesis, Université Paris VI, 2008.

Examples

```
# the performance table

performanceTable <- rbind(c(10,10,9),c(10,9,10),c(9,10,10),c(9,9,10),c(9,10,9),c(10,9,9),
  c(10,10,7),c(10,7,10),c(7,10,10),c(9,9,17),c(9,17,9),c(17,9,9),
  c(7,10,17),c(10,17,7),c(17,7,10),c(7,17,10),c(17,10,7),c(10,7,17),
  c(7,9,17),c(9,17,7),c(17,7,9),c(7,17,9),c(17,9,7),c(9,7,17))

referenceProfiles <- rbind(c(5,5,5),c(10,10,10),c(15,15,15))

lexicographicOrder <- c(2,1,3)

weights <- c(0.2,0.44,0.36)

criteriaMinMax <- c("max","max","max")

rownames(performanceTable) <- c("a1","a2","a3","a4","a5","a6","a7","a8","a9","a10","a11","a12",
  "a13","a14","a15","a16","a17","a18","a19","a20","a21","a22",
  "a23","a24")

colnames(performanceTable) <- c("c1","c2","c3")

colnames(referenceProfiles) <- c("c1","c2","c3")

names(weights) <- c("c1","c2","c3")

names(criteriaMinMax) <- colnames(performanceTable)

expectedpreorder <- list('a16','a13',c('a3','a9'),'a14','a17',c('a1','a7'),'a18','a15',
  c('a2','a8'),c('a11','a20','a22'),'a5',c('a10','a19','a24'))
```

```
'a4',c('a12','a21','a23'),'a6')
```

```
preorder<-SRMP(performanceTable, referenceProfiles, lexicographicOrder, weights, criteriaMinMax)
```

SRMPInference	<i>Exact inference of an SRMP model given a maximum number of reference profiles</i>
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Description

Exact inference approach from pairwise comparisons of alternatives for the SRMP ranking model. This method outputs an SRMP model that is as consistent as possible with the provided pairwise comparisons (i.e. the model - the number of profiles and their lexicographic order - that maximizes the number of fulfilled pairwise comparisons). The method will search for a model with the minimum possible number of profiles up to a given maximum value.

Usage

```
SRMPInference(performanceTable, criteriaMinMax, maxProfilesNumber, preferencePairs,
  indifferencePairs = NULL, alternativesIDs = NULL, criteriaIDs = NULL,
  solver="glpk", timeLimit = NULL, cplexIntegralityTolerance = NULL,
  cplexThreads = NULL)
```

Arguments

performanceTable	Matrix or data frame containing the performance table. Each row corresponds to an alternative, and each column to a criterion. Rows (resp. columns) must be named according to the IDs of the alternatives (resp. criteria).
criteriaMinMax	Vector containing the preference direction on each of the criteria. "min" (resp. "max") indicates that the criterion has to be minimized (maximized). The elements are named according to the IDs of the criteria.
maxProfilesNumber	A strictly positive numerical value which gives the highest number of reference profiles the sought SRMP model should have.
preferencePairs	A two column matrix containing on each row a pair of alternative names where the first alternative is considered to be strictly preferred to the second.
indifferencePairs	A two column matrix containing on each row a pair of alternative names the two alternatives are considered to be indifferent with respect to each other.
alternativesIDs	Vector containing IDs of alternatives, according to which the data should be filtered.
criteriaIDs	Vector containing IDs of criteria, according to which the data should be filtered.

<code>solver</code>	String specifying if the glpk solver (glpk) should be used, or the cplex (cplex) solver. By default glpk. The cplex solver requires to install the cplex binary and the cplex C API, as well as the cplexAPI R package.
<code>timeLimit</code>	Allows to fix a time limit of the execution, in seconds. By default NULL (which corresponds to no time limit).
<code>cplexIntegralityTolerance</code>	If the cplex solver is used, allows to fix a tolerance for integrality. By default NULL (which corresponds to the default value of cplex).
<code>cplexThreads</code>	If the cplex solver is used, allows to the number of threads for the calculation. By default NULL (which corresponds to the default value of cplex).

Value

The function returns a list containing:

<code>criteriaWeights</code>	The inferred criteria weights.
<code>referenceProfilesNumber</code>	The inferred reference profiles number.
<code>referenceProfiles</code>	The inferred reference profiles.
<code>lexicographicOrder</code>	The inferred lexicographic order of the profiles.
<code>fitness</code>	The percentage (0 to 1) of fulfilled pair-wise relations.
<code>solverStatus</code>	The solver status as given by glpk or cplex.
<code>humanReadableStatus</code>	A description of the solver status.

References

A-L. OLTEANU, V. MOUSSEAU, W. OUERDANE, A. ROLLAND, Y. ZHENG, Preference Elicitation for a Ranking Method based on Multiple Reference Profiles, forthcoming 2018.

Examples

```
performanceTable <- rbind(c(10,10,9),c(10,9,10),c(9,10,10),c(9,9,10),c(9,10,9),c(10,9,9),
  c(10,10,7),c(10,7,10),c(7,10,10),c(9,9,17),c(9,17,9),c(17,9,9),
  c(7,10,17),c(10,17,7),c(17,7,10),c(7,17,10),c(17,10,7),c(10,7,17),
  c(7,9,17),c(9,17,7),c(17,7,9),c(7,17,9),c(17,9,7),c(9,7,17))

criteriaMinMax <- c("max","max","max")

rownames(performanceTable) <- c("a1","a2","a3","a4","a5","a6","a7","a8","a9","a10","a11","a12",
  "a13","a14","a15","a16","a17","a18","a19","a20","a21","a22",
  "a23","a24")

colnames(performanceTable) <- c("c1","c2","c3")
```

```

names(criteriaMinMax) <- colnames(performanceTable)

preferencePairs <- matrix(c("a16", "a13", "a3", "a14", "a17", "a1", "a18", "a15", "a2", "a11", "a5",
                           "a10", "a4", "a12", "a13", "a3", "a14", "a17", "a1", "a18", "a15", "a2",
                           "a11", "a5", "a10", "a4", "a12", "a6"), 14, 2)
indifferencePairs <- matrix(c("a3", "a1", "a2", "a11", "a11", "a20", "a10", "a10", "a19", "a12", "a12",
                              "a21", "a9", "a7", "a8", "a20", "a22", "a22", "a19", "a24", "a24", "a21",
                              "a23", "a23"), 12, 2)

result<-SRMPInference(performanceTable, criteriaMinMax, 3, preferencePairs, indifferencePairs,
                      alternativesIDs = c("a1", "a3", "a7", "a9", "a13", "a14", "a15", "a16", "a17",
                                          "a18"))

```

SRMPInferenceApprox *Approximative inference of an SRMP model*

Description

Approximative inference approach from pairwise comparisons of alternatives for the SRMP ranking model. This method outputs an SRMP model that fulfils as many pairwise comparisons as possible. Neither the number of reference profiles, nor the lexicographic order are fixed beforehand, however a maximum value for the number of reference profiles needs to be provided.

Usage

```

SRMPInferenceApprox(performanceTable, criteriaMinMax, maxProfilesNumber, preferencePairs,
                    indifferencePairs = NULL, alternativesIDs = NULL, criteriaIDs = NULL,
                    timeLimit = 60, populationSize = 20, mutationProb = 0.1)

```

Arguments

performanceTable
Matrix or data frame containing the performance table. Each row corresponds to an alternative, and each column to a criterion. Rows (resp. columns) must be named according to the IDs of the alternatives (resp. criteria).

criteriaMinMax
Vector containing the preference direction on each of the criteria. "min" (resp. "max") indicates that the criterion has to be minimized (maximized). The elements are named according to the IDs of the criteria.

maxProfilesNumber
The maximum number of reference profiles of the SRMP model.

preferencePairs
A two column matrix containing on each row a pair of alternative names where the first alternative is considered to be strictly preferred to the second.

indifferencePairs
A two column matrix containing on each row a pair of alternative names the two alternatives are considered to indifferent with respect to each other.

alternativesIDs	Vector containing IDs of alternatives, according to which the data should be filtered.
criteriaIDs	Vector containing IDs of criteria, according to which the data should be filtered.
timeLimit	Allows to fix a time limit of the execution, in seconds (default 60).
populationSize	Allows to change the size of the population used by the genetic algorithm (default 20).
mutationProb	Allows to change the mutation probability used by the genetic algorithm (default 0.1).

Value

The function returns a list containing:

criteriaWeights	The inferred criteria weights.
referenceProfilesNumber	The number of inferred reference profiles.
referenceProfiles	The inferred reference profiles.
lexicographicOrder	The inferred lexicographic order of the reference profiles.
fitness	The percentage of fulfilled pair-wise relations.

References

A-L. OLTEANU, V. MOUSSEAU, W. OUERDANE, A. ROLLAND, Y. ZHENG, Preference Elicitation for a Ranking Method based on Multiple Reference Profiles, forthcoming 2018.

