

# Assignment 3: OpenGL & Phong Shading

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## 1 代码

### 1.1 主函数增加glCanvas调用

```
//previsualize this scene with OpenGL
raytracer = new Raytracer(input_file, width, height, depth_min, depth_max);
if (previsualize)
{
    //glewInit();
    //glutInit(&argc, argv);
    GLCanvas glCanvas;
    glCanvas.initialize(raytracer->getScene(), shade);
}
else
{
    shade();
}
```

### 1.2 增加Camera类函数以操纵OpenGL相机

```
void glPlaceCamera(void)
{
    gluLookAt(center.x(), center.y(), center.z(), center.x() +
direction.x(), center.y() + direction.y(), center.z() + direction.z(), up.x(),
up.y(), up.z());
}
void truckCamera(float dx, float dy)
{
    center += horizontal * dx + up * dy;
}

void rotateCamera(float rx, float ry)
{
    float tiltAngle = acos(up.Dot3(direction));
    if (tiltAngle - ry > 3.13)
        ry = tiltAngle - 3.13;
    else if (tiltAngle - ry < 0.01)
        ry = tiltAngle - 0.01;
    Matrix rotMat = Matrix::MakeAxisRotation(up, rx);
    rotMat *= Matrix::MakeAxisRotation(horizontal, ry);
    rotMat.Transform(center);
    rotMat.TransformDirection(direction);
}
```

```

        this->direction.Normalize();
        this->up = this->up - this->direction * this->up.Dot3(this->direction);
        this->up.Normalize();
        Vec3f::Cross3(this->horizontal, this->direction, this->up);
        this->horizontal.Normalize();
    }

```

## 1.3 Phongmaterial

```

class PhongMaterial : public Material {
public:
    PhongMaterial(const Vec3f& diffuseColor, const Vec3f& specularColor, float
exponent) :Material(diffuseColor), specularColor(specularColor),
exponent(exponent)
    {}
    virtual Vec3f Shade(const Ray& ray, const Hit& hit, const Vec3f& dirToLight,
const Vec3f& lightColor) const
    {
        Vec3f normal = hit.getNormal();
        Vec3f dirToView = ray.getDirection();
        dirToView.Negate();
        Vec3f h = dirToView + dirToLight;
        h.Normalize();
        float cosBeta = normal.Dot3(h);
        if (normal.Dot3(dirToLight) < 0)
        {
            cosBeta = 0;
        }
        //ignore r^2 and ks
        Vec3f specularComponent=powf(cosBeta, exponent)*
lightColor*specularColor;
        float cosTheta = normal.Dot3(dirToLight);
        if (cosTheta < 0)
        {
            cosTheta = 0;
        }
        Vec3f diffuseComponent = cosTheta * lightColor * diffuseColor;
        //no ambientComponent
        return specularComponent + diffuseComponent;
    }
}

```

## 1.4 对Object3D子类增加Paint函数

### Sphere

将球面绘制为大量三角形面

```

void paint(void)
{
    extern int thetaSteps;

```

```

extern int phiSteps;
extern bool gouraudShading;

float thetaStepLength=(float)2*M_PI/thetaSteps;
float phiStepLength=(float)M_PI/phiSteps;

getMaterial()->glSetMaterial();
glBegin(GL_QUADS);
for (float iPhi = 0; iPhi < M_PI; iPhi += phiStepLength)
{
    for (float iTheta = 0; iTheta < 2*M_PI; iTheta += thetaStepLength)
    {
        Vec3f points[4];
        points[0].Set(radius * sinf(iPhi) * cosf(iTheta), radius *
sinf(iPhi) * sinf(iTheta), radius * cosf(iPhi));
        points[1].Set(radius * sinf(iPhi) * cosf(iTheta +
thetaStepLength), radius * sinf(iPhi) * sinf(iTheta + thetaStepLength), radius *
cosf(iPhi));
        points[2].Set(radius * sinf(iPhi + phiStepLength) * cosf(iTheta
+ thetaStepLength), radius * sinf(iPhi + phiStepLength) * sinf(iTheta +
thetaStepLength), radius * cosf(iPhi + phiStepLength));
        points[3].Set(radius * sinf(iPhi + phiStepLength) *
cosf(iTheta), radius * sinf(iPhi + phiStepLength) * sinf(iTheta), radius *
cosf(iPhi + phiStepLength));

        //Gouraud interpolation
        if (gouraudShading)
        {
            Vec3f normali;
            for (int i = 0; i < 4; i++)
            {
                normali = points[i];
                normali.Normalize();
                glNormal3f(normali.x(), normali.y(), normali.z());
                points[i] += center;
                glVertex3f(points[i].x(), points[i].y(), points[i].z());
            }
        }
        //flat shading
        else
        {
            Vec3f line1;
            Vec3f line2;
            if (iPhi < M_PI / 2)
            {
                line1 = points[2] - points[1];
                line2 = points[3] - points[2];
            }
            else
            {
                line1 = points[1] - points[0];
                line2 = points[2] - points[1];
            }

            Vec3f flatNormal;
            Vec3f::Cross3(flatNormal, line2, line1);
            flatNormal.Normalize();

```

```

        glNormal3f(flatNormal.x(), flatNormal.y(), flatNormal.z());
        for (int i = 0; i < 4; i++)
        {
            points[i] += center;
            glVertex3f(points[i].x(), points[i].y(), points[i].z());
        }

    }

}
glEnd();
}

```

## Triangle

```

virtual void paint(void)
{
    getMaterial()->glSetMaterial();
    glBegin(GL_TRIANGLES);
    glNormal3f(normal.x(), normal.y(), normal.z());
    glVertex3f(a.x(), a.y(), a.z());
    glVertex3f(b.x(), b.y(), b.z());
    glVertex3f(c.x(), c.y(), c.z());
    glEnd();
}

```

## Plane

```

void paint(void)
{
    //origin projection on the plane
    //true whether d is positive or negative
    Vec3f o=normal*d;

    Vec3f v;
    //parellel
    if (normal.Dot3(Vec3f(1, 0, 0))<1)
    {
        v.Set(1, 0, 0);
    }
    else
    {
        v.Set(0, 1, 0);
    }

    Vec3f basis1;
    Vec3f::Cross3(basis1, v, normal);
    basis1.Normalize();
    Vec3f basis2;
    Vec3f::Cross3(basis2, normal, basis1);
}

```

```

        basis2.Normalize();

        vec3f points[4];
        points[0] = o + basis1 * LENGTH;
        points[1] = o + basis2 * LENGTH;
        points[2] = o - basis1 * LENGTH;
        points[3] = o - basis2 * LENGTH;

        getMaterial()->glSetMaterial();
        glBegin(GL_QUADS);
        glNormal3f(normal.x(), normal.y(), normal.z());
        glVertex3f(points[0].x(), points[0].y(), points[0].z());
        glVertex3f(points[1].x(), points[1].y(), points[1].z());
        glVertex3f(points[2].x(), points[2].y(), points[2].z());
        glVertex3f(points[3].x(), points[3].y(), points[3].z());
        glEnd();
    }

```

## Transform

```

virtual void paint(void)
{
    glPushMatrix();
    GLfloat* glMatrix = transform.glGet();
    glMultMatrixf(glMatrix);
    delete[] glMatrix;
    object->paint();
    glPopMatrix();
}

```

## Group

```

virtual void paint(void)
{
    for (auto it = objects.begin(); it != objects.end(); it++)
    {
        (*it)->paint();
    }
}

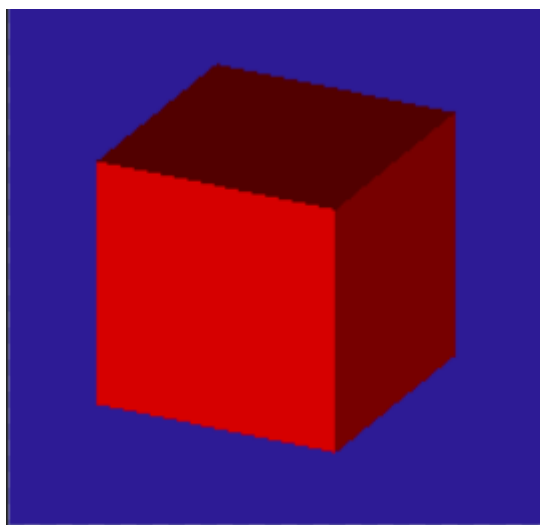
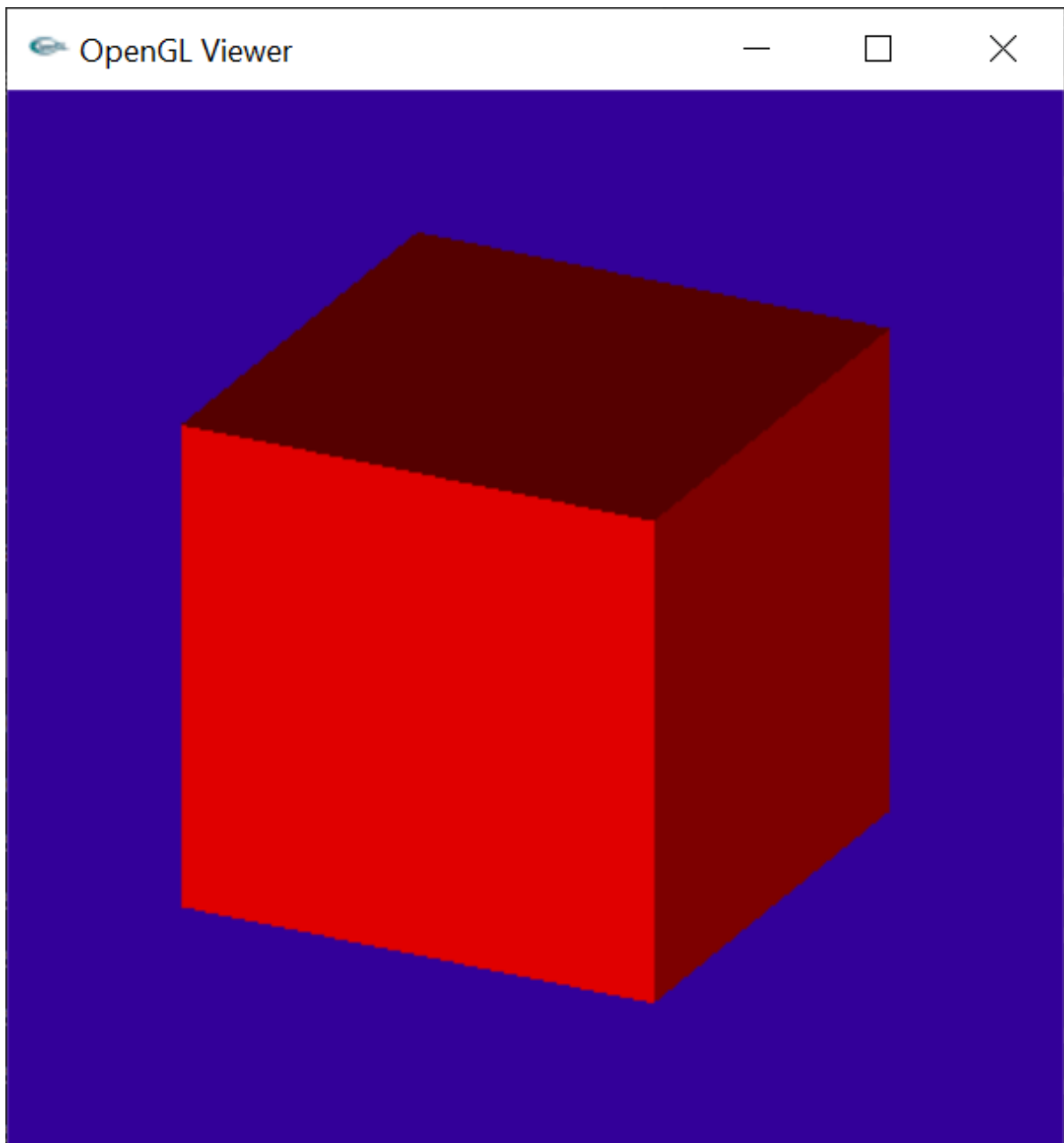
```

