
CS380: Computer Graphics

Basic OpenGL Structure

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Course URL:
<http://sgvr.kaist.ac.kr/~sungeui/CG>



Class Objectives

- **Understand the basic OpenGL program structure and how OpenGL supports different spaces**

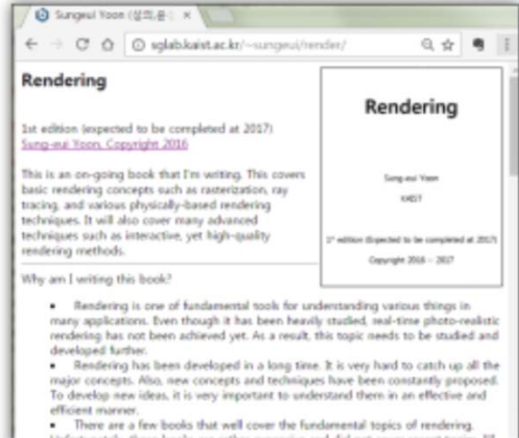
- **Last class, we talked about:**
 - **Two different, screen and world spaces**
 - **Basic OpenGL commands**
 - **Julia set**

Quiz 1

- Last time we had:

Homework for Next Class

- Read:
 - Chapter 1, Introduction
 - Chapter 2, Classic Rendering pipeline



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- Quiz link:
<https://forms.gle/k1XgbS5pUaGZAG8h8>

OpenGL

- **Graphics interface**
 - **Hardware-independent**
 - **Cross-platform graphics interface for 3D rendering and 3D hardware acceleration**
- **Two main characteristics**
 - **Small, but powerful set of low-level drawing operations**
 - **Does not have any functions to interact with any device and windowing system**
- **What are problems of OpenGL, then?**

Two Additional Libraries

- **GLU (GL utility)**
 - Provide more complex rendering methods
- **GLUT (GL utility toolkit)**
 - Provide platform-independent interface to the windowing system and input devices
- **OpenGL Ver. 4.3**
 - glfw (keyboard & windows)
 - glm (various camera manipulations and transformation)
 - i.e., similar functionality, but with different library

GLUT

- **Advantages:**
 - **Portable: Windows, Cygwin, Linux, Mac-OS**
 - **Minimal-overhead (Hides away details of opening windows, etc.)**
 - **Appeals to C-hackers (console for printf()'s, etc)**
- **Disadvantages**
 - **Limited interaction**
 - **Global variables galore**
- **Ver 4.3: GLFW covering OpenGL ES and Vulkan**

Getting GLUT

- **Web site:**

Windows:

www.xmission.com/~nate/glut.html

Others:

www.opengl.org/developers/documentation/glut.html

www.sourceforge.net/projects/uncpythontools

- **Overview**

- **See appendix of OpenGL Programming Guide**

OpenGL Tools Available

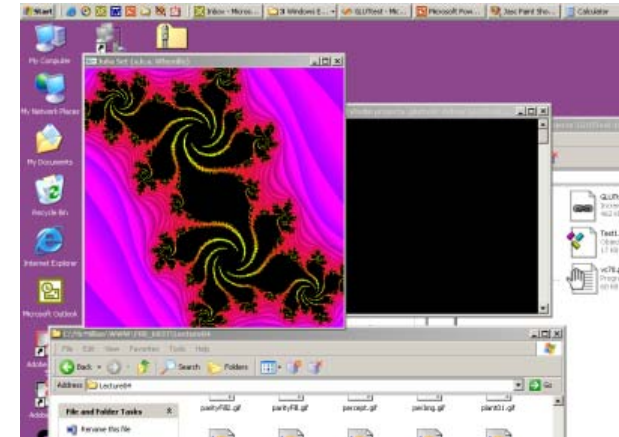
Typical OpenGL code to establish a window:

```
glutInitWindowSize(400,400);
```

```
glutInitWindowPosition(100,100);
```

Code to set up a viewport:

```
glViewport(0, 0, w, h);
```



To establish a world space coordinate system:

```
glOrtho2D(world.l, world.r, world.b, world.t);
```


