CMatrix

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Chapter 1

CMatrix: A Powerful C++ Matrix Library

CMatrix is a robust C++ matrix library designed to simplify matrix operations and provide extensive functionalities. This library is tailored for Data Science and Machine Learning projects, offering a versatile toolset for working with matrices.

1.1 Table of Contents

1.2 Installation

To install the library, follow these steps:

1. Clone the repository using the following command:

```
git clone https://github.com/B-Manitas/CMatrix.git
```

1. Include the `CMatrix.hpp` file in your project.
2. Compile your project with the following flags:

```
-std=c++11 -fopenmp
```

1.3 Exemple of Usage

Here's an example of how to use CMatrix:

```
#include "CMatrix.hpp"
int main()
{
    // Create a 2x3 matrix
    cmatrix<int> mat = {{1, 2, 3}, {4, 5, 6}};
    // Create a random 3x2 matrix
    cmatrix<int> rand = cmatrix<int>::randint(3, 2, 0, 10);
    rand.print();
    // Performs a calculation on the matrix
    mat += ((rand * 2) - 1);
    // Print the transpose of the result
    mat.transpose().print();
    return 0;
}
»> "[[18, 9], [5, 22], [20, 13]]"
```

1.4 Hierarchical Structure

CMatrix is structured as follows:

Class	Description
include	
CMatrix.hpp	The main template class that can work with any data type.
src	
CMatrix.tpp	General methods of the class.
CMatrixConstructors.hpp	Implementation of class constructors.
CMatrixGetter.hpp	Methods to retrieve information about the matrix and access its elements.
CMatrixSetter.hpp	Methods to set data in the matrix.
CMatrixCheck.tpp	Methods to verify matrix conditions and perform checks before operations to prevent errors.
CMatrixManipulation.hpp	Methods to find elements in the matrix and transform it.
CMatrixOperator.hpp	Implementation of various operators.
CMatrixStatic.hpp	Implementation of static methods of the class.
CMatrixStatistics.hpp	Methods to perform statistical operations on the matrix.
test	
CMatrixTest.hpp	Contains the tests for the class.

1.5 Documentation

For detailed information on how to use CMatrix, consult the documentation.

1.6 Libraries Used

- OpenMP: An API for parallel programming. _(Required for compile CMatrix)_
- GoogleTest: A C++ testing framework.
- GoogleBenchmark: A C++ benchmarking framework.
- Doxygen: A documentation generator.

1.7 See Also

- `CDataFrame`: A C++ DataFrame library for Data Science and Machine Learning projects.

1.8 License

This project is licensed under the MIT License, ensuring its free and open availability to the community.

Chapter 2

Deprecated List

Member cmatrix< T >::columns_vec (const size_t &n) const

Use `columns` instead.

Member cmatrix< T >::rows_vec (const size_t &n) const

Use `rows` instead.

Chapter 3

Module Index

3.1 Modules

Here is a list of all modules:

Chapter 4

Class Index

4.1 Class List

Here are the classes, structs, unions and interfaces with brief descriptions:

Chapter 5

File Index

5.1 File List

Here is a list of all files with brief descriptions:

Chapter 6

Module Documentation

6.1 CMatrix

Functions

- template< class U >
  cmatrix< U > cmatrix< T >::__cast (std::true_type) const

  Convert the matrix to a matrix of another type.
- template< class U >
  cmatrix< U > cmatrix< T >::__cast (std::false_type) const

  Convert the matrix to a matrix of another type.
- cmatrix< std::string > cmatrix< T >::__to_string (std::true_type) const

  Convert the matrix to a string matrix.
- cmatrix< std::string > cmatrix< T >::__to_string (std::false_type) const

  Convert the matrix to a string matrix.
- void cmatrix< T >::print () const

  Print the matrix in the standard output.
- void cmatrix< T >::clear ()

  Clear the matrix.
- cmatrix< T > cmatrix< T >::copy () const

  Copy the matrix.
- void cmatrix< T >::apply (const std::function< T(T, size_t, size_t)> &f)

  Apply a function to each cell of the matrix.
- void cmatrix< T >::apply (const std::function< T(T)> &f)

  Apply a function to each cell of the matrix.
- cmatrix< T > cmatrix< T >::map (const std::function< T(T, size_t, size_t)> &f) const

  Apply a function to each cell of the matrix and return the result.
- template< class U >
  cmatrix< U > cmatrix< T >::map (const std::function< U(T, size_t, size_t)> &f) const

  Apply a function to each cell of the matrix and return the result.
- cmatrix< T > cmatrix< T >::map (const std::function< T(T)> &f) const

  Apply a function to each cell of the matrix and return the result.
- template< class U >
  cmatrix< U > cmatrix< T >::map (const std::function< U(T)> &f) const

  Apply a function to each cell of the matrix and return the result.
- void cmatrix< T >::fill (const T &val)

Fill the matrix with a value.
- std::vector< std::vector< T > > cmatrix< T >::to_vector () const

  Convert the matrix to a vector.
- template<class U >
  cmatrix< U > cmatrix< T >::cast () const

  Convert the matrix to a matrix of another type.
- cmatrix< int > cmatrix< T >::to_int () const

  Convert the matrix to a matrix of integers.
- cmatrix< float > cmatrix< T >::to_float () const

  Convert the matrix to a matrix of floats.
- cmatrix< std::string > cmatrix< T >::to_string () const

  Convert the matrix to a matrix of strings.

6.1.1 Detailed Description

6.1.2 Function Documentation

6.1.2.1 __cast() [1/2]

```
template<class T >
template<class U >
cmatrix< U > cmatrix< T >::__cast (
             std::false_type  ) const  [private]
```

Convert the matrix to a matrix of another type.

Template Parameters

U	The type of the matrix to convert.

Parameters

false_type	The type of the matrix is not convertible.

Exceptions

std::invalid_argument	The type of the matrix is not convertible.

6.1.2.2 __cast() [2/2]

```
template<class T >
template<class U >
```

```
cmatrix< U > cmatrix< T >::__cast (
            std::true_type ) const [private]
```

Convert the matrix to a matrix of another type.

Template Parameters

U	The type of the matrix to convert.

Parameters

true_type	The type of the matrix is convertible.

Returns

cmatrix The converted matrix.

6.1.2.3 __to_string() [1/2]

```
template<class T >
cmatrix< std::string > cmatrix< T >::__to_string (
            std::false_type ) const [private]
```

Convert the matrix to a string matrix.

Parameters

false_type	The type of the matrix is not convertible.

Exceptions

std::invalid_argument	The type of the matrix is not convertible.

6.1.2.4 __to_string() [2/2]

```
template<class T >
cmatrix< std::string > cmatrix< T >::__to_string (
            std::true_type ) const [private]
```

Convert the matrix to a string matrix.

Parameters

true_type	The type of the matrix is convertible.

Returns

cmatrix<std::string> The converted matrix.

Note

PARALLELIZED METHOD with OpenMP.

6.1.2.5 apply() [1/2]

```
template<class T >
void cmatrix< T >::apply (
             const std::function< T(T)> & f )
```

Apply a function to each cell of the matrix.

Parameters

f	The function to apply. f(T value) -> T

Note

PARALLELIZED METHOD with OpenMP.

6.1.2.6 apply() [2/2]

```
template<class T >
void cmatrix< T >::apply (
             const std::function< T(T, size_t, size_t)> & f )
```

Apply a function to each cell of the matrix.

Parameters

f	The function to apply. f(T value, size_t id_row, size_t id_col) -> T

6.1.2.7 cast()

```
template<class T >
template<class U >
cmatrix< U > cmatrix< T >::cast
```

Convert the matrix to a matrix of another type.

Template Parameters

U	The type of the matrix.

Returns

cmatrix The matrix of another type.

Exceptions

std::invalid_argument	If the type T is not convertible to the type U.

6.1.2.8 clear()

```
template<class T >
void cmatrix< T >::clear
```

Clear the matrix.

6.1.2.9 copy()

```
template<class T >
cmatrix< T > cmatrix< T >::copy
```

Copy the matrix.

Returns

cmatrix<T> The copied matrix.

6.1.2.10 fill()

```
template<class T >
void cmatrix< T >::fill (
             const T & val )
```

Fill the matrix with a value.

Parameters

val	The value to fill the matrix.

6.1.2.11 map() [1/4]

```
template<class T >
cmatrix< T > cmatrix< T >::map (
             const std::function< T(T)> & f ) const
```

Apply a function to each cell of the matrix and return the result.

Parameters

f	The function to apply. f(T value) -> T

Returns

cmatrix<T> The result of the function.

Note

PARALLELIZED METHOD with OpenMP.

6.1.2.12 map() [2/4]

```
template<class T >
cmatrix< T > cmatrix< T >::map (
             const std::function< T(T, size_t, size_t)> & f ) const
```

Apply a function to each cell of the matrix and return the result.

Parameters

f	The function to apply. f(T value, size_t id_row, size_t id_col) -> T

Returns

cmatrix<T> The result of the function.

6.1.2.13 map() [3/4]

```
template<class T >
template<class U >
cmatrix< U > cmatrix< T >::map (
             const std::function< U(T)> & f ) const
```

Apply a function to each cell of the matrix and return the result.

Template Parameters

U	The type of the matrix.

Parameters

f	The function to apply. f(T value) -> U

Returns

cmatrix The result of the function.

Note

PARALLELIZED METHOD with OpenMP.

6.1.2.14 map() [4/4]

```
template<class T >
template<class U >
cmatrix< U > cmatrix< T >::map (
             const std::function< U(T, size_t, size_t)> & f ) const
```

Apply a function to each cell of the matrix and return the result.

Template Parameters

U	The type of the matrix.

Parameters

f	The function to apply. f(T value, size_t id_row, size_t id_col) -> U

Returns

cmatrix The result of the function.

6.1.2.15 print()

```
template<class T >
void cmatrix< T >::print
```

Print the matrix in the standard output.

6.1.2.16 to_float()

```
template<class T >
cmatrix< float > cmatrix< T >::to_float
```

Convert the matrix to a matrix of floats.

Returns

cmatrix<float> The matrix of floats.

Exceptions

std::invalid_argument	If the type T is not convertible to the type float.
std::runtime_error	If the value is out of range of the type float.

Note

PARALLELIZED METHOD with OpenMP.

6.1.2.17 to_int()

```
template<class T >
cmatrix< int > cmatrix< T >::to_int
```

Convert the matrix to a matrix of integers.

Returns

cmatrix<int> The matrix of integers.

Exceptions

std::invalid_argument	If the type T is not convertible to the type int.
std::runtime_error	If the value is out of range of the type int.

Note

PARALLELIZED METHOD with OpenMP.

6.1.2.18 to_string()

```
template<class T >
cmatrix< std::string > cmatrix< T >::to_string
```

Convert the matrix to a matrix of strings.

Returns

cmatrix<std::string> The matrix of strings.

Exceptions

std::invalid_argument	If the type T is not a primitive type.

Note

PARALLELIZED METHOD with OpenMP.

6.1.2.19 to_vector()

```
template<class T >
std::vector< std::vector< T > > cmatrix< T >::to_vector
```

Convert the matrix to a vector.

Returns

std::vector<T> The vector.

6.2 CMatrixCheck

Functions

- void cmatrix< T >::__check_size (const std::tuple< size_t, size_t > &size) const

  Check if dimensions are equals to the dimensions of the matrix.
- void cmatrix< T >::__check_size (const cmatrix< T > &m) const

  Check if dimensions are equals to the dimensions of the matrix.
- void cmatrix< T >::__check_valid_row (const std::vector< T > &row) const

  Check if the vector is a valid row of the matrix.
- void cmatrix< T >::__check_valid_col (const std::vector< T > &col) const

  Check if the vector is a valid column of the matrix.
- void cmatrix< T >::__check_valid_diag (const std::vector< T > &diag) const

  Check if the diagonal is a valid diagonal of the matrix.
- void cmatrix< T >::__check_valid_row_id (const size_t &n) const

  Check if the row is a valid row index of the matrix.
- void cmatrix< T >::__check_valid_col_id (const size_t &n) const

  Check if the column is a valid column index of the matrix.
- void cmatrix< T >::__check_expected_id (const size_t &n, const size_t &expected) const

  Check if the index is expected.
- void cmatrix< T >::__check_expected_id (const size_t &n, const size_t &expectedBegin, const size_↩
  t &exepectedEnd) const

  Check if the index is expected.
- bool cmatrix< T >::is_empty () const

  Check if the matrix is empty.
- bool cmatrix< T >::is_square () const

  Check if the matrix is a square matrix.
- bool cmatrix< T >::is_diag () const

  Check if the matrix is a diagonal matrix.
- bool cmatrix< T >::is_identity () const

  Check if the matrix is the identity matrix.
- bool cmatrix< T >::is_symetric () const

  Check if the matrix is a symmetric matrix.
- bool cmatrix< T >::is_triangular_up () const

  Check if the matrix is an upper triangular matrix.
- bool cmatrix< T >::is_triangular_low () const

  Check if the matrix is a lower triangular matrix.
- bool cmatrix< T >::all (const std::function< bool(T)> &f) const

  Check if all the cells of the matrix satisfy a condition.
- bool cmatrix< T >::all (const T &val) const

  Check if all the cells of the matrix are equal to a value.
- bool cmatrix< T >::any (const std::function< bool(T)> &f) const

  Check if at least one cell of the matrix satisfy a condition.
- bool cmatrix< T >::any (const T &val) const

  Check if at least one cell of the matrix is equal to a value.

6.2.1 Detailed Description

6.2.2 Function Documentation

6.2.2.1 __check_expected_id() [1/2]

```
template<class T >
void cmatrix< T >::__check_expected_id (
             const size_t & n,
             const size_t & expected ) const  [private]
```

Check if the index is expected.

Parameters

n	The index to check.
expected	The expected index.

Exceptions

std::invalid_argument	If the index is not the expected index.

