

GameOfLife

1.0

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1 Namespace Index	1
1.1 Namespace List	1
2 Hierarchical Index	3
2.1 Class Hierarchy	3
3 Class Index	5
3.1 Class List	5
4 File Index	7
4.1 File List	7
5 Namespace Documentation	9
5.1 functions Namespace Reference	9
5.1.1 Function Documentation	9
5.1.1.1 find_Cart_dim()	9
5.1.1.2 find_largest_divisor()	10
5.1.1.3 initialize_from_file()	10
5.1.1.4 initialize_random()	10
5.1.1.5 iteration_one_board()	10
6 Class Documentation	13
6.1 Array1D Class Reference	13
6.1.1 Detailed Description	13
6.1.2 Constructor & Destructor Documentation	14
6.1.2.1 Array1D()	14
6.1.2.2 ~Array1D()	14
6.1.3 Member Function Documentation	14
6.1.3.1 copy_into()	14
6.1.3.2 display()	14
6.1.3.3 operator()()	14
6.1.3.4 overwrite()	14
6.1.3.5 sub_arr()	15
6.1.4 Member Data Documentation	15
6.1.4.1 data	15
6.1.4.2 size	15
6.2 Board Class Reference	15
6.2.1 Detailed Description	17
6.2.2 Constructor & Destructor Documentation	17
6.2.2.1 Board()	17
6.2.3 Member Function Documentation	18
6.2.3.1 ghost_display()	18
6.2.3.2 init_from_motherboard()	18
6.2.3.3 set_bottom_ghost_row()	18

6.2.3.4 set_left_ghost_col()	18
6.2.3.5 set_right_ghost_col()	19
6.2.3.6 set_upper_ghost_row()	19
6.2.3.7 store_bottom_ghost_neighbour_row()	19
6.2.3.8 store_neighbour_row()	19
6.2.3.9 store_upper_ghost_neighbour_row()	20
6.2.3.10 update_board()	20
6.2.4 Member Data Documentation	20
6.2.4.1 bottom_ghost_row	20
6.2.4.2 left_ghost_col	20
6.2.4.3 right_ghost_col	20
6.2.4.4 temp1	20
6.2.4.5 temp2	20
6.2.4.6 temp3	21
6.2.4.7 upper_ghost_row	21
6.3 GameParams Class Reference	21
6.3.1 Detailed Description	22
6.3.2 Constructor & Destructor Documentation	22
6.3.2.1 GameParams()	22
6.3.3 Member Function Documentation	22
6.3.3.1 display()	22
6.3.3.2 readParams()	22
6.3.4 Member Data Documentation	22
6.3.4.1 board_file	22
6.3.4.2 board_size	22
6.3.4.3 evolve_steps	23
6.3.4.4 N_critical	23
6.3.4.5 num_threads	23
6.3.4.6 output_path	23
6.3.4.7 prob_live	23
6.3.4.8 random_data	23
6.3.4.9 save_interval	23
6.4 Grid Class Reference	24
6.4.1 Detailed Description	24
6.4.2 Constructor & Destructor Documentation	25
6.4.2.1 Grid()	25
6.4.2.2 ~Grid()	25
6.4.3 Member Function Documentation	25
6.4.3.1 display()	25
6.4.3.2 operator()()	25
6.4.3.3 overwrite_sub_board()	25
6.4.3.4 periodic_row()	26

6.4.3.5 read_data()	26
6.4.3.6 save()	26
6.4.3.7 store_col()	26
6.4.3.8 store_data()	27
6.4.3.9 store_row()	27
6.4.3.10 sub_col()	27
6.4.3.11 sub_row()	27
6.4.4 Member Data Documentation	29
6.4.4.1 data	29
6.4.4.2 N_col	29
6.4.4.3 N_nb_crit	29
6.4.4.4 N_row	29
6.4.4.5 size	29
7 File Documentation	31
7.1 src/lib/Array1D.hpp File Reference	31
7.2 Array1D.hpp	31
7.3 src/lib/Board.hpp File Reference	32
7.3.1 Macro Definition Documentation	32
7.3.1.1 BOARD_HPP	32
7.4 Board.hpp	32
7.5 src/lib/Functions.cpp File Reference	35
7.6 src/lib/Functions.hpp File Reference	35
7.7 Functions.hpp	35
7.8 src/lib/GameParams.hpp File Reference	36
7.9 GameParams.hpp	36
7.10 src/lib/Grid.hpp File Reference	37
7.11 Grid.hpp	37
7.12 src/main_parallel.cpp File Reference	39
7.12.1 Function Documentation	39
7.12.1.1 main()	39
7.13 src/main_simple.cpp File Reference	40
7.13.1 Function Documentation	40
7.13.1.1 main()	40
Index	41

Chapter 1

Namespace Index

1.1 Namespace List

Here is a list of all namespaces with brief descriptions:

functions	9
---------------------------	-------	---

Chapter 2

Hierarchical Index

2.1 Class Hierarchy

This inheritance list is sorted roughly, but not completely, alphabetically:

Array1D	13
GameParams	21
Grid	24
Board	15

Chapter 3

Class Index

3.1 Class List

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

Array1D	A class for 1D arrays	13
Board	15
GameParams	A class that stores the parameters for the Game of Life	21
Grid	A class for a 2D grid that contains the entire board for the Game of Life	24

Chapter 4

File Index

4.1 File List

Here is a list of all files with brief descriptions:

src/main_parallel.cpp	39
src/main_simple.cpp	40
src/lib/Array1D.hpp	31
src/lib/Board.hpp	32
src/lib/Functions.cpp	35
src/lib/Functions.hpp	35
src/lib/GameParams.hpp	36
src/lib/Grid.hpp	37

Chapter 5

Namespace Documentation

5.1 functions Namespace Reference

Functions

- void [initialize_random](#) ([Grid](#) *grid, [GameParams](#) *params)
Initialize the board with random data.
- void [initialize_from_file](#) ([Grid](#) *grid, [GameParams](#) *params, std::string file)
Initialize the board from a file.
- void [iteration_one_board](#) ([Board](#) *board, [GameParams](#) *params, [Array1D](#) *store_row, [Array1D](#) *store_col)
Update the board for a given number of steps.
- int [find_largest_divisor](#) (int n, int upper_bound)
- std::tuple< int, int > [find_Cart_dim](#) (int board_size, int nranks)
Find the dimensions of the Cartesian grid communicator, if possible.

