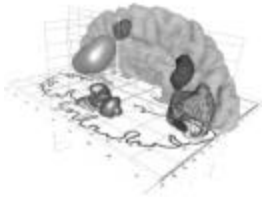
CS 4731 Lecture 2:
Intro to 2D, 3D, OpenGL and GLUT (Part I)

Emmanuel Agu

2D Vs. 3D

- 2D:
  - Flat
  - (x,y) color values on screen
  - Objects no depth or distance from viewer

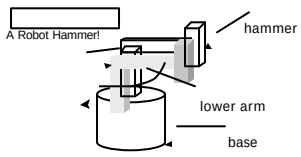
- 3D
  - (x,y,z) values on screen
  - Perspective: objects have distances from viewer



Creating 3D

- Start with 3D shapes (modeling)
  - Basic shapes(cube, sphere, etc), meshes, etc
  - Scale them (may also stretch them)
  - Position them (rotate them, translate, etc)
- Then, render scene (realism)
  - Perspective
  - Color and shading
  - Shadows
  - Texture mapping
  - Fog
  - Transparency and blending
  - Anti-aliasing
- Practical note: modeling and rendering packages being sold (Maya, 3D studio max, etc)

3D Modeling example: Robot Hammer



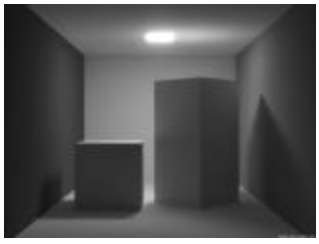
3D Modeling example: Polygonal Mesh

Original: 424,000 triangles | 60,000 triangles (14%). | 1000 triangles (0.2%)

(courtesy of Michael Garland and Data courtesy of Iris Developme nt.)

3D Effects example: Texturing

3D Effects example: Shadows



OpenGL Basics

- OpenGL's primary function – rendering
- Rendering? – Convert geometric/mathematical object descriptions into images
- OpenGL can render:
  - **Geometric primitives (lines, dots, etc)**
  - **Bitmap images (.bmp, .jpg, etc)**

OpenGL Basics

- Application Programming Interface (API)
- Low-level graphics rendering API
- Widely used – will be used in this class
- Maximal portability
  - **Display device independent**
  - **Window system independent based (Windows, X, etc)**
  - **Operating system independent (Unix, Windows, etc)**
- Event-driven

OpenGL: Event-driven

- Program only responds to events
- Do nothing until event occurs
- Example Events:
  - **mouse clicks**
  - **keyboard stroke**
  - **window resize**
- Programmer:
  - defines events
  - actions to be taken
- System:
  - maintains an event queue
  - takes programmer-defined actions

OpenGL: Event-driven

- Sequential program
  - **Start at main( )**
  - **Perform actions 1, 2, 3….*N***
  - **End**
- Event-driven program
  - **Initialize**
  - **Wait in infinite loop**
    - **Wait till defined event occurs**
    - **Take defined actions**
- World's most popular event-driven program?

OpenGL: Event-driven

- How in OpenGL?
  - Programmer registers callback functions
  - Callback function called when event occurs
- Example:
  - Declare a function myMouse to respond to mouse click
  - Register it: Tell OpenGL to call it when mouse clicked
  - Code? glutMouseFunc(myMouse);

GL Utility Toolkit (GLUT)

- OpenGL
  - is window system independent
  - Concerned only with drawing
  - No window management functions (create, resize, etc)
  - Very portable
- GLUT:
  - Minimal window management: fast prototyping
  - Interfaces with different windowing systems
  - Allows easy porting between windowing systems

GL Utility Toolkit (GLUT)

- No bells and whistles
  - No sliders
  - No dialog boxes
  - No menu bar, etc
- To add bells and whistles, need other API:
  - X window system
  - Apple: AGL
  - Microsoft :WGL, etc

Program Structure

- Configure and open window (GLUT)
- Initialize OpenGL state
- Register input callback functions (GLUT)
  - Render
  - Resize
  - Input: keyboard, mouse, etc
- My initialization
  - Set background color, clear color, drawing color, point size, establish coordinate system, etc.
- glutMainLoop( )
  - Waits here infinitely till action is selected

GLUT: Opening a window

- GLUT used to open window
  - **`glutInit(&argc, argv);`**
    - initializes
  - **`glutInitDisplayMode(GLUT_SINGLE | GLUT_RGB);`**
    - sets display mode (e.g. single buffer with RGB)
  - **`glutInitWindowSize(640,480);`**
    - sets window size (WxH)
  - **`glutInitPosition(100,150);`**
    - sets upper left corner of window
  - **`glutCreateWindow("my first attempt");`**
    - open window with title "my first attempt"

OpenGL Skeleton

```
void main(int argc, char** argv){
    // First initialize toolkit, set display mode and create window

    glutInit(&argc, argv);   // initialize toolkit
    glutInitDisplayMode(GLUT_SINGLE | GLUT_RGB);
    glutInitWindowSize(640, 480);
    glutInitWindowPosition(100, 150);
    glutCreateWindow("my first attempt");

    // ... then register callback functions,
    // ... do my initialization
    // .. wait in glutMainLoop for events

}
```

GLUT Callback Functions

- Register all events your program will react to
- Event occurs => system generates callback
- Callback: routine system calls when event occurs
- No registered callback = no action

GLUT Callback Functions

- GLUT Callback functions in skeleton
  - **glutDisplayFunc(myDisplay):** window contents need to be redrawn
  - **glutReshapeFunc(myReshape):** called when window is reshaped
  - **glutMouseFunc(myMouse):** called when mouse button is pressed
  - **glutKeyboardFunc(mykeyboard):** called when keyboard is pressed or released
- **glutMainLoop( ):** program draws initial picture and enters infinite loop till event

Example: Rendering Callback

- Do all your drawing in the display function
- Called initially and when picture changes (e.g.resize)
- First, register callback in main( ) function

  ```
  glutDisplayFunc( display );
  ```
- Then, implement display function

```
void display( void )
 {  // put drawing stuff here
    ……
   glBegin( GL_LINES );
     glVertex3fv( v[0] );
     glVertex3fv( v[1] );
   ……
   glEnd();
 }
```

OpenGL Skeleton

```
void main(int argc, char** argv){
    // First initialize toolkit, set display mode and create window
    glutInit(&argc, argv);   // initialize toolkit
    glutInitDisplayMode(GLUT_SINGLE | GLUT_RGB);
    glutInitWindowSize(640, 480);
    glutInitWindowPosition(100, 150);
    glutCreateWindow("my first attempt");

    // ... now register callback functions
    glutDisplayFunc(myDisplay);
    glutReshapeFunc(myReshape);
    glutMouseFunc(myMouse);
    glutKeyboardFunc(myKeyboard);

    myInit( );
    glutMainLoop( );
}
```

References

- Hill, chapter 2