Examples

```
performanceTable <- rbind(c(10,10,9),c(10,9,10),c(9,10,10),c(9,9,10),c(9,10,9),c(10,9,9),
  c(10,10,7),c(10,7,10),c(7,10,10),c(9,9,17),c(9,17,9),c(17,9,9),
  c(7,10,17),c(10,17,7),c(17,7,10),c(7,17,10),c(17,10,7),c(10,7,17),
  c(7,9,17),c(9,17,7),c(17,7,9),c(7,17,9),c(17,9,7),c(9,7,17))

criteriaMinMax <- c("max","max","max")

rownames(performanceTable) <- c("a1","a2","a3","a4","a5","a6","a7","a8","a9","a10","a11",
  "a12","a13","a14","a15","a16","a17","a18","a19","a20",
  "a21","a22","a23","a24")

colnames(performanceTable) <- c("c1","c2","c3")

names(criteriaMinMax) <- colnames(performanceTable)

# expected result for the tests below
```

```

expectedpreorder <- list("a16", "a13", c("a3", "a9"), "a14", "a17", c("a1", "a7"), "a18", "a15")

# test - preferences and indifferences

preferencePairs <- matrix(c("a16", "a13", "a3", "a14", "a17", "a1", "a18", "a15", "a2", "a11",
                           "a5", "a10", "a4", "a12", "a13", "a3", "a14", "a17", "a1", "a18",
                           "a15", "a2", "a11", "a5", "a10", "a4", "a12", "a6"), 14, 2)
indifferencePairs <- matrix(c("a3", "a1", "a2", "a11", "a11", "a20", "a10", "a10", "a19", "a12",
                              "a12", "a21", "a9", "a7", "a8", "a20", "a22", "a22", "a19", "a24",
                              "a24", "a21", "a23", "a23"), 12, 2)

set.seed(1)

result<-SRMPInferenceApprox(performanceTable, criteriaMinMax, 3, preferencePairs,
                             indifferencePairs, alternativesIDs = c("a1", "a3", "a7",
                             "a9", "a13", "a14", "a15", "a16", "a17", "a18"))

```

SRMPInferenceApproxFixedLexicographicOrder

Approximative inference of an SRMP model given the lexicographic order of the profiles

Description

Approximative inference approach from pairwise comparisons of alternatives for the SRMP ranking model. This method outputs an SRMP model that fulfils as many pairwise comparisons as possible. The number of reference profiles and their lexicographic order is fixed beforehand.

Usage

```

SRMPInferenceApproxFixedLexicographicOrder(performanceTable, criteriaMinMax,
                                             lexicographicOrder, preferencePairs,
                                             indifferencePairs = NULL,
                                             alternativesIDs = NULL, criteriaIDs = NULL,
                                             timeLimit = 60,
                                             populationSize = 20, mutationProb = 0.1)

```

Arguments

performanceTable

Matrix or data frame containing the performance table. Each row corresponds to an alternative, and each column to a criterion. Rows (resp. columns) must be named according to the IDs of the alternatives (resp. criteria).

criteriaMinMax

Vector containing the preference direction on each of the criteria. "min" (resp. "max") indicates that the criterion has to be minimized (maximized). The elements are named according to the IDs of the criteria.

lexicographicOrder	A vector containing the indexes of the reference profiles in a given order. The number of reference profiles to be used is derived implicitly from the size of this vector. The elements of this vector need to be a permutation of the indices from 1 to its size.
preferencePairs	A two column matrix containing on each row a pair of alternative names where the first alternative is considered to be strictly preferred to the second.
indifferencePairs	A two column matrix containing on each row a pair of alternative names the two alternatives are considered to indifferent with respect to each other.
alternativesIDs	Vector containing IDs of alternatives, according to which the data should be filtered.
criteriaIDs	Vector containing IDs of criteria, according to which the data should be filtered.
timeLimit	Allows to fix a time limit of the execution, in seconds (default 60).
populationSize	Allows to change the size of the population used by the genetic algorithm (default 20).
mutationProb	Allows to change the mutation probability used by the genetic algorithm (default 0.1).

Value

The function returns a list containing:

criteriaWeights	The inferred criteria weights.
referenceProfiles	The inferred reference profiles.
lexicographicOrder	The lexicographic order of the reference profiles, in this case the one that was originally given as input.
fitness	The percentage of fulfilled pair-wise relations.

References

A-L. OLTEANU, V. MOUSSEAU, W. OUERDANE, A. ROLLAND, Y. ZHENG, Preference Elicitation for a Ranking Method based on Multiple Reference Profiles, forthcoming 2018.

Examples

```
performanceTable <- rbind(c(10,10,9),c(10,9,10),c(9,10,10),c(9,9,10),c(9,10,9),c(10,9,9),
  c(10,10,7),c(10,7,10),c(7,10,10),c(9,9,17),c(9,17,9),c(17,9,9),
  c(7,10,17),c(10,17,7),c(17,7,10),c(7,17,10),c(17,10,7),c(10,7,17),
  c(7,9,17),c(9,17,7),c(17,7,9),c(7,17,9),c(17,9,7),c(9,7,17))

lexicographicOrder <- c(1,2,3)
```



```
alternativesIDs = NULL, criteriaIDs = NULL,
timeLimit = 60,
populationSize = 20, mutationProb = 0.1)
```

Arguments

performanceTable	Matrix or data frame containing the performance table. Each row corresponds to an alternative, and each column to a criterion. Rows (resp. columns) must be named according to the IDs of the alternatives (resp. criteria).
criteriaMinMax	Vector containing the preference direction on each of the criteria. "min" (resp. "max") indicates that the criterion has to be minimized (maximized). The elements are named according to the IDs of the criteria.
profilesNumber	The number of reference profiles of the SRMP model.
preferencePairs	A two column matrix containing on each row a pair of alternative names where the first alternative is considered to be strictly preferred to the second.
indifferencePairs	A two column matrix containing on each row a pair of alternative names the two alternatives are considered to be indifferent with respect to each other.
alternativesIDs	Vector containing IDs of alternatives, according to which the data should be filtered.
criteriaIDs	Vector containing IDs of criteria, according to which the data should be filtered.
timeLimit	Allows to fix a time limit of the execution, in seconds (default 60).
populationSize	Allows to change the size of the population used by the genetic algorithm (default 20).
mutationProb	Allows to change the mutation probability used by the genetic algorithm (default 0.1).

Value

The function returns a list containing:

criteriaWeights	The inferred criteria weights.
referenceProfiles	The inferred reference profiles.
lexicographicOrder	The inferred lexicographic order of the reference profiles.
fitness	The percentage of fulfilled pair-wise relations.

References

A-L. OLTEANU, V. MOUSSEAU, W. OUERDANE, A. ROLLAND, Y. ZHENG, Preference Elicitation for a Ranking Method based on Multiple Reference Profiles, forthcoming 2018.

Examples

```

# the performance table

performanceTable <- rbind(c(10,10,9),c(10,9,10),c(9,10,10),c(9,9,10),c(9,10,9),c(10,9,9),
  c(10,10,7),c(10,7,10),c(7,10,10),c(9,9,17),c(9,17,9),c(17,9,9),
  c(7,10,17),c(10,17,7),c(17,7,10),c(7,17,10),c(17,10,7),c(10,7,17),
  c(7,9,17),c(9,17,7),c(17,7,9),c(7,17,9),c(17,9,7),c(9,7,17))

criteriaMinMax <- c("max","max","max")

rownames(performanceTable) <- c("a1","a2","a3","a4","a5","a6","a7","a8","a9","a10","a11",
  "a12","a13","a14","a15","a16","a17","a18","a19","a20",
  "a21","a22","a23","a24")

colnames(performanceTable) <- c("c1","c2","c3")

names(criteriaMinMax) <- colnames(performanceTable)

# expected result for the tests below

expectedpreorder <- list("a16","a13",c("a3","a9"),"a14",c("a1","a7"),"a15")

# test - preferences and indifferences

preferencePairs <- matrix(c("a16","a13","a3","a14","a17","a1","a18","a15","a2","a11",
  "a5","a10","a4","a12","a13","a3","a14","a17","a1","a18",
  "a15","a2","a11","a5","a10","a4","a12","a6"),14,2)
indifferencePairs <- matrix(c("a3","a1","a2","a11","a11","a20","a10","a10","a19","a12",
  "a12","a21","a9","a7","a8","a20","a22","a22","a19","a24",
  "a24","a21","a23","a23"),12,2)

set.seed(1)

result<-SRMPInferenceApproxFixedProfilesNumber(performanceTable, criteriaMinMax, 3,
  preferencePairs, indifferencePairs,
  alternativesIDs = c("a1","a3","a7","a9",
  "a13","a14","a15","a16"))

```

SRMPInferenceFixedLexicographicOrder

Exact inference of an SRMP model given the lexicographic order of the profiles

Description

Exact inference approach from pairwise comparisons of alternatives for the SRMP ranking model. This method outputs an SRMP model that maximizes the number of fulfilled pairwise comparisons. The number of reference profiles and their lexicographic order is fixed.

Usage

```
SRMPInferenceFixedLexicographicOrder(performanceTable, criteriaMinMax, lexicographicOrder,
                                       preferencePairs, indifferencePairs = NULL,
                                       alternativesIDs = NULL, criteriaIDs = NULL,
                                       solver="glpk", timeLimit = NULL,
                                       cplexIntegralityTolerance = NULL,
                                       cplexThreads = NULL)
```

Arguments

- performanceTable** Matrix or data frame containing the performance table. Each row corresponds to an alternative, and each column to a criterion. Rows (resp. columns) must be named according to the IDs of the alternatives (resp. criteria).
- criteriaMinMax** Vector containing the preference direction on each of the criteria. "min" (resp. "max") indicates that the criterion has to be minimized (maximized). The elements are named according to the IDs of the criteria.
- lexicographicOrder** A vector containing the indexes of the reference profiles in a given order. The number of reference profiles to be used is derived implicitly from the size of this vector. The elements of this vector need to be a permutation of the indices from 1 to its size.
- preferencePairs** A two column matrix containing on each row a pair of alternative names where the first alternative is considered to be strictly preferred to the second.
- indifferencePairs** A two column matrix containing on each row a pair of alternative names the two alternatives are considered to indifferent with respect to each other.
- alternativesIDs** Vector containing IDs of alternatives, according to which the data should be filtered.
- criteriaIDs** Vector containing IDs of criteria, according to which the data should be filtered.
- solver** String specifying if the glpk solver (glpk) should be used, or the cplex (cplex) solver. By default glpk. The cplex solver requires to install the cplex binary and the cplex C API, as well as the cplexAPI R package.
- timeLimit** Allows to fix a time limit of the execution, in seconds. By default NULL (which corresponds to no time limit).
- cplexIntegralityTolerance** If the cplex solver is used, allows to fix a tolerance for integrality. By default NULL (which corresponds to the default value of cplex).
- cplexThreads** If the cplex solver is used, allows to set the number of threads for the calculation. By default NULL (which corresponds to the default value of cplex - 1).