## 2 实验结果

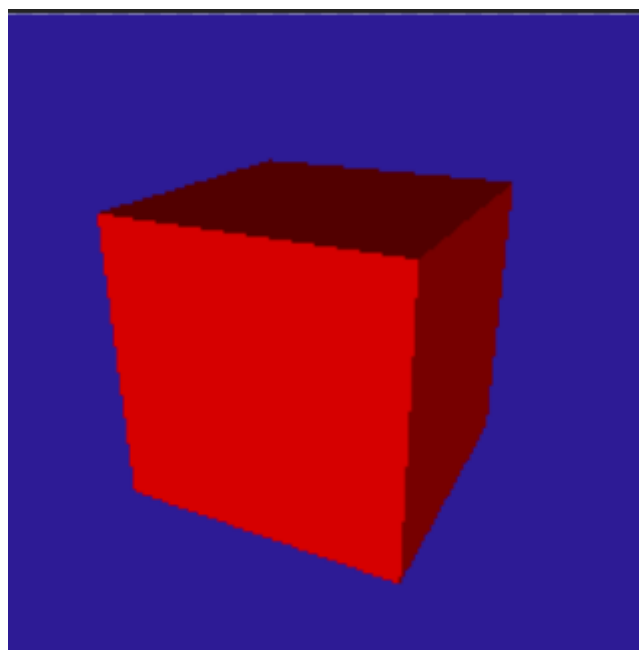
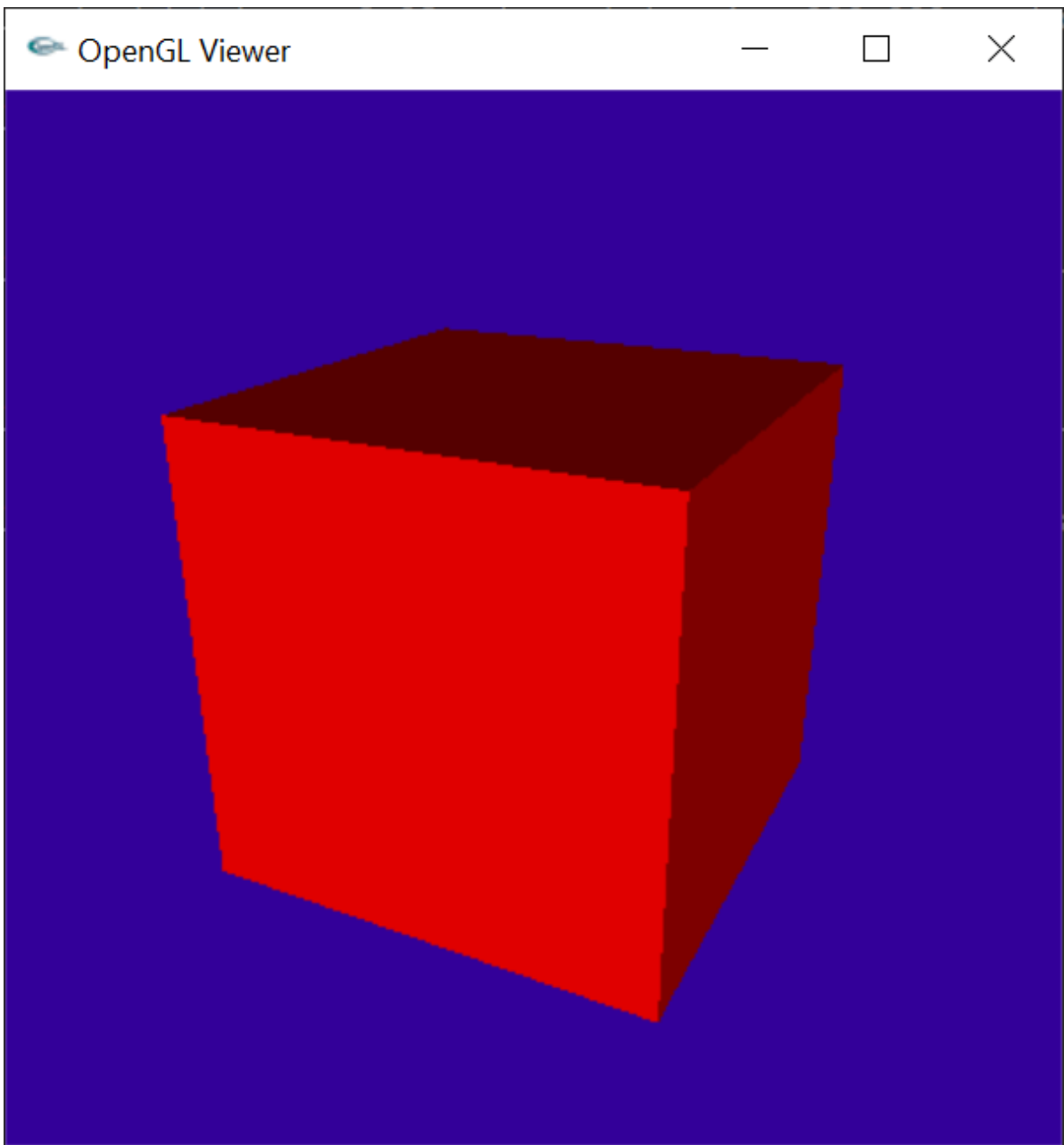
```

raytracer -input scene3_01_cube_orthographic.txt -size 200 200 -output
output3_01.tga -gui

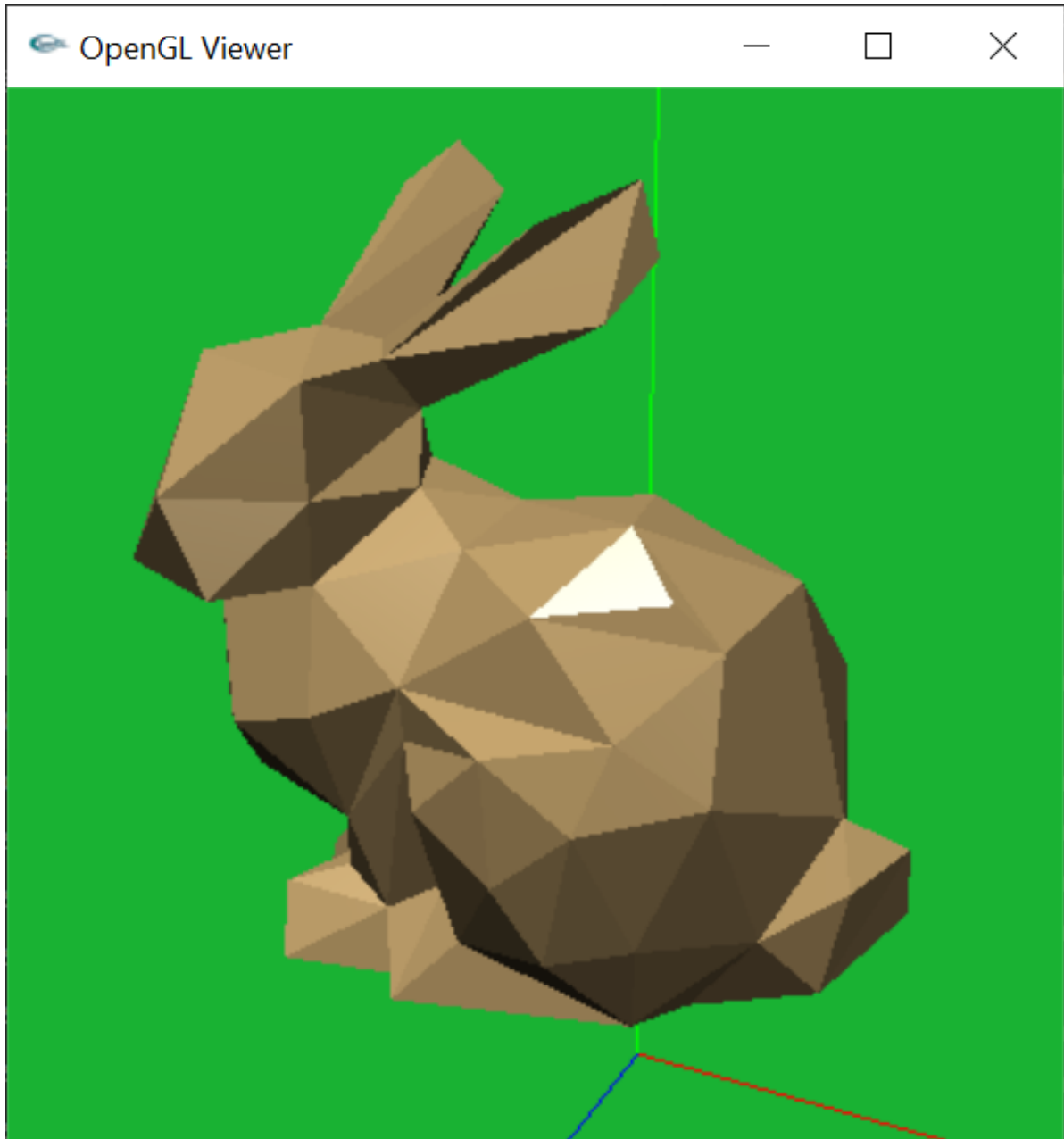
```



```
raytracer -input scene3_02_cube_perspective.txt -size 200 200 -output  
output3_02.tga -gui
```

