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1

Additional Functions Dealing with Bitsets (a,b)

Names

1.1 double **minv** (double* vector, int len)
minimal entry of a vector 3

1.2 int **minv** (int* vector, int len)
minimal entry of a vector 3

1.3 double **maxv** (double* vector, int len)
maximal entry of a vector 4

1.4 int **maxv** (int* vector, int len)
maximal entry of a vector 4

1.5 int **min_pos** (float* vector, int len)
position of the minimal element in a vector 4

1.6 int **min_pos** (int* vector, int len)
position of the minimal element in a vector 5

1.7 int **max_pos** (float* vector, int len)
position of the maximal element in a vector 5

1.8 int **max_pos** (int* vector, int len)
position of the maximal element in a vector 6

1.9 int **is_number_el** (double item, double* set, int set_size)
is a number element of a set of numbers 6

1.10 int **is_number_el** (int item, int* set, int set_size)
is a number element of a set of numbers 6

1.11 int **is_bitset_el** (bitset element, bitset* set, int q_size, int s_size)
is a bitset element of a set of bitsets? 7

1.12 int **is_bitset_el** (bitset element, structure* st)

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1.13	int*	**set** (int* array, int len, int value=0) *set all elements of an array the same value*	8

1.1

double **minv** (double* vector, int len)

minimal entry of a vector

minimal entry of a vector. Compute the minimal entry of a vector of real numbers.

Return Value: minimal entry of a vector of real numbers

Parameters: `vector` — vector of (real) numbers
`len` — lenght of vector

1.2

int **minv** (int* vector, int len)

minimal entry of a vector

minimal entry of a vector. Compute the minimal entry of a vector of integer numbers.

Return Value: minimal entry of a vector of integer numbers

Parameters: `vector` — vector of (real) numbers
`len` — lenght of vector

1.3

double **maxv** (double* vector, int len)

maximal entry of a vector

maximal entry of a vector. Compute the maximal entry of a vector of real numbers.

Return Value: maximal entry of a vector of numbers

Parameters: `vector` — vector of (real) numbers
`len` — lenght of vector

1.4

int **maxv** (int* vector, int len)

maximal entry of a vector

maximal entry of a vector. Compute the maximal entry of a vector of integer numbers.

Return Value: maximal entry of a vector of numbers

Parameters: `vector` — vector of (real) numbers
`len` — lenght of vector

1.5

int **min_pos** (float* vector, int len)

position of the minimal element in a vector

position of the minimal element in a vector. Compute the position of the minimal entry in a vector of real numbers. Attention: The first entry of the vector is on position '0'!

Return Value: position of the minimum in the vector

Parameters: `vector` — vector of real numbers
`len` — lenght of vector

1.6

int **min_pos** (int* vector, int len)

position of the minimal element in a vector

position of the minimal element in a vector. Compute the position of the minimal entry in a vector of integer numbers. Attention: The first entry of the vector is on position '0'!

Return Value: position of the minimum in the vector

Parameters: `vector` — vector of integer numbers
`len` — lenght of vector

1.7

int **max_pos** (float* vector, int len)

position of the maximal element in a vector

position of the maximal element in a vector. Compute the position of the maximal entry in a vector of real numbers. Attention: The first entry of the vector is on position '0'!

Return Value: position of the maximum in the vector

Parameters: `vector` — vector of real numbers
`len` — lenght of vector

1.8

int **max_pos** (int* vector, int len)

position of the maximal element in a vector

position of the maximal element in a vector. Compute the position of the maximal entry in a vector of integer numbers. Attention: The first entry of the vector is on position '0'!

Return Value: position of the maximum in the vector

Parameters: `vector` — vector of integer numbers
`len` — lenght of vector

1.9

int **is_number_el** (double item, double* set, int set_size)

is a number element of a set of numbers

is a number element of a set of numbers. Look, if a single real number is element of a set of real numbers.

Return Value: yes (1) or no (0)

Parameters: `item` — number to look for
`set` — pointer to set of real numbers
`set_size` — size of set of numbers

1.10

int **is_number_el** (int item, int* set, int set_size)

is a number element of a set of numbers

is a number element of a set of numbers. Look, if a single integer number is element of a set of integer numbers.

Return Value: yes (1) or no (0)

Parameters: `item` — number to look for
`set` — pointer to set of integer numbers
`set_size` — size of set of numbers

1.11

int **is_bitset_el** (bitset element, bitset* set, int q_size, int s_size)

is a bitset element of a set of bitsets?

is a bitset element of a set of bitsets?. Look, if a bitset (meaning also a vector of integer numbers of lenght q_size) is element of a set of bitsets (or a set of integer numbers).

Return Value: yes (1) or no (0)

Parameters: `element` — bitset to look for
`set` — pointer to set of bitsets
`q_size` — number of items in each bitset
`s_size` — number of bitsets in the set

1.12

int **is_bitset_el** (bitset element, structure* st)

is a bitset element of an arbitrary structure?

is a bitset element of an arbitrary structure?. Look, if a bitset is element of the given structure (or space, data...).

Return Value: yes (1) or no (0)

Parameters: `element` — bitset to look for
`set` — pointer to set of bitsets
`q_size` — number of items in each bitset
`s_size` — number of bitsets in the set

1.13

int* **set** (int* array, int len, int value=0)

set all elements of an array the same value

set all elements of an array the same value. Set all elements of the given array to the value of the given parameter. If no 'value' parameter is given, all entries of the array are set 0.

Return Value: pointer to the array

Parameters: `array` — array of integers
`len` — length of array
`value` — value to be set, default is 0

2 Additional Functions for Surmise Relations between Items

Names

2.1 srbi* **copy_srbi** (srbi* sr)
make a copy of a surmise relation matrix 9

2.2 srbi* **change_items** (srbi* sr, int nr1, int nr2)
change items 10

2.3 srbi* **remove_item_sr** (srbi* sr, int item)
remove an item 10

2.4 int **count_equ_items** (srbi* sr)
count equivalent items 11

2.5 srbi* **delete_equ_items** (srbi* sr)
delete equivalent items 11

2.6 srbi* **close_reflex_srbi** (srbi* sr)
complete surmise relations because of reflexivities 11

2.7 srbi* **close_trans_srbi** (srbi* sr)
complete transitivities in surmise relation between items 12

2.8 int **is_item_sr** (int i, int j, srbi* sr)
is there a surmise relation between two items? 12

ATTENTION: In all following functions the numbering of items starts with '0'! This means, the first item has the number '0', the last 'q_size-1'.

2.1 srbi* **copy_srbi** (srbi* sr)

make a copy of a surmise relation matrix

Return Value: pointer to copied srbi-structure
Parameters: `sr` — surmise relation structure to be copied

2.2

srbi* **change_items** (srbi* sr, int nr1, int nr2)

change items

change items. Change the position of two items in a srbi-matrix. The information numbers of the items is also changed.
Return Value: Surmise relation matrix, where items number i and j changed their position in the matrix.

Parameters: `sr` — matrix with surmise relation
`nr1` — number of first item
`nr2` — number of second item

2.3

srbi* **remove_item_sr** (srbi* sr, int item)

remove an item

remove an item. Remove one item in a surmise-relation matrix. For example: you want to eliminate item nr. `i` - the function eliminates the i-th line and the i-th column in the matrix. The informations for this item also is deleted.
Return Value: new srbi with deleted item.

Parameters: `sr` — surmise relation between items
`item` — number of the item to be deleted

2.4

int **count_equ_items** (srbi* sr)

count equivalent items

count equivalent items. Count, how many items are equivalent in the given surmise relation. Comment: two items a and b are equivalent, if aSb and bSa ('S' denotes the surmise relation between items).

Return Value: number of equivalent items

Parameters: `sr` — surmise relation between items

2.5

srbi* **delete_equ_items** (srbi* sr)

delete equivalent items

delete equivalent items. Delete one of two equivalent items. Comment: two items a and b are equivalent, if aSb and bSa.

Return Value: new srbi with deleted equivalent items.

Parameters: `sr` — matrix with surmise relations

2.6

srbi* **close_reflex_srbi** (srbi* sr)

complete surmise relations because of reflexivities

complete surmise relations because of reflexivities. For each item 'a' we always have: a is in surmise relation with a. Therefore in the matrix with surmise relations there have to be all '1's in the main diagonal. If they are missing, they are completed by this function.

Return Value: new srbi with added reflexivities.

Parameters: `sr` — matrix with surmise relations

2.7

srbi* **close_trans_srbi** (srbi* sr)

complete transitivities in surmise relation between items

complete transitivities in surmise relation between items. Complete a surmise relation matrix between items by regarding transitivity properties. Example: 'S' denotes the surmise relation between Items, a,b,c are Items; if aSb and bSc, the function will set aSc in the srbi-structure.

Return Value: complete srbi-structure with all surmise-relations

Parameters: `sr` — relation to be completed

2.8

int **is_item_sr** (int i, int j, srbi* sr)

is there a surmise relation between two items?

is there a surmise relation between two items?. Look if item number i is in surmise relation with item number j.

Return Value: yes or no (1/0)

Parameters: `i` — number of first item
`j` — number of second item
`sr` — surmise relations between the items

3

Additional Functions for Spaces

Names

3.1	int	**write_space** (space* s)	*write a space to stdout*	13
3.2	structure*	**states_with_x** (space* s, int item_x)	*states with item x*	14
3.3	data*	**transpose_matrix** (data* input)	*transpose a matrix*	14
3.4	int*	**count_data** (data* d)	*count the frequencies of answer patterns in a data matrix*	14
3.5	class	**ganter**	*Class for computing the closure under union and intersection for structures*	15

3.1

int **write_space** (space* s)

write a space to stdout

write a space to stdout. Comment: this function can be used for other structs with the same internal structure(data, structure..) just by making a typecasting.
Return Value: 1 if an error occured, 0 else.

