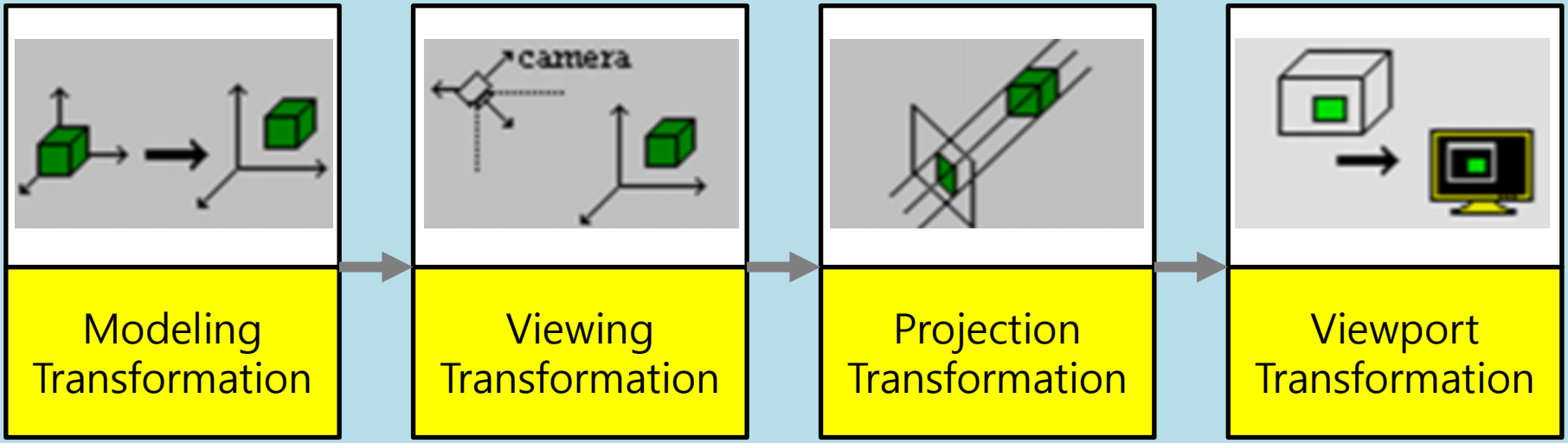
디지털 그래픽스 [10주차]

Viewing Transformation *(2)*

- **Viewport Transformation**

Perspective Transformation

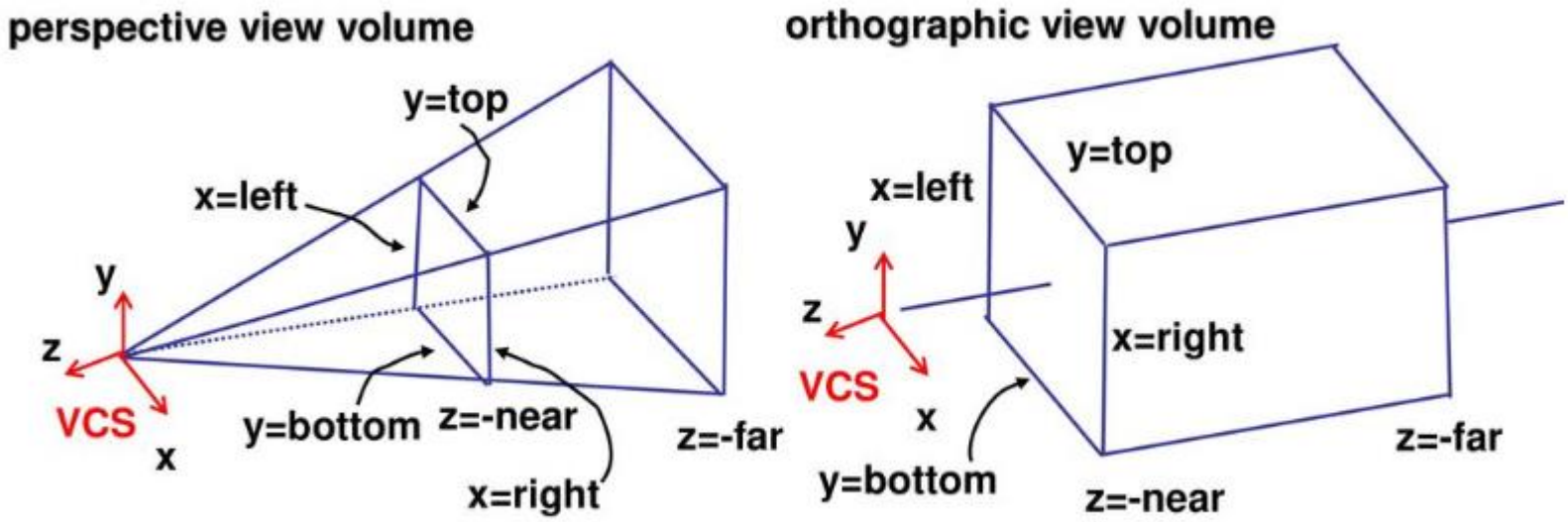
- 3차원 모델을 2차원 모니터에 디스플레이 하는 과정



Modeling transform **Viewing transform** **Projection transform**

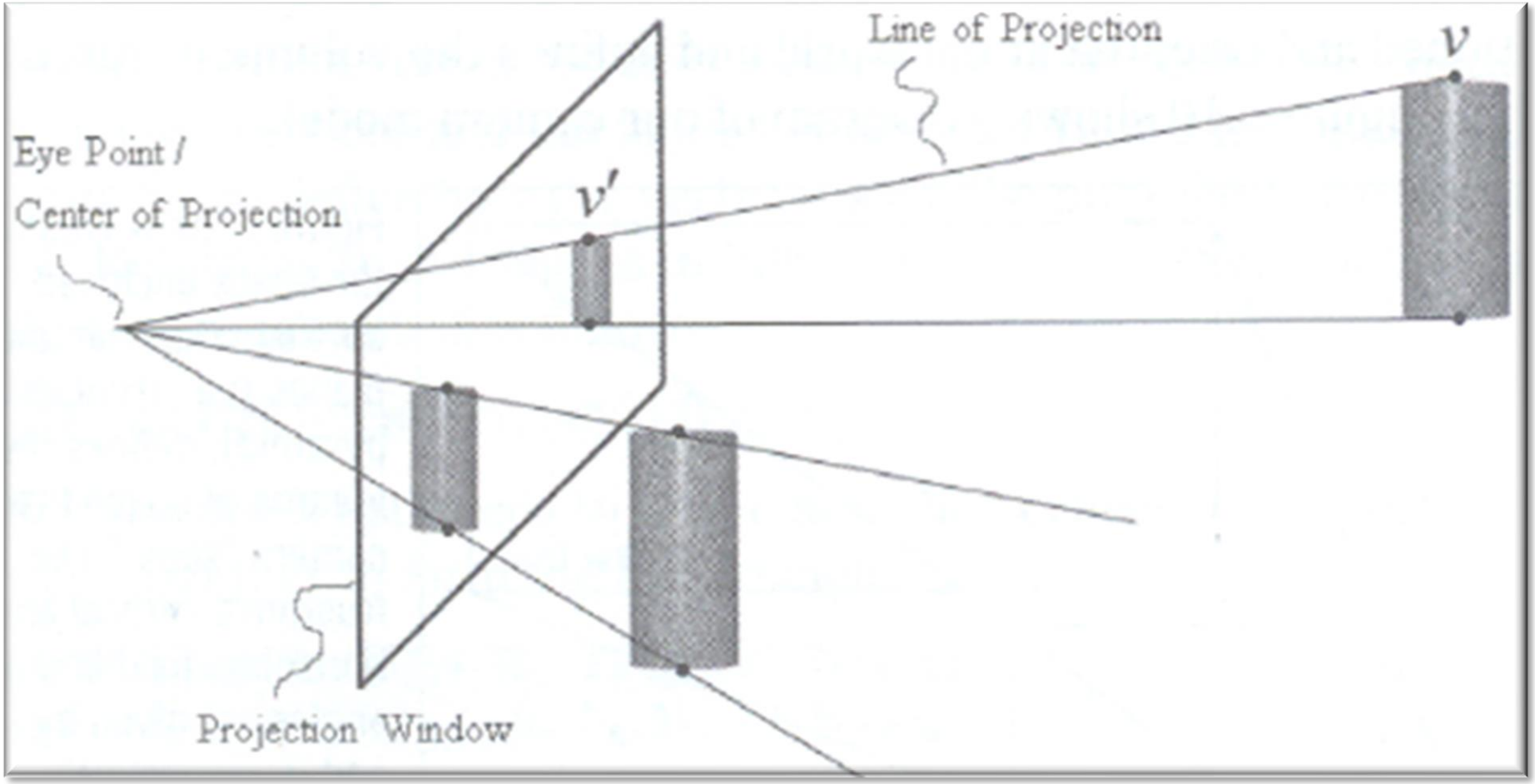
View Volume

- Perspective View Volume : 원근감
- Orthographic View Volume : 평면도 등에 사용



Perspective Illusion

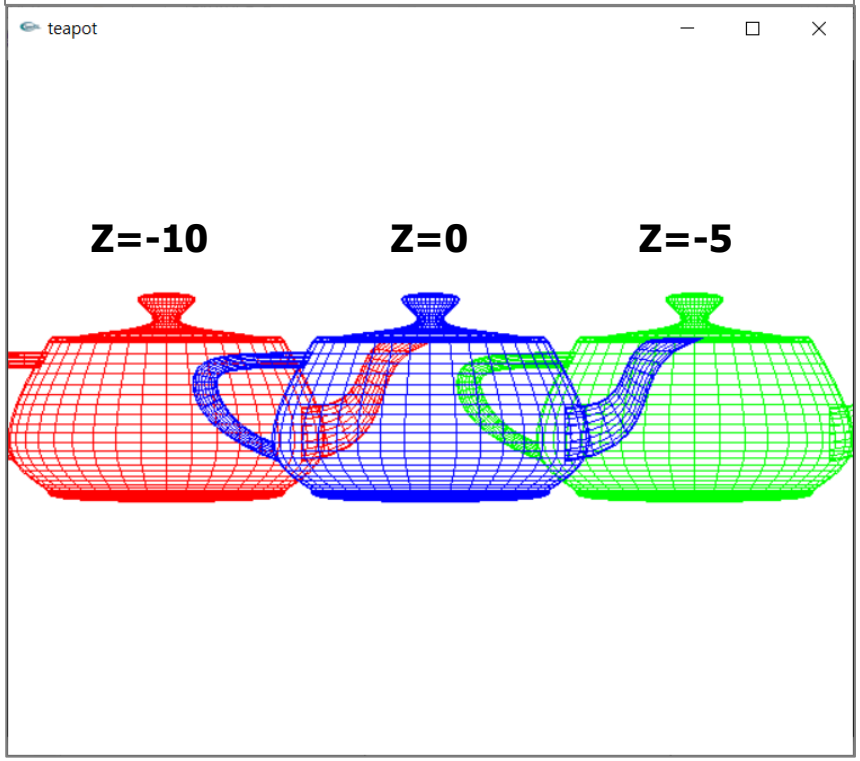
- 원근감



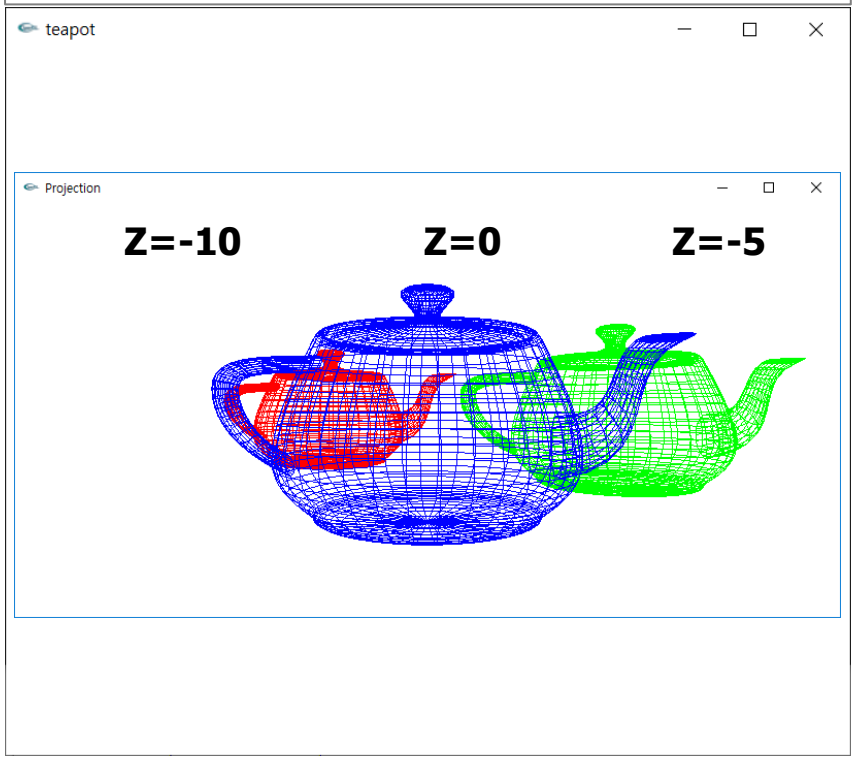
parallel vs. perspective projection

- glOrtho(..) vs. glFrustum(..)

glOrtho(-8, 8, -8, 8, 1.5, 30)