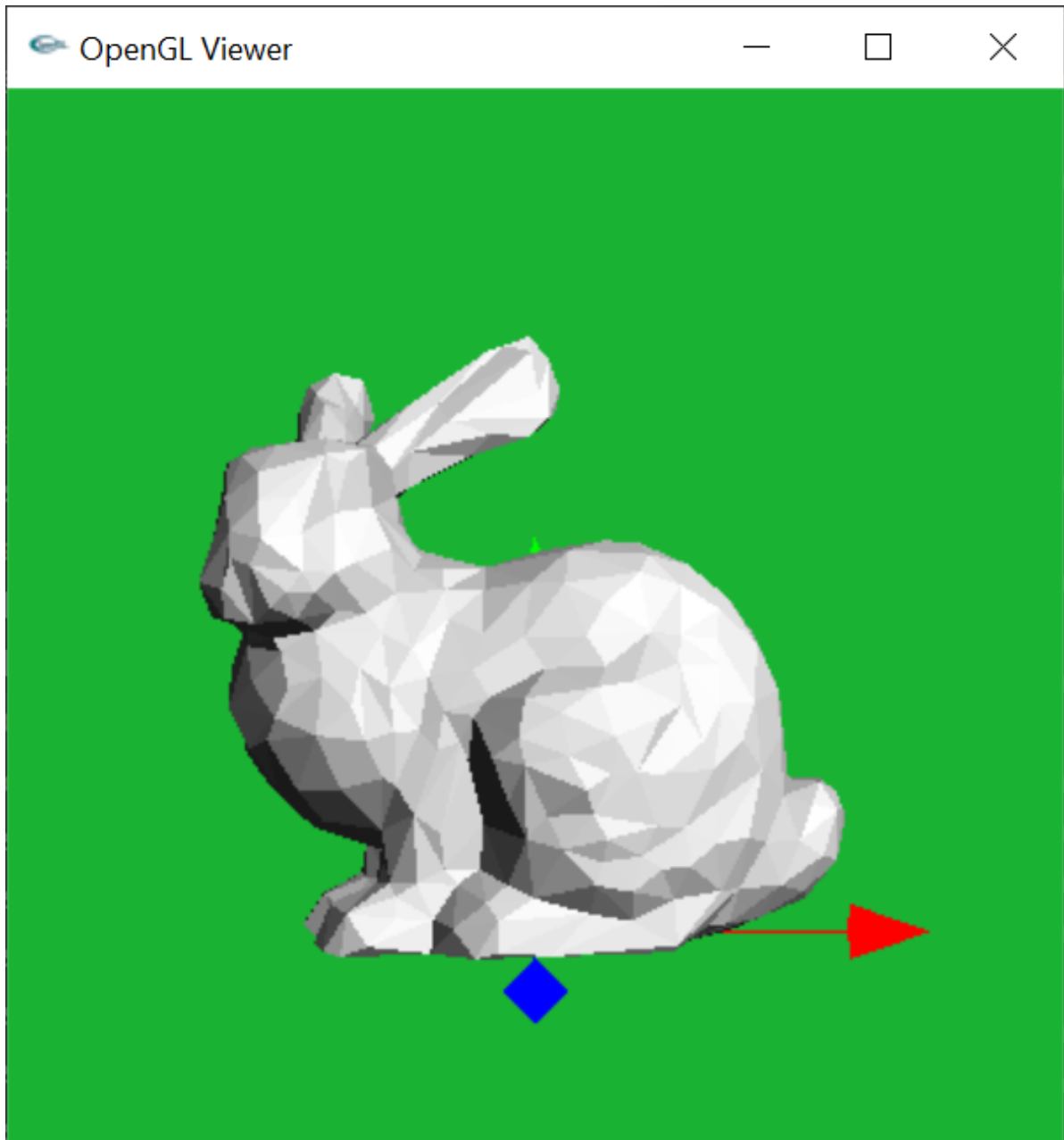


```
raytracer -input scene3_03_bunny_mesh_200.txt -size 200 200 -output  
output3_03.tga -gui
```



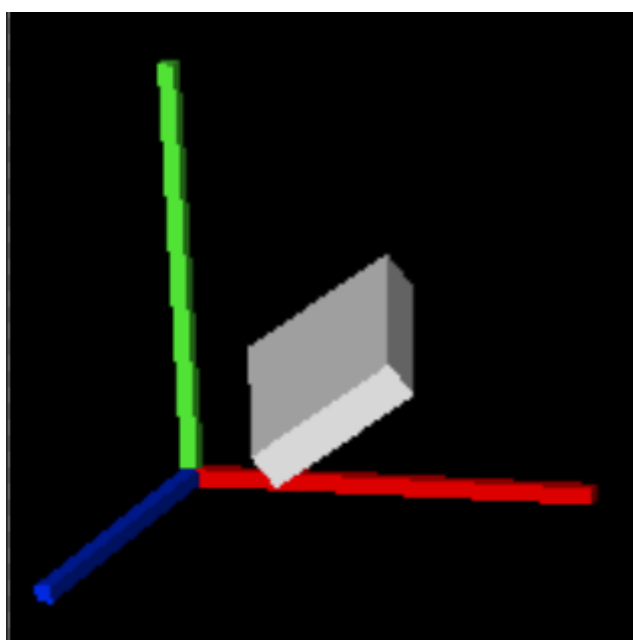
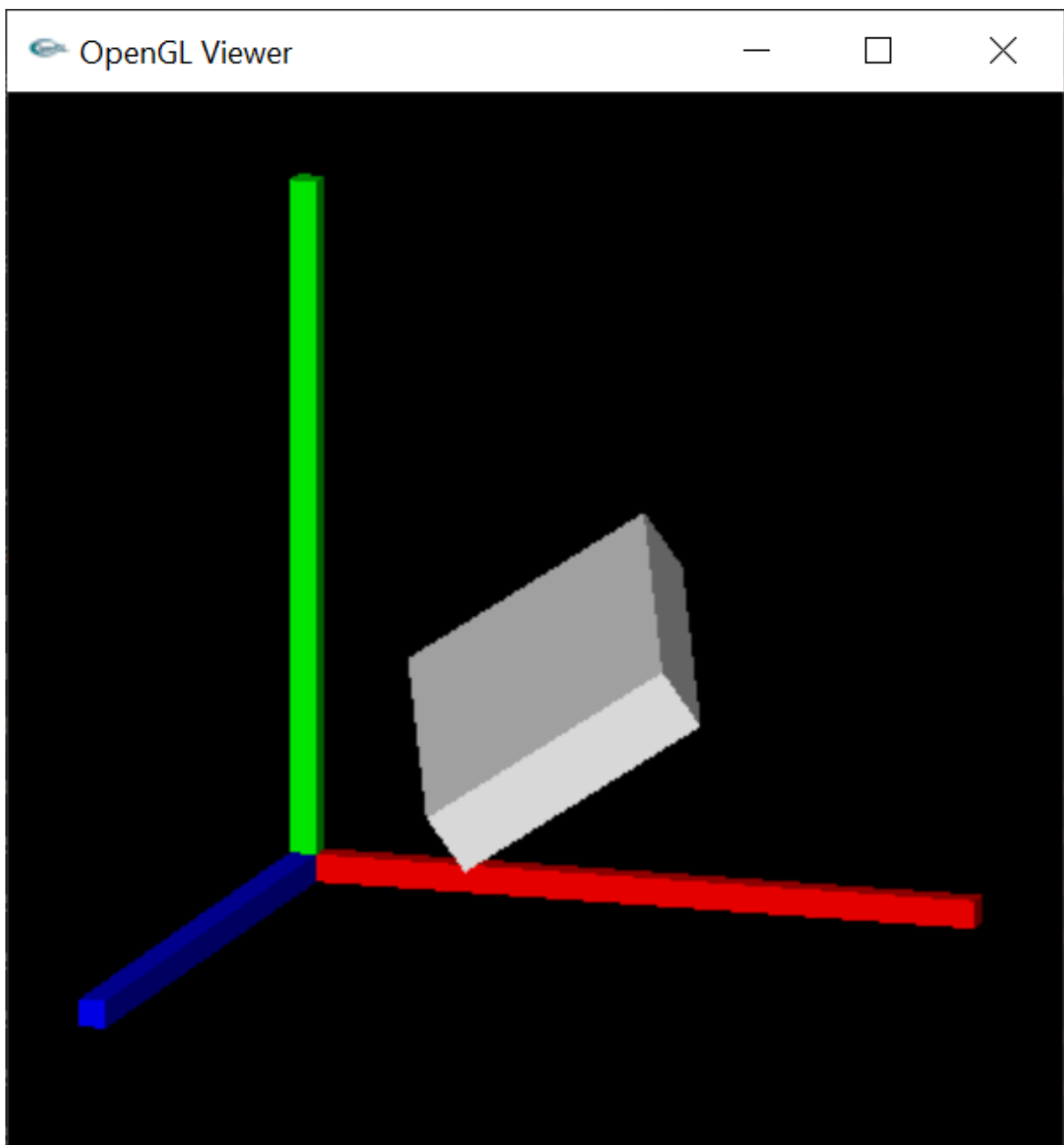


```
raytracer -input scene3_04_bunny_mesh_1k.txt -size 200 200 -output  
output3_04.tga -gui
```

