Advanced Computer Graphics: Course Organization and Survey

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KSOL course page:
Course web site: http://www.kddresearch.org/Courses/CIS736
Instructor home page: http://www.cis.ksu.edu/~bhsu

Reading for Next Class:
Syllabus and Introductory Handouts
CIS 736 students: Advanced CG Topics 1 slides
Chapter 1, Eberly (2006) 3D Game Engine Design, 2nd

Course Overview

- Graphics Systems and Techniques
  - Main emphasis: shaders, lighting, mappings (textures, etc.) in OpenGL
  - Photorealistic rendering and animation (Maya 2011, Blender; Ogre3D)
  - 2-D, 3-D models: curves, surfaces, visible surface identification, illumination
  - Special topics: global illumination (ray tracing, radiosity), particle systems,
    fractals, scientific visualization (sciviz) and information visualization (infoviz)
- Operations
  - Surface modeling, mapping
  - Pipelines for display, transformation, illumination, animation
- Computer Graphics (CG): Duality with Computer Vision
- Visualization and User Interfaces
- Applications
  - CAD/CAM/CAE: object transformations, surface/solid modeling, animation
  - Entertainment: 3-D games, photorealistic animation, etc.
  - Analysis: info visualization, decision support, intelligent displays
## Advanced CG Syllabus, Part 1 of 2

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Green, blue and red letters denote exam review, exam, and exam solution review dates.

## Advanced CG Syllabus, Part 2 of 2

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Online Recorded Lectures
for CIS 736 (Computer Graphics)

- **Project Topics for CIS 736**
- **Advanced Topics in Computer Graphics (10)**
  - 1. Filters for Texturing – Week 2
  - 2. Level-of-Detail Algorithms and Terrain – Week 3
  - 3. More Mappings – Week 6
  - 4. More on Animation – Week 8
  - 5. Character Modeling and IK – Week 9
  - 6. Global Illumination: Photon Maps (Radiosity) – Week 10
  - 7. Advanced Lighting Models – Week 11
  - 8. Advanced Ray-Tracing – Week 12
  - 9. More on Scientific, Data, Info Visualization – Week 13
  - 10. Fractals and L-Systems – Week 14

- **Recommended Background Reading for CIS 736**
- **Shared Lectures with CIS 536/636 (Introduction to Computer Graphics)**
  - Regular in-class lectures (30) and labs (7)
  - Guidelines for paper reviews – Week 6
  - Preparing term project presentations, CG demos – Weeks 11-12

- **Why Computer Graphics?**

  - **Developing Computational Capability**
    - Rendering: synthesizing realistic-looking, useful, or interesting images
    - Animation: creating visual impression of motion
    - Image processing: analyzing, transforming, displaying images efficiently
  
  - **Better Understanding of Data, Objects, Processes through Visualization**
    - Visual summarization, description, manipulation
    - Virtual environments (VR), visual monitoring, interactivity
    - Human-computer intelligent interaction (HCII): training, tutoring, analysis, control systems
  
  - **Time is Right**
    - Recent progress in algorithms and theory
    - Rapidly emergence of new I/O (display and data acquisition) technologies
    - Available computational power, improving price-performance-ratio of hardware
    - Growth and interest of graphics industries (e.g., games, entertainment, computer-aided design, visualization in science and business)
**Rendering (Image Synthesis) Pipeline**

- **Front-End** (Geometry Processing)
  - Graphics Database
  - Editing
  - Display
  - Traversal
  - Modeling
  - Transformation
  - Viewing
  - Operation

- **Back-End** (Rasterization)
  - Visible-Surface Determination
  - Scan Conversion
  - Shading / Illumination
  - Image

**“Polygons-to-Pixels” Pipeline**

**User Interfaces & Hypermedia**

- Hypermedia & Web 2.0
  - Web 2.0: SLATES (search, links, authoring, tags, extensions, signals)
  - Database format (similar to hypertext, internetworked multimedia)
  - Display-based access to text, image, audio, video, etc.

