

tAltris
v1.0

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Chapter 1

Data Structure Index

1.1 Data Structures

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Chapter 2

File Index

2.1 File List

Here is a list of all files with brief descriptions:

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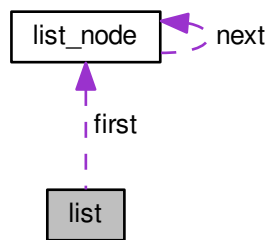
Chapter 3

Data Structure Documentation

3.1 list Struct Reference

```
#include <list.h>
```

Collaboration diagram for list:



Data Fields

- `size_t` **length**
- `struct list_node *` **first**

3.1.1 Detailed Description

Head of a singly-linked list.

3.1.2 Field Documentation

3.1.2.1 first

```
struct list_node* first
```

First node.

3.1.2.2 length

```
size_t length
```

List length.

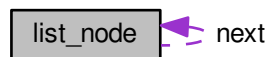
The documentation for this struct was generated from the following file:

- src/utils/ **list.h**

3.2 list_node Struct Reference

```
#include <list.h>
```

Collaboration diagram for list_node:



Data Fields

- struct **list_node** * **next**

3.2.1 Detailed Description

A node of a singly-linked list.

3.2.2 Field Documentation

3.2.2.1 next

```
struct list_node* next
```

Next node.

The documentation for this struct was generated from the following file:

- src/utls/ **list.h**

3.3 matrix Struct Reference

```
#include <matrix.h>
```

Data Fields

- size_t **rows**
- size_t **cols**
- double * **data**

3.3.1 Detailed Description

Matrix structure

3.3.2 Field Documentation

3.3.2.1 cols

```
size_t cols
```

Columns

3.3.2.2 data

```
double* data
```

Values

3.3.2.3 rows

```
size_t rows
```

Rows

The documentation for this struct was generated from the following file:

- src/utls/ **matrix.h**

Chapter 4

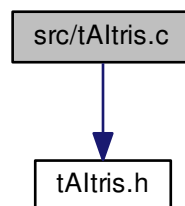
File Documentation

4.1 src/tAltris.c File Reference

Main file.

```
#include "tAltris.h"
```

Include dependency graph for tAltris.c:



Functions

- int **main** ()

4.1.1 Detailed Description

Main file.

Author

S4MasterRace

Version

1.0

4.1.2 Function Documentation

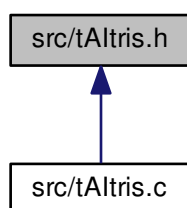
4.1.2.1 main()

```
int main ( )
```

4.2 src/tAltris.h File Reference

Main file.

This graph shows which files directly or indirectly include this file:



4.2.1 Detailed Description

Main file.

Author

S4MasterRace

Version

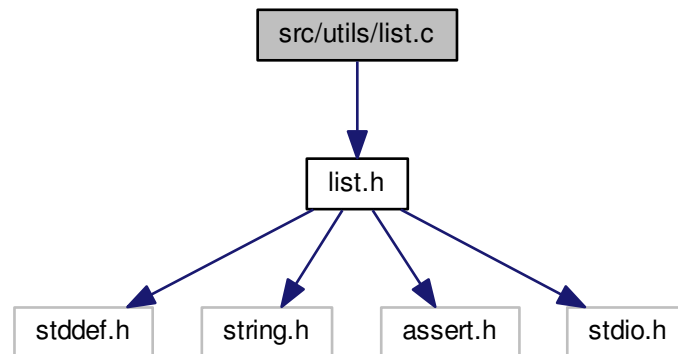
1.0

4.3 src/utls/list.c File Reference

Intrusive list implement.

```
#include "list.h"
```

Include dependency graph for list.c:



Functions

- void **list_init** (struct **list** * **list**)
- size_t **list_length** (const struct **list** * **list**)
- struct **list_node** * **list_first** (const struct **list** * **list**)
- struct **list_node** * **list_last** (const struct **list** * **list**)
- struct **list_node** * **list_next** (const struct **list_node** *node)
- struct **list_node** * **list_advance** (struct **list_node** *node, size_t distance)
- struct **list_node** * **list_at** (const struct **list** * **list**, size_t pos)
- void **list_reverse** (struct **list** * **list**)
- void **list_swap** (struct **list** *l1, struct **list** *l2)
- void **list_split_at** (struct **list** * **list**, size_t pos, struct **list** *right)
- void **list_concat** (struct **list** *l1, struct **list** *l2)
- void **list_sort** (struct **list** * **list**, int(*cmp)(struct **list_node** *, struct **list_node** *))
- int **list_is_empty** (const struct **list** * **list**)
- void **list_add** (struct **list** * **list**, struct **list_node** *node)
- void **list_append** (struct **list** * **list**, struct **list_node** *node)
- void **list_insert_after** (struct **list** * **list**, struct **list_node** *curr, struct **list_node** *node)
- void **list_insert_at** (struct **list** * **list**, struct **list_node** *node, size_t pos)
- void **list_del** (struct **list** * **list**)
- void **list_del_after** (struct **list** * **list**, struct **list_node** *node)
- void **list_del_at** (struct **list** * **list**, size_t pos)
- void **list_print** (const struct **list** * **list**)

4.3.1 Detailed Description

Intrusive list implement.

Author

S4MasterRace

Version

1.0

4.3.2 Function Documentation

4.3.2.1 list_add()

```
void list_add (
    struct list * list,
    struct list_node * node ) [inline]
```

Adds *node* in the front of *list*

Parameters

<i>list</i>	a list.
<i>node</i>	the new node.

Precondition

list must be not NULL.
node must be not NULL.

Postcondition

List size increases by 1.

Remarks

Complexity: O(1)

4.3.2.2 list_advance()

```
struct list_node* list_advance (
    struct list_node * node,
    size_t distance )
```

Returns the *n*th-node after the current one.

Parameters

<i>node</i>	a node.
<i>distance</i>	distance to move on.

Returns

the nth-node after *node*.

Precondition

node must be not NULL.

Remarks

Complexity: O(n)

4.3.2.3 list_append()

```
void list_append (
    struct list * list,
    struct list_node * node ) [inline]
```

Adds *node* at the end of *list*.

Parameters

<i>list</i>	a list.
<i>node</i>	the new node.

Precondition

list must be not NULL.
node must be not NULL.

Postcondition

List size increases by 1.

Remarks

Complexity: O(n)

4.3.2.4 list_at()

```
struct list_node* list_at (
    const struct list * list,
    size_t pos )
```

Returns node at the position `pos`.

Parameters

<i>list</i>	a list.
<i>pos</i>	position (0-based) of the node.

Returns

the node at the position `pos`.

Precondition

`list` must be not NULL.
`list` must be not empty.
`pos` must be in `[0; list_length(list)[`.

