Image Formation and OpenGL

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Objectives

- Introduction
  - image formation
  - “classic” OpenGL vs. “new” OpenGL

- Text book: Chapter 1.3~1.8

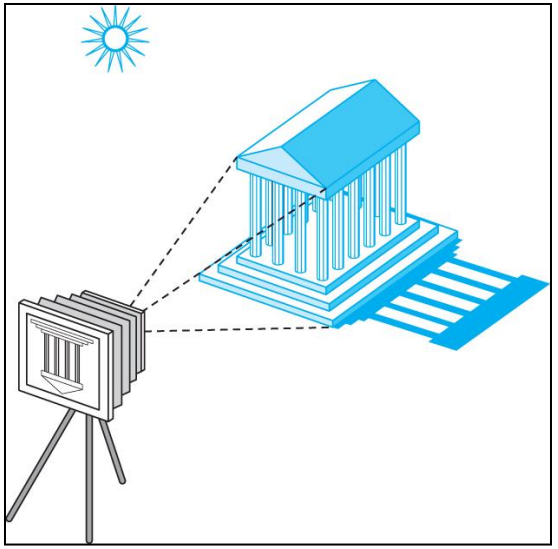
Image Formation

Elements of Image Formation

- What do we need to see the following?

Elements of Image Formation

- Objects
- Viewer
- Light source(s)
- Attributes (materials)
  - govern how light interacts with the materials in the scene



Attributes is getting more important

Separation is Important

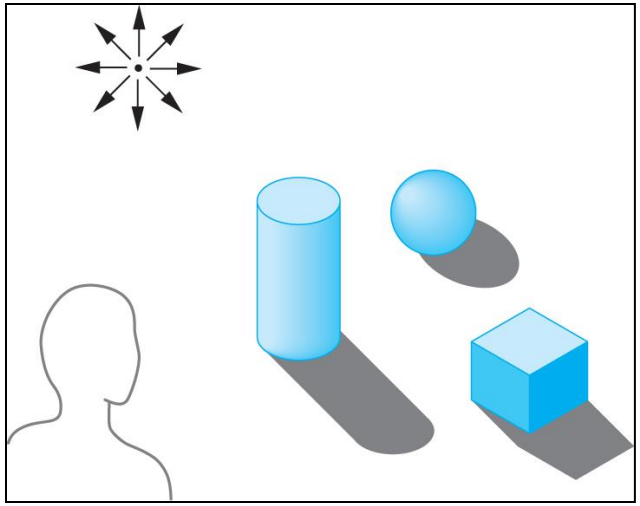
- Separation of objects, viewer, light sources, and attributes.

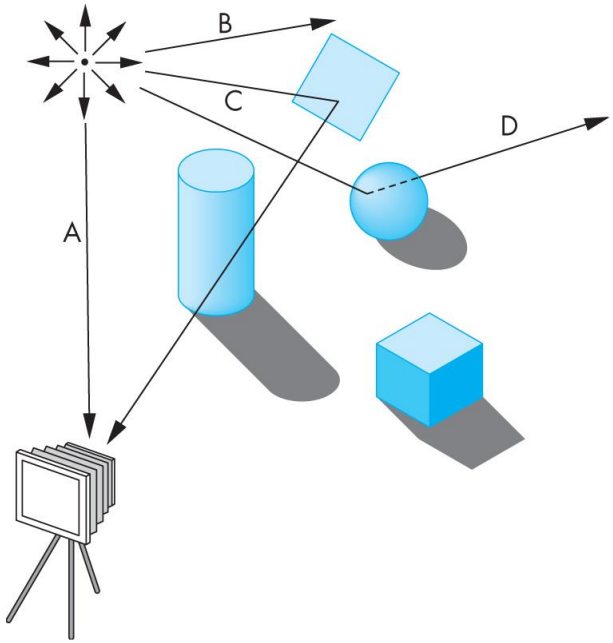
- Leads to simple software API
  - Specify objects, lights, camera, attributes
  - Let implementation determine image