- Virtual Environments
  - Immersion: interactive training, tutoring systems
  - Entertainment hypermedia

- Graphical User Interfaces (GUIs)
  - Visualization: scientific, data/information, statistics
  - GUIs: Computer-Aided Design/Engineering (CAD/CAE/CAM/CASE), etc.
Relevant Topic Areas

- Analytic Geometry
- Art and Graphic Design
- Cognitive Science
- Computer Engineering
- Engineering Design
- Education
- Film
- Human Factors
- Linear Algebra
- Numerical Analysis

Parametric Equations
- Conics
- Polygon Rendering
- Surface Modeling
- Physically-Based Modeling
- Statistical Visualization

Transformations
- Change of Coordinate Systems

Shading Pipeline & Surface Modeling
(Boundary Representations)

Special Topics:
Multitexturing & Mappings

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Technical University of Vienna

Texturing material from slides © 2002 E. Gröller & S. Jeschke, Vienna University of Technology
http://bit.ly/dJFYq9

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Mapping material from slides © 1995 – 2009 P. Hanrahan, Stanford University

Pat Hanrahan
CANON USA Professor
Director, Computer Graphics Laboratory
Computer Science and Electrical Engineering Departments
Stanford University
http://graphics.stanford.edu/~hanrahan/

Computer-Generated Animation (CGA)

Monsters Inc. (2001)
Monsters Inc. 2 (2013) © Disney/Pixar

Kung-Fu Panda © 2008 DreamWorks Animation SKG

Happy Feet © 2006 Warner Brothers

Toy Story (1995)
Toy Story 2 (1999)
Toy Story 3 (2010) © Disney/Pixar

Shrek (2001)
Shrek 2 (2004)
Shrek the Third (2007)
Shrek Forever After (2010) © DreamWorks Animation SKG

Wall-E © 2008 Disney/Pixar

Tron: Legacy © 2010 Walt Disney Pictures

Luxo Jr. © 1986 Pixar Animation Studios

© Disney/Pixar

© Warner Brothers

© DreamWorks Animation SKG
Special Topics: 
Computer-Generated Animation (CGA)

Jason Lawrence
Assistant Professor
Department of Computer Science
University of Virginia
http://www.cs.virginia.edu/~jdl/

Acknowledgment: slides by Misha Kazhdan, Allison Klein, Tom Funkhouser, Adam Finkelstein and David Dobkin

Thomas A. Funkhouser
Professor
Department of Computer Science
Computer Graphics Group
Princeton University
http://www.cs.princeton.edu/~funk/

Fractals: 
Iterated Function Systems (IFS)

Fractal of the Day: http://sprott.physics.wisc.edu/fractals.htm
Information Visualization

Completed Design

Determine Objective of Graphics System
- Entertainment
- Decision Support
- Education
- Control Interface

Determine Display Objective
- Interactively Analyze Data / Documents
- Visualize Physical Objects
- Monitor Process

Determine Representations In Graphics Database
- Solid Geometric Model
- Wireframe / Polygon Mesh
- NURBS
- Fractal System

Determine and Implement Rendering Pipeline
- Shaded-Polygon Rendering
- Ray Tracing
- Radiosity and Polygon Shading

Completed Design

Design Choices & Issues In Computer Graphics
Textbook and Recommended References

Required Textbook

Recommended References


Next Class

- **Photorealism**
  - http://realismstudio.com

- **3-D Camera Model**
  - The GraPHIGS Programming Interface: Understanding Concepts
  - © 2007 IBM
  - http://bit.ly/c54h7q
Summary

- **This course is a lot of work**
  - Programming assignments (4): expect to spend 10+ hours on each
  - Written assignments (4): about 6-10 hours
  - Term project: at least 30 hours (people have spent up to 60 or more)
- … but it can also be fun
  - Visible results
  - Nifty algorithms, high-performance hardware
  - “Putting it all together”: very interdisciplinary field
  - Decent job market for people with right development skills, ideas
  - Applicable to many other areas of CS and IT
- **Emphasis**
  - “Polygons to pixels pipeline”: viewing, VSD, lighting, shading, texturing
  - Other topics to be covered: animation, curves and surfaces, collisions
  - Brief survey of: ray tracing, visualization and color, fractals
- **Tutorials (GameDev aka Nehe):** [http://nehe.gamedev.net](http://nehe.gamedev.net)

Terminology

- **Computer Graphics: Digital Synthesis, Manipulation of Visual Content**
  - Geometry: representation and processing of surfaces
  - Animation: representation and manipulation of motion
  - Rendering: computationally reproducing appearance of light in scenes
  - Imaging: image acquisition, editing, processing
- **Different Approaches to Graphics**
  - Raster (bitmaps, picture elements aka pixels) vs. vector (lines)
  - Sample-based (cf. Photoshop) vs. geometry-based (cf. OpenGL, Direct3D)
- **Purpose of Graphics**
  - Entertainment – games, visual effects in movies and television
  - Communications – advertising, journalism
  - Modeling / simulation – displaying objects, events via graphical user interfaces (GUIs)
  - Visualization – displaying events for analysis and understanding
- **Dual Problem: Inverse Input and Output**
  - Graphics (rendering): geometry to sample (image)
  - Vision: sample to geometry