3.2

structure* **states_with_x** (space* s, int item_x)

states with item x

states with item x. Compute all states of a knowledge space containing an item x.
Return Value: structure containting alle the states that contain 'item_x', NULL if an error occured.

Parameters: `s` — knowledge space
`item_x` — number of item

3.3

data* **transpose_matrix** (data* input)

transpose a matrix

transpose a matrix. Transpose a given matrix in a data-structure by changing $a[i, j]$ to $a[j, i]$. Comment: use this functions also for spaces, structures and partitions just making a typecasting.
Return Value: pointer to a data-structure, containing the transposed matrix.

Parameters: `input` — data-structure including the matrix to be transposed

3.4

int* **count_data** (data* d)

count the frequencies of answer patterns in a data matrix

count the frequencies of answer patterns in a data matrix. Count the frequencies of different answer patterns in a given data matrix, where the line-infos are complete (they already include, which answer patterns occur how often and they include all different patterns only once.
Return Value: : vector with the frequencies of answer patterns

Parameters: `d` — data-structure with line-infos

3.5 class **ganter**

Class for computing the closure under union and intersection for structures

Public Members

3.5.1 space* **u_closure** (basis* b)
close a basis under union 16

3.5.2 int **u_closure** (basis* b, filetype mode, const char filename[])
close a basis under union 16

3.5.3 space* **u_closure** (structure* su)
close a structure under union .. 16

3.5.4 int **u_closure** (structure* su, filetype mode, const char filename[])
close a structure under union .. 17

3.5.5 structure* **s_closure** (structure* su)
close a structure under intersection 17

3.5.6 int **s_closure** (structure* su, filetype mode, const char filename[])
close a structure under intersection 18

Class for computing the closure under union and intersection for structures. The functions in this class use the Ganter algorithm to compute the closure under union and intersection. A great advantage with this algorithm is, that not the whole structure/space has to be kept in memory. The next state in the resulting structure/space is computed out of the last. Especially with large structures, it is recommendable to use the versions of closure, that store the resulting space/structure directly to a file.

3.5.1 space* **u_closure** (basis* b)

close a basis under union

close a basis under union. Compute the closure of a basis under union using Ganter's algorithm.
Return Value: resulting space, NULL, if an error occured.

Parameters: `b` — basis to be closed

3.5.2

int **u_closure** (basis* b, filetype mode, const char filename[])

close a basis under union

close a basis under union. Compute the closure under union of a basis using Ganter's algorithm. The resulting space is directly written to a file.
Return Value: number of states in the space.

Parameters: `b` — basis to be closed.
`mode` — file format.
`filename` — filename for resulting space.

3.5.3

space* **u_closure** (structure* su)

close a structure under union

close a structure under union. Compute the closure under union of a given structure using Ganter's algorithm.
Return Value: resulting space, NULL if an error occured.

Parameters: `st` — structure to be closed

3.5.4

int **u_closure** (structure* su, filetype mode, const char filename[])

close a structure under union

close a structure under union. Compute the closure under union of a structure using Ganter's algorithm. The resulting space is directly written to a file.

Return Value: number of states in the space.

Parameters: `b` — basis to be closed.
`mode` — file format.
`filename` — filename for resulting space.

3.5.5

structure* **s_closure** (structure* su)

close a structure under intersection

close a structure under intersection. Compute the closure under intersection of a given structure using Ganter's algorithm.

Return Value: resulting structure closed under intersection, NULL if an error occured.

Parameters: `st` — structure to be closed.

3.5.6

int **s_closure** (structure* su, filetype mode, const char filename[])

close a structure under intersection

close a structure under intersection. Compute the closure under intersection of a structure using Ganter's algorithm. The resulting structure is directly written to a file.

Return Value: number of states in the structure.

Parameters:

`b` — basis to be closed.
`mode` — file format.
`filename` — filename for resulting structure.

4 Working with Information Structures

Names

4.1 int **add_info** (int** info, int position, int number)
add identification numbers 19

4.2 int **change_two_infos** (int** info, int pos1, int pos2, int nr)
change the positions of two lines of informations 20

4.3 int* **remove_info** (int pos, int* line)
remove an information number . 20

4.4 int **is_number_in_info** (int num, int* line)
is a number element of a set of information numbers? 21

4.5 int* **copy_info_line** (int* info)
make a copy of an info line 21

4.6 void **set_info_line** (int* set, int* orig)
make a copy of an info line 21

ATTENTION: In all following functions the numbering of items starts with '0'! This means, the first item has the number '0', the last 'q_size-1'. The same applies for patterns or states.

4.1 int **add_info** (int** info, int position, int number)

add identification numbers

add identification numbers. In a set of information vectors, an additional information number is added at a certain position.

Return Value: 1 if an error occured, 0 else.

Parameters: `info` — pointer to matrix of information numbers
`position` — position of the information vector in the information structure, where the number should be added
`number` — number to be added

4.2

int **change_two_infos** (int** info, int pos1, int pos2, int nr)

change the positions of two lines of informations

change the positions of two lines of informations. The information numbers from the position 'pos1' are written to 'pos2' and vice versa.

Return Value: -1 if an error occured, 0 else

Parameters: `info` — pointer to matrix of information numbers
`pos1` — first position of info-numbers to be changed
`pos2` — second position of info-numbers to be changed
`nr` — number of info-lines possible in the info-struct

4.3

int* **remove_info** (int pos, int* line)

remove an information number

remove an information number. Remove a single information number out of a vector containing informations for a special position in the information matrix.

Return Value: new information line

Parameters: `pos` — position of the info-number to be removed
`line` — line in the information matrix, which should be removed

4.4

int **is_number_in_info** (int num, int* line)

is a number element of a set of information numbers?

Return Value: yes (1) or no (0)
Parameters: `num` — number to look for
`line` — pointer to vector of information numbers

4.5

int* **copy_info_line** (int* info)

make a copy of an info line

make a copy of an info line. Allocate the necessary memory and make a copy of an already existing line of information numbers.
Return Value: pointer to copied info vector
Parameters: `info` — vector of information numbers to be copied

4.6

void **set_info_line** (int* set, int* orig)

make a copy of an info line

make a copy of an info line. Make a copy of an already existing info line, if the necessary memory already is available.
Parameters: `set` — pointer to copied info line
`orig` — info line to be copied

5 Working with Item Hypotheses

Names

5.1 ihypoth* **load_ihypoth** (const char filename[])
load an item hypothesis from a file 22

5.2 int **write_ihypoth** (FILE *f, ihypoth *ih)
write an item hypothesis 23

5.3 ihypoth* **new_ihypoth** (int q_size)
allocate memory for a new item hypothesis 23

5.4 ihypoth* **copy_ihypoth** (ihypoth* ih)
make a copy of an item hypotheses structure 23

5.5 void **free_ihypoth** (ihypoth **r)
return memory to the system ... 24

5.6 srbi* **ihypoth2srbi** (ihypoth* h)
item-hypothesis to surmise relation 24

5.1 ihypoth* **load_ihypoth** (const char filename[])

load an item hypothesis from a file

load an item hypothesis from a file. This function loads an item hypothesis from a file. It determines automatically which type of data is stored in the file.

Return Value: pointer to resulting item hypothesis.

Parameters: `filename[]` — Name of file to be loaded

5.2

int **write_ihypoth** (FILE *f, ihypoth *ih)

write an item hypothesis

write an item hypothesis. This functions writes an item hypothesis to a given file (or alternatively) to stdout or stderr.

Return Value: -1 if an error occured, 0 else

Parameters: `f` — File to be written to
`ih` — pointer to item hypothesis

5.3

ihypoth* **new_ihypoth** (int q_size)

allocate memory for a new item hypothesis

Return Value: pointer to the new item hypothesis struct

Parameters: `q_size` — Number of items

5.4

ihypoth* **copy_ihypoth** (ihypoth* ih)

make a copy of an item hypotheses structure

Return Value: pointer to the resulting item hypothesis structure

Parameters: `ih` — original item hypothesis

5.5

void **free_ihypoth** (ihypoth **r)

return memory to the system

return memory to the system. Return memory used by an item hypothesis struct to the system.

5.6

srbi* **ihypoth2srbi** (ihypoth* h)

item-hypothesis to surmise relation

item-hypothesis to surmise relation . Change an hypothesis on surmise relations between some items to an surmise relation structure, all fields, which were not known in the hypotheses (all fields with '.') are set '0', the relation is completed beause of transitivity and reflexitivity properties.

6 Working with Answer Patters

Names

6.1 int **write_patterns** (patterns* pa)
write a set of answer-patterns to stdout 25

6.2 patterns* **copy_patterns** (patterns* orig)
make a copy of a set of patterns 26

6.3 patterns* **load_patterns** (const char filename[])
load a pattern set from a file ... 26

6.4 int **save_patterns** (patterns *pa, filetype mode, const char filename[])
write a pattern set to a file 26

6.5 patterns* **new_patterns** (int q_size, int p_size)
allocate memory for a pattern set
27

6.6 void **free_patterns** (patterns **p)
Return memory used by a pattern set to the system 27

6.7 data* **patterns2data** (patterns *p)
convert pattern set to data set .. 27

6.8 patterns* **data2patterns** (data* d)
convert data set to pattern setThis function is mere a cast operator 28

6.1 int **write_patterns** (patterns* pa)

write a set of answer-patterns to stdout

write a set of answer-patterns to stdout. Write a set of answer patterns to stdout, using '1' for a correct solved item, '0' for a wrong solution and 'x' for a not answered item.
Return Value: -1, if an error occured, 0 else.