5.1.1 Function Documentation

5.1.1.1 [find_Cart_dim\(\)](#)

```
std::tuple< int, int > functions::find_Cart_dim (  
    int board_size,  
    int nranks )
```

Find the dimensions of the Cartesian grid communicator, if possible.

Parameters

<i>board_size</i>	The size of the board
<i>nranks</i>	The number of ranks

Returns

A tuple with the dimensions of the Cartesian grid communicator

5.1.1.2 find_largest_divisor()

```
int functions::find_largest_divisor (
    int n,
    int upper_bound )
```

Find the largest divisor d of a number n that is smaller than \sqrt{n} and an upper bound

Parameters

<i>n</i>	The number to find the divisor of
<i>upper_bound</i>	The upper bound for the divisor

Returns

The largest divisor of n that is smaller than \sqrt{n}

5.1.1.3 initialize_from_file()

```
void functions::initialize_from_file (
    Grid * grid,
    GameParams * params,
    std::string file )
```

Initialize the board from a file.

Parameters

<i>grid</i>	The grid to be initialized
<i>params</i>	The parameters for the game
<i>file</i>	The file to read the data from

5.1.1.4 initialize_random()

```
void functions::initialize_random (
    Grid * grid,
    GameParams * params )
```

Initialize the board with random data.

Parameters

<i>grid</i>	The grid to be initialized
<i>params</i>	The parameters for the game

5.1.1.5 iteration_one_board()

```
void functions::iteration_one_board (
```



```
Board * board,  
GameParams * params,  
Array1D * store_row,  
Array1D * store_col )
```

Update the board for a given number of steps.

Parameters

<i>board</i>	The board to be updated
<i>params</i>	The parameters for the game, including the number of evolve steps
<i>store_row</i>	An array to store ghost rows
<i>store_col</i>	An array to store ghost columns

Chapter 6

Class Documentation

6.1 Array1D Class Reference

A class for 1D arrays.

```
#include <Array1D.hpp>
```

Public Member Functions

- [Array1D](#) (int [size](#))
Constructor.
- [~Array1D](#) ()
Destructor.
- int & [operator\(\)](#) (int i)
Overload the () operator to access the data.
- void [overwrite](#) ([Array1D](#) arr, int shift=0)
- void [copy_into](#) ([Array1D](#) *arr)
- [Array1D](#) [sub_arr](#) (int i_low, int i_upp)
- void [display](#) ()
Display the data of the array.

Public Attributes

- int [size](#)
Size of the array.
- int * [data](#)
Pointer to the data.

6.1.1 Detailed Description

A class for 1D arrays.

6.1.2 Constructor & Destructor Documentation

6.1.2.1 Array1D()

```
Array1D::Array1D (
    int size ) [inline]
```

Constructor.

6.1.2.2 ~Array1D()

```
Array1D::~~Array1D ( ) [inline]
```

Destructor.

6.1.3 Member Function Documentation

6.1.3.1 copy_into()

```
void Array1D::copy_into (
    Array1D * arr ) [inline]
```

Copy the data of the array into another array.

Parameters

<i>arr</i>	The array from which the data is to be copied. Accessed by reference.
------------	---

6.1.3.2 display()

```
void Array1D::display ( ) [inline]
```

Display the data of the array.

6.1.3.3 operator>()

```
int & Array1D::operator() (
    int i ) [inline]
```

Overload the () operator to access the data.

6.1.3.4 overwrite()

```
void Array1D::overwrite (
    Array1D arr,
    int shift = 0 ) [inline]
```

Overwrite the data of the array with the data of another array

Parameters

<i>arr</i>	The array to be copied into the current array
<i>shift</i>	The shift with which the array to be copied is loaded in the current array. If non-zero, arr needs to be smaller than the current array.

6.1.3.5 sub_arr()

```
Array1D Array1D::sub_arr (
    int i_low,
    int i_upp ) [inline]
```

Create a subarray of the current array.

Parameters

<i>i_low</i>	The lower index of the subarray
<i>i_upp</i>	The upper index of the subarray

6.1.4 Member Data Documentation**6.1.4.1 data**

```
int* Array1D::data
```

Pointer to the data.

6.1.4.2 size

```
int Array1D::size
```

Size of the array.

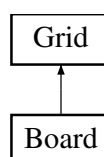
The documentation for this class was generated from the following file:

- [src/lib/Array1D.hpp](#)

6.2 Board Class Reference

```
#include <Board.hpp>
```

Inheritance diagram for Board:



Public Member Functions

- [Board](#) (int [N_row](#), int [N_col](#))
Constructor.
- void [init_from_motherboard](#) ([Grid](#) *motherboard, int row_low, int col_left)
Initialize the board with values from (a subgrid of) the motherboard.
- void [set_bottom_ghost_row](#) ([Array1D](#) *target)
Set the bottom ghost row based on an input array.
- void [set_upper_ghost_row](#) ([Array1D](#) *target)
Set the upper ghost row based on an input array.
- void [set_left_ghost_col](#) ([Array1D](#) *target)
Set the left ghost column based on an input array.
- void [set_right_ghost_col](#) ([Array1D](#) *target)
Set the right ghost column based on an input array.
- void [store_neighbour_row](#) ([Array1D](#) *store, int n_row)
Store the neighbour counts of a row in an array.
- void [store_upper_ghost_neighbour_row](#) ([Array1D](#) *store)
Store the neighbour counts of the upper ghost row in an array.
- void [store_bottom_ghost_neighbour_row](#) ([Array1D](#) *store)
Store the neighbour counts of the bottom ghost row in an array.
- void [ghost_display](#) ()
Display the board, including the ghost rows and columns.
- void [update_board](#) ()
Update the board based on the rules of the game of life.