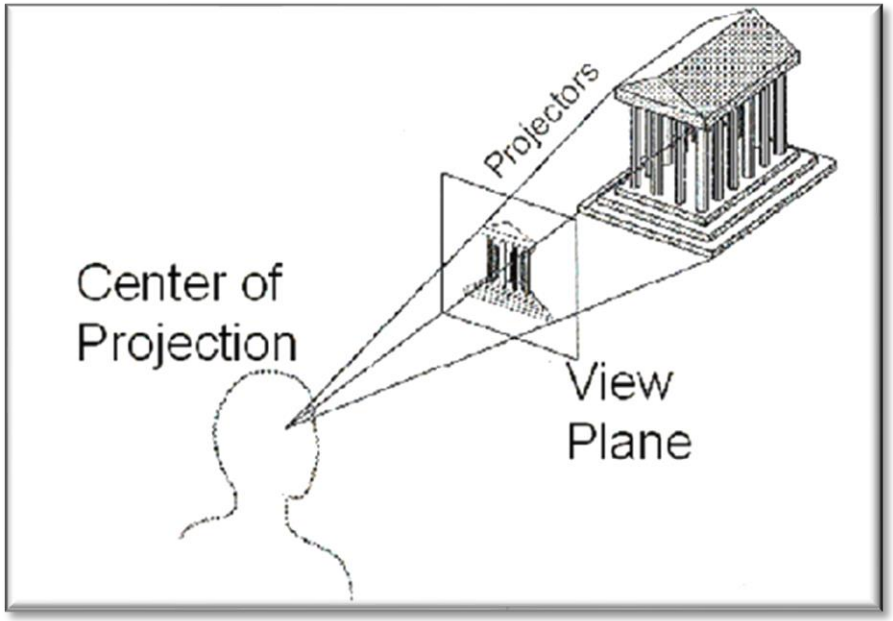


glFrustum(-8, 8, -8, 8, 1.5, 30)



Projection

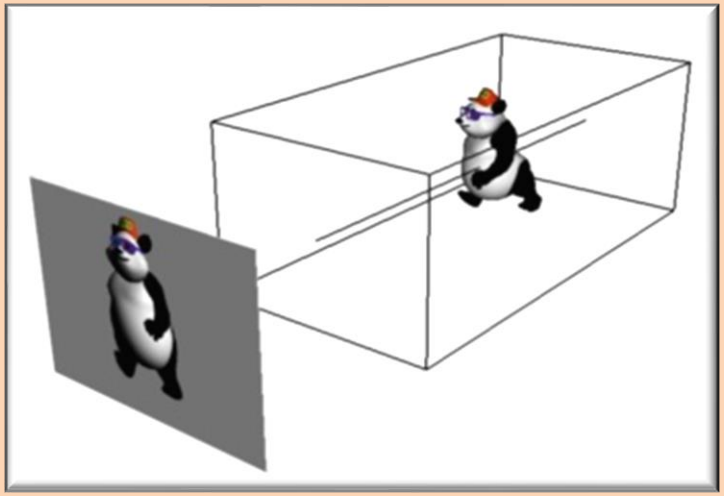
- **In Computer Graphics**
  - Map 3D coordinates to 2D coordinates
    - Based on the camera model



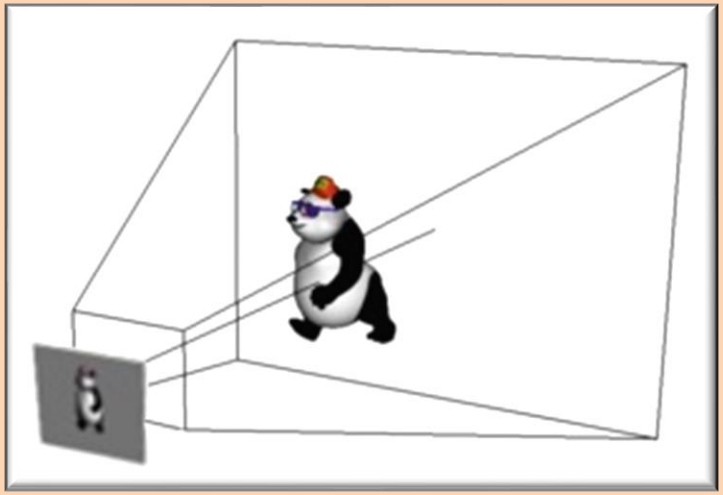
The way of projections

Geometric Projection

Parallel

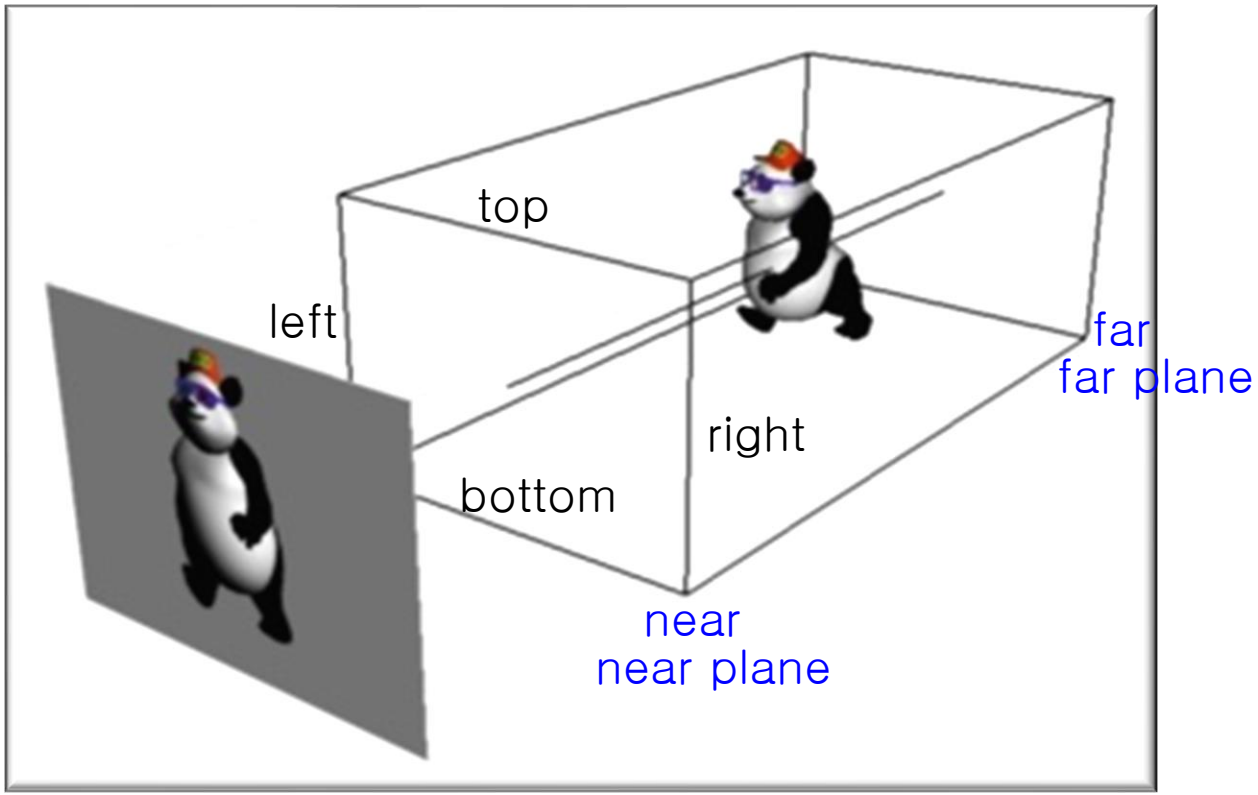


Perspective



Orthographic View Volume

- **View Volume parameters**
  - left, right, bottom, top, near, far

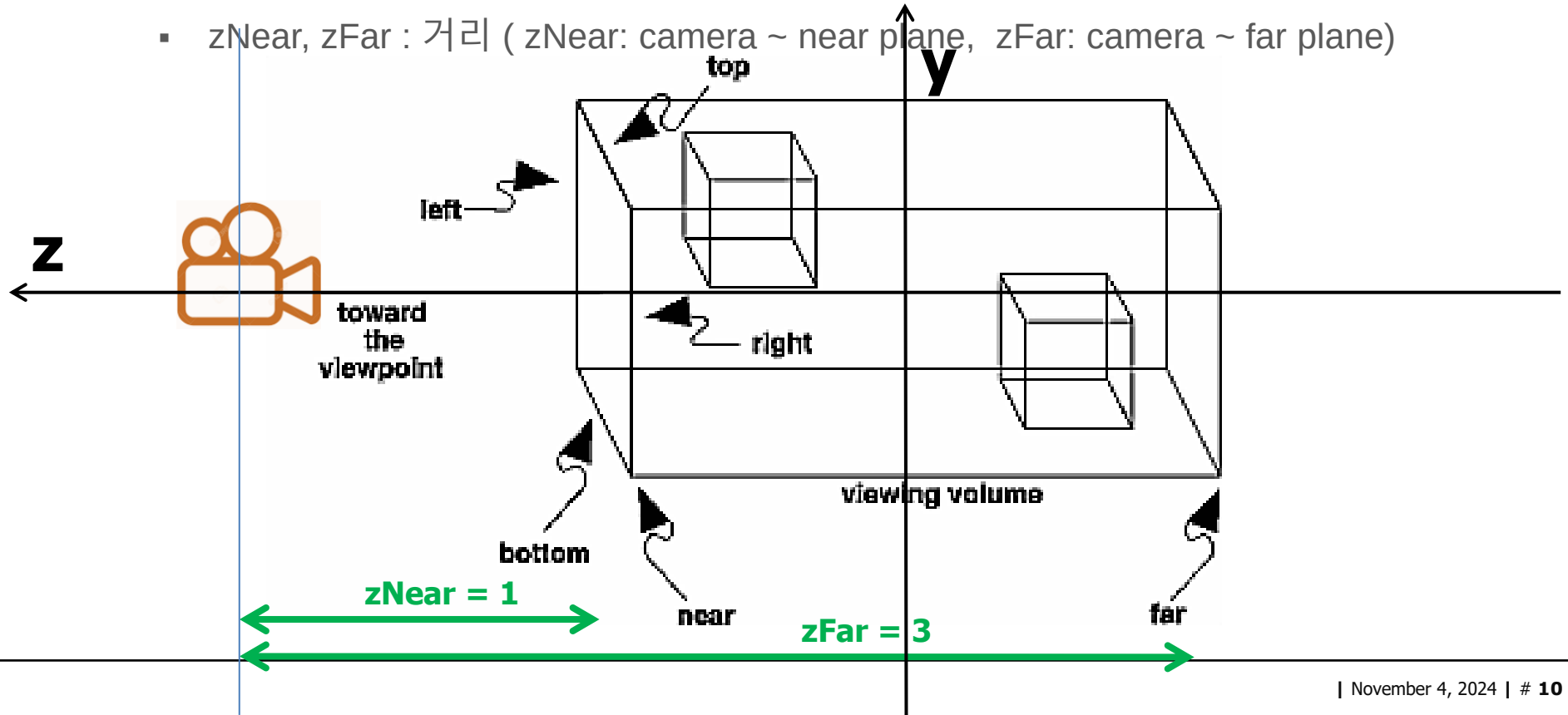


OpenGL Orthographic Projection

glOrtho(..)

OpenGL: Orthogonal Projection

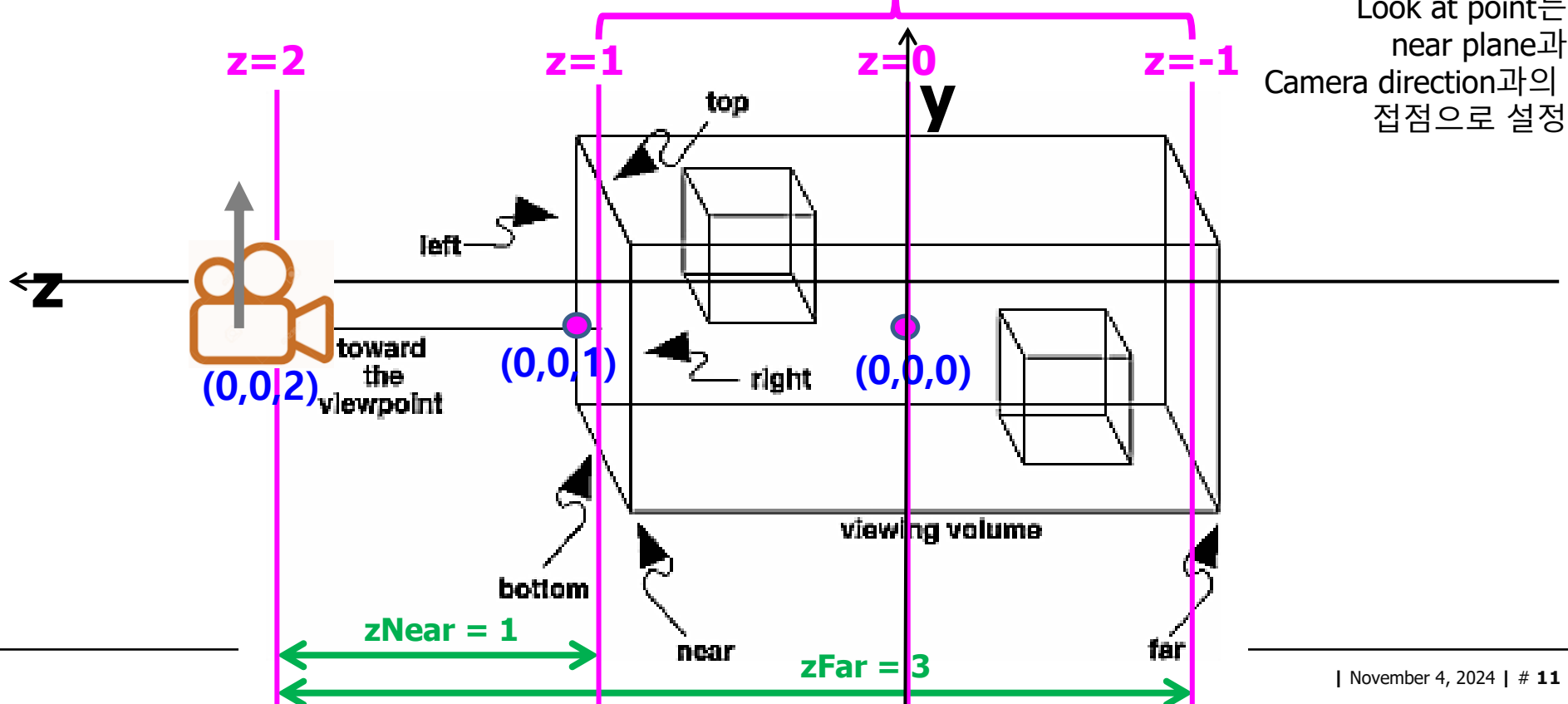
- void **glOrtho**(GLdouble left, GLdouble right,
  GLdouble bottom, GLdouble top,
  GLdouble zNear, GLdouble zFar)
  - left, right, bottom, top : 좌표
  - zNear, zFar : 거리 (zNear: camera ~ near plane, zFar: camera ~ far plane)