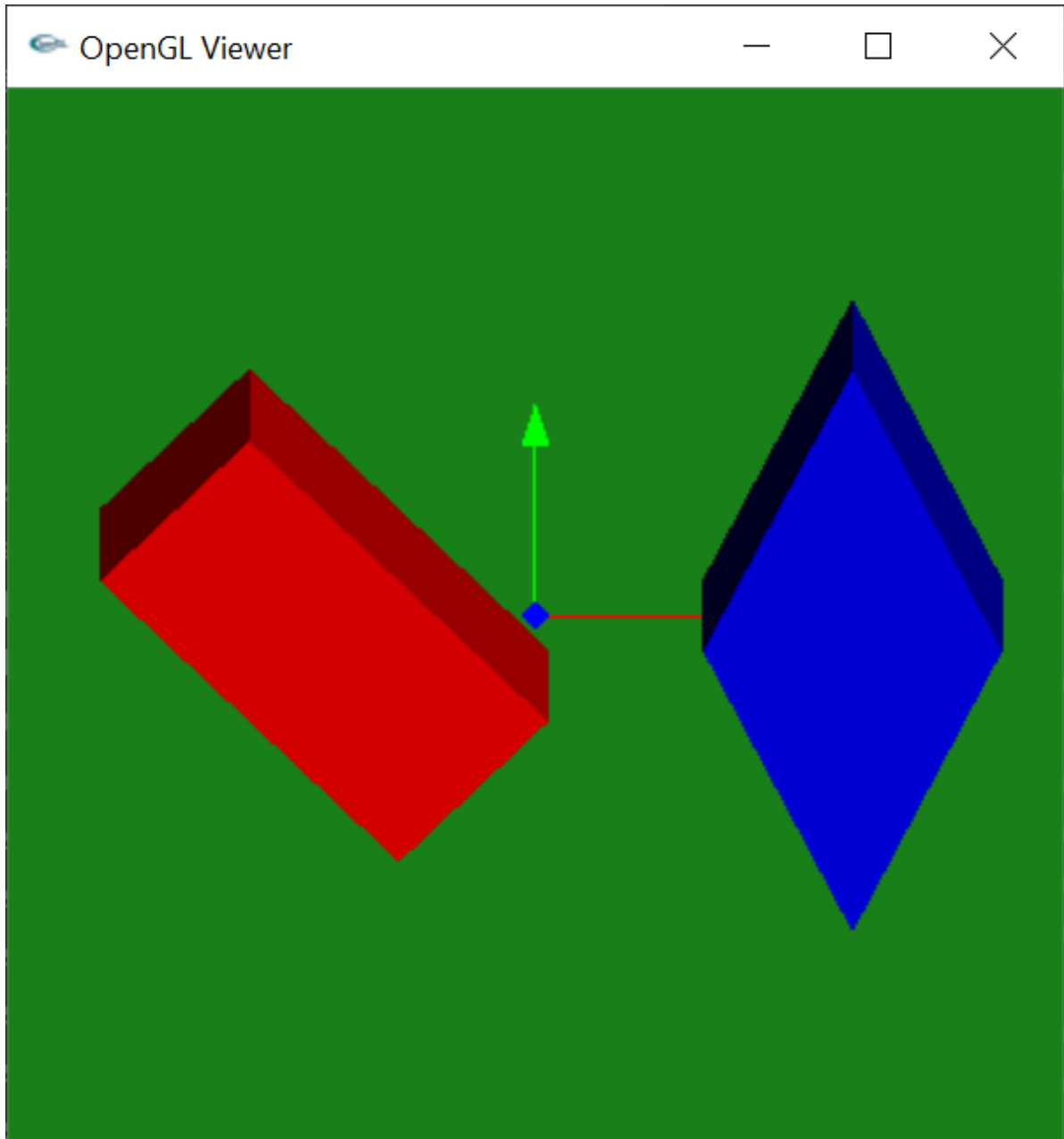


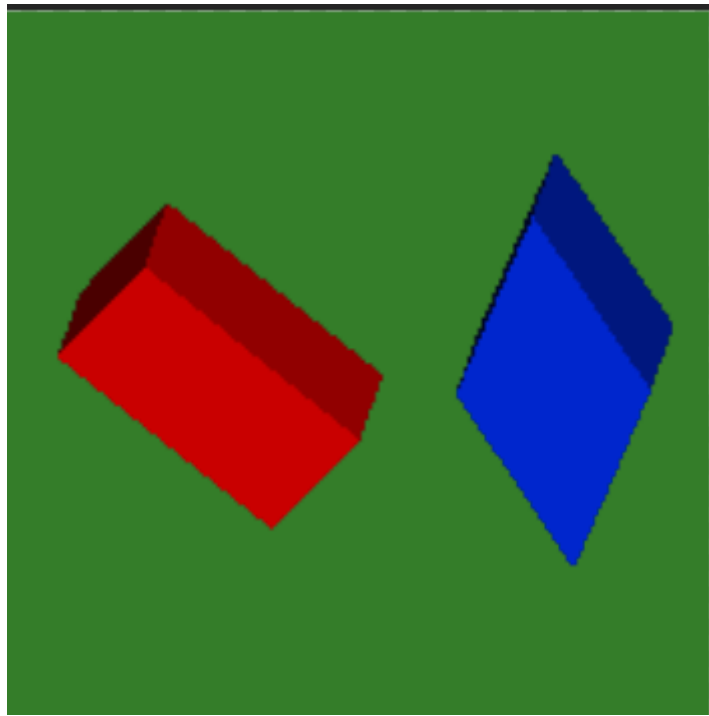


```
raytracer -input scene3_05_axes_cube.txt -size 200 200 -output output3_05.tga -  
gui
```

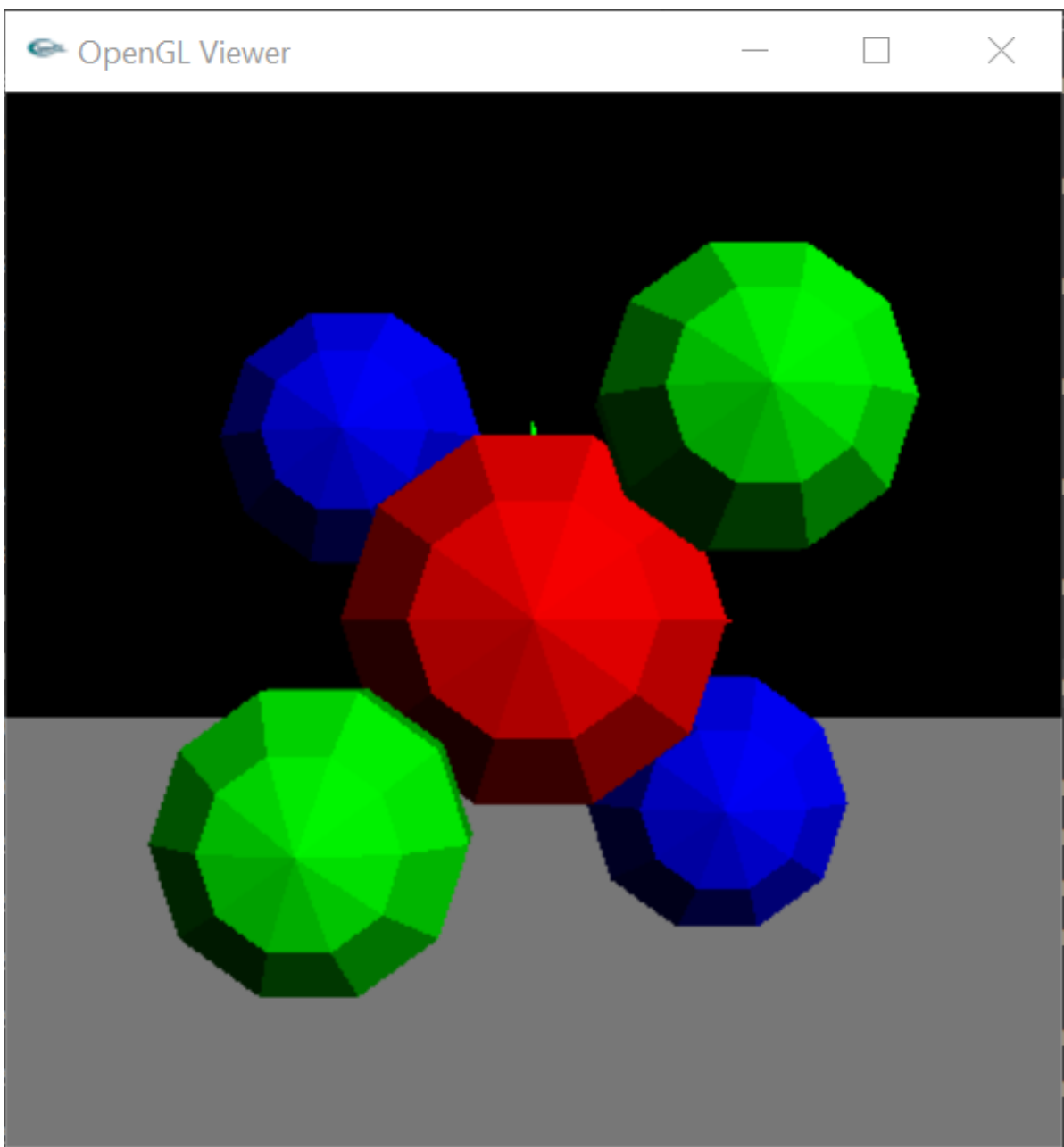


```
raytracer -input scene3_06_crazy_transforms.txt -size 200 200 -output  
output3_06.tga -gui
```