6.2

patterns* **copy_patterns** (patterns* orig)

make a copy of a set of patterns

make a copy of a set of patterns. The necessary memory is allocated.

Return Value: pointer to copied patterns.

Parameters: `orig` — original patterns to be copied

6.3

patterns* **load_patterns** (const char filename[])

load a pattern set from a file

load a pattern set from a file. This function loads a pattern set from a file.

Return Value: pointer to resulting pattern set.

Parameters: `filename[]` — name of the file to be loaded

6.4

int **save_patterns** (patterns *pa, filetype mode, const char filename[])

write a pattern set to a file

write a pattern set to a file. This function writes a set of answer patterns to a file using the new patternfile format.

Return Value: error code.

Parameters: `pa` — patterns to be stored
`mode` — format to be used
`filename[]` — name of file to be saved

6.5

patterns* **new_patterns** (int q_size, int p_size)

allocate memory for a pattern set

allocate memory for a pattern set. **Parameters:** `q_size` — number of items
`p_size` — number of patterns

6.6

void **free_patterns** (patterns **p)

Return memory used by a pattern set to the system

Parameters: `p` — patterns set

6.7

data* **patterns2data** (patterns *p)

convert pattern set to data set

convert pattern set to data set. This function takes a pattern set and converts it to a data set assuming that all un-answered items are not mastered.
Return Value: pointer to resultin data set
Parameters: `p` — patterns structure

6.8

patterns* **data2patterns** (data* d)

convert data set to pattern setThis function is mere a cast operator

convert data set to pattern set This function is mere a cast operator. In the resulting pattern set, all items are considered to be answered, i.e. the un-answered matrix is set to zero.

Return Value: pointer to resulting patterns set

Parameters: `d` — data set

7 Additional Functions for Working with Patterns

Names

7.1 patterns* **remove_item** (patterns* pa, int itemnr)
remove a single item 30

7.2 patterns* **remove_items** (patterns* pa, int* nrs, int number)
remove given items out of an answer-pattern 31

7.3 patterns* **remove_pattern** (patterns* orig, int number)
remove a pattern 31

7.4 patterns* **remove_patterns** (patterns* orig, int number, int* pat_nrs)
remove a set of answer-patterns 31

7.5 double* **percent_items_answered** (patterns* p)
how many percent of students answered each item? 32

7.6 double* **percent_items_correct** (patterns* p)
how many percent of students gave a correct answer to each item? . 32

7.7 double* **percent_pattern_answered** (patterns* p)
how many items were answered in each pattern? 33

7.8 int* **number_items_answered** (patterns* pa)
how many persons gave an answer to an item? 33

7.9 int **persons_all_items_answered** (patterns* pa)
how many persons answered all the items? 33

7.10 patterns* **delete_percent_ua_patterns** (patterns* pa, int percent)
delete patterns in which less than a given percentage of items was answered 34

7.11 patterns* **delete_percent_ua_items** (patterns* pa, int percent) *delete items that have been answered less often than a given percentage* 34

7.12 patterns* **remove_pat_with_ua** (patterns* pa)
remove all patterns, where one or more items are not answered ... 35

7.13 int **is_pattern_el** (bitset sol, bitset unans, patterns* pat)
is a pattern element of a set of patterns? 35

7.14 int **is_pattern_el** (bitset sol, bitset unans, bitset* orig_sol, bitset* orig_una, int q, int num)
is a pattern element of a set of patterns? 35

7.15 int **patt_in_space** (bitset sol, bitset unans, space* sp)
Is it possible, that an answer pattern is element of a given space? 36

ATTENTION: In all following functions the numbering of items starts with '0'! This means, the first item has the number '0', the last 'q_size-1'. The same applies for patterns.

7.1

patterns* **remove_item** (patterns* pa, int itemnr)

remove a single item

remove a single item. Remove a single item out of a patterns-structure.
Return Value: new patterns-structure with deleted item

Parameters: `pa` — pointer to patterns struct
`itemnr` — number of item to be deleted

7.2

patterns* **remove_items** (patterns* pa, int* nrs, int number)

remove given items out of an answer-pattern

remove given items out of an answer-pattern. Remove the given items out of an answer-pattern.

Return Value: patterns with removed item, 'NULL', if an error occured

Parameters:
`pa` — patterns, where the items should be removed
`nrs` — numbers of the items to be removed
`number` — how many items should be removed

7.3

patterns* **remove_pattern** (patterns* orig, int number)

remove a pattern

remove a pattern. Remove a single pattern out of a patterns-structure.

Return Value: new patterns-structure with removed pattern

Parameters:
`pa` — pointer to patterns-structe
`number` — number of pattern to be removed

7.4

patterns* **remove_patterns** (patterns* orig, int number, int* pat_nrs)

remove a set of answer-patterns

remove a set of answer-patterns. Remove a set of answer-patterns

out of a patterns-structure. Attention: Currently the numbers of the patterns to be deleted have to be enterd in increasing order!.
Return Value: new patterns-structure with patterns removed.

Parameters: `orig` — patterns-structure.
`number` — number of patterns to be removed.

7.5

double* **percent_items_answered** (patterns* p)

how many percent of students answered each item?

how many percent of students answered each item?. Calculate for each item how often it has been answered (in percent) (no difference, if the answer was correct or not).
Return Value: pointer to vector which includes the percentages for each item.

7.6

double* **percent_items_correct** (patterns* p)

how many percent of students gave a correct answer to each item?

how many percent of students gave a correct answer to each item?. Calculate for each item, how many percent of the given answeres are correct.
Return Value: pointer to vector which includes the percentages for each item.

7.7

double* **percent_pattern_answered** (patterns* p)

how many items were answered in each pattern?

how many items were answered in each pattern?. Calculate for each pattern how many percent of the items have been answered (no difference, if the answer was correct or not).
Return Value: pointer to vector which includes the percent-numbers for each pattern.

7.8

int* **number_items_answered** (patterns* pa)

how many persons gave an answer to an item?

how many persons gave an answer to an item?. Calculate for each item how many subject answered the item (making no difference, if the answer was correct or not).
Return Value: pointer to vector with number of subjects, that answered item i on the i-th position.

7.9

int **persons_all_items_answered** (patterns* pa)

how many persons answered all the items?

how many persons answered all the items?. Calculate, how many persons answered all the given items (making no difference, if the answer was correct or not).
Return Value: number of persons, that answered all items.

7.10

patterns* **delete_percent_ua_patterns** (patterns* pa, int percent)

delete patterns in which less than a given percentage of items was answered

delete patterns in which less than a given percentage of items was answered. All these patterns in a patterns struct are deleted, where less than the given percentage of the items was answered (no matter, if the answer was correct or not).

Return Value: patterns-structure with deleted patterns.

Parameters: `pa` — pointer to patterns struct
`percent` — percentage of items that must be answered, if the patterns should not be deleted

7.11

patterns* **delete_percent_ua_items** (patterns* pa, int percent)

delete items that have been answered less often than a given percentage

Return Value: patterns-structure with deleted items.

Parameters: `pa` — pointer to patterns struct
`percent` — percentage of students that must have answered the item, if the item should not be deleted

7.12

patterns* **remove_pat_with_ua** (patterns* pa)

remove all patterns, where one or more items are not answered

Return Value: pointer to patterns-structure without the patterns, where no answer to one or more items was given

7.13

int **is_pattern_el** (bitset sol, bitset unans, patterns* pat)

is a pattern element of a set of patterns?

Return Value: smallest number of the pattern in the patterns struct, which is equal to the given pattern or 0, if the given pattern is no element of the structure

Parameters: `sol` — bitset including the correct solved items the pattern
`unans` — bitset including the unanswered items in the pattern
`pat` — pointer to patterns struct

7.14

int **is_pattern_el** (bitset sol, bitset unans, bitset* orig_sol, bitset* orig_una, int q, int num)

is a pattern element of a set of patterns?

is a pattern element of a set of patterns?. Look, if a single pattern is element of a set of patterns, which is given in form of two bitsets (one for the correctly solved items, one for the unanswered items) here.

Return Value: smallest number of the pattern in the patterns struct, which is equal to the given pattern or 0, if the given pattern is no element of the structure

Parameters: `sol` — bitset including the correct solved items the pattern
`unans` — bitset including the unanswered items in the pattern
`orig_sol` — pointer to set of bitsets including correctly solved items
`orig_ua` — pointer to set of bitsets including unanswered items
`q` — number of items per bitset/pattern
`num` — number of patterns in the set of patterns

7.15

int **patt_in_space** (bitset sol, bitset unans, space* sp)

Is it possible, that an answer pattern is element of a given space?

Is it possible, that an answer pattern is element of a given space?. Look, if a pattern does not contradict any of the states in a space.