Remarks

Complexity: $O(N)$

4.3.2.5 list_concat()

```
void list_concat (
    struct list * l1,
    struct list * l2 ) [inline]
```

Concatenates two lists.

Parameters

<i>l1</i>	list 1.
<i>l2</i>	list 2.

Precondition

`l1` must be not NULL.
`l2` must be not NULL.
`l1` must be different of `l2`.

Postcondition

`l2` is reset to an empty list.

Remarks

Complexity: $O(N)$

4.3.2.6 list_del()

```
void list_del (
    struct list * list ) [inline]
```

Deletes the first node.

Parameters

<i>list</i>	a list.
-------------	---------

Precondition

list must be not NULL.
list must be not empty.

Postcondition

List size decreases by 1.

Remarks

Complexity: O(1)

4.3.2.7 list_del_after()

```
void list_del_after (
    struct list * list,
    struct list_node * node ) [inline]
```

Deletes the node at after the node *curr*.

Parameters

<i>list</i>	a list.
<i>node</i>	a node of <i>list</i> .

Precondition

list must be not NULL.
node must be not NULL.
list must be not empty.
node must a node of *list*.

Postcondition

List size decreases by 1.

Remarks

Complexity: O(1)

4.3.2.8 list_del_at()

```
void list_del_at (
    struct list * list,
    size_t pos ) [inline]
```

Deletes the node at the position *pos*.

Parameters

<i>list</i>	a list.
<i>pos</i>	index (0-based) of the node to delete.

Precondition

list must be not NULL.
list must be not empty.
pos must be in [0; list_length(*list*)].

Postcondition

List size decreases by 1.

Remarks

Complexity: O(n)

4.3.2.9 list_first()

```
struct list_node* list_first (
    const struct list * list )
```

Returns the first node.

Parameters

<i>list</i>	a list.
-------------	---------

Returns

the first node.

Precondition

`list` must be not NULL.
`list` must be not empty.

Remarks

Complexity: O(1)

4.3.2.10 list_init()

```
void list_init (
    struct list * list ) [inline]
```

Initializes the list.

Parameters

<i>list</i>	a list.
-------------	---------

Precondition

`list` must be not NULL.

Postcondition

`list` is empty.
`list` has a size of 0.

Remarks

Complexity: O(1)

4.3.2.11 list_insert_after()

```
void list_insert_after (
    struct list * list,
    struct list_node * curr,
    struct list_node * node ) [inline]
```

Inserts `node` at after the node `curr`.

Parameters

<i>list</i>	a list.
<i>curr</i>	a node of <code>list</code> .
<i>node</i>	new node.

Precondition

`list` must be not NULL.
`curr` must be not NULL.
`curr` must a node of `list`.
`node` must be not NULL.

Postcondition

List size increases by 1.

Remarks

Complexity: O(1)

4.3.2.12 list_insert_at()

```
void list_insert_at (
    struct list * list,
    struct list_node * node,
    size_t pos ) [inline]
```

Inserts `node` at the position `pos` in `list`.

Parameters

<i>list</i>	a list.
<i>node</i>	new node.
<i>pos</i>	position (0-based) where to insert the new node.

Precondition

`list` must be not NULL.
`node` must be not NULL.
`pos` must be in `[0; list_length(list)]`.

Postcondition

List size increases by 1.

Remarks

Complexity: O(n)

4.3.2.13 list_is_empty()

```
int list_is_empty (
    const struct list * list ) [inline]
```

Tests if a list is empty.

Parameters

<i>list</i>	a list.
-------------	---------

Returns

1 if the list is empty, otherwise 0.

Precondition

`list` must be not NULL.

Remarks

Complexity: O(1)

4.3.2.14 list_last()

```
struct list_node* list_last (  
    const struct list * list )
```

Returns the last node.

Parameters

<i>list</i>	a list.
-------------	---------

Returns

the last node.

Precondition

`list` must be not NULL.

Remarks

Complexity: O(N)

4.3.2.15 list_length()

```
size_t list_length (  
    const struct list * list ) [inline]
```

Returns the size of the list.

Parameters

<i>list</i>	a list.
-------------	---------

Returns

the length of the list.

Precondition

`list` must be not NULL.

Remarks

Complexity: O(1)

4.3.2.16 list_next()

```
struct list_node* list_next (  
    const struct list_node * node )
```

Returns the next node.

Parameters

<i>node</i>	a node.
-------------	---------

Returns

the next node.

Precondition

`node` must be not NULL.

Remarks

Complexity: O(1)

4.3.2.17 list_print()

```
void list_print (  
    const struct list * list )
```

Print the list

Parameters

<i>list</i>	a list
-------------	--------

4.3.2.18 list_reverse()

```
void list_reverse (
    struct list * list ) [inline]
```

Reverses the order of the elements in the list.

Parameters

<i>list</i>	a list.
-------------	---------

Precondition

list must be not NULL.

Remarks

Complexity: O(N)

4.3.2.19 list_sort()

```
void list_sort (
    struct list * list,
    int (*) (struct list_node *, struct list_node *) cmp ) [inline]
```

Sort a list using a comparison function.

The contents of the list are sorted in ascending order according to a comparison function which is called with two arguments that point to the node being compared.

The comparison function must return an integer less than, equal to, or greater than zero if the first argument is considered to be respectively less than, equal to, or greater than the second.

If two members compare as equal, their order in the sorted list is preserved.

Parameters

<i>list</i>	list to sort.
<i>cmp</i>	comparison function to use.

Precondition

`list` must be not NULL.
`cmp` must be not NULL.

Remarks

The sort is stable.
 Complexity: $O(N \log N)$
 Space complexity: $O(1)$

4.3.2.20 list_split_at()

```
void list_split_at (
    struct list * list,
    size_t pos,
    struct list * right ) [inline]
```

Splits a list in two parts at the position `pos`.

After the split:

- `list` contains nodes in `[0, pos[`
- `right` contains nodes in `[pos,length(list)[`

Examples:

```
list = [1, 2, 3]
list_split_at(list, 0, right) => ([], [1,2,3])
list_split_at(list, 1, right) => ([1], [2,3])
list_split_at(list, 2, right) => ([1,2], [3])
list_split_at(list, 3, right) => ([1,2,3], [])
list = []
list_split_at(list, 0, right) => ([], [])
```

Parameters

<i>list</i>	list to split.
<i>pos</i>	position (0-based) where to split the list.
<i>right</i>	an empty list to receive the part after <code>pos</code>

Precondition

`list` must be not NULL.
`right` must be not NULL.
`right` must be empty.
`list` must be different of `right`.

Remarks

Complexity: O(N)

4.3.2.21 list_swap()

```
void list_swap (
    struct list * l1,
    struct list * l2 ) [inline]
```

Swaps two lists.

Parameters

<i>l1</i>	list 1.
<i>l2</i>	list 2.

Precondition

l1 must be not NULL.
l2 must be not NULL.
l1 must be different of *l2*.