Value

The function returns a list containing:

criteriaWeights The inferred criteria weights.
referenceProfiles The inferred reference profiles.
fitness The percentage (0 to 1) of fulfilled pair-wise relations.
solverStatus The solver status as given by glpk or cplex.
humanReadableStatus A description of the solver status.

References

A-L. OLTEANU, V. MOUSSEAU, W. OUERDANE, A. ROLLAND, Y. ZHENG, Preference Elicitation for a Ranking Method based on Multiple Reference Profiles, forthcoming 2018.

Examples

```

# the performance table

performanceTable <- rbind(c(10,10,9),c(10,9,10),c(9,10,10),c(9,9,10),c(9,10,9),c(10,9,9),
  c(10,10,7),c(10,7,10),c(7,10,10),c(9,9,17),c(9,17,9),c(17,9,9),
  c(7,10,17),c(10,17,7),c(17,7,10),c(7,17,10),c(17,10,7),c(10,7,17),
  c(7,9,17),c(9,17,7),c(17,7,9),c(7,17,9),c(17,9,7),c(9,7,17))

lexicographicOrder <- c(2,1,3)

criteriaMinMax <- c("max","max","max")

rownames(performanceTable) <- c("a1","a2","a3","a4","a5","a6","a7","a8","a9","a10","a11","a12",
  "a13","a14","a15","a16","a17","a18","a19","a20","a21","a22",
  "a23","a24")

colnames(performanceTable) <- c("c1","c2","c3")

names(criteriaMinMax) <- colnames(performanceTable)

preferencePairs <- matrix(c("a16","a13","a3","a14","a17","a1","a18","a15","a2","a11","a5",
  "a10","a4","a12","a13","a3","a14","a17","a1","a18","a15","a2",
  "a11","a5","a10","a4","a12","a6"),14,2)
indifferencePairs <- matrix(c("a3","a1","a2","a11","a11","a20","a10","a10","a19","a12","a12",
  "a21","a9","a7","a8","a20","a22","a22","a19","a24","a24","a21",
  "a23","a23"),12,2)

result<-SRMPInferenceFixedLexicographicOrder(performanceTable, criteriaMinMax,
  lexicographicOrder, preferencePairs,
  indifferencePairs, alternativesIDs =
  c("a1","a3","a7","a9","a13","a14","a16","a17"))

```

 SRMPInferenceFixedProfilesNumber

Exact inference of an SRMP model given the number of reference profiles

Description

Exact inference approach from pairwise comparisons of alternatives for the SRMP ranking model. This method outputs an SRMP model that is as consistent as possible with the provided pairwise comparisons (i.e. the model - and the lexicographic order of the reference profiles - that maximizes the number of fulfilled pairwise comparisons). The number of reference profiles is fixed and needs to be provided.

Usage

```
SRMPInferenceFixedProfilesNumber(performanceTable, criteriaMinMax, profilesNumber,
                                   preferencePairs, indifferencePairs = NULL,
                                   alternativesIDs = NULL, criteriaIDs = NULL,
                                   solver="glpk", timeLimit = NULL,
                                   cplexIntegralityTolerance = NULL,
                                   cplexThreads = NULL)
```

Arguments

performanceTable	Matrix or data frame containing the performance table. Each row corresponds to an alternative, and each column to a criterion. Rows (resp. columns) must be named according to the IDs of the alternatives (resp. criteria).
criteriaMinMax	Vector containing the preference direction on each of the criteria. "min" (resp. "max") indicates that the criterion has to be minimized (maximized). The elements are named according to the IDs of the criteria.
profilesNumber	A strictly positive numerical value which gives the number of reference profiles in the sought SRMP model.
preferencePairs	A two column matrix containing on each row a pair of alternative names where the first alternative is considered to be strictly preferred to the second.
indifferencePairs	A two column matrix containing on each row a pair of alternative names the two alternatives are considered to be indifferent with respect to each other.
alternativesIDs	Vector containing IDs of alternatives, according to which the data should be filtered.
criteriaIDs	Vector containing IDs of criteria, according to which the data should be filtered.
solver	String specifying if the glpk solver (glpk) should be used, or the cplex (cplex) solver. By default glpk. The cplex solver requires to install the cplex binary and the cplex C API, as well as the cplexAPI R package.

<code>timeLimit</code>	Allows to fix a time limit of the execution, in seconds. By default NULL (which corresponds to no time limit).
<code>cplexIntegralityTolerance</code>	If the cplex solver is used, allows to fix a tolerance for integrality. By default NULL (which corresponds to the default value of cplex).
<code>cplexThreads</code>	If the cplex solver is used, allows to the number of threads for the calculation. By default NULL (which corresponds to the default value of cplex).

Value

The function returns a list containing:

<code>criteriaWeights</code>	The inferred criteria weights.
<code>referenceProfiles</code>	The inferred reference profiles.
<code>lexicographicOrder</code>	The inferred lexicographic order of the profiles.
<code>fitness</code>	The percentage (0 to 1) of fulfilled pair-wise relations.
<code>solverStatus</code>	The solver status as given by glpk or cplex.
<code>humanReadableStatus</code>	A description of the solver status.

References

A-L. OLTEANU, V. MOUSSEAU, W. OUERDANE, A. ROLLAND, Y. ZHENG, Preference Elicitation for a Ranking Method based on Multiple Reference Profiles, forthcoming 2018.

Examples

```
performanceTable <- rbind(c(10,10,9),c(10,9,10),c(9,10,10),c(9,9,10),c(9,10,9),c(10,9,9),
  c(10,10,7),c(10,7,10),c(7,10,10),c(9,9,17),c(9,17,9),c(17,9,9),
  c(7,10,17),c(10,17,7),c(17,7,10),c(7,17,10),c(17,10,7),c(10,7,17),
  c(7,9,17),c(9,17,7),c(17,7,9),c(7,17,9),c(17,9,7),c(9,7,17))

criteriaMinMax <- c("max","max","max")

rownames(performanceTable) <- c("a1","a2","a3","a4","a5","a6","a7","a8","a9","a10","a11","a12",
  "a13","a14","a15","a16","a17","a18","a19","a20","a21","a22",
  "a23","a24")

colnames(performanceTable) <- c("c1","c2","c3")

names(criteriaMinMax) <- colnames(performanceTable)

preferencePairs <- matrix(c("a16","a13","a3","a14","a17","a1","a18","a15","a2","a11","a5",
  "a10","a4","a12","a13","a3","a14","a17","a1","a18","a15","a2",
  "a11","a5","a10","a4","a12","a6"),14,2)

indifferencePairs <- matrix(c("a3","a1","a2","a11","a11","a20","a10","a10","a19","a12","a12",
```

```
"a21", "a9", "a7", "a8", "a20", "a22", "a22", "a19", "a24", "a24", "a21",
"a23", "a23"), 12, 2)
```

```
result<-SRMPInferenceFixedProfilesNumber(performanceTable, criteriaMinMax, 3, preferencePairs,
indifferencePairs, alternativesIDs = c("a1", "a3",
"a7", "a9", "a13", "a14", "a15", "a16", "a17", "a18"))
```

SRMPInferenceNoInconsist

Exact inference of an SRMP model given a maximum number of reference profiles - no inconsistencies

Description

Exact inference approach from pairwise comparisons of alternatives for the SRMP ranking model. This method only outputs a result when an SRMP model consistent with the provided pairwise comparisons exists. The method will search for a model with the minimum possible number of profiles up to a given maximum value. If such a model exists, this method is significantly faster than the one which handles inconsistencies.

Usage

```
SRMPInferenceNoInconsist(performanceTable, criteriaMinMax, maxProfilesNumber,
preferencePairs, indifferencePairs = NULL,
alternativesIDs = NULL, criteriaIDs = NULL,
solver="glpk", timeLimit = NULL,
cplexIntegralityTolerance = NULL,
cplexThreads = NULL)
```

Arguments

performanceTable

Matrix or data frame containing the performance table. Each row corresponds to an alternative, and each column to a criterion. Rows (resp. columns) must be named according to the IDs of the alternatives (resp. criteria).

criteriaMinMax Vector containing the preference direction on each of the criteria. "min" (resp. "max") indicates that the criterion has to be minimized (maximized). The elements are named according to the IDs of the criteria.

maxProfilesNumber

A strictly positive numerical value which gives the highest number of reference profiles the sought SRMP model should have.

preferencePairs

A two column matrix containing on each row a pair of alternative names where the first alternative is considered to be strictly preferred to the second.

indifferencePairs

A two column matrix containing on each row a pair of alternative names the two alternatives are considered to indifferent with respect to each other.

alternativesIDs	Vector containing IDs of alternatives, according to which the data should be filtered.
criteriaIDs	Vector containing IDs of criteria, according to which the data should be filtered.
solver	String specifying if the glpk solver (glpk) should be used, or the cplex (cplex) solver. By default glpk. The cplex solver requires to install the cplex binary and the cplex C API, as well as the cplexAPI R package.
timeLimit	Allows to fix a time limit of the execution, in seconds. By default NULL (which corresponds to no time limit).
cplexIntegralityTolerance	If the cplex solver is used, allows to fix a tolerance for integrality. By default NULL (which corresponds to the default value of cplex).
cplexThreads	If the cplex solver is used, allows to the number of threads for the calculation. By default NULL (which corresponds to the default value of cplex).