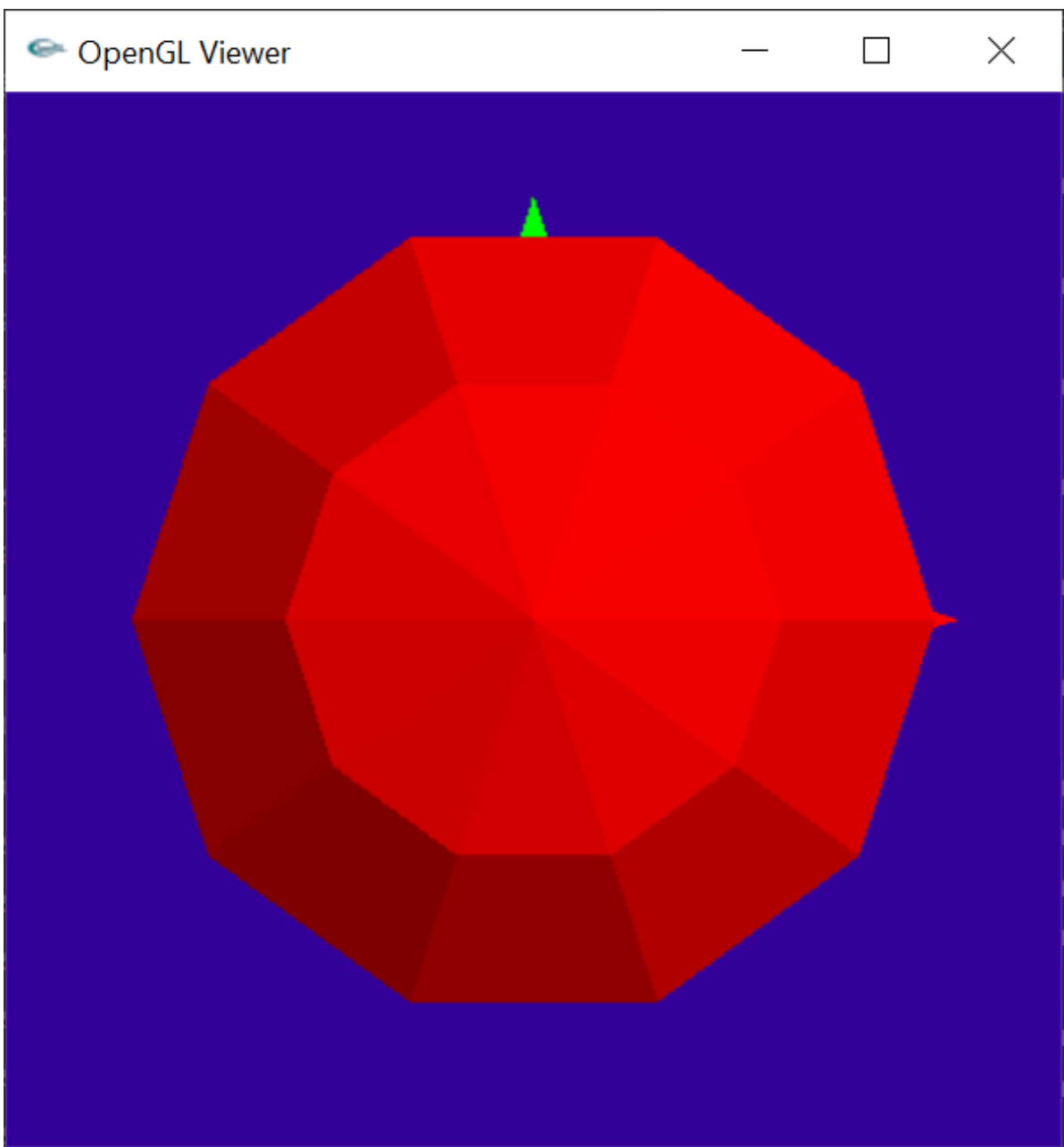


```
raytracer -input scene3_07_plane.txt -size 200 200 -output output3_07.tga -gui -  
tessellation 10 5
```

