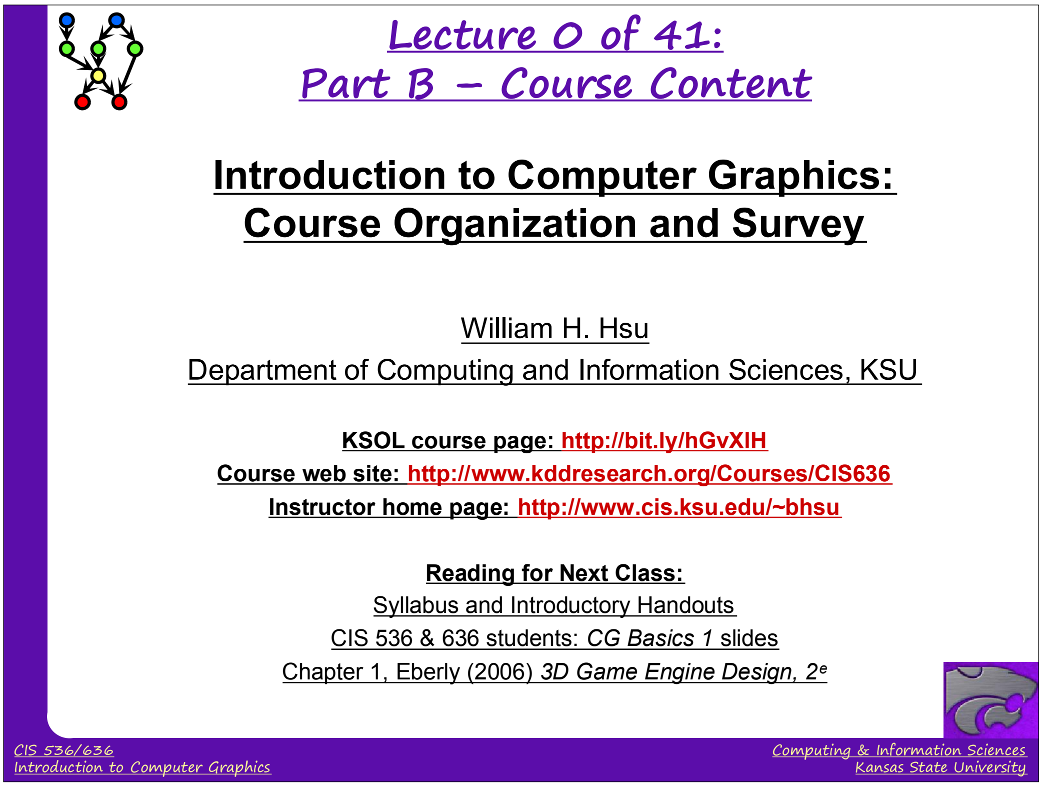


Lecture 0 of 41: Part B – Course Content

Introduction to Computer Graphics: Course Organization and Survey

William H. Hsu

Department of Computing and Information Sciences, KSU

KSOL course page: http://bit.ly/hGvXIH

Course web site: http://www.kddresearch.org/Courses/CIS636

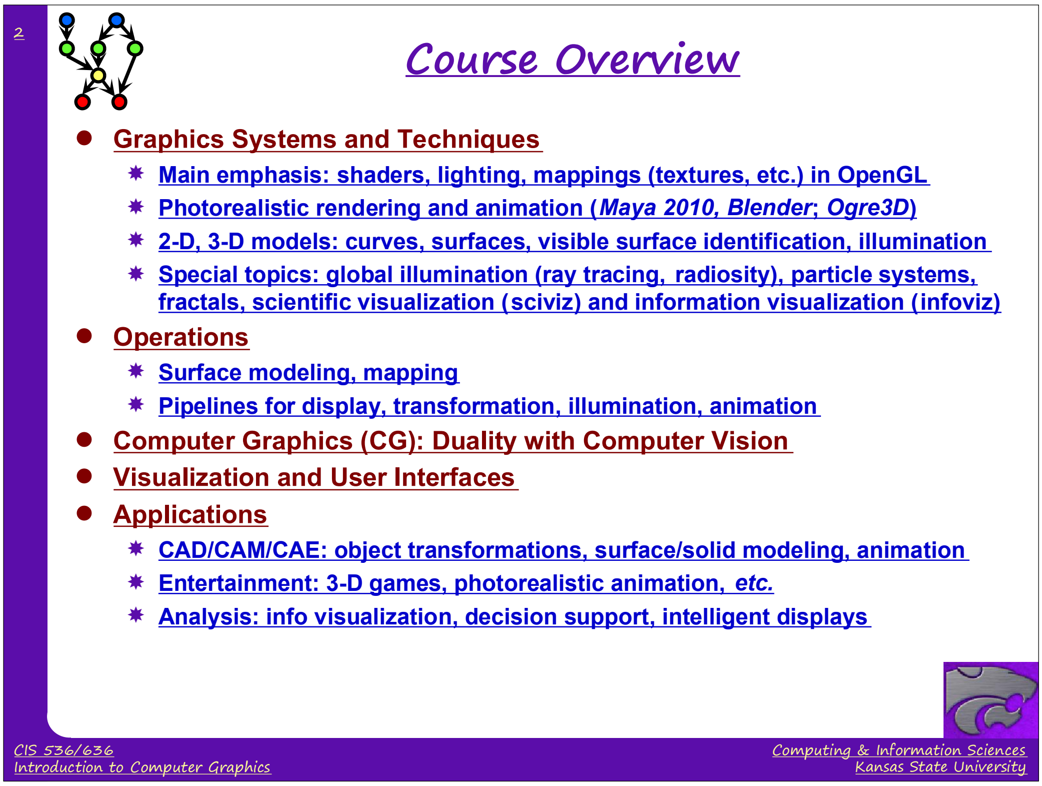
Instructor home page: http://www.cis.ksu.edu/~bhsu

Reading for Next Class:

Syllabus and Introductory Handouts