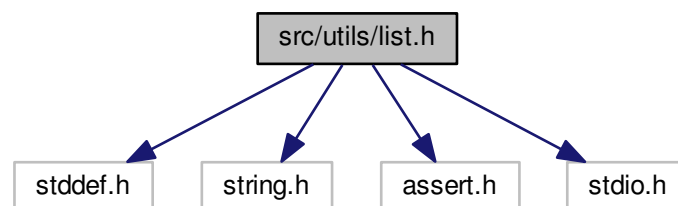
Remarks

Complexity: O(1)

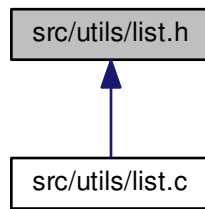
4.4 src/utls/list.h File Reference

Intrusive list implement.

```
#include <stddef.h>
#include <string.h>
#include <assert.h>
#include <stdio.h>
Include dependency graph for list.h:
```



This graph shows which files directly or indirectly include this file:



Data Structures

- struct **list**
- struct **list_node**

Macros

- #define **list_elt**(node, type, fieldname) ((type*)((char*)(node) - offsetof(type, fieldname)))
- #define **list_foreach**(list, curr) for (curr = **list_first**(list); curr != NULL; curr = **list_next**(curr))
- #define **list_foreach_elt**(list, curr, type, fieldname)
- #define **list_foreach_safe**(list, curr, tmp)
- #define **list_foreach_elt_safe**(list, curr, tmp, type, fieldname)

Functions

- void **list_init** (struct **list** * list)
- size_t **list_length** (const struct **list** * list)
- struct **list_node** * **list_first** (const struct **list** * list)
- struct **list_node** * **list_last** (const struct **list** * list)
- struct **list_node** * **list_next** (const struct **list_node** * node)
- struct **list_node** * **list_advance** (struct **list_node** * node, size_t distance)
- struct **list_node** * **list_at** (const struct **list** * list, size_t pos)
- void **list_reverse** (struct **list** * list)
- void **list_swap** (struct **list** *l1, struct **list** *l2)
- void **list_split_at** (struct **list** * list, size_t pos, struct **list** *right)
- void **list_concat** (struct **list** *l1, struct **list** *l2)
- void **list_sort** (struct **list** * list, int(*cmp)(struct **list_node** *, struct **list_node** *))
- int **list_is_empty** (const struct **list** * list)
- void **list_add** (struct **list** * list, struct **list_node** * node)
- void **list_append** (struct **list** * list, struct **list_node** * node)
- void **list_insert_after** (struct **list** * list, struct **list_node** * curr, struct **list_node** * node)
- void **list_insert_at** (struct **list** * list, struct **list_node** * node, size_t pos)
- void **list_del** (struct **list** * list)
- void **list_del_after** (struct **list** * list, struct **list_node** * node)
- void **list_del_at** (struct **list** * list, size_t pos)
- void **list_print** (const struct **list** * list)

4.4.1 Detailed Description

Intrusive list implement.

Author

S4MasterRace

Version

1.0

4.4.2 Macro Definition Documentation

4.4.2.1 list_elt

```
#define list_elt(  
    node,  
    type,  
    fieldname ) ((type*)((char*)(node) - offsetof(type, fieldname)))
```

Returns a pointer to the structure which contains the node.

Parameters

<i>node</i>	a list node (struct list_node*).
<i>type</i>	type of the structure which contains the node.
<i>fieldname</i>	name of the node (field name) in the structure.

Precondition

node must be not NULL.

Remarks

Complexity: O(1)

4.4.2.2 list_foreach

```
#define list_foreach(  
    list,  
    curr ) for (curr = list_first( list); curr != NULL; curr = list_next(curr))
```

Iterates over list (nodes).

Parameters

<i>list</i>	a list (struct list*).
<i>curr</i>	a struct list_node* used to hold the current element.

Precondition

`list` must be not NULL.
`curr` must be not NULL.

Remarks

Complexity: O(N)

4.4.2.3 list_foreach_elt

```
#define list_foreach_elt(  
    list,  
    curr,  
    type,  
    fieldname )
```

Value:

```
for (curr = list_elt(list_first(list), type, fieldname);  
     curr != NULL;  
     curr = curr->fieldname.next == NULL ? NULL :  
           list_elt(list_next(&(curr->fieldname)), type, fieldname))
```

Iterates over list (elements)

Parameters

<i>list</i>	a list (struct list*).
<i>curr</i>	pointer (type*) used to hold the current element.
<i>type</i>	type of the structure which contains the node.
<i>fieldname</i>	name of the node (field name) in the structure.

Precondition

`list` must be not NULL.
`list` must be not empty.
`curr` must be not NULL.

Remarks

Complexity: O(N)

4.4.2.4 list_foreach_elt_safe

```
#define list_foreach_elt_safe(  
    list,  
    curr,  
    tmp,  
    type,  
    fieldname )
```

Value:

```
for (curr = list_elt(list_first(list), type, fieldname), \
    tmp = list_next(&(curr->fieldname)); \
    curr != NULL; \
    curr = tmp == NULL ? NULL : list_elt(tmp, type, fieldname), \
    tmp = tmp == NULL ? NULL : list_next(tmp))
```

Iterates over list (elements), allows deletion of the current element.

Parameters

<i>list</i>	a list (struct list*).
<i>curr</i>	pointer (type*) used to hold the current element.
<i>tmp</i>	a struct list_node* used as temporary storage.
<i>type</i>	type of the structure which contains the node.
<i>fieldname</i>	name of the node (field name) in the structure.

Precondition

```
list must be not NULL.  
list must be not empty.  
curr must be not NULL.
```

Remarks

Complexity: O(N)

4.4.2.5 list_foreach_safe

```
#define list_foreach_safe(  
    list,  
    curr,  
    tmp )
```

Value:

```
for (curr = list_first(list), tmp = list_next(curr); \
    curr != NULL; \
    curr = tmp, tmp = tmp == NULL ? NULL : list_next(tmp))
```

Iterates over list (nodes), allows deletion of the current node.

Parameters

<i>list</i>	a list (struct list*).
<i>curr</i>	a struct list_node* used to hold the current element.
<i>tmp</i>	a struct list_node* used as temporary storage.

Precondition

`list` must be not NULL.
`curr` must be not NULL.
`tmp` must be not NULL.

Remarks

Complexity: O(N)

4.4.3 Function Documentation

4.4.3.1 list_add()

```
void list_add (  
    struct list * list,  
    struct list_node * node ) [inline]
```

Adds `node` in the front of `list`

Parameters

<i>list</i>	a list.
<i>node</i>	the new node.

Precondition

`list` must be not NULL.
`node` must be not NULL.

Postcondition

List size increases by 1.

