Package ‘ahpsensitivity’

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Title Sensitivity analysis tools for Multicriteria Decision Making methods

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Description Contains a set of sensitivity analysis tools for two Multicriteria Decision Making (MDCM) methods: Analytic Hierarchy Process (AHP) and Weighted Sum Model (WSM). For the AHP, the probability of rank reversals and the most influential user can be obtained. Moreover, for both methods, the most critical measure of performance can be determined.

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Imports pracma,
matrixStats

Encoding UTF-8

LazyData true

RoxygenNote 7.0.2.9000

Suggests knitr,
rmarkdown

R topics documented:

ahp.interval *A function to obtain the probabilities of rank reversals*

Description

A function to obtain the probabilities of rank reversals

Usage

```
ahp.interval(lower, upper, nmatrices, norm_test)
```

Arguments

`lower`	A list of dataframes objects with the lower bounds for each pairwise comparison matrix
`upper`	A list of dataframes objects with the upper bounds for each pairwise comparison matrix
`nmatrices`	Integer, defines the total number of random matrices to generate
`norm_test`	Logical, if TRUE determines if the components of the right eigenvector of all the generated random pairwise comparison matrices are normally distributed, via the kolmogorov-smirnoff test

Value

A list of list, for each interval pairwise comparison matrix

matrix_list List of random matrices (rm)

matrices_w List of weight of rm

norm_matrices_w List of normalized weights of rm

lambda_max List of largest eigenvalues

ci List of consistency indices

cr List of consistency ratios

w_consistent Dataframe of normalized weights of consistent random matrices (crm)

maximum Named vector, maximum value of the crm for each criteria

minimum Named vector, minimum value of the crm for each criteria

mean Named vector, mean value of the crm for each criteria

sd Named vector, standard deviation value of the crm for each criteria

normality List of list with the normality test for each criteria

p_ij Vector, probabilities of rank reversal between two alternatives A_i and A_j

p_i Vector, probabilities that a given alternative will reverse rank with other alternative

Details

The probabilities p_i, $i = 1, \ldots, n$ that a given alternative will reverse rank with another alternative are given by

$$p_i = 1 - \prod_{j=1}^{n} (1 - p_{ij})$$

where p_{ij} is the probability of rank reversal for two alternatives, it is calculated considering different cases for the lower and upper bounds on the i and j components of the right eigenvector w and the probability cumulative distribution $F_i(x_i)$:

Case	Condition	p_{ij}
1	$w_j^L \le w_i^L$ and $w_i^U \le w_j^U$	$F_j(w_i^U) - F_j(w_i^L)$
2	$w_i^L < w_j^L$ and $w_j^U < w_i^U$	$F_i(w_j^U) - F_i(w_j^U)$
3	$w_i^L < w_j^L < w_i^U < w_j^U$	$(F_i(w_i^U) - F_i(w_j^L))(F_j(w_i^U) - F_j(w_j^L))$
4	$w_j^L < w_i^L < w_j^U < w_i^U$	$(F_i(w_j^U) - F_i(w_i^L))(F_j(w_j^U) - F_j(w_i^L))$

References

Saaty, Thomas L. y Vargas, Luis G.: Uncertainty and rank order in the analytic hierarchy process. European Journal of Operational Research, 1987, 32(1), pp. 107–117. ISSN 0377- 2217. doi: 10.1016/0377-2217(87)90275-X.

`consistency.index` *A function to obtain the consistency index*

Description

A function to obtain the consistency index

Usage

```
consistency.index(lambda_max, n)
```

Arguments

`lambda_max`	largest eigenvalue
`n`	total number of criteria

Details

$$C.I. = \frac{\lambda_{max} - n}{n - 1}$$

where λ_{max} is the largest eigenvalue and n represents the total number of criteria