Sample Codes of Visualization of a Fractal



Libraries, Header Files, etc

```
#pragma comment(lib,"opengl32.lib")
#pragma comment(lib,"glu32.lib")
#pragma comment(lib,"glut32.lib")

#include <GL/glut.h>
#include <GL/glu.h>
#include <math.h>

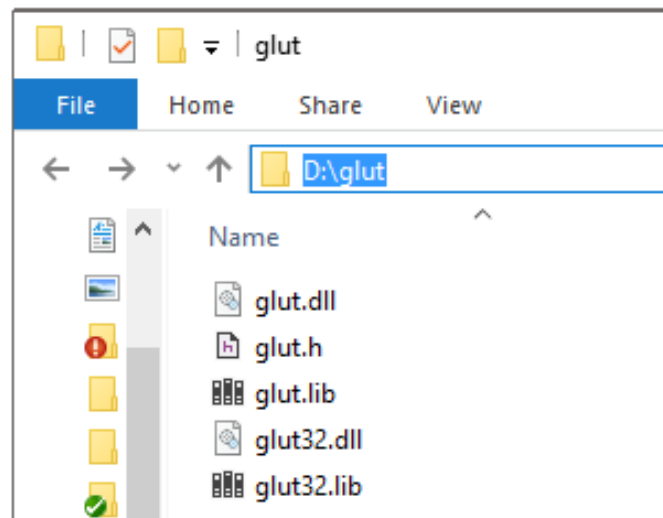
// glut callbacks
void display();
void onKeyPress(unsigned char k, int x, int y);
void onMouse( int button, int state, int x, int y);
void onReshape( int w, int h );
void idle();
```

```
class Complex {
    float re, im;
};
```

```
Complex c(0.109, 0.603);
int width = 512, height = 512;
```

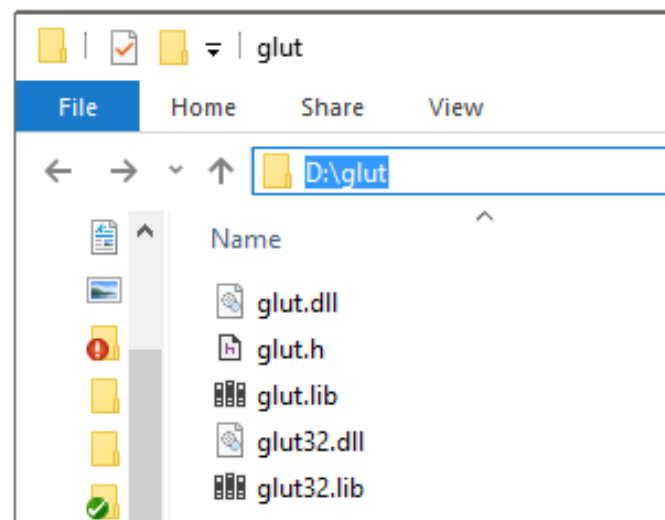
Example: Setting Header Dir. with Visual Studio 2015

Configuration Properties	Additional Include Directories	D:\GLUT
General	Additional #using Directories	
Debugging	Debug Information Format	
VC++ Directories	Common Language RunTime Support	
C/C++	Consume Windows Runtime Extension	
General	Suppress Startup Banner	Yes (/nologo)
Optimization	Warning Level	Level3 (/W3)
Preprocessor	Treat Warnings As Errors	No (/WX-)
Code Generation	Warning Version	
Language	SDL checks	
Precompiled Headers	Multi-processor Compilation	Yes (/MP)



