Space Bodies Assignment

cmkv68

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Numerical Experiments

Consistency & Convergence

The table below describes the information related to the two bodies used for the collision experiment.

Body #	$s(x)$	$s(y)$	$s(z)$	$v(x)$	$v(y)$	$v(z)$	Mass
1	+0.1	+0.1	+0.1	-2.0	-2.0	-2.0	$1e^{-11}$
2	-1.0	-1.0	-1.0	+2.0	+2.0	+2.0	$1e^{-11}$

The bodies collide at $(x, y, z) = (0.155, 0.155, 0.155)$ at time $t = 0.21$. The error is calculated between the position of the error of the new item. The following table shows the timestep used to calculate the collision, and the error value left over.

Timestep	Error	Collision?
0.001 (Adaptive)	-0.00000000351134	yes
0.000000005	-0.00000000353880	yes
0.0000000025	-0.00000000337228	yes
0.00000000125	-0.00000000481655	yes
0.000000000625	-0.00000000509412	yes
0.0000000003125	-0.00000000540662	yes
0.00000000015625	-0.00000000649210	yes

Our convergence scheme

Complexity: Run your code for 10, 100, 1,000, 10,000 particles placed randomly in space. Derive the runtime complexity of the code and compare it to your experimental data.

Below describes the table that indicates the runtime of the

The complexity of the code runs in $O(\frac{1}{2}n^2)$.

Statistics: Extend your code such that it keeps track of the number of bodies over time. Create a plot that shows how the total number of particles decreases over simulation time as particles merge.

Scaling Experiments

Repeat the experiments from Step 2 to ensure that your modifications did not break the code. From hereon, create scaling plots for 10-10,000 particles. You are strongly encouraged to use a University machine for your plots that has at least 4 cores, i.e. you present a scaling plot than spans at least 1,2,3 and 4 cores. If you have a more powerful machine at home, you are free to use this machine. Clarify explicitly in your report the machine specifica.

The machine used consists of Durham's MIRA machine, which is a 128 core intel xeon distributed system. At runtime, the program consumes less than a megabyte of memory.

Questions

1. How does the scalability for very brief simulation runs depend on the total particle count?
2. Calibrate Gustafson's law to your setup and discuss the outcome. Take your considerations on the algorithm complexity into account.
3. How does the parallel efficiency change over time if you study a long-running simulation?

Distributed Memory Simulation

Design a strategy how to parallelise your code with MPI. No implementation is required, i.e. it is a gedankenexperiment.