Lecture 1: Introduction

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What is it about?

- General introduction to techniques behind 2D and 3D graphics.

- **Theory**: fundamental mathematics and algorithms underlying modern graphics systems and techniques.

- **Practice**: be able to write reasonably complex 3D graphics programs using Java and OpenGL.

- **NOT** about learning software packages such as Maya, 3D Max or Photoshop.
What is it about?

Topics:
- Image representation and processing
- 2D, 3D modeling
- Standard graphics pipeline and OpenGL.
  - Model and View Transformations
  - Rasterization
  - Shading and Textures
  - Programmable shaders
- Ray tracing
- Additional topics: camera basics, 3D scanning and 3D printing, HDR, global illumination
Topics

- 2D Graphics
  - How to represent an image?
  - How to represent colors?
  - Image sampling and quantization
Topics

- 2D Graphics
  - Basic image adjustments
    - Brightness, contrast, saturation
  - Image filtering, convolution
    - Blur, sharpen, edge detection
  - Image transformation (warp)
  - Image compression
Assignment 1: Image Processing

- Basic adjustment, Dithering, Filtering
Assignment 1

- Image Mosaic
Assignment 1

- Depth Dependent Blur
Topics

- 2D/3D Modeling
  - Curved lines: Bezier, B-Spline, NURBS
  - Curved surfaces
  - Polygonal mesh, Subdivision surface
Assignment 2

- **2D/3D Modeling**
  - Curved lines: **Bezier, B-Spline, NURBS**
  - Curved surfaces
  - Polygonal mesh, **Subdivision surfaces**

![Diagram of Bezier, B-Spline, and NURBS curves](image)

![Examples of polygonal mesh and subdivision surfaces](image)
Assignment 2: Curves and Surfaces
Topics

- Modern Graphics Pipeline
  - Transformation
  - Rasterization, hidden surface removal
  - Illumination and shading
  - Texture mapping
  - Programmable shaders
  - OpenGL
Assignment 3: Hierarchical Modeling
Topics

- Ray Tracing
  - Ray casting
  - Recursive ray tracing
  - Shadows, reflections, refractions
  - Stochastic ray tracing
Assignment 4

- Ray Tracing
  - Ray casting
  - Recursive ray tracing
  - Shadows, reflections, refractions
  - Stochastic ray tracing
Final Project: OpenGL Scene

- Open-end, many students will probably choose to implement a 3D game
- Completed in groups of two
- In-class presentation
Final Project: OpenGL Scene

Some excellent examples from students who took this class in the past:
Additional Topics

- Camera Basics and Digital Photography
  - High dynamic range imaging
Additional Topics

- Global Illumination
Additional Topics

- 3D Scanning and printing
Related Courses

- CmpSci 474: Advanced Image Synthesis
- Computer vision, computational geometry, robotics ...
- 3D animation, web animation ...
Prerequisites

- Be familiar with Java programming (CMPSCI 187); for most assignments, we will provide starter code in Java.

- Be familiar with basic linear algebra (MATH 235), in particular vector and matrix arithmetic.

- Self-learning: you will learn and practise using OpenGL mostly by yourself.
Workload

- This is a fun course, but it also requires your efforts:
  - 4 programming assignments (every 2 weeks)
  - 1 mid-term exam
  - 1 final project (4 weeks)
  - Various Spark quizzes

- You will have to work hard, but you will learn the real stuff; grading is generous.
Suggestions

- Come to every class!
- Do quizzes.
- Start early on each assignment.
Logistics

- **Class Wikipage**
  (Note that this is not department twiki)
  If you forget, link from my homepage: http://www.cs.umass.edu/~ruiwang
  Or from the department 'courses' page

- **Class email** (goes to everyone)
  cmpsci-473-01-fal10@courses.umass.edu
Logistics

- Submission instructions
  - All assignments are due on Tuesdays at 11:00pm (but you have till midnight to upload your assignments in SPARK).

- Late policy
  - Up to 48-hour extension with penalty

- Academic honesty
- Collaboration policy
- Read the course syllabus!!
Logistics

- Textbooks
  - Readings are listed on the webpage.
Logistics

- Office Hours
  - Me:
    - Thur 4-5pm, CS 270
  - Moe Mattar:
    - Mon 4-6pm, CS 256
  - All assignments are due on Tuesdays.
Logistics

- Spark
  - Submission
    - Remember that you have to click on the Submit button!
  - Quizzes
    - All due on Thursdays before class.
- Calendar
- Discussion forum
Announcement

- Warm-up assignment due in a week
- 1 written question + 1 programming task
- Will be graded but **not** counted towards final grade
- Due on Sep 14 at 11:00pm

OpenGL Teapot!!!
How-to

- Make sure Java SDK and JOGL work
  - Install JOGL 1.1.1, not 2.0!
  - We recommend you to use an IDE such as Eclipse or Netbeans
  - Add JOGL as external jar files
  - Set your PATH variable
  - If the window appears gray initially, use this Java VM parameter:
    
    -Dsun.java2d.noddraw=true
What is Computer Graphics?

- Sliced by specialty
  - Imaging: representing 2D images
  - Modeling: representing 3D objects
  - Rendering: building 2D images from 3D models
  - Animation: simulating changes over time
  - Hardware: computer architecture for graphics
What is Computer Graphics?

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Computer Graphics = the field of visual computing
What is CG?

- Sliced by task
  - Creating pictures on a computer
  - Interacting with those pictures
  - Drawing those pictures faster
  - Displaying those pictures bigger, brighter
  - Video games
  - Visualization of complex data
  - Simulating illumination phenomena
  - Simulating the real world (plants, animals, volcano...)
  - Acquiring real-world geometry
  - Breaking stuff
  - ...

Why is CG cool?

- Interdisciplinary
  - Physics, Math, Art, Psychology, Programming...

- Visual

- Interactive

- Work can be demoed to technically illiterate friends

- Money
  - Video games: $10.5B (2004)
Applications

- Entertainment (passive, active)
- Graphics User Interface
- Interaction Techniques
- Computer Aided Design
- Visualization
- Photography
- Training
- Education
- Art
- ......
Entertainment (passive)

Final Fantasy (Square, USA)
Entertainment (passive)

Wall E (Pixar)
Entertainment (passive)

Kung Fu Panda
(Dreamworks)
Entertainment (passive)

Star Wars  *(Special Effects by: Industrial Light & Magic)*
Entertainment (active)

Doom III (ID Software)
Entertainment (active)

Age of Empire (Microsoft)
Graphical User Interfaces

Window system and large-screen interaction  
(François Guimbretière)
Computer Aided Design (CAD)

Industrial Design and Prototyping
Scientific Visualization

Airflow around a Harrier Jet (NASA Ames)
Scientific Visualization

Compressible Turbulence  (Lawrence Livermore National Labs)
Education

The Visible Human
(K.H.Hoehne)

Mathematical Surfaces
(Science Magazine Cover Sep 2006)
Art

Image Mosaic  (*Rotunda, Univ. of Virginia*)
Example-Based Sketching of Human Portraits (MSRA, Microsoft, etc)