Orthogonal Projection

```
glOrtho(-1.0, 1.0,   -1.0, 1.0,   1.0, 3.0);
gluLookAt( 0.0, 0.0, 2.0,
           0.0, 0.0, 1.0,
           0.0, 1.0, 0.0);
```

- void **glOrtho**(GLdouble left, GLdouble right,
  GLdouble bottom, GLdouble top,
  GLdouble zNear, GLdouble zFar)
  - glOrgho(**-1.0, 1.0**, **-1.0, 1.0**, **1.0, 3.0**);

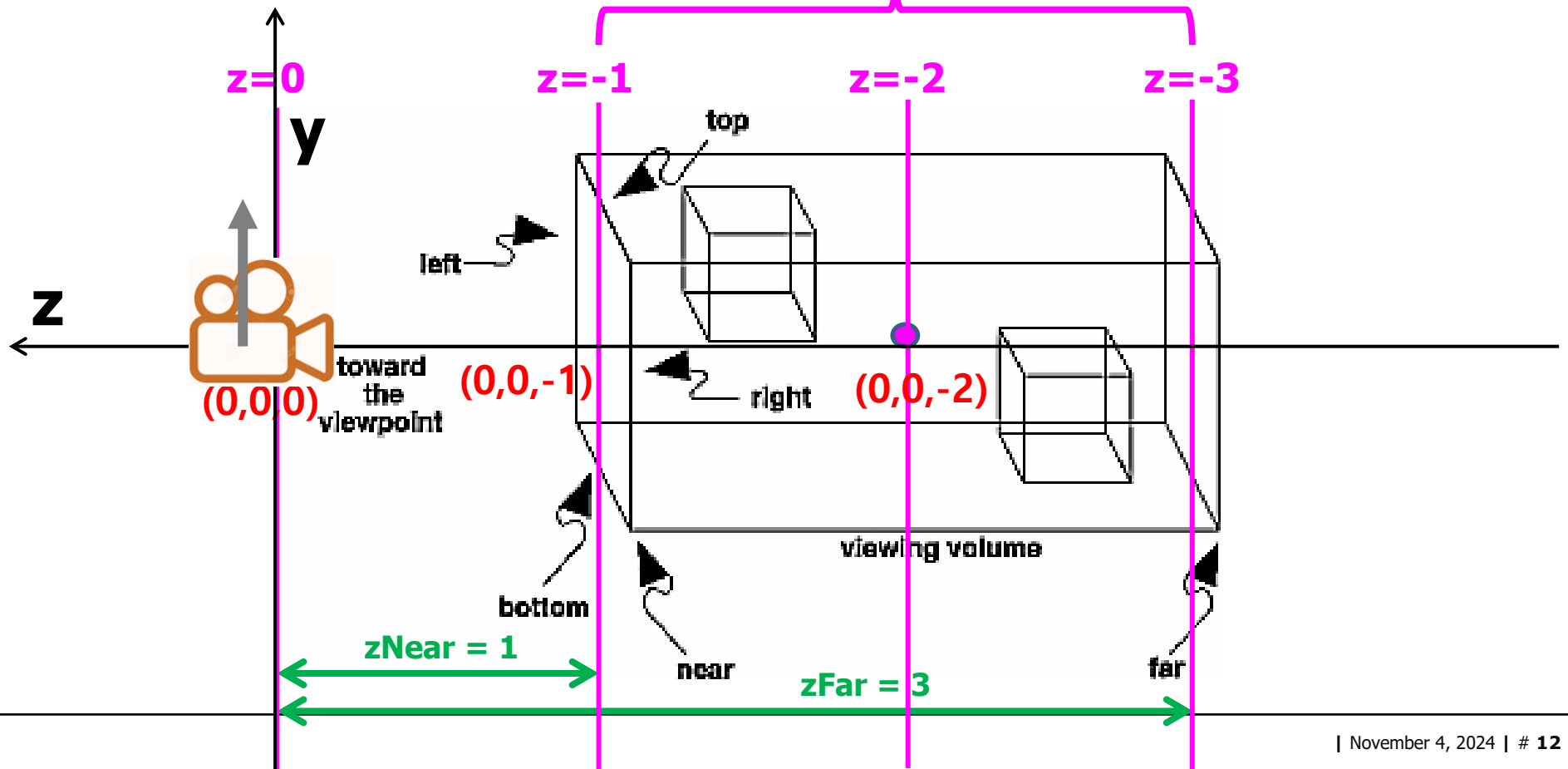


Look at point는 near plane과 Camera direction과의 접점으로 설정

Orthogonal Projection

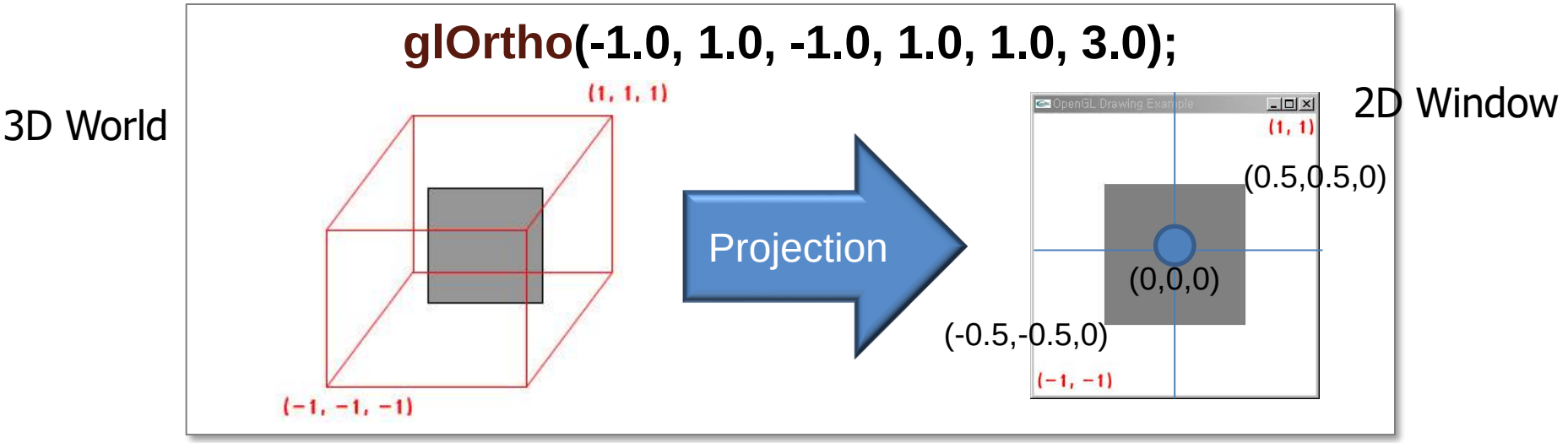
```
glOrtho(-1.0, 1.0,  -1.0, 1.0,  1.0, 3.0);
gluLookAt( 0.0, 0.0, 0.0,
           0.0, 0.0, -1.0,
           0.0, 1.0, 0.0);
```

- void **glOrtho**(GLdouble left, GLdouble right, GLdouble bottom, GLdouble top, GLdouble zNear, GLdouble zFar)
  - glOrgho(**-1.0, 1.0**, **-1.0, 1.0**, **1.0, 3.0**);



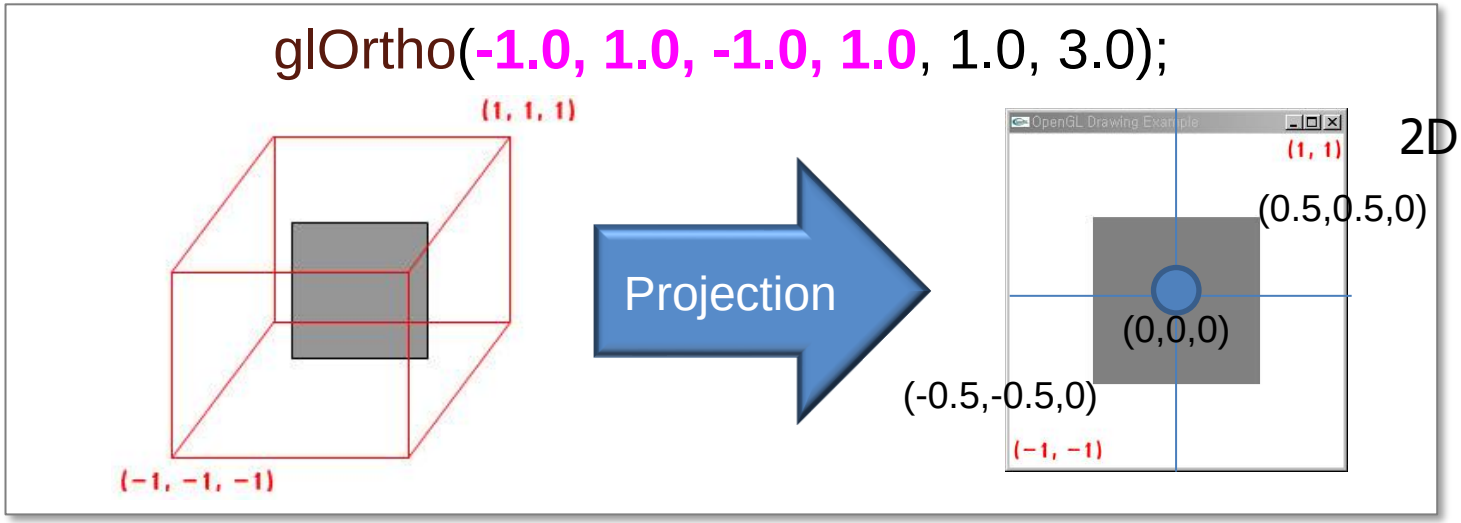
How the view volume works

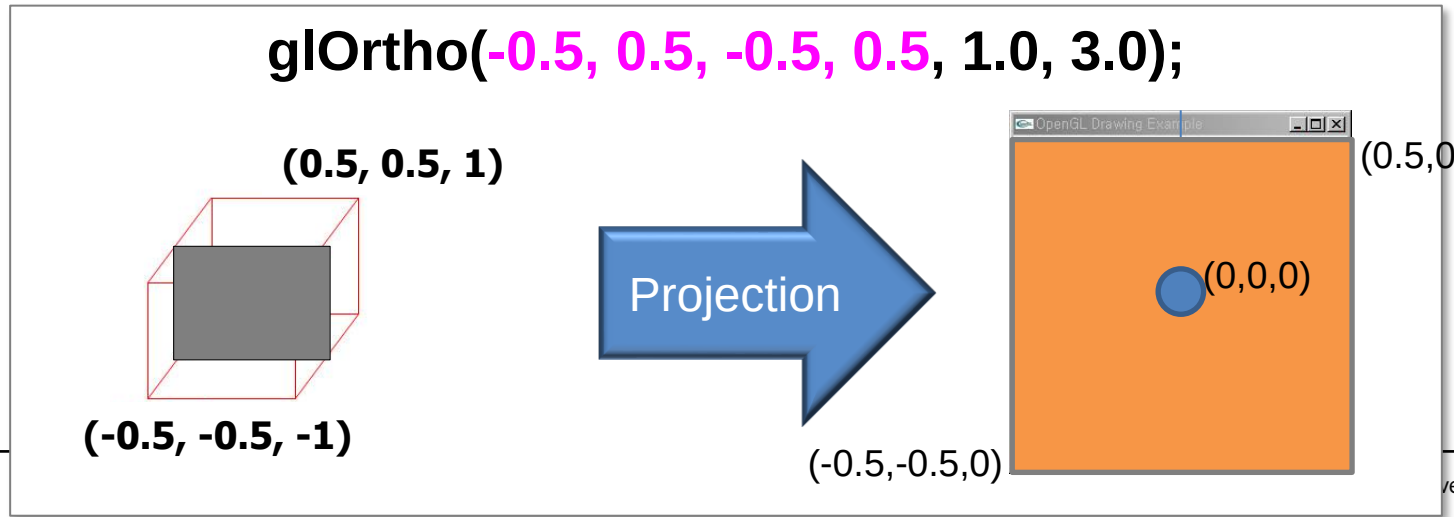
- void **glOrtho**(GLdouble left, GLdouble right, GLdouble bottom, GLdouble top, GLdouble zNear, GLdouble zFar)
  - glOrgho(**-1.0, 1.0**, **-1.0, 1.0**, **1.0, 3.0**);
- **Rectangle of size 1 at the origin**