Public Member Functions inherited from [Grid](#)

- [Grid](#) (int [N_row](#), int [N_col](#), int [N_nb_crit](#)=3)
Constructor.
- [~Grid](#) ()
Destructor.
- int & [operator\(\)](#) (int i, int j)
Overload the () operator to access the data.
- void [store_row](#) ([Array1D](#) *store, int n_row, int shift=0)
- void [store_col](#) ([Array1D](#) *store, int n_col)
- [Array1D](#) [sub_row](#) (int n_row, int i_low, int i_upp)
- [Array1D](#) [sub_col](#) (int n_col, int i_low, int i_upp)
- void [display](#) ()
Display the data of the grid.
- [Array1D](#) [periodic_row](#) (int n_row)
- void [save](#) (std::string file)
- void [store_data](#) (int *arr)
- void [read_data](#) (int *arr)
- void [overwrite_sub_board](#) (int *arr, int row_low, int row_upp, int col_low, int col_upp)

Public Attributes

- [Array1D bottom_ghost_row](#)
The ghost row at the bottom of the grid, including the corners.
- [Array1D upper_ghost_row](#)
The ghost row at the top of the grid, including the corners.
- [Array1D left_ghost_col](#)
The ghost column on the left side of the grid.
- [Array1D right_ghost_col](#)
The ghost column on the right side of the grid.
- [Array1D temp1](#)
Storage arrays to hold the horizontal neighbours counts in a row.
- [Array1D temp2](#)
- [Array1D temp3](#)

Public Attributes inherited from [Grid](#)

- [int N_row](#)
Number of rows in the grid.
- [int N_col](#)
Number of columns in the grid.
- [int * data](#)
Pointer to the data.
- [int N_nb_crit](#)
Number of critical neighbours used in the game rules.
- [int size](#)
Number of rows times the number of columns.

6.2.1 Detailed Description

A class inheriting from [Grid](#), that adds the functionality to update the board.

6.2.2 Constructor & Destructor Documentation

6.2.2.1 Board()

```
Board::Board (
    int N_row,
    int N_col ) [inline]
```

Constructor.

Parameters

N_row	The number of rows in the grid
N_col	The number of columns in the grid

6.2.3 Member Function Documentation

6.2.3.1 ghost_display()

```
void Board::ghost_display ( ) [inline]
```

Display the board, including the ghost rows and columns.

6.2.3.2 init_from_motherboard()

```
void Board::init_from_motherboard (
    Grid * motherboard,
    int row_low,
    int col_left ) [inline]
```

Initialize the board with values from (a subgrid of) the motherboard.

Parameters

<i>motherboard</i>	The motherboard grid to copy values from
<i>row_low</i>	The lowest row index to copy from the motherboard
<i>col_left</i>	The leftmost column index to copy from the motherboard

6.2.3.3 set_bottom_ghost_row()

```
void Board::set_bottom_ghost_row (
    Array1D * target ) [inline]
```

Set the bottom ghost row based on an input array.

Parameters

<i>target</i>	The array to copy values from
---------------	-------------------------------

6.2.3.4 set_left_ghost_col()

```
void Board::set_left_ghost_col (
    Array1D * target ) [inline]
```

Set the left ghost column based on an input array.

Parameters

<i>target</i>	The array to copy values from
---------------	-------------------------------

6.2.3.5 set_right_ghost_col()

```
void Board::set_right_ghost_col (
    Array1D * target ) [inline]
```

Set the right ghost column based on an input array.

Parameters

<i>target</i>	The array to copy values from
---------------	-------------------------------

6.2.3.6 set_upper_ghost_row()

```
void Board::set_upper_ghost_row (
    Array1D * target ) [inline]
```

Set the upper ghost row based on an input array.

Parameters

<i>target</i>	The array to copy values from
---------------	-------------------------------

6.2.3.7 store_bottom_ghost_neighbour_row()

```
void Board::store_bottom_ghost_neighbour_row (
    Array1D * store ) [inline]
```

Store the neighbour counts of the bottom ghost row in an array.

Parameters

<i>store</i>	The array to store the neighbour counts in
--------------	--

6.2.3.8 store_neighbour_row()

```
void Board::store_neighbour_row (
    Array1D * store,
    int n_row ) [inline]
```

Store the neighbour counts of a row in an array.

Parameters

<i>store</i>	The array to store the neighbour counts in
<i>n_row</i>	The row index to store the neighbour counts of

6.2.3.9 store_upper_ghost_neighbour_row()

```
void Board::store_upper_ghost_neighbour_row (
    Array1D * store ) [inline]
```

Store the neighbour counts of the upper ghost row in an array.

Parameters

<i>store</i>	The array to store the neighbour counts in
--------------	--

6.2.3.10 update_board()

```
void Board::update_board ( ) [inline]
```

Update the board based on the rules of the game of life.

6.2.4 Member Data Documentation

6.2.4.1 bottom_ghost_row

```
Array1D Board::bottom_ghost_row
```

The ghost row at the bottom of the grid, including the corners.

6.2.4.2 left_ghost_col

```
Array1D Board::left_ghost_col
```

The ghost column on the left side of the grid.

6.2.4.3 right_ghost_col

```
Array1D Board::right_ghost_col
```

The ghost column on the right side of the grid.

6.2.4.4 temp1

```
Array1D Board::temp1
```

Storage arrays to hold the horizontal neighbours counts in a row.

6.2.4.5 temp2

```
Array1D Board::temp2
```

6.2.4.6 temp3

`Array1D Board::temp3`

6.2.4.7 upper_ghost_row

`Array1D Board::upper_ghost_row`

The ghost row at the top of the grid, including the corners.

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

- `src/lib/Board.hpp`

6.3 GameParams Class Reference

A class that stores the parameters for the Game of Life.

```
#include <GameParams.hpp>
```

Public Member Functions

- `GameParams ()`
Default constructor.
- `void readParams (const std::string &filename)`
- `void display () const`
Function that displays the parameters.

Public Attributes

- `int board_size {10}`
The size of the board.
- `int N_critical {3}`
The number of critical neighbours for a cell to survive.
- `int save_interval {1}`
The interval at which the board is saved.
- `int evolve_steps {20}`
The number of steps over which the board is evolved.
- `int random_data {1}`
- `int num_threads {1}`
The number of OMP threads to use.
- `double prob_live {0.5}`
- `std::string board_file {"examples/"}`
The path to the initialization file, in case random_data is 0.
- `std::string output_path {"examples/"}`
The path where to store the output files.

6.3.1 Detailed Description

A class that stores the parameters for the Game of Life.

6.3.2 Constructor & Destructor Documentation

6.3.2.1 GameParams()

```
GameParams::GameParams ( ) [inline]
```

Default constructor.

6.3.3 Member Function Documentation

6.3.3.1 display()

```
void GameParams::display ( ) const [inline]
```

Function that displays the parameters.