- Leads to fast hardware implementation

Determine the color

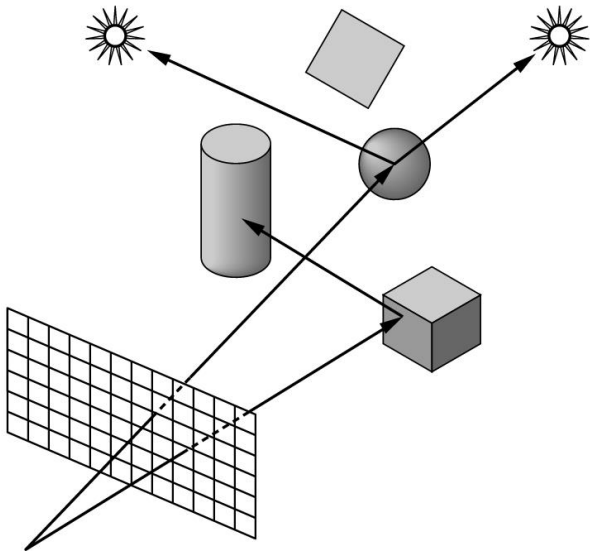
- One way to form an image is to follow rays of light from the lights
- each ray of light may have multiple interactions with objects





Ray tracing

- **Ray tracing**: follow rays of light from center of projection until they either are absorbed by objects or go off to infinity
  - Can handle global effects
    - Multiple reflections
    - Translucent objects
  - Slow
  - Must have whole data base available at all times

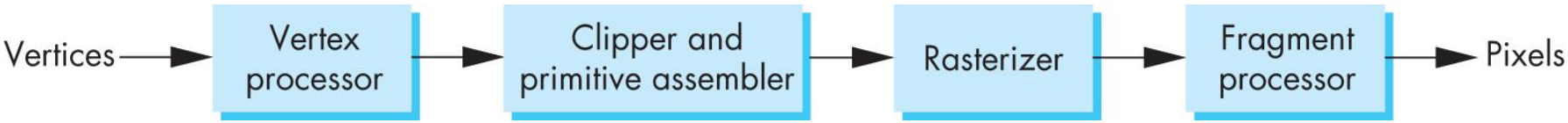


Why not ray tracing?

- Ray tracing seems more physically based so why don’t we use it to design a graphics system?
- Possible and is actually simple for simple objects such as polygons and quadrics with simple point sources
- In principle, can produce global lighting effects such as shadows and multiple reflections but ray tracing is slow and not well-suited for interactive applications
- *Now, Ray tracing with GPUs is close to real time*
  - http://www.rigidgems.sakura.ne.jp

“Simplified” Practical Approach

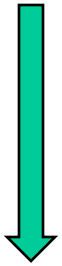
- Process objects one at a time in the order they are generated by the application
  - Can consider only local lighting
- Pipeline architecture



- All steps can be implemented in hardware on the graphics card

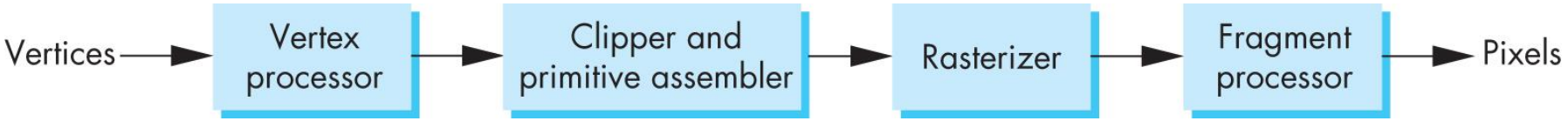
Vertex (vertices) Processing

- Much of the work in the pipeline is in converting object representations from one coordinate system to another
  - Object coordinates
  - Camera (eye) coordinates
  - Screen coordinates



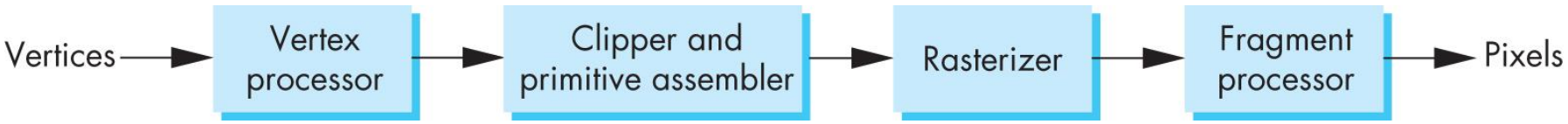
PROJECTION

- Every change of coordinates is equivalent to a matrix transformation



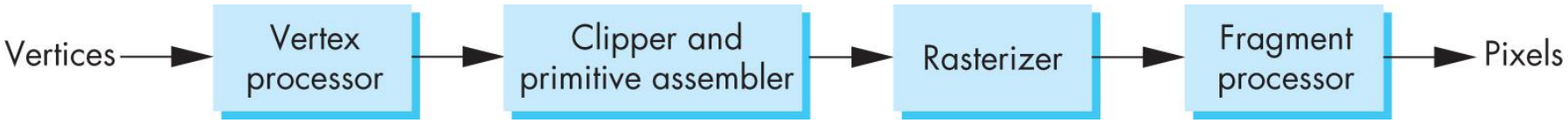
Rasterization

- If an object is visible, the appropriate pixels in the frame buffer must be assigned colors
- Rasterizer produces a set of fragments for each object
- ***Fragments*** are "potential pixels"
  - Have a location in frame bufffer
  - Color and depth attributes
- Vertex attributes are interpolated over objects by the rasterizer