How the view volume works

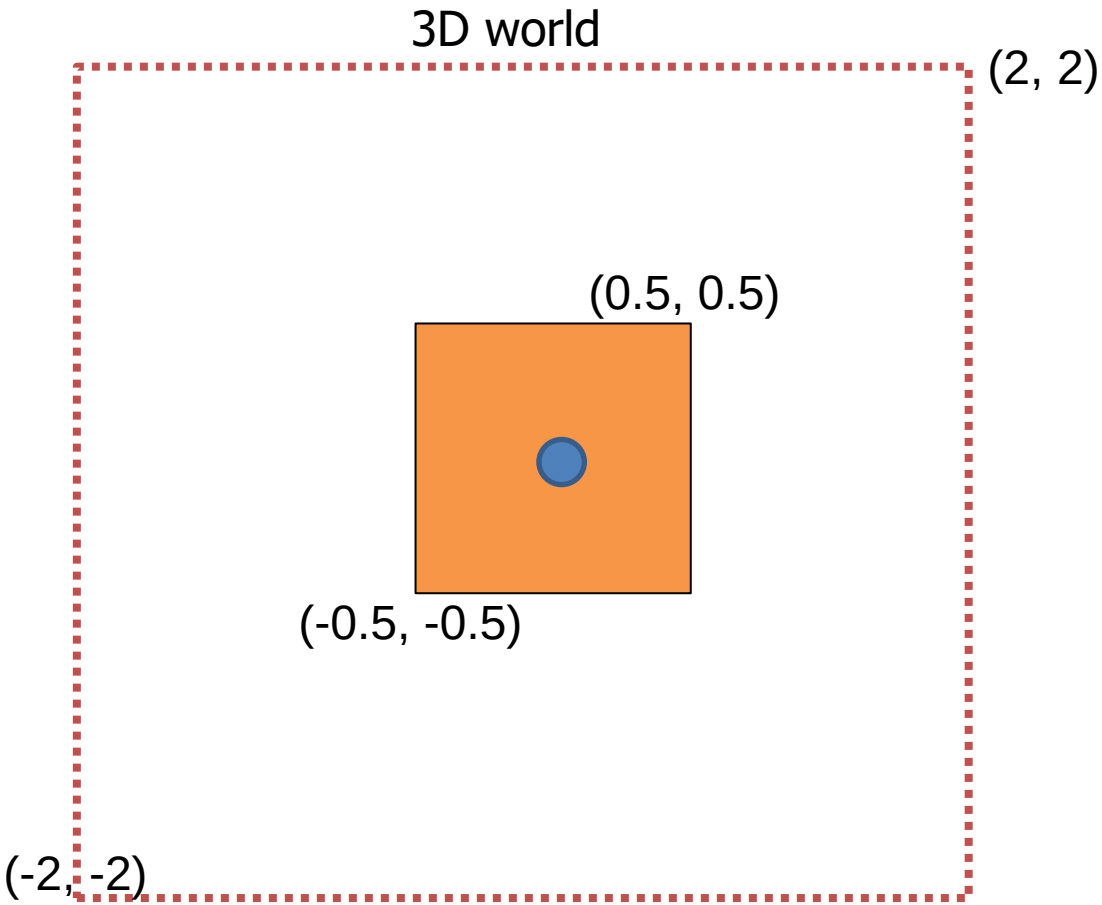
- Variations of view volume

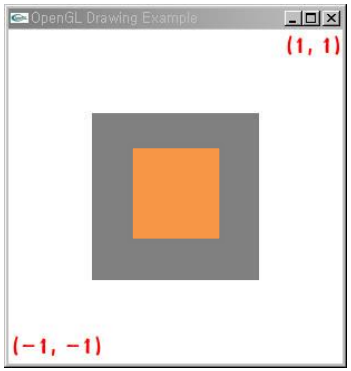




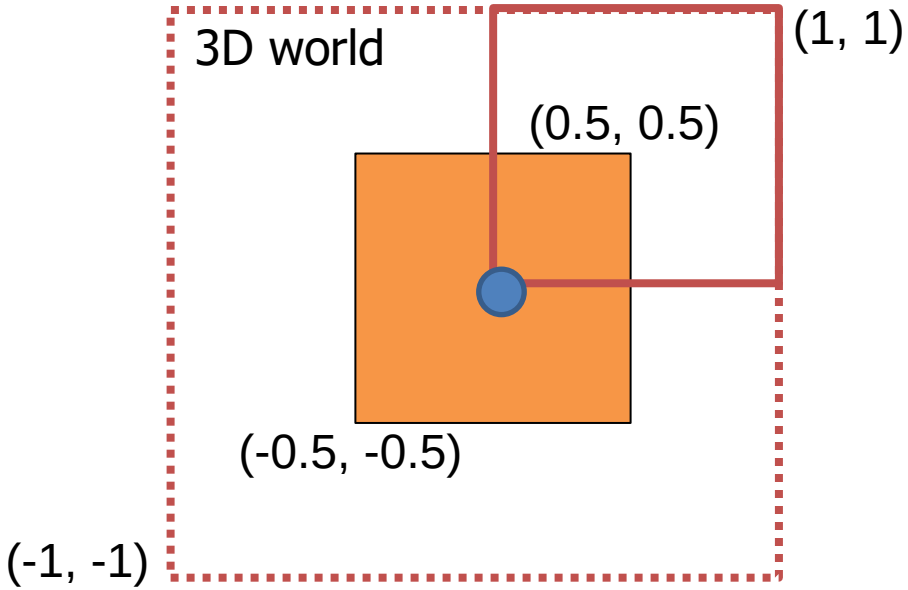
How the view volume works

- view volume
  - glOrtho(-2.0, 2.0, -2.0, 2.0, 1.0, 3.0);



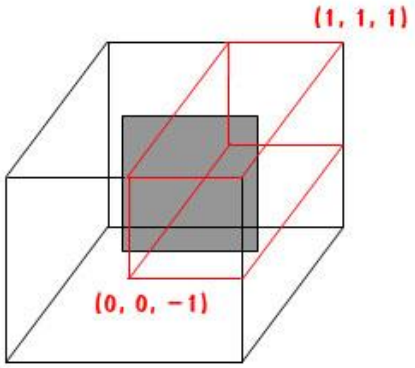


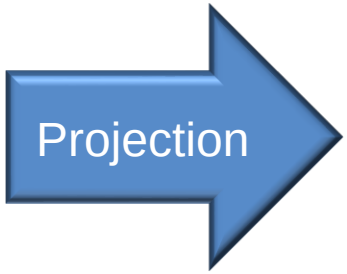
How the view volume works

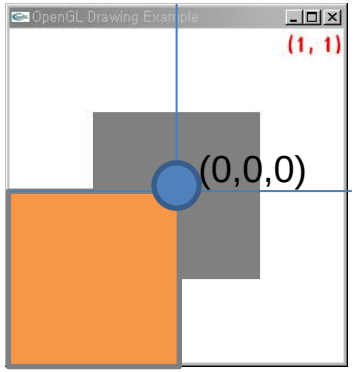


glOrtho(0.0, 1.0, 0.0, 1.0, 1.0, 3.0);

3D World



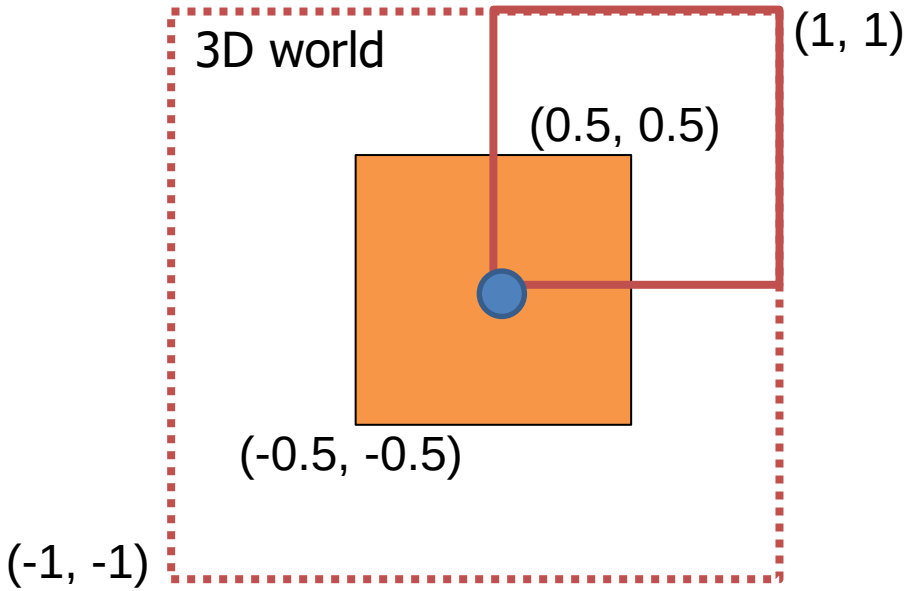


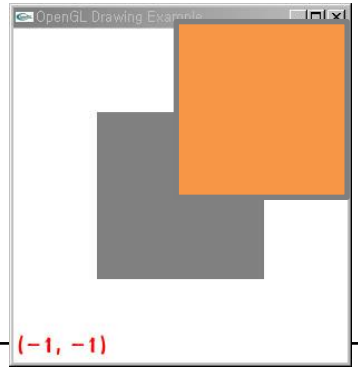


2D Window

How the view volume works

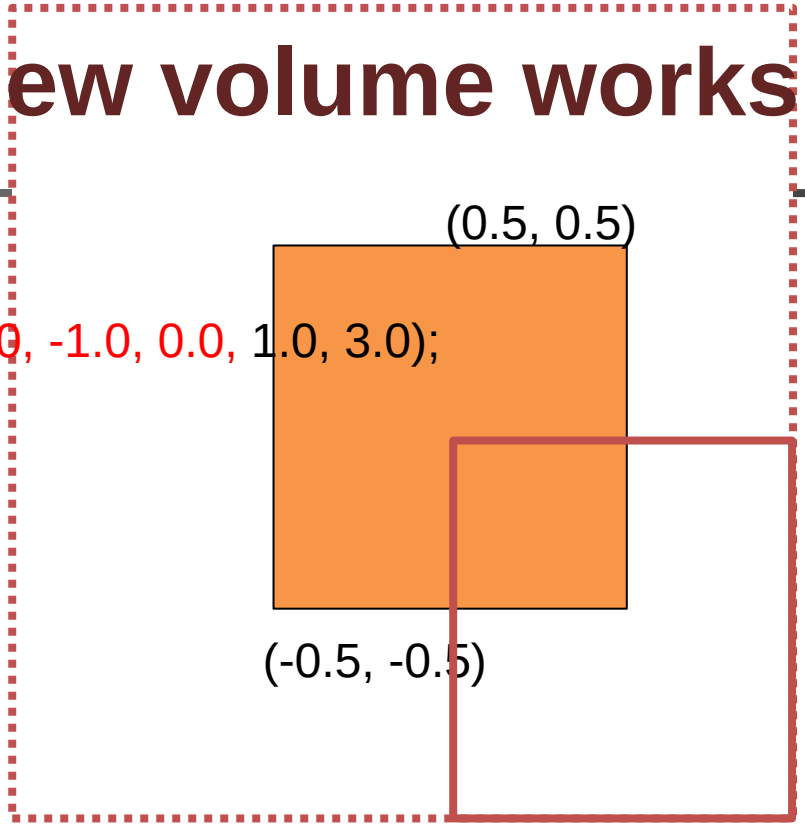
- view volume
  - glOrtho(-1.0, 0.0, -1.0, 0.0, 1.0, 3.0);





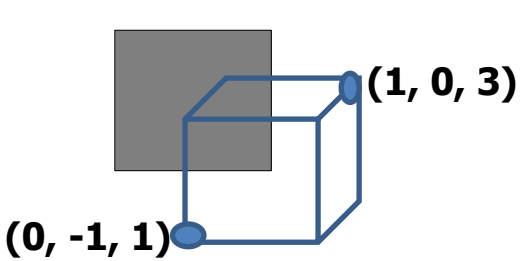
How the view volume works

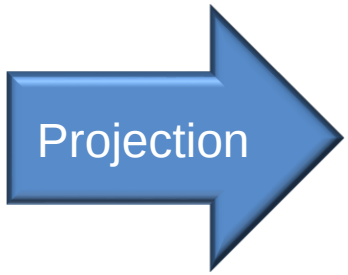
- view volume
  - glOrtho(0.0, 1.0, -1.0, 0.0, 1.0, 3.0);

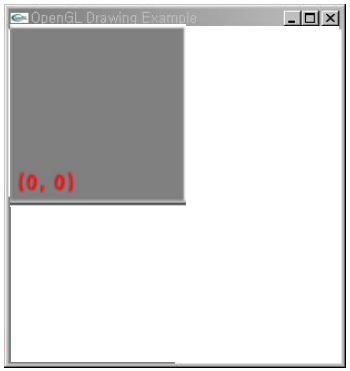


glOrtho(0.0, 1.0, -1.0, 0.0, 1.0, 3.0);

3D World



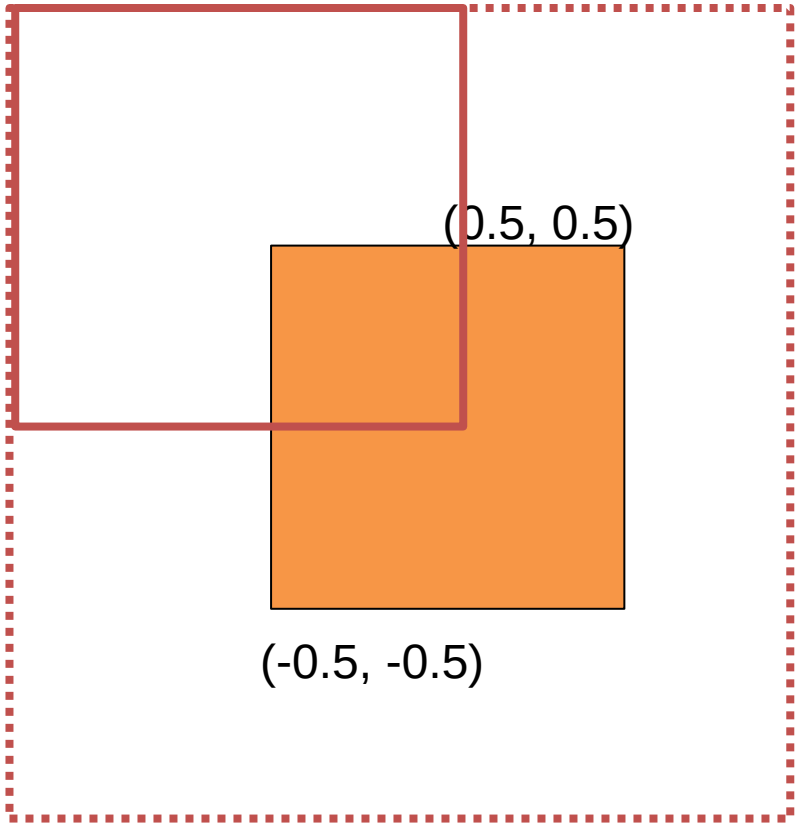


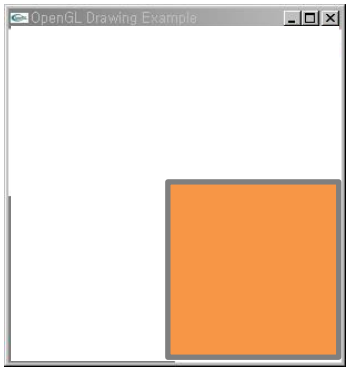


2D Window

How the view volume works

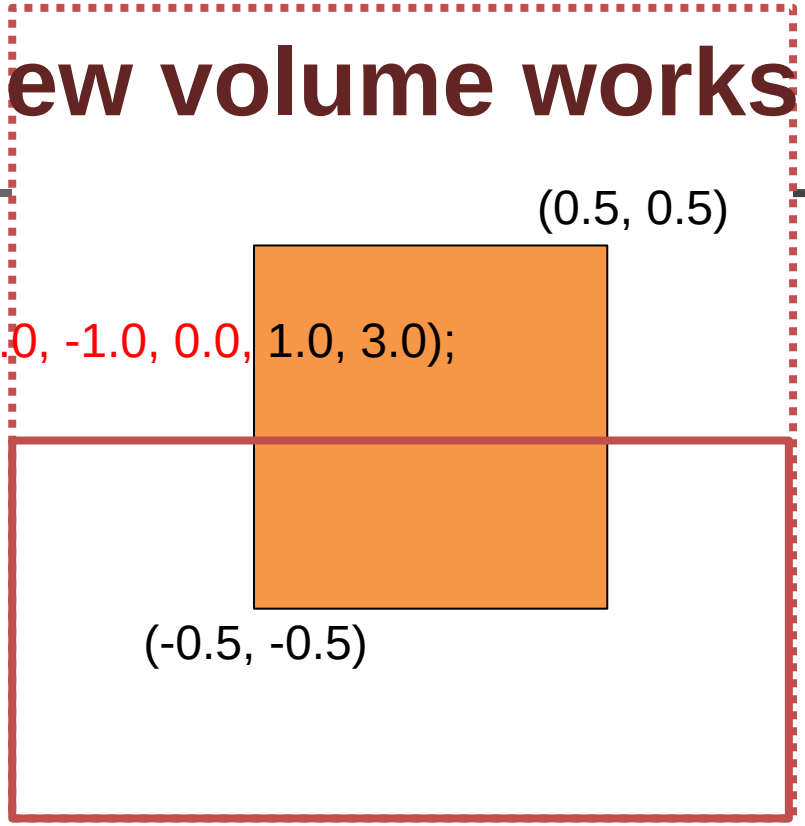
- view volume
  - glOrtho(-1.0, 0.0, 0.0, 1.0, 1.0, 3.0);