6.3.3.2 readParams()

```
void GameParams::readParams (
    const std::string & filename ) [inline]
```

Function that reads the parameters from a text file

Parameters

<i>filename</i>	path to params file, parsed through command line
-----------------	--

6.3.4 Member Data Documentation

6.3.4.1 board_file

```
std::string GameParams::board_file {"examples/"}
```

The path to the initialization file, in case `random_data` is 0.

6.3.4.2 board_size

```
int GameParams::board_size {10}
```

The size of the board.

6.3.4.3 evolve_steps

```
int GameParams::evolve_steps {20}
```

The number of steps over which the board is evolved.

6.3.4.4 N_critical

```
int GameParams::N_critical {3}
```

The number of critical neighbours for a cell to survive.

6.3.4.5 num_threads

```
int GameParams::num_threads {1}
```

The number of OMP threads to use.

6.3.4.6 output_path

```
std::string GameParams::output_path {"examples/"}
```

The path where to store the output files.

6.3.4.7 prob_live

```
double GameParams::prob_live {0.5}
```

The probability that a cell is alive at the start, parameter in a Binomial distribution

6.3.4.8 random_data

```
int GameParams::random_data {1}
```

Whether to initialize the board with random data or from a file. 1: random, 0: file (board_file)

6.3.4.9 save_interval

```
int GameParams::save_interval {1}
```

The interval at which the board is saved.

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

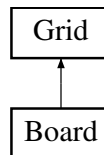
- [src/lib/GameParams.hpp](#)

6.4 Grid Class Reference

A class for a 2D grid that contains the entire board for the Game of Life.

```
#include <Grid.hpp>
```

Inheritance diagram for Grid:



Public Member Functions

- [Grid](#) (int [N_row](#), int [N_col](#), int [N_nb_crit](#)=3)
Constructor.
- [~Grid](#) ()
Destructor.
- int & [operator](#)() (int i, int j)
Overload the () operator to access the data.
- void [store_row](#) ([Array1D](#) *store, int n_row, int shift=0)
- void [store_col](#) ([Array1D](#) *store, int n_col)
- [Array1D](#) [sub_row](#) (int n_row, int i_low, int i_upp)
- [Array1D](#) [sub_col](#) (int n_col, int i_low, int i_upp)
- void [display](#) ()
Display the data of the grid.
- [Array1D](#) [periodic_row](#) (int n_row)
- void [save](#) (std::string file)
- void [store_data](#) (int *arr)
- void [read_data](#) (int *arr)
- void [overwrite_sub_board](#) (int *arr, int row_low, int row_upp, int col_low, int col_upp)

Public Attributes

- int [N_row](#)
Number of rows in the grid.
- int [N_col](#)
Number of columns in the grid.
- int * [data](#)
Pointer to the data.
- int [N_nb_crit](#)
Number of critical neighbours used in the game rules.
- int [size](#)
Number of rows times the number of columns.

6.4.1 Detailed Description

A class for a 2D grid that contains the entire board for the Game of Life.

6.4.2 Constructor & Destructor Documentation

6.4.2.1 Grid()

```
Grid::Grid (
    int N_row,
    int N_col,
    int N_nb_crit = 3 ) [inline]
```

Constructor.

6.4.2.2 ~Grid()

```
Grid::~~Grid ( ) [inline]
```

Destructor.

6.4.3 Member Function Documentation

6.4.3.1 display()

```
void Grid::display ( ) [inline]
```

Display the data of the grid.

6.4.3.2 operator>()

```
int & Grid::operator() (
    int i,
    int j ) [inline]
```

Overload the () operator to access the data.

6.4.3.3 overwrite_sub_board()

```
void Grid::overwrite_sub_board (
    int * arr,
    int row_low,
    int row_upp,
    int col_low,
    int col_upp ) [inline]
```

Overwrite a subgrid of the grid with the data in an array

Parameters

<i>arr</i>	The array from which the data is to be copied
<i>row_low</i>	The index of the lower row of the subgrid
<i>row_upp</i>	The index of the upper row of the subgrid
<i>col_low</i>	The index of the lower column of the subgrid
<i>col_upp</i>	The index of the upper column of the subgrid

6.4.3.4 periodic_row()

```
Array1D Grid::periodic_row (
    int n_row ) [inline]
```

Return a row, with one cell added to the left and right, for periodic boundary conditions

Parameters

<i>n_row</i>	The index of the row to be returned with the additional cells
--------------	---

6.4.3.5 read_data()

```
void Grid::read_data (
    int * arr ) [inline]
```

Read the data of the grid from an array

Parameters

<i>arr</i>	The array from which the data is to be read
------------	---

6.4.3.6 save()

```
void Grid::save (
    std::string file ) [inline]
```

Save the data of the grid to a file

Parameters

<i>file</i>	The name of the file to which the data is to be saved
-------------	---

6.4.3.7 store_col()

```
void Grid::store_col (
    Array1D * store,
    int n_col ) [inline]
```

Store a column of the grid in an [Array1D](#) object

Parameters

<i>store</i>	The Array1D object in which the column is to be stored
<i>n_col</i>	The index of the column to be stored

6.4.3.8 store_data()

```
void Grid::store_data (
    int * arr ) [inline]
```

Store the data of the grid in an array

Parameters

<i>arr</i>	The array in which the data is to be stored
------------	---

6.4.3.9 store_row()

```
void Grid::store_row (
    Array1D * store,
    int n_row,
    int shift = 0 ) [inline]
```

Store a row of the grid in an [Array1D](#) object

Parameters

<i>store</i>	The Array1D object in which the row is to be stored
<i>n_row</i>	The index of the row to be stored
<i>shift</i>	The shift with which the row is loaded in the Array1D object

6.4.3.10 sub_col()

```
Array1D Grid::sub_col (
    int n_col,
    int i_low,
    int i_upp ) [inline]
```

Return a subarray of a given column

Parameters

<i>n_col</i>	The index of the column from which the subarray is to be taken
<i>i_low</i>	The lower index of the subarray
<i>i_upp</i>	The upper index of the subarray

6.4.3.11 sub_row()

```
Array1D Grid::sub_row (
    int n_row,
    int i_low,
    int i_upp ) [inline]
```

Return a subarray of a given row

Parameters

<i>n_row</i>	The index of the row from which the subarray is to be taken
<i>i_low</i>	The lower index of the subarray
<i>i_upp</i>	The upper index of the subarray

6.4.4 Member Data Documentation

6.4.4.1 data

```
int* Grid::data
```

Pointer to the data.