6.2.2.2 __check_expected_id() [2/2]

```
template<class T >
void cmatrix< T >::__check_expected_id (
             const size_t & n,
             const size_t & expectedBegin,
             const size_t & exepectedEnd ) const  [private]
```

Check if the index is expected.

Parameters

n	The index to check.
expectedBegin	The expected begin index inclusive.
exepectedEnd	The expected end index inlusive.

Exceptions

std::invalid_argument	If the index is not the expected index.

6.2.2.3 __check_size() [1/2]

```
template<class T >
void cmatrix< T >::__check_size (
             const cmatrix< T > & m ) const  [private]
```

Check if dimensions are equals to the dimensions of the matrix.

Parameters

m	The matrix.

Exceptions

std::invalid_argument	If the dimensions are not equals to the dimensions of the matrix.

6.2.2.4 __check_size() [2/2]

```
template<class T >
void cmatrix< T >::__check_size (
             const std::tuple< size_t, size_t > & size ) const  [private]
```

Check if dimensions are equals to the dimensions of the matrix.

Parameters

size	The vertical and horizontal dimensions.

Exceptions

std::invalid_argument	If the dimensions are not equals to the dimensions of the matrix.

6.2.2.5 __check_valid_col()

```
template<class T >
void cmatrix< T >::__check_valid_col (
             const std::vector< T > & col ) const  [private]
```

Check if the vector is a valid column of the matrix.

Parameters

col	The column to check.

Exceptions

std::invalid_argument	If the vector is not a valid column of the matrix.

Note

The column must be a vector of the same type of the matrix.

6.2.2.6 __check_valid_col_id()

```
template<class T >
void cmatrix< T >::__check_valid_col_id (
             const size_t & n ) const  [private]
```

Check if the column is a valid column index of the matrix.

Parameters

col	The column index to check.

Exceptions

std::invalid_argument	If the column is not a valid column index of the matrix.

6.2.2.7 __check_valid_diag()

```
template<class T >
void cmatrix< T >::__check_valid_diag (
             const std::vector< T > & diag ) const  [private]
```

Check if the diagonal is a valid diagonal of the matrix.

Parameters

diag	The diagonal to check.

Exceptions

std::invalid_argument	If the vector is not a valid diagonal of the matrix.

6.2.2.8 __check_valid_row()

```
template<class T >
void cmatrix< T >::__check_valid_row (
             const std::vector< T > & row ) const  [private]
```

Check if the vector is a valid row of the matrix.

Parameters

row	The row to check.

Exceptions

std::invalid_argument	If the vector is not a valid row of the matrix.

Note

The row must be a vector of the same type of the matrix.

6.2.2.9 __check_valid_row_id()

```
template<class T >
void cmatrix< T >::__check_valid_row_id (
             const size_t & n ) const  [private]
```

Check if the row is a valid row index of the matrix.

Parameters

row	The row index to check.

Exceptions

std::invalid_argument	If the row is not a valid row index of the matrix.

6.2.2.10 all() [1/2]

```
template<class T >
bool cmatrix< T >::all (
             const std::function< bool(T)> & f ) const
```

Check if all the cells of the matrix satisfy a condition.

Parameters

f	The condition to satisfy. f(T value) -> bool

Returns

true If all the cells satisfy the condition.

false If at least one cell does not satisfy the condition.

Note

The empty matrix always return true.

6.2.2.11 all() [2/2]

```
template<class T >
bool cmatrix< T >::all (
             const T & val ) const
```

Check if all the cells of the matrix are equal to a value.

Parameters

val	The value to check.

Returns

true If all the cells are equal to the value.

false If at least one cell is not equal to the value.

Note

The empty matrix always return true.

6.2.2.12 any() [1/2]

```
template<class T >
bool cmatrix< T >::any (
             const std::function< bool(T)> & f ) const
```

Check if at least one cell of the matrix satisfy a condition.

Parameters

f	The condition to satisfy. f(T value) -> bool

Returns

true If at least one cell satisfy the condition.

false If all the cells does not satisfy the condition.

Note

The empty matrix always return false.

6.2.2.13 any() [2/2]

```
template<class T >
bool cmatrix< T >::any (
            const T & val ) const
```

Check if at least one cell of the matrix is equal to a value.

Parameters

val	The value to check.

Returns

true If at least one cell is equal to the value.

false If all the cells are not equal to the value.

Note

The empty matrix always return false.

6.2.2.14 is_diag()

```
template<class T >
bool cmatrix< T >::is_diag
```

Check if the matrix is a diagonal matrix.

Returns

true If the matrix is a diagonal matrix.

false If the matrix is not a diagonal matrix.

6.2.2.15 is_empty()

```
template<class T >
bool cmatrix< T >::is_empty
```

Check if the matrix is empty.

Returns

true If the matrix is empty.

false If the matrix is not empty.

6.2.2.16 is_identity()

```
template<class T >
bool cmatrix< T >::is_identity
```

Check if the matrix is the identity matrix.

Returns

true If the matrix is the identity matrix.

false If the matrix is not the identity matrix.

6.2.2.17 is_square()

```
template<class T >
bool cmatrix< T >::is_square
```

Check if the matrix is a square matrix.

Returns

true If the matrix is a square matrix.

false If the matrix is not a square matrix.

6.2.2.18 is_symetric()

```
template<class T >
bool cmatrix< T >::is_symetric
```

Check if the matrix is a symmetric matrix.

Returns

true If the matrix is a symmetric matrix.

false If the matrix is not a symmetric matrix.

6.2.2.19 is_triangular_low()

```
template<class T >
bool cmatrix< T >::is_triangular_low
```

Check if the matrix is a lower triangular matrix.

Returns

true If the matrix is a lower triangular matrix.

false If the matrix is not a lower triangular matrix.

6.2.2.20 is_triangular_up()

```
template<class T >
bool cmatrix< T >::is_triangular_up
```

Check if the matrix is an upper triangular matrix.

Returns

true If the matrix is an upper triangular matrix.

false If the matrix is not an upper triangular matrix.

6.3 CMatrixGetter

Functions

- std::vector< T > cmatrix< T >::rows_vec (const size_t &n) const

  Get a row of the matrix.
- std::vector< T > cmatrix< T >::columns_vec (const size_t &n) const

  Get a column of the matrix as a flattened vector.
- cmatrix< T > cmatrix< T >::rows (const size_t &ids) const

  Get the rows of the matrix.
- cmatrix< T > cmatrix< T >::rows (const std::initializer_list< size_t > &ids) const

  Get the rows of the matrix.
- cmatrix< T > cmatrix< T >::rows (const std::vector< size_t > &ids) const

  Get the rows of the matrix.
- cmatrix< T > cmatrix< T >::columns (const size_t &ids) const

  Get the columns of the matrix.
- cmatrix< T > cmatrix< T >::columns (const std::initializer_list< size_t > &ids) const

  Get the columns of the matrix.
- cmatrix< T > cmatrix< T >::columns (const std::vector< size_t > &ids) const

  Get the columns of the matrix.
- cmatrix< T > cmatrix< T >::cells (const size_t &row, const size_t &col) const

  Get the cells of the matrix.
- cmatrix< T > cmatrix< T >::cells (const std::initializer_list< std::pair< size_t, size_t >> &ids) const

  Get the cells of the matrix.
- cmatrix< T > cmatrix< T >::cells (const std::vector< std::pair< size_t, size_t >> &ids) const

  Get the cells of the matrix.
- T cmatrix< T >::cell (const size_t &row, const size_t &col) const

  Get a cell of the matrix.
- cmatrix< T > cmatrix< T >::slice_rows (const size_t &start, const size_t &end) const

  Get the rows between two indexes.
- cmatrix< T > cmatrix< T >::slice_columns (const size_t &start, const size_t &end) const

  Get the columns between two indexes.
- size_t cmatrix< T >::width () const

  The number of columns of the matrix.
- size_t cmatrix< T >::height () const

  The number of rows of the matrix.
- std::pair< size_t, size_t > cmatrix< T >::size () const

  The dimensions of the matrix.
- cmatrix< T > cmatrix< T >::transpose () const

  Get the transpose of the matrix.
- std::vector< T > cmatrix< T >::diag () const

  Get the diagonal of the matrix.

6.3.1 Detailed Description

6.3.2 Function Documentation

6.3.2.1 cell()

```
template<class T >
T cmatrix< T >::cell (
            const size_t & row,
            const size_t & col ) const
```

Get a cell of the matrix.

Parameters

row	The row of the cell to get.
col	The column of the cell to get.

Returns

T The cell.

Exceptions

std::out_of_range	If the index is out of range.

6.3.2.2 cells() [1/3]

```
template<class T >
cmatrix< T > cmatrix< T >::cells (
            const size_t & row,
            const size_t & col ) const
```

Get the cells of the matrix.

Parameters

row	The row of the cell to get.
col	The column of the cell to get.

Returns

cmatrix<T> The cells of the matrix.

Exceptions

std::out_of_range	If the index is out of range.

6.3.2.3 cells() [2/3]

```
template<class T >
cmatrix< T > cmatrix< T >::cells (
            const std::initializer_list< std::pair< size_t, size_t >> & ids ) const
```

Get the cells of the matrix.

Parameters

ids	The indexes of the cells to get. (row, column)

Returns

cmatrix<T> The cells of the matrix.

Exceptions

std::out_of_range	If the index is out of range.

6.3.2.4 cells() [3/3]

```
template<class T >
cmatrix< T > cmatrix< T >::cells (
            const std::vector< std::pair< size_t, size_t >> & ids ) const
```

Get the cells of the matrix.

Parameters

ids	The indexes of the cells to get. (row, column)

Returns

cmatrix<T> The cells of the matrix.

Exceptions

std::out_of_range	If the index is out of range.

6.3.2.5 columns() [1/3]

```
template<class T >
cmatrix< T > cmatrix< T >::columns (
            const size_t & ids ) const
```

Get the columns of the matrix.

Parameters

ids	The indexes of the columns to get.

Returns

cmatrix<T> The columns of the matrix.

Exceptions

std::out_of_range	If the index is out of range.

6.3.2.6 columns() [2/3]

```
template<class T >
cmatrix< T > cmatrix< T >::columns (
              const std::initializer_list< size_t > & ids ) const
```

Get the columns of the matrix.

Parameters

ids	The indexes of the columns to get.

Returns

cmatrix<T> The columns of the matrix.

Exceptions

std::out_of_range	If the index is out of range.

6.3.2.7 columns() [3/3]

```
template<class T >
cmatrix< T > cmatrix< T >::columns (
              const std::vector< size_t > & ids ) const
```

Get the columns of the matrix.

Parameters

ids	The indexes of the columns to get.

Returns

cmatrix<T> The columns of the matrix.

Exceptions

std::out_of_range	If the index is out of range.

6.3.2.8 columns_vec()

```
template<class T >
std::vector< T > cmatrix< T >::columns_vec (
              const size_t & n ) const
```

Get a column of the matrix as a flattened vector.

Parameters

n	The index of the column to get.

Returns

std::vector<T> The column as a flattened vector.

Exceptions

std::out_of_range	If the index is out of range.

Deprecated Use `columns` instead.

6.3.2.9 diag()

```
template<class T >
std::vector< T > cmatrix< T >::diag
```

Get the diagonal of the matrix.

Returns

std::vector<T> The diagonal of the matrix.

6.3.2.10 height()

```
template<class T >
size_t cmatrix< T >::height
```

The number of rows of the matrix.

Returns

size_t The number of rows.

6.3.2.11 rows() [1/3]

```
template<class T >
cmatrix< T > cmatrix< T >::rows (
            const size_t & ids ) const
```

Get the rows of the matrix.

Parameters

ids	The indexes of the rows to get.

Returns

cmatrix<T> The rows of the matrix.

Exceptions

std::out_of_range	If the index is out of range.

6.3.2.12 rows() [2/3]

```
template<class T >
cmatrix< T > cmatrix< T >::rows (
            const std::initializer_list< size_t > & ids ) const
```

Get the rows of the matrix.

Parameters

ids	The indexes of the rows to get.

Returns

cmatrix<T> The rows of the matrix.

Exceptions

std::out_of_range	If the index is out of range.

6.3.2.13 rows() [3/3]

```
template<class T >
cmatrix< T > cmatrix< T >::rows (
             const std::vector< size_t > & ids ) const
```

Get the rows of the matrix.

Parameters

ids	The indexes of the rows to get.

Returns

cmatrix<T> The rows of the matrix.

Exceptions

std::out_of_range	If the index is out of range.

6.3.2.14 rows_vec()

```
template<class T >
std::vector< T > cmatrix< T >::rows_vec (
             const size_t & n ) const
```

Get a row of the matrix.

Parameters

n	The index of the row to get.

Returns

std::vector<T> The row.

Exceptions

std::out_of_range	If the index is out of range.

Deprecated Use `rows` instead.

6.3.2.15 size()

```
template<class T >
std::pair< size_t, size_t > cmatrix< T >::size
```

The dimensions of the matrix.

Returns

std::pair<size_t, size_t> The number of rows and columns.

6.3.2.16 slice_columns()

```
template<class T >
cmatrix< T > cmatrix< T >::slice_columns (
            const size_t & start,
            const size_t & end ) const
```

Get the columns between two indexes.

Parameters

start	The start index inclusive.
end	The end index inclusive.

Returns

cmatrix<T> The columns between two indexes.

Exceptions

std::out_of_range	If the index is out of range.
std::invalid_argument	If the start index is greater than the end index.

6.3.2.17 slice_rows()

```
template<class T >
cmatrix< T > cmatrix< T >::slice_rows (
             const size_t & start,
             const size_t & end ) const
```

Get the rows between two indexes.

Parameters

start	The start index inclusive.
end	The end index inclusive.

Returns

cmatrix<T> The rows between two indexes.

Exceptions

std::out_of_range	If the index is out of range.
std::invalid_argument	If the start index is greater than the end index.

6.3.2.18 transpose()

```
template<class T >
cmatrix< T > cmatrix< T >::transpose
```

Get the transpose of the matrix.

Returns

cmatrix<T> The transpose of the matrix.

Note

PARALLELIZED METHOD with OpenMP.

