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)
- White=(1,1,1)
- Yellow=(1,1,0)
- Cyan=(0,1,1)
- Magenta=(1,0,1)

Diagram showing the RGB color model with the mentioned colors and their coordinates.
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)
Black = (0,0,0)
White = (1,1,1)
Magenta = (1,0,1)
Cyan = (0,1,1)
Blue = (0,0,1)
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 \} : “skin material”
\{ f_2 \} : “brown hair”
...

[Hoppe 99’]
Definitions of Triangle Meshes

Connectivity:
\{f_1\} : \{v_1, v_2, v_3\}
\{f_2\} : \{v_3, v_2, v_4\}
...

Geometry:
\{v_1\} : (x,y,z)
\{v_2\} : (x,y,z)
...

Face Attributes:
\{f_1\} : "skin material"
\{f_2\} : "brown hair"
...

Corner Attributes:
\{v_2, f_1\} : (n_x, n_y, n_z) (u,v)
\{v_2, f_2\} : (n_x, n_y, n_z) (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