计算机图形学第六次作业

1.实现Phong光照模型

1.1 场景中绘制一个cube

- 写出顶点坐标和颜色属性

```
    //顶点坐标初始化
      float vertices[] = {
      -0.2f, -0.2f, -0.2f,  0.0f, 0.5f, 0.1f,
       0.2f, -0.2f, -0.2f,  0.0f, 0.5f, 0.1f,
       0.2f,  0.2f, -0.2f,  0.0f, 0.5f, 0.1f,
       0.2f,  0.2f, -0.2f,  0.0f, 0.5f, 0.1f,
      -0.2f,  0.2f, -0.2f,  0.0f, 0.5f, 0.1f,
      -0.2f, -0.2f, -0.2f,  0.0f, 0.5f, 0.1f,

      -0.2f, -0.2f,  0.2f,  1.0f, 0.7f, 0.6f,
       0.2f, -0.2f,  0.2f,  1.0f, 0.7f, 0.6f,
       0.2f,  0.2f,  0.2f,  1.0f, 0.7f, 0.6f,
       0.2f,  0.2f,  0.2f,  1.0f, 0.7f, 0.6f,
      -0.2f,  0.2f,  0.2f,  1.0f, 0.7f, 0.6f,
      -0.2f, -0.2f,  0.2f,  1.0f, 0.7f, 0.6f,

      -0.2f,  0.2f,  0.2f,  0.3f, 0.8f, 0.3f,
      -0.2f,  0.2f, -0.2f,  0.3f, 0.8f, 0.3f,
      -0.2f, -0.2f, -0.2f,  0.3f, 0.8f, 0.3f,
      -0.2f, -0.2f, -0.2f,  0.3f, 0.8f, 0.3f,
      -0.2f, -0.2f,  0.2f,  0.3f, 0.8f, 0.3f,
      -0.2f,  0.2f,  0.2f,  0.3f, 0.8f, 0.3f,

       0.2f,  0.2f,  0.2f,  0.6f, 0.2f, 0.9f,
       0.2f,  0.2f, -0.2f,  0.6f, 0.2f, 0.9f,
       0.2f, -0.2f, -0.2f,  0.6f, 0.2f, 0.9f,
       0.2f, -0.2f, -0.2f,  0.6f, 0.2f, 0.9f,
       0.2f, -0.2f,  0.2f,  0.6f, 0.2f, 0.9f,
       0.2f,  0.2f,  0.2f,  0.6f, 0.2f, 0.9f,

      -0.2f, -0.2f, -0.2f,  0.6f, 0.0f, 0.5f,
       0.2f, -0.2f, -0.2f,  0.6f, 0.0f, 0.5f,
       0.2f, -0.2f,  0.2f,  0.6f, 0.0f, 0.5f,
       0.2f, -0.2f,  0.2f,  0.6f, 0.0f, 0.5f,
      -0.2f, -0.2f,  0.2f,  0.6f, 0.0f, 0.5f,
      -0.2f, -0.2f, -0.2f,  0.6f, 0.0f, 0.5f,

      -0.2f,  0.2f, -0.2f,  0.9f, 0.9f, 0.9f,
       0.2f,  0.2f, -0.2f,  0.9f, 0.9f, 0.9f,
       0.2f,  0.2f,  0.2f,  0.9f, 0.9f, 0.9f,
```

```
     0.2f,  0.2f,  0.2f,  0.9f, 0.9f, 0.9f,
    -0.2f,  0.2f,  0.2f,  0.9f, 0.9f, 0.9f,
    -0.2f,  0.2f, -0.2f,  0.9f, 0.9f, 0.9f,
    };
```