Fragment Processing

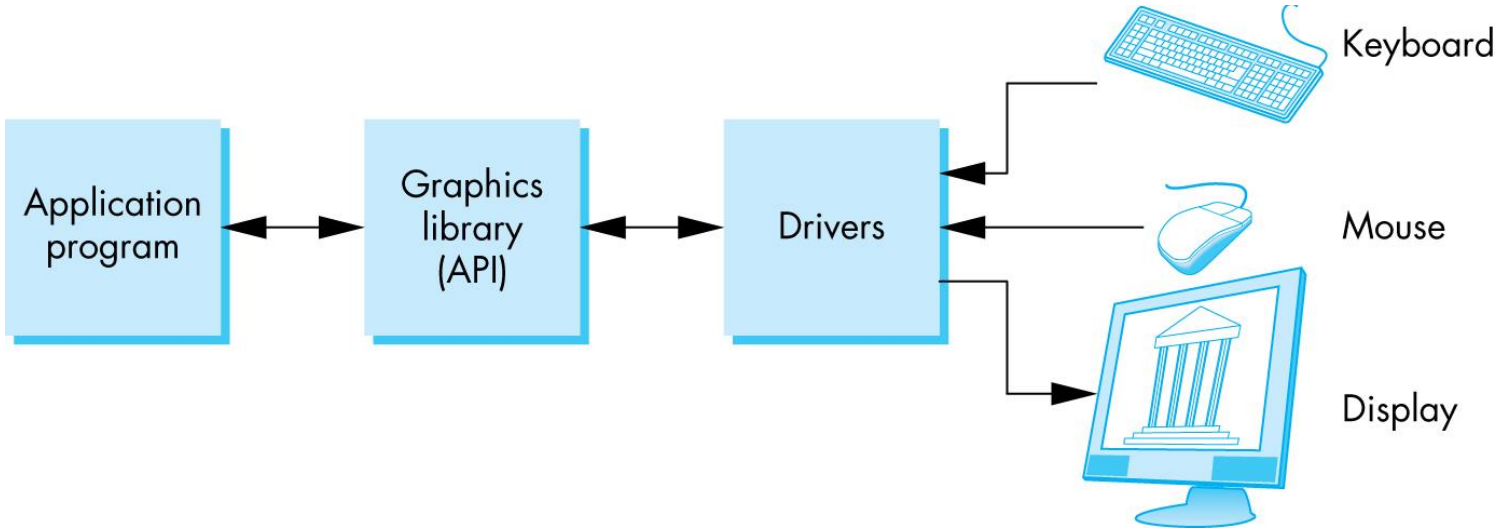
- Fragments are processed to determine the color of the corresponding pixel in the frame buffer
- Colors can be determined by texture mapping or interpolation of vertex colors
- Fragments may be blocked by other fragments closer to the camera
  - Hidden-surface removal



OpenGL: the API

The Programmer's Interface

- Programmer sees the graphics system through a software interface: the Application Programmer Interface (API)