Value

The function returns a list containing:

criteriaWeights	The inferred criteria weights.
referenceProfilesNumber	The inferred reference profiles number.
referenceProfiles	The inferred reference profiles.
lexicographicOrder	The inferred lexicographic order of the profiles.
solverStatus	The solver status as given by glpk or cplex.
humanReadableStatus	A description of the solver status.

References

A-L. OLTEANU, V. MOUSSEAU, W. OUERDANE, A. ROLLAND, Y. ZHENG, Preference Elicitation for a Ranking Method based on Multiple Reference Profiles, forthcoming 2018.

Examples

```
performanceTable <- rbind(c(10,10,9),c(10,9,10),c(9,10,10),c(9,9,10),c(9,10,9),c(10,9,9),
  c(10,10,7),c(10,7,10),c(7,10,10),c(9,9,17),c(9,17,9),c(17,9,9),
  c(7,10,17),c(10,17,7),c(17,7,10),c(7,17,10),c(17,10,7),c(10,7,17),
  c(7,9,17),c(9,17,7),c(17,7,9),c(7,17,9),c(17,9,7),c(9,7,17))

criteriaMinMax <- c("max","max","max")

rownames(performanceTable) <- c("a1","a2","a3","a4","a5","a6","a7","a8","a9","a10","a11","a12",
  "a13","a14","a15","a16","a17","a18","a19","a20","a21","a22",
```



```

"a23", "a24")

colnames(performanceTable) <- c("c1", "c2", "c3")

names(criteriaMinMax) <- colnames(performanceTable)

preferencePairs <- matrix(c("a16", "a13", "a3", "a14", "a17", "a1", "a18", "a15", "a2", "a11", "a5",
    "a10", "a4", "a12", "a13", "a3", "a14", "a17", "a1", "a18", "a15", "a2",
    "a11", "a5", "a10", "a4", "a12", "a6"), 14, 2)
indifferencePairs <- matrix(c("a3", "a1", "a2", "a11", "a11", "a20", "a10", "a10", "a19", "a12", "a12",
    "a21", "a9", "a7", "a8", "a20", "a22", "a22", "a19", "a24", "a24", "a21",
    "a23", "a23"), 12, 2)

result <- SRMPInferenceNoInconsist(performanceTable, criteriaMinMax, 3, preferencePairs,
    indifferencePairs, alternativesIDs = c("a1", "a2", "a3", "a4",
    "a5", "a6", "a7", "a8", "a10", "a11", "a12", "a14", "a16", "a17", "a18",
    "a19", "a20", "a21", "a23", "a24"))

```

SRMPInferenceNoInconsistFixedLexicographicOrder

Exact inference of an SRMP model given the lexicographic order of the profiles - no inconsistencies

Description

Exact inference approach from pairwise comparisons of alternatives for the SRMP ranking model. This method only outputs a result when an SRMP model consistent with the provided pairwise comparisons exists. The number of reference profiles and their lexicographic order is fixed. If such a model exists, this method is significantly faster than the one which handles inconsistencies.

Usage

```

SRMPInferenceNoInconsistFixedLexicographicOrder(performanceTable, criteriaMinMax,
    lexicographicOrder, preferencePairs,
    indifferencePairs = NULL,
    alternativesIDs = NULL,
    criteriaIDs = NULL,
    solver="glpk", timeLimit = NULL,
    cplexIntegralityTolerance = NULL,
    cplexThreads = NULL)

```

Arguments

performanceTable

Matrix or data frame containing the performance table. Each row corresponds to an alternative, and each column to a criterion. Rows (resp. columns) must be named according to the IDs of the alternatives (resp. criteria).

<code>criteriaMinMax</code>	Vector containing the preference direction on each of the criteria. "min" (resp. "max") indicates that the criterion has to be minimized (maximized). The elements are named according to the IDs of the criteria.
<code>lexicographicOrder</code>	A vector containing the indexes of the reference profiles in a given order. The number of reference profiles to be used is derived implicitly from the size of this vector. The elements of this vector need to be a permutation of the indices from 1 to its size.
<code>preferencePairs</code>	A two column matrix containing on each row a pair of alternative names where the first alternative is considered to be strictly preferred to the second.
<code>indifferencePairs</code>	A two column matrix containing on each row a pair of alternative names the two alternatives are considered to indifferent with respect to each other.
<code>alternativesIDs</code>	Vector containing IDs of alternatives, according to which the data should be filtered.
<code>criteriaIDs</code>	Vector containing IDs of criteria, according to which the data should be filtered.
<code>solver</code>	String specifying if the glpk solver (glpk) should be used, or the cplex (cplex) solver. By default glpk. The cplex solver requires to install the cplex binary and the cplex C API, as well as the cplexAPI R package.
<code>timeLimit</code>	Allows to fix a time limit of the execution, in seconds. By default NULL (which corresponds to no time limit).
<code>cplexIntegralityTolerance</code>	If the cplex solver is used, allows to fix a tolerance for integrality. By default NULL (which corresponds to the default value of cplex).
<code>cplexThreads</code>	If the cplex solver is used, allows to the number of threads for the calculation. By default NULL (which corresponds to the default value of cplex).

Value

The function returns a list containing:

<code>criteriaWeights</code>	The inferred criteria weights.
<code>referenceProfiles</code>	The inferred reference profiles.
<code>solverStatus</code>	The solver status as given by glpk or cplex.
<code>humanReadableStatus</code>	A description of the solver status.

References

A-L. OLTEANU, V. MOUSSEAU, W. OUERDANE, A. ROLLAND, Y. ZHENG, Preference Elicitation for a Ranking Method based on Multiple Reference Profiles, forthcoming 2018.

Examples

```
# the performance table

performanceTable <- rbind(c(10,10,9),c(10,9,10),c(9,10,10),c(9,9,10),c(9,10,9),c(10,9,9),
  c(10,10,7),c(10,7,10),c(7,10,10),c(9,9,17),c(9,17,9),c(17,9,9),
  c(7,10,17),c(10,17,7),c(17,7,10),c(7,17,10),c(17,10,7),c(10,7,17),
  c(7,9,17),c(9,17,7),c(17,7,9),c(7,17,9),c(17,9,7),c(9,7,17))

lexicographicOrder <- c(2,1,3)

criteriaMinMax <- c("max","max","max")

rownames(performanceTable) <- c("a1","a2","a3","a4","a5","a6","a7","a8","a9","a10","a11","a12",
  "a13","a14","a15","a16","a17","a18","a19","a20","a21","a22",
  "a23","a24")

colnames(performanceTable) <- c("c1","c2","c3")

names(criteriaMinMax) <- colnames(performanceTable)

preferencePairs <- matrix(c("a16","a13","a3","a14","a17","a1","a18","a15","a2","a11","a5",
  "a10","a4","a12","a13","a3","a14","a17","a1","a18","a15","a2",
  "a11","a5","a10","a4","a12","a6"),14,2)
indifferencePairs <- matrix(c("a3","a1","a2","a11","a11","a20","a10","a10","a19","a12","a12",
  "a21","a9","a7","a8","a20","a22","a22","a19","a24","a24","a21",
  "a23","a23"),12,2)

result<-SRMPInferenceNoInconsistFixedLexicographicOrder(performanceTable, criteriaMinMax,
  lexicographicOrder, preferencePairs,
  indifferencePairs, alternativesIDs =
  c("a1","a2","a3","a4","a5","a6","a7",
    "a8","a10","a11","a12","a14","a16",
    "a17","a18","a19","a20","a21","a23",
    "a24"))
```

SRMPInferenceNoInconsistFixedProfilesNumber

Exact inference of an SRMP model given the number of reference profiles - no inconsistencies

Description

Exact inference approach from pairwise comparisons of alternatives for the SRMP ranking model. This method only outputs a result when an SRMP model consistent with the provided pairwise comparisons exists. The number of reference profiles is fixed and need to be provided. If such a model exists, this method is significantly faster than the one which handles inconsistencies.