Remarks

Complexity: O(1)

4.4.3.2 list_advance()

```
struct list_node* list_advance (
    struct list_node * node,
    size_t distance )
```

Returns the nth-node after the current one.

Parameters

<i>node</i>	a node.
<i>distance</i>	distance to move on.

Returns

the nth-node after *node*.

Precondition

node must be not NULL.

Remarks

Complexity: O(n)

4.4.3.3 list_append()

```
void list_append (
    struct list * list,
    struct list_node * node ) [inline]
```

Adds *node* at the end of *list*.

Parameters

<i>list</i>	a list.
<i>node</i>	the new node.

Precondition

list must be not NULL.
node must be not NULL.

Postcondition

List size increases by 1.

Remarks

Complexity: O(n)

4.4.3.4 list_at()

```
struct list_node* list_at (
    const struct list * list,
    size_t pos )
```

Returns node at the position `pos`.

Parameters

<i>list</i>	a list.
<i>pos</i>	position (0-based) of the node.

Returns

the node at the position `pos`.

Precondition

`list` must be not NULL.
`list` must be not empty.
`pos` must be in `[0; list_length(list)[`.

Remarks

Complexity: O(N)

4.4.3.5 list_concat()

```
void list_concat (
    struct list * l1,
    struct list * l2 ) [inline]
```

Concatenates two lists.

Parameters

<i>l1</i>	list 1.
<i>l2</i>	list 2.

Precondition

l1 must be not NULL.
l2 must be not NULL.
l1 must be different of l2.

Postcondition

l2 is reset to an empty list.

Remarks

Complexity: O(N)

4.4.3.6 list_del()

```
void list_del (
    struct list * list ) [inline]
```

Deletes the first node.

Parameters

<i>list</i>	a list.
-------------	---------

Precondition

list must be not NULL.
list must be not empty.

Postcondition

List size decreases by 1.

Remarks

Complexity: O(1)

4.4.3.7 list_del_after()

```
void list_del_after (
    struct list * list,
    struct list_node * node ) [inline]
```

Deletes the node at after the node curr.

Parameters

<i>list</i>	a list.
<i>node</i>	a node of <code>list</code> .

Precondition

`list` must be not NULL.
`node` must be not NULL.
`list` must be not empty.
`node` must a node of `list`.

Postcondition

List size decreases by 1.

Remarks

Complexity: O(1)

4.4.3.8 list_del_at()

```
void list_del_at (  
    struct list * list,  
    size_t pos ) [inline]
```

Deletes the node at the position `pos`.

Parameters

<i>list</i>	a list.
<i>pos</i>	index (0-based) of the node to delete.

Precondition

`list` must be not NULL.
`list` must be not empty.
`pos` must be in `[0; list_length(list)[`.

Postcondition

List size decreases by 1.

Remarks

Complexity: O(n)

4.4.3.9 list_first()

```
struct list_node* list_first (
    const struct list * list )
```

Returns the first node.

Parameters

<i>list</i>	a list.
-------------	---------

Returns

the first node.

Precondition

`list` must be not NULL.
`list` must be not empty.

Remarks

Complexity: O(1)

4.4.3.10 list_init()

```
void list_init (
    struct list * list ) [inline]
```

Initializes the list.

Parameters

<i>list</i>	a list.
-------------	---------

Precondition

`list` must be not NULL.

Postcondition

`list` is empty.
`list` has a size of 0.

Remarks

Complexity: O(1)

4.4.3.11 list_insert_after()

```
void list_insert_after (
    struct list * list,
    struct list_node * curr,
    struct list_node * node ) [inline]
```

Inserts *node* at after the node *curr*.

Parameters

<i>list</i>	a list.
<i>curr</i>	a node of <i>list</i> .
<i>node</i>	new node.

Precondition

list must be not NULL.
curr must be not NULL.
curr must a node of *list*.
node must be not NULL.

Postcondition

List size increases by 1.

Remarks

Complexity: O(1)

4.4.3.12 list_insert_at()

```
void list_insert_at (
    struct list * list,
    struct list_node * node,
    size_t pos ) [inline]
```

Inserts *node* at the position *pos* in *list*.

Parameters

<i>list</i>	a list.
<i>node</i>	new node.
<i>pos</i>	position (0-based) where to insert the new node.

Precondition

`list` must be not NULL.
`node` must be not NULL.
`pos` must be in $[0; \text{list_length}(\text{list})]$.

Postcondition

List size increases by 1.

Remarks

Complexity: $O(n)$

4.4.3.13 `list_is_empty()`

```
int list_is_empty (
    const struct list * list ) [inline]
```

Tests if a list is empty.

Parameters

<i>list</i>	a list.
-------------	---------

Returns

1 if the list is empty, otherwise 0.

Precondition

`list` must be not NULL.

Remarks

Complexity: $O(1)$

4.4.3.14 `list_last()`

```
struct list_node* list_last (
    const struct list * list )
```

Returns the last node.

Parameters

<i>list</i>	a list.
-------------	---------

Returns

the last node.

Precondition

`list` must be not NULL.

Remarks

Complexity: O(N)

4.4.3.15 list_length()

```
size_t list_length (  
    const struct list * list ) [inline]
```

Returns the size of the list.

Parameters

<i>list</i>	a list.
-------------	---------

Returns

the length of the list.

Precondition

`list` must be not NULL.

Remarks

Complexity: O(1)

4.4.3.16 list_next()

```
struct list_node* list_next (  
    const struct list_node * node )
```

Returns the next node.

Parameters

<i>node</i>	a node.
-------------	---------

Returns

the next node.

Precondition

node must be not NULL.

Remarks

Complexity: O(1)

4.4.3.17 list_print()

```
void list_print (
    const struct list * list )
```

Print the list

Parameters

<i>list</i>	a list
-------------	--------

4.4.3.18 list_reverse()

```
void list_reverse (
    struct list * list ) [inline]
```

Reverses the order of the elements in the list.

Parameters

<i>list</i>	a list.
-------------	---------

Precondition

list must be not NULL.

Remarks

Complexity: $O(N)$

4.4.3.19 list_sort()

```
void list_sort (
    struct list * list,
    int(*) (struct list_node *, struct list_node *) cmp ) [inline]
```

Sort a list using a comparison function.

The contents of the list are sorted in ascending order according to a comparison function which is called with two arguments that point to the node being compared.

The comparison function must return an integer less than, equal to, or greater than zero if the first argument is considered to be respectively less than, equal to, or greater than the second.

If two members compare as equal, their order in the sorted list is preserved.

Parameters

<i>list</i>	list to sort.
<i>cmp</i>	comparison function to use.

Precondition

list must be not NULL.
cmp must be not NULL.

Remarks

The sort is stable.
Complexity: $O(N \log N)$
Space complexity: $O(1)$

4.4.3.20 list_split_at()

```
void list_split_at (
    struct list * list,
    size_t pos,
    struct list * right ) [inline]
```

Splits a list in two parts at the position *pos*.