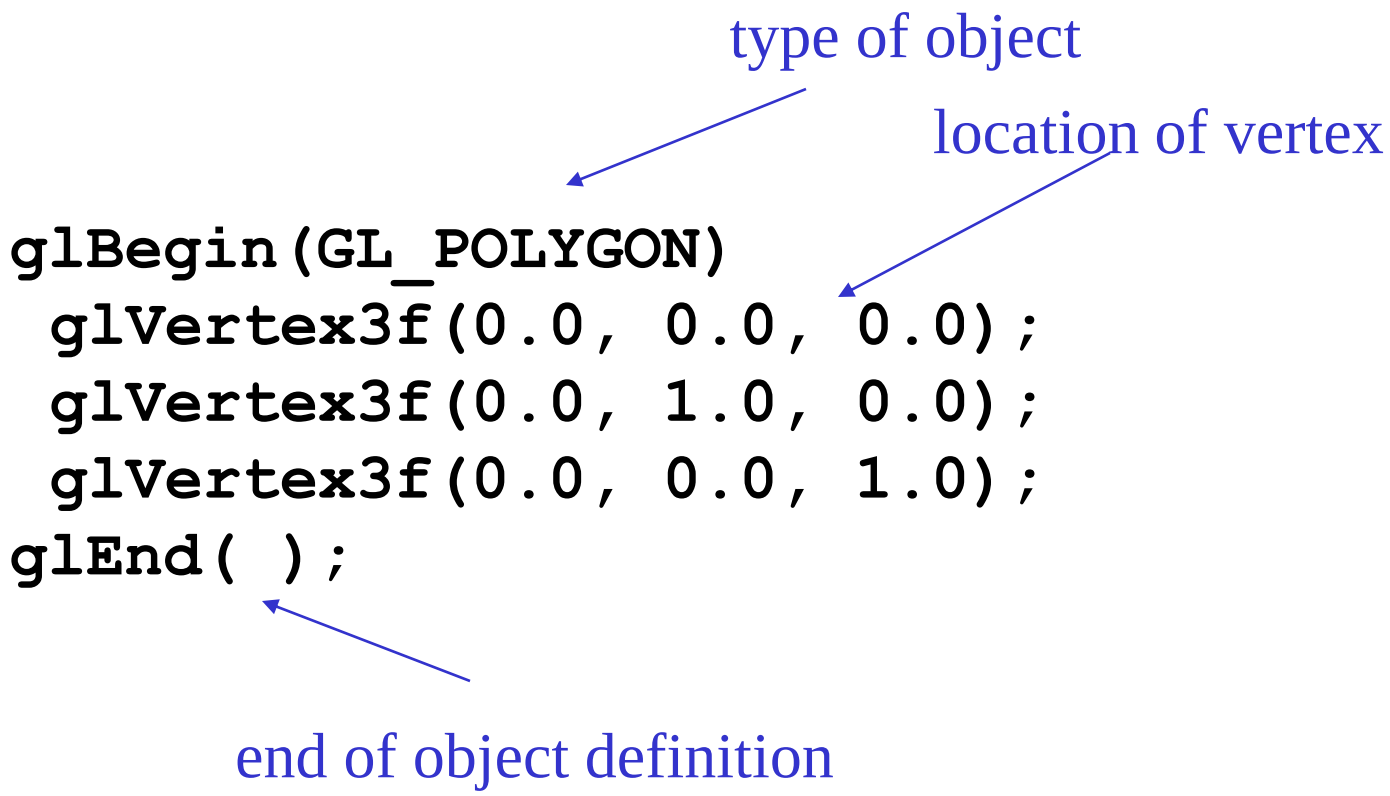
API Contents

- Functions that specify what we need to form an image
  - Objects
  - Viewer
  - Light Source(s)
  - Attributes (Materials)
- Other information
  - Input from devices such as mouse and keyboard
  - Capabilities of system

Object Specification

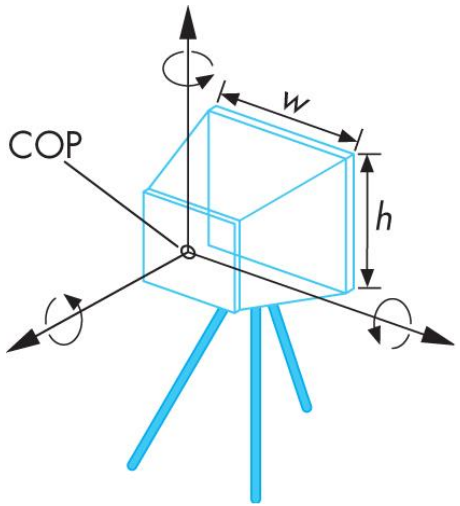
- Most APIs support a limited set of primitives including
  - Points (0D object)
  - Line segments (1D objects)
  - Polygons (2D objects)
  - Some curves and surfaces
    - Quadrics
    - Parametric polynomials
- All are defined through locations in space or *vertices*

Object Specification (old style)



Camera Specification (old style)

- Six degrees of freedom
  - Position of center of lens
  - Orientation
- Lens
- Film size
- Orientation of film plane



- → glPerspective(…), gluLookAt(…)