CIS 536 & 636 students: *CG Basics 1* slides

Chapter 1, Eberly (2006) *3D Game Engine Design, 2^e*



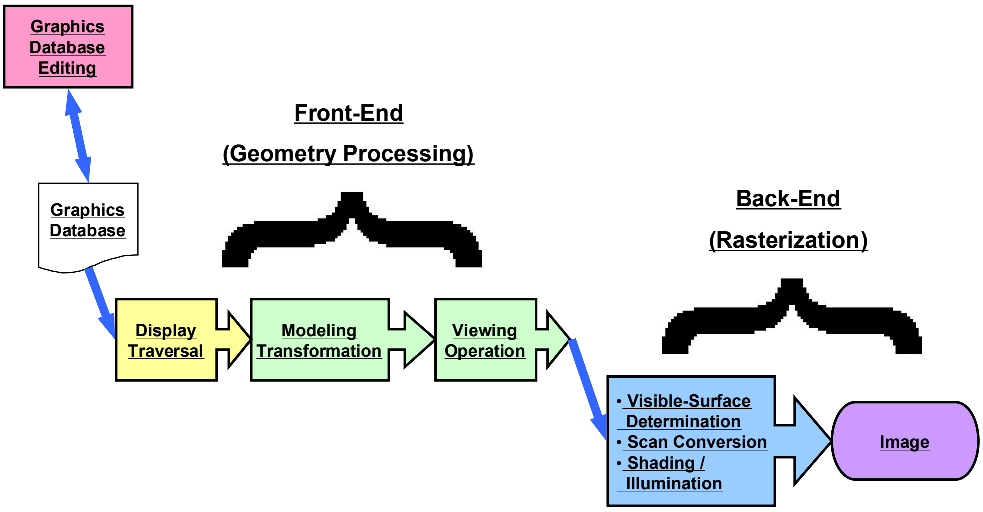
Course Overview

- 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



Graphics Database Editing

Graphics Database

Front-End

(Geometry Processing)

Display Traversal

Modeling Transformation

Viewing Operation

Back-End

(Rasterization)

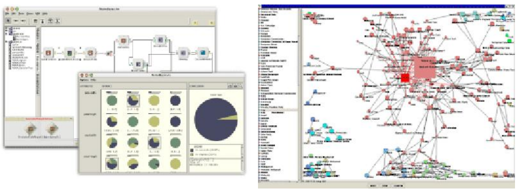
- Visible-Surface Determination
- Scan Conversion
- Shading / Illumination

