Package 'CDSS'

July 21, 2025

Type Package

Title Course-Dependent Skill Structures

Version 0.3-0

Date 2025-04-07

Depends R (>= 4.3.0)

Imports readODS (>= 2.0.0), openxlsx (>= 4.2.0)

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NeedsCompilation no

Description Deriving skill structures from skill assignment data for courses (sets of learning objects).

Encoding UTF-8

RoxygenNote 7.3.2

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Repository CRAN

Date/Publication 2025-04-11 11:20:13 UTC

Contents

CDSS *CDSS: Course dependent skill structures*

Description

The CDSS package provides functions for a complete workflow from skill assignment tables to surmise mappings on the sets of skills and learning objects, respectively.

Suggested workflow for the general case

1. Read the skill assignment using one of the `read_skill_assignments_xxx()` functions.
2. Check the compliance to the definition for skill assignments using `cdss_sa_compliance()`.
3. Convert the skill assignment into a skill multi-assignment using `cdss_sa2sma()`.
4. Close the skill multi-assignment under completion using `cdss_sma2csma()`.
5. Compute the surmise function on skills using `cdss_csma2sf()`.
6. Continue with functions from the `kstMatrix` package, e.g., to obtain a basis and further on a skill space.

Suggested workflow for the special case of one LO per skill

1. Read the skill assignment using one of the `read_skill_assignments_xxx()` functions.
2. Check whether the skill assignment allows for the derivation of a surmise relation using `cdss_sa_describes_sr()`.
3. If yes, derive an attribution relation from the skill assignment using `cdss_sa2ar_skill()`.
4. Close the attribution relation to a surmise relation using `cdss_close_ar()`.
5. Continue with functions from the `kstMatrix` package, e.g., to obtain a basis and further on a skill space.

Data files

The installation of this package includes several data files as examples in the `extdata` sub directory (see the Examples below for how to access the files there). There are four data sets, `KST`, `KST-Intro`, `SkillAssignment`, and `ErroneousSkillAssignment`. The `SkillAssignment` data set is available in three formats, ODS, XLSX, and CSV (in CSV format, there are two files each, `SkillAssignment-R.csv` and `SkillAssignment-T.csv`, for required and taught skills, respectively). The other three data sets are available in ODS format only.

`SkillAssignment` and `ErroneousSkillAssignment` are small example data sets where the latter fails for `cdss_sa_compliance()`. `KST` contains a skill assignment for the course on knowledge space theory under https://moodle.qhelp.eu/. `KST-Intro` contains the reduction of `KST` to the first chapter of that course.

References

Hockemeyer, C. (2022). Building Course-Dependent Skill Structures - Applying Competence based Knowledge Space Theory to Itself. Manuscript in preparation.

Acknowledgements

The creation of this R package was financially supported by the Erasmus+ Programme of the European Commission through the QHELP project (https://qhelp.eu/).

Examples

```
library(readODS)
fpath <- system.file("extdata", "SkillAssignment.ods", package="CDSS")
sa <- cdss_read_skill_assignment_ods(fpath)
sa
sma <- cdss_sa2sma(sa)
sma
csma <- cdss_sma2csma(sma)
csma
sf <- cdss_csma2sf(csma)
sf
```

`cdss_binary_matrix_product` *Compute a binary matrix product*

Description

`cdss_binary_matrix_product` expects two binary matrices and computes there Boolean product.

Usage

```
cdss_binary_matrix_product(m, n)
```

Arguments

m	Binary matrix
n	Binary matrix

Value

Boolean matrix product of m and n

See Also

Other Utility functions: cdss_close_ar(), cdss_reduce_sf()

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cdss_circular_requirements

Vector of learning objects requiring and teaching the same skill

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Description

cdss_circular_requirements expects skill assignment and returns a vector of learning objects which require a skill that they teach.

Usage

```
cdss_circular_requirements(sa)
```

Arguments

sa	Skill assignment

Value

Vector of learning objects

See Also

Other Functions testing validity of skill assignments: cdss_missing_los(), cdss_nonteaching_los(), cdss_sa_compliance()

cdss_close_ar *Close an attribution relation to get a surmise relation.*

Description

cdss_close_ar expects a quadratic binary matrix and closes it under reflexivity and transitivity.

