Physically-based Methods for 3D Games and Medical Applications

Motivation

Entertainment technologies at CGL
- Christoph Niederberger: Behavior Modeling for Game Agents
- Matthias Mueller: Physics-Based Real-Time Animation
- collaboration with NovodeX

Medical applications at CGL
- Daniel Bielser: Interactive Soft-Tissue Cutting
- Bruno Heidelberger: Collision Detection for Deformable Objects
- Matthias Teschner: Interactive Deformable Modeling Surgical Simulators
- collaboration within NCCR COME

Outline

Topics Overview
Requirements
Sources
Schedule
Introduction to Topics
Demos
Topics

• deformable modeling based on particles, springs, finite elements
• rigid-body simulation
• collision detection and collision response
• applications in games, medicine, cloth, hair, ...
• simulation of real-world phenomena, fluids, gases, ...
• physically-based methods implemented in graphics hardware

Requirements

• interest in a relevant topic
• review of related scientific publications (see "source" slide)
• check with coordinators
  – for the relevance of the chosen topic or paper(s)
  – for a slot in the seminar schedule: first come, first serve
• preparation of an oral presentation in German or English
• ~ 30 min presentation, ~ 15 min discussion (content, style)
• preparation of an accompanying document, at least handouts
• exercise talk

Presentation Structure

• title, information on author, affiliation, source
• motivation, introduction to the topic
• outline of the presentation
• description of the problem
• methods to solve the problem
• results
• discussion about benefits and drawbacks
• conclusion

Sources 1

• http://www.cs.unc.edu/~lin/COMP259/PAPERS/list.html
  – collision detection, rigid bodies, deformable modeling, applications
  – use www.acm.org/dl to download ACM publication
• http://graphics.stanford.edu/~fedkiw/
  – SIGGRAPH paper on collision detection, fire, smoke, liquids
• http://numerik.math.uni-duisburg.de/people/strzodka/strzodka.htm
  – graphics hardware for numerical computations
Sources 2

- www.google.ch
  - everything

- http://web.informatik.uni-bonn.de/II/ag-klein/people/zach/
  - collision detection

- http://www-grail.usc.edu/pubs.html
  - deformable modeling, collision detection, cloth

- http://miralabwww.unige.ch/newMIRA/MIRALabHtml.htm
  - cloth, hair, deformable modeling

Sources 3

- http://www.cs.ucl.ac.uk/research/vr/Projects/3DCentre/cloth_simulation_links.htm
  - general links to cloth simulation, no publications

- http://graphics.stanford.edu/courses/cs348c-95-fall/topics.html
  - fire, smoke, plants, trees, skin, hair, cloth -> www.acm.org/dl

  - natural phenomena

Sources 4

  - collision detection

  - rigid bodies, deformable objects, collision, cloth

- http://www.cs.berkeley.edu/~job/
  - plastic, elastic deformation, fracture

- http://www.cs.brown.edu/~tor/
  - list of SIGGRAPH papers 2000 - 2002

Schedule

- tentative, http://graphics.ethz.ch/seminar/ -> schedule

- Presentations of
  - mass-spring / particle models
  - collision detection techniques
  - finite element methods (elastic, plastic, fracture)
  - fluids, gases
  - rigid bodies

- 14 – 20 slots for student presentations
**Mass-Spring Models**

- optimization-based static deformation
- dynamic deformation based on numerical integration
- explicit, implicit, taylor-based integration methods
- damping, force-deformation-relation

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**Finite-Element Method**

- discretization of continuum equations on tetrahedral meshes
- linear and nonlinear models
- fast deformation computation
- plastic deformation
- fracture
Fluid Models

- voxel- (Euler) vs. particle- (Lagrange) approach
- solving partial differential equations (PDEs)
- surface tracking
- interactions fluid surface, rigid bodies

Examples

Smoke

Fire
Collision Detection

- bounding volumes
- space subdivision
- distance fields
- using graphics hardware
- collision detection for deformable objects

Examples

Cloth Simulation

Cloth Simulation

The Making of a Shirt
Mark Meyer Mathieu Desbrun Al Barr
Callas/MCC

Recorded entirely in realtime
Parental Discretion Advised
Cloth Simulation

Rigid Bodies

Requirements 2

- interest in a relevant topic
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Demos