6.3.2.19 width()

```
template<class T >
size_t cmatrix< T >::width
```

The number of columns of the matrix.

Returns

size_t The number of columns.

6.4 CMatrixManipulation

Functions

- void cmatrix< T >::insert_row (const size_t &pos, const std::vector< T > &val)

  Insert a column in the matrix.
- void cmatrix< T >::insert_column (const size_t &pos, const std::vector< T > &val)

  Insert a row in the matrix.
- void cmatrix< T >::push_row_front (const std::vector< T > &val)

  Push a row in the front of the matrix.
- void cmatrix< T >::push_row_back (const std::vector< T > &val)

  Push a row in the back of the matrix.
- void cmatrix< T >::push_col_front (const std::vector< T > &val)

  Push a column in the front of the matrix.
- void cmatrix< T >::push_col_back (const std::vector< T > &val)

  Push a column in the back of the matrix.
- int cmatrix< T >::find_row (const std::function< bool(std::vector< T >)> &f) const
- int cmatrix< T >::find_row (const std::vector< T > &val) const

  Find the first row matching the given row.
- int cmatrix< T >::find_column (const std::function< bool(std::vector< T >)> &f) const

  Find the first column matching the condition.
- int cmatrix< T >::find_column (const std::vector< T > &val) const

  Find the first column matching the given column.
- std::pair< int, int > cmatrix< T >::find (const std::function< bool(T)> &f) const

  Find the first cell matching the condition.
- std::pair< int, int > cmatrix< T >::find (const T &val) const

  Find the first cell matching the given cell.
- std::vector< std::pair< size_t, size_t > > cmatrix< T >::find_all (const T &val) const

  Find all cells matching the condition.
- std::vector< std::pair< size_t, size_t > > cmatrix< T >::find_all (const std::function< bool(T)> &f) const

  Find all cells matching the condition.
- cmatrix< bool > cmatrix< T >::mask (const std::function< bool(T)> &f) const

  Create a mask of the matrix matching the condition.
- cmatrix< bool > cmatrix< T >::mask (const std::function< bool(T, T)> &f, const cmatrix< T > &m) const

  Create a mask of the matrix matching the mask of another matrix.
- cmatrix< bool > cmatrix< T >::not_ () const

  Negate the mask of the matrix.
- cmatrix< bool > cmatrix< T >::eq (const cmatrix< T > &m) const

  Check if each cell of the matrix are equals to the cells of another matrix.
- cmatrix< bool > cmatrix< T >::eq (const T &val) const

  Check if each cell of the matrix are equals to a value.
- cmatrix< bool > cmatrix< T >::neq (const cmatrix< T > &m) const

  Check if each cell of the matrix are not equals to the cells of another matrix.
- cmatrix< bool > cmatrix< T >::neq (const T &val) const

  Check if each cell of the matrix are not equals to a value.
- cmatrix< bool > cmatrix< T >::leq (const cmatrix< T > &m) const

  Check if each cell of the matrix are less or equals to the cells of another matrix.
- cmatrix< bool > cmatrix< T >::leq (const T &val) const

  Check if each cell of the matrix are less or equals to a value.
- cmatrix< bool > cmatrix< T >::geq (const cmatrix< T > &m) const

Check if each cell of the matrix are greater or equals to the cells of another matrix.

- cmatrix< bool > cmatrix< T >::geq (const T &val) const

  Check if each cell of the matrix are greater or equals to a value.
- cmatrix< bool > cmatrix< T >::lt (const cmatrix< T > &m) const

  Check if each cell of the matrix are less than the cells of another matrix.
- cmatrix< bool > cmatrix< T >::lt (const T &val) const

  Check if each cell of the matrix are less than a value.
- cmatrix< bool > cmatrix< T >::gt (const cmatrix< T > &m) const

  Check if each cell of the matrix are greater than the cells of another matrix.
- cmatrix< bool > cmatrix< T >::gt (const T &val) const

  Check if each cell of the matrix are greater than a value.
- void cmatrix< T >::remove_row (const size_t &n)

  Remove a row of the matrix.
- void cmatrix< T >::remove_column (const size_t &n)

  Remove a column of the matrix.
- void cmatrix< T >::concatenate (const cmatrix< T > &m, const unsigned int &axis=0)

  Concatenate a matrix to the matrix.

6.4.1 Detailed Description

6.4.2 Function Documentation

6.4.2.1 concatenate()

```
template<class T >
void cmatrix< T >::concatenate (
            const cmatrix< T > & m,
            const unsigned int & axis = 0 )
```

Concatenate a matrix to the matrix.

Parameters

m	The matrix to concatenate.
axis	The axis to concatenate. 0 for the rows, 1 for the columns. (default: 0)

Exceptions

std::invalid_argument	If the axis is not 0 or 1.
std::invalid_argument	If the dimensions of matrices are not equals.

6.4.2.2 eq() [1/2]

```
template<class T >
```

```
cmatrix< bool > cmatrix< T >::eq (
             const cmatrix< T > & m ) const
```

Check if each cell of the matrix are equals to the cells of another matrix.

Parameters

m	The matrix to compare.

Returns

cmatrix<bool> The mask of the matrix.

Exceptions

std::invalid_argument	If the dimensions of the matrices are not equals.

6.4.2.3 eq() [2/2]

```
template<class T >
cmatrix< bool > cmatrix< T >::eq (
             const T & val ) const
```

Check if each cell of the matrix are equals to a value.

Parameters

val	The value to compare.

Returns

cmatrix<bool> The mask of the matrix.

6.4.2.4 find() [1/2]

```
template<class T >
std::pair< int, int > cmatrix< T >::find (
             const std::function< bool(T)> & f ) const
```

Find the first cell matching the condition.

Parameters

f	The condition to satisfy. f(T value) -> bool

Returns

std::pair<int, int> The first index (row, column) of the cell. (-1, -1) if not found.

Note

The empty matrix always return (-1, -1).

6.4.2.5 find() [2/2]

```
template<class T >
std::pair< int, int > cmatrix< T >::find (
             const T & val ) const
```

Find the first cell matching the given cell.

Parameters

val	The cell to find.

Returns

std::pair<int, int> The first index (row, column) of the cell. (-1, -1) if not found.

Note

The cell must be of the same type of the matrix.

6.4.2.6 find_all() [1/2]

```
template<class T >
std::vector< std::pair< size_t, size_t > > cmatrix< T >::find_all (
             const std::function< bool(T)> & f ) const
```

Find all cells matching the condition.

Parameters

f	The condition to satisfy. f(T value) -> bool

Returns

std::vector<std::pair<size_t, size_t>> The indexes (row, column) of the cells.

Note

The empty matrix always return an empty vector.

6.4.2.7 find_all() [2/2]

```
template<class T >
std::vector< std::pair< size_t, size_t > > cmatrix< T >::find_all (
            const T & val ) const
```

Find all cells matching the condition.

Parameters

val	The value to find.

Returns

std::vector<std::pair<size_t, size_t>> The indexes (row, column) of the cells.

Note

The empty matrix always return an empty vector.

6.4.2.8 find_column() [1/2]

```
template<class T >
int cmatrix< T >::find_column (
            const std::function< bool(std::vector< T >)> & f ) const
```

Find the first column matching the condition.

Parameters

f	The condition to satisfy. f(std::vector<T> col) -> bool

Returns

int The first index of the column. -1 if not found.

Note

The empty matrix always return -1.

6.4.2.9 find_column() [2/2]

```
template<class T >
int cmatrix< T >::find_column (
             const std::vector< T > & val ) const
```

Find the first column matching the given column.

Parameters

val	The column to find.

Returns

int The first index of the row. -1 if not found.

Note

The column must be a vector of the same type of the matrix.

6.4.2.10 find_row() [1/2]

```
template<class T >
int cmatrix< T >::find_row (
             const std::function< bool(std::vector< T >)> & f ) const
```

@bried Find the first row matching the condition.

Parameters

f	The condition to satisfy. f(std::vector<T> row) -> bool

Returns

int The first index of the row. -1 if not found.

Note

The empty matrix always return -1.

6.4.2.11 find_row() [2/2]

```
template<class T >
int cmatrix< T >::find_row (
             const std::vector< T > & val ) const
```

Find the first row matching the given row.

Parameters

val	The row to find.

Returns

int The first index of the row. -1 if not found.

Note

The row must be a vector of the same type of the matrix.

6.4.2.12 geq() [1/2]

```
template<class T >
cmatrix< bool > cmatrix< T >::geq (
            const cmatrix< T > & m ) const
```

Check if each cell of the matrix are greater or equals to the cells of another matrix.

Parameters

m	The matrix to compare.

Returns

cmatrix<bool> The mask of the matrix.

Exceptions

std::invalid_argument	If the dimensions of the matrices are not equals.

6.4.2.13 geq() [2/2]

```
template<class T >
cmatrix< bool > cmatrix< T >::geq (
            const T & val ) const
```

Check if each cell of the matrix are greater or equals to a value.

Parameters

val	The value to compare.

Returns

cmatrix<bool> The mask of the matrix.

6.4.2.14 gt() [1/2]

```
template<class T >
cmatrix< bool > cmatrix< T >::gt (
            const cmatrix< T > & m ) const
```

Check if each cell of the matrix are greater than the cells of another matrix.

Parameters

m	The matrix to compare.

Returns

cmatrix<bool> The mask of the matrix.

Exceptions

std::invalid_argument	If the dimensions of the matrices are not equals.

6.4.2.15 gt() [2/2]

```
template<class T >
cmatrix< bool > cmatrix< T >::gt (
            const T & val ) const
```

Check if each cell of the matrix are greater than a value.

Parameters

val	The value to compare.

Returns

cmatrix<bool> The mask of the matrix.

6.4.2.16 insert_column()

```
template<class T >
void cmatrix< T >::insert_column (
             const size_t & pos,
             const std::vector< T > & val )
```

Insert a row in the matrix.

Parameters

pos	The index of the row to insert.
val	The value to insert.

Exceptions

std::out_of_range	If the index is out of range.
std::invalid_argument	If the size of the vector `val` is not equal to the number of columns of the matrix.

Note

The row must be a vector of the same type of the matrix.

PARALLELIZED METHOD with OpenMP.

6.4.2.17 insert_row()

```
template<class T >
void cmatrix< T >::insert_row (
             const size_t & pos,
             const std::vector< T > & val )
```

Insert a column in the matrix.

Parameters

pos	The index of the column to insert.
val	The value to insert.

Exceptions

std::out_of_range	If the index is out of range.
std::invalid_argument	If the size of the vector `val` is not equal to the number of rows of the matrix.

Note

The column must be a vector of the same type of the matrix.

6.4.2.18 leq() [1/2]

```
template<class T >
cmatrix< bool > cmatrix< T >::leq (
             const cmatrix< T > & m ) const
```

Check if each cell of the matrix are less or equals to the cells of another matrix.

Parameters

m	The matrix to compare.

Returns

cmatrix<bool> The mask of the matrix.

Exceptions

std::invalid_argument	If the dimensions of the matrices are not equals.

6.4.2.19 leq() [2/2]

```
template<class T >
cmatrix< bool > cmatrix< T >::leq (
             const T & val ) const
```

Check if each cell of the matrix are less or equals to a value.

Parameters

val	The value to compare.

Returns

cmatrix<bool> The mask of the matrix.

6.4.2.20 lt() [1/2]

```
template<class T >
cmatrix< bool > cmatrix< T >::lt (
             const cmatrix< T > & m ) const
```

Check if each cell of the matrix are less than the cells of another matrix.

Parameters

m	The matrix to compare.

Returns

cmatrix<bool> The mask of the matrix.

Exceptions

std::invalid_argument	If the dimensions of the matrices are not equals.

6.4.2.21 lt() [2/2]

```
template<class T >
cmatrix< bool > cmatrix< T >::lt (
            const T & val ) const
```

Check if each cell of the matrix are less than a value.

Parameters

val	The value to compare.

Returns

cmatrix<bool> The mask of the matrix.

6.4.2.22 mask() [1/2]

```
template<class T >
cmatrix< bool > cmatrix< T >::mask (
            const std::function< bool(T)> & f ) const
```

Create a mask of the matrix matching the condition.

Parameters

f	The condition to satisfy. f(T value) -> bool

Returns

cmatrix<bool> The mask of the matrix.

6.4.2.23 mask() [2/2]

```
template<class T >
cmatrix< bool > cmatrix< T >::mask (
            const std::function< bool(T, T)> & f,
            const cmatrix< T > & m ) const
```

Create a mask of the matrix matching the mask of another matrix.

Parameters

f	The condition to satisfy. f(T value, T value) -> bool
m	The mask of the matrix.

Returns

cmatrix<bool> The mask of the matrix.

Exceptions

std::invalid_argument	If the dimensions of the matrices are not equals.

6.4.2.24 neq() [1/2]

```
template<class T >
cmatrix< bool > cmatrix< T >::neq (
            const cmatrix< T > & m ) const
```

Check if each cell of the matrix are not equals to the cells of another matrix.

Parameters

m	The matrix to compare.

Returns

cmatrix<bool> The mask of the matrix.

Exceptions

std::invalid_argument	If the dimensions of the matrices are not equals.

6.4.2.25 neq() [2/2]

```
template<class T >
cmatrix< bool > cmatrix< T >::neq (
             const T & val ) const
```

Check if each cell of the matrix are not equals to a value.

Parameters

val	The value to compare.

Returns

cmatrix<bool> The mask of the matrix.

6.4.2.26 not_()

```
template<class T >
cmatrix<bool> cmatrix< T >::not_ ( ) const
```

Negate the mask of the matrix.

Returns

cmatrix<bool> The negated mask of the matrix.

Note

The type of the matrix must be bool.

6.4.2.27 push_col_back()

```
template<class T >
void cmatrix< T >::push_col_back (
             const std::vector< T > & val )
```

Push a column in the back of the matrix.

Parameters

val	The column to push.

Exceptions

std::invalid_argument	If the size of the vector `val` is not equal to the number of rows of the matrix.