Image

"Polygons-to-Pixels" Pipeline

5

User Interfaces & Hypermedia



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

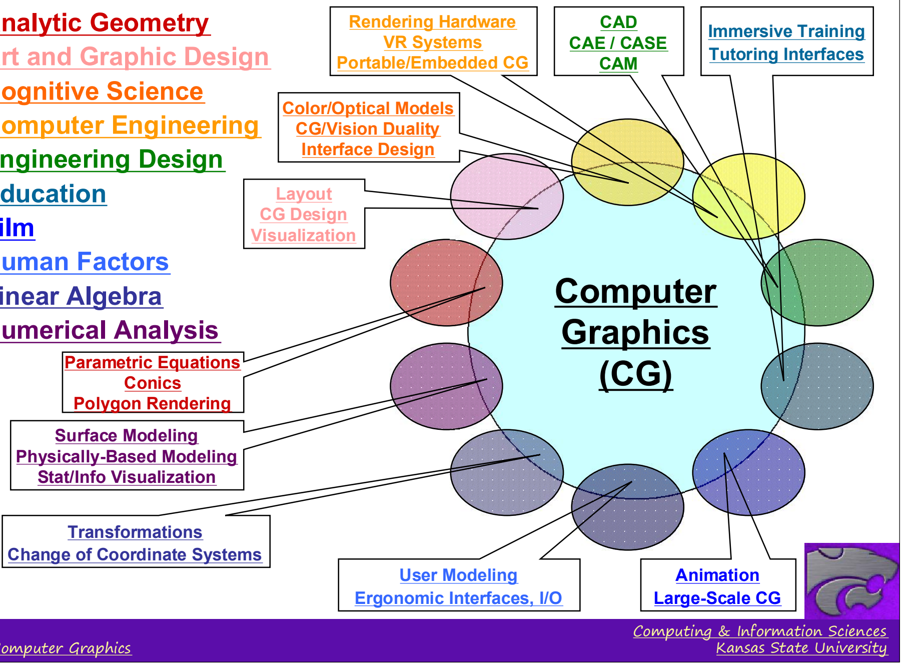
NCSA SEASR/MEANDRE (2008 – present): http://seasr.org
Visual programming systems for high-performance knowledge discovery in databases (KDD), cloud computing, and more

- 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.*

6

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

CAD
CAE / CASE
CAM

Immersive Training
Tutoring Interfaces

Color/Optical Models
CG/Vision Duality
Interface Design

Layout
CG Design
Visualization

Computer Graphics (CG)

Parametric Equations
Conics
Polygon Rendering

Surface Modeling
Physically-Based Modeling
Stat/Info Visualization

Transformations
Change of Coordinate Systems

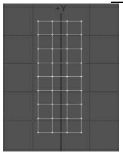
User Modeling
Ergonomic Interfaces, I/O

Animation
Large-Scale CG

Shading Pipeline & Surface Modeling (Boundary Representations)

http://bit.ly/aagZJn

1



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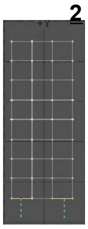

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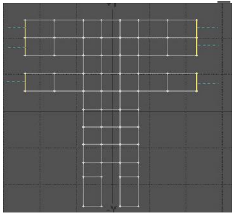

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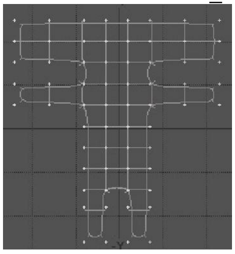

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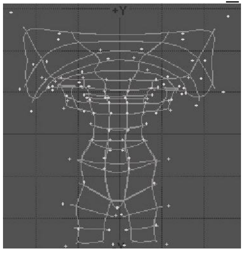

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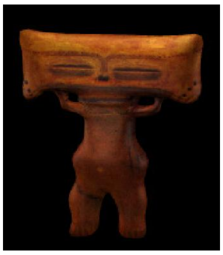

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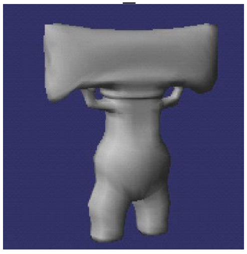
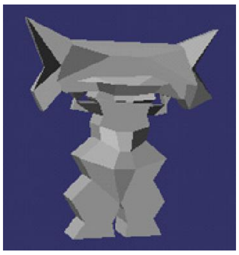




6

Computer-Generated Animation (CGA)

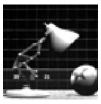
Monsters Inc. (2001)
Monsters Inc. 2 (2012)
© Disney/Pixar