Return Value: yes (1) or no (0)

Parameters: `sol` — bitset including the correct solved items the pattern
`unans` — bitset including the unanswered items in the pattern
`sp` — knowledge space

8 Equivalence Properties of Items

Names

8.1 int **is_equivalent_items** (int item1, int item2, srbi* sr)
are two items equivalent? 37

8.2 int **is_up_parallel** (int item1, int item2, srbi* sr)
are two item 'up-parallel'? 38

8.3 int **is_down_parallel** (int item1, int item2, srbi* sr)
are two items 'down-parallel'? . 38

8.4 int **is_parallel** (int item1, int item2, srbi* sr)
are two item parallel? 38

ATTENTION: In all following functions the numbering of items starts with '0'! This means, the first item has the number '0', the last 'q_size-1'. ATTENTION: We have to find new and better names for the different levels of parallelity and equivalence.

8.1 int **is_equivalent_items** (int item1, int item2, srbi* sr)

are two items equivalent?

are two items equivalent?. Look, if two items a and b are equivalent. Comment: two items a and b are called equivalent here, if aSb and bSa ('S' denotes the surmise relation between items).

Return Value: yes or no (1 or 0), -1 if an error occured

Parameters: `item1` — first item
`item2` — second item
`sr` — surmise relation between items

8.2

int **is_up_parallel** (int item1, int item2, srbi* sr)

are two item 'up-parallel'?

are two item 'up-parallel'?. Comment: two items a and b are called 'up-parallel' here, if for all items c, c!=a and c!=b, in the knowledge-space we have: cSa => cSb

Return Value: yes or no (1 or 0), -1 if an error occured

Parameters: `item1` — first item
`item2` — second item
`sr` — surmise relation between items

8.3

int **is_down_parallel** (int item1, int item2, srbi* sr)

are two items 'down-parallel'?

are two items 'down-parallel'?. Comment: two items are called 'down-parallel' here, if for all items c, c!=a and c!=b, in the knowledge-space we have: aSc => bSc

Return Value: yes or no (1 or 0), -1 if an error occured

Parameters: `item1` — first item
`item2` — second item
`sr` — surmise relation between items

8.4

int **is_parallel** (int item1, int item2, srbi* sr)

are two item parallel?

are two item parallel?. comment: two items a and b are called 'parallel' here, iff they are up and down parallel

Return Value: yes or no (1 or 0), -1 if an error occured

Parameters: `item1` — first item
`item2` — second item
`sr` — surmise relation between items

9 Data Structures for Working with Tests

Names

9.1 class **partition** *Partition of a set of items into tests* 40

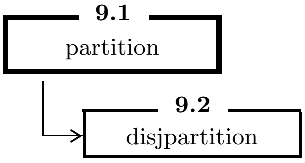
9.2 class **disjpartition** : public partition *Partition of items into disjoint tests* 44

9.3 class **srbt** *Surmise relations between tests* . 47

9.1 class **partition**

Partition of a set of items into tests

Inheritance



Public Members

int	**q_size**	*number of items*
int	**t_size**	*number of tests*
bitset_basis*	**matrix**	*binary matrix (which item belongs to which test)*
int**	**item_info**	*information numbers for each item*
int**	**test_info**	*information numbers for each test*

9.1.1 **partition** () *standard constructor* 42

9.1.2 **partition** (int q_size, int t_size) *'new'-constructor* 42

9.1.3 **partition** (partition* orig) *'copy'-constructor* 42

9.1.4 **partition** (const char filename[]) *'load'-constructor* 42

9.1.5 **partition** (char* buffer, int q_size, int t_size) *constructor for reading from a buffer* 43

9.1.6 virtual **~partition** () *destructor* 43

9.1.7 int **save** (filetype mode, const char filename[]) *save a partition to a file* 43

9.1.8 void **write** () *write a partition* 44

Protected Members

int	**wordq**	*number of words needed to store q_size bits*
int	**storage**	*storage needed for the binary matrix*
structtype	**stype**	*type of structure (partition or disjoint partition) - for internal use*

9.1.9 int **get_memory** () *allocate memory for the partition, according to the given number of items and test* 44

Partition of a set of items into tests. The class partition includes the basic structure for the partitioning of a set of items into tests. The binary matrix includes a '1', if an items belongs to a certain test, '0' else.

9.1.1

partition ()

standard constructor

standard constructor. This costructor is called from the inherited class.

9.1.2

partition (int q_size, int t_size)

'new'-constructor

'new'-constructor. This constructor allocates memory for a new partition. If not enough memory is available, the class destructor is called.
Parameters: `q_size` — number of items
`t_size` — number of tests

9.1.3

partition (partition* orig)

'copy'-constructor

'copy'-constructor. Make a copy of an existing partition
Parameters: `orig` — original partition

9.1.4

partition (const char filename[])

'load'-constructor

'load'-constructor. Load a partition from file. If the file can not be opened or nor free memory is available, the class destructor is called. If the type of file is not 'partition' or 'disjoint partition', no partition is loaded, the class destructor is called.
Parameters: `filename[]` — name of inputfile

9.1.5

partition (char* buffer, int q_size, int t_size)

constructor for reading from a buffer

constructor for reading from a buffer. Read a partition with defined size from a buffer

Parameters: `buffer` — bitset matrix including the partition
`q_size` — number of items
`t_size` — number of tests

9.1.6

virtual ~**partition** ()

destructor

destructor. Return used memory to the system, set and structype variable to UNKNOWN and the variables q_size and t_size to '-1'.

9.1.7

int **save** (filetype mode, const char filename[])

save a partition to a file

Return Value: '1' if an error occured, '0' else

Parameters: `mode` — mode of the file to be written (binary or ASCII, partition or disjpartition)
`filename` — name of outputfile

9.1.8

void **write** ()

write a partition

write a partition. Write a partition in form of a matrix to stdout

9.1.9

int **get_memory** ()

allocate memory for the partition, according to the given number of items and test

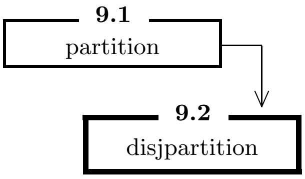
Return Value: '1' if an error occured, '0' else.

9.2

class **disjpartition** : public partition

Partition of items into disjoint tests

Inheritance



Public Members

9.2.1 **disjpartition** (const char filename[])
'load-constructor' 45

9.2.2 **disjpartition** (int q_size, int t_size)
'new-constructor' 45

9.2.3 **disjpartition** (disjpartition* dp)
'copy-constructor' 46

9.2.4 **disjpartition** (char* buffer, int q, int t)
costructor for reading from a buffer 46

9.2.5 int **is_disjointpartition** ()
is a given partition disjoint? ... 46

Partition of items into disjoint tests. The class disjpartition is derived from partition: It has one additional property: Each item in the partition must belong exactly to one test.

9.2.1

disjpartition (const char filename[])

'load-constructor'

'load-constructor'. Load a disjoint partition from a file. If 'type of file' is 'partition', it is tested, if each item belongs exactly to one test. If 'type of file' is neither 'partition' nor 'disjoint partition', no partition is loaded, the class destructor is called.
Parameters: `filename[]` — name of inputfile

9.2.2

disjpartition (int q_size, int t_size)

'new-constructor'

'new-constructor'. Allocate memory for a new disjoint partition of given size.

Parameters: `q_size` — number of items
`t_size` — number of tests

9.2.3

disjpartition (disjpartition* dp)

'copy-constructor'

'copy-constructor'. Make a copy of a disjoint partition. The necessary memory is allocated.
Parameters: `dp` — original disjoint partition

9.2.4

disjpartition (char* buffer, int q, int t)

costructor for reading from a buffer

costructor for reading from a buffer. Read a matrix meaning a disjoint partition from a buffer.
Parameters: `buffer` — vector including the disjoint partition
`q` — number of items
`t` — number of tests

9.2.5

int **is_disjointpartition** ()

is a given partition disjoint?

Return Value: '1', if the partition is disjoint, '0' else

9.3

class **srbt**

Surmise relations between tests

Public Members

	char**	**smatrix**	*surmise relation between tests*	
	char**	**slmatrix**	*left-covering surmise relation*	
	char**	**srmatrix**	*right-covering surmise relation*	
	int**	**test_info**	*information numbers for each test*	
		srbt ()	*standard constructor*	
9.3.1		**srbt** (int t_size)	*'new'-constructorAllocate memory for a new srbt class with given number of tests*	48
9.3.2		**srbt** (const char filename[])	*load-constructorLoad a srbt-structure from a file*	48
9.3.3		**srbt** (srbt* sr)	*'copy'-constructorMake a copy of an existing surmise relation*	49
9.3.4		**srbt** (partition* p, srbi* si)	*constructor for calculating the surmise relations between tests out of surmise relation between items and the partition of items into tests*	49
9.3.5		**˜srbt** ()	*destructor*	49
9.3.6	int	**save** (const char filename[])	*save a srbt-structure to a file*	50
9.3.7	void	**write** (FILE* f)	*write all three kinds of surmise relations*	50

Private Members

int	**stype**	*type of structure*

int	**getmemory** ()	*allocate memory for a srbt-struct with given t_size;*

Surmise relations between tests. In this class three different forms of surmise relations between tests can be stored: 'normal' surmise relation between tests, right-covering surmise relation, left-covering surmise relation. All these relations are coded in form of a matrix, which has as many lines and columns as the number of tests. Writing a '1' in the i-th column and the j-th line means, that tests i is in surmise relation to tests j, writing a '0' on this position means, that these tests are not in surmise relation. The order of storage in the file is: surmise relation, right-covering surmise relation, left-covering surmise relation. A comment line with an appropriate headline is stored for each matrix.

