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Assignment on Massively Parallel Algorithms - Sheet 5

Due Date June 16, 2024

Exercise 1 (Heat Transfer, *9 Credits*)

Download the Framework `heat_transfer`, compile, and run it. You will see an animated simulation of heat flowing through some medium.

Hint: You need `freeglut`-library to compile the framework. I have included the library sources, which I hope will work for everyone. I could not test the compilation on Linux, though I assume it will be easy to install freeglut on Linux. Let me know if you have any issue with this.

a) Extend the program to support a fixed number (known at compile time) of heat sources and heat sinks. A heat source/sink can have the shape of a box. *(1 Credit)*

b) Consider a set of n variable heat sources and sinks. In contrast to part a, the heat sources and sinks now are circular with the diameter as additional (to the position and temperature) parameter. The number and positions of the heat sources/sinks are not known at compile time. They can, for example, be set by the user during run-time. (You can but don't have to implement the user driven positioning of sources/sinks). For simplicity, you can use a simple array to store the sources/sinks. *(3 Credit)*

   Develop an efficient algorithm to reset the temperature of the heat sources/sinks in each simulation step. Think about both, expensive memory accesses and computational effort. Is it better to parallelize with respect to the sources or the simulation grid? Explain your decision. *(1 Credit)*

   Bonus: Be creative by implementing an interesting way to move/change the heat sources/sinks.

c) Let's disturb the flow of heat with a displacement field, building upon one of the previous solutions. That means after each time step, there is a displacement step that moves all temperature values, perhaps like a gentle breeze wafting through a heated room, or perhaps like a slowly swirling vortex. *(4 Credit)*

   The displacement vector is a two dimensional parameter passed to the kernel function. The direction of the vector determines the direction of the displacement field and the length of the vector the strength of the field.

   Bonus: Implement the displacement without divergent boundary checks, meaning all threads perform the same operations.