Usage

```
SRMPInferenceNoInconsistFixedProfilesNumber(performanceTable, criteriaMinMax,
                                              profilesNumber, preferencePairs,
                                              indifferencePairs = NULL,
                                              alternativesIDs = NULL, criteriaIDs = NULL,
                                              solver="glpk", timeLimit = NULL,
                                              cplexIntegralityTolerance = NULL,
                                              cplexThreads = NULL)
```

Arguments

performanceTable Matrix or data frame containing the performance table. Each row corresponds to an alternative, and each column to a criterion. Rows (resp. columns) must be named according to the IDs of the alternatives (resp. criteria).

criteriaMinMax Vector containing the preference direction on each of the criteria. "min" (resp. "max") indicates that the criterion has to be minimized (maximized). The elements are named according to the IDs of the criteria.

profilesNumber A strictly positive numerical value which gives the number of reference profiles in the sought SRMP model.

preferencePairs A two column matrix containing on each row a pair of alternative names where the first alternative is considered to be strictly preferred to the second.

indifferencePairs A two column matrix containing on each row a pair of alternative names the two alternatives are considered to indifferent with respect to each other.

alternativesIDs Vector containing IDs of alternatives, according to which the data should be filtered.

criteriaIDs Vector containing IDs of criteria, according to which the data should be filtered.

solver String specifying if the glpk solver (glpk) should be used, or the cplex (cplex) solver. By default glpk. The cplex solver requires to install the cplex binary and the cplex C API, as well as the cplexAPI R package.

timeLimit Allows to fix a time limit of the execution, in seconds. By default NULL (which corresponds to no time limit).

cplexIntegralityTolerance If the cplex solver is used, allows to fix a tolerance for integrality. By default NULL (which corresponds to the default value of cplex).

cplexThreads If the cplex solver is used, allows to the number of threads for the calculation. By default NULL (which corresponds to the default value of cplex).

Value

The function returns a list containing:

criteriaWeights The inferred criteria weights.

referenceProfiles
The inferred reference profiles.

lexicographicOrder
The inferred lexicographic order of the profiles.

solverStatus
The solver status as given by glpk or cplex.

humanReadableStatus
A description of the solver status.

References

A-L. OLTEANU, V. MOUSSEAU, W. OUERDANE, A. ROLLAND, Y. ZHENG, Preference Elicitation for a Ranking Method based on Multiple Reference Profiles, forthcoming 2018.

Examples

```
performanceTable <- rbind(c(10,10,9),c(10,9,10),c(9,10,10),c(9,9,10),c(9,10,9),c(10,9,9),
  c(10,10,7),c(10,7,10),c(7,10,10),c(9,9,17),c(9,17,9),c(17,9,9),
  c(7,10,17),c(10,17,7),c(17,7,10),c(7,17,10),c(17,10,7),c(10,7,17),
  c(7,9,17),c(9,17,7),c(17,7,9),c(7,17,9),c(17,9,7),c(9,7,17))

criteriaMinMax <- c("max","max","max")

rownames(performanceTable) <- c("a1","a2","a3","a4","a5","a6","a7","a8","a9","a10","a11","a12",
  "a13","a14","a15","a16","a17","a18","a19","a20","a21","a22",
  "a23","a24")

colnames(performanceTable) <- c("c1","c2","c3")

names(criteriaMinMax) <- colnames(performanceTable)

preferencePairs <- matrix(c("a16","a13","a3","a14","a17","a1","a18","a15","a2","a11","a5",
  "a10","a4","a12","a13","a3","a14","a17","a1","a18","a15","a2",
  "a11","a5","a10","a4","a12","a6"),14,2)

indifferencePairs <- matrix(c("a3","a1","a2","a11","a11","a20","a10","a10","a19","a12","a12",
  "a21","a9","a7","a8","a20","a22","a22","a19","a24","a24","a21",
  "a23","a23"),12,2)

result<-SRMPIInferenceNoInconsistFixedProfilesNumber(performanceTable, criteriaMinMax, 3,
  preferencePairs, indifferencePairs,
  alternativesIDs = c("a1","a2","a3","a4",
    "a5","a6","a7","a8","a10","a11","a12",
    "a14","a16","a17","a18","a19","a20","a21",
    "a23","a24"))
```

Description

SURE is a multi-criteria decision analysis method which was developed by Richard Hodgett and Sajid Siraj. More details on the method are available in <https://doi.org/10.1016/j.eswa.2018.08.048>

Usage

```
SURE(performanceTableMin,
      performanceTable,
      performanceTableMax,
      criteriaWeights,
      criteriaMinMax,
      alternativesIDs = NULL,
      criteriaIDs = NULL,
      NoOfSimulations = 100000)
```

Arguments

<code>performanceTableMin</code>	Matrix or data frame containing the minimum performance table. Each column corresponds to an alternative, and each row to a criterion. Columns (resp. rows) must be named according to the IDs of the alternatives (resp. criteria).
<code>performanceTable</code>	Matrix or data frame containing the most likely performance table. Each column corresponds to an alternative, and each row to a criterion. Columns (resp. rows) must be named according to the IDs of the alternatives (resp. criteria).
<code>performanceTableMax</code>	Matrix or data frame containing the maximum performance table. Each column corresponds to an alternative, and each row to a criterion. Columns (resp. rows) must be named according to the IDs of the alternatives (resp. criteria).
<code>criteriaWeights</code>	Vector containing the weights of the criteria. The elements are named according to the IDs of the criteria.
<code>criteriaMinMax</code>	Vector containing the preference direction on each of the criteria. "min" (resp. "max") indicates that the criterion has to be minimized (maximized). The elements are named according to the IDs of the criteria.
<code>alternativesIDs</code>	Vector containing IDs of alternatives, according to which the data should be filtered.
<code>criteriaIDs</code>	Vector containing IDs of criteria, according to which the data should be filtered.
<code>NoOfSimulations</code>	Integer stating the number of Simulations to use.

Value

The function returns an element of type SURE which contains the SURE simulated scores for each alternative.

References

Richard E. Hodgett, Sajid Siraj (2019). SURE: A method for decision-making under uncertainty. *Expert Systems with Applications*, Volume 115, 684-694.

Examples

```
performanceTableMin <- t(matrix(c(78,87,79,19,8,68,74,8,90,89,74.5,9,20,81,30),
                                nrow=3,ncol=5, byrow=TRUE))
performanceTable <- t(matrix(c(80,87,86,19,8,70,74,10,90,89,75,9,33,82,30),
                              nrow=3,ncol=5, byrow=TRUE))
performanceTableMax <- t(matrix(c(81,87,95,19,8,72,74,15,90,89,75.5,9,36,84,30),
                                nrow=3,ncol=5, byrow=TRUE))

row.names(performanceTable) <- c("Yield","Toxicity","Cost","Separation","Odour")
colnames(performanceTable) <- c("Route One","Route Two","Route Three")
row.names(performanceTableMin) <- row.names(performanceTable)
colnames(performanceTableMin) <- colnames(performanceTable)
row.names(performanceTableMax) <- row.names(performanceTable)
colnames(performanceTableMax) <- colnames(performanceTable)

criteriaWeights <- c(0.339,0.077,0.434,0.127,0.023)
names(criteriaWeights) <- row.names(performanceTable)

criteriaMinMax <- c("max", "max", "max", "max", "max")
names(criteriaMinMax) <- row.names(performanceTable)

test1 <- SURE(performanceTableMin,
              performanceTable,
              performanceTableMax,
              criteriaWeights,
              criteriaMinMax, NoOfSimulations = 101)

summary(test1)
plotSURE(test1)
plotSURE(test1, greyScale = TRUE, separate = TRUE)

test2 <- SURE(performanceTableMin,
              performanceTable,
              performanceTableMax,
              criteriaWeights,
              criteriaMinMax,
              alternativesIDs = c("Route Two","Route Three"),
              criteriaIDs = c("Yield","Toxicity","Separation"),
              NoOfSimulations = 101)

summary(test2)
plotSURE(test2)
plotSURE(test2, greyScale = TRUE, separate = TRUE)
```

TOPSIS	<i>Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method</i>
--------	--

Description

TOPSIS is a multi-criteria decision analysis method which was originally developed by Hwang and Yoon in 1981.

Usage

```
TOPSIS(performanceTable,
       criteriaWeights,
       criteriaMinMax,
       positiveIdealSolutions = NULL,
       negativeIdealSolutions = NULL,
       alternativesIDs = NULL,
       criteriaIDs = NULL)
```

Arguments

performanceTable Matrix or data frame containing the performance table. Each row corresponds to an alternative, and each column to a criterion. Rows (resp. columns) must be named according to the IDs of the alternatives (resp. criteria).

criteriaWeights Vector containing the weights of the criteria. The elements are named according to the IDs of the criteria.

criteriaMinMax Vector containing the preference direction on each of the criteria. "min" (resp. "max") indicates that the criterion has to be minimized (maximized). The elements are named according to the IDs of the criteria.

positiveIdealSolutions Vector containing the positive ideal solutions for each criteria. The elements are named according to the IDs of the criteria.

negativeIdealSolutions Vector containing the negative ideal solutions for each criteria. The elements are named according to the IDs of the criteria.

alternativesIDs Vector containing IDs of alternatives, according to which the data should be filtered.

criteriaIDs Vector containing IDs of criteria, according to which the data should be filtered.

Value

The function returns a vector containing the TOPSIS score for each alternative.

References

Hwang, C.L.; Yoon, K. (1981). Multiple Attribute Decision Making: Methods and Applications. New York: Springer-Verlag. <http://hodgett.co.uk/topsis-in-excel/>

Examples

```
performanceTable <- matrix(c(5490,51.4,8.5,285,6500,70.6,7,
                             288,6489,54.3,7.5,290),
                           nrow=3,
                           ncol=4,
                           byrow=TRUE)

row.names(performanceTable) <- c("Corsa","Clio","Fiesta")

colnames(performanceTable) <- c("Purchase Price","Economy",
                                "Aesthetics","Boot Capacity")

weights <- c(0.35,0.25,0.25,0.15)

criteriaMinMax <- c("min", "max", "max", "max")

positiveIdealSolutions <- c(0.179573776, 0.171636015, 0.159499658, 0.087302767)
negativeIdealSolutions <- c(0.212610118, 0.124958799, 0.131352659, 0.085797547)

names(weights) <- colnames(performanceTable)
names(criteriaMinMax) <- colnames(performanceTable)
names(positiveIdealSolutions) <- colnames(performanceTable)
names(negativeIdealSolutions) <- colnames(performanceTable)

overall1 <- TOPSIS(performanceTable, weights, criteriaMinMax)

overall2 <- TOPSIS(performanceTable,
                  weights,
                  criteriaMinMax,
                  positiveIdealSolutions,
                  negativeIdealSolutions)

overall3 <- TOPSIS(performanceTable,
                  weights,
                  criteriaMinMax,
                  alternativesIDs = c("Corsa","Clio"),
                  criteriaIDs = c("Purchase Price","Economy","Aesthetics"))

overall4 <- TOPSIS(performanceTable,
                  weights,
                  criteriaMinMax,
                  positiveIdealSolutions,
                  negativeIdealSolutions,
                  alternativesIDs = c("Corsa","Clio"),
                  criteriaIDs = c("Purchase Price","Economy","Aesthetics"))
```

 UTA

UTA method to elicit value functions.