- 重写shader.vs

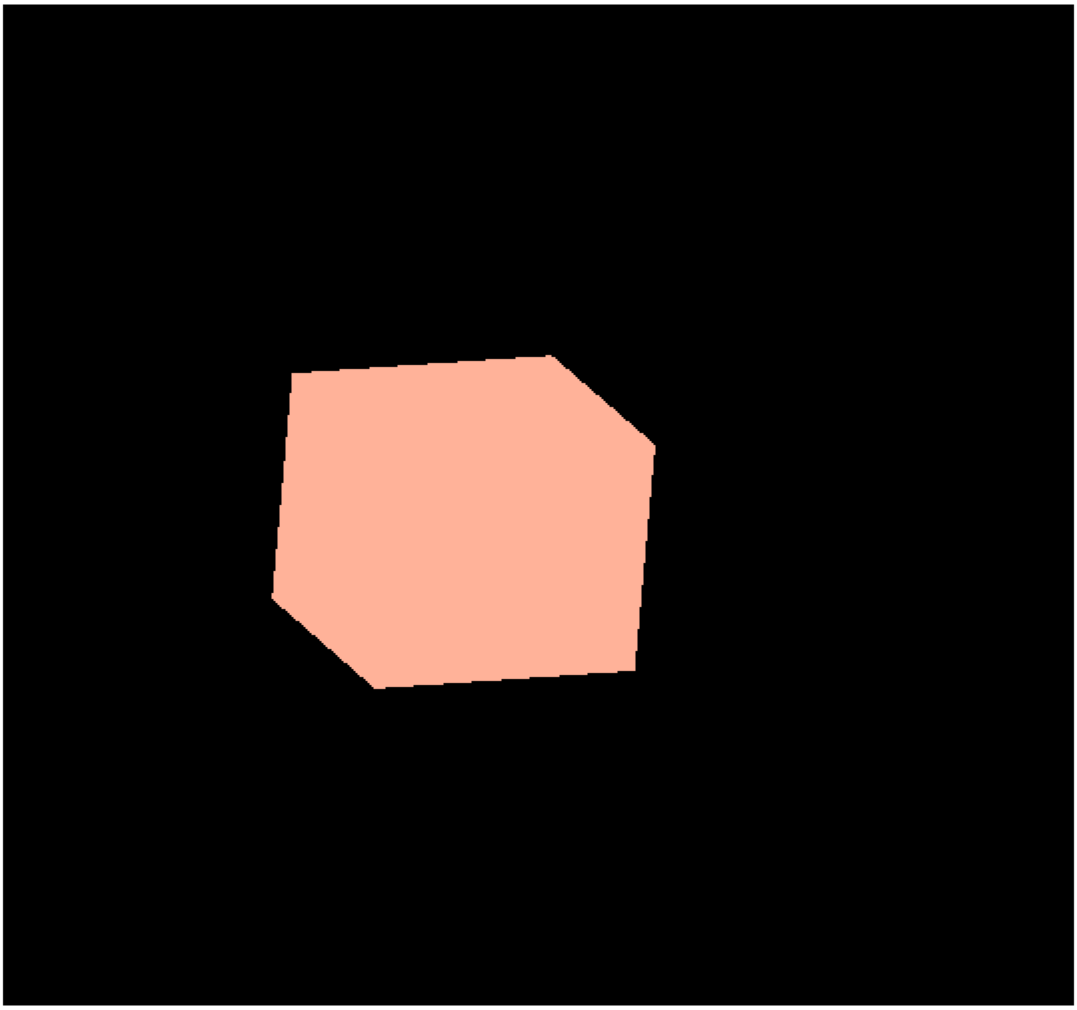
```
  #version 330 core
  out vec4 FragColor;

  uniform vec3 objectColor;
  uniform vec3 lightColor;

  void main(){
      FragColor = vec4(lightColor * objectColor, 1.0);
  }
```

- 指定颜色

```
cubeshader.usepro();
cubeshader.setVec3("objectColor", glm::vec3(1.0f, 0.7f, 0.6f));
cubeshader.setVec3("lightColor", glm::vec3(1.0f, 1.0f, 1.0f));
```

- 使用变换矩阵移动cube

```
//按照单位矩阵对三个变换矩阵进行初始化
glm::mat4 model = glm::mat4(1.0f);
glm::mat4 view = glm::mat4(1.0f);
glm::mat4 projection = glm::mat4(1.0f);
model = glm::rotate(model, glm::radians(90.0f) * 20, glm::vec3(1.0f, 1.0f, 0.0f));
view = glm::translate(view, glm::vec3(0.0f, 0.0f, -50.0f));
projection = glm::perspective(glm::radians(45.0f), (float)SCR_WIDTH / (float)SCR_HEIGHT, 0.1f,
100.0f);
unsigned int modelLoc = glGetUniformLocation(cubeshader.programid, "model");
unsigned int viewLoc = glGetUniformLocation(cubeshader.programid, "view");
glUniformMatrix4fv(modelLoc, 1, GL_FALSE, glm::value_ptr(model));
glUniformMatrix4fv(viewLoc, 1, GL_FALSE, &view[0][0]);
cubeshader.setMat4("projection", projection);
glBindVertexArray(VAO);
//绘制三十六个顶点
glDrawArrays(GL_TRIANGLES, 0, 36);
```



