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Massively Parallel Computing
Assignment 6

Instructions

Download the framework `exercise06.zip` from the ILIAS course web page.

Present your results to the exercise instructors to get a grading on this exercise sheet.

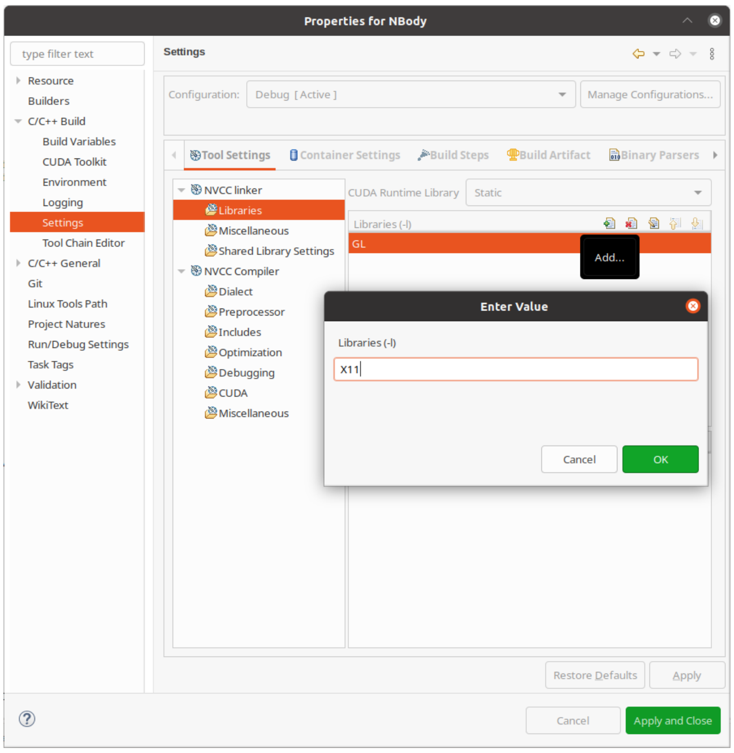
6.1 NBody Simulation (100 P)

- Start with the source code in the `NBody` folder.
- You will have to link against libGL.so (`-lGL` flag) and libX11.so (`-lX11` flag) to build the program. When using CMake, this is already configured for you. In Eclipse, add them as shown in Figure 1.
- Implement the following ToDos:
  1. Allocate GPU memory for all the data you will need in your kernels.
  2. Free all the GPU memory you allocated before program termination.
  3. Write a kernel that updates the accelerations of all bodies based on the gravitational attraction of all other bodies once per frame. This is the kernel which does most of the work.
     The acceleration a of a body i can be calculated with

     $$a_i = G \cdot \sum_{j=0}^{N-1} \frac{m_j r_{ij}}{(\|r_{ij}\|^2 + \varepsilon^2)^{3/2}} \tag{1}$$

     where
     - G is the gravitational constant given as `GRAVITY` in the code,
     - m_j is the mass of body j,
     - r_{ij} is the vector from body i to body j and
     - ε^2 is a damping factor given as `EPS_2` in the code.
  4. Write a kernel that updates the velocities and positions of all bodies based on their accelerations once per frame.
     - To update a body's velocity, just add its current acceleration to its velocity.
     - To update a body's position, just add its current velocity to the its position.
  5. In each frame, download the positions of all bodies to `hPositions` which will be used by OpenGL for visualization.

- *Hints:*
  - Calculate the acceleration of one body per thread.
  - Cooperatively load the data of many bodies per block and use them for the acceleration calculation in all threads.
  - You can find detailed information about how to achieve really good performance in `https://developer.nvidia.com/gpugems/GPUGems3/gpugems3_ch31.html`.
  - Reduce `NUM_FRAMES` to 100 while profiling - not lower because the GPU's boost clock might not be reached otherwise.
- *Bonus:* Get your implementation as fast as possible. Beside optimizations in your code, also use compiler flags to optimize further!
  About 5.6 ms per frame with 50.000 bodies is quite good on a GeForce RTX 2080 Ti.


Properties for NBody

Settings

Configuration: Debug [Active]

CUDA Runtime Library: Static

Libraries (-l): GL

Enter Value

Libraries (-l): X11

Figure 1: The necessary libraries can be added in Eclipse via the project properties.