Note

The column must be a vector of the same type of the matrix.

6.4.2.28 push_col_front()

```
template<class T >
void cmatrix< T >::push_col_front (
             const std::vector< T > & val )
```

Push a column in the front of the matrix.

Parameters

val	The column to push.

Exceptions

std::invalid_argument	If the size of the vector `val` is not equal to the number of rows of the matrix.

Note

The column must be a vector of the same type of the matrix.

6.4.2.29 push_row_back()

```
template<class T >
void cmatrix< T >::push_row_back (
             const std::vector< T > & val )
```

Push a row in the back of the matrix.

Parameters

val	The row to push.

Exceptions

std::invalid_argument	If the size of the vector `val` is not equal to the number of columns of the matrix.

Note

The row must be a vector of the same type of the matrix.

6.4.2.30 push_row_front()

```
template<class T >
void cmatrix< T >::push_row_front (
             const std::vector< T > & val )
```

Push a row in the front of the matrix.

Parameters

val	The row to push.

Exceptions

std::invalid_argument	If the size of the vector `val` is not equal to the number of columns of the matrix.

Note

The row must be a vector of the same type of the matrix.

6.4.2.31 remove_column()

```
template<class T >
void cmatrix< T >::remove_column (
             const size_t & n )
```

Remove a column of the matrix.

Parameters

n	The index of the column to remove.

Exceptions

std::out_of_range	If the index is out of range.
std::invalid_argument	If the matrix is empty.

6.4.2.32 remove_row()

```
template<class T >
void cmatrix< T >::remove_row (
             const size_t & n )
```

Remove a row of the matrix.

Parameters

n	The index of the row to remove.

Exceptions

std::out_of_range	If the index is out of range.
std::invalid_argument	If the matrix is empty.

6.5 CMatrixMath

Functions

- bool cmatrix< T >::near (const cmatrix< T > &val, const T &tolerance=1e-5) const

  Test if the matrix is near another matrix.
- bool cmatrix< T >::near (const T &val, const T &tolerance=1e-5) const

  Test if the matrix is near a value.
- bool cmatrix< T >::nearq (const cmatrix< T > &val, const T &tolerance=1e-5) const

  Test if the matrix is not near another matrix.
- bool cmatrix< T >::nearq (const T &val, const T &tolerance=1e-5) const

  Test if the matrix is not near a value.
- cmatrix< T > cmatrix< T >::matmul (const cmatrix< T > &m) const

  Get the product with another matrix.
- cmatrix< T > cmatrix< T >::matpow (const unsigned int &n) const

  Get the power of the matrix.
- cmatrix< T > cmatrix< T >::log () const

  Get the natural logarithm of the matrix.
- cmatrix< T > cmatrix< T >::log2 () const

  Get the log2 of the matrix.
- cmatrix< T > cmatrix< T >::log10 () const

  Get the log10 of the matrix.
- cmatrix< T > cmatrix< T >::exp () const

  Get the exponential of the matrix.

6.5.1 Detailed Description

6.5.2 Function Documentation

6.5.2.1 exp()

```
template<class T >
cmatrix< T > cmatrix< T >::exp
```

Get the exponential of the matrix.

Returns

cmatrix<T> The result of the exponential.

Note

PARALLELIZED METHOD with OpenMP.

6.5.2.2 log()

```
template<class T >
cmatrix< T > cmatrix< T >::log
```

Get the natural logarithm of the matrix.

Returns

cmatrix<T> The result of the log.

Note

PARALLELIZED METHOD with OpenMP.

6.5.2.3 log10()

```
template<class T >
cmatrix< T > cmatrix< T >::log10
```

Get the log10 of the matrix.

Returns

cmatrix<T> The result of the log.

Note

PARALLELIZED METHOD with OpenMP.

6.5.2.4 log2()

```
template<class T >
cmatrix< T > cmatrix< T >::log2
```

Get the log2 of the matrix.

Returns

cmatrix<T> The result of the log.

Note

PARALLELIZED METHOD with OpenMP.

6.5.2.5 matmul()

```
template<class T >
cmatrix< T > cmatrix< T >::matmul (
             const cmatrix< T > & m ) const
```

Get the product with another matrix.

Parameters

m	The matrix to multiply.

Returns

cmatrix<T> The result of the product.

Exceptions

std::invalid_argument	If the number of columns of the matrix is not equal to the number of rows of the matrix `m`.

Note

PARALLELIZED METHOD with OpenMP.

6.5.2.6 matpow()

```
template<class T >
cmatrix< T > cmatrix< T >::matpow (
             const unsigned int & n ) const
```

Get the power of the matrix.

Parameters

n	The power.

Returns

cmatrix<T> The result of the power.

Exceptions

std::invalid_argument	If the matrix is not a square matrix.

Note

PARALLELIZED METHOD with OpenMP.

6.5.2.7 near() [1/2]

```
template<class T >
bool cmatrix< T >::near (
             const cmatrix< T > & val,
             const T & tolerance = 1e-5 ) const
```

Test if the matrix is near another matrix.

Parameters

val	The matrix to test.
tolerance	The tolerance of the test. (default: 1e-5)

Returns

true If the matrix is near the matrix `val`.

false If the matrix is not near the matrix `val`.

6.5.2.8 near() [2/2]

```
template<class T >
bool cmatrix< T >::near (
             const T & val,
             const T & tolerance = 1e-5 ) const
```

Test if the matrix is near a value.

Parameters

val	The value to test.
tolerance	The tolerance of the test. (default: 1e-5)

Returns

true If the matrix is near the value `val`.

false If the matrix is not near the value `val`.

6.5.2.9 nearq() [1/2]

```
template<class T >
bool cmatrix< T >::nearq (
             const cmatrix< T > & val,
             const T & tolerance = 1e-5 ) const
```

Test if the matrix is not near another matrix.

Parameters

val	The matrix to test.
tolerance	The tolerance of the test. (default: 1e-5)

Returns

true If the matrix is not near the matrix `val`.

false If the matrix is near the matrix `val`.

6.5.2.10 nearq() [2/2]

```
template<class T >
bool cmatrix< T >::nearq (
             const T & val,
             const T & tolerance = 1e-5 ) const
```

Test if the matrix is not near a value.

Parameters

val	The value to test.
tolerance	The tolerance of the test. (default: 1e-5)

Returns

true If the matrix is not near the value `val`.

false If the matrix is near the value `val`.

6.6 CMatrixOperator

Functions

- cmatrix< T > cmatrix< T >::__map_op_arithmetic (const std::function< T(T, T)> &f, const cmatrix< T > &m) const

  Apply a operator to each cell of the matrix.
- cmatrix< T > cmatrix< T >::__map_op_arithmetic (const std::function< T(T, T)> &f, const T &val) const

  Apply a operator to each cell of the matrix.
- cmatrix< T > & cmatrix< T >::operator= (const std::initializer_list< std::initializer_list< T >> &m)

  The assignment operator.
- cmatrix< T > & cmatrix< T >::operator= (const cmatrix< T > &m)

  The assignment operator.
- bool cmatrix< T >::operator== (const cmatrix< T > &m) const

  The equality operator.
- bool cmatrix< T >::operator!= (const cmatrix< T > &m) const

  The inequality operator.
- cmatrix< bool > cmatrix< T >::operator== (const T &n) const

  The equality operator comparing the matrix with a value.
- cmatrix< bool > cmatrix< T >::operator!= (const T &n) const

  The inequality operator comparing the matrix with a value.
- cmatrix< bool > cmatrix< T >::operator< (const cmatrix< T > &m) const

  The strictly less than operator comparing the matrix with another matrix.
- cmatrix< bool > cmatrix< T >::operator< (const T &n) const

  The strictly less than operator comparing the matrix with a value.
- cmatrix< bool > cmatrix< T >::operator<= (const cmatrix< T > &m) const

  The less than operator comparing the matrix with another matrix.
- cmatrix< bool > cmatrix< T >::operator<= (const T &n) const

  The less than operator comparing the matrix with a value.
- cmatrix< bool > cmatrix< T >::operator> (const cmatrix< T > &m) const

  The strictly greater than operator comparing the matrix with another matrix.
- cmatrix< bool > cmatrix< T >::operator> (const T &n) const

  The strictly greater than operator comparing the matrix with a value.
- cmatrix< bool > cmatrix< T >::operator>= (const cmatrix< T > &m) const

  The greater than operator comparing the matrix with another matrix.
- cmatrix< bool > cmatrix< T >::operator>= (const T &n) const

  The greater than operator comparing the matrix with a value.
- cmatrix< T > cmatrix< T >::operator+ (const cmatrix< T > &m) const

  The addition operator.
- cmatrix< T > cmatrix< T >::operator+ (const T &n) const

  The addition operator.
- cmatrix< T > cmatrix< T >::operator- (const cmatrix< T > &m) const

  The subtraction operator.
- cmatrix< T > cmatrix< T >::operator- (const T &val) const

  The subtraction operator.
- cmatrix< T > cmatrix< T >::operator∗ (const cmatrix< T > &m) const

  The multiplication operator element-wise.
- cmatrix< T > cmatrix< T >::operator∗ (const T &n) const

  The multiplication operator.
- cmatrix< T > cmatrix< T >::operator/ (const T &n) const

The division operator.

- cmatrix< T > cmatrix< T >::operator^ (const unsigned int &m) const

    The power operator element-wise.
- cmatrix< T > & cmatrix< T >::operator+= (const cmatrix< T > &m)

    The addition assignment operator.
- cmatrix< T > & cmatrix< T >::operator+= (const T &n)

    The addition assignment operator.
- cmatrix< T > & cmatrix< T >::operator-= (const cmatrix< T > &m)

    The subtraction assignment operator.
- cmatrix< T > & cmatrix< T >::operator-= (const T &n)

    The subtraction assignment operator.
- cmatrix< T > & cmatrix< T >::operator*= (const cmatrix< T > &m)

    The multiplication assignment operator.
- cmatrix< T > & cmatrix< T >::operator*= (const T &n)

    The multiplication assignment operator.
- cmatrix< T > & cmatrix< T >::operator/= (const T &n)

    The division assignment operator.
- cmatrix< T > & cmatrix< T >::operator^= (const unsigned int &m)

    The power assignment operator.

Friends

- template<class U >
  std::ostream & cmatrix< T >::operator<< (std::ostream &out, const cmatrix< U > &m)

    The output operator.
- template<class U >
  cmatrix< U > cmatrix< T >::operator+ (const U &n, const cmatrix< U > &m)

    The addition operator.
- template<class U >
  cmatrix< U > cmatrix< T >::operator- (const U &n, const cmatrix< U > &m)

    The subtraction operator.
- template<class U >
  cmatrix< U > cmatrix< T >::operator- (const cmatrix< U > &m)

    The negation operator.
- template<class U >
  cmatrix< U > cmatrix< T >::operator* (const U &n, const cmatrix< U > &m)

    The multiplication operator.

6.6.1 Detailed Description

6.6.2 Function Documentation

6.6.2.1 __map_op_arithmetic() [1/2]

```
template<class T >
cmatrix< T > cmatrix< T >::__map_op_arithmetic (
            const std::function< T(T, T)> & f,
            const cmatrix< T > & m ) const  [private]
```

Apply a operator to each cell of the matrix.

Parameters

f	The operator to apply. f(T value, T value) -> T
m	The matrix to apply.

Returns

cmatrix<T> The result of the operator.

Note

PARALLELIZED METHOD with OpenMP.

6.6.2.2 __map_op_arithmetic() [2/2]

```
template<class T >
cmatrix< T > cmatrix< T >::__map_op_arithmetic (
             const std::function< T(T, T)> & f,
             const T & val ) const  [private]
```

Apply a operator to each cell of the matrix.

Parameters

f	The operator to apply. f(T value, T value) -> T
val	The value to apply.

Returns

cmatrix<T> The result of the operator.

Note

PARALLELIZED METHOD with OpenMP.

6.6.2.3 operator"!=() [1/2]

```
template<class T >
bool cmatrix< T >::operator!= (
             const cmatrix< T > & m ) const
```

The inequality operator.

Parameters

m	The matrix to compare.

Returns

true If the matrices are not equal.

false If the matrices are equal.

Note

The matrix must be of the same type of the matrix.

6.6.2.4 operator"!=() [2/2]

```
template<class T >
cmatrix< bool > cmatrix< T >::operator!= (
             const T & n ) const
```

The inequality operator comparing the matrix with a value.

Parameters

val	The value to compare.

Returns

cmatrix<bool> The matrix of booleans.

6.6.2.5 operator*() [1/2]

```
template<class T >
cmatrix< T > cmatrix< T >::operator* (
             const cmatrix< T > & m ) const
```

The multiplication operator element-wise.

Parameters

m	The matrix to multiply.

Returns

cmatrix<T> The product of the matrices.

Note

The matrix must be of the same type of the matrix.

PARALLELIZED METHOD with OpenMP.

6.6.2.6 operator*() [2/2]

```
template<class T >
cmatrix< T > cmatrix< T >::operator* (
            const T & n ) const
```

The multiplication operator.

Parameters

n	The value to multiply.

Returns

cmatrix<T> The product of the matrices.

6.6.2.7 operator*=() [1/2]

```
template<class T >
cmatrix< T > & cmatrix< T >::operator*= (
            const cmatrix< T > & m )
```

The multiplication assignment operator.

Parameters

m	The matrix to multiply.

Returns

cmatrix<T>& The product of the matrices.

Note

The matrix must be of the same type of the matrix.

PARALLELIZED METHOD with OpenMP.

6.6.2.8 operator*=() [2/2]

```
template<class T >
cmatrix< T > & cmatrix< T >::operator*= (
            const T & n )
```

The multiplication assignment operator.

Parameters

n	The value to multiply.

Returns

cmatrix<T>& The product of the matrices.

Note

PARALLELIZED METHOD with OpenMP.

6.6.2.9 operator+() [1/2]

```
template<class T >
cmatrix< T > cmatrix< T >::operator+ (
            const cmatrix< T > & m ) const
```

The addition operator.