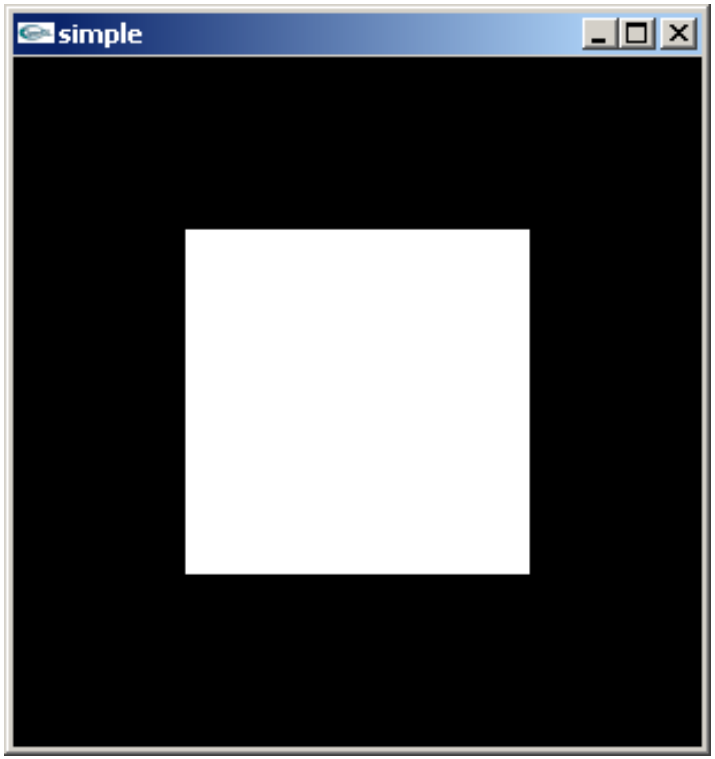
Lights and Materials (old style)

- Types of lights
  - Point sources vs distributed sources
  - Spot lights
  - Near and far sources
  - Color properties
- Material properties
  - Absorption: color properties
  - Scattering
    - Diffuse
    - Specular

→ glLight(…), glMaterial(…)

A Simple Program (old style)

Generate a square on a solid background



Let’s start to CODE it!

- Preparation

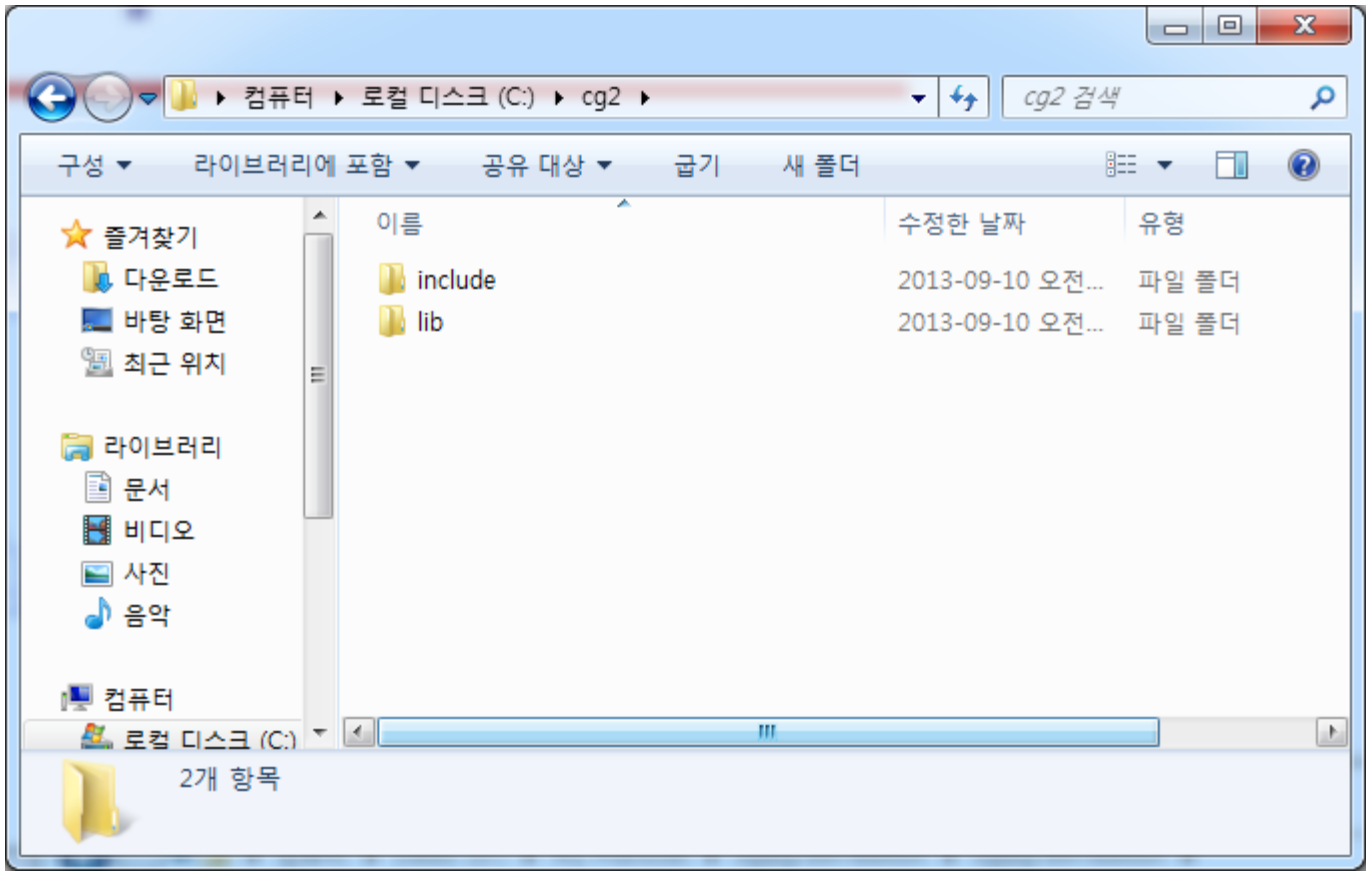
1. Download necessary libraries
   - Header files: Include folder
   - LIB files : lib folder
   - DLL files : bin(or system32) folder
2. Change the project setting
   - Directory setting

