Graphics and Games

IS 101Y/CMSC 104Y
First Year IT

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• Announcements
• Quizzes
• Project Questions
• Other questions
Questions about Reading Asst

Games with a Purpose
Human Crowd Computation Game

- Form into groups of 3
  - One is Picture; two are taggers
- Picture shows an image
- Taggers list words (30 seconds)
  - Words common between lists are added to db of tags

Games

- What things are important for developing compelling/successful computer games?

- What background/skills would someone need to work in the field?
Computer Graphics

• Using computer to generate simulated scenes or worlds
• Can require tricking eye to believe 2D collection of pixels is really a continuous 3D world
• Coding-intensive application with strong basis in creativity and human perception

• Five key problems
  – What shape is it?
  – What do you see?
  – What does it look like?
  – How does it move?
  – Why does it have to look like a photograph?

What shape is it?
Modeling Approaches

• **Modeling problem**
  – Define shape, color, and other visual properties

• **Modeling solutions**
  – Manual primitive creation
  – Scans from physical object
  – Functional descriptions
  – Grammar-based generation
  – Biologically-inspired simulations

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Scanning

![Scanning Image 1](image1.png)
![Scanning Image 2](image2.png)
Functional Descriptions

- Define visual attributes with function, defined over space
  - Shape
  - Density
  - Color

Grammar-based Generation

- Use (mostly) context-free grammars (CFG) to specify structural change over generations
- A CFG $G=(V,T,S,P)$ with
  - $V$ is a set of non-terminals
  - $T$ is a set of terminals
  - $S$ is the start symbol
  - $P$ is a set of productions (rules) of the form:
    - $A \rightarrow x$, where $A \in V$, $x \in (V \cup T)^*$
Biological Simulations

Mimic developmental process:
- cellular automata
- reaction diffusion

What do you see?
Painter’s Algorithm

- Basic approach
  - Draw polygons, from farthest to closest

- Given
  - List of polygons \{P_1, P_2, ..., P_n\}
  - An array of Intensity \([x,y]\)

- Begin
  - Sort polygon list on minimum Z
    (largest z value comes first in sorted list)
  - For each polygon \(P\) in selected list do
    - For each pixel \((x,y)\) that intersects \(P\) do
      - Intensity\([x,y]\) = intensity of \(P\) at \((x,y)\)
  - Display Intensity array

Z-Buffer

- Basic approach
  - Draw polygons, remembering depth of stuff drawn so far

- Given
  - List of polygons \{P_1, P_2, ..., P_n\}
  - An array x-buffer\([x,y]\) initialized to +infinity
  - An array Intensity\([x,y]\)

- Begin
  - For each polygon \(P\) in selected list do
    - For each pixel \((x,y)\) that intersects \(P\) do
      - Calculate z-depth of \(P\) at \((x,y)\)
      - If z-depth < x-buffer\([x,y]\) then
        - Intensity\([x,y]\) = intensity of \(P\) at \((x,y)\)
        - x-buffer\([x,y]\) = z-depth
  - Display Intensity array
Raytracing

- Basic approach
  - Cast ray from viewpoint through pixels into scene

- Given
  
  List of polygons \{ P_1, P_2, \ldots, P_n \}
  
  An array of intensity \[ x, y \]

  
  For each pixel \( (x, y) \) {
  
    form a ray \( R \) in object space through the camera position \( C \) and the pixel \( (x, y) \)
  
    Intensity \[ x, y \] = trace \( R \)
  
  }

  Display array Intensity

What does it look like?
Illumination Approaches

- Illumination problem
  - Model how objects interact with light
- Modeling solutions
  - Simple physics/optics
  - More realistic physics
    » Surface physics
    » Surface microstructure
    » Subsurface scattering
    » Shadows
    » Light transport

Simple Optics: Diffuse Reflection

Lambert’s Law:
the radiant energy from any small surface area dA in any direction \( \theta \) relative to the surface normal is proportional to \( \cos \theta \)

\[
I_{\text{diff}} = k_d I_l \cos \theta \\
= k_d I_l (N \cdot L)
\]

\( \theta \) = angle of incidence
Surface Physics

- Conductor (like metal)
- Dielectric (like glass)
- Composite (like plastic)
Subsurface Scattering

Shadows
How does it move?

Motion Dynamics Approaches

• Motion dynamics problem
  – Define geometric movements and deformations of objections under motion

• Dynamics solutions
  – Simulate physics of simple objects
  – Model structure and constraints
  – Capture motion from reality
  – Simulate group dynamics
  – Use your imagination
Simulate Physics

Motion Capture
Behavioral Simulation

Use Your Imagination

John Lasseter

Play
Tricks from Traditional Animation

• Squash and Stretch
  – Defining the rigidity and mass of an object by distorting its shape during an action

• Secondary Action
  – Action that results directly from another action

Why does it have to look like a photograph?
Artistic Rendering Approaches

• Artistic rendering problem (NPR)
  – Produce images from geometric models that are more expressive or mimic alternative media

• Artistic rendering solutions
  – Mimic characteristics of media
  – Physically simulate media
  – Break rules
  – Learn styles

Mimic media
Physical Media Simulation

Break Rules