CS 348C: Computer Graphics: Animation and Simulation

Instructor: Prof. Doug James


Location
Mitchb67, TuTh 1:30PM - 2:50PM

Office Hours (Prof) TBD (Gates 362), or by appointment

Office Hours: TBD

Prerequisites
Recommended: CS148 and/or CS205A. Prerequisite: linear algebra. (or permission of instructor)

Textbook
Ante Qu (Gates 376, CS PhD student)

None; lecture notes and research papers assigned as readings will be posted here.

Communication
Piazza: http://piazza.com/stanford/fall2017/cs348c/home

Requirements
Students are expected to attend the lectures, participate in class discussions, and read the supplemental materials.

Assignments
There will be programming assignments, and a final project based on a student-selected topic.

Exams
None.

Explore Courses
Link
Emphasis this quarter:

Physics-based Simulation

– For offline animation (e.g., motion pictures)
– For interactive animation (e.g., games)
– For multi-sensory feedback (e.g., surgical sim)
– For new applications
  • VR/AR/MR simulation
  • Physics-based design and fabrication
  • Robotic planning
  • Machine learning, e.g., synthetic datasets
– For whatever you want…

*Hands-on Approach!*
COM S 567: Physically Based Animation for Computer Graphics

Spring 2007

PROFESSOR: Doug James

TAs: TBA

HELP SESSIONS AND OFFICE HOURS: TBA

DESCRIPTION: Modern computer animation and interactive digital entertainment are making increasingly sophisticated use of tools from scientific and engineering computing. This course introduces students to common physically based modeling techniques for animation of virtual characters, fluids and gases, rigid and deformable solids, and other systems. Aspects of interactive simulation and multi-sensory feedback will also be discussed. A hands-on programming approach will be taken, with an emphasis on small interactive computer programs.

TIME: MW 2:55-4:10pm
FIRST CLASS: Mon Jan 22  (Come to first class for more information!)

LOCATION: Hollister 306

GRADE OPTION: letter or S/U

NUMBER OF CREDITS: 4

PREREQUISITES: Permission of the instructor, or COM 322 (Intro to Scientific Computing), or COM S 465 (Computer Graphics). Students from CIS 300 (Intro to Computer Game Design) are strongly encouraged. Java applet programming in assignments

EXAMS: None (Grade based on assignments and project)

ACADEMIC POLICIES

APPROACH:

- Just do it!
- Hands-on, fun approach
- Build confidence and understanding using simple 2D physics
- Focus on algorithms and implementation—equations are a given
- Biweekly Java applet projects
- Lectures: ½ background & ½ survey
- Final project of your choosing (15% grade)

BIWEEKLY PROGRAMMING ASSIGNMENTS (Tentative):

1. "Hello Particles"
2. Collisions
3. Rigid & deformable bodies
4. Active characters (tournament competition)
5. Fluids
6. Rigid Objects + Fluid
COM S 567
Physically Based Animation for Computer Graphics
Spring 2007

PROFESSOR: Doug James  http://www.cs.cornell.edu/~djames
djames@cs.cornell.edu

TAs: TBA

DESCRIPTION: Modern computer animation and interactive digital entertainment are making increasingly sophisticated use of tools from scientific and engineering computing. This course introduces students to common physically-based solvers, and other systems. Aspects of interactive simulation and multi-sensor feedback will also be discussed. A hands-on programming approach will be taken, with an emphasis on small interactive computer programs.

TIME: MW 2:55-4:10pm
FIRST CLASS: Mon Jan 22  (Come to first class for more information!)

LOCATION: Hollister 306

GRADE OPTION: letter or S/U

NUMBER OF CREDITS: 4

PREREQUISITES: Permission of the Instructor, or COM S 322 (Intro to Scientific Computing), or COM S 465 (Computer Graphics I). Students from CIS 300 (Intro to Computer Game Design) are strongly encouraged. Java applet programming in assignments.

EXAMS: None (Grade based on assignments and project)

ACADEMIC POLICIES:

APPROACH:

- Just do it!
- Hands-on, fun approach
- Build confidence and understanding using simple 2D physics
- Focus on algorithms and implementation - equations are given
- Biography Java applet projects
- Biweekly 15% background & ½ survey
- Lectures: ½ background & ½ survey
- Final project: your choosing (15% grade)

BIEWEEKLY PROGRAMMING ASSIGNMENTS (Tentative):

1. "Hello Particles"
2. Collisions
3. Rigid & deformable bodies
4. Active characters (tournament competition)
5. Fluids
6. Rigid objects + Fluid
Personal teaching history...
COM S 567
Physically Based Animation for Computer Graphics
Spring 2007

PROFESSOR: Doug James
http://www.cs.cornell.edu/~djas
James@cs.cornell.edu

TA: TBA

DESCRIPTION: Modern computer animation and interactive digital entertainment are making increasingly sophisticated use of tools from scientific and engineering computing. This course introduces students to common physically based modeling techniques for animation of virtual characters, fluids, and solids. Rigid and deformable solids, and other systems, aspects of interactive simulation, and multi-agent feedback will also be discussed. A hands-on programming approach will be taken, with an emphasis on small interactive computer programs.

