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 XPM format
    • ties together 3D projection and 2D drawing
New Graphics & Vision Track?

Take CS 430 & CS 435 and one other

- CS 430 Computer Graphics *
- CS 431 Advanced Rendering Techniques
- CS 432 Interactive Computer Graphics
- CS 435 Computational Photography *
- Can “double-up” 432 with HCI Track

* Required
Interactive Computer Graphics

- Now offered every year
- Learn and program OpenGL
- Computer Graphics I was a pre-requisite
- Useful for Games classes
  - Most final projects are games
- Part of the HCI track
Advanced Rendering Techniques

- Not sure when it will be offered again
- 3D Computer Graphics
- Ray tracing algorithm
- Lighting, rendering, photorealism
- Bezier & polygonal meshes
- Hierarchical models
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 6 programming assignments (plan on 8-to-15 hrs)
• Suggestion: print out handouts before class, use them to take notes
• Grad students submit a paper presentation
• 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: A Brief History

• In The Beginning…
  1963
  Ivan Sutherland’s *Sketchpad*
• Modified oscilloscope for drawing
• The original CAD system

Courtesy Marc Levoy @ Stanford U
Graphics Hardware History

• Good summary of the development of the graphics processor
  – http://accad.osu.edu/~waynec/history/lesson15.html

• Part of an excellent on-line history of computer graphics and animation
  – http://accad.osu.edu/~waynec/history/lessons.html
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 bitmaps
  – XPM: X11 Pixmap Format
• 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, …)
For programming assignments

• Use XPM 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 extend visible surface calculation
- HW6 – 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 XPM
• 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 January 20th
• Get started now!