Game Programming

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What is Computer Graphics?

- Modeling
- Rendering
- Animation
The Graphics Process

- 3D Geometric Models
- 3D Animation Definition
- Lighting Information
- Texture Information
- Rendering
- Image Storage & Display
Basic Graphics System

Input devices

Processor

Frame buffer

Memory

Image formed in FB

Output device
Synthetic Camera Model

- View frustrum/view volume
- Objects/models
- Projector
- Lighting
- Image plane/view plane
- Projection of $p$
- Camera
Elements of Image Formation

- Objects
- Viewer
- Light source(s)

- Attributes that govern how light interacts with the materials in the scene
- Note the independence of the objects, viewer, and light source(s)
Luminance and Color Images

- Luminance
  - Monochromatic
  - Values are gray levels
  - Analogous to working with black and white film or television

- Color
  - Has perceptual attributes of hue, saturation, and lightness
  - Do we have to match every frequency in visible spectrum? No!
Additive and Subtractive Color

Additive color
- Form a color by adding amounts of three primaries
  - CRTs, projection systems, positive film
  - Primaries are Red (R), Green (G), Blue (B)

Subtractive color
- Form a color by filtering white light with Cyan (C), Magenta (M), and Yellow (Y) filters
  - Light-material interactions
  - Printing
  - Negative film
The RGB Color Model – for CRT

Black = (0, 0, 0)
Red = (1, 0, 0)
Green = (0, 1, 0)
Yellow = (1, 1, 0)
Cyan = (0, 1, 1)
Magenta = (1, 0, 1)
White = (1, 1, 1)
Blue = (0, 0, 1)
Color Depth

- Can choose number of bits for each of $r$, $g$ and $b$
  - More bits per component means more colors can be distinguished, but image files will be larger
  - 8 bits (1 byte) per component: 24-bit color, millions of colors

- If $r = g = b$, color is a shade of gray, so grayscale can be represented by a single value
  - 8 bits permits 256 grays
The CMY Color Model – for hardcopy

- Yellow = (1,1,0)
- Red = (1,0,0)
- Green = (0,1,0)
- White = (1,1,1)
- Magenta = (1,0,1)
- Cyan = (0,1,1)
- Blue = (0,0,1)
- Black = (0,0,0)
The HSV Color Model  – for user-oriented

- Alternative way of specifying color
- *Hue* (roughly, dominant wavelength)
- *Saturation* (purity)
- *Value* (brightness)

- Model HSV as a cylinder: *H* angle, *S* distance from axis, *V* distance along axis

- Basis of popular style of *color picker*
The HSV Color Model – for user-oriented

☐ H : hue
☐ S : saturation
☐ V : value
   (or B for blight)
Pipeline Rendering

Transform
Illuminate
Transform
Clip
Project
Rasterize

Model & Camera Parameters
Rendering Pipeline
Framebuffer
Display
Definitions of Triangle Meshes

\[ \{f_1\} : \{ v_1, v_2, v_3 \} \]  
\[ \{f_2\} : \{ v_3, v_2, v_4 \} \]  
...  
\[ \{v_1\} : (x,y,z) \]  
\[ \{v_2\} : (x,y,z) \]  
...  
\[ \{f_1\} : \text{“skin material”} \]  
\[ \{f_2\} : \text{“brown hair”} \]  
...  

[Hoppe 99’]
Definitions of Triangle Meshes

{f₁} : {v₁, v₂, v₃}  
{f₂} : {v₃, v₂, v₄}  
...
{v₁} : (x,y,z)  
{v₂} : (x,y,z)  
...
{f₁} : “skin material”  
{f₂} : “brown hair”  
...
{v₂,f₁} : (nₓ,nᵧ,nₗ) (u,v)  
{v₂,f₂} : (nₓ,nᵧ,nₗ) (u,v)  
...

[Hoppe 99’]
Rendering: Transformations

- So far, discussion has been in screen space.
- But model is stored in model space (a.k.a. object space or world space).
- Three sets of geometric transformations:
  - Modeling transforms
  - Viewing transforms
  - Projection transforms
The Rendering Pipeline

- Scene graph
- Object geometry

- Modeling
  Transforms

- Lighting
  Calculations

- Viewing
  Transform

- Clipping

- Projection
  Transform

- Rasterization