Examples

```
consistency.index(lambda_max = 1, n = 6)
```

`consistency.ratio` *A function to obtain the consistency ratio*

Description

A function to obtain the consistency ratio

Usage

```
consistency.ratio(ci, ri)
```

Arguments

`ci`	Consistency index
`ri`	Random inconsistency

Details

$$C.R. = \frac{C.I.}{R.I.}$$

Note

The random inconsistency number is a function of the number of criteria

Examples

```
consistency.ratio(.05, 0.90)
```

`group.sens` *Group sensitivity*

Description

This function allows you to identify the most influential expert on the group

Usage

```
group.sens(users_list, pert)
```

Arguments

`users_list`	List with the pairwise comparison matrices
`pert`	Double, the perturbation magnitude for the finite differences method

Value

A list of lists for each user

users_list List with the pairwise comparison matrices

n Number of criteria

users_total Integer, the total number of users

pert Double, the perturbation magnitude for the finite differences method

users_w List with weights for the pairwise comparison matrices

norm_users_w List with the normalized weights for the pairwise comparison matrices

group_matrix Matrix with the normalized weight for all criteria (rows: criteria, columns: users)

sensitivity List of matrices with the sensitivity coefficients for each user

References

Marie Ivanco, Gene Hou, Jennifer Michaeli, Sensitivity analysis method to address user disparities in the analytic hierarchy process, Expert Systems with Applications, Volume 90, 2017, Pages 111-126, ISSN 0957-4174, https://doi.org/10.1016/j.eswa.2017.08.003.

`group.vector` *Create a group vector*

Description

This function allows you to create the group vector

Usage

```
group.vector(x, users_total)
```

Arguments

`x`	a list of matrices with the normalized weight for all criteria and users (rows: critera, columns: user)
`users_total`	the total number of users in the group

Value

A list of vectors

Details

The group aggregated vector is obtained by following

$$G_r^{(i,j_{i-1})} = \sqrt[P]{\bar{w}_r^1 \bar{w}_r^2 \ldots \bar{w}_r^P}$$

where P represents the total number of users in the group and $\bar{w}_r$ is the normalized weight of the rth criterion

References

Marie Ivanco, Gene Hou, Jennifer Michaeli, Sensitivity analysis method to address user disparities in the analytic hierarchy process, Expert Systems with Applications, Volume 90, 2017, Pages 111-126, ISSN 0957-4174, https://doi.org/10.1016/j.eswa.2017.08.003.

`norm.fun` *The normalized criteria weight*

Description

This function allows you to obtain the normalized criteria weight (normalized geometric mean) for one user

Usage

```
norm.fun(x)
```

Arguments

`x`	Vector of criteria weight

Value

A vector

Details

For each component r of the vector the normalized weight is obtained by

$$\bar{w_r} = \frac{w_r}{\sum_{q=1}^{n} w_q}$$

where n is the total number of criteria

Examples

```
w <- c(.7,.2,.3)
norm.fun(w)
```

pcmatrix *A function to create a pairwise comparison matrix*

Description

A function to create a pairwise comparison matrix

Usage

```
pcmatrix(x, n)
```

Arguments

x	Vector, it contains the upper triangular elements of the matrix
n	Integer, total number of criteria

Details

Given a vector with the upper triangular elements of a pairwise comparison matrix, this function returns a matrix in the pairwise comparison form

$$C = \begin{bmatrix} 1 & a_{12} & \dots & a_{1m} \\ 1/a_{12} & 1 & \dots & a_{2m} \\ \dots & \dots & 1 & \dots \\ 1/a_{1m} & 1/a_{2m} & \dots & 1 \end{bmatrix}$$

Examples

```
pcmatrix(c(1,2,3,4,5,6), 4)
```

random.pcmatrices *A function to obtain random matrices*

Description

A function to obtain random matrices

Usage

```
random.pcmatrices(data_lower, data_upper, nmatrices)
```

Arguments

data_lower	A list of dataframes objects with the lower bounds for each pairwise comparison matrix
data_upper	A list of dataframes objects with the upper bounds for each pairwise comparison matrix
nmatrices	Integer, total number of random matrices to generate