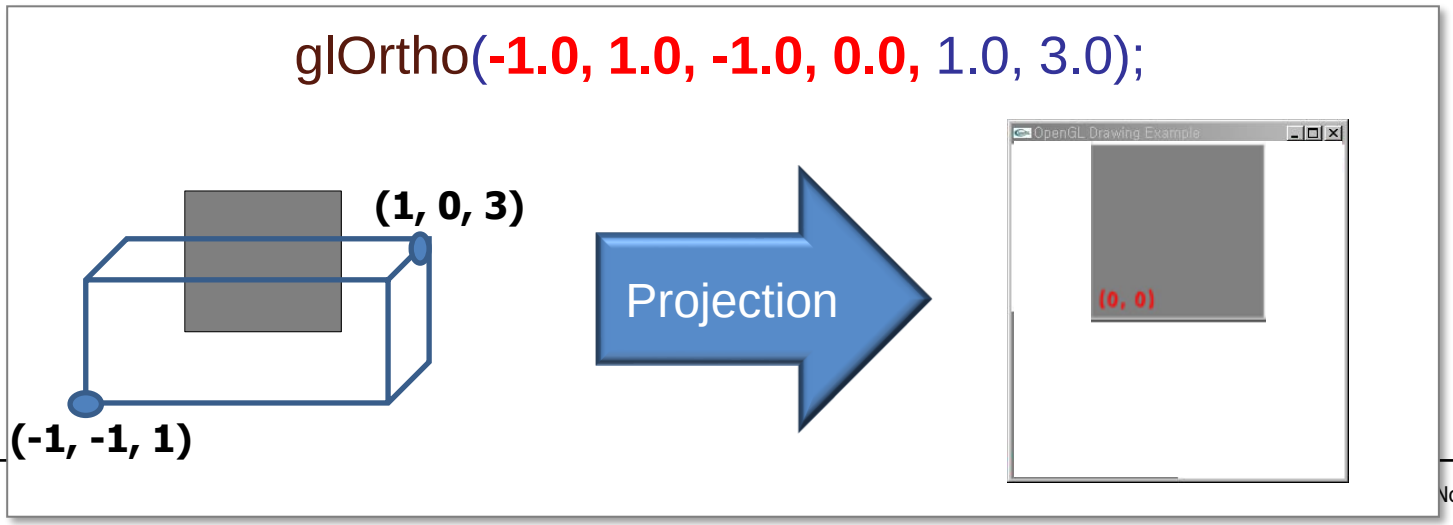


How the view volume works

- view volume
  - glOrtho(-1.0, 1.0, -1.0, 0.0, 1.0, 3.0);

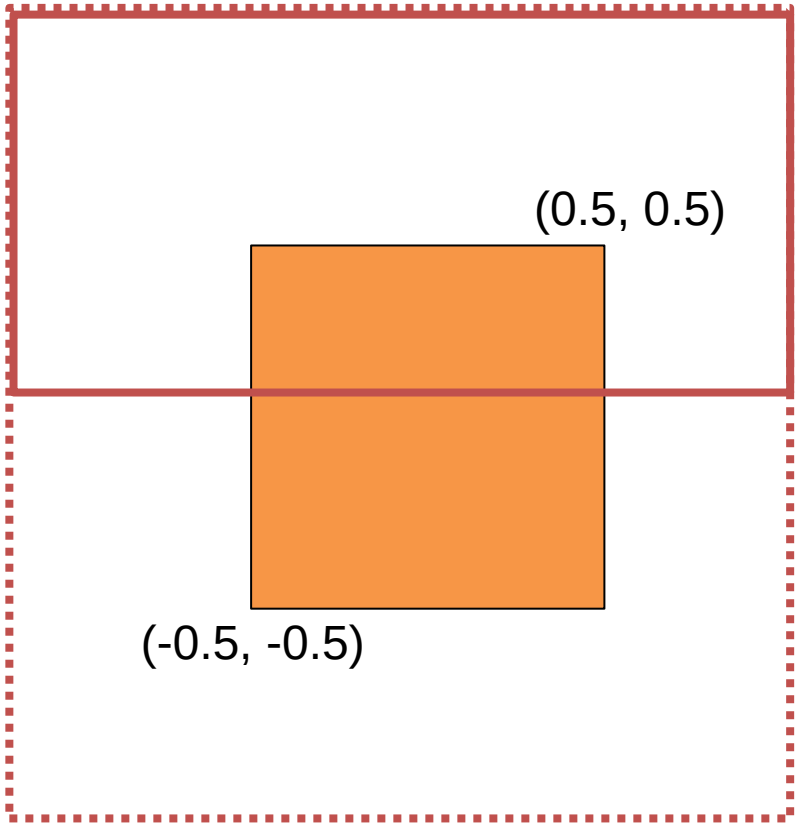


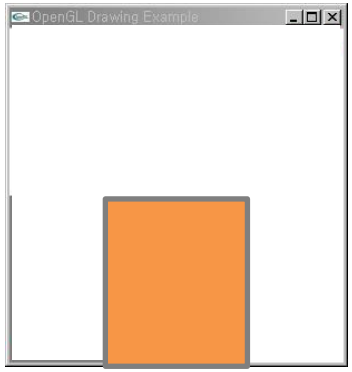
glOrtho(**-1.0, 1.0, -1.0, 0.0,** 1.0, 3.0);



How the view volume works

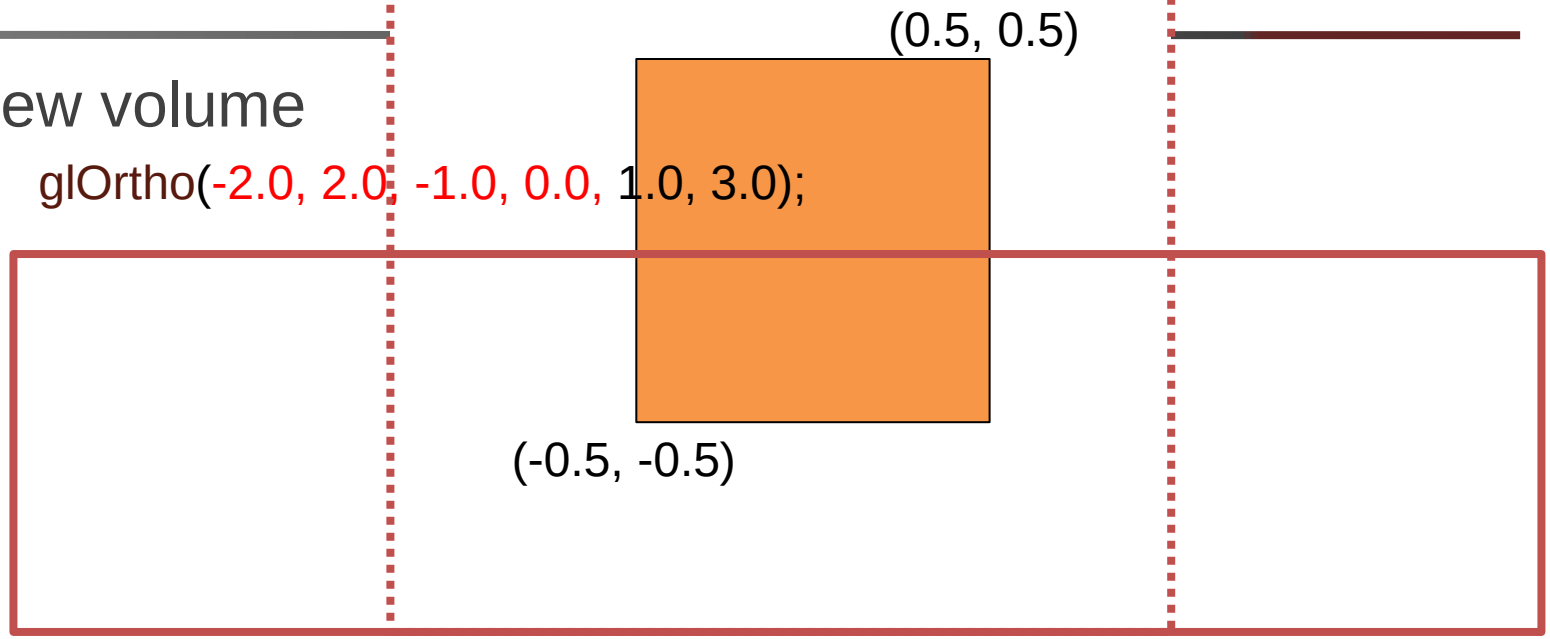
- view volume
  - glOrtho(-1.0, 1.0, 0.0, 1.0, 1.0, 3.0);



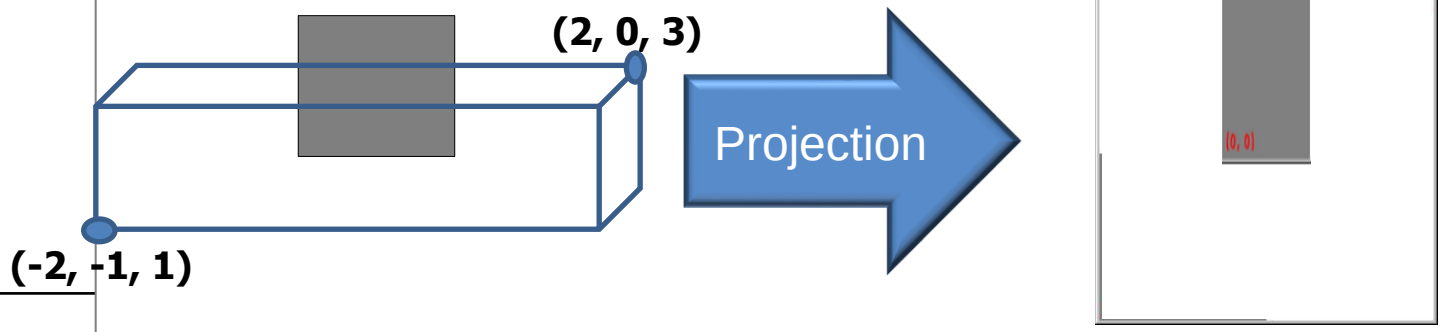


How the view volume works

- view volume
  - glOrtho(-2.0, 2.0, -1.0, 0.0, 1.0, 3.0);

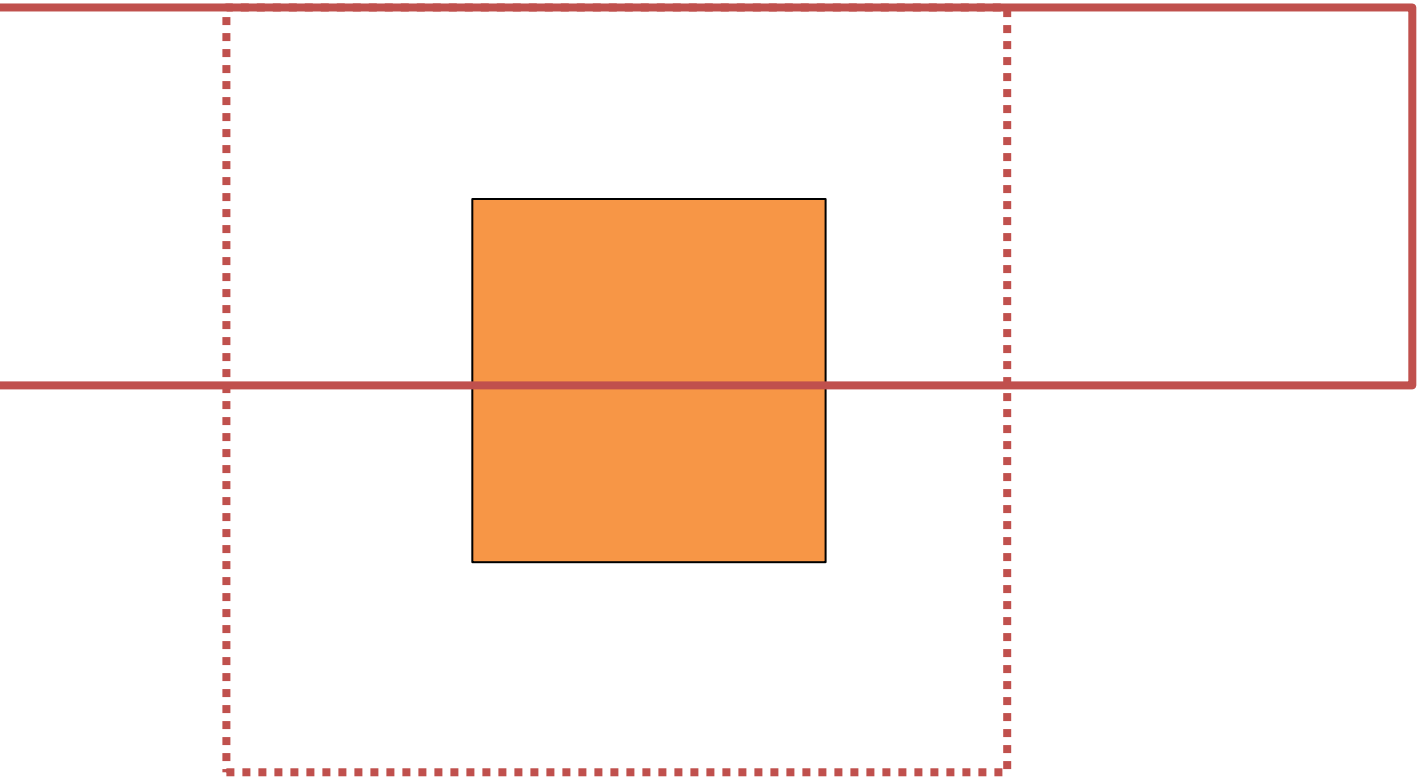


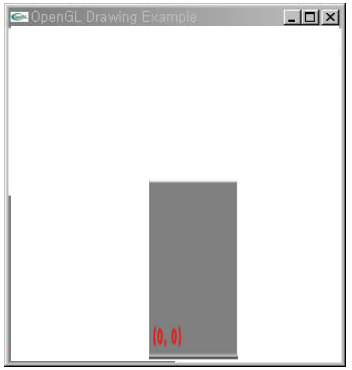
glOrtho(-2.0, 2.0, -1.0, 0.0, 1.0, 3.0);