Required Libraries

- freeglut: http://freeglut.sourceforge.net/
- GLEW: http://glew.sourceforge.net/

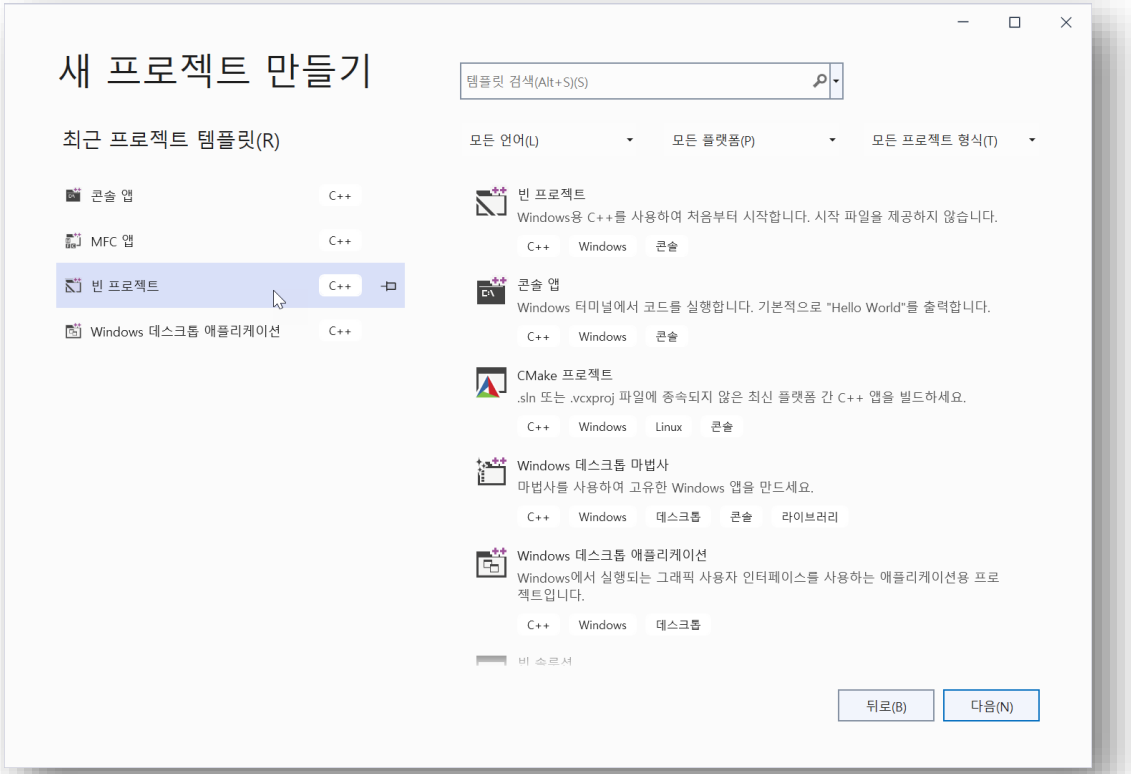
I put both of them and more at our homepage:
freeglut_and_glew.zip
➔ Download it and unzip it at “c:/cg2/”

What you should have in your “c:/cg2/” folder:



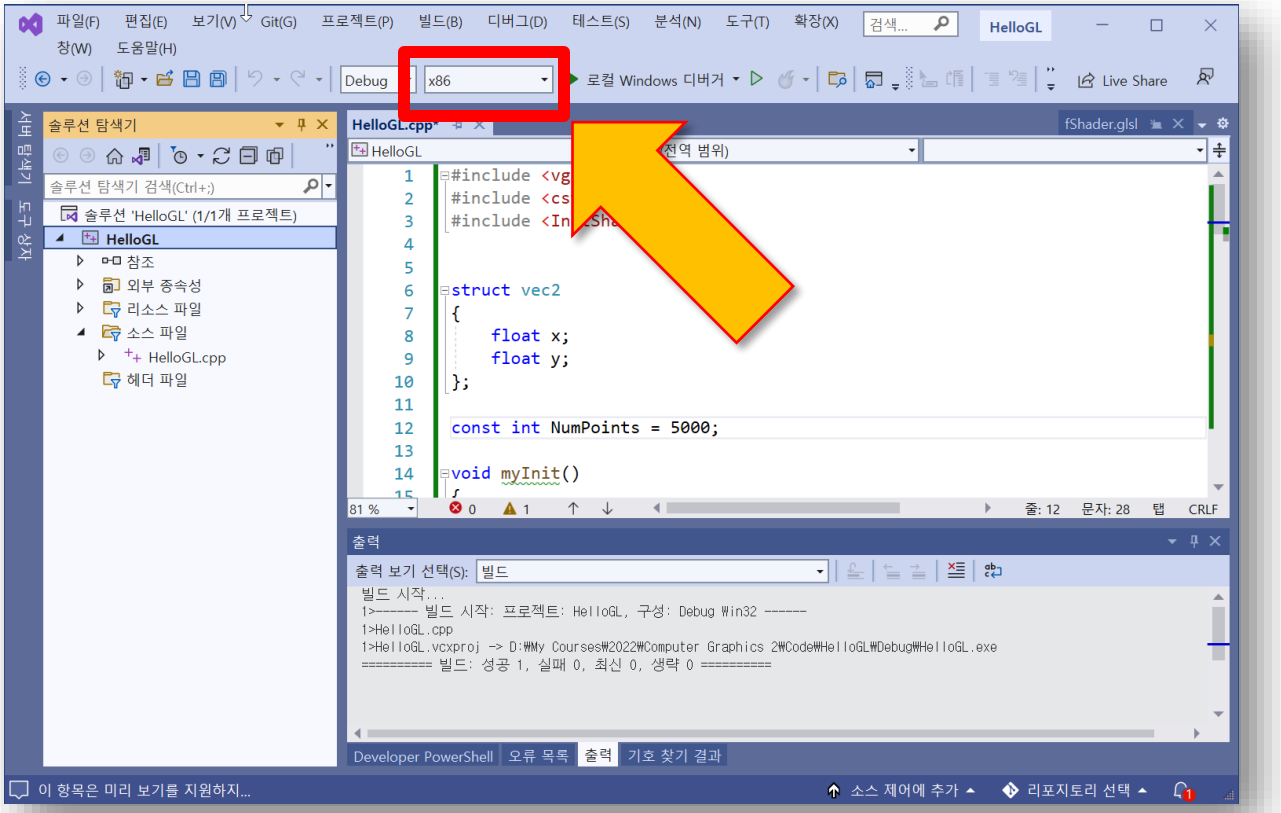
Project Setting:

- Start a new project with a "console application" project with an empty project option.