6.4.4.2 N_col

```
int Grid::N_col
```

Number of columns in the grid.

6.4.4.3 N_nb_crit

```
int Grid::N_nb_crit
```

Number of critical neighbours used in the game rules.

6.4.4.4 N_row

```
int Grid::N_row
```

Number of rows in the grid.

6.4.4.5 size

```
int Grid::size
```

Number of rows times the number of columns.

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

- [src/lib/Grid.hpp](#)

Chapter 7

File Documentation

7.1 src/lib/Array1D.hpp File Reference

```
#include <iostream>
```

Classes

- class [Array1D](#)
A class for 1D arrays.

7.2 Array1D.hpp

[Go to the documentation of this file.](#)

```
00001 #include <iostream>
00002
00003 #ifndef ARRAY1D_HPP
00004 #define ARRAY1D_HPP
00005
00006 class Array1D {
00007 public:
00008     int size;
00009     int* data;
00010
00011     Array1D(int size) {
00012         this->size = size;
00013         this->data = new int[size];
00014     }
00015
00016     ~Array1D() { delete[] this->data; }
00017
00018     int& operator()(int i) { return this->data[i]; }
00019
00020     void overwrite(Array1D arr, int shift = 0) {
00021         for (int i = 0; i < arr.size; ++i) {
00022             data[i + shift] = arr(i);
00023         }
00024     }
00025
00026     void copy_into(Array1D* arr) {
00027         for (int i = 0; i < size; ++i) {
00028             data[i] = (*arr)(i);
00029         }
00030     }
00031
00032     Array1D sub_arr(int i_low, int i_upp) {
00033         int len;
00034         if (i_low > i_upp) {
```

```

00052     len = size + i_upp - i_low;
00053 } else {
00054     len = i_upp - i_low;
00055 }
00056 Array1D sub(len);
00057 for (int i = 0; i < len; ++i) {
00058     sub(i) = data[(i_low + i) % size];
00059 }
00060 return sub;
00061 }
00062
00064 void display() {
00065     for (int i = 0; i < size; ++i) {
00066         std::cout << data[i] << " ";
00067     }
00068     std::cout << std::endl;
00069 }
00070 };
00071
00072 #endif

```

7.3 src/lib/Board.hpp File Reference

```

#include <omp.h>
#include <cassert>
#include <fstream>
#include <iostream>
#include "Array1D.hpp"
#include "Grid.hpp"

```

Classes

- class [Board](#)

Macros

- #define [BOARD_HPP](#)

7.3.1 Macro Definition Documentation

7.3.1.1 BOARD_HPP

```
#define BOARD_HPP
```

7.4 Board.hpp

[Go to the documentation of this file.](#)

```

00001 #include <omp.h>
00002
00003 #include <cassert>
00004 #include <fstream>
00005 #include <iostream>
00006
00007 #include "Array1D.hpp"
00008 #include "Grid.hpp"
00009
00010 #ifndef BOARD_HPP

```

```

00011 #define BOARD_HPP
00012
00015 class Board : public Grid {
00016 public:
00018     Array1D bottom_ghost_row;
00020     Array1D upper_ghost_row;
00022     Array1D left_ghost_col;
00024     Array1D right_ghost_col;
00025
00027     Array1D temp1, temp2, temp3;
00028
00030
00034     Board(int N_row, int N_col)
00035         : Grid(N_row, N_col),
00036           bottom_ghost_row(N_col + 2),
00037           upper_ghost_row(N_col + 2),
00038           left_ghost_col(N_row),
00039           right_ghost_col(N_row),
00040           temp1(N_col),
00041           temp2(N_col),
00042           temp3(N_col) {
00043         // Check if the grid is large enough to be sensible in the update procedure.
00044         assert(N_row > 2 && N_col > 2);
00045     }
00046
00048
00053     void init_from_motherboard(Grid* motherboard, int row_low, int col_left) {
00054         N_nb_crit = (*motherboard).N_nb_crit;
00055 #pragma omp parallel for collapse(2)
00056         for (int i = 0; i < N_row; ++i) {
00057             for (int j = 0; j < N_col; ++j) {
00058                 data[i * N_col + j] = (*motherboard)(row_low + i, col_left + j);
00059             }
00060         }
00061     }
00062
00064
00067     void set_bottom_ghost_row(Array1D* target) {
00068         assert(target->size == N_col + 2);
00069 #pragma omp parallel for
00070         for (int i = 0; i < N_col + 2; ++i) {
00071             bottom_ghost_row(i) = (*target)(i);
00072         }
00073     }
00074
00076
00079     void set_upper_ghost_row(Array1D* target) {
00080         assert(target->size == N_col + 2);
00081 #pragma omp parallel for
00082         for (int i = 0; i < N_col + 2; ++i) {
00083             upper_ghost_row(i) = (*target)(i);
00084         }
00085     }
00086
00088
00091     void set_left_ghost_col(Array1D* target) {
00092         assert(target->size == N_row);
00093 #pragma omp parallel for
00094         for (int i = 0; i < N_row; ++i) {
00095             left_ghost_col(i) = (*target)(i);
00096         }
00097     }
00098
00100
00103     void set_right_ghost_col(Array1D* target) {
00104         assert(target->size == N_row);
00105 #pragma omp parallel for
00106         for (int i = 0; i < N_row; ++i) {
00107             right_ghost_col(i) = (*target)(i);
00108         }
00109     }
00111
00115     void store_neighbour_row(Array1D* store, int n_row) {
00116         (*store)(0) = left_ghost_col(n_row) + data[n_row * N_col + 0] +
00117                     data[n_row * N_col + 1];
00118 #pragma omp parallel for
00119         for (int i = 1; i < N_col - 1; ++i) {
00120             (*store)(i) = data[n_row * N_col + i - 1] + data[n_row * N_col + i] +
00121                         data[n_row * N_col + i + 1];
00122         }
00123         (*store)(N_col - 1) = data[n_row * N_col + N_col - 2] +
00124                             data[n_row * N_col + N_col - 1] +
00125                             right_ghost_col(n_row);
00126     }
00127
00129
00132     void store_upper_ghost_neighbour_row(Array1D* store) {