How the view volume works

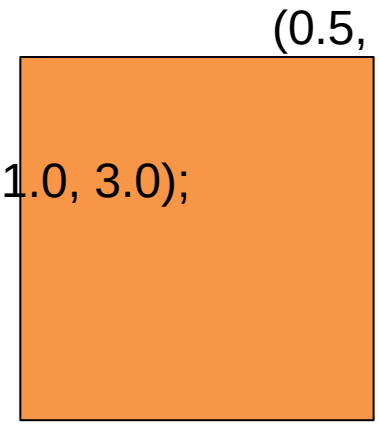
- view volume
  - glOrtho(-2.0, 2.0, 0.0, 1.0, 1.0, 3.0);

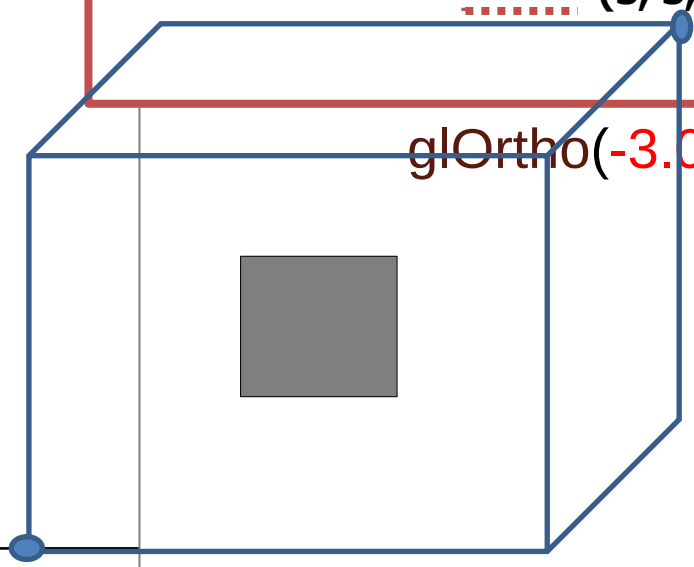




How the view volume works

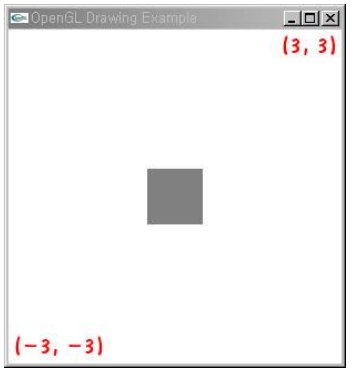
- view volume
  - glOrtho(-3.0, 3.0, -3.0, 3.0, 1.0, 3.0);





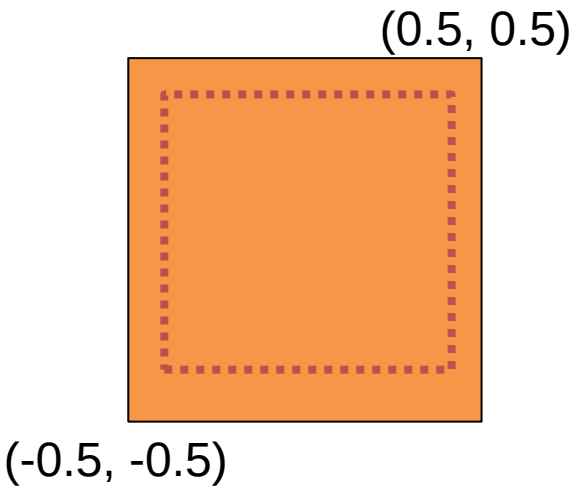
glOrtho(-3.0, 3.0, -3.0, 3.0, 1.0, 3.0);

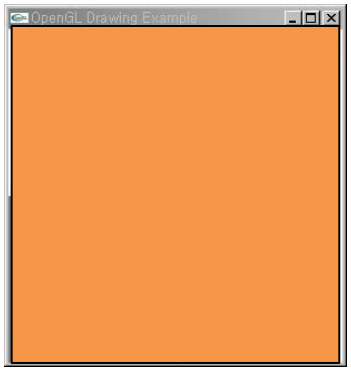
Projection



How the view volume works

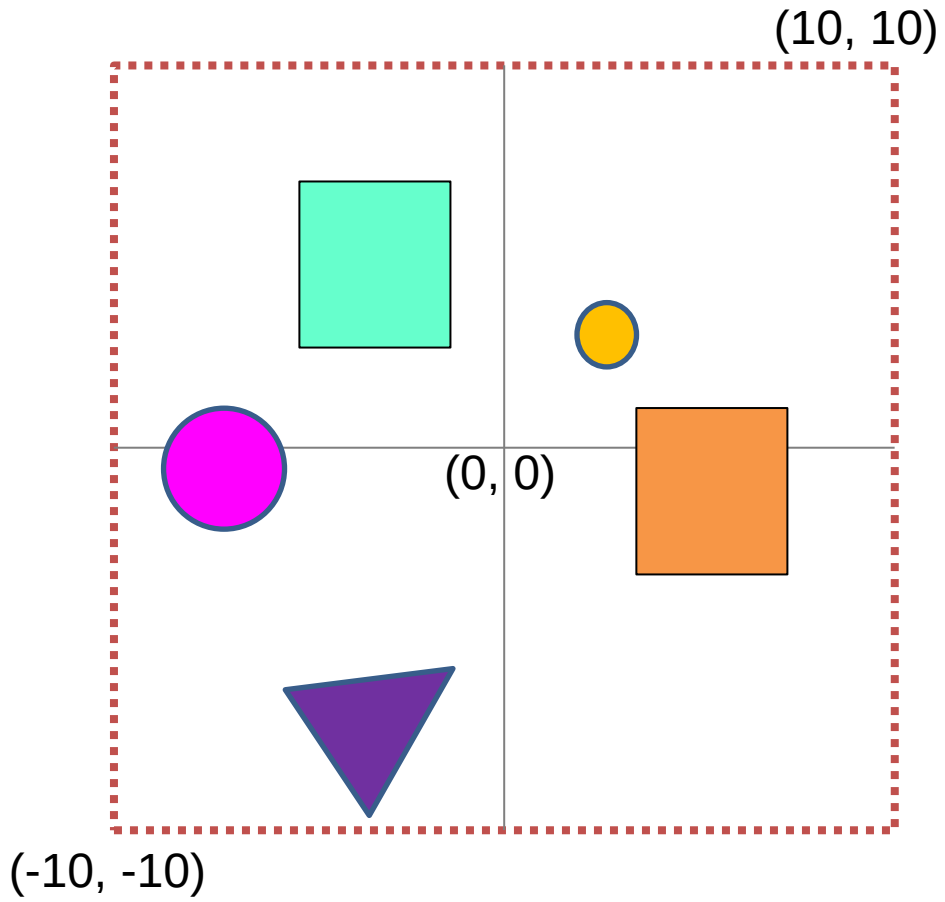
- view volume
  - glOrtho(-0.3, 0.3, -0.3, 0.3, 1.0, 3.0);





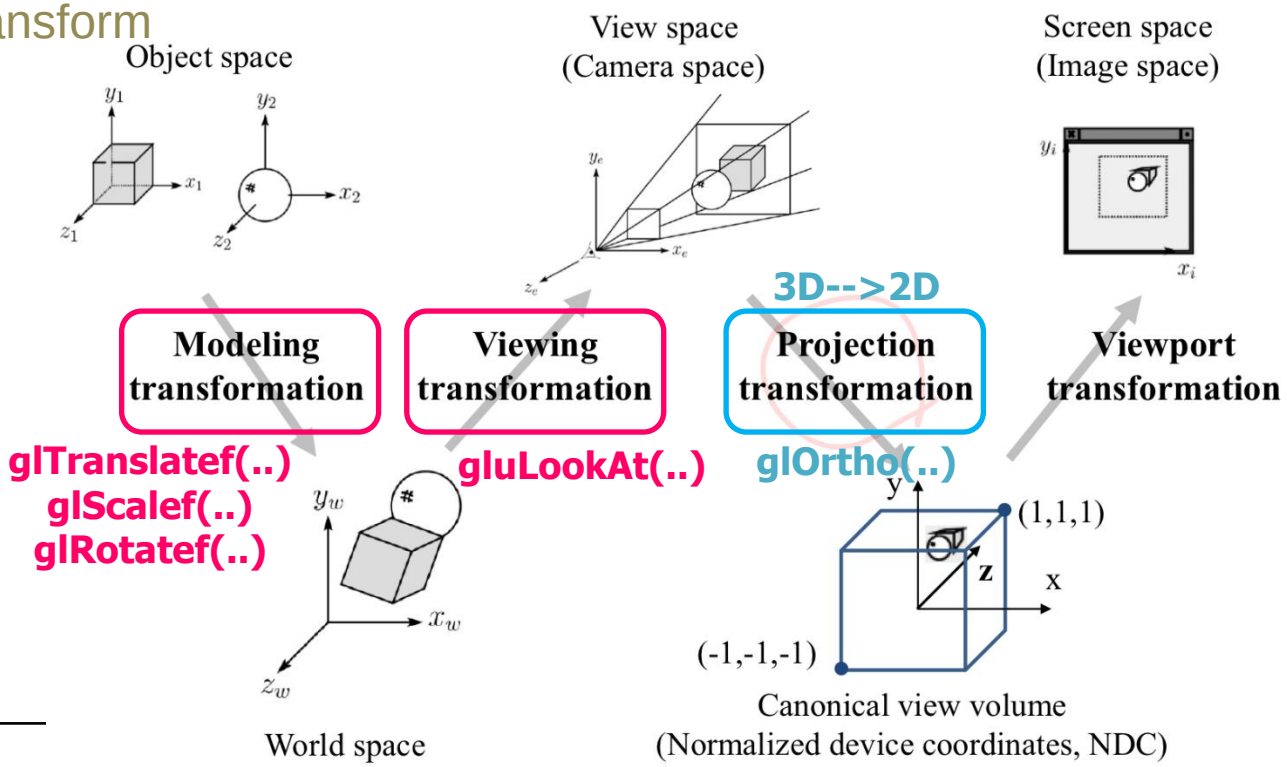
How the view volume works

- view volume
  - glOrtho(-10, 10, -10, 10, 1.0, 3.0);



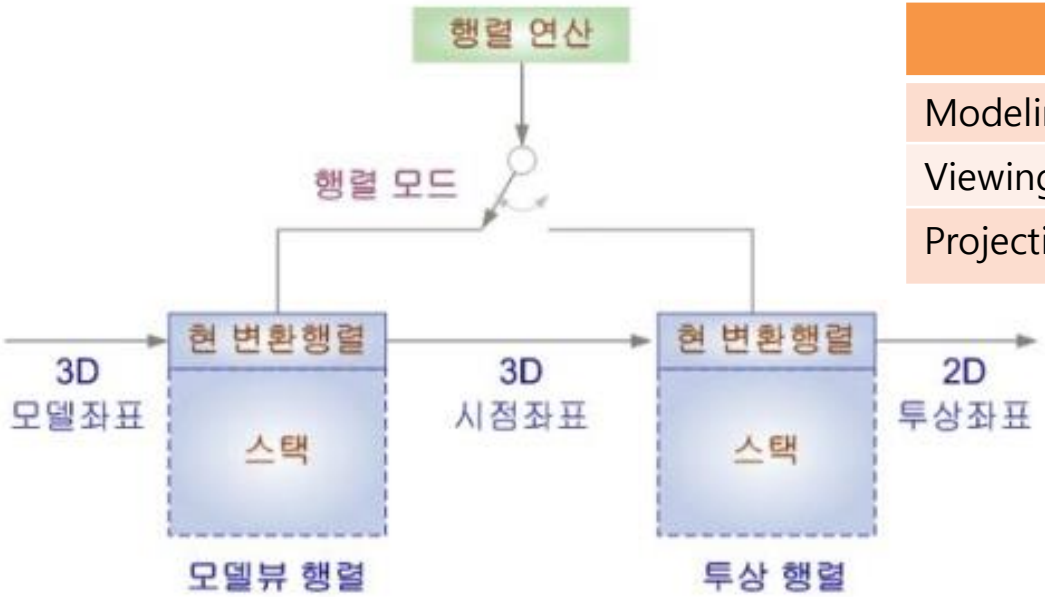
Transformation

- **Matrix mode**
  - 행렬 모드, 행렬 종류
  - void glMatrixMode(mode)
    - modeling transform, viewing transform(camera)
    - projection transform



glOrtho()

- **Matrix mode**
  - 행렬 모드, 행렬 종류
  - void glMatrixMode(mode)
    - modeling transform, viewing transform(camera) **--> GL_MODELVIEW**
    - projection transform **-->GL_PROJECTION**



