CS380: Computer Graphics
Basic OpenGL Structure

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(윤성의)

Course URL:
http://sglab.kaist.ac.kr/~sungeui/CG

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Class Objectives

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

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

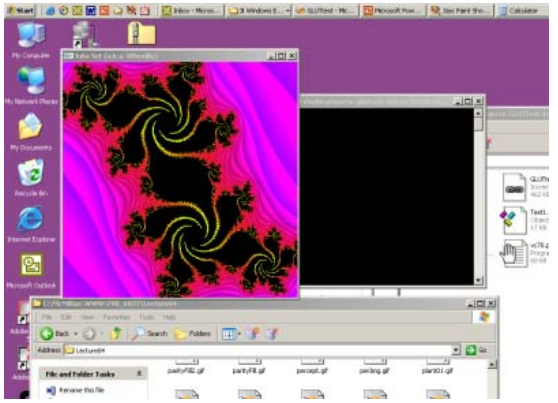
- **Web site:**
  - **Windows:**
    - www.xmission.com/~nate/glut.html
  - **Others:**
    - www.opengl.org/developers/documentation/glut.html
    - www.sourceforge.net/projects/uncpythontools

- **Overview:**
  - Appendix D 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

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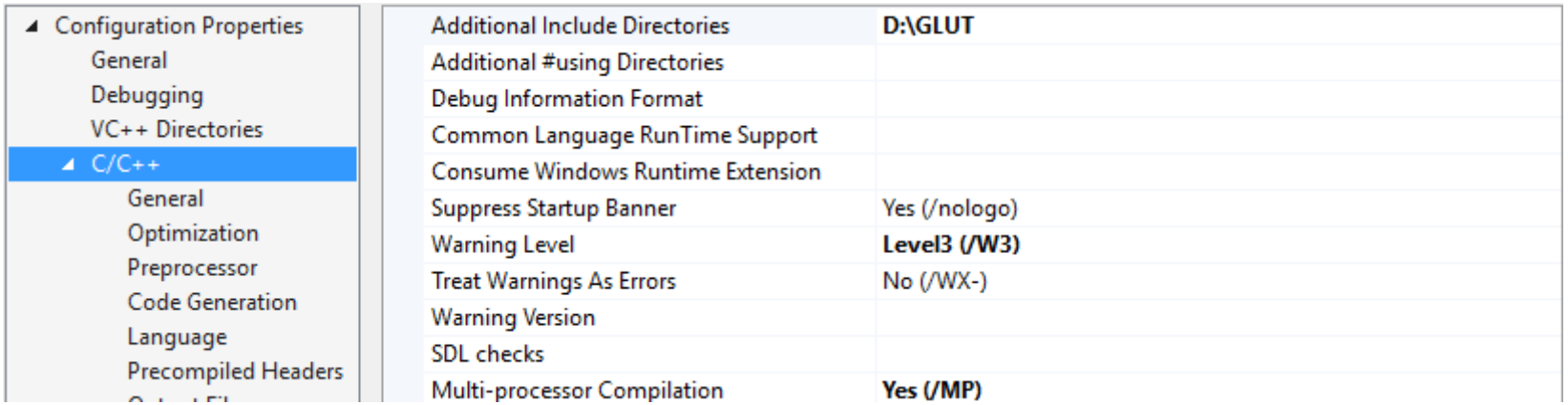
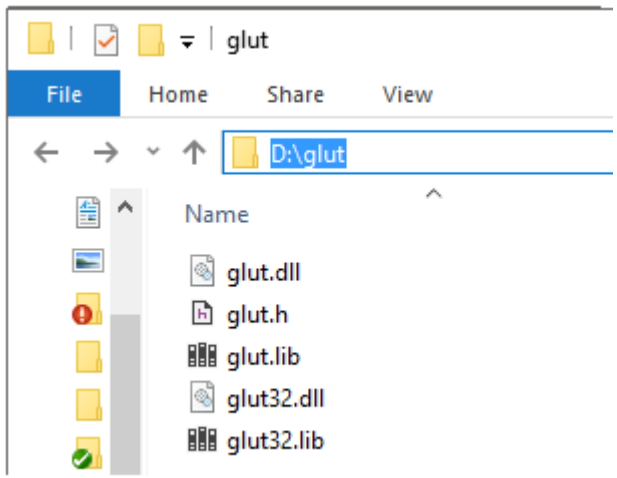
Libraries, Header Files, etc

```
#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();
```