Usage

```
cdss_close_ar(ar)
```

Arguments

ar	Attribution relation matrix

Value

surmise relation or NULL

See Also

Other Utility functions: cdss_binary_matrix_product(), cdss_reduce_sf()

cdss_csma2sf *Derive a surmise function from a complete skill multi-assignment*

Description

cdss_csma2sf expects a complete skill multi-assignment object and returns the corresponding surmise function on the set of skills.

Usage

```
cdss_csma2sf(csma)
```

Arguments

csma	Skill multi-assignment to be completed

Value

Object of class cdss_csma.

cdss_lo_csma2sf *Derive a surmise function between learning objects from a complete skill multi-assignment*

Description

cdss_lo_csma2sf expects a complete skill multi-assignment and derives a surmise function on the set of learning objects.

Usage

```
cdss_lo_csma2sf(csma)
```

Arguments

csma	Complete skill multi-assignment object

Value

Object of class cdss_sf (attribution function).

See Also

Other functions building skill (multi) assignment matrices: cdss_lo_sa2af(), cdss_sa2sma(), cdss_tables2sa()

cdss_lo_sa2af *Determine Attribution function for LOs from a skill assignment*

Description

cdss_lo_sa2af expects a skill assignment and derives an attribution function on the set of learning objects.

Usage

```
cdss_lo_sa2af(sa)
```

Arguments

sa	Skill assignment object

Value

Object of class cdss_af (attribution function).

See Also

Other functions building skill (multi) assignment matrices: `cdss_lo_csma2sf()`, `cdss_sa2sma()`, `cdss_tables2sa()`

`cdss_lo_sa2ar` *Create an attribution relation on learning objects from a skill assignment.*

Description

`cdss_lo_sa2ar` expects a skill assignment and derives an attribution relation on learning objects if the skill assignment fulfills the necessary conditions, i.e. if there is only one teaching LO per skill.

Usage

```
cdss_lo_sa2ar(sa)
```

Arguments

`sa`	Skill assignment object

Value

attribution relation or NULL

See Also

Other functions deriving skill structures from skill assignments: `cdss_sa2ar_skill()`, `cdss_sa_describes_sr()`

`cdss_missing_los` *Vector of skills without teaching learning objects.*

Description

`cdss_missing_los` expects a skill assignment and returns a vector of skills which are not taught by any learning object.

Usage

```
cdss_missing_los(sa)
```

Arguments

`sa`	SKill assignment

Value

Vector of skills

See Also

Other Functions testing validity of skill assignments: `cdss_circular_requirements()`, `cdss_nonteaching_los()`, `cdss_sa_compliance()`

`cdss_nonteaching_los` *Vector of learning objects not teaching any skills.*

Description

`cdss_nonteaching_los` expects a skill assignment and returns a vector of learning objects which do not teach any skill.

Usage

```
cdss_nonteaching_los(sa)
```

Arguments

`sa`	SKill assignment

Value

Vector of learning objects

See Also

Other Functions testing validity of skill assignments: `cdss_circular_requirements()`, `cdss_missing_los()`, `cdss_sa_compliance()`

`cdss_read_skill_assignment_csv`
Read an assignment of taught and required skills for a set of learning objects from CSV-files.

Description

`cdss_read_skill_assignment` expects two CSV-files with two columns each. The first column contains the IDs of learning objects and the second row the IDs of single skills required or taught, respectively, by this learning object. It returns a list of two binary matrices, "taught" and "required". Each matrix has one row per learning object and one column per skill. The cells contain a "1" if the skill is taught or required, respectively, by the learning object and a "0" otherwise,

Usage

```
cdss_read_skill_assignment_csv(
  taught,
  required,
  header = TRUE,
  sep = ",",
  dec = ".",
  warnonly = FALSE,
  verbose = TRUE
)
```

Arguments

taught	CSV-file with assignments of taught competencies to learning objects
required	CSV-file with assignments of required competencies to learning objects
header	Boolean specifying whether the CSV-files contain a header line (default = TRUE)
sep	Column separator (default ",")
dec	Decimal point character (default ".")
warnonly	Are non-compliant SAs allowed? (default = FALSE)
verbose	Verbosity of compliance test (default = TRUE)

Value

List of two binary matrices, "taught" and "required".

See Also

Other functions reading skill assignments: cdss_read_skill_assignment_ods(), cdss_read_skill_assignment_xlsx()
cdss_wf_read_skill_assignment()

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cdss_read_skill_assignment_ods

Read an assignment of taught and required skills for a set of learning objects from an ODS-file.

