Smoothed-particle hydrodynamics

MATH0471 – Spring 2017

v.2 (14/03/2017)

This project consists in studying, implementing and validating a numerical scheme for the solution of Navier-Stokes equations using the "smoothed-particle hydrodynamics" (SPH) computational method. SPH originated in the late 1970's for astrophysical problems, and has been used since then in numerous application areas. The method is a mesh-free, particle-based Lagrangian method, where the coordinates move with the fluid (particles).

We ask you to study, implement and test the SPH method presented in the following reference: Louis Goffin, "Development of a didactic SPH model", Travail de fin d'études réalisé en vue de l'obtention du grade de Master Ingénieur Civil des Constructions, Université de Liège, année académique 2012-2013.

The project is organized with 4 intermediate deadlines, and with students divided into 2 groups (group A and group B). For each deadline, one 8-page progress report (mandatory, but not graded, with the first section for group A and the second for group B) is due: section 1 should detail the computer implementation; section 2 should detail the mathematical, numerical and physical experiments:

1. Reading of L. Goffin's master thesis (groups A and B); literature review of SPH and particle search methods (group A); implementation of the kernel and of the particle search using the linked list method described in Section 3.2.4 of L. Goffin's thesis (group B); validation and performance testing the search algorithm (group A); design of an input file format for SPH simulations based on cubes (group A).

   Deadline: **February 28th** (section 1 by group B; section 2 by group A).

2. Implementation of sequential 3D SPH for the Navier-Stokes formulation described in L. Goffin's master thesis using an Explicit Euler and a two-step Runge Kutta scheme (group A); validation and performance testing of the code on the falling water cube test-case from Section 5.1.1 of L. Goffin's thesis (group B).

   Deadline: **March 21th** (section 1 by group A; section 2 by group B).

3. Parallelization of the SPH code using MPI (group B); application on the dam break problem (section 5.1.3 of L. Goffin's thesis) (group A).

   Deadline: **April 4th** (section 1 by group B; section 2 by group A).

4. Parallelization of the SPH using OpenMP (group A); application on the tsumami problem from INFO0939 (group B).

   Deadline: **April 25th** (section 1 by group A; section 2 by group B).

The full C/C++ code (in a single ZIP archive, directly configurable and compilable on the NIC4 CECI cluster) should be sent for each deadline to both `cgeuzaine@ulg.ac.be` and `r.boman@ulg.ac.be`.

The **final report** (single report of 60 pages that should present the method and numerical results, the computer implementation and a detailed analysis of physical experiments on non-trivial configurations) is due on **May 19th**. An oral presentation of the main project results will be organized during the June exam session; individual theoretical and practical questions will be asked to each member of the two student groups.