Package ‘kstMatrix’

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Title Basic Functions in Knowledge Space Theory Using Matrix Representation
Description Knowledge space theory by Doignon and Falmagne (1999) <doi:10.1007/978-3-642-58625-5> is a set- and order-theoretical framework, which proposes mathematical formalisms to operationalize knowledge structures in a particular domain. The ‘kstMatrix’ package provides basic functionalities to generate, handle, and manipulate knowledge structures and knowledge spaces. Opposed to the ‘kst’ package, ‘kstMatrix’ uses matrix representations for knowledge structures. Furthermore, ‘kstMatrix’ contains several knowledge spaces developed by the research group around Cornelia Dowling through querying experts.

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Knowledge spaces on AutoCAD knowledge

Description

Bases of knowledge spaces on AutoCAD knowledge obtained from querying experts.

Usage

cad

Format

A list containing seven bases (cad1 to cad6, and cadmaj) in binary matrix form. Each matrix has 28 columns representing the different knowledge items and a varying number of rows containing the basis elements.

Details

Six experts were queried about prerequisite relationships between 28 AutoCAD knowledge items (Dowling, 1991; 1993). A seventh basis represents those prerequisite relationships on which the majority (4 out of 6) of the experts agree (Dowling & Hockemeyer, 1998).
**Knowledge spaces on fractions**

**Description**

Bases of knowledge spaces on fractions obtained from querying experts.

**Usage**

fractions

**Format**

A list containing four bases (frac1 to frac3, and fracmaj) in binary matrix form. Each matrix has 77 columns representing the different knowledge items and a varying number of rows containing the basis elements.

**Details**

Three experts were queried about prerequisite relationships between 77 items on fractions (Baumunk & Dowling, 1997). A forth basis represents those prerequisite relationships on which the majority of the experts agree (Dowling & Hockemeyer, 1998).

**References**


**kmbasis**  
*Compute the basis of a knowledge space*

**Description**

*kmbasis* returns a matrix representing the basis of a knowledge space. If `x` is a knowledge structure or an arbitrary family of sets, *kmbasis* returns the basis of the smallest knowledge space containing `x`.

**Usage**

```r
kmbasis(x)
```

**Arguments**

- `x`: Binary matrix representing a knowledge space

**Value**

Binary matrix representing the basis of the knowledge space.

**Examples**

```r
ekmbasis(xpl$space)
```

---

**kmdist**  
*Compute the distance between a data set and a knowledge structure*

**Description**

*kmdist* returns a named vector with the frequencies of distances between a set of response patterns and a knowledge structure. This vector can be used to compute, e.g., the Discrepancy Index (DI) or the Distance Agreement Coefficient (DA).

**Usage**

```r
kmdist(data, struct)
```

**Arguments**

- `data`: Binary matrix representing a set of response patterns
- `struct`: Binary matrix representing a knowledge structure

**Value**

Distance distribution vector
**kmfringe**

**Examples**

```r
kmdist(xpl$data, xpl$space)
```

---

**kmfringe**  
Compute the fringe of a state within a knowledge structure

**Description**

`kmfringe` computes the fringe of a state within a knowledge structure, i.e. the set of items by which the state differs from its neighbours.

**Usage**

```r
ekfringe(state, struct)
```

**Arguments**

- `state` Binary vector representing a knowledge state
- `struct` Binary matrix representing a knowledge structure

**Value**

Binary vector representing the fringe

**Examples**

```r
ekfringe(c(1,0,0,0), xpl$space)
```

---

**kmiswellgraded**  
Check for wellgradedness of a knowledge structure

**Description**

`kmiswellgraded` returns whether a knowledge structure is wellgraded.

**Usage**

```r
kmiswellgraded(x)
```

**Arguments**

- `x` Binary matrix representing a knowledge space
kmneighbourhood

Value

Logical value specifying whether ‘x’ is wellgraded

References


Examples

kmiswellgraded(xpl$space)

kmneighbourhood(state, struct)

Arguments

state Binary vector representing a knowledge state
struct Binary matrix representing a knowledge structure

Value

Matrix containing the neighbouring states, one per row

Examples

kmneighbourhood(c(1,1,0,0), xpl$space)
**kmnotions**

*Determine the notions of a knowledge structure*

**Description**

`kmnotions` returns a matrix representing the notions of a knowledge structure.

**Usage**

```r
kmnotions(x)
```

**Arguments**

`x`  
Binary matrix representing a knowledge structure

**Value**

Binary matrix representing notions in the knowledge structure

The matrix has a '1' in row 'i' and column 'j' if 'i' and 'j' belong to the same notion (i.e. are equivalent). It is a symmetric matrix with '1's in the main diagonal.

**Examples**

```r
kmnotions(xpl$space)
```

**kmsimulate**

*Simulate a set of response patterns according to the BLIM*

**Description**

`kmsimulate` returns a data set of `n` simulated response patterns based on the knowledge structure `x` given as a binary matrix. The simulation follows the BLIM (Basic Local Independence Model; see Doignon & Falmagne, 1999).