TIME: MW 2:05-4:10pm
FIRST CLASS: Mon Jan 22 (Come to first class for more information!)

LOCATION: Hollister 306

GRADE OPTION: letter or S/U

NUMBER OF CREDITS: 4

PREREQUISITES: Permission of the instructor, or COM S 322, Intro to Scientific Computing, or COM S 465, Computer Graphics I. Students from CS 500 (Intro to Computer Game Design) are strongly encouraged.

EXAMS: None (Grades based on assignments and project)

ACADEMIC POLICIES

APPROACH:
- Just do it!
- Hands-on, fun approach
- Build confidence and understanding using simple 2D physics
- Focus on algorithms and implementation—equations are given
- Weekly Java applet projects
- A couple of 1/2 background & 1/2 survey
- Final project of your choosing (15% grade)

BIWEEKLY PROGRAMMING ASSIGNMENTS (Tentative):

1. "Hello, Particles"
2. Collisions
3. Rigid & deformable bodies
4. Active characters (animation competition)
5. Fluids
6. Rigid objects + Fluid
COM S 567
Physically Based Animation for Computer Graphics
Spring 2007

PROFESSOR: Doug James
http://www.cs.comast.edu/~djamies

tas: TBA

HELP SESSIONS AND OFFICE HOURS: TBA
http://www.cs.comast.edu/~djamies

DESCRIPTION: Modern computer animation and interactive digital entertainment are making increasingly sophisticated use of tools from scientific and engineering computer modeling and simulation. This course introduces students to common physically-based modeling techniques for animation of virtual characters, fluids and gases, rigid and deformable solids, and other systems. Aspects of interactive simulation and multi-sensory feedback will also be discussed. A hands-on programming approach will be taken, with an emphasis on small interactive computer programs.

TIME: MW 1:35-4:40pm
FIRST CLASS: Mon Jan 22 (Come to first class for more information!)

LOCATION: Hollister 306

GRADE OPTION: letter or S/U

NUMBER OF CREDITS: 4

PREREQUISITES: Permission of the instructor, or COM S 222 (Intro to Scientific Computing), or COM S 465 (Computer Graphics I). Students from COM S 300 (Intro to Computer Game Design) are strongly encouraged. Java applet programming in assignments.

EXAMS: None (Grade based on assignments and project)

ACADEMIC POLICIES

APPROACH:
- Just do it!
- Hands-on, turn approach
- Build confidence and understanding using simple 2D physics
- Focus on algorithms and implementation—solutions are a given
- Practice with Java applet projects
- Practice with "Hello, Painter" and "Coin Toss" survey
- Final project of your choosing (15% grade)

BIWEEKLY PROGRAMMING ASSIGNMENTS (Tentative):
1. "Hello, Painter"
2. Collisions
3. Rigid & deformable bodies
4. Active characters (animation competition)
5. Fluids
6. Rigid objects + Fluid

Personal teaching history...
COM S 557
Physically Based Animation for Computer Graphics
Spring 2007

PROFESSOR: Doug James
http://www.cs.cornell.edu/~djjames
jjames@cs.cornell.edu

HELP SESSIONS AND OFFICE HOURS: TBA

DESCRIPTION: Modern computer animation and interactive digital entertainment are making increasingly sophisticated use of tools from scientific and engineering computing. This course introduces students to common physically based models, and other systems, for animation of virtual characters, fluids and gases, rigid and deformable solids, and other systems. Aspects of interactive simulation and multi-session feedback will also be discussed. A hands-on programming approach will be taken, with an emphasis on small interactive computer programs.

TIME: MW 2:55/4:10pm
FIRST CLASS: Mon Jan 22 (Come to first class for more information!)

LOCATION: Hoisington 306

GRADE OPTION: letter or S/U

NUMBER OF CREDITS: 4

PREREQUISITES: Permission of the instructor, or COM S 322 (Intro to Scientific Computing), or COM S 465 (Computer Graphics). Students from CS 300 (Intro to Computer Game Design) are strongly encouraged. Java application programming in assignments.