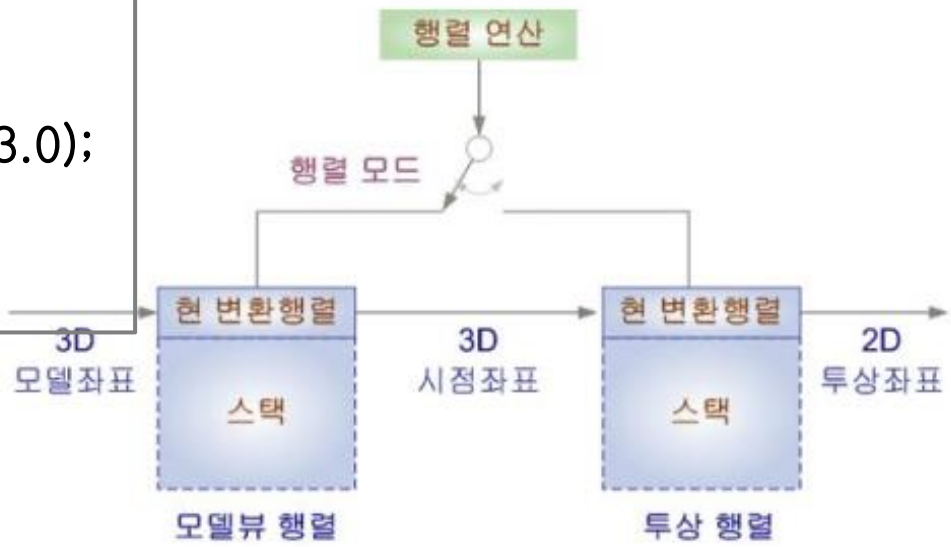
	OpenGL f.	Matrix Mode
Modeling Transform	glTranslatef(..)	GL_MODELVIEW
Viewing Transform	gluLookAt(..)	GL_MODELVIEW
Projection Transform	glOrtho(..)	GL_PROJECTION

GL_MODELVIEW GL_PROJECTION

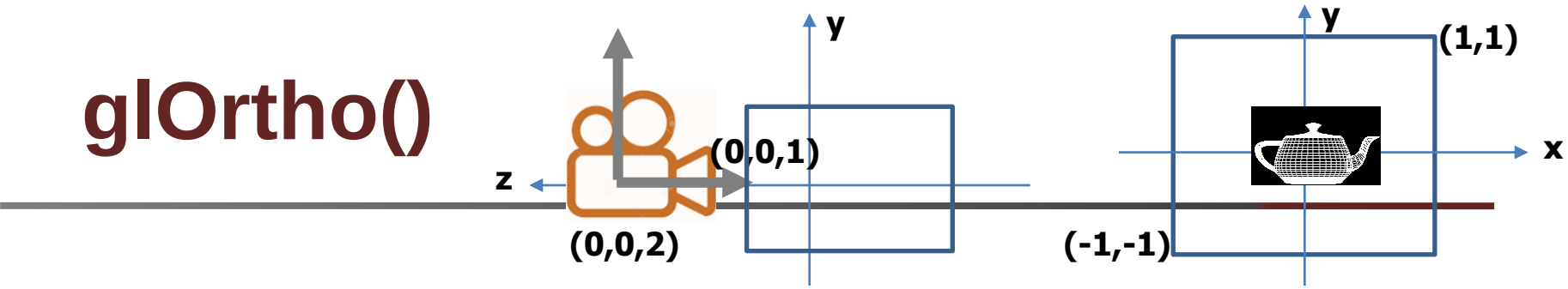
glOrtho()

- **Matrix mode**
  - 조작하고자 하는 행렬 선택
  - void glMatrixMode(mode)
    - GL_MODELVIEW : model transform, viewing transform(camera)
    - GL_PROJECTION : projection transform
- **Current Transformation matrix** (현 변환 행렬)

```
glMatrixMode(GL_PROJECTION);
glLoadIdentity();
glOrtho(-1.0, 1.0, -1.0, 1.0, 1.0, 3.0);
glMatrixMode(GL_MODELVIEW);
glLoadIdentity();
```



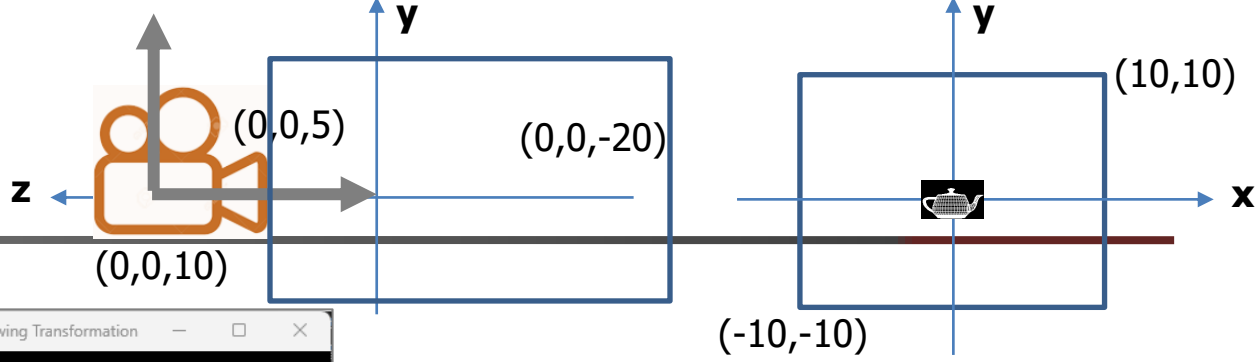
glOrtho()

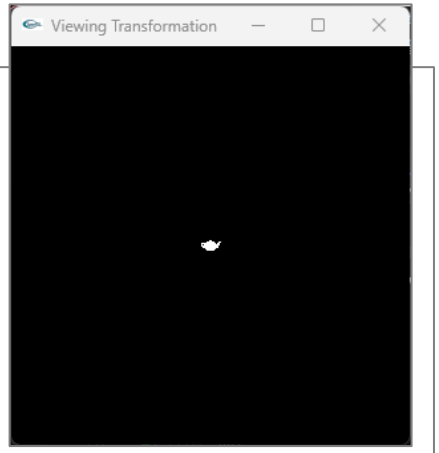



```
#include <iostream>
#include <gl/glut.h>
#include <gl/glu.h>
using namespace std;

void display(void)
{
      glClear(GL_COLOR_BUFFER_BIT |
                  GL_DEPTH_BUFFER_BIT);
      glLoadIdentity();
      gluLookAt(0.0, 0.0, 2.0, // camera pos
                  0.0, 0.0, 1.0,      // lookat point
                  0.0, 1.0, 0.0);     // up vector
      glColor3f(1, 1, 1);
      glutWireTeapot(0.3);
      glFlush();
}
```

```
void reshape(int w, int h)
{
      glMatrixMode(GL_PROJECTION);
      glLoadIdentity();
      glOrtho(-1.0, 1.0, -1.0, 1.0, 1.0, 3.0);
      glMatrixMode(GL_MODELVIEW);
}

int main(int argc, char** argv)
{
      glutInit(&argc, argv);
      glutInitDisplayMode(GLUT_RGBA |
GLUT_DEPTH | GLUT_SINGLE);
      glutCreateWindow("Viewing
                  Transformation");
      glClearColor(0.0, 0.0, 0.0, 0.0);
      glutReshapeFunc(reshape);
      glutDisplayFunc(display);
      glutMainLoop();
      return 0;
}
```

glOrtho()

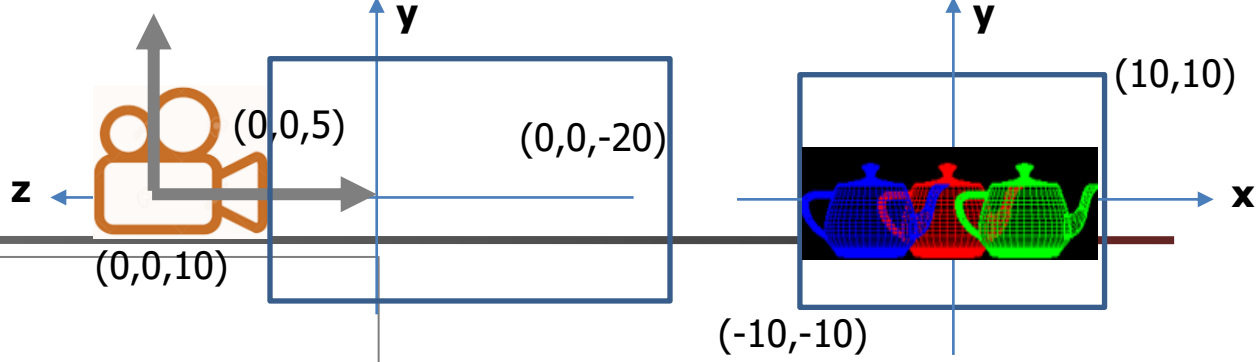




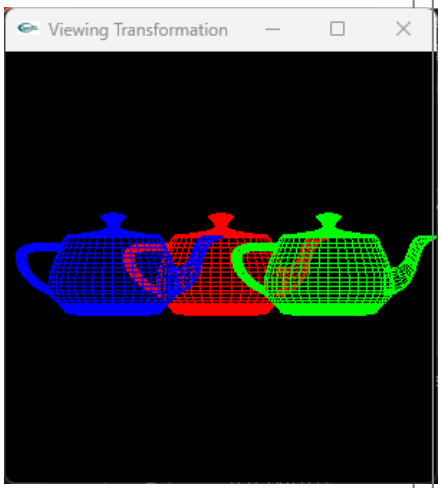

```
#include <iostream>
#include <gl/glut.h>
#include <gl/glu.h>
using namespace std;

void display(void)
{
    glClear(GL_COLOR_BUFFER_BIT |
            GL_DEPTH_BUFFER_BIT);
    glLoadIdentity();
    gluLookAt(0.0, 0.0, 10.0,// camera pos
              0.0, 0.0, 0.0,     // lookat point
              0.0, 1.0, 0.0);    // up vector
    glColor3f(1, 1, 1);
    glutWireTeapot(0.3);
    glFlush();
}
```

```
void reshape(int w, int h)
{
    glMatrixMode(GL_PROJECTION);
    glLoadIdentity();
    glOrtho(-10.0, 10.0, -10.0, 10.0, 5.0, 30.0);
    glMatrixMode(GL_MODELVIEW);
}

int main(int argc, char** argv)
{
    glutInit(&argc, argv);
    glutInitDisplayMode(GLUT_RGBA |
GLUT_DEPTH | GLUT_SINGLE);
    glutCreateWindow("Viewing
                Transformation");
    glClearColor(0.0, 0.0, 0.0, 0.0);
    glutReshapeFunc(reshape);
    glutDisplayFunc(display);
    glutMainLoop();
    return 0;
}
```

glOrtho()



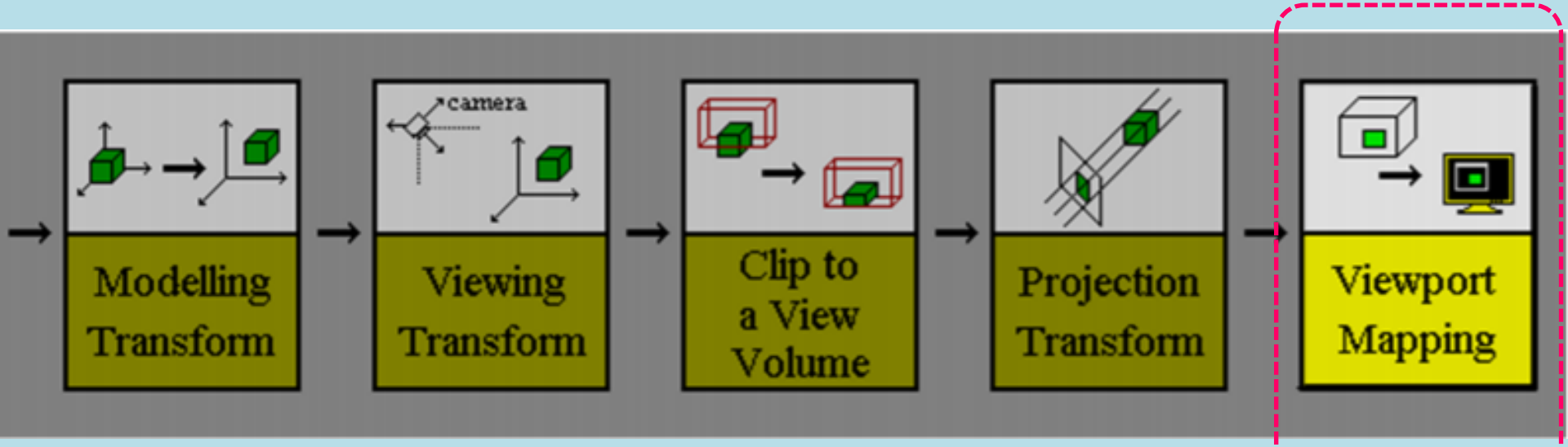

```
#include <iostream>
#include <gl/glut.h>
#include <gl/glu.h>
using namespace std;

void display(void)
{
	glClear(GL_COLOR_BUFFER_BIT |
		GL_DEPTH_BUFFER_BIT);
	glLoadIdentity();
	gluLookAt(0.0, 0.0, 10.0, 0.0, 0.0, 0.0, 0.0,
1.0, 0.0);
	glColor3f(1, 0, 0);
	glutWireTeapot(3);
	glColor3f(0, 1, 0);
	glTranslatef(5,0,-5);
	glutWireTeapot(3);
	glColor3f(0, 0, 1);
	glTranslatef(-10,0,-5);
	glutWireTeapot(3);
	glFlush();
}
```




```
void reshape(int w, int h)
{
	glMatrixMode(GL_PROJECTION);
	glLoadIdentity();
	glOrtho(-10.0, 10.0, -10.0, 10.0, 5.0, 30.0);
	glMatrixMode(GL_MODELVIEW);
}

int main(int argc, char** argv)
{
	glutInit(&argc, argv);
	glutInitDisplayMode(GLUT_RGBA |
GLUT_DEPTH | GLUT_SINGLE);
	glutCreateWindow("Viewing
			Transformation");
	glClearColor(0.0, 0.0, 0.0, 0.0);
	glutReshapeFunc(reshape);
	glutDisplayFunc(display);
	glutMainLoop();
	return 0;
}
```