After the split:

- `list` contains nodes in `[0, pos[`
- `right` contains nodes in `[pos,length(list)[`

Examples:

```
list = [1, 2, 3]
list_split_at(list, 0, right) => ([], [1,2,3])
list_split_at(list, 1, right) => ([1], [2,3])
list_split_at(list, 2, right) => ([1,2], [3])
list_split_at(list, 3, right) => ([1,2,3], [])
list = []
list_split_at(list, 0, right) => ([], [])
```

Parameters

<i>list</i>	list to split.
<i>pos</i>	position (0-based) where to split the list.
<i>right</i>	an empty list to receive the part after <code>pos</code>

Precondition

`list` must be not NULL.
`right` must be not NULL.
`right` must be empty.
`list` must be different of `right`.

Remarks

Complexity: O(N)

4.4.3.21 list_swap()

```
void list_swap (
    struct list * l1,
    struct list * l2 ) [inline]
```

Swaps two lists.

Parameters

<i>l1</i>	list 1.
<i>l2</i>	list 2.

Precondition

`l1` must be not NULL.
`l2` must be not NULL.
`l1` must be different of `l2`.

Remarks

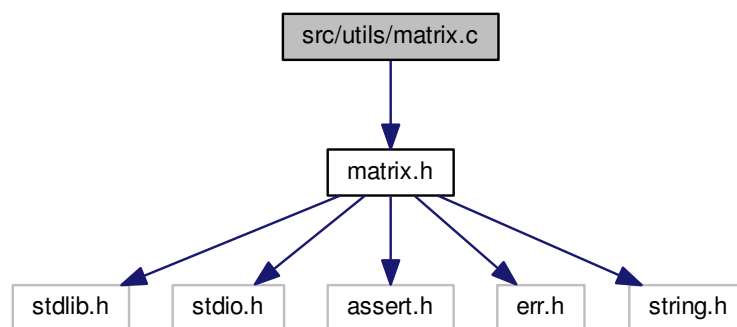
Complexity: $O(1)$

4.5 src/utls/matrix.c File Reference

Matrix implement.

```
#include "matrix.h"
```

Include dependency graph for matrix.c:



Functions

- `struct matrix * matrix_create (size_t rows, size_t cols)`
- `struct matrix * matrix_create_from_array (size_t rows, size_t cols, const double values[])`
- `void matrix_free (struct matrix *mx)`
- `size_t matrix_rows (const struct matrix *mx)`
- `size_t matrix_cols (const struct matrix *mx)`
- `double matrix_at (const struct matrix *mx, size_t rows, size_t cols)`
- `void matrix_set (struct matrix *mx, size_t rows, size_t cols, double value)`
- `struct matrix * matrix_copy (const struct matrix *mx)`
- `void matrix_transpose (const struct matrix *mx, struct matrix *tmx)`
- `void matrix_sum (const struct matrix *mx1, const struct matrix *mx2, struct matrix *sum)`
- `void matrix_hadamard_product (const struct matrix *mx1, const struct matrix *mx2, struct matrix *prod)`
- `void matrix_product (const struct matrix *mx1, const struct matrix *mx2, struct matrix *prod)`
- `void matrix_scale (const struct matrix *mx, double scale, struct matrix *smx)`
- `double matrix_dot_product (const struct matrix *v1, const struct matrix *v2)`
- `void matrix_identity (struct matrix *mx)`
- `int matrix_is_square (const struct matrix *mx)`
- `int matrix_is_diagonal (const struct matrix *mx)`
- `int matrix_is_upper_triangular (const struct matrix *mx)`
- `void matrix_diagonal (const struct matrix *v, struct matrix *mx)`
- `void matrix_print (const struct matrix *mx)`

4.5.1 Detailed Description

Matrix implement.

Author

S4MasterRace

Version

1.0

4.5.2 Function Documentation

4.5.2.1 `matrix_at()`

```
double matrix_at (
    const struct matrix * mx,
    size_t rows,
    size_t cols ) [inline]
```

Get value at `rows` rows and `cols` columns of `mx`

Parameters

<i>mx</i>	a matrix
<i>rows</i>	rows
<i>cols</i>	columns

Returns

the value at `rows` rows and `cols` columns of `mx`

Precondition

`mx` must be not NULL
`rows` must be between `[0, matrix_rows(mx) [`
`cols` must be between `[0, matrix_cols(mx) [`

Remarks

Complexity: O(1)

4.5.2.2 `matrix_cols()`

```
size_t matrix_cols (
    const struct matrix * mx ) [inline]
```

Get the number of columns of `mx`

Parameters

<i>mx</i>	a matrix
-----------	----------

Returns

the number of columns *mx*

Precondition

mx must be not NULL

Remarks

Complexity: O(1)

4.5.2.3 matrix_copy()

```
struct matrix* matrix_copy (  
    const struct matrix * mx )
```

Copy the matrix *mx*

Parameters

<i>mx</i>	a matrix
-----------	----------

Returns

the copy of *mx*

Precondition

mx must be not NULL

Remarks

Complexity: O(1)

4.5.2.4 matrix_create()

```
struct matrix* matrix_create (  
    size_t rows,  
    size_t cols )
```

Create a matrix of size *rows* rows and *cols* columns

Parameters

<i>rows</i>	number of rows
<i>cols</i>	number of columns

Returns

the initialized matrix of size `rows` rows and `cols` columns

Precondition

`rows` must be greater than zero

`cols` must be greater than zero

Remarks

Complexity: O(1)

4.5.2.5 matrix_create_from_array()

```
struct matrix* matrix_create_from_array (
    size_t rows,
    size_t cols,
    const double values[] )
```

Create a matrix of size `rows` rows and `cols` columns from `values`

Parameters

<i>rows</i>	number of rows
<i>cols</i>	number of columns
<i>values</i>	an array

Returns

the initialized matrix of size `rows` rows and `cols` columns from `values`

Precondition

`rows` must be greater than zero

`cols` must be greater than zero

`values` must be not NULL

Remarks

Complexity: O(N)

4.5.2.6 matrix_diagonal()

```
void matrix_diagonal (
    const struct matrix * v,
    struct matrix * mx )
```

Take a vector `v` and put it to the diagonal of `mx`

Parameters

<code>v</code>	a vector
<code>mx</code>	a matrix

Precondition

`v` must be not NULL
`mx` must be not NULL
`matrix_cols(v)` must be equal to one
`matrix_rows(v)` must be equal to `matrix_rows(mx)`
`matrix_rows(mx)` must be equal to `matrix_cols(mx)`

Postcondition

The diagonal of `mx` is `v`

4.5.2.7 matrix_dot_product()

```
double matrix_dot_product (
    const struct matrix * v1,
    const struct matrix * v2 )
```