1.2 自己写shader实现两种shading: Phong Shading 和 Gouraud Shading，并解释两种shading的实现原理

- phongshading.fs

```
#version 330 core
out vec4 FragColor;
//normal为法向量的参数
in vec3 objectNormal;
in vec3 Frag_pos;

uniform vec3 light_pos;
uniform vec3 view_pos;
uniform vec3 light_Color;
uniform vec3 object_Color;

void main() {
    // 用光的颜色乘以一个很小的常量环境因子，再乘以物体的颜色，以获得环境光照
    float aStrength = 0.1;
    vec3 ambient = aStrength * light_Color;

    // 把法线和方向向量都进行标准化
    vec3 norm = normalize(objectNormal);
    vec3 lightDir = normalize(light_pos - Frag_pos);
  //计算光源对当前片段实际的漫反射影响。结果值再乘以光的颜色，得到漫反射分量
    float diff = max(dot(norm, lightDir), 0.0);
```

```
    vec3 diffuse = diff * light_Color;

    // 定义镜面强度变量
    float specularStrength = 0.5;
  // 计算视线方向向量
    vec3 viewDir = normalize(view_pos - Frag_pos);
  // 计算围绕法线轴的反射向量
    vec3 reflectDir = reflect(-lightDir, norm);
  // 带入反光度进行计算
    float spec = pow(max(dot(viewDir, reflectDir), 0.0), 32);
    vec3 specular = specularStrength * spec * light_Color;

    vec3 result = (ambient + diffuse + specular) * object_Color;
    FragColor = vec4(result, 1.0);
}
```

- phongshading.vs

```
#version 330 core
layout (location = 0) in vec3 aPos;
layout (location = 1) in vec3 aNormal;

out vec3 Frag_pos;
out vec3 objectNormal;

uniform mat4 model;
uniform mat4 view;
uniform mat4 projection;

void main(){
    Frag_pos = vec3(model * vec4(aPos, 1.0));
    //使用法线矩阵将法向量转换为世界空间坐标
    objectNormal = mat3(transpose(inverse(model))) * aNormal;
    gl_Position = projection * view * vec4(Frag_pos, 1.0);
}
```

- GouraudShading.fs

```
#version 330 core
out vec4 FragColor;

in vec3 lighting_color;

uniform vec3 object_color;

void main(){
   FragColor = vec4(lighting_color * object_color, 1.0);
}
```

- GouraudShading.vs

```
#version 330 core
layout (location = 0) in vec3 aPos;
layout (location = 1) in vec3 aNormal;

out vec3 lighting_color;

```

```
uniform vec3 light_pos;
uniform vec3 view_pos;
uniform vec3 light_color;

uniform mat4 model;
uniform mat4 view;
uniform mat4 projection;

void main() {
    gl_Position = projection * view * model * vec4(aPos, 1.0);

    //使用法线矩阵将法向量转换为世界空间坐标
    vec3 Position = vec3(model * vec4(aPos, 1.0));
    vec3 Normal = mat3(transpose(inverse(model))) * aNormal;

    // 用光的颜色乘以一个很小的常量环境因子，再乘以物体的颜色，以获得环境光照
    float ambientStrength = 0.1;
    vec3 ambient = ambientStrength * light_color;

    // 把法线和方向向量都进行标准化
    vec3 norm = normalize(Normal);
    vec3 lightDir = normalize(light_pos - Position);
    //计算光源对当前片段实际的漫反射影响。结果值再乘以光的颜色，得到漫反射分量
    float diff = max(dot(norm, lightDir), 0.0);
    vec3 diffuse = diff * light_color;

     // 定义镜面强度变量
    float specularStrength = 1.0;
    // 计算视线方向向量
    vec3 viewDir = normalize(view_pos - Position);
    // 计算围绕法线轴的反射向量
    vec3 reflectDir = reflect(-lightDir, norm);
    // 带入反光度进行计算
    float spec = pow(max(dot(viewDir, reflectDir), 0.0), 32);
    vec3 specular = specularStrength * spec * light_color;
    // 计算光照颜色
    lighting_color = ambient + diffuse + specular;
}
```