9.3.1

srbt (int t_size)

'new'-constructorAllocate memory for a new srbt class with given number of tests

'new'-constructor Allocate memory for a new srbt class with given number of tests. **Parameters:** `t_size` — number of tests.

9.3.2

srbt (const char filename[])

load-constructorLoad a srbt-structure from a file

load-constructor Load a srbt-structure from a file. If an error occures (file cannot be opened, or type of file is not srbt, the class destructor is called).

9.3.3

srbt (srbt* sr)

'copy'-constructorMake a copy of an existing surmise relation

'copy'-constructor Make a copy of an existing surmise relation. The necessary memory is allocated.
Parameters: `sr` — surmise relations between tests to be copied

9.3.4

srbt (partition* p, srbi* si)

constructor for calculating the surmise relations between tests out of surmise relation between items and the partition of items into tests

Parameters: `p` — partition of items into tests
`si` — surmise relation between items

9.3.5

~srbt ()

destructor

destructor. The destructor for the srbt-class returns used memory to the system, sets the structtype variable to UNKNOWN and the number of tests to '-1'.

9.3.6

int **save** (const char filename[])

save a srbt-structure to a file

save a srbt-structure to a file. All three matrices for surmise relation between tests, right-and leftcovering surmise relation are written to a file together with appropriate headlines for each relation matrix and the according header for srbt-files.
Parameters: `filename[]` — name of outputfile

9.3.7

void **write** (FILE* f)

write all three kinds of surmise relations

write all three kinds of surmise relations. All three matrices (surmise relation, right-and leftcovering surmise relations) are written to a file.
Parameters: `f` — name of file (also possible: stdout/stderr

10

Investigating Equal Structures

Names

int **is_equal_struct** (structure* s1 , structure* s2)
look, if two structures are equal

int **is_equal_struct** (partition* p1 , partition* p2)
look, if two partitions are equal

int **is_equal_struct** (disjpartition* p1 , disjpartition* p2)
look, if two disjoint partitions are equal.

int **is_equal_struct** (space* s1, space* s2)
look, if two spaces are equal.

int **is_equal_struct** (data* d1, data* d2)
look, if two data structs are equal.

10.1 int **is_equal_test** (partition* p, int test1, int test2)
look, if two tests in a partition are equal 51

The fuctions "is_equal_struct" work for structures, partitions, disjoint partitions, data an spaces. In all these functions two structs are called equal, iff they have the same number of tests/patterns/states, the same number of items and if each line (=test/pattern/state) in "struct1" is element of "struct2" and vice versa. This function does not consider any form of equivalence or parallelity between items. **Return Value:** 1 if the structs are equal, 0 else.

10.1

int **is_equal_test** (partition* p, int test1, int test2)

look, if two tests in a partition are equal

look, if two tests in a partition are equal. This function looks, if two tests in a given partition contain the same items. It does not consider any form of equivalence or parallelity between items.

Return Value: yes or no (1 or 0), -1 if an error occured.

Parameters:
`p` — partition into tests
`test1` — number of first test
`test2` — number of second test

11

Working with (Disjoint) Partitions

Names

11.1 bitset **get_test** (partition* p, int position)
get a single test from a partition 54

11.2 bitset **get_test** (partition* p, int position)
get a single test from a disjoint partition 54

11.3 int **set_test** (partition* p, int position, bitset value)
set a test in a partition 54

11.4 int **set_test** (disjpartition* p, int position, bitset value)
set a test in a disjoint partition 55

11.5 partition* **remove_tests** (partition* p, int start, int end=-1)
remove tests within a partition . 55

11.6 disjpartition*
remove_tests (disjpartition* p, int start,
int end=-1)
remove tests from a disjoint partition 56

11.7 partition* **testunion** (partition* p, int test1, int test2)
union of two tests in a partition 56

11.8 int **is_disj_partition** (partition* p)
is a partition disjoint? 56

11.9 int **count_item_test** (partition* p, int testnr)
count, how many items are in the given test 57

11.10 srbi* **order_items** (partition* p, srbi* sr)
order items 57

11.1

bitset **get_test** (partition* p, int position)

get a single test from a partition

Return Value: bitset with requested test
Parameters: `p` — partition into tests
`position` — index of the test to be copied

11.2

bitset **get_test** (partition* p, int position)

get a single test from a disjoint partition

Return Value: bitset with requested test
Parameters: `p` — disjoint partition into tests
`position` — index of the test to be copied

11.3

int **set_test** (partition* p, int position, bitset value)

set a test in a partition

Return Value: -1, if an error occured, 0 else
Parameters: `p` — partition into tests
`position` — index of the test to be set
`value` — new value of the test

11.4

int **set_test** (disjpartition* p, int position, bitset value)

set a test in a disjoint partition

Return Value:	-1, if an error occured, 0 else
Parameters:	`p` — partition into tests `position` — index of the test to be set `value` — new value of the test

11.5

partition* **remove_tests** (partition* p, int start, int end=-1)

remove tests within a partition

remove tests within a partition. Remove a set of tests from a partition, starting with the test on the 'start' position, ending with the test on the 'end' postition, replace the tests on these positions with the last tests in the partition. Comment: the 'end' parameter is a default parameter - it can be left out, if only one test should be removed.

Return Value:	partition with removed test
Parameters:	`p` — partition into tests `start` — position of the first test to be removed `end` — position of the last test to be removed, can be left out

11.6

disjpartition* **remove_tests** (disjpartition* p, int start, int end=-1) *remove tests from a disjoint partition*

remove tests from a disjoint partition. Remove a set of tests from a partition or disjoint paritition, starting with the test on the 'start' position, ending with the test on the 'end' postition, replace the tests on these positions with the last tests in the partition. Comment: the 'end' parameter is a default parameter - it can be left out, if only one test should be removed.

Return Value: disjoint partition with removed test

Parameters: `p` — disjoint partition into tests
`start` — position of the first test to be removed
`end` — position of the last test to be removed, can be left out

11.7

partition* **testunion** (partition* p, int test1, int test2)

union of two tests in a partition

union of two tests in a partition. Calculate the union of two given tests in a partition and return a new patition which includes the union of the two given tests instead of the two tests.

Return Value: new partition with one test less

Parameters: `p` — partition into tests
`test1` — number of first test
`test2` — number of second test

11.8

int **is_disj_partition** (partition* p)

is a partition disjoint?

is a partition disjoint?. Look, if each item in the partition belongs to exactly one test.

Return Value: 1 if the partition is disjoint, 0 else

Parameters: `p` — pointer to the partition

11.9

int **count_item_test** (partition* p, int testnr)

count, how many items are in the given test

Return Value: number of items in the requested test

Parameters: `p` — pointer to the partition
`testnr` — number of test in the partition

11.10

srbi* **order_items** (partition* p, srbi* sr)

order items

order items. Order the in a given matrix of surmise relations in a way, that the first n items belong to the first test in the partition, the next m items belong to the second test and so on. The identity numbers for each item are also changed.

Return Value: ordered surmise relation between items

Parameters: `p` — partition
`sr` — surmise relations between items

12

Surmise Relations Within and Across Tests

Names

12.1 srbi* **write_SRwT_matrix** (partition* p, srbi* sr)
write all surmise relations within tests in form of a matrix 58

12.2 srbi* **write_SRwT_rel** (partition* p, srbi* sr)
write all surmise relations within tests in form of item pairs 59

12.3 srbi* **write_SRxT_matrix** (partition* p, srbi* sr)
write all surmise relations across tests in form of a matrix 59

12.4 srbi* **write_SRxT_rel** (partition* p, srbi* sr)
write all surmise relations across tests in form of item pairs 59

12.1

srbi* **write_SRwT_matrix** (partition* p, srbi* sr)

write all surmise relations within tests in form of a matrix

write all surmise relations within tests in form of a matrix. Only the surmise relations within tests, meaning the surmise relations between items of the same test, are regarded. Surmise relations for items which are in two different tests are all set to '0'. The resulting matrix is written to stdout.

Return Value: surmise relations for items within tests

Parameters: `p` — partition into tests
`sr` — surmise relations between items

12.2

srbi* **write_SRwT_rel** (partition* p, srbi* sr)

write all surmise relations within tests in form of item pairs

write all surmise relations within tests in form of item pairs. All surmise relations for items between tests are written to stdout in form of item pairs, e.g. item1 S item2.