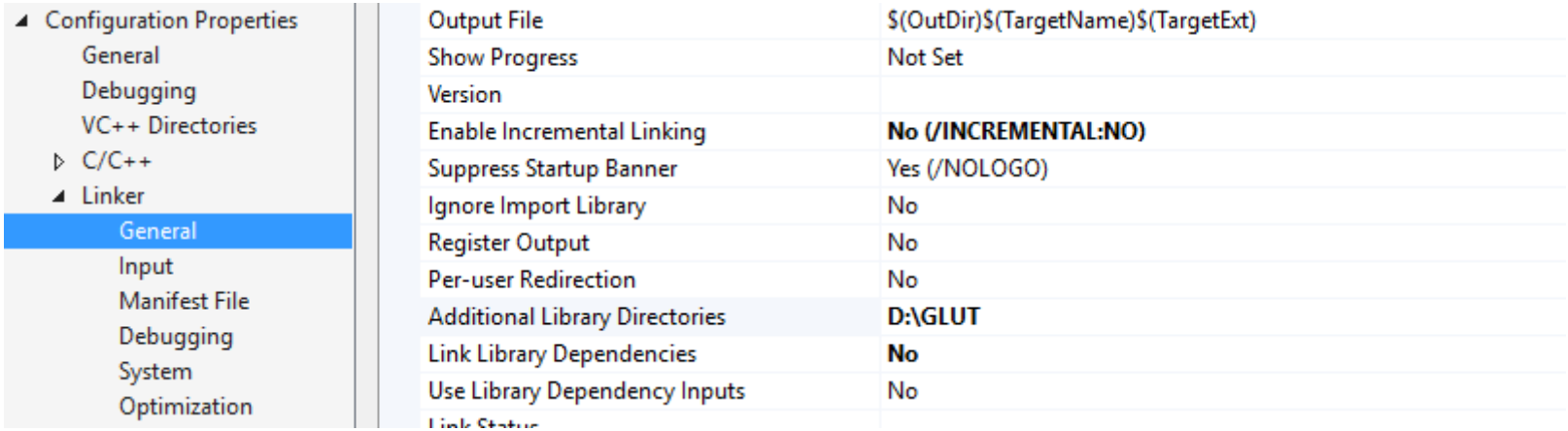
```
class Complex {
    float re, im;
};


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

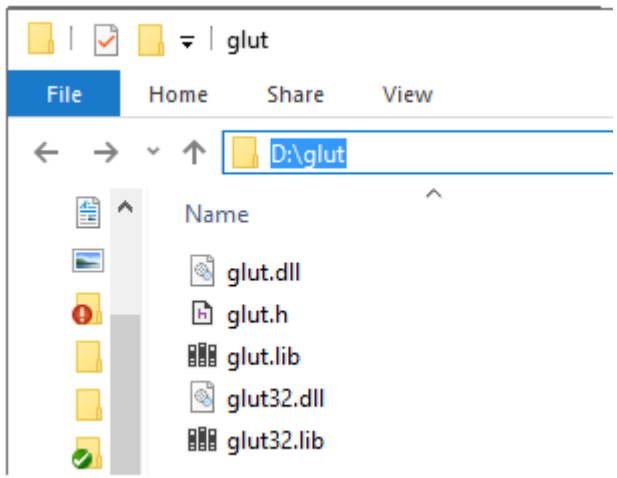
Example: Setting Header Dir. with Visual Studio 2015





Example: Setting Library Dir. with Visual Studio 2015





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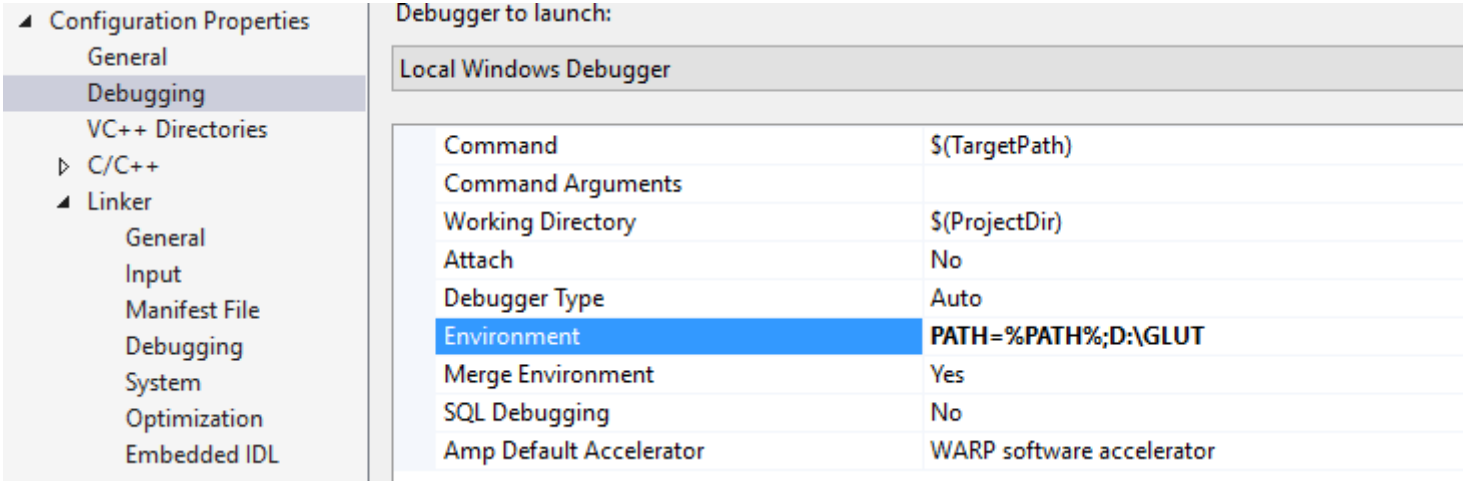
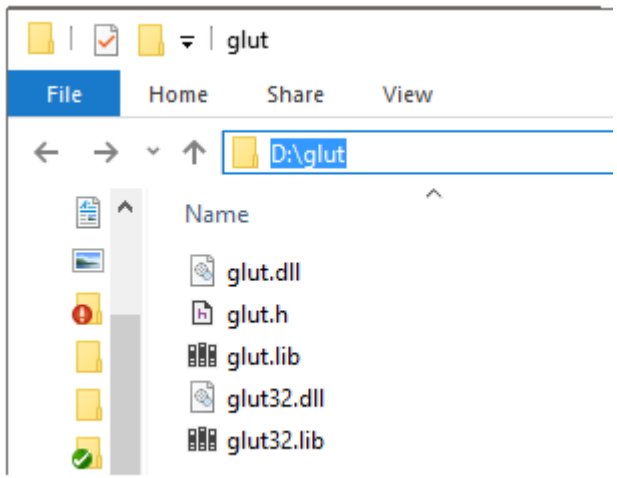
Example: Setting DLL Dir. with Visual Studio 2015





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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():**

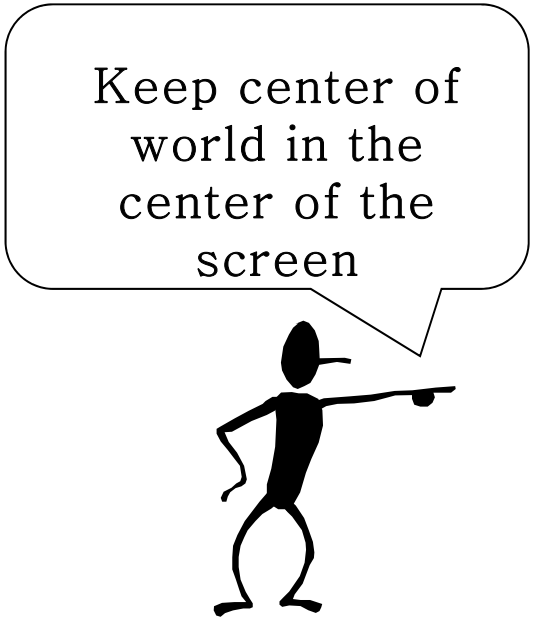
```
void initialize()
{
   // Clear the screen
   glClearColor(0,0,1,0);
   glClear(GL_COLOR_BUFFER_BIT);