```

```

00133 #pragma omp parallel for
00134     for (int i = 0; i < N_col; ++i) {
00135         (*store)(i) =
00136             upper_ghost_row(i) + upper_ghost_row(i + 1) + upper_ghost_row(i + 2);
00137     }
00138 }
00139
00141 void store_bottom_ghost_neighbour_row(Array1D* store) {
00142 #pragma omp parallel for
00143     for (int i = 0; i < N_col; ++i) {
00144         (*store)(i) = bottom_ghost_row(i) + bottom_ghost_row(i + 1) +
00145             bottom_ghost_row(i + 2);
00146     }
00147 }
00148
00151 void ghost_display() {
00152     upper_ghost_row.display();
00153     for (int i = 0; i < N_row; ++i) {
00154         std::cout << left_ghost_col(i) << " ";
00155         for (int j = 0; j < N_col; ++j) {
00156             std::cout << data[i * N_col + j] << " ";
00157         }
00158         std::cout << right_ghost_col(i) << std::endl;
00159     }
00160     bottom_ghost_row.display();
00161 }
00162
00164 void update_board() {
00165     // Storage
00166     int N_nb(0);
00167     int val{0};
00168
00170     // Start with the top row, which requires the neighbours of the upper ghost
00171     // row
00172     store_upper_ghost_neighbour_row(&temp1);
00173     store_neighbour_row(&temp2, 0);
00174     store_neighbour_row(&temp3, 1);
00175 #pragma omp parallel for
00176     for (int j = 0; j < N_col; ++j) {
00177         val = data[j];
00178         N_nb = temp1(j) + temp2(j) + temp3(j) - val;
00179         data[j] = (1 - val) * (N_nb == N_nb_crit) +
00180             val * (N_nb == N_nb_crit || N_nb == N_nb_crit - 1);
00181     }
00182
00184     // Then the middle rows
00185     for (int i = 1; i < N_row - 1; ++i) {
00186         temp1.copy_into(&temp2);
00187         temp2.copy_into(&temp3);
00188         store_neighbour_row(&temp3, i + 1);
00189 #pragma omp parallel for
00190         for (int j = 0; j < N_col; ++j) {
00191             val = data[i * N_col + j];
00192             N_nb = temp1(j) + temp2(j) + temp3(j) - val;
00193             data[i * N_col + j] =
00194                 (1 - val) * (N_nb == N_nb_crit) +
00195                 val * (N_nb == N_nb_crit || N_nb == N_nb_crit - 1);
00196         }
00197     }
00198
00199     // Finally the bottom row, which requires the neighbours of the bottom ghost
00200     // row
00201     temp1.copy_into(&temp2);
00202     temp2.copy_into(&temp3);
00203     store_bottom_ghost_neighbour_row(&temp3);
00204 #pragma omp parallel for
00205     for (int j = 0; j < N_col; ++j) {
00206         val = data[(N_row - 1) * N_col + j];
00207         N_nb = temp1(j) + temp2(j) + temp3(j) - val;
00208         data[(N_row - 1) * N_col + j] =
00209             (1 - val) * (N_nb == N_nb_crit) +
00210             val * (N_nb == N_nb_crit || N_nb == N_nb_crit - 1);
00211     }
00212 }
00213 };
00214
00215 #endif

```


7.5 src/lib/Functions.cpp File Reference

```
#include "Functions.hpp"
#include <omp.h>
#include <algorithm>
#include <fstream>
#include <iostream>
#include <random>
#include <sstream>
#include "Array1D.hpp"
#include "Board.hpp"
#include "GameParams.hpp"
#include "Grid.hpp"
```

7.6 src/lib/Functions.hpp File Reference

```
#include <tuple>
#include "Board.hpp"
#include "GameParams.hpp"
```

Namespaces

- namespace [functions](#)

Functions

- void [functions::initialize_random](#) ([Grid](#) *grid, [GameParams](#) *params)
Initialize the board with random data.
- void [functions::initialize_from_file](#) ([Grid](#) *grid, [GameParams](#) *params, std::string file)
Initialize the board from a file.
- void [functions::iteration_one_board](#) ([Board](#) *board, [GameParams](#) *params, [Array1D](#) *store_row, [Array1D](#) *store_col)
Update the board for a given number of steps.
- int [functions::find_largest_divisor](#) (int n, int upper_bound)
- std::tuple< int, int > [functions::find_Cart_dim](#) (int board_size, int nranks)
Find the dimensions of the Cartesian grid communicator, if possible.

7.7 Functions.hpp

[Go to the documentation of this file.](#)

```
00001 #ifndef FUNCTIONS_HPP
00002 #define FUNCTIONS_HPP
00003
00004 #include <tuple>
00005
00006 #include "Board.hpp"
00007 #include "GameParams.hpp"
00008
00009 namespace functions {
00010
```

```

00011 void initialize_random(Grid* grid, GameParams* params);
00012
00013 void initialize_from_file(Grid* grid, GameParams* params, std::string file);
00014
00015 void iteration_one_board(Board* board, GameParams* params, Array1D* store_row,
00016                        Array1D* store_col);
00017
00018 int find_largest_divisor(int n, int upper_bound);
00019
00020 std::tuple<int, int> find_Cart_dim(int board_size, int nranks);
00021
00022 } // namespace functions
00023
00024 #endif

```

7.8 src/lib/GameParams.hpp File Reference

```

#include <fstream>
#include <iostream>
#include <sstream>
#include <string>

```

Classes

- class [GameParams](#)

A class that stores the parameters for the Game of Life.