Example: Setting Library Dir. with Visual Studio 2015

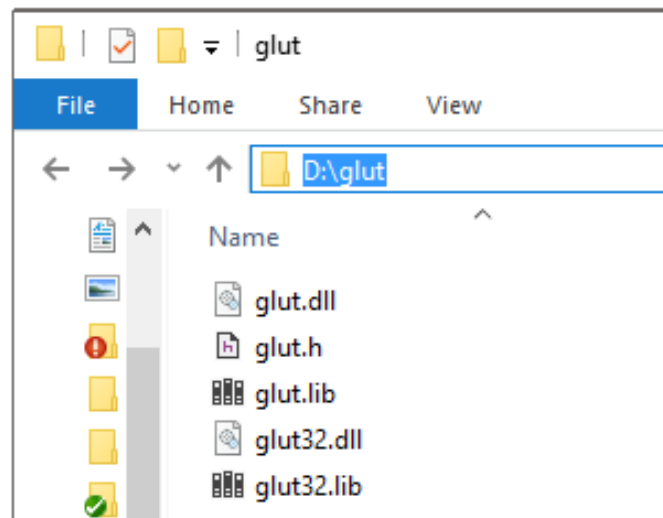
Configuration Properties	Output File	\$(OutDir)\$(TargetName)\$(TargetExt)
General	Show Progress	Not Set
Debugging	Version	
VC++ Directories	Enable Incremental Linking	No (/INCREMENTAL:NO)
C/C++	Suppress Startup Banner	Yes (/NOLOGO)
Linker	Ignore Import Library	No
General	Register Output	No
Input	Per-user Redirection	No
Manifest File	Additional Library Directories	D:\GLUT
Debugging	Link Library Dependencies	No
System	Use Library Dependency Inputs	No
Optimization	Link Status	



Example: Setting DLL Dir. with Visual Studio 2015

The screenshot shows the 'Configuration Properties' dialog in Visual Studio 2015. The 'Linker' section is expanded to the 'Environment' tab. The 'Debugger to launch:' field is set to 'Local Windows Debugger'. The 'Environment' tab shows the following settings:

Property	Value
Command	\$(TargetPath)
Command Arguments	
Working Directory	\$(ProjectDir)
Attach	No
Debugger Type	Auto
Environment	PATH=%PATH%;D:\GLUT
Merge Environment	Yes
SQL Debugging	No
Amp Default Accelerator	WARP software accelerator



Initializing GLUT

```
void main (int argc, char * argv []) {  
    glutInit(& argc, argv);  
    glutInitDisplayMode(GLUT_SINGLE | GLUT_RGB);  
  
    glutInitWindowSize(width, height);  
    glutInitWindowPosition(100, 100);  
    glutCreateWindow("Julia Set");  
  
    glutDisplayFunc(display);  
    glutMouseFunc(onMouseButton);  
    glutKeyboardFunc(onKeyPress);  
    glutReshapeFunc(onReshape);  
  
    Initialize ();  
    glutMainLoop();  
}
```

Initialize

- Executed at the beginning of display():

```
void initialize()
{
    // Clear the screen
    glClearColor(0,0,1,0);
    glClear(GL_COLOR_BUFFER_BIT);

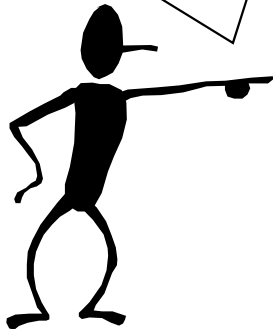
    glMatrixMode(GL_PROJECTION);    // related to a camera setting
    glLoadIdentity();
    gluOrtho2D(world.l, world.r, world.b, world.t);

    glMatrixMode(GL_MODELVIEW);    // related to model transformation
    glLoadIdentity();
}
```

