

Report

High Performance Programming Assignment 3

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1. Problem description

The problem at hand deals with the calculation of mutual gravitational influences between a number of N objects in a two dimensional space. This so called N-Body problem is solved through the application of Newton's law of gravitation. The gravitational force of each of the N objects on all other N objects is calculated in a step size Δt for a total of n timesteps. The program initializes the simulation by reading the all necessary information about the N objects and their position from the provided input files.

The program can be executed by the following command:

./galsim N filename nsteps delta_t graphics

needing the following input parameters:

N as the number of stars/particles to simulate

filename of the file to read the initial configuration from

nsteps for the number of timesteps

delta_t for the timestep size Δt

graphics as 1 or 0 for whether graphics should be shown.

2. Solution description

The codes structure can be split into three parts.

In the first section, wrapped in a function, the input file gets read. To ensure the consistency of the input data file a number of checks is made, including checking the file size using the number of N expected objects in the file and checking whether all data was read successfully.

In the second section the calculation of the gravitational forces for all objects and over all timesteps is executed. For this purpose two nested for-loops are used, with the outer one iterating over the number of timesteps and the inner one containing the actual calculation of the adjusted values for all N objects.

In the final section the calculated final result is written to an output file called *result.gal*, using the same format as the input file.

3. Optimization measures

Besides considering fast code execution throughout the whole development process, three measures have been specifically implemented to achieve short run time.

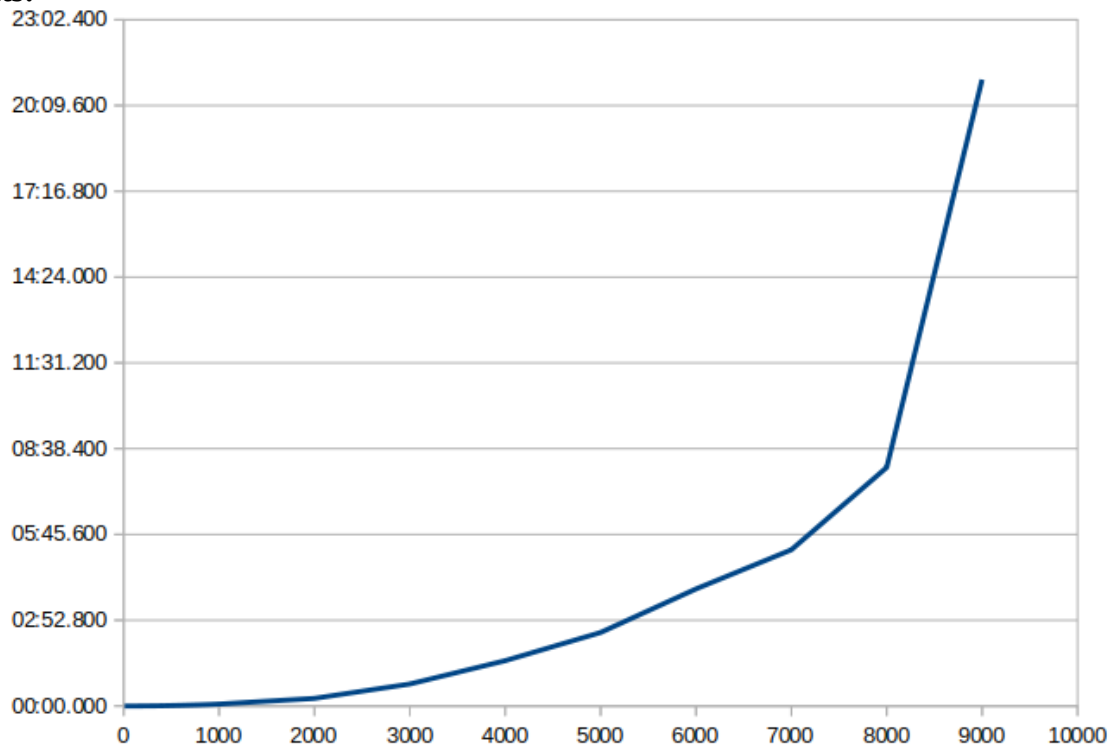
- Code compilation using the -O3 flag, ensuring accurate results while achieving a high grade of compiler optimization.
- Usage of constant variables for for-loop conditions to achieve faster loop execution.
- Computing values used in the calculation of the gravitational forces in advance to speed up the calculation.

These measures described before allowed us to achieve the following run times.

Processor specifications:

Intel® Core™ i7-7500U CPU @ 2.70GHz × 4

Results:



N is displayed on the x-axis and the run time of the calculation in minutes, seconds and milliseconds on the y-axis. All calculations were conducted for a time step size of 10^{-5} and 1,000 time steps each.

The expected $O(N^2)$ complexity can be observed in the increase in execution time with an increasing N.

4. Division of labor

The work for the assignment was split up, wherein Jiayi focused on coding and debugging and Dominik on the report and measurements.