> Phong Shading中的三个光照分量是环境光照（ambient）、漫反射（diffuse）和镜面反射（specular），对于**环境光照**，直接将影响系数与光源颜色相乘即可，再将得到的环境光照分量同物体颜色相乘作为片段着色器的输出。对于**漫反射光照**，物体上与光线方向越接近的片段能从光源处获得更多的亮度，根据入射光的角度以及对应的法向量就可以计算出结果。对于**镜面反射**，除了依赖于入射光和法向量之外，也依赖于观察者所处的位置，需要对于观察者和物体、光线之间的相对位置进行处理。最终结果是对三个分量进行整合的结果。
>
> **Gouraud模型**是在顶点着色器中对光照进行处理。Gouraud模型通过对顶点的赋值来决定像素的颜色值。具体的思路是计算顶点的法向量，决定顶点的光照颜色，然后根据多边形上各点距顶点的距离进行插值，从而绘制多边形上各点投影对应的像素。

1.3 合理设置视点、光照位置、光照颜色等参数，使光照效果明显显示

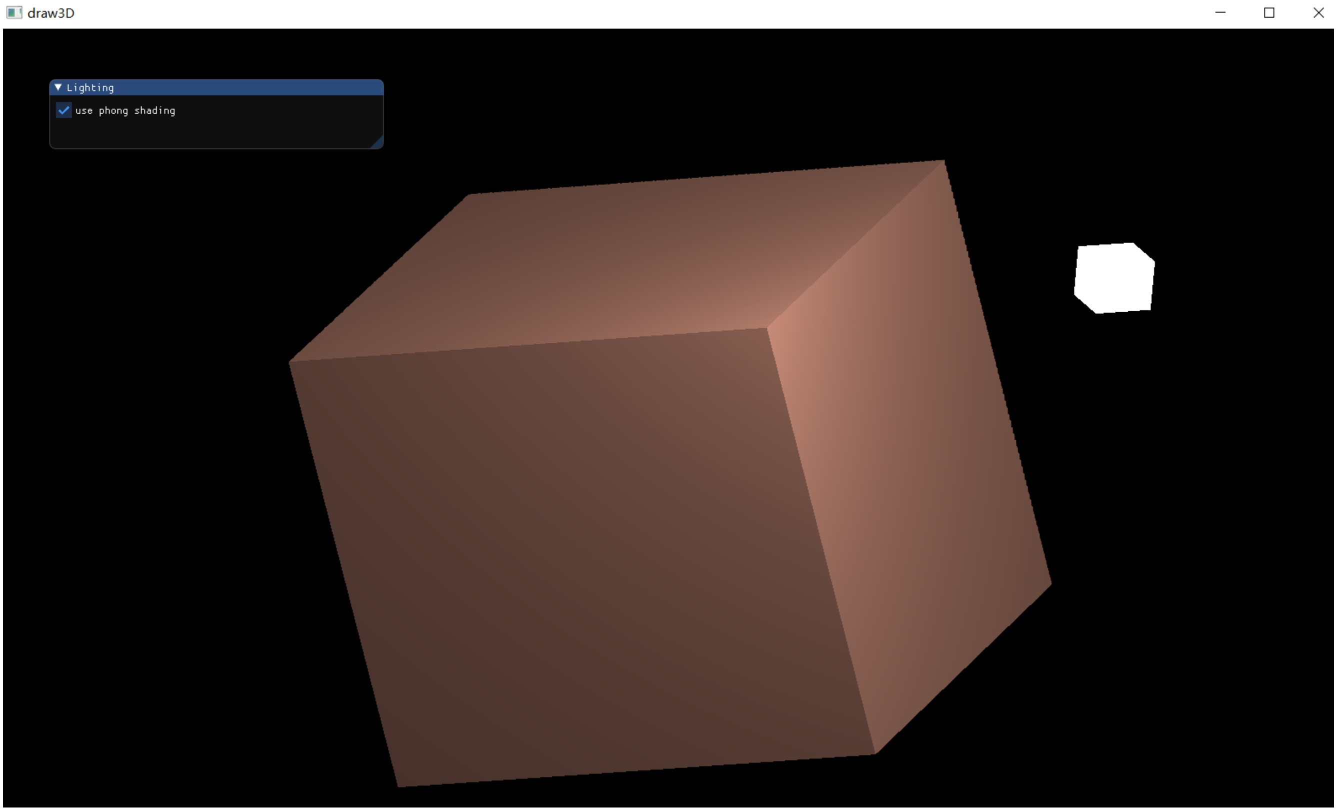
- 参数设置

```
//顶点坐标初始化
float vertices[] = {
  -0.2f, -0.2f, -0.2f,  0.0f,  0.0f, -1.0f,
  0.2f, -0.2f, -0.2f,  0.0f,  0.0f, -1.0f,
  0.2f,  0.2f, -0.2f,  0.0f,  0.0f, -1.0f,
```