   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**




```
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;
}
```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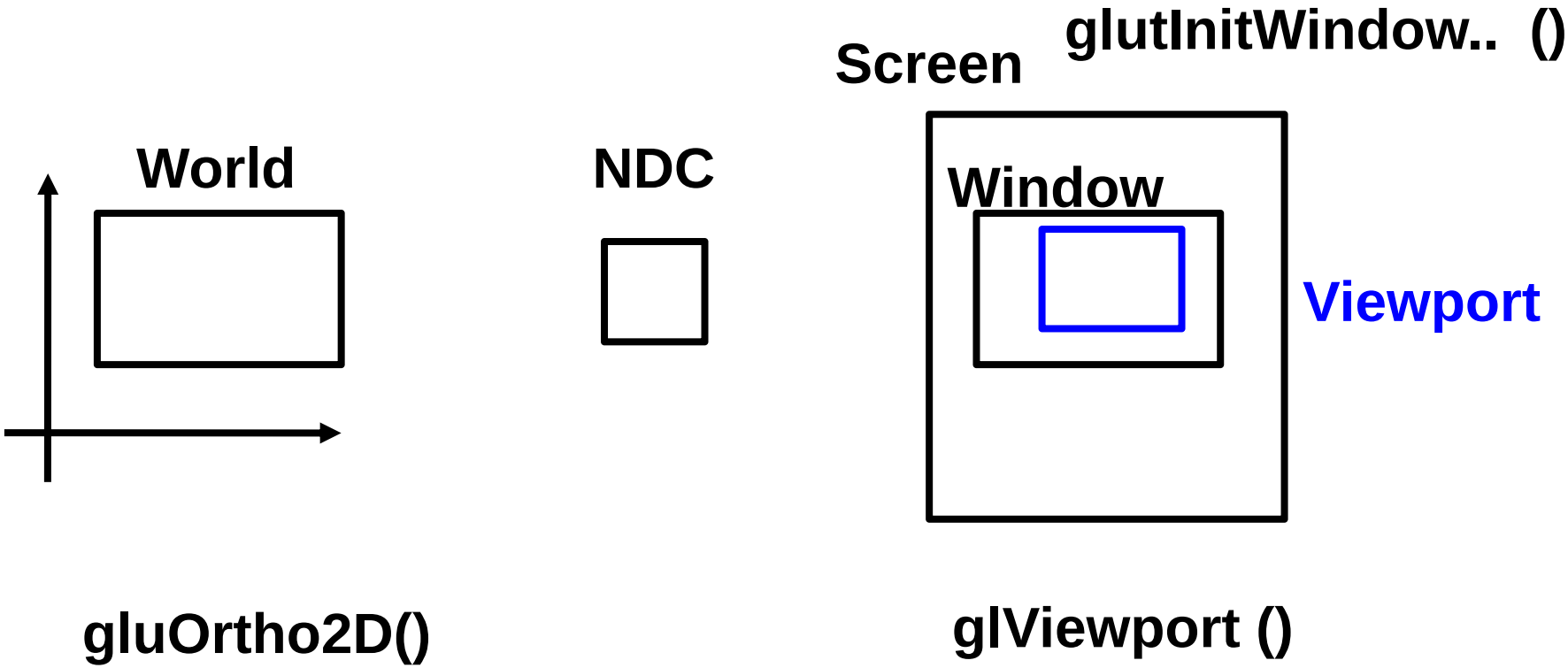
Mapping from World to Screen in OpenGL