Parameters

m	The matrix to add.

Returns

cmatrix<T> The sum of the matrices.

Note

The matrix must be of the same type of the matrix.
PARALLELIZED METHOD with OpenMP.

6.6.2.10 operator+() [2/2]

```
template<class T >
cmatrix< T > cmatrix< T >::operator+ (
            const T & n ) const
```

The addition operator.

Parameters

n	The value to add.

Returns

cmatrix<T> The sum of the matrices.

Note

PARALLELIZED METHOD with OpenMP.

6.6.2.11 operator+=() [1/2]

```
template<class T >
cmatrix< T > & cmatrix< T >::operator+= (
            const cmatrix< T > & m )
```

The addition assignment operator.

Parameters

m	The matrix to add.

Returns

cmatrix<T>& The sum of the matrices.

Note

The matrix must be of the same type of the matrix.

PARALLELIZED METHOD with OpenMP.

6.6.2.12 operator+=() [2/2]

```
template<class T >
cmatrix< T > & cmatrix< T >::operator+= (
            const T & n )
```

The addition assignment operator.

Parameters

n	The value to add.

Returns

cmatrix<T>& The sum of the matrices.

Note

PARALLELIZED METHOD with OpenMP.

6.6.2.13 operator-() [1/2]

```
template<class T >
cmatrix< T > cmatrix< T >::operator- (
             const cmatrix< T > & m ) const
```

The subtraction operator.

Parameters

m	The matrix to subtract.

Returns

cmatrix<T> The difference of the matrices.

Note

PARALLELIZED METHOD with OpenMP.

The matrix must be of the same type of the matrix.

6.6.2.14 operator-() [2/2]

```
template<class T >
cmatrix< T > cmatrix< T >::operator- (
             const T & val ) const
```

The subtraction operator.

Parameters

n	The value to subtract.

Returns

cmatrix<T> The difference of the matrices.

Note

PARALLELIZED METHOD with OpenMP.

6.6.2.15 operator-=() [1/2]

```
template<class T >
cmatrix< T > & cmatrix< T >::operator-= (
            const cmatrix< T > & m )
```

The subtraction assignment operator.

Parameters

m	The matrix to subtract.

Returns

cmatrix<T>& The difference of the matrices.

Note

The matrix must be of the same type of the matrix.

PARALLELIZED METHOD with OpenMP.

6.6.2.16 operator-=() [2/2]

```
template<class T >
cmatrix< T > & cmatrix< T >::operator-= (
            const T & n )
```

The subtraction assignment operator.

Parameters

n	The value to subtract.

Returns

cmatrix<T>& The difference of the matrices.

Note

PARALLELIZED METHOD with OpenMP.

6.6.2.17 operator/()

```
template<class T >
cmatrix< T > cmatrix< T >::operator/ (
            const T & n ) const
```

The division operator.

Parameters

n	The value to divide.

Returns

cmatrix<T> The quotient of the matrices.

Note

PARALLELIZED METHOD with OpenMP.

6.6.2.18 operator/=()

```
template<class T >
cmatrix< T > & cmatrix< T >::operator/= (
            const T & n )
```

The division assignment operator.

Parameters

n	The value to divide.

Returns

cmatrix<T>& The quotient of the matrices.

Note

PARALLELIZED METHOD with OpenMP.

6.6.2.19 operator<() [1/2]

```
template<class T >
cmatrix< bool > cmatrix< T >::operator< (
            const cmatrix< T > & m ) const
```

The strictly less than operator comparing the matrix with another matrix.

Parameters

m	The matrix to compare.

Returns

cmatrix<bool> The matrix of booleans.

6.6.2.20 operator<() [2/2]

```
template<class T >
cmatrix< bool > cmatrix< T >::operator< (
            const T & n ) const
```

The strictly less than operator comparing the matrix with a value.

Parameters

val	The value to compare.

Returns

cmatrix<bool> The matrix of booleans.

6.6.2.21 operator<=() [1/2]

```
template<class T >
cmatrix< bool > cmatrix< T >::operator<= (
            const cmatrix< T > & m ) const
```

The less than operator comparing the matrix with another matrix.

Parameters

m	The matrix to compare.

Returns

cmatrix<bool> The matrix of booleans.

6.6.2.22 operator<=() [2/2]

```
template<class T >
cmatrix< bool > cmatrix< T >::operator<= (
            const T & n ) const
```

The less than operator comparing the matrix with a value.

Parameters

val	The value to compare.

Returns

cmatrix<bool> The matrix of booleans.

6.6.2.23 operator=() [1/2]

```
template<class T >
cmatrix< T > & cmatrix< T >::operator= (
            const cmatrix< T > & m )
```

The assignment operator.

Parameters

m	The matrix to copy.

Returns

cmatrix<T>& The copied matrix.

Note

The matrix must be of the same type of the matrix.

6.6.2.24 operator=() [2/2]

```
template<class T >
cmatrix< T > & cmatrix< T >::operator= (
            const std::initializer_list< std::initializer_list< T >> & m )
```

The assignment operator.

Parameters

m	The matrix to copy.

Returns

cmatrix<T>& The copied matrix.

Note

The matrix must be of the same type of the matrix.

6.6.2.25 operator==() [1/2]

```
template<class T >
bool cmatrix< T >::operator== (
             const cmatrix< T > & m ) const
```

The equality operator.

Parameters

m	The matrix to compare.

Returns

true If the matrices are equal.

false If the matrices are not equal.

Note

The matrix must be of the same type of the matrix.

6.6.2.26 operator==() [2/2]

```
template<class T >
cmatrix< bool > cmatrix< T >::operator== (
             const T & n ) const
```

The equality operator comparing the matrix with a value.

Parameters

val	The value to compare.

Returns

cmatrix<bool> The matrix of booleans.

6.6.2.27 operator>() [1/2]

```
template<class T >
cmatrix< bool > cmatrix< T >::operator> (
            const cmatrix< T > & m ) const
```

The strictly greater than operator comparing the matrix with another matrix.

Parameters

m	The matrix to compare.

Returns

cmatrix<bool> The matrix of booleans.

6.6.2.28 operator>() [2/2]

```
template<class T >
cmatrix< bool > cmatrix< T >::operator> (
            const T & n ) const
```

The strictly greater than operator comparing the matrix with a value.

Parameters

val	The value to compare.

Returns

cmatrix<bool> The matrix of booleans.

6.6.2.29 operator>=() [1/2]

```
template<class T >
cmatrix< bool > cmatrix< T >::operator>= (
            const cmatrix< T > & m ) const
```

The greater than operator comparing the matrix with another matrix.

Parameters

m	The matrix to compare.

Returns

cmatrix<bool> The matrix of booleans.

6.6.2.30 operator>=() [2/2]

```
template<class T >
cmatrix< bool > cmatrix< T >::operator>= (
              const T & n ) const
```

The greater than operator comparing the matrix with a value.

Parameters

val	The value to compare.

Returns

cmatrix<bool> The matrix of booleans.

6.6.2.31 operator^()

```
template<class T >
cmatrix< T > cmatrix< T >::operator^ (
              const unsigned int & m ) const
```

The power operator element-wise.

Parameters

m	The power. Must be a positive integer.

Returns

cmatrix<T> The powered matrix.

Exceptions

std::invalid_argument	If the matrix is not a square matrix.

6.6.2.32 operator^=()

```
template<class T >
cmatrix< T > & cmatrix< T >::operator^= (
            const unsigned int & m )
```

The power assignment operator.

Parameters

m	The power. Must be a positive integer.

Returns

cmatrix<T>& The powered matrix.

Exceptions

std::invalid_argument	If the matrix is not a square matrix.

6.6.3 Friends

6.6.3.1 operator*

```
template<class T >
template<class U >
cmatrix<U> operator* (
            const U & n,
            const cmatrix< U > & m ) [friend]
```

The multiplication operator.

Parameters

n	The value to multiply.
m	The matrix to multiply.

Returns

cmatrix<T> The product of the matrices.

6.6.3.2 operator+

```
template<class T >
template<class U >
cmatrix<U> operator+ (
             const U & n,
             const cmatrix< U > & m )  [friend]
```

The addition operator.

Parameters

n	The value to add.
m	The matrix to add.

Returns

cmatrix<T> The sum of the matrices.

Note

PARALLELIZED METHOD with OpenMP.

6.6.3.3 operator- [1/2]

```
template<class T >
template<class U >
cmatrix<U> operator- (
             const cmatrix< U > & m )  [friend]
```

The negation operator.

Parameters

m	The matrix to negate.

Returns

cmatrix<T> The negated matrix.

Note

PARALLELIZED METHOD with OpenMP.

6.6.3.4 operator- [2/2]

```
template<class T >
template<class U >
cmatrix<U> operator- (
             const U & n,
             const cmatrix< U > & m )  [friend]
```

The subtraction operator.

Parameters

n	The value to subtract.
m	The matrix to subtract.

Returns

cmatrix<T> The difference of the matrices.

Note

PARALLELIZED METHOD with OpenMP.

6.6.3.5 operator<<

```
template<class T >
template<class U >
std::ostream& operator<< (
             std::ostream & out,
             const cmatrix< U > & m )  [friend]
```

The output operator.

Parameters

out	The output stream.
m	The matrix to print.

Returns

std::ostream& The output stream.

6.7 CMatrixSetter

Functions

- void cmatrix< T >::set_row (const size_t &n, const std::vector< T > &val)

  Set a row of the matrix.
- void cmatrix< T >::set_column (const size_t &n, const std::vector< T > &val)

  Set a column of the matrix.
- void cmatrix< T >::set_cell (const size_t &row, const size_t &col, const T &val)

  Set a cell of the matrix.
- void cmatrix< T >::set_diag (const std::vector< T > &val)

  Set the diagonal of the matrix.

6.7.1 Detailed Description

6.7.2 Function Documentation

6.7.2.1 set_cell()

```
template<class T >
void cmatrix< T >::set_cell (
             const size_t & row,
             const size_t & col,
             const T & val )
```

Set a cell of the matrix.

Parameters

row	The row of the cell to set.
col	The column of the cell to set.
val	The value to set.

Exceptions

std::out_of_range	If the index is out of range.

Note

The cell must be of the same type of the matrix.

6.7.2.2 set_column()

```
template<class T >
void cmatrix< T >::set_column (
             const size_t & n,
             const std::vector< T > & val )
```

Set a column of the matrix.

Parameters

n	The index of the column to set.
val	The value to set.

Exceptions

std::out_of_range	If the index is out of range.
std::invalid_argument	If the size of the vector `val` is not equal to the number of rows of the matrix.

Note

The column must be a vector of the same type of the matrix.

6.7.2.3 set_diag()

```
template<class T >
void cmatrix< T >::set_diag (
             const std::vector< T > & val )
```

Set the diagonal of the matrix.

Parameters

val	The diagonal to set.

Exceptions

std::invalid_argument	If the size of the vector `val` is not equal to the minimum of the number of rows and columns of the matrix.

Note

The diagonal must be a vector of the same type of the matrix.

6.7.2.4 set_row()

```
template<class T >
void cmatrix< T >::set_row (
             const size_t & n,
             const std::vector< T > & val )
```

Set a row of the matrix.

Parameters

n	The index of the row to set.
val	The value to set.

Exceptions

std::out_of_range	If the index is out of range.
std::invalid_argument	If the size of the vector `val` is not equal to the number of columns of the matrix.

Note

The row must be a vector of the same type of the matrix.

6.8 CMatrixStatic

Functions

- static bool cmatrix< T >::is_matrix (const std::vector< std::vector< T >> &m)

  Check if a nested vector is a matrix. To be a matrix, all the rows and columns must have the same length.
- static cmatrix< int > cmatrix< T >::randint (const size_t &height, const size_t &width, const int &min=0, const int &max=100, const int &seed=time(nullptr))

  Generate a random matrix of integers.
- static cmatrix< float > cmatrix< T >::randfloat (const size_t &height, const size_t &width, const float &min=0, const float &max=1, const int &seed=time(nullptr))

  Generate a random matrix of floats.
- static cmatrix< int > cmatrix< T >::zeros (const size_t &width, const size_t &height)

  Generate a matrix of zeros.
- static cmatrix< int > cmatrix< T >::identity (const size_t &size)

  Generate the identity matrix.
- static cmatrix< T > cmatrix< T >::merge (const cmatrix< T > &m1, const cmatrix< T > &m2, const unsigned int &axis=0)

  Merge two matrices.

6.8.1 Detailed Description

6.8.2 Function Documentation

6.8.2.1 identity()

```
template<class T >
static cmatrix<int> cmatrix< T >::identity (
            const size_t & size )  [static]
```

Generate the identity matrix.

Parameters

size	The number of rows and columns.

Returns

cmatrix<int> The identity matrix.

6.8.2.2 is_matrix()

```
template<class T >
bool cmatrix< T >::is_matrix (
            const std::vector< std::vector< T >> & m )  [static]
```

Check if a nested vector is a matrix. To be a matrix, all the rows and columns must have the same length.

Parameters

m	The nested vector to check.

Returns

true If the nested vector is a matrix.

false If the nested vector is not a matrix.

6.8.2.3 merge()

```
template<class T >
cmatrix< T > cmatrix< T >::merge (
            const cmatrix< T > & m1,
            const cmatrix< T > & m2,
            const unsigned int & axis = 0 )  [static]
```

Merge two matrices.

Parameters

m1	The first matrix.
m2	The second matrix.
axis	The axis to merge. 0 for the rows, 1 for the columns. (default: 0)

Returns

cmatrix<T> The merged matrix.

6.8.2.4 randfloat()

```
template<class T >
static cmatrix<float> cmatrix< T >::randfloat (
            const size_t & height,
            const size_t & width,
            const float & min = 0,
            const float & max = 1,
            const int & seed = time(nullptr) )  [static]
```

Generate a random matrix of floats.

Parameters

height	The number of rows.
width	The number of columns.
min	The minimum value of the matrix (included). (default: 0)
max	The maximum value of the matrix (included). (default: 1)
seed	The seed of the random generator. (default: time(nullptr))

Returns

cmatrix<float> The random matrix of floats.