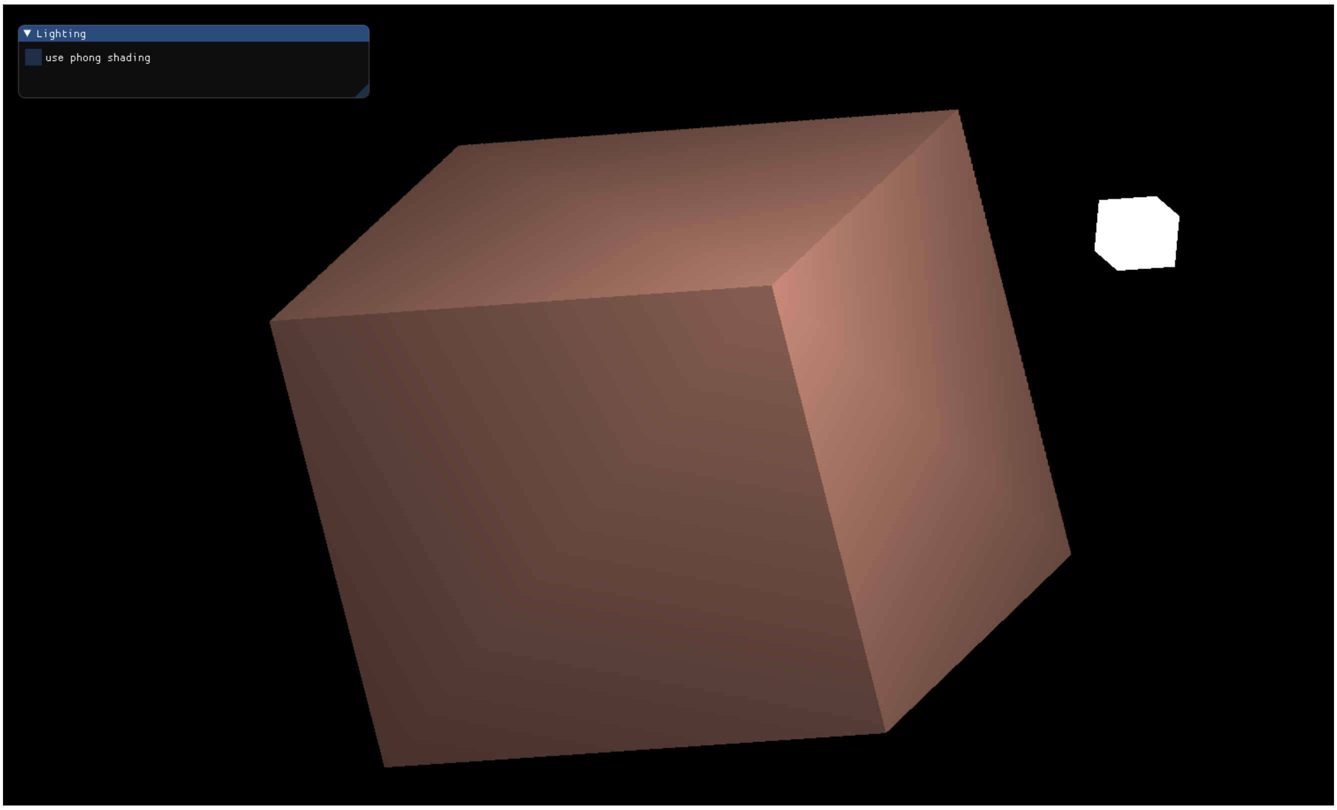
```
    0.2f,  0.2f, -0.2f,  0.0f,  0.0f, -1.0f,
   -0.2f,  0.2f, -0.2f,  0.0f,  0.0f, -1.0f,
   -0.2f, -0.2f, -0.2f,  0.0f,  0.0f, -1.0f,

   -0.2f, -0.2f,  0.2f,  0.0f,  0.0f,  1.0f,
    0.2f, -0.2f,  0.2f,  0.0f,  0.0f,  1.0f,
    0.2f,  0.2f,  0.2f,  0.0f,  0.0f,  1.0f,
    0.2f,  0.2f,  0.2f,  0.0f,  0.0f,  1.0f,
   -0.2f,  0.2f,  0.2f,  0.0f,  0.0f,  1.0f,
   -0.2f, -0.2f,  0.2f,  0.0f,  0.0f,  1.0f,

   -0.2f,  0.2f,  0.2f, -1.0f,  0.0f,  0.0f,
   -0.2f,  0.2f, -0.2f, -1.0f,  0.0f,  0.0f,
   -0.2f, -0.2f, -0.2f, -1.0f,  0.0f,  0.0f,
   -0.2f, -0.2f, -0.2f, -1.0f,  0.0f,  0.0f,
   -0.2f, -0.2f,  0.2f, -1.0f,  0.0f,  0.0f,
   -0.2f,  0.2f,  0.2f, -1.0f,  0.0f,  0.0f,

    0.2f,  0.2f,  0.2f,  1.0f,  0.0f,  0.0f,
    0.2f,  0.2f, -0.2f,  1.0f,  0.0f,  0.0f,
    0.2f, -0.2f, -0.2f,  1.0f,  0.0f,  0.0f,
    0.2f, -0.2f, -0.2f,  1.0f,  0.0f,  0.0f,
    0.2f, -0.2f,  0.2f,  1.0f,  0.0f,  0.0f,
    0.2f,  0.2f,  0.2f,  1.0f,  0.0f,  0.0f,

   -0.2f, -0.2f, -0.2f,  0.0f, -1.0f,  0.0f,
