



## Physically-based Methods for 3D Games and Medical Applications

CGL Novodex




## Motivation

Entertainment technologies at CGL

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


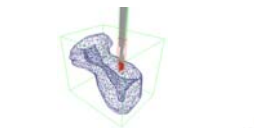
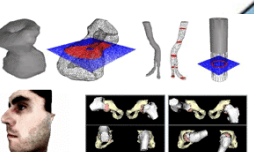






## Motivation

Medical applications at CGL


- Daniel Bielser:  
Interactive Soft-Tissue Cutting
- Bruno Heidelberg:  
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](http://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](http://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](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](http://www.acm.org/dl)
- <http://www.dgp.toronto.edu/people/stam/reality/Research/pub.html>
  - natural phenomena




## Sources 4

- <http://www.stanford.edu/~jgao/collision-detection.html>
  - collision detection
- <http://www-2.cs.cmu.edu/~baraff/papers/index.html>
  - 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




## Examples

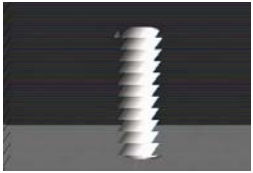
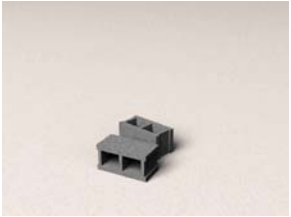




## Finite-Element Method

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




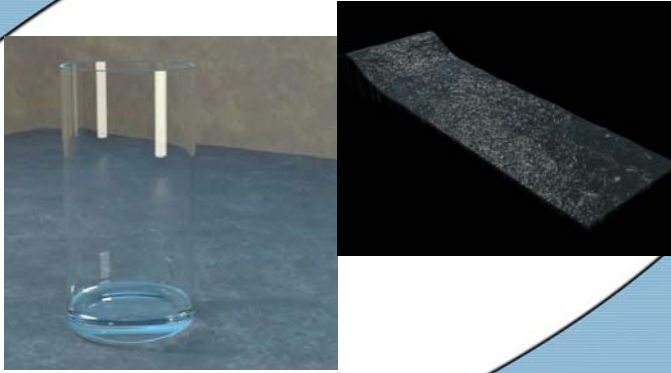
## Examples




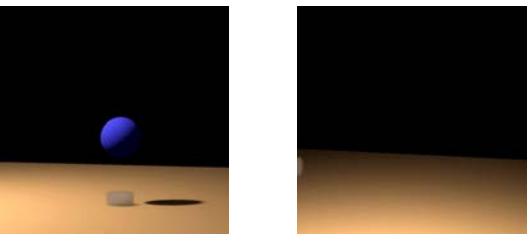
 **Fluid Models**


- 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

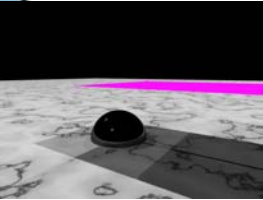
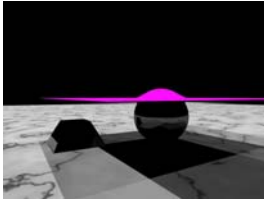


## Examples

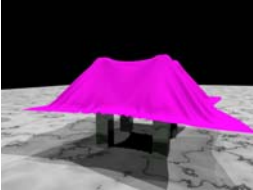






## Cloth Simulation

Stanford

## Cloth Simulation

*The Making of a Skirt*


Mark Meyer Mathieu Desbrun Al Barr  
Caltech/USC

*Recorded entirely in realtime*



Parental Discretion Advised

Made by Geneva Lake (1998)



First film to mix virtual people with real ones on a real floor



## Cloth Simulation




## Rigid Bodies



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