Value

A list of matrices

Details

Given matrices

$$C^L = \begin{bmatrix} 1 & a^L_{12} & \dots & a^L_{1m} \\ 1/a^L_{12} & 1 & \dots & a^L_{2m} \\ \dots & \dots & 1 & \dots \\ 1/a^L_{1m} & 1/a^L_{2m} & \dots & 1 \end{bmatrix}, \quad C^U = \begin{bmatrix} 1 & a^U_{12} & \dots & a^U_{1m} \\ 1/a^U_{12} & 1 & \dots & a^U_{2m} \\ \dots & \dots & 1 & \dots \\ 1/a^U_{1m} & 1/a^U_{2m} & \dots & 1 \end{bmatrix}$$

with the lower and upper bounds of an interval pairwise comparison matrix, this function generates a set of random matrices within the interval. The random numbers for each comparison are generated with an uniform distribution.

References

Saaty, Thomas L. y Vargas, Luis G.: Uncertainty and rank order in the analytic hierarchy process. European Journal of Operational Research, 1987, 32(1), pp. 107–117. ISSN 0377- 2217. doi: 10.1016/0377-2217(87)90275-X.

See Also

runif about the uniform distribution

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weights.matrix *A function to obtain the criteria weight*

Description

Given a pairwise comparison matrix this function allows you to obtain the criteria weight (row geometric mean) for one user and any number of criteria

Usage

```
## S3 method for class 'matrix'
weights(x, n)
```

Arguments

x	a pairwise comparison matrix
n	Integer, the total number of criteria

Details

The weight criteria is obtained by the computation of the geometric mean

$$\bar{w}_r^{P_j} = \sqrt[m]{a_{r1} a_{r2} \dots a_{rm}}$$

where a_{rm} are elements in the pairwise comparisons matrix

$$C = \begin{bmatrix} 1 & a_{12} & \dots & a_{1m} \\ 1/a_{12} & 1 & \dots & a_{2m} \\ \dots & \dots & 1 & \dots \\ 1/a_{1m} & 1/a_{2m} & \dots & 1 \end{bmatrix}$$

References

Marie Ivanco, Gene Hou, Jennifer Michaeli, Sensitivity analysis method to address user disparities in the analytic hierarchy process, Expert Systems with Applications, Volume 90, 2017, Pages 111-126, ISSN 0957-4174, https://doi.org/10.1016/j.eswa.2017.08.003.

Examples

```
pcm <- pcmatrix(c(1,2,3,4,5,6), 4)
weights.matrix(pcm, 4)
```

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wsm.tau *A function to obtain the most critical measure of performance in terms of some reference value for a set of indices*

Description

A function to obtain the most critical measure of performance in terms of some reference value for a set of indices

Usage

```
wsm.tau(x_ij, w_ij, indices, rho)
```

Arguments

x_ij	A list of matrices with the standarized measures of performance for each index i and each criteria j
w_ij	A list of matrices with the importance weights for each criteria j
indices	A list of dataframes with the preferences for each alternative
rho	A list with the references values for each index

Details

For each index i, the minimum change in a measure of performance x_{ij}^h for a criteria j that generates a rank reversal is obtained with

$$\tau_{ij}^h = \frac{V_i^h - V_i^\rho}{w_{ij} x_{ij}^h}$$

In terms of τ_{ij}^h, the critical indicator value

$$\mathcal{C}_{ij} = \frac{1}{\Delta_{ij}} \times p_{ij}$$

considers the sensitivity coefficient $\Delta_{ij} = |\tau_{ij}^h|^{Q_1}$ (first quartile Q_1) and the probability of rank reversals p_{ij}. Moreover, the modified measure of performance is given by

$$\hat{x}_{ij}^h = x_{ij}^h - \tau_{ij}^h$$

References

Sensitivity analysis for household vulnerability assessment: a case of study from Brazil surveys

Triantaphyllou, Evangelos y Sánchez, Alfonso: A Sensitivity Analysis Approach for Some Deterministic Multi-Criteria Decision-Making Methods*. Decision Sciences, 1997, 28(1), pp. 151–194. doi: 10.1111/j.1540-5915.1997.tb01306.x. https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1540-5915.1997.tb01306.x

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