6.8.2.5 randint()

```
template<class T >
static cmatrix<int> cmatrix< T >::randint (
             const size_t & height,
             const size_t & width,
             const int & min = 0,
             const int & max = 100,
             const int & seed = time(nullptr) )  [static]
```

Generate a random matrix of integers.

Parameters

height	The number of height.
width	The number of columns.
min	The minimum value of the matrix (included). (default: 0)
max	The maximum value of the matrix (included). (default: 100)
seed	The seed of the random generator. (default: time(nullptr))

Returns

cmatrix<int> The random matrix of integers.

6.8.2.6 zeros()

```
template<class T >
static cmatrix<int> cmatrix< T >::zeros (
             const size_t & width,
             const size_t & height )  [static]
```

Generate a matrix of zeros.

Parameters

width	The number of columns.
height	The number of rows.

Returns

cmatrix<int> The matrix of zeros.

6.9 CMatrixStatistics

Functions

- cmatrix< float > cmatrix< T >::__mean (const unsigned int &axis, std::true_type) const

  Compute the mean value for each row (axis: 0) or column (axis: 1) of the matrix. This method is used when the type of the matrix is arithmetic.
- cmatrix< float > cmatrix< T >::__mean (const unsigned int &axis, std::false_type) const

  Compute the mean value for each row (axis: 0) or column (axis: 1) of the matrix. This method is used when the type of the matrix is not arithmetic.
- cmatrix< float > cmatrix< T >::__std (const unsigned int &axis, std::true_type) const

  Compute the std value for each row (axis: 0) or column (axis: 1) of the matrix. This method is used when the type of the matrix is arithmetic.
- cmatrix< float > cmatrix< T >::__std (const unsigned int &axis, std::false_type) const

  Compute the std value for each row (axis: 0) or column (axis: 1) of the matrix. This method is used when the type of the matrix is not arithmetic.
- cmatrix< T > cmatrix< T >::min (const unsigned int &axis=0) const

  Get the minimum value for each row (axis: 0) or column (axis: 1) of the matrix.
- T cmatrix< T >::min_all () const

  Get the minimum value of all the elements of the matrix.
- cmatrix< T > cmatrix< T >::max (const unsigned int &axis=0) const

  Get the maximum value for each row (axis: 0) or column (axis: 1) of the matrix.
- T cmatrix< T >::max_all () const

  Get the maximum value of all the elements of the matrix.
- cmatrix< T > cmatrix< T >::sum (const unsigned int &axis=0, const T &zero=T()) const

  Get the sum of the matrix for each row (axis: 0) or column (axis: 1) of the matrix.
- T cmatrix< T >::sum_all (const T &zero=T()) const

  Get the sum of all the elements of the matrix.
- cmatrix< float > cmatrix< T >::mean (const unsigned int &axis=0) const

  Get the mean value for each row (axis: 0) or column (axis: 1) of the matrix.
- cmatrix< float > cmatrix< T >::std (const unsigned int &axis=0) const

  Get the standard deviation value for each row (axis: 0) or column (axis: 1) of the matrix.
- cmatrix< T > cmatrix< T >::median (const unsigned int &axis=0) const

  Get the median value for each row (axis: 0) or column (axis: 1) of the matrix.

6.9.1 Detailed Description

6.9.2 Function Documentation

6.9.2.1 __mean() [1/2]

```
template<typename T >
cmatrix< float > cmatrix< T >::__mean (
            const unsigned int & axis,
            std::false_type ) const [private]
```

Compute the mean value for each row (axis: 0) or column (axis: 1) of the matrix. This method is used when the type of the matrix is not arithmetic.

Parameters

axis	The axis to get the mean value. 0 for the rows, 1 for the columns. (default: 0)
false_type	The type of the matrix is not arithmetic.

Exceptions

std::invalid_argument	If the matrix is not arithmetic.

6.9.2.2 __mean() [2/2]

```
template<typename T >
cmatrix< float > cmatrix< T >::__mean (
             const unsigned int & axis,
             std::true_type  ) const  [private]
```

Compute the mean value for each row (axis: 0) or column (axis: 1) of the matrix. This method is used when the type of the matrix is arithmetic.

Parameters

axis	The axis to get the mean value. 0 for the rows, 1 for the columns. (default: 0)
true_type	The type of the matrix is arithmetic.

Returns

cmatrix<float> The mean value for each row or column of the matrix.

Exceptions

std::invalid_argument	If the axis is not 0 or 1.

6.9.2.3 __std() [1/2]

```
template<class T >
cmatrix< float > cmatrix< T >::__std (
             const unsigned int & axis,
             std::false_type  ) const  [private]
```

Compute the std value for each row (axis: 0) or column (axis: 1) of the matrix. This method is used when the type of the matrix is not arithmetic.

Parameters

axis	The axis to get the std value. 0 for the rows, 1 for the columns. (default: 0)
false_type	The type of the matrix is not arithmetic.

Exceptions

std::invalid_argument	If the matrix is not arithmetic.

6.9.2.4 __std() [2/2]

```
template<class T >
cmatrix< float > cmatrix< T >::__std (
              const unsigned int & axis,
              std::true_type  ) const  [private]
```

Compute the std value for each row (axis: 0) or column (axis: 1) of the matrix. This method is used when the type of the matrix is arithmetic.

Parameters

axis	The axis to get the std value. 0 for the rows, 1 for the columns. (default: 0)
true_type	The type of the matrix is arithmetic.

Returns

cmatrix<float> The std value for each row or column of the matrix.

Exceptions

std::invalid_argument	If the axis is not 0 or 1.

Note

PARALLELIZED METHOD with OpenMP.

6.9.2.5 max()

```
template<class T >
cmatrix< T > cmatrix< T >::max (
              const unsigned int & axis = 0 ) const
```

Get the maximum value for each row (axis: 0) or column (axis: 1) of the matrix.

Parameters

axis	The axis to get the maximum value. 0 for the rows, 1 for the columns. (default: 0)

Returns

cmatrix<T> The maximum value for each row or column of the matrix.

Exceptions

std::invalid_argument	If the axis is not 0 or 1.

Note

The type of the matrix must implement the operator >.

PARALLELIZED METHOD with OpenMP.

6.9.2.6 max_all()

```
template<class T >
T cmatrix< T >::max_all
```

Get the maximum value of all the elements of the matrix.

Returns

T The maximum value of all the elements of the matrix.

Exceptions

std::invalid_argument	If the matrix is empty.

Note

The type of the matrix must implement the operator >.

6.9.2.7 mean()

```
template<typename T >
cmatrix< float > cmatrix< T >::mean (
             const unsigned int & axis = 0 ) const
```

Get the mean value for each row (axis: 0) or column (axis: 1) of the matrix.

Parameters

axis	The axis to get the mean value. 0 for the rows, 1 for the columns. (default: 0)

Returns

cmatrix<float> The mean value for each row or column of the matrix.

Exceptions

std::invalid_argument	If the axis is not 0 or 1.
std::invalid_argument	If the matrix is not arithmetic.

Note

The matrix must be of arithmetic type.

6.9.2.8 median()

```
template<class T >
cmatrix< T > cmatrix< T >::median (
            const unsigned int & axis = 0 ) const
```

Get the median value for each row (axis: 0) or column (axis: 1) of the matrix.

Parameters

axis	The axis to get the median value. 0 for the rows, 1 for the columns. (default: 0)

Returns

cmatrix<T> The median value of the matrix for each row or column of the matrix.

Exceptions

std::invalid_argument	If the axis is not 0 or 1.

Note

The matrix must implement the operator <.

If the number of elements is even, the median is the smallest value of the two middle values.

PARALLELIZED METHOD with OpenMP.

6.9.2.9 min()

```
template<class T >
cmatrix< T > cmatrix< T >::min (
             const unsigned int & axis = 0 ) const
```

Get the minimum value for each row (axis: 0) or column (axis: 1) of the matrix.

Parameters

axis	The axis to get the minimum value. 0 for the rows, 1 for the columns. (default: 0)

Returns

cmatrix<T> The minimum value for each row or column of the matrix.

Exceptions

std::invalid_argument	If the axis is not 0 or 1.

Note

The type of the matrix must implement the operator <.

PARALLELIZED METHOD with OpenMP.

6.9.2.10 min_all()

```
template<class T >
T cmatrix< T >::min_all
```

Get the minimum value of all the elements of the matrix.

Returns

T The minimum value of all the elements of the matrix.

Exceptions

std::invalid_argument	If the matrix is empty.

Note

The type of the matrix must implement the operator <.

6.9.2.11 std()

```
template<class T >
cmatrix< float > cmatrix< T >::std (
            const unsigned int & axis = 0 ) const
```

Get the standard deviation value for each row (axis: 0) or column (axis: 1) of the matrix.

Parameters

axis	The axis to get the standard deviation. 0 for the rows, 1 for the columns. (default: 0)

Returns

cmatrix<float> The standard deviation for each row or column of the matrix.

Exceptions

std::invalid_argument	If the axis is not 0 or 1.
std::invalid_argument	If the matrix is not arithmetic.
std::invalid_argument	If the number of elements is less than 2 for the axis.

Note

The matrix must be of arithmetic type.

PARALLELIZED METHOD with OpenMP.

6.9.2.12 sum()

```
template<class T >
cmatrix< T > cmatrix< T >::sum (
            const unsigned int & axis = 0,
            const T & zero = T() ) const
```

Get the sum of the matrix for each row (axis: 0) or column (axis: 1) of the matrix.

Parameters

axis	The axis to get the sum. 0 for the rows, 1 for the columns. (default: 0)
zero	The zero value of the sum. (default: the value of the default constructor of the type T)

Returns

cmatrix<T> The sum of the matrix.

Exceptions

std::invalid_argument	If the axis is not 0 or 1.

Note

PARALLELIZED METHOD with OpenMP.

6.9.2.13 sum_all()

```
template<class T >
T cmatrix< T >::sum_all (
             const T & zero = T() ) const
```

Get the sum of all the elements of the matrix.

Parameters

zero	The zero value of the sum. (default: the value of the default constructor of the type T)

Returns

T The sum of all the elements of the matrix.

Chapter 7

Class Documentation

7.1 cmatrix< T > Class Template Reference

The main template class that can work with any data type.

```
#include <CMatrix.hpp>
```

Public Member Functions

- cmatrix (const std::initializer_list< std::initializer_list< T >> &m)

  Construct a new cmatrix object.
- cmatrix (const std::vector< std::vector< T >> &m)

  Construct a new cmatrix object.
- cmatrix ()

  Construct a new cmatrix object.
- cmatrix (const size_t &height, const size_t &width)

  Construct a new cmatrix object.
- cmatrix (const size_t &height, const size_t &width, const T &val)

  Construct a new cmatrix object.
- template<class U >
  cmatrix (const cmatrix< U > &m)

  Cast a matrix to another type.
- ∼cmatrix ()
- std::vector< T > rows_vec (const size_t &n) const

  Get a row of the matrix.
- std::vector< T > columns_vec (const size_t &n) const

  Get a column of the matrix as a flattened vector.
- cmatrix< T > rows (const size_t &ids) const

  Get the rows of the matrix.
- cmatrix< T > rows (const std::initializer_list< size_t > &ids) const

  Get the rows of the matrix.
- cmatrix< T > rows (const std::vector< size_t > &ids) const

  Get the rows of the matrix.
- cmatrix< T > columns (const size_t &ids) const

  Get the columns of the matrix.

- cmatrix< T > columns (const std::initializer_list< size_t > &ids) const

  Get the columns of the matrix.
- cmatrix< T > columns (const std::vector< size_t > &ids) const

  Get the columns of the matrix.
- cmatrix< T > cells (const size_t &row, const size_t &col) const

  Get the cells of the matrix.
- cmatrix< T > cells (const std::initializer_list< std::pair< size_t, size_t >> &ids) const

  Get the cells of the matrix.
- cmatrix< T > cells (const std::vector< std::pair< size_t, size_t >> &ids) const

  Get the cells of the matrix.
- T cell (const size_t &row, const size_t &col) const

  Get a cell of the matrix.
- cmatrix< T > slice_rows (const size_t &start, const size_t &end) const

  Get the rows between two indexes.
- cmatrix< T > slice_columns (const size_t &start, const size_t &end) const

  Get the columns between two indexes.
- size_t width () const

  The number of columns of the matrix.
- size_t height () const

  The number of rows of the matrix.
- std::pair< size_t, size_t > size () const

  The dimensions of the matrix.
- cmatrix< T > transpose () const

  Get the transpose of the matrix.
- std::vector< T > diag () const

  Get the diagonal of the matrix.
- void set_row (const size_t &n, const std::vector< T > &val)

  Set a row of the matrix.
- void set_column (const size_t &n, const std::vector< T > &val)

  Set a column of the matrix.
- void set_cell (const size_t &row, const size_t &col, const T &val)

  Set a cell of the matrix.
- void set_diag (const std::vector< T > &val)

  Set the diagonal of the matrix.
- void insert_row (const size_t &pos, const std::vector< T > &val)

  Insert a column in the matrix.
- void insert_column (const size_t &pos, const std::vector< T > &val)

  Insert a row in the matrix.
- void push_row_front (const std::vector< T > &val)

  Push a row in the front of the matrix.
- void push_row_back (const std::vector< T > &val)

  Push a row in the back of the matrix.
- void push_col_front (const std::vector< T > &val)

  Push a column in the front of the matrix.
- void push_col_back (const std::vector< T > &val)

  Push a column in the back of the matrix.
- int find_row (const std::function< bool(std::vector< T >)> &f) const
- int find_row (const std::vector< T > &val) const

  Find the first row matching the given row.
- int find_column (const std::function< bool(std::vector< T >)> &f) const

  Find the first column matching the condition.