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

Tron: Legacy
© 2010
Walt Disney Pictures

Kung-Fu Panda
© 2008 DreamWorks
Animation SKG

Happy Feet
© 2006
Warner Brothers

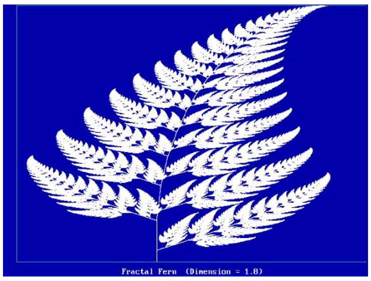


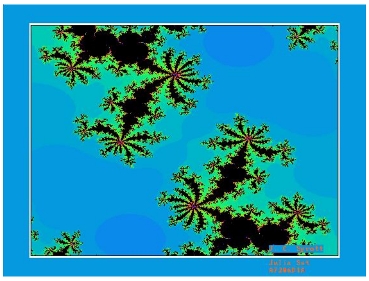
Luxo Jr.
© 1986 Pixar Animation Studios

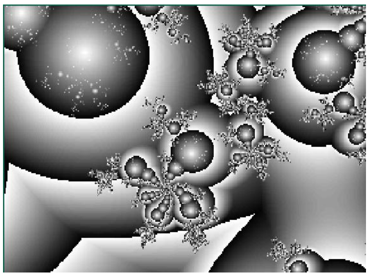
Shrek (2001)
Shrek 2 (2004)
Shrek the Third (2007)
Shrek Forever After (2010)
© DreamWorks Animation SKG

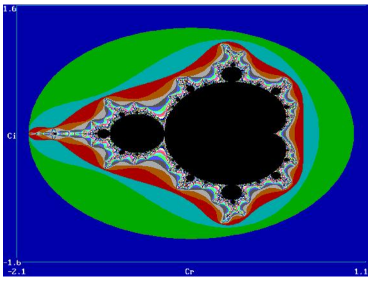
Wall-E
© 2008 Disney/Pixar

Fractals :
Iterated Function Systems (IFSs)