Do the dot product of vector `v1` with vector `v2`

Parameters

<code>v1</code>	a vector
<code>v2</code>	a vector

Returns

the dot product of vector `v1` with vector `v2`

Precondition

`v1` must be not NULL
`v2` must be not NULL
`matrix_cols(v1)` and `matrix_cols(v2)` must be equal to one
`matrix_rows(v1)` must be equal to `matrix_rows(v2)`

Remarks

Complexity: $O(N)$

4.5.2.8 matrix_free()

```
void matrix_free (
    struct matrix * mx ) [inline]
```

Free the matrix *mx*

Parameters

<i>mx</i>	a matrix
-----------	----------

Precondition

mx must be not NULL

Postcondition

mx is freed

Remarks

Complexity: $O(1)$

4.5.2.9 matrix_hadamard_product()

```
void matrix_hadamard_product (
    const struct matrix * mx1,
    const struct matrix * mx2,
    struct matrix * prod )
```

Do the hadamard product of matrix *mx1* with *mx2*

Parameters

<i>mx1</i>	a matrix
<i>mx2</i>	a matrix
<i>prod</i>	a matrix

Precondition

`mx1` must be not NULL
`mx2` must be not NULL
`prod` must be not NULL
`matrix_rows(mx1)` must be equal to `matrix_rows(mx2)`
`matrix_cols(mx1)` must be equal to `matrix_cols(mx2)`
`matrix_rows(prod)` must be equal to `matrix_rows(mx1)`
`matrix_cols(prod)` must be equal to `matrix_cols(mx1)`

Postcondition

`prod` is the hadamard product of matrix `mx1` with `mx2`

Remarks

Complexity: $O(N)$

4.5.2.10 `matrix_identity()`

```
void matrix_identity (
    struct matrix * mx )
```

Set the matrix `mx` to an identity matrix

Parameters

<i>mx</i>	a matrix
-----------	----------

Precondition

`mx` must be not NULL
`matrix_rows(mx)` must be equal to `matrix_cols(mx)`

Postcondition

`mx` is an identity matrix

Remarks

Complexity: $O(N)$

4.5.2.11 `matrix_is_diagonal()`

```
int matrix_is_diagonal (
    const struct matrix * mx ) [inline]
```

Check if the matrix `mx` is diagonaled

Parameters

<i>mx</i>	a matrix
-----------	----------

Returns

1 if the matrix is diagonaled, 0 otherwise

Precondition

mx must be not NULL

Remarks

Complexity: O(N)

4.5.2.12 matrix_is_square()

```
int matrix_is_square (  
    const struct matrix * mx ) [inline]
```

Check if the matrix *mx* is squared

Parameters

<i>mx</i>	a matrix
-----------	----------

Returns

1 if the matrix is squared, 0 otherwise

Precondition

mx must be not NULL

Remarks

Complexity: O(1)

4.5.2.13 matrix_is_upper_triangularized()

```
int matrix_is_upper_triangularized (  
    const struct matrix * mx ) [inline]
```

Check if the matrix *mx* is upper triangularized

Parameters

<i>mx</i>	a matrix
-----------	----------

Returns

1 if the matrix is upper triangulared, 0 otherwise

Precondition

mx must be not NULL

Remarks

Complexity: O(N)

4.5.2.14 matrix_print()

```
void matrix_print (
    const struct matrix * mx )
```

Print the matrix *mx*

Parameters

<i>mx</i>	a matrix
-----------	----------

Precondition

mx must be not NULL

Postcondition

Print the matrix *mx*

4.5.2.15 matrix_product()

```
void matrix_product (
    const struct matrix * mx1,
    const struct matrix * mx2,
    struct matrix * prod )
```

Multiply the matrix *mx1* with *mx2*

Parameters

<i>mx1</i>	a matrix
<i>mx2</i>	a matrix
<i>prod</i>	a matrix

Precondition

`mx1` must be not NULL
`mx2` must be not NULL
`prod` must be not NULL
`prod` must be not equal to `mx1`
`prod` must be not equal to `mx2`
`matrix_cols(mx1)` must be equal to `matrix_rows(mx2)`
`matrix_rows(prod)` must be equal to `matrix_rows(mx1)`
`matrix_cols(prod)` must be equal to `matrix_cols(mx2)`

Postcondition

`prod` is the product of `mx1` with `mx2`

Remarks

Complexity: $O(nmp)$

4.5.2.16 `matrix_rows()`

```
size_t matrix_rows (
    const struct matrix * mx ) [inline]
```

Get the number of rows `mx`

Parameters

<i>mx</i>	a matrix
-----------	----------

Returns

the number of rows of `mx`

Precondition

`mx` must be not NULL

Remarks

Complexity: $O(1)$

4.5.2.17 `matrix_scale()`

```
void matrix_scale (
    const struct matrix * mx,
    double scale,
    struct matrix * smx )
```

Scale the matrix *mx* with *scale*

Parameters

<i>mx</i>	a matrix
<i>scale</i>	the scale factor
<i>smx</i>	a matrix

Precondition

mx must be not NULL
smx must be not NULL
`matrix_rows(smx)` must be equal to `matrix_rows(mx)`
`matrix_cols(smx)` must be equal to `matrix_cols(mx)`

Postcondition

smx is the *scale* scaled matrix of *mx*

Remarks

Complexity: O(N)

4.5.2.18 `matrix_set()`

```
void matrix_set (
    struct matrix * mx,
    size_t rows,
    size_t cols,
    double value ) [inline]
```

Set the value at *rows* rows and *cols* columns with *value* of *mx*

Parameters

<i>mx</i>	a matrix
<i>rows</i>	rows
<i>cols</i>	columns
<i>value</i>	a value

Precondition

`mx` must be not NULL
`rows` must be between `[0, matrix_rows(mx) [`
`cols` must be between `[0, matrix_cols(mx) [`

Postcondition

the value at `rows` `rows` and `cols` columns is `value`

Remarks

Complexity: O(1)

4.5.2.19 matrix_sum()

```
void matrix_sum (
    const struct matrix * mx1,
    const struct matrix * mx2,
    struct matrix * sum )
```

Sum the matrix `mx1` with `mx2`

Parameters

<i>mx1</i>	a matrix
<i>mx2</i>	a matrix
<i>sum</i>	a matrix

Precondition

`mx1` must be not NULL
`mx2` must be not NULL
`sum` must be not NULL
`matrix_rows(mx1)` must be equal to `matrix_rows(mx2)`
`matrix_cols(mx1)` must be equal to `matrix_cols(mx2)`
`matrix_rows(sum)` must be equal to `matrix_rows(mx1)`
`matrix_cols(sum)` must be equal to `matrix_cols(mx1)`

Postcondition

`sum` is the sum of matrix `mx1` with `mx2`

Remarks

Complexity: O(N)

4.5.2.20 matrix_transpose()

```
void matrix_transpose (
    const struct matrix * mx,
    struct matrix * tmx )
```