- int find_column (const std::vector< T > &val) const

  Find the first column matching the given column.
- std::pair< int, int > find (const std::function< bool(T)> &f) const

  Find the first cell matching the condition.
- std::pair< int, int > find (const T &val) const

  Find the first cell matching the given cell.
- std::vector< std::pair< size_t, size_t > > find_all (const T &val) const

  Find all cells matching the condition.
- std::vector< std::pair< size_t, size_t > > find_all (const std::function< bool(T)> &f) const

  Find all cells matching the condition.
- cmatrix< bool > mask (const std::function< bool(T)> &f) const

  Create a mask of the matrix matching the condition.
- cmatrix< bool > mask (const std::function< bool(T, T)> &f, const cmatrix< T > &m) const

  Create a mask of the matrix matching the mask of another matrix.
- cmatrix< bool > not_ () const

  Negate the mask of the matrix.
- cmatrix< bool > eq (const cmatrix< T > &m) const

  Check if each cell of the matrix are equals to the cells of another matrix.
- cmatrix< bool > eq (const T &val) const

  Check if each cell of the matrix are equals to a value.
- cmatrix< bool > neq (const cmatrix< T > &m) const

  Check if each cell of the matrix are not equals to the cells of another matrix.
- cmatrix< bool > neq (const T &val) const

  Check if each cell of the matrix are not equals to a value.
- cmatrix< bool > leq (const cmatrix< T > &m) const

  Check if each cell of the matrix are less or equals to the cells of another matrix.
- cmatrix< bool > leq (const T &val) const

  Check if each cell of the matrix are less or equals to a value.
- cmatrix< bool > geq (const cmatrix< T > &m) const

  Check if each cell of the matrix are greater or equals to the cells of another matrix.
- cmatrix< bool > geq (const T &val) const

  Check if each cell of the matrix are greater or equals to a value.
- cmatrix< bool > lt (const cmatrix< T > &m) const

  Check if each cell of the matrix are less than the cells of another matrix.
- cmatrix< bool > lt (const T &val) const

  Check if each cell of the matrix are less than a value.
- cmatrix< bool > gt (const cmatrix< T > &m) const

  Check if each cell of the matrix are greater than the cells of another matrix.
- cmatrix< bool > gt (const T &val) const

  Check if each cell of the matrix are greater than a value.
- void remove_row (const size_t &n)

  Remove a row of the matrix.
- void remove_column (const size_t &n)

  Remove a column of the matrix.
- void concatenate (const cmatrix< T > &m, const unsigned int &axis=0)

  Concatenate a matrix to the matrix.
- bool is_empty () const

  Check if the matrix is empty.
- bool is_square () const

  Check if the matrix is a square matrix.
- bool is_diag () const

Check if the matrix is a diagonal matrix.
- bool is_identity () const

  Check if the matrix is the identity matrix.
- bool is_symetric () const

  Check if the matrix is a symmetric matrix.
- bool is_triangular_up () const

  Check if the matrix is an upper triangular matrix.
- bool is_triangular_low () const

  Check if the matrix is a lower triangular matrix.
- bool all (const std::function< bool(T)> &f) const

  Check if all the cells of the matrix satisfy a condition.
- bool all (const T &val) const

  Check if all the cells of the matrix are equal to a value.
- bool any (const std::function< bool(T)> &f) const

  Check if at least one cell of the matrix satisfy a condition.
- bool any (const T &val) const

  Check if at least one cell of the matrix is equal to a value.
- cmatrix< T > min (const unsigned int &axis=0) const

  Get the minimum value for each row (axis: 0) or column (axis: 1) of the matrix.
- T min_all () const

  Get the minimum value of all the elements of the matrix.
- cmatrix< T > max (const unsigned int &axis=0) const

  Get the maximum value for each row (axis: 0) or column (axis: 1) of the matrix.
- T max_all () const

  Get the maximum value of all the elements of the matrix.
- cmatrix< T > sum (const unsigned int &axis=0, const T &zero=T()) const

  Get the sum of the matrix for each row (axis: 0) or column (axis: 1) of the matrix.
- T sum_all (const T &zero=T()) const

  Get the sum of all the elements of the matrix.
- cmatrix< float > mean (const unsigned int &axis=0) const

  Get the mean value for each row (axis: 0) or column (axis: 1) of the matrix.
- cmatrix< float > std (const unsigned int &axis=0) const

  Get the standard deviation value for each row (axis: 0) or column (axis: 1) of the matrix.
- cmatrix< T > median (const unsigned int &axis=0) const

  Get the median value for each row (axis: 0) or column (axis: 1) of the matrix.
- bool near (const cmatrix< T > &val, const T &tolerance=1e-5) const

  Test if the matrix is near another matrix.
- bool near (const T &val, const T &tolerance=1e-5) const

  Test if the matrix is near a value.
- bool nearq (const cmatrix< T > &val, const T &tolerance=1e-5) const

  Test if the matrix is not near another matrix.
- bool nearq (const T &val, const T &tolerance=1e-5) const

  Test if the matrix is not near a value.
- cmatrix< T > matmul (const cmatrix< T > &m) const

  Get the product with another matrix.
- cmatrix< T > matpow (const unsigned int &n) const

  Get the power of the matrix.
- cmatrix< T > log () const

  Get the natural logarithm of the matrix.
- cmatrix< T > log2 () const

  Get the log2 of the matrix.

- cmatrix< T > log10 () const

  Get the log10 of the matrix.
- cmatrix< T > exp () const

  Get the exponential of the matrix.
- void print () const

  Print the matrix in the standard output.
- void clear ()

  Clear the matrix.
- cmatrix< T > copy () const

  Copy the matrix.
- void apply (const std::function< T(T, size_t, size_t)> &f)

  Apply a function to each cell of the matrix.
- void apply (const std::function< T(T)> &f)

  Apply a function to each cell of the matrix.
- cmatrix< T > map (const std::function< T(T, size_t, size_t)> &f) const

  Apply a function to each cell of the matrix and return the result.
- template<class U >
  cmatrix< U > map (const std::function< U(T, size_t, size_t)> &f) const

  Apply a function to each cell of the matrix and return the result.
- cmatrix< T > map (const std::function< T(T)> &f) const

  Apply a function to each cell of the matrix and return the result.
- template<class U >
  cmatrix< U > map (const std::function< U(T)> &f) const

  Apply a function to each cell of the matrix and return the result.
- void fill (const T &val)

  Fill the matrix with a value.
- std::vector< std::vector< T > > to_vector () const

  Convert the matrix to a vector.
- template<class U >
  cmatrix< U > cast () const

  Convert the matrix to a matrix of another type.
- cmatrix< int > to_int () const

  Convert the matrix to a matrix of integers.
- cmatrix< float > to_float () const

  Convert the matrix to a matrix of floats.
- cmatrix< std::string > to_string () const

  Convert the matrix to a matrix of strings.
- cmatrix< T > & operator= (const std::initializer_list< std::initializer_list< T >> &m)

  The assignment operator.
- cmatrix< T > & operator= (const cmatrix< T > &m)

  The assignment operator.
- bool operator== (const cmatrix< T > &m) const

  The equality operator.
- bool operator!= (const cmatrix< T > &m) const

  The inequality operator.
- cmatrix< bool > operator== (const T &n) const

  The equality operator comparing the matrix with a value.
- cmatrix< bool > operator!= (const T &n) const

  The inequality operator comparing the matrix with a value.
- cmatrix< bool > operator< (const cmatrix< T > &m) const

  The strictly less than operator comparing the matrix with another matrix.

- cmatrix< bool > operator< (const T &n) const

  The strictly less than operator comparing the matrix with a value.
- cmatrix< bool > operator<= (const cmatrix< T > &m) const

  The less than operator comparing the matrix with another matrix.
- cmatrix< bool > operator<= (const T &n) const

  The less than operator comparing the matrix with a value.
- cmatrix< bool > operator> (const cmatrix< T > &m) const

  The strictly greater than operator comparing the matrix with another matrix.
- cmatrix< bool > operator> (const T &n) const

  The strictly greater than operator comparing the matrix with a value.
- cmatrix< bool > operator>= (const cmatrix< T > &m) const

  The greater than operator comparing the matrix with another matrix.
- cmatrix< bool > operator>= (const T &n) const

  The greater than operator comparing the matrix with a value.
- cmatrix< T > operator+ (const cmatrix< T > &m) const

  The addition operator.
- cmatrix< T > operator+ (const T &n) const

  The addition operator.
- cmatrix< T > operator- (const cmatrix< T > &m) const

  The subtraction operator.
- cmatrix< T > operator- (const T &val) const

  The subtraction operator.
- cmatrix< T > operator* (const cmatrix< T > &m) const

  The multiplication operator element-wise.
- cmatrix< T > operator* (const T &n) const

  The multiplication operator.
- cmatrix< T > operator/ (const T &n) const

  The division operator.
- cmatrix< T > operator^ (const unsigned int &m) const

  The power operator element-wise.
- cmatrix< T > & operator+= (const cmatrix< T > &m)

  The addition assignment operator.
- cmatrix< T > & operator+= (const T &n)

  The addition assignment operator.
- cmatrix< T > & operator-= (const cmatrix< T > &m)

  The subtraction assignment operator.
- cmatrix< T > & operator-= (const T &n)

  The subtraction assignment operator.
- cmatrix< T > & operator*= (const cmatrix< T > &m)

  The multiplication assignment operator.
- cmatrix< T > & operator*= (const T &n)

  The multiplication assignment operator.
- cmatrix< T > & operator/= (const T &n)

  The division assignment operator.
- cmatrix< T > & operator^= (const unsigned int &m)

  The power assignment operator.
- cmatrix< int > to_int () const
- cmatrix< float > to_float () const
- cmatrix< bool > not_ () const
- cmatrix< int > randint (const size_t &height, const size_t &width, const int &min, const int &max, const int &seed)

- cmatrix< float > randfloat (const size_t &height, const size_t &width, const float &min, const float &max, const int &seed)
- cmatrix< int > zeros (const size_t &width, const size_t &height)
- cmatrix< int > identity (const size_t &size)

Static Public Member Functions

- static bool is_matrix (const std::vector< std::vector< T >> &m)

  Check if a nested vector is a matrix. To be a matrix, all the rows and columns must have the same length.
- static cmatrix< int > randint (const size_t &height, const size_t &width, const int &min=0, const int &max=100, const int &seed=time(nullptr))

  Generate a random matrix of integers.
- static cmatrix< float > randfloat (const size_t &height, const size_t &width, const float &min=0, const float &max=1, const int &seed=time(nullptr))

  Generate a random matrix of floats.
- static cmatrix< int > zeros (const size_t &width, const size_t &height)

  Generate a matrix of zeros.
- static cmatrix< int > identity (const size_t &size)

  Generate the identity matrix.
- static cmatrix< T > merge (const cmatrix< T > &m1, const cmatrix< T > &m2, const unsigned int &axis=0)

  Merge two matrices.

Private Member Functions

- void __check_size (const std::tuple< size_t, size_t > &size) const

  Check if dimensions are equals to the dimensions of the matrix.
- void __check_size (const cmatrix< T > &m) const

  Check if dimensions are equals to the dimensions of the matrix.
- void __check_valid_row (const std::vector< T > &row) const

  Check if the vector is a valid row of the matrix.
- void __check_valid_col (const std::vector< T > &col) const

  Check if the vector is a valid column of the matrix.
- void __check_valid_diag (const std::vector< T > &diag) const

  Check if the diagonal is a valid diagonal of the matrix.
- void __check_valid_row_id (const size_t &n) const

  Check if the row is a valid row index of the matrix.
- void __check_valid_col_id (const size_t &n) const

  Check if the column is a valid column index of the matrix.
- void __check_expected_id (const size_t &n, const size_t &expected) const

  Check if the index is expected.
- void __check_expected_id (const size_t &n, const size_t &expectedBegin, const size_t &exepectedEnd) const

  Check if the index is expected.
- cmatrix< float > __mean (const unsigned int &axis, std::true_type) const

  Compute the mean value for each row (axis: 0) or column (axis: 1) of the matrix. This method is used when the type of the matrix is arithmetic.
- cmatrix< float > __mean (const unsigned int &axis, std::false_type) const

  Compute the mean value for each row (axis: 0) or column (axis: 1) of the matrix. This method is used when the type of the matrix is not arithmetic.
- cmatrix< float > __std (const unsigned int &axis, std::true_type) const

Compute the std value for each row (axis: 0) or column (axis: 1) of the matrix. This method is used when the type of the matrix is arithmetic.

- cmatrix< float > __std (const unsigned int &axis, std::false_type) const

  Compute the std value for each row (axis: 0) or column (axis: 1) of the matrix. This method is used when the type of the matrix is not arithmetic.
- cmatrix< T > __map_op_arithmetic (const std::function< T(T, T)> &f, const cmatrix< T > &m) const

  Apply a operator to each cell of the matrix.
- cmatrix< T > __map_op_arithmetic (const std::function< T(T, T)> &f, const T &val) const

  Apply a operator to each cell of the matrix.
- template<class U >
  cmatrix< U > __cast (std::true_type) const

  Convert the matrix to a matrix of another type.
- template<class U >
  cmatrix< U > __cast (std::false_type) const

  Convert the matrix to a matrix of another type.
- cmatrix< std::string > __to_string (std::true_type) const

  Convert the matrix to a string matrix.
- cmatrix< std::string > __to_string (std::false_type) const

  Convert the matrix to a string matrix.

Private Attributes

- std::vector< std::vector< T > > matrix = std::vector<std::vector<T>>()

Friends

- template<class U >
  std::ostream & operator<< (std::ostream &out, const cmatrix< U > &m)

  The output operator.
- template<class U >
  cmatrix< U > operator+ (const U &n, const cmatrix< U > &m)

  The addition operator.
- template<class U >
  cmatrix< U > operator- (const U &n, const cmatrix< U > &m)

  The subtraction operator.
- template<class U >
  cmatrix< U > operator- (const cmatrix< U > &m)

  The negation operator.
- template<class U >
  cmatrix< U > operator∗ (const U &n, const cmatrix< U > &m)

  The multiplication operator.

7.1.1 Detailed Description

template<class T>
class cmatrix< T >

The main template class that can work with any data type.