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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

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

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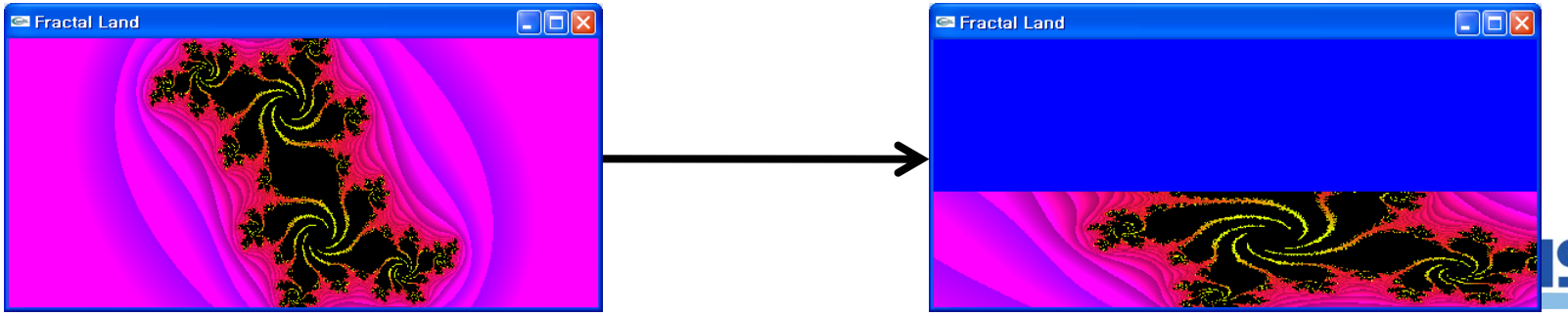
Homework

- **Make it work even if using the following code:**

```
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 );
}
```



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 their abstract every Tue. class**

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 questions**
  - **2 for typical questions**
  - **3 for questions with thoughts or that surprised me**

- **Submit at least four times during the whole semester**

Next Time

- **Transformations**

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