Introduction to Computer Graphics:
Course Organization and Survey

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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)

Back-End
(Rasterization)

“Polygons-to-Pixels” Pipeline

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

Graphics Database Editing

Graphics Database

Display Traversal → Modeling Transformation → Viewing Operation

Image
User Interfaces & Hypermedia

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

- **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.

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

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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
- Immersive Training Tutoring Interfaces
- CAD
- CAE / CASE CAM
- Animation
- Large-Scale CG
- User Modeling
- Ergonomic Interfaces, I/O
Shading Pipeline & Surface Modeling (Boundary Representations)

Computer-Generated Animation (CGA)

Monsters Inc. (2001)
Monsters Inc. 2 (2012)
© 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

Happy Feet
© 2006
Warner Brothers

Luxo Jr.
© 1986 Pixar Animation Studios
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

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

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

Determine Representations in Graphics Database
- Solid Geometric Models
- Wireframe / Polygon Mesh
- NURBS
- Fractal System

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

Completed Design
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

www.realismstudio.com

- 3-D Camera Model

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 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](http://nehe.gamedev.net)
Computing & Information Sciences
Kansas State University

CIS 536/636
Introduction to Computer Graphics

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