CS 430
Computer Graphics

Introduction
Week 1, Lecture 1

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Overview

- Course Policies/Issues
- Brief History of Computer Graphics
- The Field of Computer Graphics: A view from 66,000ft
- Structure of this course
- Homework overview
- Introduction and discussion of homework #1
Computer Graphics I: Course Goals

• Provide introduction to **fundamentals** of 2D and 3D computer graphics
  – Representation (lines/curves/surfaces)
  – Drawing, clipping, transformations and viewing
  – Implementation of a basic graphics system
    • simple frame buffer with PBM format
    • ties together 3D projection and 2D drawing
Interactive Computer Graphics
CS 432

- Learn and program WebGL
- Computer Graphics was a pre-requisite
  - Not anymore
- Useful for Games classes
- Part of the HCI and Intelligent Systems tracks
Advanced Rendering Techniques (Advanced Computer Graphics)

- Not sure when it will be offered again
- 3D Computer Graphics
- CS 430/536 is a pre-requisite
- Implement Ray Tracing algorithm
- Lighting, rendering, photorealism
- Study Radiosity and Photon Mapping
ART Student Images
Computer Graphics I: Technical Material

• Course coverage
  – Mathematical preliminaries
  – 2D lines and curves
  – Geometric transformations
  – Line and polygon drawing
  – 3D viewing, 3D curves and surfaces
  – Splines, B-Splines and NURBS
  – Solid Modeling
  – Color, hidden surface removal, Z-buffering
Computer Graphics I: Course Highlights

- Bresenham’s scan conversion algorithm
- Cohen-Sutherland clipping algorithm
- Sutherland-Hodgman polygon clipping
- The De Casteljau Algorithm
- Polygon filling
- B-Splines, NURBS, De Boor’s Algorithm
- Z-buffer algorithm; backface culling
Computer Graphics I: Course Management Issues

• All course policies are in the syllabus
• Extensive use of PDF handouts
• Must read email every day
• There will be 5 programming assignments (plan on 8-to-15 hrs)
• Suggestion: print out handouts before class, use them to take notes
• Final exam on material not covered by the programming assignments
• **READ THE SYLLABUS!!**
Computer Graphics I: Collaboration Policies

- Thou Shall
  - write your own code
  - do your own math
  - attribute any work that is not your own
  - talk amongst yourselves, share ideas
- Thou Shall Not
  - Share/copy code
  - Use ideas without attribution
  - Utilize geometry/graphics libraries
- All code will be auto checked for plagiarism
- Violations will result in an automatic F
Go to class web page
CG Technical Areas

• Geometric Modeling
  – Mathematics and algorithms that define 2D and 3D geometric objects
CG Technical Areas

- Human/Computer Interaction
  - Methods for creating graphics data via user input

Surface Drawing, Steven Schkolne
CG Technical Areas

• Lighting and Shading
  – Math, physics and algorithms that specify how light interacts with matter
CG Technical Areas

• Rendering
  – Algorithms that take geometry, lighting, shading and viewing information and generate an image
CG Technical Areas

• Visualization
  – Techniques for visually communicating and exploring scientific, medical or abstract data
CG Technical Areas

• Perception
  – Study of how humans perceive light and information
CG Technical Areas

• Animation
  – Algorithms for making models change over time
CG Technical Areas

- Simulation
  - Using physics to make models move
CG Technical Areas

- Software and Hardware
  - Designing software and hardware systems to implement graphics algorithms
Computer Graphics: In The Beginning

- MIT - 1963
  Ivan Sutherland’s *Sketchpad*
- Modified oscilloscope for drawing
- The original CAD system

Courtesy Marc Levoy @ Stanford U
Computer Graphics from 66,000ft

- Display types
- Display/Rendering algorithms
- Application areas
  - Entertainment
  - CAD/CAM
  - Scientific & medical visualization
  - Training & education
  - Synthetic realities
  - Art and design
  - Games
2D Graphics

- **Raster:**
  - Pixels
    - X11 bitmap, XBM
    - X11 pixmap, XPM
    - GIF
    - TIFF
    - PNG
    - JPG
  - Lossy, jaggies when transforming, good for photos.