Description

Elicits value functions from a ranking of alternatives, according to the UTA method.

Usage

```
UTA(performanceTable, criteriaMinMax,
    criteriaNumberOfBreakPoints, epsilon,
    alternativesRanks = NULL,
    alternativesPreferences = NULL,
    alternativesIndifferences = NULL,
    criteriaLbs=NULL, criteriaUBs=NULL,
    alternativesIDs = NULL, criteriaIDs = NULL,
    kPostOptimality = NULL)
```

Arguments

performanceTable Matrix or data frame containing the performance table. Each row corresponds to an alternative, and each column to a criterion. Rows (resp. columns) must be named according to the IDs of the alternatives (resp. criteria).

criteriaMinMax Vector containing the preference direction on each of the criteria. "min" (resp. "max") indicates that the criterion has to be minimized (maximized). The elements are named according to the IDs of the criteria.

criteriaNumberOfBreakPoints Vector containing the number of breakpoints of the piecewise linear value functions to be determined. Minimum 2. The elements are named according to the IDs of the criteria.

epsilon Numeric value containing the minimal difference in value between two consecutive alternatives in the final ranking.

alternativesRanks Optional vector containing the ranks of the alternatives. The elements are named according to the IDs of the alternatives. If not present, then at least one of `alternativesPreferences` or `alternativesIndifferences` should be given.

alternativesPreferences Optional matrix containing the preference constraints on the alternatives. Each line of the matrix corresponds to a constraint of the type alternative a is strictly preferred to alternative b. If not present, then either `alternativesRanks` or `alternativesIndifferences` should be given.

alternativesIndifferences Optional matrix containing the indifference constraints on the alternatives. Each line of the matrix corresponds to a constraint of the type alternative a is indifferent to alternative b. If not present, then either `alternativesRanks` or `alternativesPreferences` should be given.

criteriaLBs	Vector containing the lower bounds of the criteria to be considered for the elicitation of the value functions. If not specified, the lower bounds present in the performance table are taken.
criteriaUBs	Vector containing the upper bounds of the criteria to be considered for the elicitation of the value functions. If not specified, the upper bounds present in the performance table are taken.
alternativesIDs	Vector containing IDs of alternatives, according to which the data should be filtered.
criteriaIDs	Vector containing IDs of criteria, according to which the data should be filtered.
kPostOptimality	A small positive threshold used during the postoptimality analysis (see article on UTA by Siskos and Lagreze in EJOR, 1982). If not specified, no postoptimality analysis is performed.

Value

The function returns a list structured as follows :

optimum	The value of the objective function.
valueFunctions	A list containing the value functions which have been determined. Each value function is defined by a matrix of breakpoints, where the first row corresponds to the abscissa (row labelled "x") and where the second row corresponds to the ordinate (row labelled "y").
overallValues	A vector of the overall values of the input alternatives.
ranks	A vector of the ranks of the alternatives obtained via the elicited value functions. Ties method = "min".
Kendall	Kendall's tau between the input ranking and the one obtained via the elicited value functions. NULL if no input ranking is given but alternativesPreferences or alternativesIndifferences.
errors	A vector of the errors (sigma) which have to be added to the overall values of the alternatives in order to respect the input ranking.
minimumWeightsPO	In case a post-optimality analysis is performed, the minimal weight of each criterion, else NULL.
maximumWeightsPO	In case a post-optimality analysis is performed, the maximal weight of each criterion, else NULL.
averageValueFunctionsPO	In case a post-optimality analysis is performed, average value functions respecting the input ranking, else NULL.

References

E. Jacquet-Lagreze, J. Siskos, Assessing a set of additive utility functions for multicriteria decision-making, the UTA method, European Journal of Operational Research, Volume 10, Issue 2, 151–164, June 1982.

Examples

```
# the separation threshold

epsilon <-0.05

# the performance table

performanceTable <- rbind(
  c(3,10,1),
  c(4,20,2),
  c(2,20,0),
  c(6,40,0),
  c(30,30,3))

rownames(performanceTable) <- c("RER", "METRO1", "METRO2", "BUS", "TAXI")

colnames(performanceTable) <- c("Price", "Time", "Comfort")

# ranks of the alternatives

alternativesRanks <- c(1,2,2,3,4)

names(alternativesRanks) <- row.names(performanceTable)

# criteria to minimize or maximize

criteriaMinMax <- c("min", "min", "max")

names(criteriaMinMax) <- colnames(performanceTable)

# number of break points for each criterion

criteriaNumberOfBreakPoints <- c(3,4,4)

names(criteriaNumberOfBreakPoints) <- colnames(performanceTable)

x<-UTA(performanceTable, criteriaMinMax,
      criteriaNumberOfBreakPoints, epsilon,
      alternativesRanks = alternativesRanks)

# plot the value functions obtained

plotPiecewiseLinearValueFunctions(x$valueFunctions)

# apply the value functions on the original performance table

transformedPerformanceTable <- applyPiecewiseLinearValueFunctionsOnPerformanceTable(
  x$valueFunctions,
  performanceTable)

# calculate the overall score of each alternative
```

```

weightedSum(transformedPerformanceTable,c(1,1,1))

# -----
# ranking some cars (from original article on UTA by Siskos and Lagreze, 1982)

# the separation threshold

epsilon <-0.01

# the performance table

performanceTable <- rbind(
c(173, 11.4, 10.01, 10, 7.88, 49500),
c(176, 12.3, 10.48, 11, 7.96, 46700),
c(142, 8.2, 7.30, 5, 5.65, 32100),
c(148, 10.5, 9.61, 7, 6.15, 39150),
c(178, 14.5, 11.05, 13, 8.06, 64700),
c(180, 13.6, 10.40, 13, 8.47, 75700),
c(182, 12.7, 12.26, 11, 7.81, 68593),
c(145, 14.3, 12.95, 11, 8.38, 55000),
c(161, 8.6, 8.42, 7, 5.11, 35200),
c(117, 7.2, 6.75, 3, 5.81, 24800)
)

rownames(performanceTable) <- c(
  "Peugeot 505 GR",
  "Opel Record 2000 LS",
  "Citroen Visa Super E",
  "VW Golf 1300 GLS",
  "Citroen CX 2400 Pallas",
  "Mercedes 230",
  "BMW 520",
  "Volvo 244 DL",
  "Peugeot 104 ZS",
  "Citroen Dyane")

colnames(performanceTable) <- c(
  "MaximalSpeed",
  "ConsumptionTown",
  "Consumption120kmh",
  "HP",
  "Space",
  "Price")

# ranks of the alternatives

alternativesRanks <- c(1,2,3,4,5,6,7,8,9,10)

names(alternativesRanks) <- row.names(performanceTable)

# criteria to minimize or maximize

criteriaMinMax <- c("max","min","min","max","max","min")

```

```
names(criteriaMinMax) <- colnames(performanceTable)

# number of break points for each criterion

criteriaNumberOfBreakPoints <- c(5,4,4,5,4,5)

names(criteriaNumberOfBreakPoints) <- colnames(performanceTable)

# lower bounds of the criteria for the determination of value functions

criteriaLBs=c(110,7,6,3,5,20000)

names(criteriaLBs) <- colnames(performanceTable)

# upper bounds of the criteria for the determination of value functions

criteriaUBs=c(190,15,13,13,9,80000)

names(criteriaUBs) <- colnames(performanceTable)

x<-UTA(performanceTable, criteriaMinMax,
       criteriaNumberOfBreakPoints, epsilon,
       alternativesRanks = alternativesRanks,
       criteriaLBs = criteriaLBs, criteriaUBs = criteriaUBs)

# plot the value functions obtained

plotPiecewiseLinearValueFunctions(x$valueFunctions)

# apply the value functions on the original performance table

transformedPerformanceTable <- applyPiecewiseLinearValueFunctionsOnPerformanceTable(
  x$valueFunctions,
  performanceTable)

# calculate the overall score of each alternative

weights<-c(1,1,1,1,1,1)

names(weights)<-colnames(performanceTable)

weightedSum(transformedPerformanceTable,c(1,1,1,1,1,1))

# the same analysis with less extreme value functions
# from the post-optimality analysis

x<-UTA(performanceTable, criteriaMinMax,
       criteriaNumberOfBreakPoints, epsilon,
       alternativesRanks = alternativesRanks,
       criteriaLBs = criteriaLBs,
       criteriaUBs = criteriaUBs,
```

```

        kPostOptimality = 0.01)

# plot the value functions obtained

plotPiecewiseLinearValueFunctions(x$saverageValueFunctionsP0)

# apply the value functions on the original performance table

transformedPerformanceTable <- applyPiecewiseLinearValueFunctionsOnPerformanceTable(
  x$saverageValueFunctionsP0,
  performanceTable)

# calculate the overall score of each alternative

weights<-c(1,1,1,1,1,1)

names(weights)<-colnames(performanceTable)

weightedSum(transformedPerformanceTable,c(1,1,1,1,1,1))

# -----
# Let us consider only 2 criteria : Price and MaximalSpeed. What happens ?

# x<-UTA(performanceTable, criteriaMinMax,
#        criteriaNumberOfBreakPoints, epsilon,
#        alternativesRanks = alternativesRanks,
#        criteriaLBs = criterialBs, criteriaUBs = criteriaUBs,
#        criteriaIDs = c("MaximalSpeed","Price"))

# plot the value functions obtained

# plotPiecewiseLinearValueFunctions(x$valueFunctions,
#                                   criteriaIDs = c("MaximalSpeed","Price"))

# apply the value functions on the original performance table

# transformedPerformanceTable <- applyPiecewiseLinearValueFunctionsOnPerformanceTable(
#   x$valueFunctions,
#   performanceTable,
#   criteriaIDs = c("MaximalSpeed","Price")
# )

# calculate the overall score of each alternative

# weights<-c(1,1,1,1,1,1)

# names(weights)<-colnames(performanceTable)

# weightedSum(transformedPerformanceTable,
#              weights, criteriaIDs = c("MaximalSpeed","Price"))