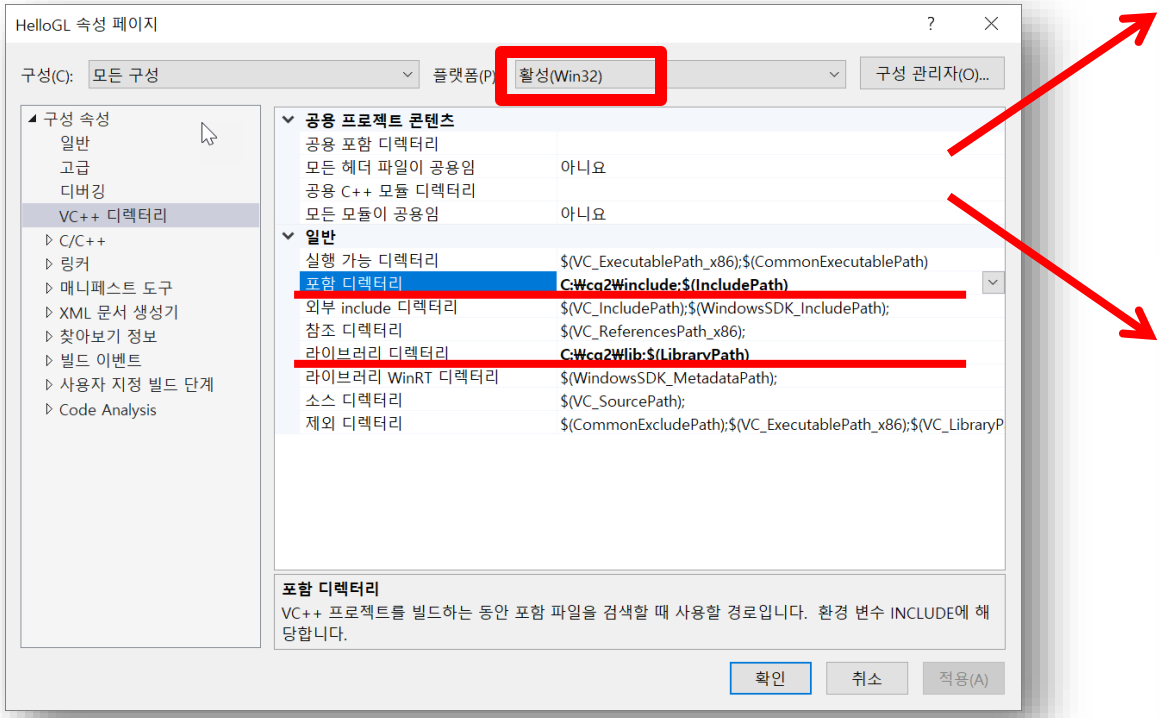
Set Target Platform: x86

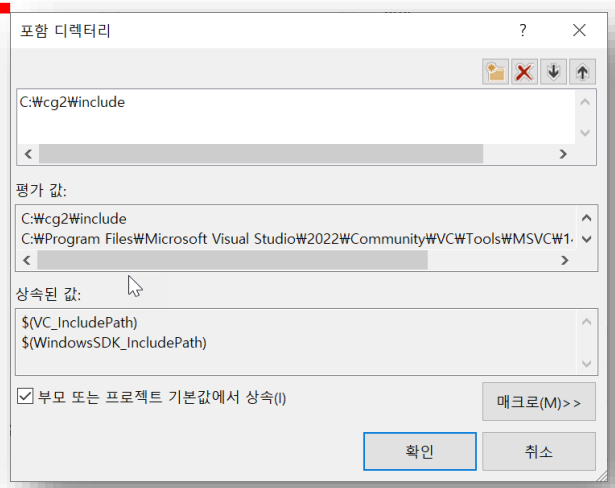
- 다음과 같이 반드시 Target Platform을 x86으로 설정 (x64 아님!)

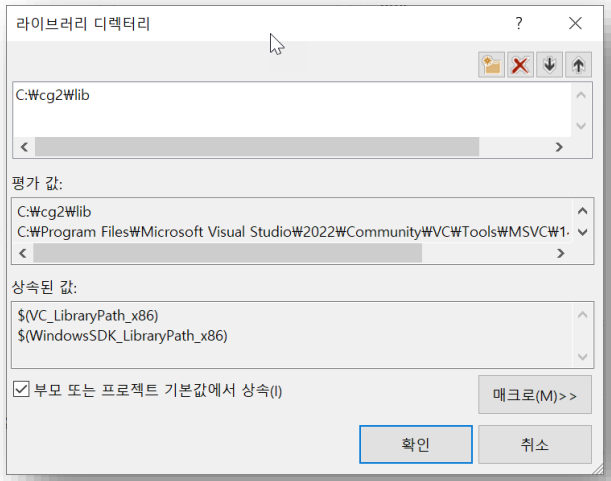


Project Setting

- Set the directories:







Create a new main.cpp file

- And add the following line at the beginning of the code:

```
#include <vgl.h>
```

Now ALL SET!!!!

Hello GL Program:

```
#include <vgl.h>

void display()
{
        glClear(GL_COLOR_BUFFER_BIT);
        glBegin(GL_TRIANGLES);
                glVertex2f(-0.5, -0.5);
                glVertex2f(0.5, -0.5);
                glVertex2f(-0.5, 0.5);
                glVertex2f(0.5, -0.5);
                glVertex2f(0.5, 0.5);
                glVertex2f(-0.5, 0.5);
        glEnd();
        glFlush();
}
```

```
int main(int argc, char** argv)
{
        glutInit(&argc, argv);
        glutInitDisplayMode(GLUT_SINGLE | GLUT_RGBA);
        glutInitWindowSize(512, 512);
        glutCreateWindow("Hello GL");

        glutDisplayFunc(display);
        glutMainLoop();

        return 0;
}
```