Return Value: surmise relations for items within tests

Parameters: `p` — partition
`sr` — matrix with surmise relations

12.3

srbi* **write_SRxT_matrix** (partition* p, srbi* sr)

write all surmise relations across tests in form of a matrix

write all surmise relations across tests in form of a matrix. Only the surmise relations for items in different tests are regarded, the resulting matrix is written to stdout

Return Value: surmise relations for items across tests

Parameters: `p` — partition
`sr` — surmise relations betweent tests

12.4

srbi* **write_SRxT_rel** (partition* p, srbi* sr)

write all surmise relations across tests in form of item pairs

write all surmise relations across tests in form of item pairs. Only the surmise relations for items in different tests are regarded, the resulting relations are written to stdout in form of item pairs

Return Value: surmise relations for items across tests

Parameters: `p` — partition
`sr` — surmise relations between items

13 Creating Different Kinds of Partitions

Names

13.1 disjpartition*
random_part (int q_size, int max_t_size=0)
create a random disjoint partition 61

13.2 disjpartition*
random_part_t (int q_size, int t_size)
create a random partition with a given number of tests 61

13.3 disjpartition*
equal_part (int q_size, int t_size)
create a random disjoint partition where each test has the same number of items 62

13.4 disjpartition*
min_item_part (int q_size, int min_item_no, int t_size)
create a random disjoint partition into tests, where each test has at least a given minimal number of items 62

13.5 disjpartition*
trans_part (int max_t_size, srbi* sr)
create a transitiv disjoint partition into tests 63

13.6 disjpartition*
antisym_part (int max_t_size, srbi* sr)
create an antisymmetric disjoint partition into tests 63

13.7 disjpartition*
connex_part (srbi* sr)
create a disjoint partition into connex tests 63

13.8 disjpartition*

left_cover_part (int max_t_size, srbi* sr)
create a left-covering disjoint partition 64

13.9 disjpartition* **right_cover_part** (int max_t_size, srbi* sr)
create a right-covering disjoint partition 64

13.10 partition* **make_partition** (int q_size, int t_size)
create a partition 64

13.1

disjpartition* **random_part** (int q_size, int max_t_size=0)

create a random disjoint partition

create a random disjoint partition. Create a random disjoint partition, where the number of tests is selected randomly, it will be between 1 and max_t_size . Comment: the maximal number of tests is a default parameter, default is q_size/2.

Return Value: resulting disjoint partition

Parameters: `q_size` — number of items
`max_t_size` — maximal number of tests

13.2

disjpartition* **random_part_t** (int q_size, int t_size)

create a random partition with a given number of tests

Return Value: resulting disjoint partition

Parameters: `q_size` — number of items
`t_size` — number of tests

13.3

disjpartition* **equal_part** (int q_size, int t_size)

create a random disjoint partition where each test has the same number of items

Return Value: resulting disjoint partition, NULL if q_size modulo t_size not zero

Parameters:
`q_size` — number of items
`t_size` — number of tests

13.4

disjpartition* **min_item_part** (int q_size, int min_item_no, int t_size)

create a random disjoint partition into tests, where each test has at least a given minimal number of items

Return Value: resulting disjoint partition

Parameters:
`q_size` — number of items
`t_size` — number of tests
`min_item_no` — minimal number of items per test

13.5

disjpartition* **trans_part** (int max_t_size, srbi* sr)

create a transitiv disjoint partition into tests

create a transitiv disjoint partition into tests. WARNING: Not implemented! The mathematical solutions are still missing! You have to enter a maximal size of tests, because the trivial solution (one item per test) is always possible.
Return Value: resulting disjoint partition

Parameters: `max_t_size` — maximal number of tests to be created
`sr` — surmise relations between items

13.6

disjpartition* **antisym_part** (int max_t_size, srbi* sr)

create an antisymmetric disjoint partition into tests

create an antisymmetric disjoint partition into tests. WARNING: Not implemented! The mathematical solutions are still missing! You have to enter a maximal size of tests, because the trivial solution (one item per test) is always possible.
Return Value: resulting disjoint partition

Parameters: `max_t_size` — maximal number of tests to be created
`sr` — surmise relations between items

13.7

disjpartition* **connex_part** (srbi* sr)

create a disjoint partition into connex tests

create a disjoint partition into connex tests. A disjoint partition into connex tests is generated, the number of tests will be as small as possible.
Return Value: resulting disjoint partition

Parameters: `sr` — surmise relations between items

13.8

disjpartition* **left_cover_part** (int max_t_size, srbi* sr)

create a left-covering disjoint partition

create a left-covering disjoint partition. WARNING: Not implemented! The mathematical solutions are still missing! You have to enter a maximal size of tests, because the trivial solution (one item per test) is always possible.

Return Value: resulting disjoint partition

Parameters: `max_t_size` — maximal number of tests to be created
`sr` — surmise relations between items

13.9

disjpartition* **right_cover_part** (int max_t_size, srbi* sr)

create a right-covering disjoint partition

create a right-covering disjoint partition. WARNING: Not implemented! The mathematical solutions are still missing! You have to enter a maximal size of tests, because the trivial solution (one item per test) is always possible.

Return Value: resulting disjoint partition

Parameters: `max_t_size` — maximal number of tests to be created
`sr` — surmise relations between items

13.10

partition* **make_partition** (int q_size, int t_size)

create a partition

create a partition. The user can enter which item belongs to each test manually, he is asked for each test, which items he want to set to the test.

Return Value: created partition

Parameters: `q_size` — number of items
`t_size` — number of tests

14

Surmise Relations between Tests

Names

14.1 int **is_test_sr** (partition* p, int test1, int test2, srbi* sr)
is there a surmise relation between two tests? 66

14.2 int **is_test_leftsr** (partition* p, int test1, int test2, srbi* sr)
is there a left-covering surmise relation between two tests? 66

14.3 int **is_test_rightsr** (partition* p, int test1, int test2, srbi* sr)
is there a right-covering surmise relation between two tests? 66

14.4 int **is_test_totalsr** (partition*p, int test1, int test2, srbi* sr)
is there a total-covering surmise relation? 67

14.5 int **is_test_transitive** (partition* p, int test1, int test2, int test3, srbi* sr)
is a group of three tests in a partition transitive? 67

14.6 int **is_test_antisymm** (partition* p, int test1, int test2, srbi* sr)
are two tests antisymmetric? ... 68

14.7 int **is_connex_test** (int testnr, partition* p, srbi* sr)
is a given test in a partition connex? 68

ATTENTION: In all following functions the numbering of tests starts with '0'! This means, the first test in a partition has the number '0', the last 't_size-1'.

14.1

int **is_test_sr** (partition* p, int test1, int test2, srbi* sr)

is there a surmise relation between two tests?

is there a surmise relation between two tests?. Look, if test 1 is in surmise relation with test 2.

Return Value: yes or no (1/0)

Parameters:
`p` — partition into tests
`test1` — number of first test
`test2` — number of second test
`sr` — surmise relations between items

14.2

int **is_test_leftsr** (partition* p, int test1, int test2, srbi* sr)

is there a left-covering surmise relation between two tests?

is there a left-covering surmise relation between two tests?. Look, if test 1 is in left-covering surmise relation with test 2.

Return Value: yes or no (1/0)

Parameters:
`p` — partition into tests
`test1` — number of first test
`test2` — number of second test
`sr` — surmise relations between items

14.3

int **is_test_rightsr** (partition* p, int test1, int test2, srbi* sr)

is there a right-covering surmise relation between two tests?

is there a right-covering surmise relation between two tests?. Look, if test 1 is in right-covering surmise-relation with test 2.

Return Value: yes or no (1/0)

Parameters:
`p` — partition into tests
`test1` — number of first test
`test2` — number of second test
`sr` — surmise relations between items

14.4

int **is_test_totalsr** (partition*p, int test1, int test2, srbi* sr)

is there a total-covering surmise relation?

is there a total-covering surmise relation?. Look, if the two tests are in total-covering surmise relation, that means they are in left- and right-covering surmise relation.

Return Value: yes or no (1 or 0)

Parameters:
`p` — partition into tests
`test1` — number of first test
`test2` — number of second test
`sr` — surmise relations between items

14.5

int **is_test_transitive** (partition* p, int test1, int test2, int test3, srbi* sr)

is a group of three tests in a partition transitive?

is a group of three tests in a partition transitive?. This function looks, if a group of three tests in a partition is transitive, it is important to give the tests in the correct order: if test1 S test2 and test2 S test3 and test1 S test3, the three tests are transitive (S denotes the surmise relation between tests).

Return Value: 2, if not test1 S test2 or test2 S test3, 1 if the three tests are transitive, 0 if they are not, -1 if an error occured

Parameters: `p` — partition into tests
`test1` — number of first test
`test2` — number of second test
`test3` — number of third test
`sr` — surmise relation between items

14.6

int **is_test_antisymm** (partition* p, int test1, int test2, srbi* sr)

are two tests antisymmetric?

are two tests antisymmetric?. Look, if two tests in a partition are antisymmetric (meaning: test1 S test2, but test2 not S test1, S meaning the surmise relation between tests).

Return Value: yes or no (1 or 0);

Parameters: `p` — partition into tests
`test1` — number of first test
`test2` — number of second test
`sr` — surmise relations between items

14.7

int **is_connex_test** (int testnr, partition* p, srbi* sr)

is a given test in a partition connex?

is a given test in a partition connex?. Look, if the given test in a partition is connex, which means, that for each item exists a prerequisite in this test or it is a prerequisite of another item.

Return Value: yes or no (1 or 0)

Parameters: `testnr` — number of test to be investigated
`p` — partition to be investigated
`sr` — surmise relations between items

15

Properties of Partitions

Names

15.1 int **is_part_connex** (partition* p, srbi* sr)
is a given partition connex? 69

15.2 int **is_part_leftsr** (partition* p, srbi* sr)
are all test in a given partition in a left-covering surmise relation? 70

15.3 int **is_part_rightsr** (partition* p, srbi* sr)
are all test in a given partition in a right-covering surmise relation? 70

15.4 int **is_part_totalsr** (partition* p, srbi* sr)
are all test in a given partition in a total-covering surmise relation? 70

15.5 int **is_transitive_part** (partition* p, srbi* sr)
is the partition into tests transitive? 71

15.6 int **is_antisymm_part** (partition* p, srbi* sr)
is a partition into tests antisymmetric? 71

15.1

int **is_part_connex** (partition* p, srbi* sr)

is a given partition connex?

is a given partition connex?. This functions investigates, if for each test A in the partition exists another tests B so that either A S B or B S A ('S' denotes the surmise relation between tests.)