EXAMS: None (Grade based on assignments and project)

ACADEMIC POLICIES

APPROACH:
- Just do it!
- Hands-on, fun approach
- Build confidence and understanding using simple 2D physics simulations
- Solutions are given
- Focus on algorithms and implementation
- Java applet projects
- Weekly Java applet projects & ½ survey
- Lectures: ½ background & ½ survey
- Final project of your choosing (15% grade)

Bieweekly Programming Assignments (Tentative):
1. “Hello, Parrots”
2. Collisions
3. Rigid & deformable bodies
4. Active characters (tournaments)
5. Fluids
6. Rigid Objects + Fluid
Example Assignment:
Robust Collision Processing ("The Spaghetti Factory")
http://www.cs.cornell.edu/courses/cs5643/2010sp/a2Spaghetti/
Example Assignment:
Robust Collision Processing ("The Spaghetti Factory")
http://www.cs.cornell.edu/courses/cs5643/2010sp/a2Spaghetti/
Example Assignment: Robust Collision Processing ("The Spaghetti Factory")

http://www.cs.cornell.edu/courses/cs5643/2010sp/a2Spaghetti/
Example Assignment:
Robust Collision Processing ("The Spaghetti Factory")
http://www.cs.cornell.edu/courses/cs5643/2010sp/a2Spaghetti/
Wait... real spaghetti has...
Many Simulation Topics
Particle Systems

http://www.cs.unc.edu/~davemc/Particle/
Particle Systems

[Reeves 1983]
Deformable Models
Hair Animation

From “Tangled” [Disney] [Selle et al. 2008]
Hair Animation

Adaptive Nonlinearity for Collisions in Complex Rod Assemblies [Kaufman et al. 2014]
http://www.cs.columbia.edu/cg/adonis/
Yarn-level Cloth
Yarn-level Cloth

[Kaldor et al. 2010]
Braid Cables Pattern

Stitch Meshes [Yuksel et al. 2012]
Collision Detection & Resolution

[James and Pai 2004]
Collision Detection & Resolution

Sixteen bunnies

Self-collision speedup: 29x
Total simulation speedup: 11x

[Barbic and James 2010]
Energy-based Self-Collision Culling
for Arbitrary Mesh Deformations

[Zheng & James 2012]
Contact

- Contact formulations
- Friction
- Constraint solvers
Constraints

(a) Compound pulley  (b) Robotic arm  (c) Chain gears  (d) Line shaft

[Sueda et al. 2012]
Rigid Bodies

Catenary Arch

\[ \mu = 0.6 \]
Particle-based Fluids

Position Based Fluids [Macklin & Müller 2013]
Fluids using Particle-in-cell (PIC) & FLIP

2D water, PIC method

Note the high numerical viscosity.
Affine PIC (APIC) method

Chenfanfu Jiang
Craig Schroeder
Andrew Selle
Joseph Teran
Alexey Stomakhin

University of California, Los Angeles
Walt Disney Animation Studios

https://www.youtube.com/watch?v=jPG5H5ZoL5Y
Simulating Natural Phenomena

Figure 6: Castle destruction. Modeled structures like this castle can be destroyed using our method. ©Disney.

A material point method for snow simulation

[Stomakhin et al. 2013]
Snowballs
More Fluids
Procedural Turbulence

Wavelet Turbulence [Kim et al. 2008]
Visual Effects

SCANLINE VFX

“Battleship,” Universal Pictures 2012
“Schrödinger’s Smoke”

Schrödinger’s Smoke [Chern et al. 2016]
https://youtu.be/5C9BLAXCell?t=1m43s
Where there’s smoke there’s...
Artistic Control?
Physics-based Sculpting
“Kelvinlets” [SIGGRAPH 2017]

Preview: 3D Kelvinlet brush deformations

Grab
Motion Design & Control
Many-Worlds Browsing

[Twigg and James 2007]
Reverse-Time Dynamics

[Twigg and James 2008]
Derivative-based Motion Control

- [http://people.csail.mit.edu/jovan/rbedit-project.html](http://people.csail.mit.edu/jovan/rbedit-project.html)
Smoke Control
Game Physics

Cloth Balloons
with Rigid Body and Self Collision Handling
GPU-based Physics

FLEX
Unified GPU Physics
What about sound?
Rigid Fluid

Rigid Fluid: Animating the Interplay Between Rigid Bodies and Fluid

Mark Carlson
Peter J. Mucha
Greg Turk

Georgia Institute of Technology

Sound FX by Andrew Lackey, M.P.S.E.
Physically Based Sound

Harmonic Fluids

Changxi Zheng
Doug L. James
Cornell University

SIGGRAPH 2009
Physically Based Sound
Physically Based Sound
Other issues

- Robustness
- Parallel simulation; domain specific languages
- Characters
- Crowds
What’s next

- Read Baraff and Witkin course notes
- Start Thursday
- Initial written assignment
- Programming Projects (Tentative)
  1. Collision Processing (Spaghetti Factory)
  2. Motion Control (Derivative-based)
  3. Fluid simulation (APIC)
  4. Final project (student's choice)
     - Think about what you’d like to do
- Industry lectures, e.g., Ted Kim (Pixar)