- **Vector:**
  - Drawing instructions
    - Postscript
    - CGM
    - Fig
    - DWG
  - Non-lossy, smooth when scaling, good for line art and diagrams.
2D Graphics

• Raster:

• Vector:
Adobe Photoshop: 2D Raster Graphics
2D Raster Graphics
Adobe Illustrator: 2D Vector Graphics
2D Vector Graphics
3D Rendering

- 1960s - the visibility problem
  - Roberts (1963), Appel (1967) - hidden-line algorithms
  - Sutherland (1974) - visibility = sorting

- 1970s - raster graphics
  - Gouraud (1971) - diffuse lighting
  - Phong (1974) - specular lighting
  - Blinn (1974) - curved surfaces, texture
  - Crow (1977) - anti-aliasing

Courtesy Marc Levoy @ Stanford U
3D Rendering

Toward Reality in the 1980s

• global illumination
  – Whitted (1980) - ray tracing
  – Goral, Torrance et al. (1984), Cohen (1985) - radiosity
  – Kajiya (1986) - the rendering equation

• photorealism
  – Cook & Torrance (1982) – rough surface reflectance
  – Cook (1984) - shade trees
  – Perlin (1985) - shading languages
  – Hanrahan and Lawson (1990) - RenderMan

Courtesy Marc Levoy @ Stanford U
Away from Reality

- early 1990s - non-photorealistic rendering
  - Drebin et al. (1988), Levoy (1988) - volume rendering
  - Haeberli (1990) - impressionistic paint programs
  - Salesin et al. (1994-) - automatic pen-and-ink illustration
  - Meier (1996) - painterly rendering

Courtesy Marc Levoy @ Stanford U
And Back Again

- late 1990s & 2000s - photon mapping, subsurface scattering and participating medium
  - H. Wann Jensen
Application Areas

- **Entertainment**
- CAD/CAM
- Scientific & Medical visualization
- Training & Education
- Synthetic Realities
  - VR, AR, etc.
- Art and design
- Games

Pixar
Lord Of the Rings Troll
Application Areas

- Entertainment
- **CAD/CAM**
- Scientific & Medical visualization
- Training & Education
- Synthetic Realities
  - VR, AR, etc.
- Art and design
- Games

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Regli et al @ Drexel
Application Areas

- Entertainment
- CAD/CAM
- **Scientific & Medical Visualization**
- Training & Education
- Synthetic Realities
  - VR, AR, etc.
- Art and design
- Games

Lombeyda & Breen @ CalTech
Application Areas

• Entertainment
• CAD/CAM
• Scientific visualization
• Training & Education
• Synthetic Realities
  – VR, AR, etc.
• Art and design
• Games
Application Areas

- Entertainment
- CAD/CAM
- Scientific visualization
- Training & Education
- **Synthetic Realities**
  - VR, AR, etc.
- Art and design
- Games

Telepresence

Augmented Reality

FakeSpace Cave
Application Areas

• Entertainment
• CAD/CAM
• Scientific visualization
• Training & Education
• Synthetic Realities
  – VR, AR, etc.
• Art and design
• Games
Application Areas

- Entertainment
- CAD/CAM
- Scientific visualization
- Training & Education
- Synthetic Realities
  - VR, AR, etc.
- Art and design
- Games
Programming Assignments

- **No APIs**: OpenGL, GLUT, Mesa, DirectX…
- Just line and filled polygon rendering
  - Color in last assignment
- Output in the form of 2D ASCII bitmaps
  - PBM and PPM
- Program source (and makefile) turned in via Bb Learn
- **Executable MUST RUN on Linux (tux)**
- **Whatever language you want**, so long as you can deliver a program that TA can run (c, c++, java, python, …)
For programming assignments

• Use PBM as B/W “software” frame buffers
• We will be implementing parts of the 2D Engine, 3D Engine and Pixel Cache of a graphics accelerator
• Issue: How to translate the mathematics of 2D/3D shapes to the 2D screen?
• Tip: Renew your friendship with your linear algebra textbook
• Read homeworks ahead. It will help you to structure your code for future requirements.
Assignment Dependencies

- Every HW - Read in geometry and write images
- HW1 - Clip 2D lines and draw them
- HW2 - Clip 2D polygons and draw edges with HW1
- HW3 - Use HW2 to clip 2D polygons and fill in interiors
- HW4 - Project 3D polygon edges (3D lines) into 2D. Draw them with HW2
- HW5 - Project 3D triangles into 2D. Combine HW3 and HW4, and add depth buffer
- EC - Generate lines and draw with HW1
# Programming Assignments Dependencies

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Data Structures

• Initially B/W, then RGB Frame Buffer
• 2D Lines
• 2D/3D polygons (vertices and edges)
• Triangle mesh
• 3D camera/scene
When it’s all over!
Don’t forget ICG & ART!
Programming assignment 1

- Input PostScript-like file
- Output B/W PBM
- Primary I/O formats for the course
- Create data structure to hold points and lines in memory (*the world model*)
- Implement 2D translation, rotation and scaling of the world model
- Implement line drawing and clipping
- Due October 4th
- Get started now!