Simulation in Computer Graphics (2IMV15)

Course Goals

The course aims at teaching students theoretical and practical aspects of simulation techniques for computer graphics. More specifically, students are introduced to physically-based animation of the dynamics of deformable objects, rigid bodies and fluids. Attention is drawn on the interplay of various simulation components such as model generation, collision detection, contact handling, constraints and achieved physical effects.

The course is intended at students who already have a good knowledge of computer graphics, programming and data structures, and a basic knowledge of linear algebra. Students are expected to program in C/C++ from the beginning. However, with considerable effort, a student could learn any of these languages while taking the course; for the software we build in this class, the distinction between C and C++ is minor.

Prerequisites

Computer graphics, linear algebra, data structures, algorithms (recommended).

Instructor

Andrei Jalba, MF 7.092

Course Material

The course uses the following teaching material:

1 A. Witkin and D. Baraff, SIGGRAPH 2001, Course Notes, Physically Based Modeling

2 X. Provot, 1995, Deformation Constraints in a Mass-Spring Model to describe Rigid Cloth Behavior

3 D. Baraff and A. Witkin, 1998, Large steps in cloth simulation

4 A. Selle, M. Lentine and R. Fedkiw, 2002, A mass spring model for hair simulation

5 M. Kauppila, Implementing the implicit Euler method for mass-spring systems

6 J. Shewchuk, 1994, An Introduction to the Conjugate Gradient Method Without the Agonizing Pain

7 M. Muller, D. Charypar and M. Gross, 2003, Particle-Based Fluid Simulation for Interactive Applications

8 J. Stam, 2003, Real-Time Fluid Dynamics for Games

The course notes [1] on physically-based modeling are used in several lectures; a nice survey paper of the field is [2]. Applications of mass-spring systems, useful for the first assignment, are given by refs. [3,4,5], whereas refs. [7,8] provide the basis for fluid simulations and the second assignment.

Overview

The course is organized as follows. *Lectures* will be provided on-campus, weekly during the Wednesdays and Fridays time slots; see detailed course schedule below.

During this course, two *practical assignments* have to be completed. Students work in groups of four on the assignments and register as such in Canvas. For each assignment, each group is required to write a *report* in the form of a (scientific) paper (4 – 8 A4 pages) describing *interesting technical aspects* (e.g., derivations, equations, algorithm pseudo-code, etc.) about their solution/implementation of the assignment. Furthermore, *results* (containing snapshots, figures and tables) have to be included in the paper as well. Additionally, make sure that you include an appendix in which you explain what and how each group member contributed to the project. If large differences in contributions among the members of a group are noticed, the grades will be adjusted accordingly. Use the Latex template `vgtc_journal_latex.zip` provided via Canvas/Files. Apart from reports (evaluated by the instructor), each group has to prepare a short *demo video* demonstrating their solutions; the duration should be no more than 5 minutes including questions. Students with the best (two) demos, *selected by vote* during the demo days – see schedule below, are awarded bonus points for the final grade. All deliverables – all items above and the source code with instructions for compiling and running the code are handed in via Canvas.

The descriptions of the practical assignments will be provided separately through Canvas. Skeleton source code for getting you jump started with coding will also be provided.

Grading

- Assignment 1 report and implementation: 40%;
- Assignment 1 demo video 1: 10%;

- Assignment 2 report and implementation: 40%;
- Assignment 2 demo video 2: 10%;

Schedule

The schedule may change during the course. Please keep checking it !

Date	**Subject**	**Reading Material**
29 April	Intro. Differential equations 1	ref [1], pages B1 – B8.
4 May	Particles. Implicit integration. Start assignment 1	ref. [1], pages C1 – C12, E1 – E5, refs. [2,4,5].
11 May	Constrained dynamics	ref. [1], pages F1 – F12, ref. [6].
13 May	PDEs basics	–
18 May	Stable fluids. Lab	ref. [8].
20 May	No lecture. Lab	–
25 May	No lecture. Demo day 1. Deadline project 1	–
1 June	Free surfaces. Start assignment 2	–
3 June	Particle fluids	ref. [7].
8 June	Rigid bodies	ref. [1], pages D1 – D31.
10 June	Rigid body collisions	ref. [1], pages D32 – D68.
15 June	No lecture. Lab	–
17 June	No lecture. Lab	–
22 June	No lecture. Demo day 2. Deadline project 2	–