Template Parameters

T	The type of elements in the cmatrix.

7.1.2 Constructor & Destructor Documentation

7.1.2.1 cmatrix() [1/6]

```
template<class T >
cmatrix< T >::cmatrix (
            const std::initializer_list< std::initializer_list< T >> & m )
```

Construct a new cmatrix object.

Parameters

m	The matrix to copy.

Exceptions

std::invalid_argument	If the initializer list is not a matrix.
std::invalid_argument	If the type is bool.

7.1.2.2 cmatrix() [2/6]

```
template<class T >
cmatrix< T >::cmatrix (
            const std::vector< std::vector< T >> & m )
```

Construct a new cmatrix object.

Parameters

m	The vector matrix.

Exceptions

std::invalid_argument	If the vector is not a matrix.
std::invalid_argument	If the type is bool.

7.1.2.3 cmatrix() [3/6]

```
template<class T >
cmatrix< T >::cmatrix
```

Construct a new cmatrix object.

Exceptions

std::invalid_argument	If the type is bool.

7.1.2.4 cmatrix() [4/6]

```
template<class T >
cmatrix< T >::cmatrix (
            const size_t & height,
            const size_t & width )
```

Construct a new cmatrix object.

Parameters

height	The number of rows.
width	The number of columns.

Exceptions

std::invalid_argument	If the type is bool.

7.1.2.5 cmatrix() [5/6]

```
template<class T >
cmatrix< T >::cmatrix (
            const size_t & height,
            const size_t & width,
            const T & val )
```

Construct a new cmatrix object.

Parameters

height	The number of rows.
width	The number of columns.
val	The value to fill the matrix.

Exceptions

std::invalid_argument	If the type is bool.

7.1.2.6 cmatrix() [6/6]

```
template<class T >
template<class U >
cmatrix< T >::cmatrix (
            const cmatrix< U > & m )
```

Cast a matrix to another type.

Parameters

m	The matrix to copy.

Template Parameters

U	The type of the matrix to copy.

Exceptions

std::invalid_argument	If the type is bool.

7.1.2.7 ∼cmatrix()

```
template<class T >
cmatrix< T >::∼cmatrix
```

7.1.3 Member Function Documentation

7.1.3.1 identity()

```
cmatrix< int > cmatrix< int >::identity (
            const size_t & size )
```

7.1.3.2 not_()

```
cmatrix< bool > cmatrix< bool >::not_ ( ) const
```

7.1.3.3 randfloat()

```
cmatrix< float > cmatrix< float >::randfloat (
             const size_t & height,
             const size_t & width,
             const float & min,
             const float & max,
             const int & seed )
```

7.1.3.4 randint()

```
cmatrix< int > cmatrix< int >::randint (
             const size_t & height,
             const size_t & width,
             const int & min,
             const int & max,
             const int & seed )
```

7.1.3.5 to_float()

```
cmatrix< float > cmatrix< std::string >::to_float ( ) const
```

7.1.3.6 to_int()

```
cmatrix< int > cmatrix< std::string >::to_int ( ) const
```

7.1.3.7 zeros()

```
cmatrix< int > cmatrix< int >::zeros (
             const size_t & width,
             const size_t & height )
```

7.1.4 Member Data Documentation

7.1.4.1 matrix

```
template<class T >
std::vector<std::vector<T> > cmatrix< T >::matrix = std::vector<std::vector<T>>()  [private]
```

The documentation for this class was generated from the following files:

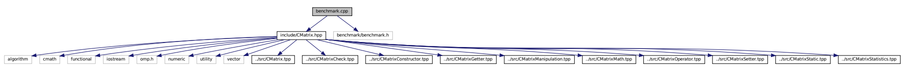
- include/CMatrix.hpp
- src/CMatrix.tpp
- src/CMatrixCheck.tpp
- src/CMatrixConstructor.tpp
- src/CMatrixGetter.tpp
- src/CMatrixManipulation.tpp
- src/CMatrixMath.tpp
- src/CMatrixOperator.tpp
- src/CMatrixSetter.tpp
- src/CMatrixStatic.tpp
- src/CMatrixStatistics.tpp

Chapter 8

File Documentation

8.1 benchmark.cpp File Reference

```
#include "include/CMatrix.hpp"
#include <benchmark/benchmark.h>
```
Include dependency graph for benchmark.cpp:



Functions

- static void bench (benchmark::State &state)
- BENCHMARK (bench) -> Unit(benchmark::kMillisecond)
- BENCHMARK_MAIN ()

8.1.1 Function Documentation

8.1.1.1 bench()

```
static void bench (
             benchmark::State & state )  [static]
```

8.1.1.2 BENCHMARK()

```
BENCHMARK (
             bench  ) -> Unit(benchmark::kMillisecond)
```

8.1.1.3 BENCHMARK_MAIN()

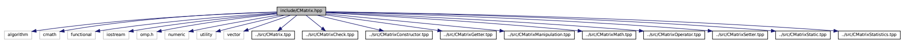
```
BENCHMARK_MAIN ( )
```

8.2 include/CMatrix.hpp File Reference

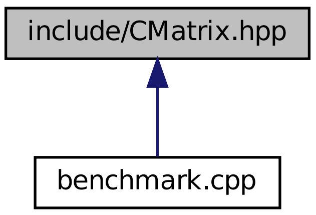
File containing the main template class of the 'cmatrix' library.

```
#include <algorithm>
#include <cmath>
#include <functional>
#include <iostream>
#include <omp.h>
#include <numeric>
#include <utility>
#include <vector>
#include "../src/CMatrix.tpp"
#include "../src/CMatrixCheck.tpp"
#include "../src/CMatrixConstructor.tpp"
#include "../src/CMatrixGetter.tpp"
#include "../src/CMatrixManipulation.tpp"
#include "../src/CMatrixMath.tpp"
#include "../src/CMatrixOperator.tpp"
#include "../src/CMatrixSetter.tpp"
#include "../src/CMatrixStatic.tpp"
#include "../src/CMatrixStatistics.tpp"
```

Include dependency graph for CMatrix.hpp:



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



Classes

- class cmatrix< T >

  The main template class that can work with any data type.

8.2.1 Detailed Description

File containing the main template class of the 'cmatrix' library.

Author

Manitas Bahri https://github.com/b-manitas

Date

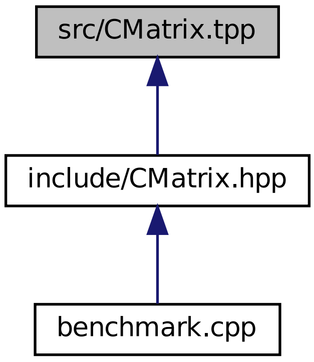
2023 @license MIT License

8.3 readme.md File Reference

8.4 src/CMatrix.tpp File Reference

This file contains the implementation of general methods of the class.

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



8.4.1 Detailed Description

This file contains the implementation of general methods of the class.

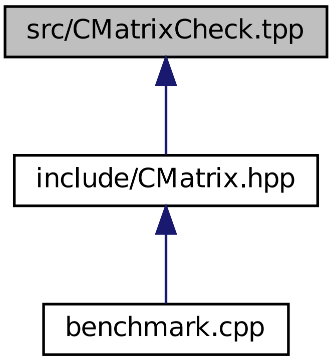
See also

cmatrix

8.5 src/CMatrixCheck.tpp File Reference

This file contains the implementation of methods to verify matrix conditions and perform checks before operations to prevent errors.

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



8.5.1 Detailed Description

This file contains the implementation of methods to verify matrix conditions and perform checks before operations to prevent errors.

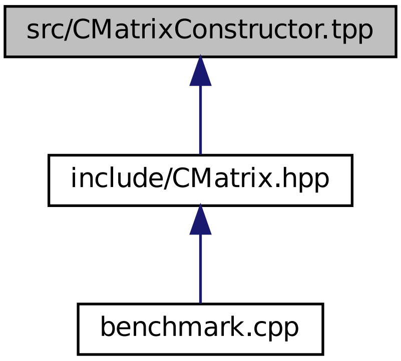
See also

cmatrix

8.6 src/CMatrixConstructor.tpp File Reference

This file contains the implementation of constructors and destructors.

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



8.6.1 Detailed Description

This file contains the implementation of constructors and destructors.

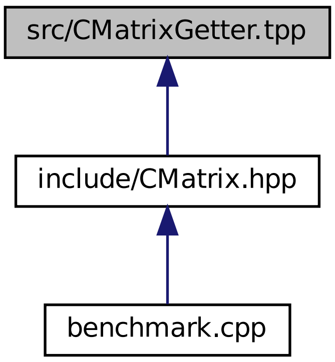
See also

cmatrix

8.7 src/CMatrixGetter.tpp File Reference

This file contains the implementation of methods to retrieve information from the matrix and get its elements.

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



8.7.1 Detailed Description

This file contains the implementation of methods to retrieve information from the matrix and get its elements.

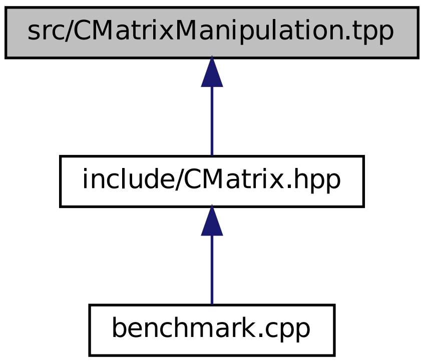
See also

cmatrix

8.8 src/CMatrixManipulation.tpp File Reference

This file contains the implementation of methods to find elements and to perform manipulations on the matrix.

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



8.8.1 Detailed Description

This file contains the implementation of methods to find elements and to perform manipulations on the matrix.

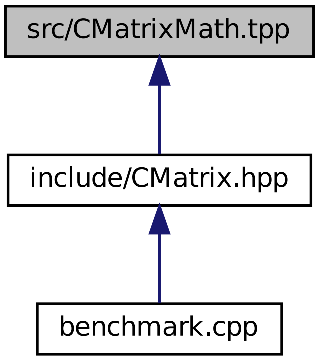
See also

cmatrix

8.9 src/CMatrixMath.tpp File Reference

This file contains the implementation of mathematical functions.

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



8.9.1 Detailed Description

This file contains the implementation of mathematical functions.

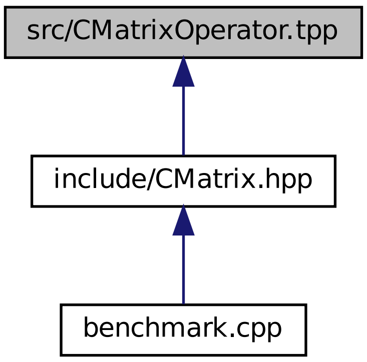
See also

cmatrix

8.10 src/CMatrixOperator.tpp File Reference

This file contains the implementation of operators.

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



Functions

- template<class T >
  cmatrix< T > operator+ (const T &n, const cmatrix< T > &m)
- template<class T >
  cmatrix< T > operator- (const T &n, const cmatrix< T > &m)
- template<class T >
  cmatrix< T > operator- (const cmatrix< T > &m)
- template<class T >
  cmatrix< T > operator* (const T &n, const cmatrix< T > &m)
- template<class T >
  std::ostream & operator<< (std::ostream &out, const cmatrix< T > &m)

8.10.1 Detailed Description

This file contains the implementation of operators.

See also

cmatrix

8.10.2 Function Documentation

8.10.2.1 operator*()

```
template<class T >
cmatrix<T> operator* (
            const T & n,
            const cmatrix< T > & m )
```

8.10.2.2 operator+()

```
template<class T >
cmatrix<T> operator+ (
            const T & n,
            const cmatrix< T > & m )
```

8.10.2.3 operator-() [1/2]

```
template<class T >
cmatrix<T> operator- (
            const cmatrix< T > & m )
```

8.10.2.4 operator-() [2/2]

```
template<class T >
cmatrix<T> operator- (
            const T & n,
            const cmatrix< T > & m )
```

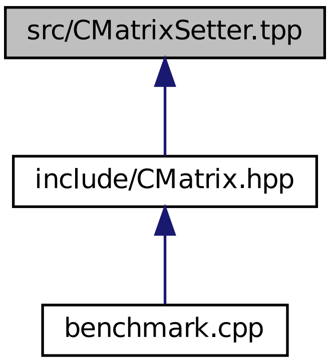
8.10.2.5 operator<<()

```
template<class T >
std::ostream& operator<< (
            std::ostream & out,
            const cmatrix< T > & m )
```

8.11 src/CMatrixSetter.tpp File Reference

This file contains the implementation of methods to set values in the matrix.

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



8.11.1 Detailed Description

This file contains the implementation of methods to set values in the matrix.

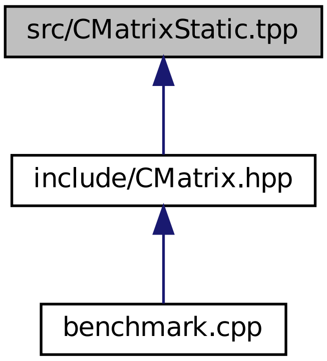
See also

cmatrix

8.12 src/CMatrixStatic.tpp File Reference

This file contains the implementation of static methods of the class.

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



8.12.1 Detailed Description

This file contains the implementation of static methods of the class.

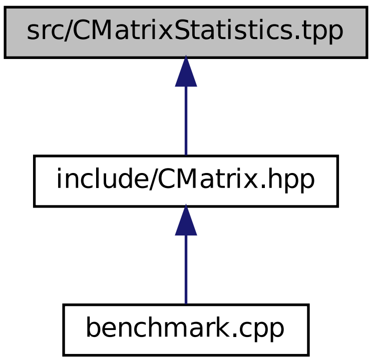
See also

cmatrix

8.13 src/CMatrixStatistics.tpp File Reference

This file contains the implementation of methods to perform statistical operations on the matrix.

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



8.13.1 Detailed Description

This file contains the implementation of methods to perform statistical operations on the matrix.

See also

cmatrix

Index