Assignment I: Multi body simulation

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1 Question b

Describe the data structures that you use to store the mapping of particles in the cells. Give the source code (in the header file) of these data structures.

head[]: An array storing the index of the first particle in each cell. The index corresponds to a specific cell in the 2D grid of cells. The value represents the index of the first particle in that cell. If the cell contains multiple particles, the next particle's index is found in **next[first_particle]**. If the cell is empty, the value is set to -1.

tail[]: An array storing the index of the last particle in each cell. This was added to eliminate the need to traverse the entire linked list when adding a new particle to a cell. If the cell is empty, the value is set to -1.

next[]: An array where each index corresponds to a particle index and has the value of the next particle's index in the same cell. If there is no next particle, it is set to -1.

ntot: The total number of particles.

```
typedef struct
{
    int head[NR_CELL_X * NR_CELL_Y];
    int tail[NR_CELL_X * NR_CELL_Y];
    int next[MAX_PARTICLES];
    int ntot;
} CLList;
```

2 Question c

Measure the speed-up of the algorithm for various cell sizes. Plot a graph with the speed-up on the vertical axis and the cell size on the horizontal axis. As the programming language C does not have standard libraries to plot graphs, you may use MATLAB, Python or anything else to create the graph.

The highest speed-up was measured at 206 [s]/15 [s] = 13.7 ti for the program without OMP combined with the smallest cell size. At the smaller cell size, OMP seems to harm the execution time of the program.

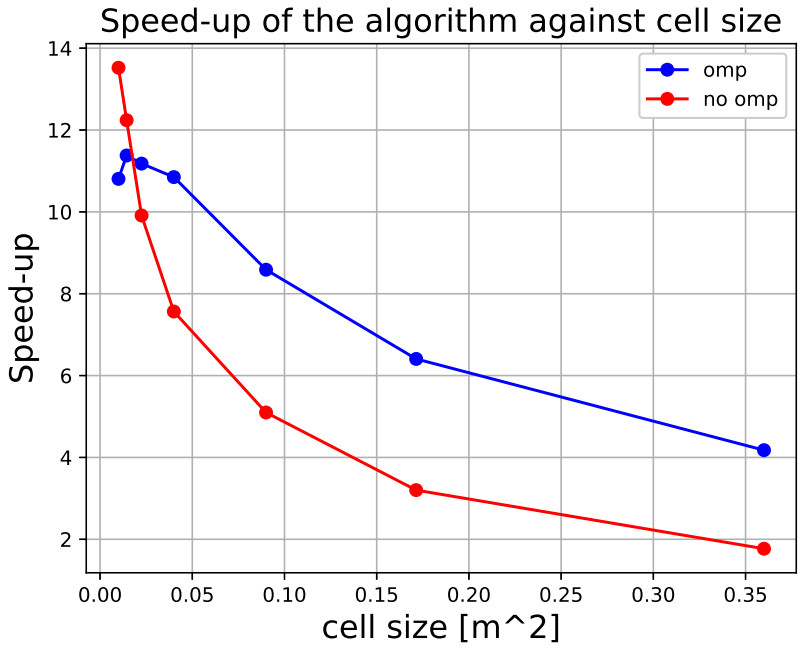

Figure 1: Execution time of the program against the number of cells in the X and Y directions.

3 Question d

What is the minimum cell size for which this technique will still work? Explain why.

The minimum cell size is

$$L_{min} = 2R_{max}, \tag{1}$$

where R_{max} is the radius of the largest possible particle. This ensures that when two particles with the largest possible radius are in neighbouring cells on opposite boundaries, the interaction is still calculated.

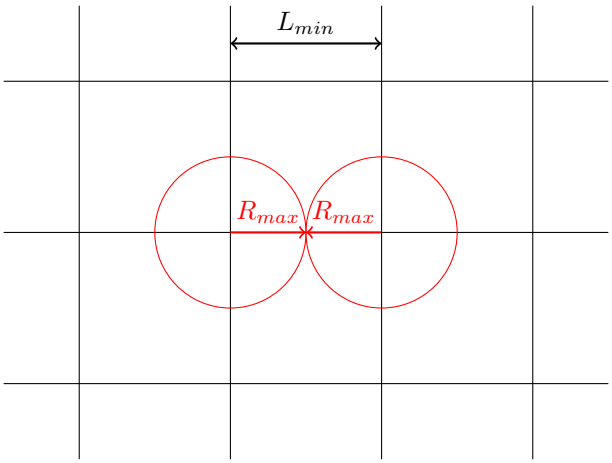

Figure 2: Minimum cell size diagram