Transpose the matrix *mx*

Parameters

<i>mx</i>	a matrix
<i>tmx</i>	a matrix

Precondition

mx must be not NULL
tmx must be not NULL
tmx must be not equal to *mx*
 matrix_rows(*tmx*) must be equal to matrix_cols(*mx*)
 matrix_cols(*tmx*) must be equal to matrix_rows(*mx*)

Postcondition

tmx is the transposed matrix of *mx*

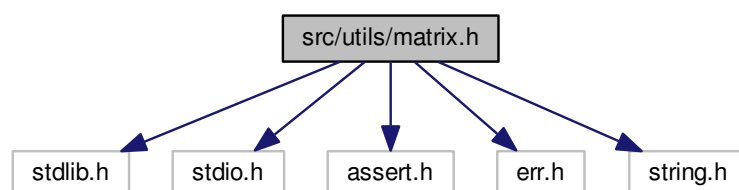
Remarks

Complexity: O(N)

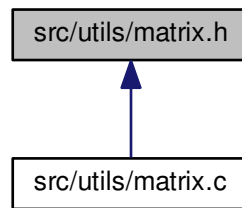
4.6 src/utils/matrix.h File Reference

Matrix implement.

```
#include <stdlib.h>
#include <stdio.h>
#include <assert.h>
#include <err.h>
#include <string.h>
Include dependency graph for matrix.h:
```



This graph shows which files directly or indirectly include this file:



Data Structures

- struct **matrix**

Functions

- struct **matrix** * **matrix_create** (size_t rows, size_t cols)
- struct **matrix** * **matrix_create_from_array** (size_t rows, size_t cols, const double values[])
- void **matrix_free** (struct **matrix** *mx)
- size_t **matrix_rows** (const struct **matrix** *mx)
- size_t **matrix_cols** (const struct **matrix** *mx)
- double **matrix_at** (const struct **matrix** *mx, size_t rows, size_t cols)
- void **matrix_set** (struct **matrix** *mx, size_t rows, size_t cols, double value)
- struct **matrix** * **matrix_copy** (const struct **matrix** *mx)
- void **matrix_transpose** (const struct **matrix** *mx, struct **matrix** *tmx)
- void **matrix_sum** (const struct **matrix** *mx1, const struct **matrix** *mx2, struct **matrix** *sum)
- void **matrix_hadamard_product** (const struct **matrix** *mx1, const struct **matrix** *mx2, struct **matrix** *prod)
- void **matrix_product** (const struct **matrix** *mx1, const struct **matrix** *mx2, struct **matrix** *prod)
- void **matrix_scale** (const struct **matrix** *mx, double scale, struct **matrix** *smx)
- double **matrix_dot_product** (const struct **matrix** *v1, const struct **matrix** *v2)
- void **matrix_identity** (struct **matrix** *mx)
- int **matrix_is_square** (const struct **matrix** *mx)
- int **matrix_is_diagonal** (const struct **matrix** *mx)
- int **matrix_is_upper_triangular** (const struct **matrix** *mx)
- void **matrix_diagonal** (const struct **matrix** *v, struct **matrix** *mx)
- void **matrix_print** (const struct **matrix** *mx)

4.6.1 Detailed Description

Matrix implement.

Author

S4MasterRace

Version

1.0

4.6.2 Function Documentation

4.6.2.1 matrix_at()

```
double matrix_at (
    const struct matrix * mx,
    size_t rows,
    size_t cols ) [inline]
```

Get value at `rows` rows and `cols` columns of `mx`

Parameters

<i>mx</i>	a matrix
<i>rows</i>	rows
<i>cols</i>	columns

Returns

the value at `rows` rows and `cols` columns of `mx`

Precondition

`mx` must be not NULL
`rows` must be between `[0, matrix_rows(mx) [`
`cols` must be between `[0, matrix_cols(mx) [`

Remarks

Complexity: O(1)

4.6.2.2 matrix_cols()

```
size_t matrix_cols (
    const struct matrix * mx ) [inline]
```

Get the number of columns of `mx`

Parameters

<i>mx</i>	a matrix
-----------	----------

Returns

the number of columns `mx`

Precondition

`mx` must be not NULL

Remarks

Complexity: O(1)

4.6.2.3 `matrix_copy()`

```
struct matrix* matrix_copy (
    const struct matrix * mx )
```

Copy the matrix `mx`

Parameters

<i>mx</i>	a matrix
-----------	----------

Returns

the copy of `mx`

Precondition

`mx` must be not NULL

Remarks

Complexity: O(1)

4.6.2.4 `matrix_create()`

```
struct matrix* matrix_create (
    size_t rows,
    size_t cols )
```

Create a matrix of size `rows` rows and `cols` columns

Parameters

<i>rows</i>	number of rows
<i>cols</i>	number of columns

Returns

the initialized matrix of size `rows` rows and `cols` columns

Precondition

`rows` must be greater than zero

`cols` must be greater than zero

Remarks

Complexity: $O(1)$

4.6.2.5 matrix_create_from_array()

```
struct matrix* matrix_create_from_array (
    size_t rows,
    size_t cols,
    const double values[] )
```

Create a matrix of size `rows` rows and `cols` columns from `values`

Parameters

<i>rows</i>	number of rows
<i>cols</i>	number of columns
<i>values</i>	an array

Returns

the initialized matrix of size `rows` rows and `cols` columns from `values`

Precondition

`rows` must be greater than zero

`cols` must be greater than zero

`values` must be not NULL

Remarks

Complexity: $O(N)$

4.6.2.6 matrix_diagonal()

```
void matrix_diagonal (
    const struct matrix * v,
    struct matrix * mx )
```

Take a vector `v` and put it to the diagonal of `mx`

Parameters

<i>v</i>	a vector
<i>mx</i>	a matrix

Precondition

v must be not NULL
mx must be not NULL
`matrix_cols(v)` must be equal to one
`matrix_rows(v)` must be equal to `matrix_rows(mx)`
`matrix_rows(mx)` must be equal to `matrix_cols(mx)`

Postcondition

The diagonal of *mx* is *v*

4.6.2.7 matrix_dot_product()

```
double matrix_dot_product (
    const struct matrix * v1,
    const struct matrix * v2 )
```

Do the dot product of vector *v1* with vector *v2*

Parameters

<i>v1</i>	a vector
<i>v2</i>	a vector

Returns

the dot product of vector *v1* with vector *v2*

Precondition

v1 must be not NULL
v2 must be not NULL
`matrix_cols(v1)` and `matrix_cols(v2)` must be equal to one
`matrix_rows(v1)` must be equal to `matrix_rows(v2)`

Remarks

Complexity: O(N)

4.6.2.8 matrix_free()

```
void matrix_free (
    struct matrix * mx ) [inline]
```

