Lecture 0 of 41:
Part B – Course Content

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, 2e
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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Lightly-shaded entries denote the due date of a written problem set. Heavy-shaded entries, that of a machine problem (programming assignment). Blue-shaded entries, that of a paper review, and the green-shaded entry, that of the term project.

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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• 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
  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)

Back-End
(Rasterization)

“Polygons-to-Pixels” Pipeline

- Visible-Surface Determination
- Scan Conversion
- Shading / Illumination

Display Traversal → Modeling Transformation → Viewing Operation → Image
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.

Visual programming systems for high-performance knowledge discovery in databases (KDD), cloud computing, and more

D2K © 1999-2004 National Center for Supercomputing Applications
http://alg.ncsa.uiuc.edu/do/tools/d2k
Relevant Topic Areas

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

Computer Graphics (CG)

- Parametric Equations
- Conics
- Polygon Rendering
- Surface Modeling
- Physically-Based Modeling
- Stat/Info Visualization
- Transformations
- Change of Coordinate Systems

- Rendering Hardware
- VR Systems
- Portable/Embedded CG
- Color/Optical Models
- CG/Vision Duality
- Interface Design
- Layout
- CG Design
- Visualization

- User Modeling
- Ergonomic Interfaces, I/O

- Immersive Training
- Tutoring Interfaces
- CAD
- CAE / CASE
- CAM
- CAD
- CAE / CASE
- CAM
- Portable/Embedded CG
- Color/Optical Models
- CG/Vision Duality
- Interface Design
- Layout
- CG Design
- Visualization

- Animation
- Large-Scale CG
Shading Pipeline & Surface Modeling
(Boundary Representations)

Special Topics:
Multitexturing & Mappings

Stefan Jeschke
Research Assistant

Eduard Gröller
Associate Professor
Director, Visualization Working Group

Institute of Computer Graphics and Algorithms
Technical University of Vienna

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

Mapping material from slides © 1995 – 2009 P. Hanrahan, Stanford University
Computer-Generated Animation (CGA)

Monsters Inc. (2001)
© Disney/Pixar

Monsters Inc. 2 (2012)
© Disney/Pixar

Kung-Fu Panda
© 2008 DreamWorks Animation SKG

Happy Feet
© 2006 Warner Brothers

Toy Story (1995)
© Disney/Pixar

Toy Story 2 (1999)
© Disney/Pixar

Toy Story 3 (2010)
© Disney/Pixar

Shrek (2001)
© DreamWorks Animation SKG

Shrek 2 (2004)

Shrek the Third (2007)
© DreamWorks Animation SKG

Shrek Forever After (2010)

Tron: Legacy
© 2010 Walt Disney Pictures

Wall-E
© 2008 Disney/Pixar

Happy Feet
© 2006 Warner Brothers

Luxo Jr.
© 1986 Pixar Animation Studios

Computer-Generated Animation (CGA)
Special Topics:
Computer-Generated Animation (CGA)

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

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http://www.cs.virginia.edu/~jdl/

Thomas A. Funkhouser
Professor
Department of Computer Science
Computer Graphics Group
Princeton University
http://www.cs.princeton.edu/~funk/
Fractals: Iterated Function Systems (IFSs)

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

Legend:
- height: Sum of Sales
- color: Average of Sales Ratio

Average of Sales Ratio

Visible Decisions SeeIT © 1999 VDI http://www.advizorsolutions.com
Design Choices & Issues
In Computer Graphics

Determine Objectives of Graphics System
- Entertainment
- Decision Support
- Education
- Control Interface
- Monitor Process
- Interactively Display Objective
- Visualize Physical Objects

Determine Representations In Graphics Database
- Solid Geometric Model
- Wireframe / Polygon Mesh
- NURBS
- Fractal System
- Shaded-Polygon Rendering
- Ray Tracing
- Radiosity and Polygon Shading

Determine and Implement Rendering Pipeline

Completed Design
Required Textbook


Recommended References


Next Class

- Photorealism

http://realismstudio.com

- 3-D Camera Model

© 2001 Square Enix Studios

The GraPHiGS Programming Interface: Understanding Concepts
© 2007 IBM
http://bit.ly/cS4h7g
Summary

- **This course is a lot of work**
  - Reading: Eberly 2e – big book, like Foley *et al.*
  - 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