```

```
# -----
# An example without alternativesRanks, but with alternativesPreferences
# and alternativesIndifferences

alternativesPreferences <- rbind(c("Peugeot 505 GR", "Opel Record 2000 LS"),
                                c("Opel Record 2000 LS", "Citroen Visa Super E"))

alternativesIndifferences <- rbind(c("Peugeot 104 ZS", "Citroen Dyane"))

x<-UTA(performanceTable, criteriaMinMax,
        criteriaNumberOfBreakPoints, epsilon = 0.1,
        alternativesPreferences = alternativesPreferences,
        alternativesIndifferences = alternativesIndifferences,
        criterialBs = criterialBs, criteriaUBs = criteriaUBs
        )
```

UTADIS	<i>UTADIS method to elicit value functions in view of sorting alternatives in ordered categories</i>
--------	--

Description

Elicits value functions from assignment examples, according to the UTADIS method.

Usage

```
UTADIS(performanceTable, criteriaMinMax,
        criteriaNumberOfBreakPoints,
        alternativesAssignments, categoriesRanks, epsilon,
        criterialBs=NULL, criteriaUBs=NULL,
        alternativesIDs = NULL, criteriaIDs = NULL,
        categoriesIDs = NULL)
```

Arguments

performanceTable Matrix or data frame containing the performance table. Each row corresponds to an alternative, and each column to a criterion. Rows (resp. columns) must be named according to the IDs of the alternatives (resp. criteria).

criteriaMinMax Vector containing the preference direction on each of the criteria. "min" (resp. "max") indicates that the criterion has to be minimized (maximized). The elements are named according to the IDs of the criteria.

criteriaNumberOfBreakPoints Vector containing the number of breakpoints of the piecewise linear value functions to be determined. Minimum 2. The elements are named according to the IDs of the criteria.

alternativesAssignments	Vector containing the assignments of the alternatives to categories. Minimum 2 categories. The elements of the vector are named according to the IDs of the alternatives.
categoriesRanks	Vector containing the ranks of the categories. Minimum 2 categories. The elements of the vector are named according to the IDs of the categories.
epsilon	Numeric value containing the minimal difference in value between the upper bound of a category and an alternative of that category.
criteriaLBs	Vector containing the lower bounds of the criteria to be considered for the elicitation of the value functions. If not specified, the lower bounds present in the performance table are taken.
criteriaUBs	Vector containing the upper bounds of the criteria to be considered for the elicitation of the value functions. If not specified, the upper bounds present in the performance table are taken.
alternativesIDs	Vector containing IDs of alternatives, according to which the data should be filtered.
criteriaIDs	Vector containing IDs of criteria, according to which the data should be filtered.
categoriesIDs	Vector containing IDs of categories, according to which the data should be filtered.

Value

The function returns a list structured as follows :

optimum	The value of the objective function.
valueFunctions	A list containing the value functions which have been determined. Each value function is defined by a matrix of breakpoints, where the first row corresponds to the abscissa (row labelled "x") and where the second row corresponds to the ordinate (row labelled "y").
overallValues	A vector of the overall values of the input alternatives.
categoriesLBs	A vector containing the lower bounds of the considered categories.
errors	A list containing the errors (sigmaPlus and sigmaMinus) which have to be subtracted and added to the overall values of the alternatives in order to respect the input ranking.

References

J.M. Devaud, G. Groussaud, and E. Jacquet-Lagrèze, UTADIS : Une méthode de construction de fonctions d'utilité additives rendant compte de jugements globaux, European Working Group on Multicriteria Decision Aid, Bochum, 1980.

Examples

```

# the separation threshold

epsilon <-0.05

# the performance table

performanceTable <- rbind(
  c(3,10,1),
  c(4,20,2),
  c(2,20,0),
  c(6,40,0),
  c(30,30,3))

rownames(performanceTable) <- c("RER","METRO1","METRO2","BUS","TAXI")

colnames(performanceTable) <- c("Price","Time","Comfort")

# ranks of the alternatives

alternativesAssignments <- c("good","medium","medium","bad","bad")

names(alternativesAssignments) <- row.names(performanceTable)

# criteria to minimize or maximize

criteriaMinMax <- c("min","min","max")

names(criteriaMinMax) <- colnames(performanceTable)

# number of break points for each criterion

criteriaNumberOfBreakPoints <- c(3,4,4)

names(criteriaNumberOfBreakPoints) <- colnames(performanceTable)

# ranks of the categories

categoriesRanks <- c(1,2,3)

names(categoriesRanks) <- c("good","medium","bad")

x<-UTADIS(performanceTable, criteriaMinMax, criteriaNumberOfBreakPoints,
          alternativesAssignments, categoriesRanks,0.1)

# filtering out category "good" and assignment examples "RER" and "TAXI"

y<-UTADIS(performanceTable, criteriaMinMax, criteriaNumberOfBreakPoints,
          alternativesAssignments, categoriesRanks,0.1,
          categoriesIDs=c("medium","bad"),
          alternativesIDs=c("METRO1","METRO2","BUS"))

```

```
# working furthermore on only 2 criteria : "Comfort" and "Time"

z<-UTADIS(performanceTable, criteriaMinMax, criteriaNumberOfBreakPoints,
          alternativesAssignments, categoriesRanks,0.1,
          criteriaIDs=c("Comfort","Time"))
```

UTASTAR

*UTASTAR method to elicit value functions.***Description**

Elicits value functions from a ranking of alternatives, according to the UTASTAR method.

Usage

```
UTASTAR(performanceTable, criteriaMinMax,
        criteriaNumberOfBreakPoints, epsilon,
        alternativesRanks = NULL,
        alternativesPreferences = NULL,
        alternativesIndifferences = NULL,
        criteriaLbs=NULL, criteriaUBs=NULL,
        alternativesIDs = NULL, criteriaIDs = NULL,
        kPostOptimality = NULL)
```

Arguments

performanceTable Matrix or data frame containing the performance table. Each row corresponds to an alternative, and each column to a criterion. Rows (resp. columns) must be named according to the IDs of the alternatives (resp. criteria).

criteriaMinMax Vector containing the preference direction on each of the criteria. "min" (resp. "max") indicates that the criterion has to be minimized (maximized). The elements are named according to the IDs of the criteria.

criteriaNumberOfBreakPoints Vector containing the number of breakpoints of the piecewise linear value functions to be determined. Minimum 2. The elements are named according to the IDs of the criteria.

epsilon Numeric value containing the minimal difference in value between two consecutive alternatives in the final ranking.

alternativesRanks Optional vector containing the ranks of the alternatives. The elements are named according to the IDs of the alternatives. If not present, then at least one of **alternativesPreferences** or **alternativesIndifferences** should be given.

alternativesPreferences Optional matrix containing the preference constraints on the alternatives. Each line of the matrix corresponds to a constraint of the type alternative a is strictly preferred to alternative b. If not present, then either **alternativesRanks** or **alternativesIndifferences** should be given.

<code>alternativesIndifferences</code>	Optional matrix containing the indifference constraints on the alternatives. Each line of the matrix corresponds to a constraint of the type alternative a is indifferent to alternative b. If not present, then either <code>alternativesRanks</code> or <code>alternativesPreferences</code> should be given.
<code>criteriaLBs</code>	Vector containing the lower bounds of the criteria to be considered for the elicitation of the value functions. If not specified, the lower bounds present in the performance table are taken.
<code>criteriaUBs</code>	Vector containing the upper bounds of the criteria to be considered for the elicitation of the value functions. If not specified, the upper bounds present in the performance table are taken.
<code>alternativesIDs</code>	Vector containing IDs of alternatives, according to which the data should be filtered.
<code>criteriaIDs</code>	Vector containing IDs of criteria, according to which the data should be filtered.
<code>kPostOptimality</code>	A small positive threshold used during the postoptimality analysis (see article on UTA by Siskos and Lagreze in EJOR, 1982). If not specified, no postoptimality analysis is performed.