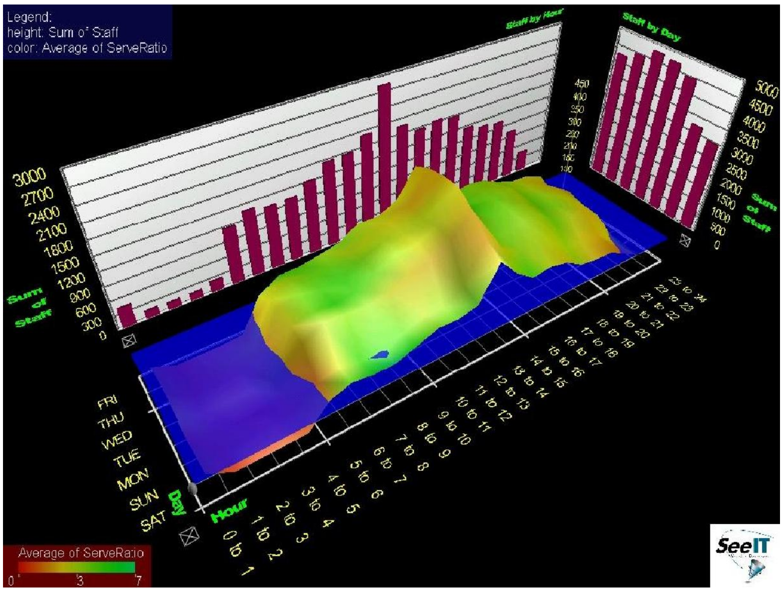






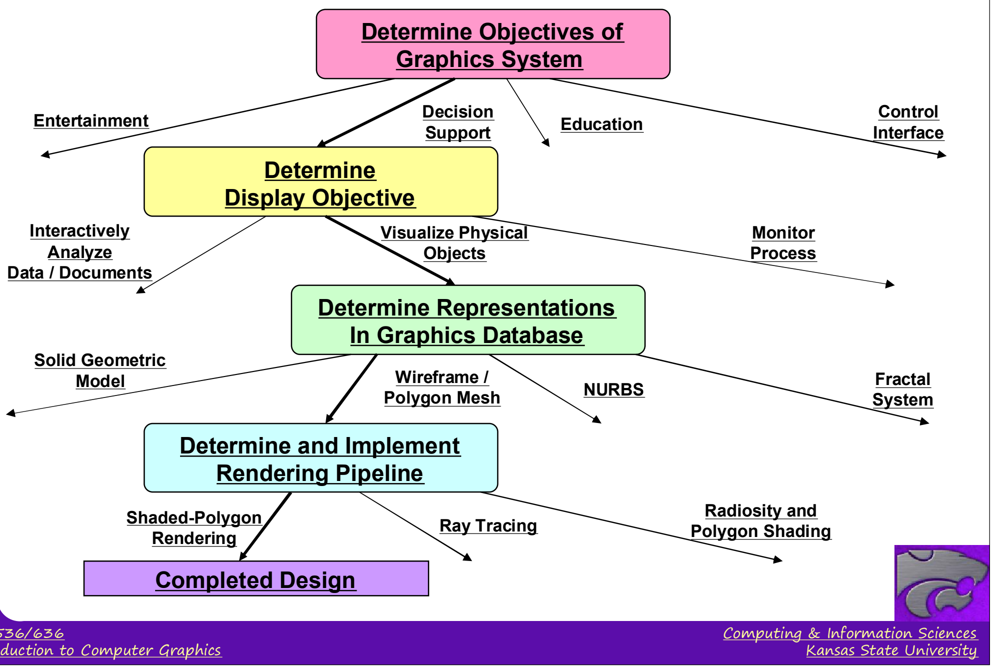
Fractal of the Day: http://sprott.physics.wisc.edu/fractals.htm

Information Visualization



Visible Decisions *SeeIT* © 1999 VDI http://www.advizorsolutions.com

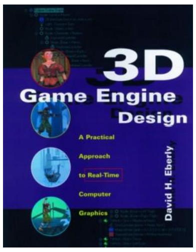
Design Choices & Issues In Computer Graphics


Determine Objectives 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

Math Review for CIS 536 / 636

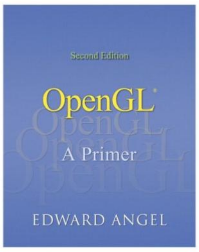
- Overview: First Month (Weeks 2-5 of Course)
  - Review of mathematical foundations of CG: analytic geometry, linear algebra
  - Line and polygon rendering
  - Matrix transformations
  - Graphical interfaces
- Line and Polygon Rendering (Week 3)
  - Basic line drawing and 2-D clipping
  - Bresenham's 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

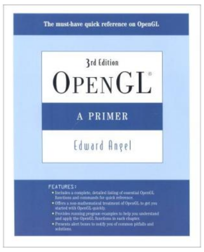


1st edition (outdated)

2nd edition



2nd edition (OK to use)



3rd edition

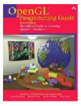
Required Textbook

Eberly, D. H. (2006). *3D Game Engine Design: A Practical Approach to Real-Time Computer Graphics, second edition.* San Francisco, CA: Morgan Kauffman.

Recommended References

Angel, E. O. (2007). *OpenGL: A Primer, third edition*. Reading, MA: Addison-Wesley. [2nd edition on reserve]

Shreiner, D., Woo, M., Neider, J., & Davis, T. (2009). *OpenGL® Programming Guide: The Official Guide to Learning OpenGL®, Versions 3.0 and 3.1, seventh edition*. ["The Red Book": use 7th ed. or later]



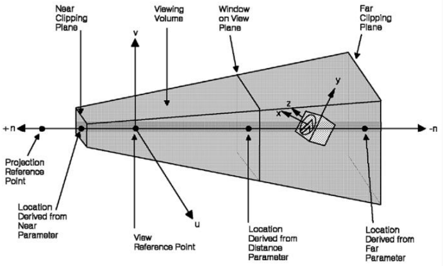
Next Class

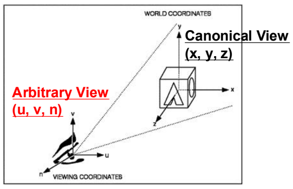
- **Photorealism**

http://realismstudio.com

© 2001 Square Enix Studios http://bit.ly/9YzCZy

- **3-D Camera Model**


Near Clipping Plane
Viewing Volume
Window on View Plane
Far Clipping Plane
v
y
z
x
+n
-n
Projection Reference Point
Location Derived from Near Parameter
View Reference Point
u
Location Derived from Distance Parameter
Location Derived from Far Parameter



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

Summary

- This course is a lot of work
  - Reading: Eberly 2^{e} – 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

Terminology

- Computer Graphics: Digital Synthesis, Manipulation of Visual Content
- Graphics Problems (see "Computer Graphics", Wikipedia)
  - 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