**Usage**

```r
kmsimulate(x, n, beta, eta)
```

**Arguments**

`x`  
Binary matrix representing a knowledge space

`n`  
Number of simulated response patterns

`beta`  
Careless error probability value or vector

`eta`  
Lucky guess probability value or vector
Details

The beta and eta parameters must be either single numericals or vectors with a length identical to the number of rows in the x matrix. A mixture is possible.

The 'sample' function used by 'kmsimulate' might work inaccurately for knowledge structures 'x' with 2^31 or more states.

Value

Binary matrix representing the simulated data set

References


Examples

kmsimulate(xpl$space, 50, 0.2, 0.1)
kmsimulate(xpl$space, 50, c(0.2, 0.25, 0.15, 0.2), c(0.1, 0.15, 0.05, 0.1))
kmsimulate(xpl$space, 50, c(0.2, 0.25, 0.15, 0.2), 0)

kmsurmiscrelation

Description

kmsurmiscrelation returns a matrix representing the surmise relation of a quasi-ordinal knowledge space. If x is a general knowledge space, a knowledge structure or an arbitrary family of sets, kmsurmiscrelation returns the surmise relation of the smallest quasi-ordinal knowledge space containing x.

Usage

kmsurmiscrelation(x)

Arguments

x 
  Binary matrix representing a quasi-ordinal knowledge space

Value

Binary matrix representing the surmise relation of the corresponding quasi-ordinal knowledge space

Note: The columns of the surmise relation matrix describe the minimal state for the respective item in the quasi-ordinal knowledge space.

Examples

kmsurmiscrelation(xpl$space)
**kmsymmsediff**  
*Compute the symmetric set difference between two sets*

**Description**

Compute the symmetric set difference between two sets

**Usage**

```r
kmsymmsediff(x, y)
kmsetdistance(x, y)
```

**Arguments**

- `x`: Binary vector representing a set
- `y`: Binary vector representing a set

**Value**

- `kmsymmsediff`: Symmetric set difference between 'x' and 'y'
- `kmsetdistance`: Distance between the sets 'x' and 'y', i.e. the cardinality of the symmetric set difference

**Examples**

```r
kmsymmsediff(c(1,0,0), c(1,1,0))
kmsetdistance(c(1,0,0), c(1,1,0))
```

---

**kmtrivial**  
*Create trivial knowledge spaces*

**Description**

These functions create trivial knowledge spaces of a given item number. The minimal space contains just the empty set and the full item set while the maximal space is equal to the power set.

**Usage**

```r
kmminimalspace(noi)
kmmaximalspace(noi)
```
Arguments

noi Number of items

Details

Please note that the computation time for creating large power sets can grow quite large easily.

Value

A binary matrix representing the respective knowledge space

Examples

\begin{verbatim}
kmminimalspace(5)
kmmaximalspace(5)
\end{verbatim}

kmunionclosure Close a family of sets under union

Description

kmunionclosure returns a matrix representing a knowledge space. Please note that it takes quite some time for computing larger knowledge spaces.

Usage

kmunionclosure(x)

Arguments

x Binary matrix representing a family of sets

Value

Binary matrix representing the corresponding knowledge space, i.e. the closure of the family under union including the empty set and the full set.

kmconstrDowling implements the irredudant algorithm deveoped by Dowling (1993).

References


Examples

\begin{verbatim}
kmunionclosure(xpl$basis)
\end{verbatim}
**kmvalidate**  
*Validate a knowledge structure against a data set*

**Description**

kmvalidate returns a list with three elements, a named vector with the frequencies of distances between a set of response patterns and a knowledge structure, the Discrepancy Index (DI), and the Distance Agreement Coefficient (DA).

**Usage**

```
kmvalidate(data, struct)
```

**Arguments**

- **data**: Binary matrix representing a set of response patterns  
- **struct**: Binary matrix representing a knowledge structure

**Value**

A list with three elements:

- **dist**: Distance distribution vector  
- **DI**: Discrepancy Index  
- **DA**: Distance Agreement Coefficient

**Warning**

The DA computation can take quite some time for larger item sets as the power set has to be computed.

**Examples**

```
kmvalidate(xpl$data, xpl$space)
```
readwrite 

Knowledge spaces on reading and writing abilities

Description
Bases of knowledge spaces on reading/writing abilities obtained from querying experts.

Usage
readwrite

Format
A list containing four bases (rw1 to rw3, and rwmaj) in binary matrix form. Each matrix has 48 columns representing the different knowledge items and a varying number of rows containing the basis elements.

Details
Three experts were queried about prerequisite relationships between 48 items on reading and writing abilities (Dowling, 1991; 1993). A forth basis represents those prerequisite relationships on which the majority of the experts agree (Dowling & Hockemeyer, 1998).

References

xpl

Small example knowledge space

Description
Basis and space matrix of a small fictional knowledge space, and a small data set to be used in examples.

Usage
xpl
Format

A list containing the basis, the space, and the data matrix
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