Value

The function returns a list structured as follows :

<code>optimum</code>	The value of the objective function.
<code>valueFunctions</code>	A list containing the value functions which have been determined. Each value function is defined by a matrix of breakpoints, where the first row corresponds to the abscissa (row labelled "x") and where the second row corresponds to the ordinate (row labelled "y").
<code>overallValues</code>	A vector of the overall values of the input alternatives.
<code>ranks</code>	A vector of the ranks of the alternatives obtained via the elicited value functions. Ties method = "min".
<code>Kendall</code>	Kendall's tau between the input ranking and the one obtained via the elicited value functions.
<code>errors</code>	A list containing the errors (<code>sigmaPlus</code> and <code>sigmaMinus</code>) which have to be subtracted and added to the overall values of the alternatives in order to respect the input ranking.
<code>minimumWeightsPO</code>	In case a post-optimality analysis is performed, the minimal weight of each criterion, else NULL.
<code>maximumWeightsPO</code>	In case a post-optimality analysis is performed, the maximal weight of each criterion, else NULL.
<code>averageValueFunctionsPO</code>	In case a post-optimality analysis is performed, average value functions respecting the input ranking, else NULL.

References

Siskos, Y. and D. Yannacopoulos, UTASTAR: An ordinal regression method for building additive value functions, *Investigacao Operacional*, 5 (1), 39–53, 1985.

Examples

```
# the separation threshold

epsilon <-0.05

# the performance table

performanceTable <- rbind(
  c(3,10,1),
  c(4,20,2),
  c(2,20,0),
  c(6,40,0),
  c(30,30,3))

rownames(performanceTable) <- c("RER", "METRO1", "METRO2", "BUS", "TAXI")

colnames(performanceTable) <- c("Price", "Time", "Comfort")

# ranks of the alternatives

alternativesRanks <- c(1,2,2,3,4)

names(alternativesRanks) <- row.names(performanceTable)

# criteria to minimize or maximize

criteriaMinMax <- c("min", "min", "max")

names(criteriaMinMax) <- colnames(performanceTable)

# number of break points for each criterion

criteriaNumberOfBreakPoints <- c(3,4,4)

names(criteriaNumberOfBreakPoints) <- colnames(performanceTable)

x<-UTASTAR(performanceTable, criteriaMinMax,
           criteriaNumberOfBreakPoints, epsilon,
           alternativesRanks = alternativesRanks)

# plot the value functions obtained

plotPiecewiseLinearValueFunctions(x$valueFunctions)

# apply the value functions on the original performance table

transformedPerformanceTable <- applyPiecewiseLinearValueFunctionsOnPerformanceTable(
```

```

    x$valueFunctions,
    performanceTable)

# calculate the overall score of each alternative

weightedSum(transformedPerformanceTable,c(1,1,1))

# -----
# ranking some cars (from original article on UTA by Siskos and Lagreze, 1982)

# the separation threshold

epsilon <-0.01

# the performance table

performanceTable <- rbind(
c(173, 11.4, 10.01, 10, 7.88, 49500),
c(176, 12.3, 10.48, 11, 7.96, 46700),
c(142, 8.2, 7.30, 5, 5.65, 32100),
c(148, 10.5, 9.61, 7, 6.15, 39150),
c(178, 14.5, 11.05, 13, 8.06, 64700),
c(180, 13.6, 10.40, 13, 8.47, 75700),
c(182, 12.7, 12.26, 11, 7.81, 68593),
c(145, 14.3, 12.95, 11, 8.38, 55000),
c(161, 8.6, 8.42, 7, 5.11, 35200),
c(117, 7.2, 6.75, 3, 5.81, 24800)
)

rownames(performanceTable) <- c(
  "Peugeot 505 GR",
  "Opel Record 2000 LS",
  "Citroen Visa Super E",
  "VW Golf 1300 GLS",
  "Citroen CX 2400 Pallas",
  "Mercedes 230",
  "BMW 520",
  "Volvo 244 DL",
  "Peugeot 104 ZS",
  "Citroen Dyane")

colnames(performanceTable) <- c(
  "MaximalSpeed",
  "ConsumptionTown",
  "Consumption120kmh",
  "HP",
  "Space",
  "Price")

# ranks of the alternatives

alternativesRanks <- c(1,2,3,4,5,6,7,8,9,10)

```

```
names(alternativesRanks) <- row.names(performanceTable)

# criteria to minimize or maximize

criteriaMinMax <- c("max", "min", "min", "max", "max", "min")

names(criteriaMinMax) <- colnames(performanceTable)

# number of break points for each criterion

criteriaNumberOfBreakPoints <- c(5,4,4,5,4,5)

names(criteriaNumberOfBreakPoints) <- colnames(performanceTable)

# lower bounds of the criteria for the determination of value functions

criteriaLBs=c(110,7,6,3,5,20000)

names(criteriaLBs) <- colnames(performanceTable)

# upper bounds of the criteria for the determination of value functions

criteriaUBs=c(190,15,13,13,9,80000)

names(criteriaUBs) <- colnames(performanceTable)

x<-UTASTAR(performanceTable, criteriaMinMax,
           criteriaNumberOfBreakPoints, epsilon,
           alternativesRanks = alternativesRanks,
           criteriaLBs = criteriaLBs, criteriaUBs = criteriaUBs)

# plot the value functions obtained

plotPiecewiseLinearValueFunctions(x$valueFunctions)

# apply the value functions on the original performance table

transformedPerformanceTable <- applyPiecewiseLinearValueFunctionsOnPerformanceTable(
  x$valueFunctions,
  performanceTable)

# calculate the overall score of each alternative

weights<-c(1,1,1,1,1,1)

names(weights)<-colnames(performanceTable)

weightedSum(transformedPerformanceTable,c(1,1,1,1,1,1))

# the same analysis with less extreme value functions
# from the post-optimality analysis
```

```

x<-UTASTAR(performanceTable, criteriaMinMax,
           criteriaNumberOfBreakPoints, epsilon,
           alternativesRanks = alternativesRanks,
           criteriaLBs = criteriaLBs,
           criteriaUBs = criteriaUBs,
           kPostOptimality = 0.01)

# plot the value functions obtained

plotPiecewiseLinearValueFunctions(x$averageValueFunctionsP0)

# apply the value functions on the original performance table

transformedPerformanceTable <- applyPiecewiseLinearValueFunctionsOnPerformanceTable(
  x$averageValueFunctionsP0,
  performanceTable)

# calculate the overall score of each alternative

weights<-c(1,1,1,1,1,1)

names(weights)<-colnames(performanceTable)

weightedSum(transformedPerformanceTable,c(1,1,1,1,1,1))

# -----
# Let us consider only 2 criteria : Price and MaximalSpeed. What happens ?

x<-UTASTAR(performanceTable, criteriaMinMax,
           criteriaNumberOfBreakPoints, epsilon,
           alternativesRanks = alternativesRanks,
           criteriaLBs = criteriaLBs, criteriaUBs = criteriaUBs,
           criteriaIDs = c("MaximalSpeed","Price"))

# plot the value functions obtained

plotPiecewiseLinearValueFunctions(x$valueFunctions,
                                 criteriaIDs = c("MaximalSpeed","Price"))

# apply the value functions on the original performance table

transformedPerformanceTable <- applyPiecewiseLinearValueFunctionsOnPerformanceTable(
  x$valueFunctions,
  performanceTable,
  criteriaIDs = c("MaximalSpeed","Price")
)

# calculate the overall score of each alternative

weights<-c(1,1,1,1,1,1)

```



```

names(weights)<-colnames(performanceTable)

weightedSum(transformedPerformanceTable,
             weights, criteriaIDs = c("MaximalSpeed","Price"))

# -----
# An example without alternativesRanks, but with alternativesPreferences
# and alternativesIndifferences

alternativesPreferences <- rbind(c("Peugeot 505 GR","Opel Record 2000 LS"),
                                c("Opel Record 2000 LS","Citroen Visa Super E"))

alternativesIndifferences <- rbind(c("Peugeot 104 ZS","Citroen Dyane"))

x<-UTASTAR(performanceTable, criteriaMinMax,
           criteriaNumberOfBreakPoints, epsilon = 0.1,
           alternativesPreferences = alternativesPreferences,
           alternativesIndifferences = alternativesIndifferences,
           criteriaLBs = criteriaLBs, criteriaUBs = criteriaUBs
           )

```

weightedSum

Weighted sum of evaluations of alternatives.

Description

Computes the weighted sum of the evaluations of alternatives, stored in a performance table, with respect to a vector of criteria weights.

Usage

```

weightedSum(performanceTable, criteriaWeights,
            alternativesIDs = NULL, criteriaIDs = NULL)

```

Arguments

performanceTable

Matrix or data frame containing the performance table. Each row corresponds to an alternative, and each column to a criterion. Rows (resp. columns) must be named according to the IDs of the alternatives (resp. criteria).

criteriaWeights

Vector containing the weights of the criteria. The elements are named according to the IDs of the criteria.

alternativesIDs

Vector containing IDs of alternatives, according to which the performance table should be filtered.

criteriaIDs

Vector containing IDs of criteria, according to which the performance table should be filtered.

Value

The function returns a vector containing the weighted sum of the alternatives with respect to the criteria weights.

Examples

```
performanceTable <- matrix(runif(3*4), ncol=3)

row.names(performanceTable) <- c("x1", "x2", "x3", "x4")

colnames(performanceTable) <- c("g1", "g2", "g3")

weights <- c(1,2,3)

names(weights) <- c("g1", "g2", "g3")

overall1 <- weightedSum(performanceTable, weights)

overall2 <- weightedSum(performanceTable, weights,
  alternativesIDs <- c("x2", "x3"), criteriaIDs <- c("g2", "g3"))
```

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