CS 4472 Physically Based Modeling

Synopsis
A modeling and simulation course which emphasizes programming of real-world physics. We will perform individual and group projects. One possible goal: add real-time kinematics, dynamics and collision detection to VRML 97.

Instructor
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Office hours are any time that you find me there. I am usually available as indicated by the schedule posted outside my office. Make an appointment if you want to be sure to see me. If necessary you may call me at home (earlier than 2200 please).

Schedule
Monday - Thursday 1000-1050, Root 200C. We will occasionally meet five times per week due to travel periods. Final exam will be project demonstrations during the week of June 7-10.

Travel & holiday (no class planned)

April 15  Day trip to San Jose Tech Museum
April 26-30  Interactive 3D Graphics Symposium and ONR DC
May 3-5  Graphics Standards workshop, Fairfax VA
May 31  Memorial Day

Textbook

Other books and book excerpts will be used as we go.

Guidelines
1. You must devote time to reading and programming to succeed in this course.

2. Students are encouraged to study together. Every assignment that you hand in must be your own work unless clearly marked otherwise. As in any endeavor your individual integrity is essential. If in doubt about crediting sources, follow the thesis guidelines (in both reports and source code). If still in doubt, ask.

3. I am designing this course to significantly help you in your thesis and other courses. Your comments, questions and suggestions are always welcome.
CS 4472 Physically Based Modeling

Course Objectives

? Gain a broad view of modeling and simulation using real-world physics
? Integration of complex forces and moments in real time
? Realistically animate physical entities such as vehicles
? Utilize VRML and Java for maximum network connectivity and scalability
? Support thesis work and projects in other classes
? Examine a variety of other physically based modeling topics (camera, sonar, etc.)
? Provide tools, techniques and a repeatable methodology that you can use later

Class Policy and Study Recommendations

? Reading the material will certainly help to make these topics intelligible.
? Discussion and dialog will make class a lot more immediate.
? Projects make up your entire grade, just like the real world. Exams are boring.
? Grading is based on merit and performance. I expect you to work hard and get an A.
? You learn how to program solutions to problems by doing. Thus big projects.
? You must have an electronic mail address so that I can send messages.
? You need to have a home page so that you are immediately conversant with the numerous Web concepts we will be discussing.
? You will need access to a Web browser compliant with VRML 97, for more info consult http://web.nps.navy.mil/~brutzman/vrml
? Numerous online references will be provided.
? Think big! We are working on general computational solutions for real-time reality.
CS 4472 Physically Based Modeling: Topics of Study

We will examine the following subjects while deriving real-time physics for VRML.

- Virtual World for an Autonomous Underwater Vehicle
  - includes coordinate frames, kinematics, dynamics, inertial frames, forces & moments
  - hydrodynamics in detail - perhaps the worst case of any type of dynamics
  - running missions in the virtual world (homework: create and play back a mission)
- Quaternions
- Distributed Interactive Simulation (DIS) protocol
  - overview, principles and practice
  - DIS libraries in C++ and Java
- Analytic simulation with virtual world playback: AUV minefield search evaluation
- Object-to-object collision detection
- Internetwork infrastructure and virtual reality transfer protocol (vrtp)
- Sonar visualization
- Sound modeling
- Camera control
Potential Projects in Physically Based Modeling

Object-to-object Collision Detection

VRML-Java EXTERNPROTO syntax, semantics and performance

Hydrodynamics

integrate DIS protocol with general AUV hydrodynamics model in Java, for local physically based modeling associated with local vehicle entities in client browsers

Redo hydrodynamics Euler equations using quaternions

Convert AUV robot software to networked PC operation using public domain gcc/g++

Generalized or specialized vehicle dynamics models in Java

goal is to create a reusable template for Internet-wide vehicle operations

integrate UNC’s object-to-object collision detection library

add performance profiling code tightly coupled with multicast Java DIS library

Spatialized vehicle or sensor-beam audio model using VRML & Java

Distributed Interactive Simulation (DIS) library

multicast Java library readied for prime time distribution, linked with VRML

public domain C++ library readied for prime time distribution

reader/writer routines in 3D and using Java Abstract Window Toolkit (AWT) control panels

Sonar

sonar range routines using Open Inventor & VRML scenes accessible via cgi-bin query

sonar visualization graphics prototyping
Camera control

scene & actors are only 50% of any movie, everything else (which is often overlooked) is camera
(angle, motion, field of view, lighting, control, following the Action, @tc.)

Standard viewpoints libraries for various entities

prototype Amart@ameras for VRML using Java; treat cameras as yet another entity

Other potential projects will be identified as we proceed through the material. There is a lot of work
possible. This is an area that has seen much scattered work. Our present challenge is to create general
solutions which solve these problems once and for all, then integrate them into a
PROTO/EXTERNPROTO set of nodes which can be used for VRML 97. If fully successful, we will also
be prototyping VR functionality for VRML-NG.

Welcome to the frontier!
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<th>Week</th>
<th>Reading</th>
<th>Topic</th>
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<td>Week 1</td>
<td>Digital Illusion 4</td>
<td>Internetworked Graphics: Bottlenecks and Breakthroughs</td>
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<td>MAR 29–APR 1</td>
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<tr>
<td>Week 2</td>
<td>dis-java-vrml website, Locke paper</td>
<td>Distributed Interactive Simulation (DIS) protocol, dis-java-vrml examples</td>
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<td>APR 5-8</td>
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<td>Week 3</td>
<td>Java-VRML paper Project paper &amp; software</td>
<td>Java-VRML scripting, PROTOs/EXTERNPROTOs AUV minefield search</td>
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<td>APR 12-15</td>
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<td>Week 4</td>
<td>Tim Holliday thesis Caroline Deltheil dissertation</td>
<td>Sonar modeling and sonar visualization Vision modeling and vision simulation</td>
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<td>APR 19-22</td>
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<td>Week 5</td>
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<td>APR 26-29</td>
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<td>Week 6</td>
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<td>Week 7</td>
<td>Cooke paper Design project</td>
<td>Quaternion versus Euler representations Integration methods for real-time response Integrating kinematics, dynamics, collision detection</td>
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<td>MAY 10-13</td>
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<td>Week 8</td>
<td>AUV Tutorial &amp; book V-Collide paper, library</td>
<td>Virtual World for an Autonomous Underwater Vehicle Object-to-object collision detection</td>
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<td>MAY 17-20</td>
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<td>Week 9</td>
<td>Chapter, real time paper</td>
<td>AUV Hydrodynamics</td>
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<td>MAY 24-27</td>
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<td>Week 10</td>
<td>Greg Leaver thesis</td>
<td>Large-scale terrain design: modeling Monterey Bay</td>
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<td>Week 11</td>
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<td>Final class project demos</td>
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<td>JUN 7-10</td>
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<td>Week 12</td>
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<td>Finals week: no class or exams</td>
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