Description

cdss_read_skill_assignment_ods expects an ODS-file with two sheets assigning taught and required, respectively, skills to learning objects with two columns each. The first column contains the IDs of learning objects and the second row the IDs of single skills required or taught, respectively, by this learning object. It returns a list of two binary matrices, "taught" and "required". Each matrix has one row per learning object and one column per skill. The cells contain a "1" if the skill is taught or required, respectively, by the learning object and a "0" otherwise,

Usage

```
cdss_read_skill_assignment_ods(
  filename,
  taughtname = "Taught",
  requiredname = "Required",
  warnonly = FALSE,
  verbose = TRUE
)
```

Arguments

filename	Name of the ODS-file
taughtname	Name of the sheet with required assignment (default = "Taught")
requiredname	Name of the sheet with required assignment (default = "Required")
warnonly	Are non-compliant SAs allowed? (default = FALSE)
verbose	Verbosity of compliance test (default = TRUE)

Value

List of two binary matrices, "taught" and "required".

See Also

Other functions reading skill assignments: cdss_read_skill_assignment_csv(), cdss_read_skill_assignment_xlsx(), cdss_wf_read_skill_assignment()

---

cdss_read_skill_assignment_xlsx

Read an assignment of taught and required skills for a set of learning objects from an XLSX-file.

Description

cdss_read_skill_assignment_xlsx expects an XLSX-file with two sheets assigning taught and required, respectively, skills to learning objects with two columns each. The first column contains the IDs of learning objects and the second row the IDs of single skills required or taught, respectively, by this learning object. It returns a list of two binary matrices, "taught" and "required". Each matrix has one row per learning object and one column per skill. The cells contain a "1" if the skill is taught or required, respectively, by the learning object and a "0" otherwise,

Usage

```
cdss_read_skill_assignment_xlsx(
  filename,
  taughtname = "Taught",
  requiredname = "Required",
  warnonly = FALSE,
  verbose = TRUE
)
```

Arguments

filename	Name of the XLSX-file
taughtname	Name of the sheet with required assignment (default = "Taught")
requiredname	Name of the sheet with required assignment (default = "Required")
warnonly	Are non-compliant SAs allowed? (default = FALSE)
verbose	Verbosity of compliance test (default = TRUE)

Value

List of two binary matrices, "taught" and "required".

See Also

Other functions reading skill assignments: cdss_read_skill_assignment_csv(), cdss_read_skill_assignment_ods(), cdss_wf_read_skill_assignment()

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cdss_reduce_sf *Reduce a surmise function with respect to item equivalence*

Description

cdss_reduce_sf takes a surmise function and returns its reduction to non-equivalent items.

Usage

```
cdss_reduce_sf(sf)
```

Arguments

sf	Surmise function

Value

Surmise function reduced by equivalences

See Also

Other Utility functions: cdss_binary_matrix_product(), cdss_close_ar()

cdss_sa2ar_skill *Create an attribution relation on skills from a skill assignment.*

Description

cdss_sa2ar_skill expects a skill assignment and derives an attribution relation on skills if the skill assignment fulfills the necessary conditions, i.e. if there is only one teaching LO per skill.

Usage

```
cdss_sa2ar_skill(sa)
```

Arguments

sa	Skill assignment object

Value

attribution relation or NULL

See Also

Other functions deriving skill structures from skill assignments: cdss_lo_sa2ar(), cdss_sa_describes_sr()

cdss_sa2sma *Convert skill assignment matrices to skill multi-assignment*

Description

cdss_sa2sma expects a list of two matrices (taught and required) of a skill assignment. It returns a skill multi-assignment object.

Usage

```
cdss_sa2sma(sa)
```

Arguments

sa	Skill assignment object

Value

Object of class cdss_sma.

See Also

Other functions building skill (multi) assignment matrices: cdss_lo_csma2sf(), cdss_lo_sa2af(), cdss_tables2sa()

cdss_sa_compliance *Check whether a skill assignment is compliant to the CDCS conditions.*

Description

cdss_sa_compliance expects a skill assignment and checks whether it is compliant to the conditions for CDCS.