Reshape

- **Reshape gets called when the window size changes**

Keep center of
world in the center
of the screen



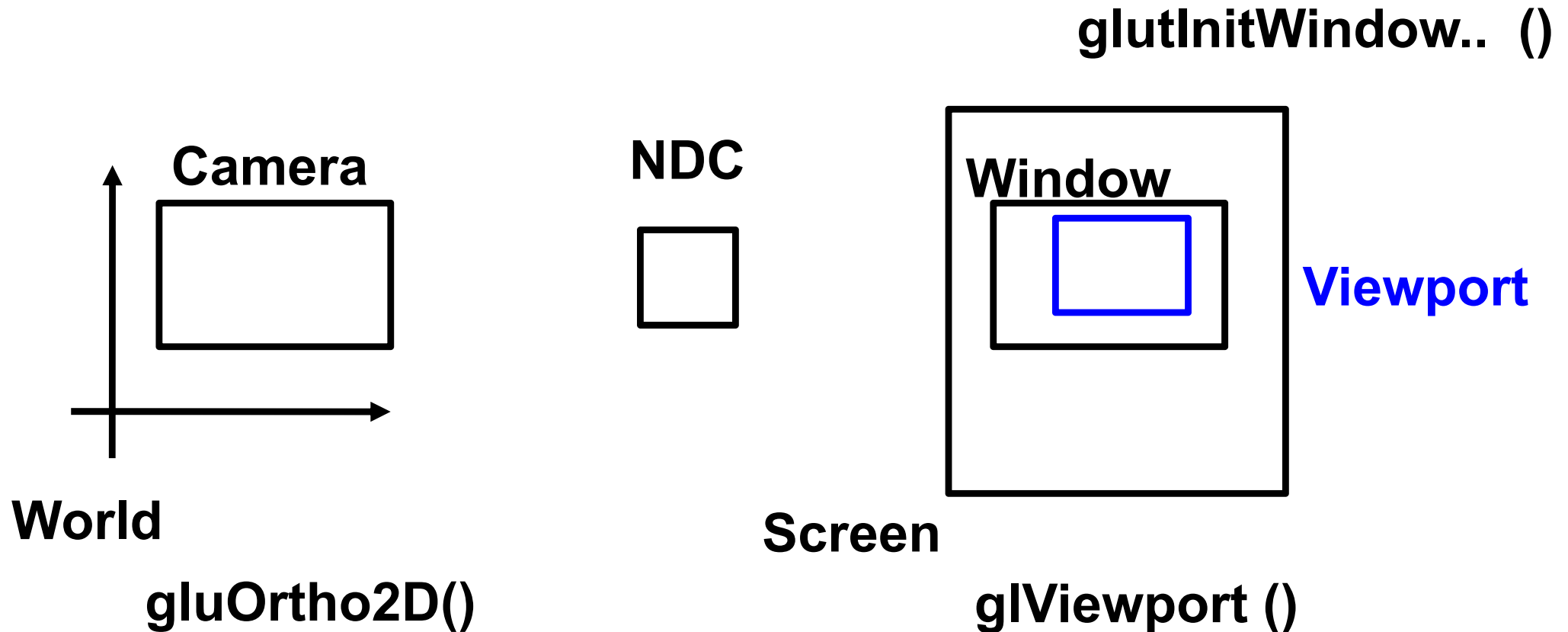
```
void onReshape (int w, int h)
{
    width = w;
    height = h;

    glViewport (0, 0, w, h);

    float cx = 0.5*(world.r + world.l);
    float dy = world.t - world.b;;

    world.l = cx - 0.5*dy * w/h;
    world.r = cx + 0.5*dy * w/h;
}
```


Mapping from World to Screen in OpenGL



Main Display Code

```
void display () {
    initialize();

    float delta = (world.r - world.l)/float(width);
    for( int j=0; j < height; j++ ) {
        for( int i=0; i < width; i++ ) {
            float x = world.l + i*delta;           // convert pixel location to world coordinates
            float y = world.b + j*delta;

            int its;  float R; Complex p(x,y);
            julia( p, c, its, R );
            if (its == 255)                          // set a color
                glColor3d(0,0,0);
            else {
                float r = R/float(3);  float g = its/float(128);  float b = R/float(its+1);
                glColor3d(r,g,b);
            }

            glBegin(GL_POLYGON)                       // Draw pixel
            glVertex2d(x, y);
            glVertex2d(x, y+delta);
            glVertex2d(x+delta, y+delta);
            glVertex2d(x+delta, y);
            glEnd();
        }
    }
    glFlush();
}
```

Now the GUI Stuff

```
void mouse( int button, int state, int mx, int my )
{
    float x = xScreenToWorld(mx);
    float y = yScreenToWorld(my);

    float dx = (world.r - world.l);
    float dy = (world.t - world.b);

    if( (button == GLUT_LEFT_BUTTON) && (state == GLUT_DOWN) ) {
        world.l = x - dx/4;    world.r = x + dx/4;
        world.b = y - dy/4;    world.t = y + dy/4;
    }
    else if( (button == GLUT_RIGHT_BUTTON) && (state == GLUT_DOWN) ) {
        world.l = x - dx;    world.r = x + dx;
        world.b = y - dy;    world.t = y + dy;
    }

    glutPostRedisplay ();
}
```