7.9 GameParams.hpp

[Go to the documentation of this file.](#)

```

00001 #ifndef GAMEPARAMS_HPP
00002 #define GAMEPARAMS_HPP
00003
00004 #include <fstream>
00005 #include <iostream>
00006 #include <sstream>
00007 #include <string>
00008
00010 class GameParams {
00011 public:
00013     int board_size{10};
00015     int N_critical{3};
00017     int save_interval{1};
00019     int evolve_steps{20};
00022     int random_data{1};
00024     int num_threads{1};
00027     double prob_live{0.5};
00029     std::string board_file{"examples/"};
00031     std::string output_path{"examples/"};
00032
00034     GameParams() {}
00035
00038     void readParams(const std::string& filename) {
00039         std::ifstream inputFile(filename); // Open the text file for reading
00040
00041         if (!inputFile) { // Check if the file was opened successfully
00042             std::cerr << "Unable to open file " << filename << std::endl;
00043             return;
00044         }
00045
00046         // Read parameters from the file and set member variables
00047         std::string line;
00048         while (std::getline(inputFile, line)) {
00049             if (line.empty() || line[0] == '#' || line.substr(0, 2) == "//") {
00050                 continue;
00051             }
00052

```

```

00053     std::istringstream iss(line);
00054     std::string paramName, equalsSign, paramValue;
00055
00056     // Parse the line into parameter name, '=', and parameter value
00057     if (iss » paramName » equalsSign » paramValue && equalsSign == "=") {
00058         // Set member variables based on parameter name
00059         if (paramName == "board_size") {
00060             std::istringstream(paramValue) » board_size;
00061         } else if (paramName == "N_critical") {
00062             std::istringstream(paramValue) » N_critical;
00063         } else if (paramName == "save_interval") {
00064             std::istringstream(paramValue) » save_interval;
00065         } else if (paramName == "num_evolve_steps") {
00066             std::istringstream(paramValue) » evolve_steps;
00067         } else if (paramName == "random_data") {
00068             std::istringstream(paramValue) » random_data;
00069         } else if (paramName == "prob_live") {
00070             std::istringstream(paramValue) » prob_live;
00071         } else if (paramName == "board_file") {
00072             std::istringstream(paramValue) » board_file;
00073         } else if (paramName == "output_path") {
00074             std::istringstream(paramValue) » output_path;
00075         } else if (paramName == "num_threads") {
00076             std::istringstream(paramValue) » num_threads;
00077         }
00078     }
00079 }
00080
00081 // Close the file
00082 inputFile.close();
00083 }
00084
00085 void display() const {
00086     std::cout << "board size: " << board_size << std::endl;
00087     std::cout << "N_critical: " << N_critical << std::endl;
00088     std::cout << "save interval: " << save_interval << std::endl;
00089     std::cout << "evolve steps: " << evolve_steps << std::endl;
00090     std::cout << "num omp threads: " << num_threads << std::endl;
00091     std::cout << "probability to live: " << prob_live << std::endl;
00092     if (random_data) {
00093         std::cout << "initialization: random" << std::endl;
00094     } else {
00095         std::cout << "initialization: " << board_file << std::endl;
00096     }
00097 }
00098 };
00099 };
00100
00101 #endif

```

7.10 src/lib/Grid.hpp File Reference

```

#include <omp.h>
#include <fstream>
#include <iostream>
#include "Array1D.hpp"

```

Classes

- class [Grid](#)

A class for a 2D grid that contains the entire board for the Game of Life.

7.11 Grid.hpp

[Go to the documentation of this file.](#)

```

00001 #include <omp.h>
00002
00003 #include <fstream>

```

```

00004 #include <iostream>
00005
00006 #include "Array1D.hpp"
00007
00008 #ifndef GRID_HPP
00009 #define GRID_HPP
00010
00012 class Grid {
00013 public:
00015     int N_row;
00017     int N_col;
00019     int* data;
00021     int N_nb_crit;
00023     int size;
00024
00026     Grid(int N_row, int N_col, int N_nb_crit = 3) {
00027         this->N_row = N_row;
00028         this->N_col = N_col;
00029         this->N_nb_crit = N_nb_crit;
00030         this->data = new int[N_row * N_col];
00031         size = N_row * N_col;
00032     }
00034     ~Grid() { delete[] this->data; }
00035
00037     int& operator()(int i, int j) { return this->data[i * N_col + j]; }
00038
00043
00044     void store_row(Array1D* store, int n_row, int shift = 0) {
00045 #pragma omp parallel for
00046         for (int i = 0; i < N_col; ++i) {
00047             (*store)(i + shift) = data[n_row * N_col + i];
00048         }
00049     }
00050
00054     void store_col(Array1D* store, int n_col) {
00055 #pragma omp parallel for
00056         for (int i = 0; i < N_row; ++i) {
00057             (*store)(i) = data[i * N_col + n_col];
00058         }
00059     }
00060
00065     Array1D sub_row(int n_row, int i_low, int i_upp) {
00066         Array1D temp(N_col);
00067         store_row(&temp, n_row);
00068         return temp.sub_arr(i_low, i_upp);
00069     }
00070
00076     Array1D sub_col(int n_col, int i_low, int i_upp) {
00077         Array1D temp(N_row);
00078         store_col(&temp, n_col);
00079         return temp.sub_arr(i_low, i_upp);
00080     }
00081
00083     void display() {
00084         for (int i = 0; i < N_row; ++i) {
00085             for (int j = 0; j < N_col; ++j) {
00086                 std::cout << data[i * N_col + j] << " ";
00087             }
00088             std::cout << std::endl;
00089         }
00090     }
00091
00095     Array1D periodic_row(int n_row) {
00096         Array1D temp(N_col + 2);
00097         temp(0) = data[n_row * N_col + N_col - 1];
00098         store_row(&temp, n_row, 1);
00099         temp(N_col + 1) = data[n_row * N_col];
00100         return temp;
00101     }
00102
00105     void save(std::string file) {
00106         std::ofstream outputFile(file);
00107
00108         if (!outputFile.is_open()) {
00109             std::cerr << "Error opening file for writing!" << std::endl;
00110         }
00111
00112         for (int i = 0; i < N_row; ++i) {
00113             for (int j = 0; j < N_col - 1; ++j) {
00114                 outputFile << data[i * N_col + j] << " ";
00115             }
00116             outputFile << data[i * N_col + N_col - 1];
00117             outputFile << std::endl;
00118         }
00119
00120         outputFile.close();
00121     }

```

```

00122
00125 void store_data(int* arr) {
00126 #pragma omp parallel for
00127     for (int i = 0; i < size; i++) {
00128         arr[i] = data[i];
00129     }
00130 }
00131
00134 void read_data(int* arr) {
00135 #pragma omp parallel for
00136     for (int i = 0; i < size; i++) {
00137         data[i] = arr[i];
00138     }
00139 }
00140
00147 void overwrite_sub_board(int* arr, int row_low, int row_upp, int col_low,
00148                          int col_upp) {
00149     int n_rows = row_upp - row_low;
00150     int n_cols = col_upp - col_low;
00151 #pragma omp parallel for collapse(2)
00152     for (int i = 0; i < n_rows; i++) {
00153         for (int j = 0; j < n_cols; j++) {
00154             data[(row_low + i) * N_col + col_low + j] = arr[i * n_cols + j];
00155         }
00156     }
00157 }
00158 };
00159
00160 #endif