Return Value: yes or no (1 or 0)

Parameters: `p` — partition into tests to be investigated
`sr` — surmise relations between items

15.2

int **is_part_leftsr** (partition* p, srbi* sr)

are all test in a given partition in a left-covering surmise relation?

Return Value: yes or no (1 or 0)
Parameters: `p` — partition into tests to be investigated
`sr` — surmise relations between items

15.3

int **is_part_rightsr** (partition* p, srbi* sr)

are all test in a given partition in a right-covering surmise relation?

Return Value: yes or no (1 or 0)
Parameters: `p` — partition into tests to be investigated
`sr` — surmise relations between items

15.4

int **is_part_totalsr** (partition* p, srbi* sr)

are all test in a given partition in a total-covering surmise relation?

Return Value: yes or no (1 or 0)
Parameters: `p` — partition into tests to be investigated
`sr` — surmise relations between items

15.5

int **is_transitive_part** (partition* p, srbi* sr)

is the partition into tests transitive?

is the partition into tests transitive?. Look, if transitivity holds for all tests in a partition.

Return Value: yes or no (1/0)

Parameters: `p` — partition into tests
`sr` — surmise relation between items

15.6

int **is_antisymm_part** (partition* p, srbi* sr)

is a partition into tests antisymmetric?

Return Value: yes or no (1 or 0);

Parameters: `p` — partition into tests
`sr` — surmise relation between items

16

Functions for Equivalence Properties of Tests

Names

16.1 int **is_weak_parallel** (partition* p, int testA, int testB, srbi* sr)
are two tests 'weak parallel'? . . . 73

16.2 int **is_leftc_parallel** (partition* p, int testA, int testB, srbi* sr)
are two tests 'left-covering parallel'? . . . 73

16.3 int **is_rightc_parallel** (partition* p, int testA, int testB, srbi* sr)
are two tests 'right-covering parallel'? . . . 73

16.4 int **is_totalc_parallel** (partition* p, int testA, int testB, srbi* sr)
are two tests 'total-covering parallel'? . . . 74

16.5 int **is_equivalent_test** (partition* p, int testA, int testB, srbi* sr=NULL)
are two tests in a partition equivalent? . . . 74

16.6 int **is_equivalent_test** (partition* p , int testA , int testB , space* s)
are two tests in a partition equivalent? . . . 75

ATTENTION: Better names for the different forms of parallelity must be found

16.1

int **is_weak_parallel** (partition* p, int testA, int testB, srbi* sr)

are two tests 'weak parallel'?

are two tests 'weak parallel'?. Look, if two tests A an B in a partition are 'weak parallel', meaning that ASB and BSA ('S' denoting the surmise relation between tests).

Return Value: yes (1) or no(0).

Parameters:
`p` — partition into tests
`testA` — first test
`testB` — second test
`sr` — matrix with surmise relations between items

16.2

int **is_leftc_parallel** (partition* p, int testA, int testB, srbi* sr)

are two tests 'left-covering parallel'?

are two tests 'left-covering parallel'?. Look, if two tests A and B in a partition are 'left-covering parallel', meaning AS_lB and BS_lA (S_l denoting the left-covering surmise relation).

Return Value: yes (1) or no(0).

Parameters:
`p` — partition into tests
`testA` — first test
`testB` — second test
`sr` — matrix with surmise relations between items

16.3

int **is_rightc_parallel** (partition* p, int testA, int testB, srbi* sr)

are two tests 'right-covering parallel'?

are two tests 'right-covering parallel'?. Look, if two tests A and B in a partition are 'right-covering parallel', meaning that

AS_rB and BS_rA (S_r denoting the right-covering surmise relation).
Return Value: yes (1) or no(0).

Parameters:
`p` — partition into tests
`testA` — first test
`testB` — second test
`sr` — matrix with surmise relations between items

16.4

int **is_totalc_parallel** (partition* p, int testA, int testB, srbi* sr)

are two tests 'total-covering parallel'?

are two tests 'total-covering parallel'?. Look, if two tests A and B in a partition are 'total-covering parallel', meaning that AS_tB and BS_tA (S_t denoting the total-covering surmise relation).
Return Value: yes (1) or no(0).

Parameters:
`p` — partition into tests
`testA` — first test
`testB` — second test
`sr` — matrix with surmise relations between items

16.5

int **is_equivalent_test** (partition* p, int testA, int testB, srbi* sr=NULL)

are two tests in a partition equivalent?

are two tests in a partition equivalent?. Look, if two tests in a partition contain the same items or - if the matrix with the surmise relations between items is given - if two test contain equivalent items.
Return Value: yes or no (1 or 0), -1 if an error occured

Parameters:

`p` — partition into tests
`testA` — first test
`testB` — second test
`sr` — matrix with surmise relations between items, default parameter

16.6

int **is_equivalent_test** (partition* p , int testA , int testB , space* s)

are two tests in a partition equivalent?

are two tests in a partition equivalent?. This funcition tests the equivalency of two test by following definition: In a given knowledge space exists for each item 'a' in testA an item 'b' in testB so, that the set of states containing item a is equal to the set of all states containing item b.

Return Value: s yes or no (1 or 0), -1 if an error occured

Parameters:

`p` — partition into tests
`testA` — first test
`testB` — second test
`s` — knowledge space

17

Functions for working with vectors of integer numbers

Names

17.1	data_v*	**new_data_v** (int len)	*allocate memory for a new data vector of integer numbers*	78
17.2	void	**free_data_v** (data_v* d)	*return memory used by a vector to the system*	78
17.3	data_v*	**copy_data_v** (data_v* orig)	*make a copy of a vector*	78
	void	**write_data_v** (data_v* d)	*write a data vector of integer numbers to stdout*	
17.4	int	**is_zero** (data_v* d)	*are all entries in a data vector equal zero?*	79
17.5	int	**equal** (data_v* d1, data_v* d2)	*are two data vectors equal?*	79
17.6	data_v*	**minus** (data_v* d1, data_v* d2)	*calculate the coordinatewise difference of two data vectors*	79
17.7	data_v*	**minus** (bitset a, bitset b, int set_size)	*calculate the coordinatewise difference of two bitsets*	80
17.8	data_v*	**sgn_minus** (data_v* v1, data_v* d2)	*calculate the signum of the coordinatewise difference of two data vectors*	80
17.9	data_v*	**larger_matrix** (data_v* v)	*calculate a matrix out of a vector by calculating the product of the vector with himself and the operation 'minus'*	80
17.10	data_v*	**product** (data_v*, data_v*)		

calculate the coordinatewise product of two data vectors 81

17.11 data_v* **product** (bitset a, bitset b, int set_size)
calculate the coordinatewise product of two bitsets, which are interpreted as '01'-vectors here ... 81

17.12 int **plus_number** (data_v* d)
count the number of positive entries in a given data vector 82

17.13 int **minus_number** (data_v* d)
count the number of negative entries in a given data vector 82

17.14 int **vz_search** (data_v* d)
look, if the entries of the data vector have different algebraic signs
82

17.15 int **summ** (data_v* d) *summ the entries of a vector* ... 83

17.16 data_v* **bitset2data_v** (bitset b, int set_size)
transform a bitset to a data vector including the same entries 83

17.17 int **is_negative_entry** (data_v* s)
does the data vector include a negative entry? 83

17.18 void **split_vector** (data_v* s1, data_v* s2, data_v* s,
disjpartition* p)
split a data vector in two vectors 84

17.19 data_v** **transpose_data_v** (data_v** d, int n)
transpose a matrix of polytomous answer patterns 84

17.20 data_v** **count_data_v** (data_v** in_data, int* count,
int* num)
count the number of different data vectors in a structure of 'num' data vectors 85

17.1

data_v* **new_data_v** (int len)

allocate memory for a new data vector of integer numbers

Return Value: pointer to new vector
Parameters: `len` — lenght of new vector

17.2

void **free_data_v** (data_v* d)

return memory used by a vector to the system

Parameters: `d` — pointer to the data vector of integer numbers

17.3

data_v* **copy_data_v** (data_v* orig)

make a copy of a vector

Return Value: pointer to copied vector
Parameters: `orig` — pointer to original vector

17.4

int **is_zero** (data_v* d)

are all entries in a data vector equal zero?

Return Value: yes (1) or no (0)
Parameters: `d` — pointer to data vector

17.5

int **equal** (data_v* d1, data_v* d2)

are two data vectors equal?

are two data vectors equal?. Two data vectors are equal iff they have the same lenght and the same entries on all positions.
Return Value: yes(1) or no(0)
Parameters: `d1` — pointer to first vector
`d2` — pointer to second vector

17.6

data_v* **minus** (data_v* d1, data_v* d2)

calculate the coordinatewise difference of two data vectors

calculate the coordinatewise difference of two data vectors. Entry nr. i of the difference vector is calculated by subtracting entry nr. i of the second vector from entry nr. i of the first vector (d1[i] -d2[i])
Return Value: pointer to difference vector
Parameters: `d1` — first data vector
`d2` — second data vector, which is subtracted from d1

17.7

data_v* **minus** (bitset a, bitset b, int set_size)

calculate the coordinatewise difference of two bitsets

calculate the coordinatewise difference of two bitsets. The coordinatewise difference of two bitsets is calculated, the result is written to a data vector (the elements of this vector can be -1,0,1). The second bitset given is subtracted from the first.