Screen-to-World Mapping

```
float xScreenToWorld(float scrX)
{
    return ((world.r - world.l) * scrX / float(width)) + world.l;
}
```

```
float yScreenToWorld(float scrY)
{
    return ((world.t - world.b) * (1 - scrY / float(height))) + world.b;
}
```

**This is simply the inverse function to
the world-to-screen mapping**

Keyboard Handling

```
void keyboard (unsigned char key, int x, int y)
{
    if ((key == 'r') || (key == 'R'))
    {
        // return to initial position
        c = Complex(0.109, 0.603);
        world.l = -1;    world.r = 1;
        world.b = -1;    world.t = 1;
    }

    glutPostRedisplay ();
}
```

Source Code

- **C code is available at the course homepage**

Class Objectives were:

- **Understand the basic OpenGL program structure and how OpenGL supports different spaces**

Homework: Programming Assignment 1

- **Download the code, compile the code, and play it**



Homework

- **Make it work if using the following code (just mapping the screen ratio to the world one):**

```
void reshape( int w, int h)
```

```
{
```

```
width = w; height = h;
```

```
glViewport(0, 0, w, h );
```

```
float cx = 0.5*(world.r + world.l);
```

```
float dy = world.t - world.b;;
```

```
world.l = cx - 0.5*dy * w/h;
```

```
world.r = cx + 0.5*dy * w/h;
```

```
}
```

```
void reshape( int w, int h)
```

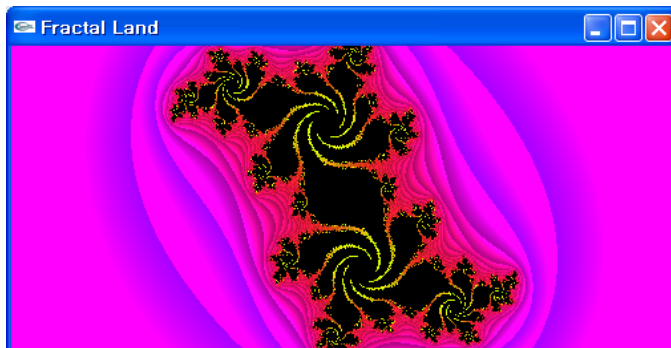
```
{
```

```
width = w;
```

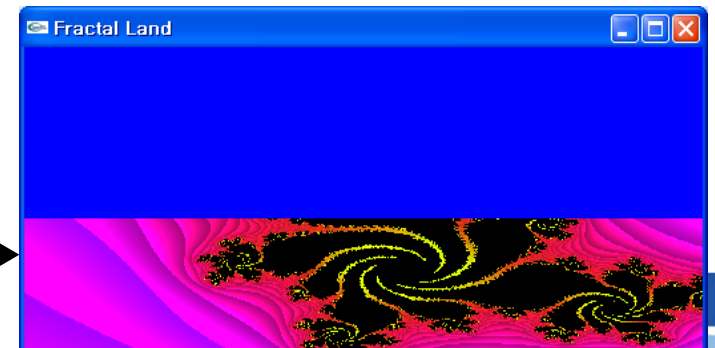
```
height = h;
```

```
glViewport(0, 0, w, h );
```

```
}
```



We got this issue. Fix it!



Homework

- **Read:**
 - **Ch. 3, Transformation Matrices**
 - **Ch. 3.1, Viewport Transformation**
- **Go over the next lecture slides before the class**
- **Watch 2 SIGGRAPH videos and submit your summaries before every Mon. class**
 - **Submit online through our course homepage**
 - **Just one paragraph for each summary**

Any Questions?

- **Come up with one question on what we have discussed in the class and submit at the end of the class**
 - **1 for already answered or typical questions**
 - **2 for questions with thoughts or that surprised me**

- **Submit two times during the whole semester**

Next Time

- **Transformations**