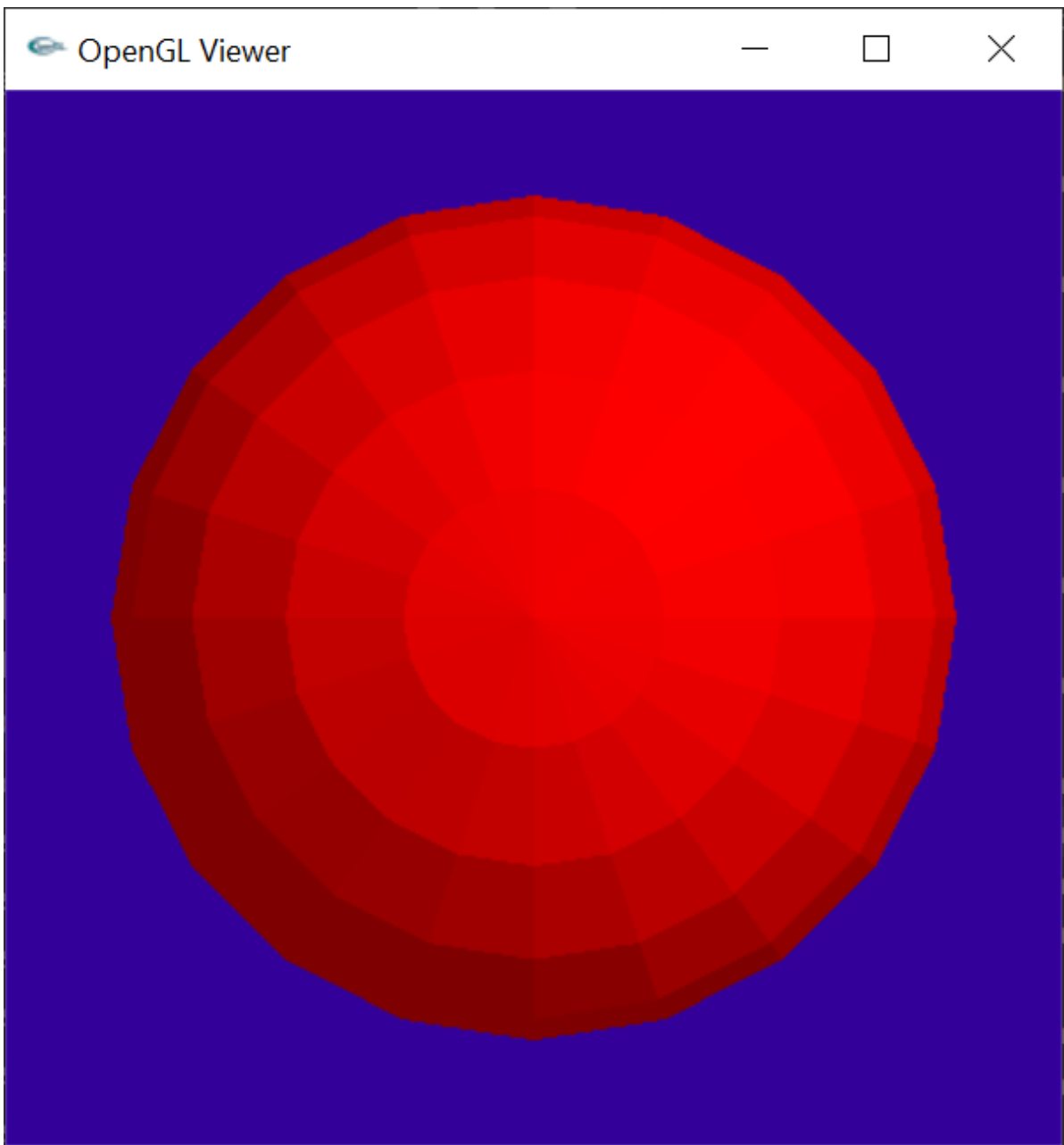


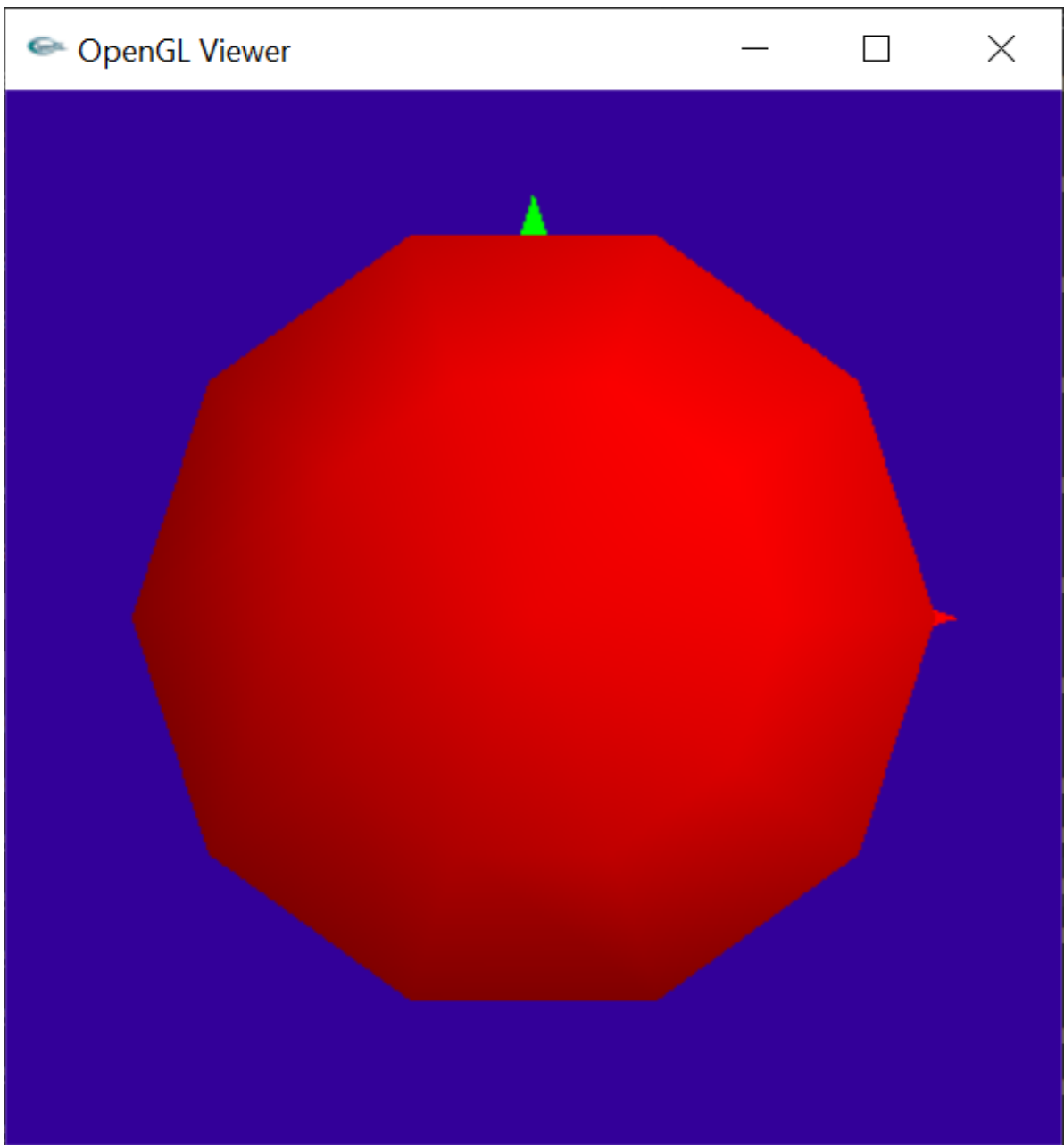


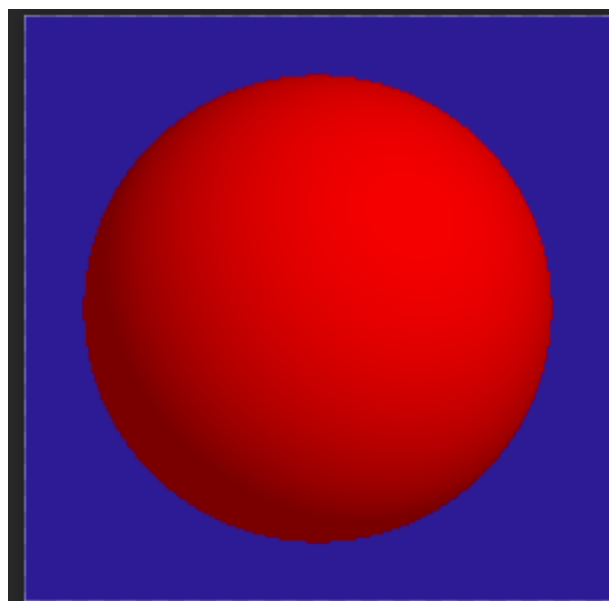
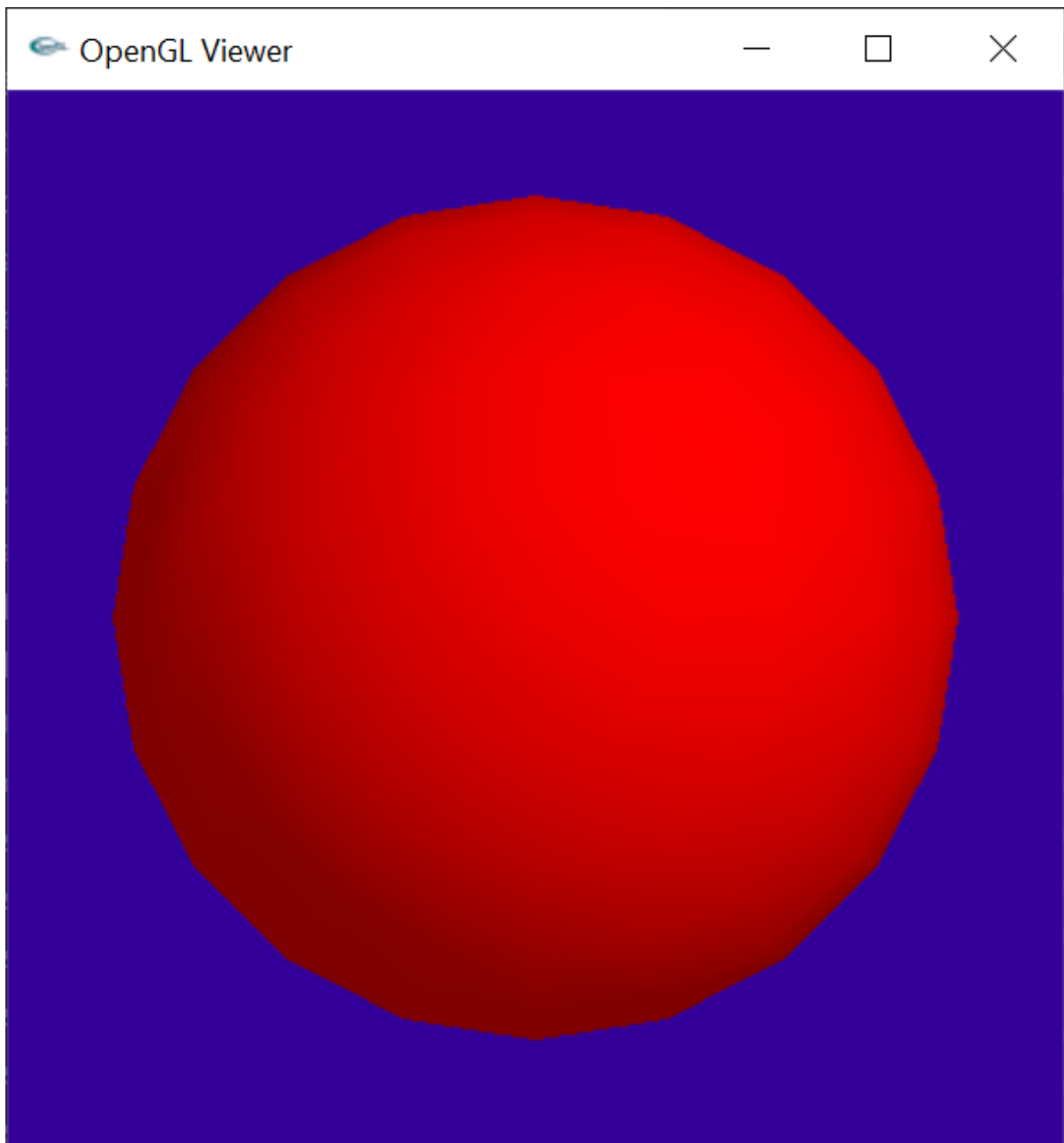
```
raytracer -input scene3_08_sphere.txt -size 200 200 -output output3_08.tga -gui  
-tessellation 10 5  
raytracer -input scene3_08_sphere.txt -size 200 200 -output output3_08.tga -gui  
-tessellation 20 10  
raytracer -input scene3_08_sphere.txt -size 200 200 -output output3_08.tga -gui  
-tessellation 10 5 -gouraud  
raytracer -input scene3_08_sphere.txt -size 200 200 -output output3_08.tga -gui  
-tessellation 20 10 -gouraud
```