Viewing Transformation

- 3차원 모델을 2차원 모니터에 디스플레이 하는 과정



3D 모델을
3차원 세계에 배치

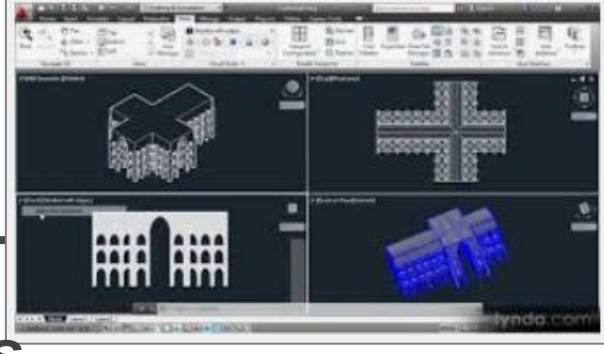
카메라 배치
카메라 기준

카메라
View volume

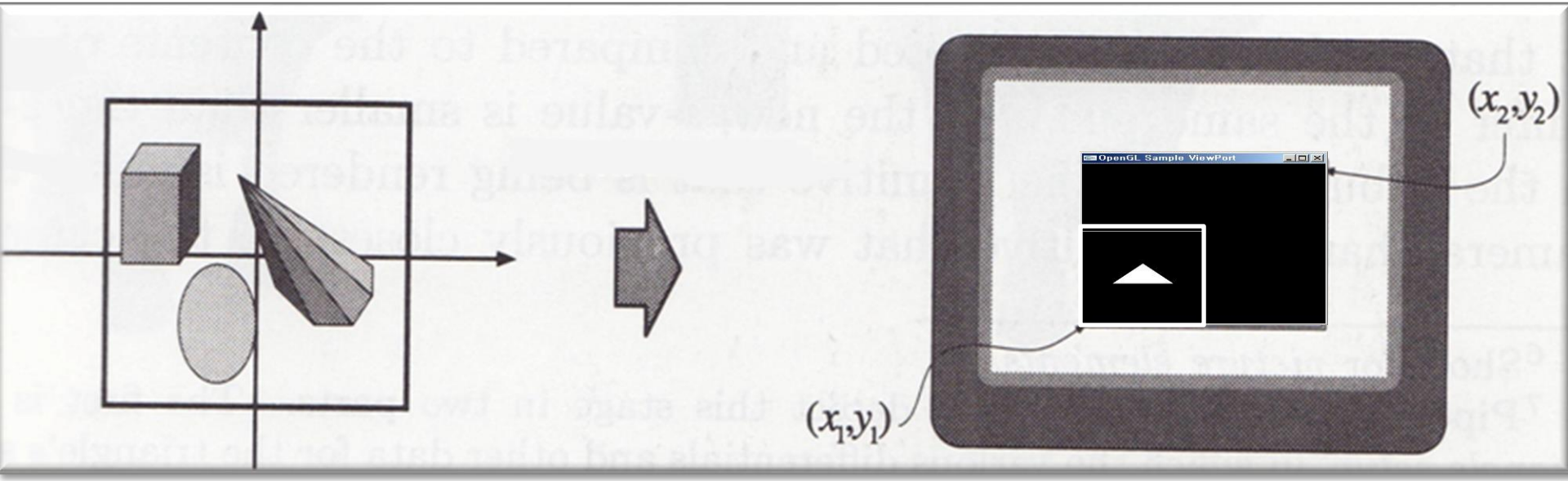
3차원 물체를
→ 2차원 면에 투영

윈도우 내부
일부분에 매핑

Viewport Transformation

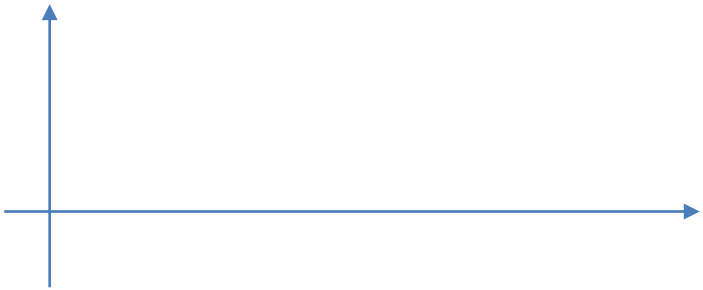


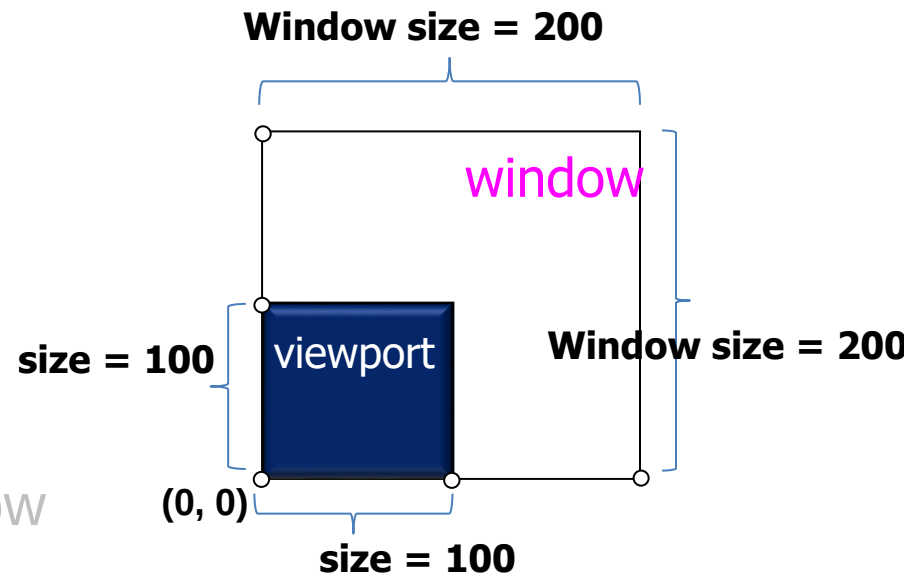
- **Translates the viewing coordinates**
  - into the device coordinates
- **View volume vs. viewport**
  - Where we want to see vs. where we want to display



Viewport Transformation

- void **glViewport**(GLint x, GLint y, GLsizei width, GLsizei height)
  - left-low corner coordinate (x, y)
  - viewport **size** (width, height)





- **Example**

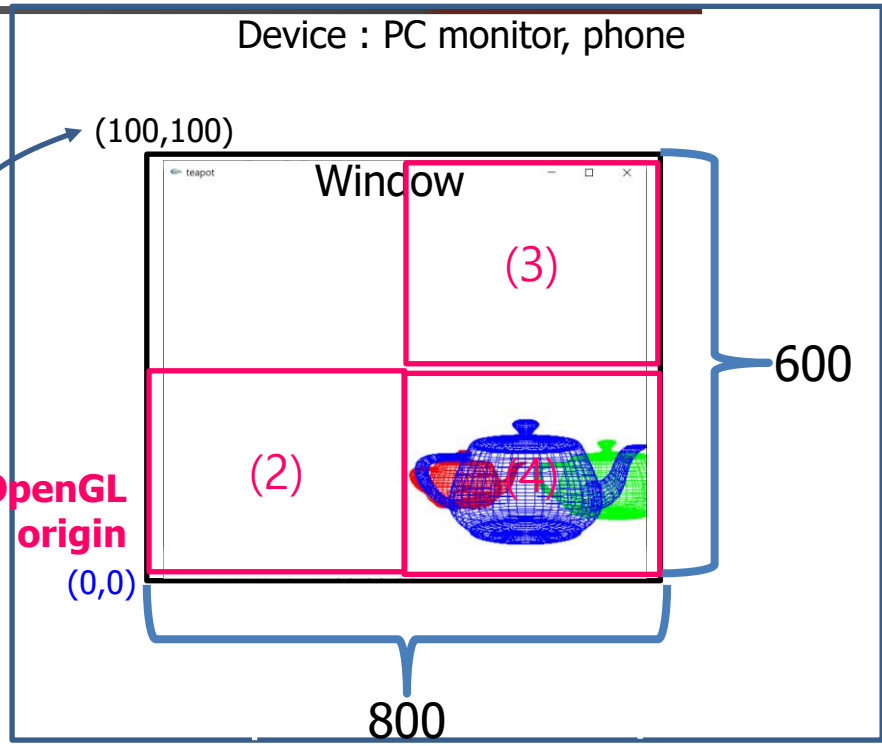
```
// initialize the size of a window
glutInitWindowSize(200, 200);
// sets the position and size of a viewport
glViewport(0, 0, 100, 100);  // 기준: left lower corner
```

glViewport()

glViewport(GLint x, GLint y, GLsizei width, GLsizei height)

- 위치 : reshape()

```
#define WIDTH 800
#define HEIGHT 600

void init()
{
        glutInitWindowPosition(100, 100);
        glutInitWindowSize(WIDTH, HEIGHT);
}
```

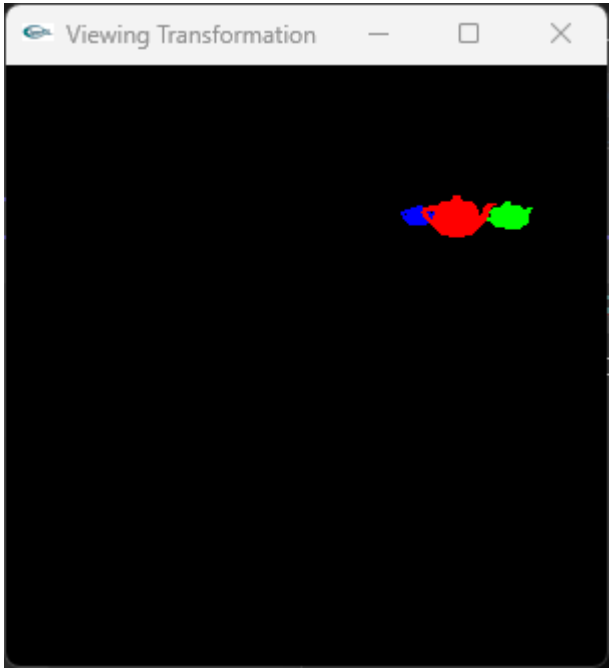



```
void reshape(int w, int h)
{
        (1) glViewport(0, 0, w, h);
        (2) glViewport(0, 0, w/2, h/2);
        (3) glViewport(w/2, h/2, w/2, h/2);
        (4) glViewport(w/2, 0, w/2, h/2);
}
```

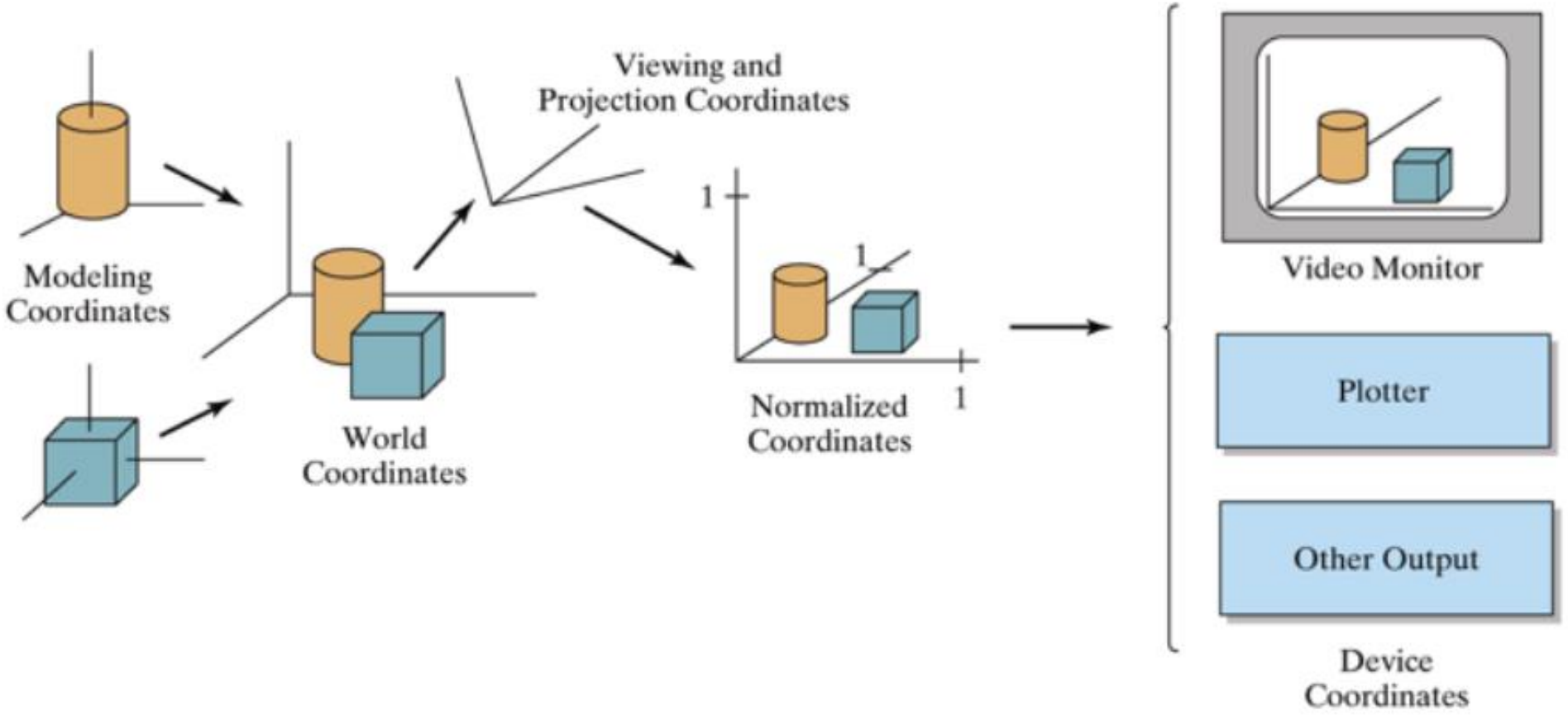
glViewport()

- 위치 : reshape()

```
void reshape(int w, int h)  // window width, height 파라메터 전달
{
    glViewport(w/2, h/2, w/2, h/2);
    glMatrixMode(GL_PROJECTION);
    glLoadIdentity();
    glFrustum(-10.0, 10.0, -10.0, 10.0, 5.0, 30.0);
    glMatrixMode(GL_MODELVIEW);
}
```



summary: Viewing Pipeline



Viewing Transformation

Thank you !

glOrtho
glFrustum
gluPerspective