ME-476

Particle-based methods

Sawley Mark

Cursus	Sem.	Type
Computational science and Engineering	MA2, MA4	Opt.
Mechanical engineering	MA2, MA4	Opt.

Language of teaching	English
Credits	4
Withdrawal	Unauthorized
Session	Summer
Semester	Spring
Exam	During the semester
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	1 weekly
Exercises	1 weekly
Practical work	2 weekly
Number of positions	

Summary

This course provides an introduction to particle-based methods for the numerical resolution of partial differential equations describing continuum phenomena or for the simulation of particulate flows. Details are given for Smoothed Particle Hydrodynamics (SPH) and the Discrete Element Method (DEM).

Content

Particle-based computational methods are being increasingly employed for solving a variety of problems in engineering and applied science. While such Lagrangian methods can yield significant advantages compared to traditional mesh-based methods, their accurate and efficient implementation also provides a number of challenges.
This course presents the fundamental aspects of two methods:

- *Smoothed Particle Hydrodynamics (SPH)* is used to resolve partial differential equations, generally for convection-dominated fluid flows, and is based on the interpolation of field quantities around discrete points that are free to move in space.
- *Discrete Element Method (DEM)* is used for simulating granular and particulate flows and tracks particle motions and detects and models collisions between particles and with their environment.

The course provides an introduction to these two methods and their domains of application (e.g. fluid and solid mechanics, computer graphics). The theoretical basis of each method, including specific aspects such as parallelization and visualization, is presented in introductory lectures. Following a literature search and private study, students give oral presentations on more advanced aspects. Exercises using open-source software and a mini-project provide practical experience in the application of these methods. Illustrations of the use of particle-based methods is also provided by researchers from industry.

Keywords

Numerical simulation, Fluid and granular flow, Smoothed particle hydrodynamics, Discrete element method

Learning Prerequisites

Required courses

- Numerical analysis
- Discretization methods (e.g. finite differences, finite elements, finite volumes)
- Fluid and/or solid mechanics

Important concepts to start the course

• Numerical simulation in fluid or solid mechanics

Learning Outcomes

By the end of the course, the student must be able to:

• Describe the difference between the Eulerian and Lagrangian approaches , AH20

• Identify the different steps in a numerical simulation (e.g. geometry and mesh generation, computation, post - processing) and integrate all the essential basic concepts in a numerical flow simulation , AH 23

• Describe different methods used to discretize differential equations, such as finite differences, finite elements, finite volumes, lattice Boltzmann, SPH , AH 30

• Perform a numerical simulation with appropriate software; understand the limits of each software in terms of its application domain and accuracy of the results obtained , AH41

Transversal skills

• Give feedback (critique) in an appropriate fashion.

• Use both general and domain specific IT resources and tools

• Summarize an article or a technical report.

• Make an oral presentation.

• Write a scientific or technical report.

• Assess one's own level of skill acquisition, and plan their on-going learning goals.

Teaching methods

Lectures, literature review, analysis of scientific articles, group talks, practical numerical simulations, individual mini-project

Expected student activities

• Interactivity in the classroom

• Literature search and private study

• Oral presentations in groups and individually

• Mini-project (written report and oral presentation)

Assessment methods

Continuous evaluation by group talks (40%) and mini-project written report & oral presentation (60%)

Supervision

Office hours	No
Assistants	Yes
Forum	No

Resources

Bibliography

Course material is available on-line; various reference texts

Moodle Link

- http://moodle.epfl.ch/course/view.php?id=10431