Return Value: pointer to difference vector

Parameters: `a` — first bitset
`b` — second bitset, to be subtracted from a

17.8

data_v* **sgn_minus** (data_v* v1, data_v* d2)

calculate the signum of the coordinatewise difference of two data vectors

Return Value: pointer to the signum vector of the difference vector

17.9

data_v* **larger_matrix** (data_v* v)

calculate a matrix out of a vector by calculating the product of the vector with himself and the operation 'minus'

calculate a matrix out of a vector by calculating the product of the vector with himself and the operation 'minus'. This function calculates a quadratic matrix out of a vector (line number of the matrix = length of the vector). Call the given vector v, the lenght of v len, the resulting matrix m, then for all i,j < len: m[j][i] = v[i]-v[j]. The resulting matrix is returned in form of a data vector of length (len*len).

Return Value: pointer to resulting matrix, NULL if an error occured

Parameters: `v` — pointer to data vector

17.10

data_v* **product** (data_v*, data_v*)

calculate the coordinatewise product of two data vectors

Return Value: pointer to the resulting product vector of the same lenght as the input vectors, NULL if an error occured

17.11

data_v* **product** (bitset a, bitset b, int set_size)

calculate the coordinatewise product of two bitsets, which are interpreted as '01'-vectors here

Return Value: pointer to the resulting product vector of the same lenght as the bitsets, NULL if an error occured

Parameters: `a` — first bitset
`b` — second bitset
`set_size` — lenght of the bitsets a and b

17.12

int **plus_number** (data_v* d)

count the number of positive entries in a given data vector

Return Value: number of positive entries in the data vector

17.13

int **minus_number** (data_v* d)

count the number of negative entries in a given data vector

Return Value: number of negative entries in the data vector

17.14

int **vz_search** (data_v* d)

look, if the entries of the data vector have different algebraic signs

Return Value: yes(1) or no(0), -1 if an error occured.

17.15

int **summ** (data_v* d)

summ the entries of a vector

Return Value: summed entries

17.16

data_v* **bitset2data_v** (bitset b, int set_size)

transform a bitset to a data vector including the same entries

Return Value: pointer to data vector including the same entries

Parameters: `b` — bitset to be transformed
`set_size` — lenght of bitset

17.17

int **is_negative_entry** (data_v* s)

does the data vector include a negative entry?

Return Value: s -1, if the vector includes a negative entry, +1, if all entries in the vector are positive (or all are zero), 0 if no data vector was given.

17.18

void **split_vector** (data_v* s1, data_v* s2, data_v* s, disjpartition* p)

split a data vector in two vectors

Parameters:
`s` — original data vector
`p` — has the form of a disjoint partition with 2 tests: which item of the original vector will belong to the first, which item will belong to the second vector?
`s1` — first part of the original vector, corresponding to the first 'test' in p
`s2` — second part of the original vector

17.19

data_v** **transpose_data_v** (data_v** d, int n)

transpose a matrix of polytomous answer patterns

transpose a matrix of polytomous answer patterns. A matrix of polytomous answer patterns is given in form of n data vectors of the same length l. The result of this function is a pointer to l data vectors of lenght n, which correspond to the transposed matrix of the original structure.
Return Value: s pointer to l data vectors of length n which correspond to the transformed matrix of d

Parameters:
`d` — pointer to a structure of n data vectors of lenght l
`n` — number of data vectors

17.20

data_v** **count_data_v** (data_v** in_data, int* count, int* num)

count the number of different data vectors in a structure of 'num' data vectors

Return Value: s pointer to a set of data vectors, where each vector occurs only once.

Parameters: `in_data` — pointer to num data vectors of the same length

`count` — vector of integer numbers; will include, how often each pattern occurs

18

Functions for working with Isotonic Probabilistic Models

Names

18.1 int **similar_discord** (int* sim, int* dis, data* dat, int* count)
count the number of similar and discordantly ordered pairs of vectors in a data structure 87

18.2 int **similar_discord** (int* sim, int* dis, data_v** dat, int* count, int num)
count the number of similar and discordantly ordered pairs of vectors in a set of polytomous response vectors 88

18.3 double **pred** (data* d, int* count = NULL)
calculate the Index of Predictability of a data set fo dichotomous response variables 88

18.4 double **pred** (data_v** d, int num, int* count)
calculate the Index of Predictability of a set of data vectors of polytomous response variables 88

18.5 double **prede** (int q, int vpn, int* probabil)
calculate the Index of Predictabilty of a set of all possible answer patterns of a given number of items and students 89

18.6 double **predset** (data* d, disjpartition* p, int* count = NULL)
calculate the Set-Predictability of a criterion and predictor sets of items 89

18.7 double **predset** (data_v** d, int num, disjpartition* p, int* count)
calculate the Set-Predictability of a criterion and predictor sets of items 90

18.8 double* **wo1it** (data* d, int* count = NULL)

Direct test of Axiom (W1) of ISOP for all items 90

18.9 double* **wo2vekt** (data* d, int* count = NULL)
Direct test of Axiom (W2) of ISOP for all response vectors ... 91

Currently, each of the functions is written twice, once for the usage with 'traditional' data structures consisting of bitsets and including only dichtomous answer possibilities, and once for a structure on data vectors including also polytomous answer variables.

18.1

int **similar_discord** (int* sim, int* dis, data* dat, int* count)

count the number of similar and discordantly ordered pairs of vectors in a data structure

Return Value: s -1, if an error occured, 0 else.

Parameters:
`sim` — returns the number of similar pairs
`dis` — returns the number of discordantly pairs @oaram dat pointer to data structure
`count` — vector of integer numbers including how often each answer pattern occus in the data structure.

18.2

int **similar_discord** (int* sim, int* dis, data_v** dat, int* count, int num)

count the number of similar and discordantly ordered pairs of vectors in a set of polytomous response vectors

Return Value: s -1, if an error occured, 0 else.

Parameters:
`sim` — returns the number of similar pairs
`dis` — returns the number of discordantly pairs @oaram dat pointer to a set of polytomous data vectors
`num` — number of data vectors
`count` — vector of integer numbers including how often each answer pattern occus in the data structure.

18.3

double **pred** (data* d, int* count = NULL)

calculate the Index of Predictability of a data set fo dichotomous response variables

calculate the Index of Predictability of a data set fo dichotomous response variables. The numbers of similar and discordantly ordered pairs of vectors are printed to stdout together with the Indices of Isotonicity, Predictability and the standard deviation of the Index of Predictability.

Return Value: s Index of Predictabiliy

Parameters:
`d` — data structure
`count` — integer vector, which includes how often each answer pattern in the data set occurs. This parameter is a default parameter, if no count-vector is given, it is calculated in the function

18.4

double **pred** (data_v** d, int num, int* count)

calculate the Index of Predictability of a set of data vectors of polytomous response variables

calculate the Index of Predictability of a set of data vectors of polytomous response variables. The numbers of similar and discordantly ordered

pairs of vectors are printed to stdout together with the Indices of Isotonicity, Predictability and the standard deviation of the Index of Predictability.
Return Value: s Index of Predictabiliy

Parameters: `d` — pointer to a set of data vectors
`num` — number of vectors in the data set
`count` — integer vector, which includes how often each answer pattern in the data set occurs.

18.5

double **prede** (int q, int vpn, int* probabil)

calculate the Index of Predictabilty of a set of all possible answer patterns of a given number of items and students

calculate the Index of Predictabilty of a set of all possible answer patterns of a given number of items and students. The function calculates the expected frequency of answer patterns out of the given probabilities: Call the number of items q, there are 2^q possible answer patterns. In the probability vector the user stores the probabilities for a wrong answer to each item. The freuquencies of answer patterns are calculated out of this probabilities.
Return Value: s Index of Predictability of item pairs

Parameters: `q` — number of items
`vpn` — number of answer patterns
`probabil` — integer vector of probabilities for a wrong answer to each item.

18.6

double **predset** (data* d, disjpartition* p, int* count = NULL)

calculate the Set-Predictability of a criterion and predictor sets of items

Return Value: s Index of Set-Predictabiliy

Parameters:
`d` — data structure
`p` — Disjoint partition of items in a criterion and predictor set (corresponds to a disjoint partition with 2 tests
`count` — integer vector, which includes how often each answer pattern in the data set occurs. This parameter is a default parameter, if no count-vector is given, it is calculated in the function

18.7

```
double  predset (data_v** d, int num, disjpartition* p, int*
                 count)
```

calculate the Set-Predictability of a criterion and predictor sets of items

Return Value: s Index of Set-Predictabiliy

Parameters:
`d` — pointer to a set of data vectors
`num` — number of data vectors
`p` — Disjoint partition of items in a criterion and predictor set (corresponds to a disjoint partition with 2 tests
`count` — integer vector, which includes how often each answer pattern in the data set occurs

18.8

```
double*  wo1it (data* d, int* count = NULL)
```

Direct test of Axiom (W1) of ISOP for all items

Return Value: s vector with indices w1 for each item

Parameters: `d` — data structure
`count` — integer vector, which includes how often each answer pattern in the data set occurs. This parameter is a default parameter, if no count-vector is given, it is calculated in the function

18.9

double* **wo2vekt** (data* d, int* count = NULL)

Direct test of Axiom (W2) of ISOP for all response vectors

Return Value: s vector with indices w2 for each response vector
Parameters: `d` — data structure
`count` — integer vector, which includes how often each answer pattern in the data set occurs. This parameter is a default parameter, if no count-vector is given, it is calculated in the function

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