Lecture 0 of 41:
Part B – Course Content

Introduction to Computer Graphics:
Course Organization and Survey

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KSOL course page: http://bit.ly/hGvX1H
Course web site: http://www.kddresearch.org/Courses/CIS636
Instructor home page: http://www.cis.ksu.edu/~bhsu

Reading for Next Class:
Syllabus and Introductory Handouts
CIS 536 & 636 students: CG Basics 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 2010, 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
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)
  - Display Traversal
  - Modeling Transformation
  - Viewing Operation

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

"Polygons-to-Pixels" Pipeline
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.

**NCSA SEASR/MEANDRE**
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.nccs.uiuc.edu/do/tools/d2k](http://alg.nccs.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**

**Rendering Hardware**
- VR Systems
- Portable/Embedded CG

**Computer Graphics (CG)**
- **CAD**
- **CAE**
- **CASE**
- **CAM**
- **Immersive Training**
- **Tutoring Interfaces**

**Color/Visual Models**
- CG/visualization duality
- Interface design

**Transformations**
- Change of Coordinate Systems

**Surface Modeling**
- Physically-Based Modeling
- Stat/Info Visualization

**User Modeling**
- Ergonomic Interfaces, I/O

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


Computer-Generated Animation (CGA)

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

Tron: Legacy
© 2010
Walt Disney Pictures

Kung-Fu Panda
© 2008 DreamWorks Animation SKG

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

Happy Feet
© 2006
Warner Brothers

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

Luxo Jr.
© 1986 Pixar Animation Studios

Wall-E
© 2008 Disney/Pixar

Toy Story 3
© Disney/Pixar

Happy Feet
© 2006
Warner Brothers

I WANT YOU FOR PIXAR

Tron: Legacy
© 2010
Walt Disney Pictures
Fractals: Iterated Function Systems (IFSs)

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

Information Visualization

Visible Decisions SeeIT © 1999 VDI http://www.advizorsolutions.com
**Math Review for CIS 536 / 636**

- **Overview: First Month (Weeks 2-5 of Course)**
  - Review of mathematical foundations of CG: analytic geometry, linear algebra
  - Line and polygon rendering
  - Matrix transformations
  - Graphical interfaces
- **Line and Polygon Rendering (Week 3)**
  - Basic line drawing and 2-D clipping
  - Bresenham’s algorithm
  - Follow-up: 3-D clipping, z-buffering (painter’s algorithm)
- **Matrix Transformations (Week 4)**
  - Application of linear transformations to rendering
  - Basic operations: translation, rotation, scaling, shearing
  - Follow-up: review of standard graphics libraries (starting with OpenGL)
- **Weeks 5 – 6: More OpenGL and Direct3D**
- **Graphical Interfaces**
  - Brief overview
  - Survey of windowing environments (SDL in OpenGL, DirectX)
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
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 20 hours (people have spent up to 50 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

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