```

7.12 src/main_parallel.cpp File Reference

```

#include <mpi.h>
#include <omp.h>
#include <cassert>
#include <iostream>
#include <tuple>
#include "lib/Array1D.hpp"
#include "lib/Board.hpp"
#include "lib/Functions.hpp"
#include "lib/GameParams.hpp"
#include "lib/Grid.hpp"

```

Functions

- int [main](#) (int argc, char *argv[])

7.12.1 Function Documentation

7.12.1.1 main()

```

int main (
    int argc,
    char * argv[] )

```

7.13 src/main_simple.cpp File Reference

```
#include <iostream>
#include "lib/Array1D.hpp"
#include "lib/Board.hpp"
#include "lib/Functions.hpp"
#include "lib/GameParams.hpp"
#include "lib/Grid.hpp"
```

Functions

- int [main](#) (int argc, char *argv[])

7.13.1 Function Documentation

7.13.1.1 main()

```
int main (
    int argc,
    char * argv[] )
```

Index

- ~Array1D
 - Array1D, [14](#)
- ~Grid
 - Grid, [25](#)
- Array1D, [13](#)
 - ~Array1D, [14](#)
 - Array1D, [14](#)
 - copy_into, [14](#)
 - data, [15](#)
 - display, [14](#)
 - operator(), [14](#)
 - overwrite, [14](#)
 - size, [15](#)
 - sub_arr, [15](#)
- Board, [15](#)
 - Board, [17](#)
 - bottom_ghost_row, [20](#)
 - ghost_display, [18](#)
 - init_from_motherboard, [18](#)
 - left_ghost_col, [20](#)
 - right_ghost_col, [20](#)
 - set_bottom_ghost_row, [18](#)
 - set_left_ghost_col, [18](#)
 - set_right_ghost_col, [18](#)
 - set_upper_ghost_row, [19](#)
 - store_bottom_ghost_neighbour_row, [19](#)
 - store_neighbour_row, [19](#)
 - store_upper_ghost_neighbour_row, [19](#)
 - temp1, [20](#)
 - temp2, [20](#)
 - temp3, [20](#)
 - update_board, [20](#)
 - upper_ghost_row, [21](#)
- Board.hpp
 - BOARD_HPP, [32](#)
- board_file
 - GameParams, [22](#)
- BOARD_HPP
 - Board.hpp, [32](#)
- board_size
 - GameParams, [22](#)
- bottom_ghost_row
 - Board, [20](#)
- copy_into
 - Array1D, [14](#)
- data
 - Array1D, [15](#)
 - Grid, [29](#)
- display
 - Array1D, [14](#)
 - GameParams, [22](#)
 - Grid, [25](#)
- evolve_steps
 - GameParams, [22](#)
- find_Cart_dim
 - functions, [9](#)
- find_largest_divisor
 - functions, [9](#)
- functions, [9](#)
 - find_Cart_dim, [9](#)
 - find_largest_divisor, [9](#)
 - initialize_from_file, [10](#)
 - initialize_random, [10](#)
 - iteration_one_board, [10](#)
- GameParams, [21](#)
 - board_file, [22](#)
 - board_size, [22](#)
 - display, [22](#)
 - evolve_steps, [22](#)
 - GameParams, [22](#)
 - N_critical, [23](#)
 - num_threads, [23](#)
 - output_path, [23](#)
 - prob_live, [23](#)
 - random_data, [23](#)
 - readParams, [22](#)
 - save_interval, [23](#)
- ghost_display
 - Board, [18](#)
- Grid, [24](#)
 - ~Grid, [25](#)
 - data, [29](#)
 - display, [25](#)
 - Grid, [25](#)
 - N_col, [29](#)
 - N_nb_crit, [29](#)
 - N_row, [29](#)
 - operator(), [25](#)
 - overwrite_sub_board, [25](#)
 - periodic_row, [26](#)
 - read_data, [26](#)
 - save, [26](#)
 - size, [29](#)

- store_col, 26
- store_data, 26
- store_row, 27
- sub_col, 27
- sub_row, 27
- init_from_motherboard
 - Board, 18
- initialize_from_file
 - functions, 10
- initialize_random
 - functions, 10
- iteration_one_board
 - functions, 10
- left_ghost_col
 - Board, 20
- main
 - main_parallel.cpp, 39
 - main_simple.cpp, 40
- main_parallel.cpp
 - main, 39
- main_simple.cpp
 - main, 40
- N_col
 - Grid, 29
- N_critical
 - GameParams, 23
- N_nb_crit
 - Grid, 29
- N_row
 - Grid, 29
- num_threads
 - GameParams, 23
- operator()
 - Array1D, 14
 - Grid, 25
- output_path
 - GameParams, 23
- overwrite
 - Array1D, 14
- overwrite_sub_board
 - Grid, 25
- periodic_row
 - Grid, 26
- prob_live
 - GameParams, 23
- random_data
 - GameParams, 23
- read_data
 - Grid, 26
- readParams
 - GameParams, 22
- right_ghost_col
 - Board, 20
- save
 - Grid, 26
- save_interval
 - GameParams, 23
- set_bottom_ghost_row
 - Board, 18
- set_left_ghost_col
 - Board, 18
- set_right_ghost_col
 - Board, 18
- set_upper_ghost_row
 - Board, 19
- size
 - Array1D, 15
 - Grid, 29
- src/lib/Array1D.hpp, 31
- src/lib/Board.hpp, 32
- src/lib/Functions.cpp, 35
- src/lib/Functions.hpp, 35
- src/lib/GameParams.hpp, 36
- src/lib/Grid.hpp, 37
- src/main_parallel.cpp, 39
- src/main_simple.cpp, 40
- store_bottom_ghost_neighbour_row
 - Board, 19
- store_col
 - Grid, 26
- store_data
 - Grid, 26
- store_neighbour_row
 - Board, 19
- store_row
 - Grid, 27
- store_upper_ghost_neighbour_row
 - Board, 19
- sub_arr
 - Array1D, 15
- sub_col
 - Grid, 27
- sub_row
 - Grid, 27
- temp1
 - Board, 20
- temp2
 - Board, 20
- temp3
 - Board, 20
- update_board
 - Board, 20
- upper_ghost_row
 - Board, 21