Usage

```
cdss_sa_compliance(sa, warnings = FALSE)
```

Arguments

sa	Skill assignment
warnings	Toggles whether warnings should be printed

Value

Boolean

See Also

Other Functions testing validity of skill assignments: cdss_circular_requirements(), cdss_missing_los(), cdss_nonteaching_los()

cdss_sa_describes_sr *Check whether a surmise relation can be derived from a given skill assignment.*

Description

cdss_sa_describes_sr expects a list of two matrices (taught and required) of a skill assignment. It returns TRUE if the skill assignment describes a surmise relation (i.e. there is only one teaching LO per skill) and FALSE.

Usage

```
cdss_sa_describes_sr(sa, verbose = FALSE)
```

Arguments

sa	Skill assignment object
verbose	Flag, default is FALSE

Value

Logical value

See Also

Other functions deriving skill structures from skill assignments: `cdss_lo_sa2ar()`, `cdss_sa2ar_skill()`

`cdss_sma2csma` *Complete a skill multi-assignment*

Description

`cdss_sma2csma` expects a skill multi-assignment object and returns the corresponding complete skill multi-assignment. If this would involve cycles, the function stops by default - except if `allowcycles` is set to `TRUE`. In that case, the result may be ill-defined!

Usage

```
cdss_sma2csma(sma, allowcycles = FALSE)
```

Arguments

`sma`	Skill multi-assignment to be completed
`allowcycles`	Whether prerequisite cycles should be allowed (default = FALSE)

Value

Object of class `cdss_csma`.

`cdss_tables2sa` *Build matrices of taught and required, respectively, skills for learning objects from respective tables.*

Description

`cdss_tables2sa` expects two data frames with two columns each. The first column contains the IDs of learning objects and the second row the IDs of single skills required or taught, respectively, by this learning object. It returns a list of two binary matrices, "taught" and "required". Each matrix has one row per learning object and one column per skill. The cells contain a "1" if the skill is taught or required, respectively, by the learning object and a "0" otherwise.

Usage

```
cdss_tables2sa(taught, required)
```

Arguments

taught	Data table containing the assignment of taught skills to learning objects
required	Data table containing the assignment of required skills to learning objects

Value

List of two binary matrices, "taught" and "required".

See Also

Other functions building skill (multi) assignment matrices: cdss_lo_csma2sf(), cdss_lo_sa2af(), cdss_sa2sma()

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cdss_wf_read_skill_assignment

Read an assignment of taught and required skills for a set of learning objects from file and do the whole workflow up to a surmise function on skills

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Description

cdss_wf_read_skill_assignment expects an ODS or XLSX file with two sheets assigning taught and required, respectively, skills to learning objects with two columns each. Alternatively, two CSV files can be specified. In the sheets/CSV files, the first column contains the IDs of learning objects and the second row the IDs of single skills required or taught, respectively, by this learning object. It returns a list of two binary matrices, "taught" and "required". Each matrix has one row per learning object and one column per skill. The cells contain a "1" if the skill is taught or required, respectively, by the learning object and a "0" otherwise,

Usage

```
cdss_wf_read_skill_assignment(
  filename,
  filename2 = NULL,
  filetype = "auto",
  taughtname = "Taught",
  requiredname = "Required",
  header = TRUE,
  sep = ",",
  dec = ".",
  warnonly = FALSE,
  verbose = TRUE
)
```

Arguments

filename	Name of the file (in case of CSV files the one with TAUGHT assignments)
filename2	Name of the CSV file with REQUIRED assignments (if applicable)
filetype	Type of the file, allowed values are "auto", "ODS", "XLSX", and "CSV"
taughtname	Name of the sheet with required assignment (default = "Taught")
requiredname	Name of the sheet with required assignment (default = "Required")
header	Boolean specifying whether the CSV-files contain a header line (default = TRUE)
sep	Column separator for CSV files (default ",")
dec	Decimal point character for CSV files (default ".")
warnonly	Are non-compliant SAs allowed? (default = FALSE)
verbose	Verbosity of compliance test (default = TRUE)

Value

List of four elements: sfs (surmise function between skills), sfl (surmise function between learning objects) srs (surmise relation between skills, if available; NULL otherwise) srl (surmise relation between learning objectrs, if available; NULL otherwise)

See Also

Other functions reading skill assignments: cdss_read_skill_assignment_csv(), cdss_read_skill_assignment_ods(), cdss_read_skill_assignment_xlsx()

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