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

Suggests Rgraphviz, cplexAPI

License EUPL (== 1.1)

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

NeedsCompilation no

Repository CRAN

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R topics documented:

`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 datashould 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-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) 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 datashould 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 it's 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 datashould 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.

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)

npt <- applyPiecewiseLinearValueFunctionsOnPerformanceTable(x$valueFunctions,
                                                             performanceTable)

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)
```

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 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.

`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 and category k represents the performance above which an alternative is guaranteed to outrank the lower profile of category k, and thus may no be assigned below category k. 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 datashould 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","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"),
                    c("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","P","P","P","P","P","P",
                    "P","P","P","P","P","P","F","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","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","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","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` — Pozitive integer denoting the upper limit of the number of sets to be retrieved.
- `largerIncompatibleSetsMargin` — Pozitive 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 datashould 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 noncompen-satory 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","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"),
                    c("P","P","P","F","F","F","F","F","F","F","F","F",
                    "P","P","P","P","P","P","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","F","F","F","F","F","F","P"),
                    c("P","P","P","F","F","F","F","F","F","P","P","P",
                    "F","F","F","F","F","F","F","F","F","F","F","F","P"),
                    c("P","P","P","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","P","P","P",
                    "P","P","P","P","P","P","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 and category k represents the performance above which an alternative outranks the lower profile of category k 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 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. 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 datashould 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 inficators 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")


# LPDMRSortIndetifyUsedVetoProfiles

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

LPDMRSortIdentifyUsedVetoProfiles

Identify veto 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 veto profiles evaluations have an impact on the final assignment of at least one of the input alternatives.

Usage

```
LPDMRSortIdentifyUsedVetoProfiles(performanceTable, assignments,
                                  categoriesRanks, criteriaMinMax,
                                  majorityThreshold,
                                  criteriaWeights,
                                  profilesPerformances,
                                  vetoPerformances,
                                  dictatorPerformances = NULL,
                                  majorityRule = "V",
                                  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.

`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 and category k represents the performance above which an alternative outranks the lower profile of category k 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 datashould 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 inficators 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")


# LPDMRSortIndetifyUsedVetoProfiles

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 noncompen- satory 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 vetoes 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).

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 noncompen- satory 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"),
                    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"),
                    c("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","P","P","P","P","P","P",
                        "P","P","P","P","P","P","F","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","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","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","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)

overall2 <- 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.

`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 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 datashould 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 noncompen- satory 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`
: Pozitive integer denoting the upper limit of the number of sets to be retrieved.

`largerIncompatibleSetsMargin`
: Pozitive 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 datashould 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 noncompen- satory 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 datashould 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 inficators 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")

# MRSortIndetifyUsedVetoProfiles

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.

`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).

`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).

`fitness` The classification accuracy of the inferred model (from 0 to 1).

References

Bouyssou, D. and Marchant, T. An axiomatic approach to noncompen- satory 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", "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)

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 noncompen- satory 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")

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"))
```

---

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).

Examples

```
examplematrix <- 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))
pairwiseConsistencyMeasures(examplematrix)
```

`plotAlternativesValuesPreorder`
Function to plot a preorder of alternatives, based on some score or ranking.

Description

Plots a preorder of alternatives as a graph, representing the ranking of the alternatives, w.r.t. some scores or ranks. A decreasing order or increasing order can be specified, w.r.t. to these scores or ranks.

Usage

```
plotAlternativesValuesPreorder(alternativesValues,
                                decreasing = TRUE,
                                alternativesIDs = NULL)
```

Arguments

`alternativesValues`
A vector containing some values related to alternatives, as scores or ranks. The elements of the vector are named according to the IDs of the alternatives.

`decreasing`
A boolean to indicate if the alternatives are to be sorted increasingly (FALSE) or decreasingly (TRUE) w.r.t. the alternativesValues.

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

Examples

```
library(MCDA)

alternativesValues <- c(10,1,8,3,8,3,4,4,8,5)

names(alternativesValues) <- c("x10","x1","x9","x2","x8",
                               "x3","x7","x4","x6","x5")

plotAlternativesValuesPreorder(alternativesValues,
                               decreasing=TRUE,
                               alternativesIDs=c("x10","x3","x7",
                                                 "x4","x6","x5"))
```

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.

`categoriesDictators`
: 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.

`categoriesVetoes`
: 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.

`majorityRule`
: 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.

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

`majorityThreshold`
: 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.

`alternativesIDs`
: Vector containing IDs of alternatives, according to which the datashould be filtered.

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

`legendRatio`
: The ratio between the legend and plot heights. By defaut 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 overlayed 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)
```

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 vetor 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.

`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 datashould be filtered.

`criteriaIDs`
: 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 ordinale de préférences avec points de référence pour l'aide a 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 — *Exact inference of an SRMP model given a maximum 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 - 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 pozitive 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 datashould 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.

`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

```
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 datashould 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 derrived 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 datashould 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)

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

SRMPInferenceApproxFixedProfilesNumber

Approximative inference of an SRMP model given the number of reference 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 is fixed beforehand, however the algorithm will explore any lexicographic order between them.

Usage

```
SRMPInferenceApproxFixedProfilesNumber(performanceTable, criteriaMinMax,
                                       profilesNumber, 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.

`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 indifferent with respect to each other.

`alternativesIDs`
: Vector containing IDs of alternatives, according to which the datashould 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 derrived 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 datashould 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 pozitive 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 datashould 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.

`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

```
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 pozitive 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 datashould 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).

`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 derrived 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 datashould 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.

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<-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 pozitive 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 datashould 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<-SRMPInferenceNoInconsistFixedProfilesNumber(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"))
```

TOPSIS — *Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method*

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 datashould 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$averageValueFunctionsPO)

# apply the value functions on the original performance table

transformedPerformanceTable <- applyPiecewiseLinearValueFunctionsOnPerformanceTable(
      x$averageValueFunctionsPO,
      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 — *UTADIS method to elicit value functions in view of sorting alternatives in ordered categories*

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 datashould 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 substracted 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 assigment 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.

`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 datashould 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.

errors
: A list containing the errors (sigmaPlus and sigmaMinus) which have to be substracted and 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

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$averageValueFunctionsPO)

# apply the value functions on the original performance table

transformedPerformanceTable <- applyPiecewiseLinearValueFunctionsOnPerformanceTable(
      x$averageValueFunctionsPO,
      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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