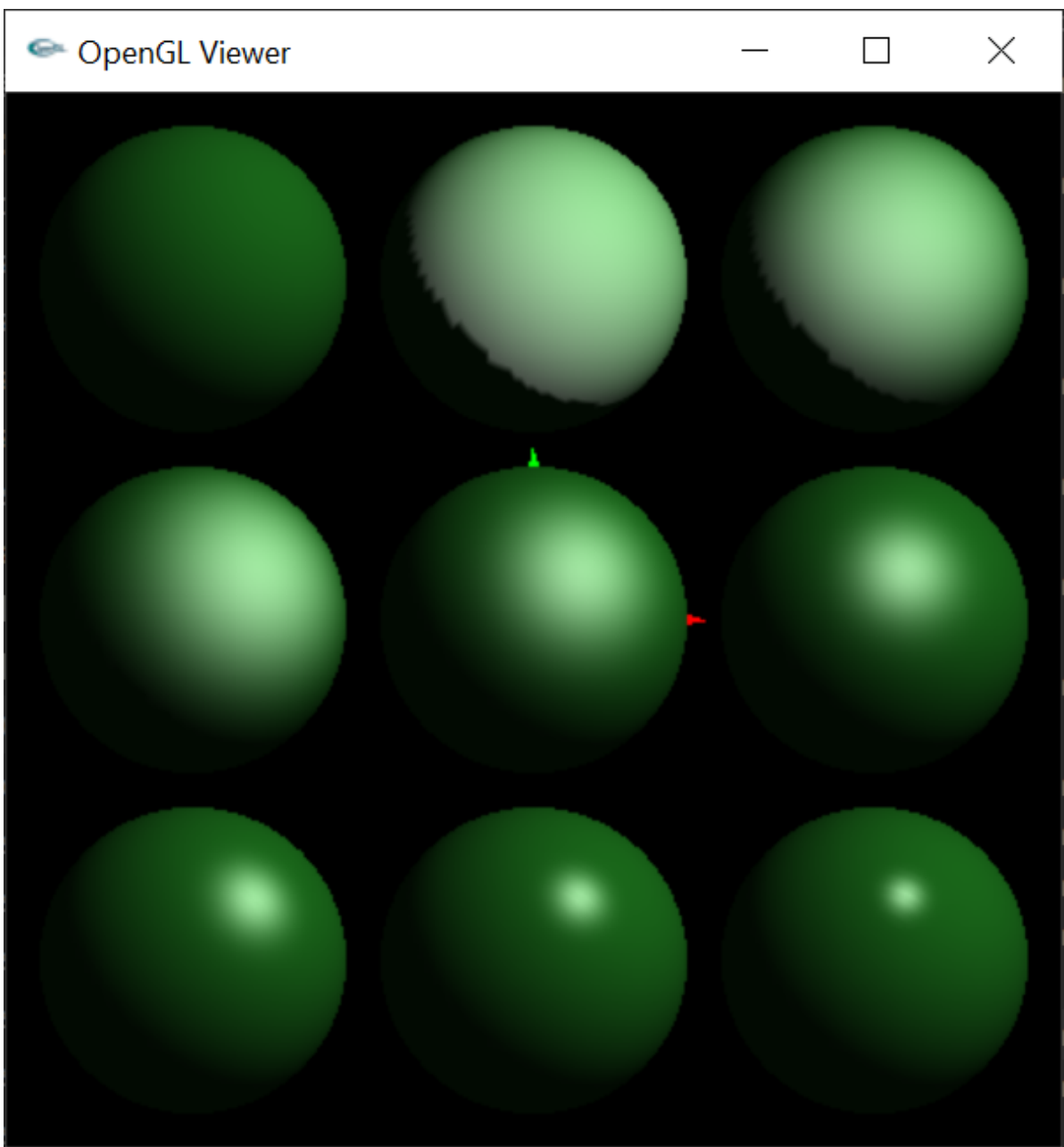


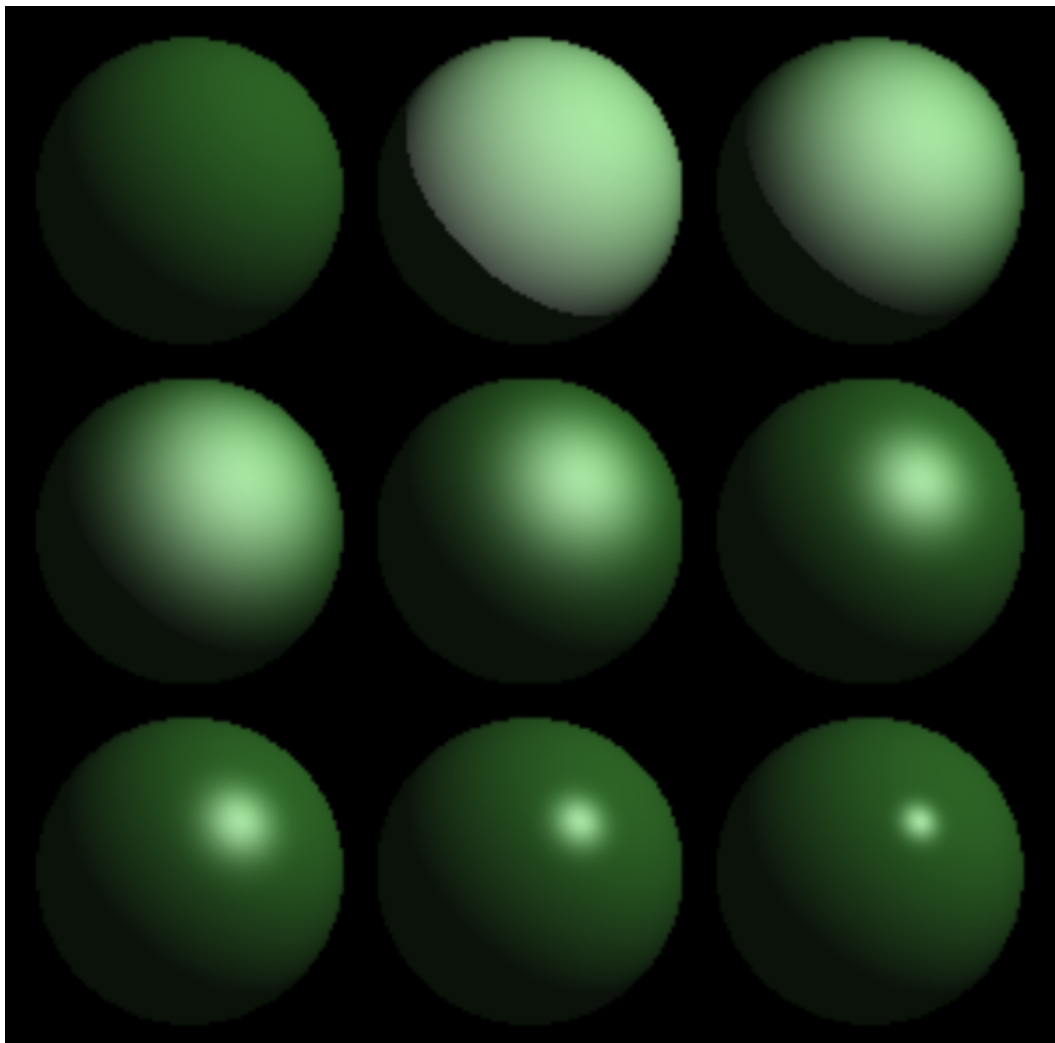




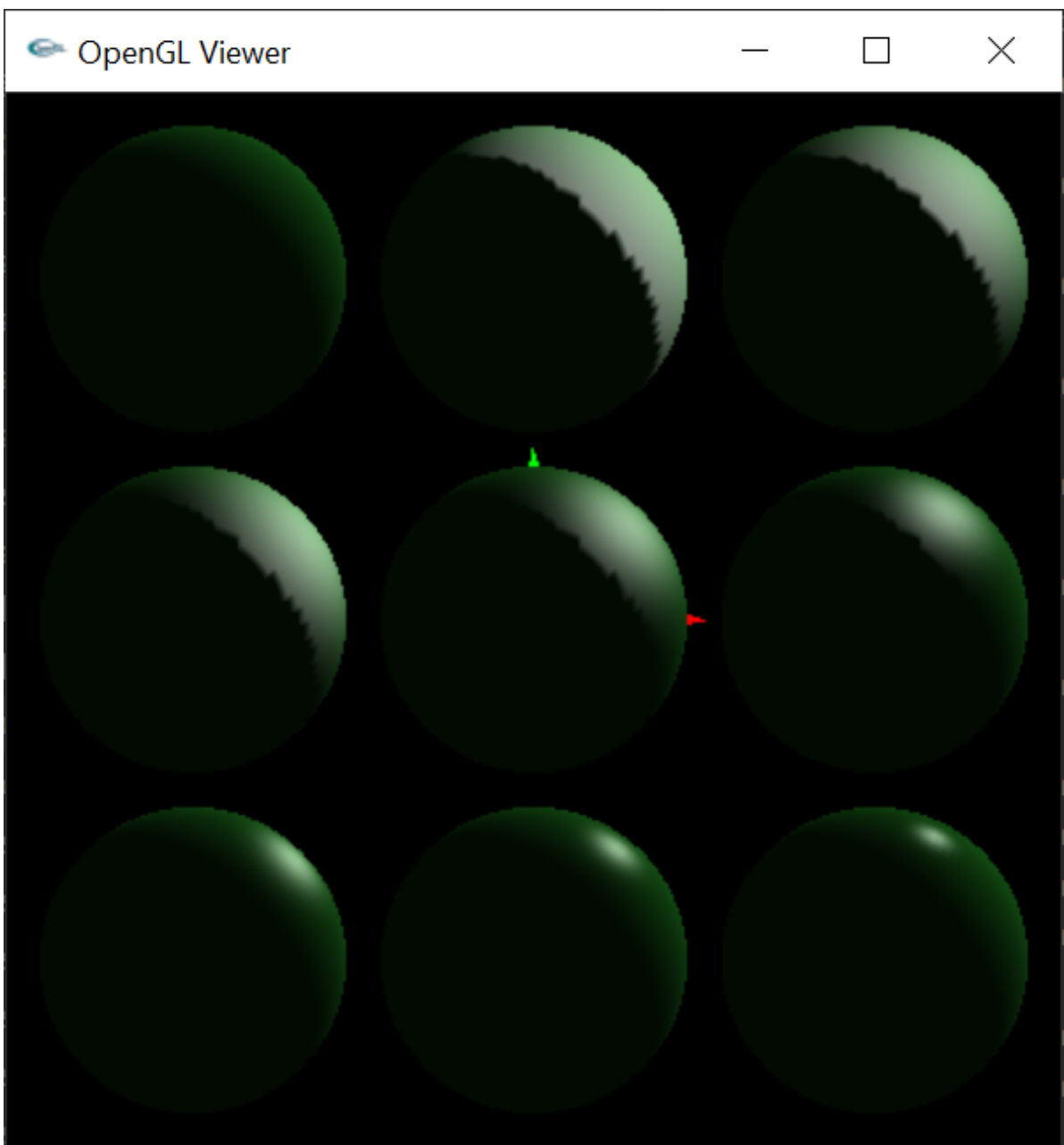


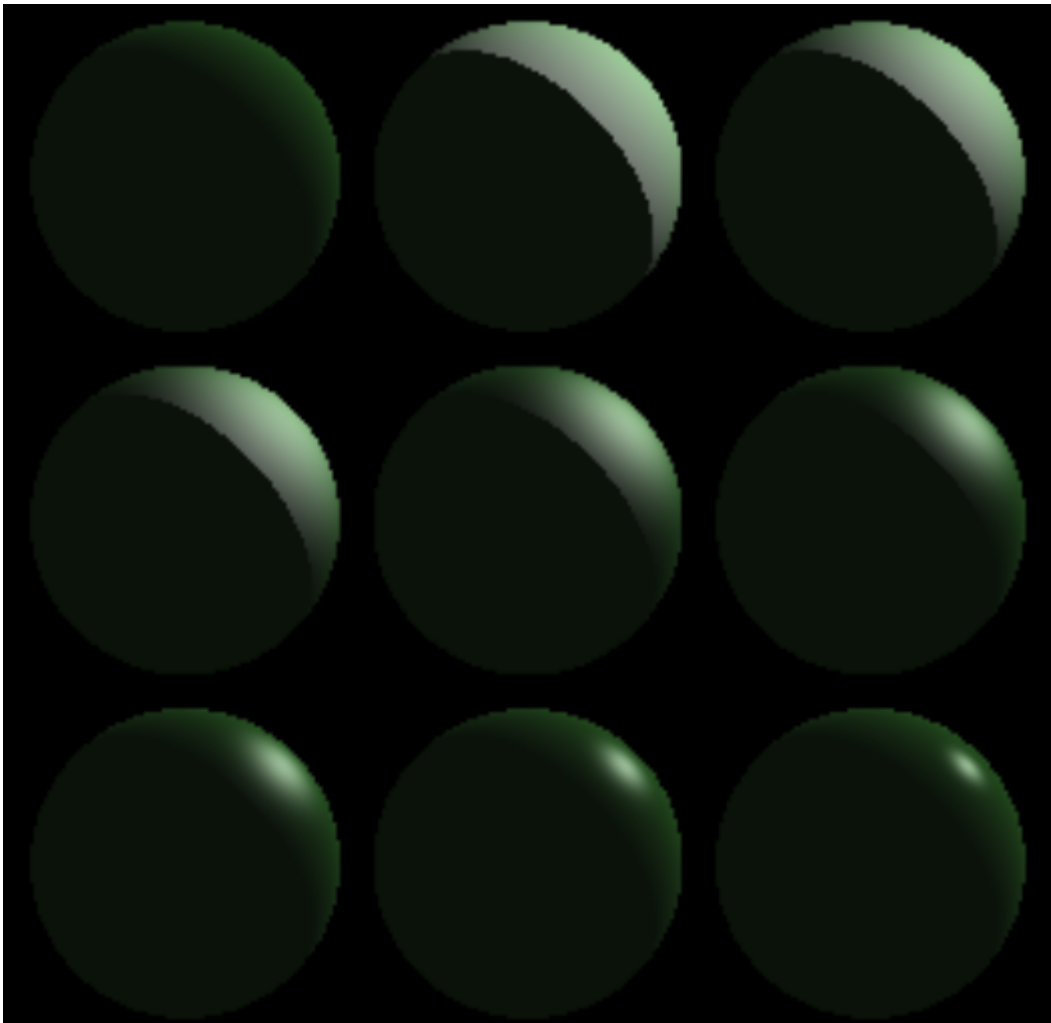
```
raytracer -input scene3_09_exponent_variations.txt -size 300 300 -output  
output3_09.tga -gui -tessellation 100 50 -gouraud
```



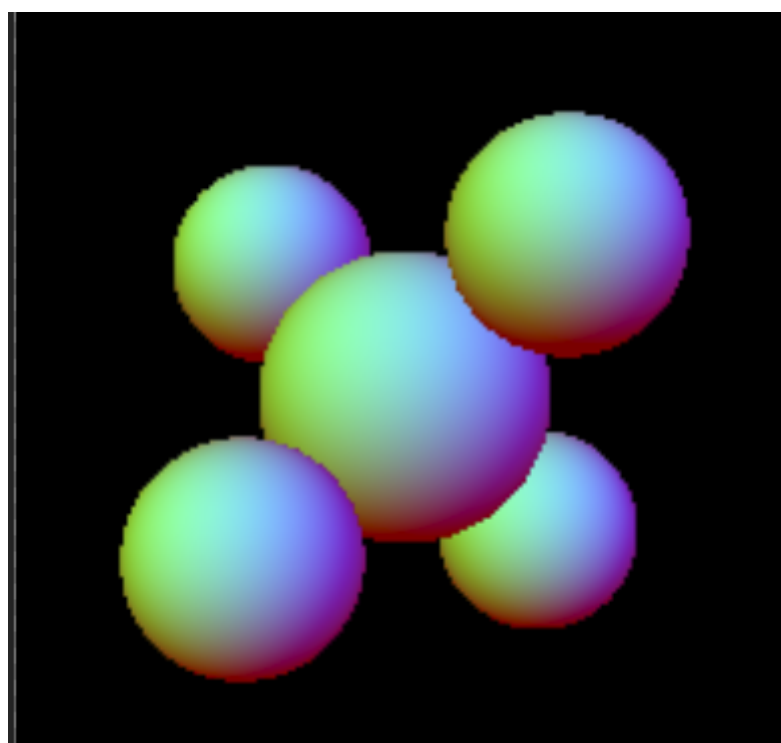
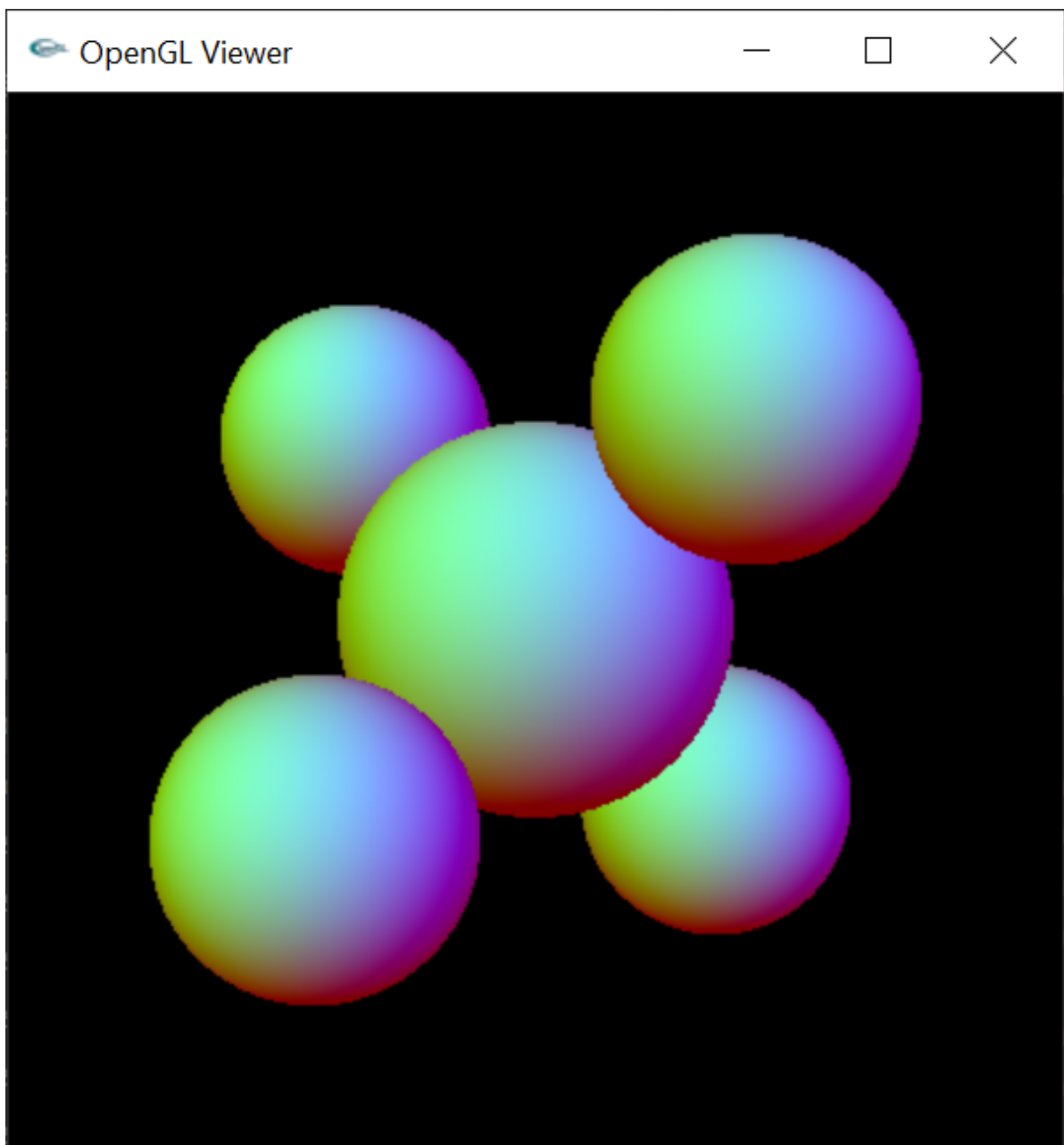


```
raytracer -input scene3_10_exponent_variations_back.txt -size 300 300 -output  
output3_10.tga -gui -tessellation 100 50 -gouraud
```





```
raytracer -input scene3_11_weird_lighting_diffuse.txt -size 200 200 -output  
output3_11.tga -gui -tessellation 100 50 -gouraud
```





```
raytracer -input scene3_12_weird_lighting_specular.txt -size 200 200 -output  
output3_12.tga -gui -tessellation 100 50 -gouraud
```