Free the matrix *mx*

Parameters

<i>mx</i>	a matrix
-----------	----------

Precondition

mx must be not NULL

Postcondition

mx is freed

Remarks

Complexity: O(1)

4.6.2.9 matrix_hadamard_product()

```
void matrix_hadamard_product (
    const struct matrix * mx1,
    const struct matrix * mx2,
    struct matrix * prod )
```

Do the hadamard product of matrix *mx1* with *mx2*

Parameters

<i>mx1</i>	a matrix
<i>mx2</i>	a matrix
<i>prod</i>	a matrix

Precondition

mx1 must be not NULL

mx2 must be not NULL

prod must be not NULL

matrix_rows(*mx1*) must be equal to matrix_rows(*mx2*)

matrix_cols(*mx1*) must be equal to matrix_cols(*mx2*)

matrix_rows(*prod*) must be equal to matrix_rows(*mx1*)

matrix_cols(*prod*) must be equal to matrix_cols(*mx1*)

Postcondition

`prod` is the hadamard product of matrix `mx1` with `mx2`

Remarks

Complexity: $O(N)$

4.6.2.10 `matrix_identity()`

```
void matrix_identity (
    struct matrix * mx )
```

Set the matrix `mx` to an identity matrix

Parameters

<i>mx</i>	a matrix
-----------	----------

Precondition

`mx` must be not NULL
`matrix_rows(mx)` must be equal to `matrix_cols(mx)`

Postcondition

`mx` is an identity matrix

Remarks

Complexity: $O(N)$

4.6.2.11 `matrix_is_diagonal()`

```
int matrix_is_diagonal (
    const struct matrix * mx ) [inline]
```

Check if the matrix `mx` is diagonaled

Parameters

<i>mx</i>	a matrix
-----------	----------

Returns

1 if the matrix is diagonaled, 0 otherwise

Precondition

`mx` must be not NULL

Remarks

Complexity: $O(N)$

4.6.2.12 `matrix_is_square()`

```
int matrix_is_square (
    const struct matrix * mx ) [inline]
```

Check if the matrix `mx` is squared

Parameters

<i>mx</i>	a matrix
-----------	----------

Returns

1 if the matrix is squared, 0 otherwise

Precondition

`mx` must be not NULL

Remarks

Complexity: $O(1)$

4.6.2.13 `matrix_is_upper_triangularized()`

```
int matrix_is_upper_triangularized (
    const struct matrix * mx ) [inline]
```

Check if the matrix `mx` is upper triangularized

Parameters

<i>mx</i>	a matrix
-----------	----------

Returns

1 if the matrix is upper triangulared, 0 otherwise

Precondition

`mx` must be not NULL

Remarks

Complexity: O(N)

4.6.2.14 matrix_print()

```
void matrix_print (
    const struct matrix * mx )
```

Print the matrix `mx`

Parameters

<i>mx</i>	a matrix
-----------	----------

Precondition

`mx` must be not NULL

Postcondition

Print the matrix `mx`

4.6.2.15 matrix_product()

```
void matrix_product (
    const struct matrix * mx1,
    const struct matrix * mx2,
    struct matrix * prod )
```

Multiply the matrix `mx1` with `mx2`

Parameters

<i>mx1</i>	a matrix
<i>mx2</i>	a matrix
<i>prod</i>	a matrix

Precondition

`mx1` must be not NULL
`mx2` must be not NULL
`prod` must be not NULL
`prod` must be not equal to `mx1`
`prod` must be not equal to `mx2`
`matrix_cols(mx1)` must be equal to `matrix_rows(mx2)`
`matrix_rows(prod)` must be equal to `matrix_rows(mx1)`
`matrix_cols(prod)` must be equal to `matrix_cols(mx2)`

Postcondition

`prod` is the product of `mx1` with `mx2`

Remarks

Complexity: $O(nmp)$

4.6.2.16 `matrix_rows()`

```
size_t matrix_rows (
    const struct matrix * mx ) [inline]
```

Get the number of rows `mx`

Parameters

<i>mx</i>	a matrix
-----------	----------

Returns

the number of rows of `mx`

Precondition

`mx` must be not NULL

Remarks

Complexity: $O(1)$

4.6.2.17 `matrix_scale()`

```
void matrix_scale (
    const struct matrix * mx,
    double scale,
    struct matrix * smx )
```

Scale the matrix `mx` with `scale`

Parameters

<i>mx</i>	a matrix
<i>scale</i>	the scale factor
<i>smx</i>	a matrix

Precondition

`mx` must be not NULL
`smx` must be not NULL
`matrix_rows(smx)` must be equal to `matrix_rows(mx)`
`matrix_cols(smx)` must be equal to `matrix_cols(mx)`

Postcondition

`smx` is the `scale` scaled matrix of `mx`

Remarks

Complexity: O(N)

4.6.2.18 `matrix_set()`

```
void matrix_set (
    struct matrix * mx,
    size_t rows,
    size_t cols,
    double value ) [inline]
```

Set the value at `rows` rows and `cols` columns with value of `mx`

Parameters

<i>mx</i>	a matrix
<i>rows</i>	rows
<i>cols</i>	columns
<i>value</i>	a value

Precondition

`mx` must be not NULL
`rows` must be between `[0, matrix_rows(mx) [`
`cols` must be between `[0, matrix_cols(mx) [`

Postcondition

the value at `rows` rows and `cols` columns is `value`

Remarks

Complexity: $O(1)$

4.6.2.19 matrix_sum()

```
void matrix_sum (
    const struct matrix * mx1,
    const struct matrix * mx2,
    struct matrix * sum )
```

Sum the matrix *mx1* with *mx2*

Parameters

<i>mx1</i>	a matrix
<i>mx2</i>	a matrix
<i>sum</i>	a matrix

Precondition

mx1 must be not NULL
mx2 must be not NULL
sum must be not NULL
matrix_rows(*mx1*) must be equal to *matrix_rows*(*mx2*)
matrix_cols(*mx1*) must be equal to *matrix_cols*(*mx2*)
matrix_rows(*sum*) must be equal to *matrix_rows*(*mx1*)
matrix_cols(*sum*) must be equal to *matrix_cols*(*mx1*)

Postcondition

sum is the sum of matrix *mx1* with *mx2*

Remarks

Complexity: $O(N)$

4.6.2.20 matrix_transpose()

```
void matrix_transpose (
    const struct matrix * mx,
    struct matrix * tmx )
```

Transpose the matrix *mx*

Parameters

<i>mx</i>	a matrix
<i>tmx</i>	a matrix

Precondition

mx must be not NULL
tmx must be not NULL
tmx must be not equal to *mx*
`matrix_rows(tmx)` must be equal to `matrix_cols(mx)`
`matrix_cols(tmx)` must be equal to `matrix_rows(mx)`

Postcondition

tmx is the transposed matrix of *mx*

Remarks

Complexity: O(N)

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