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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.

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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 Dodsworth, Clark Jr., editor, *Digital Illusion: Entertaining the Future with High Technology*, Addison Wesley Longman Inc., Reading Massachusetts, 1997.

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.

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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 Aaction,@ etc.)

Standard viewpoints libraries for various entities

prototype Asmart@ cameras 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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Week	Reading	Topic
Week 1 MAR 29–APR 1	Digital Illusion 4	Internetworked Graphics: Bottlenecks and Breakthroug
Week 2 APR 5-8	dis-java-vrml website, Locke paper	Distributed Interactive Simulation (DIS) protocol, dis-java-vrml examples
Week 3 APR 12-15	Java-VRML paper Project paper & software	Java-VRML scripting, PROTOs/EXTERNPROTOs AUV minefield search
Week 4 APR 19-22	Tim Holliday thesis Caroline Deltheil dissertation	Sonar modeling and sonar visualization Vision modeling and vision simulation
Week 5 APR 26-29		travel
Week 6 MAY 3-6		travel; Thursday review
Week 7 MAY 10-13	Cooke paper Design project	Quaternion versus Euler representations Integration methods for real-time response Integrating kinematics, dynamics, collision detection
Week 8 MAY 17-20	AUV Tutorial & book V-Collide paper, library	Virtual World for an Autonomous Underwater Vehicle Object-to-object collision detection
Week 9 MAY 24-27	Chapter, real time paper	AUV Hydrodynamics
Week 10 MAY 31-JUN 3	Greg Leaver thesis	Large-scale terrain design: modeling Monterey Bay
Week 11 JUN 7-10		Final class project demos
Week 12 JUN 14-17		Finals week: no class or exams