    0.2f, -0.2f, -0.2f,  0.0f, -1.0f,  0.0f,
    0.2f, -0.2f,  0.2f,  0.0f, -1.0f,  0.0f,
    0.2f, -0.2f,  0.2f,  0.0f, -1.0f,  0.0f,
   -0.2f, -0.2f,  0.2f,  0.0f, -1.0f,  0.0f,
   -0.2f, -0.2f, -0.2f,  0.0f, -1.0f,  0.0f,

   -0.2f,  0.2f, -0.2f,  0.0f,  1.0f,  0.0f,
    0.2f,  0.2f, -0.2f,  0.0f,  1.0f,  0.0f,
    0.2f,  0.2f,  0.2f,  0.0f,  1.0f,  0.0f,
    0.2f,  0.2f,  0.2f,  0.0f,  1.0f,  0.0f,
   -0.2f,  0.2f,  0.2f,  0.0f,  1.0f,  0.0f,
   -0.2f,  0.2f, -0.2f,  0.0f,  1.0f,  0.0f
};
//新建着色器类
myshader cubeshader("phongshading.vs", "phongshading.fs");
myshader cubegshader("GouraudShading.vs", "GouraudShading.fs");
myshader lightshader("newshader.vs", "newshader.fs");
if (use_phong) {
    cubeshader.usepro();
    cubeshader.setVec3("object_Color", glm::vec3(1.0f, 0.7f, 0.6f));
    cubeshader.setVec3("light_Color", glm::vec3(1.0f, 1.0f, 1.0f));
    cubeshader.setVec3("light_pos", lightpos);
    cubeshader.setVec3("view_pos", glm::vec3(40.0f, 0.0f, 40.0f));
    unsigned int modelLoc = glGetUniformLocation(cubeshader.programid, "model");
    unsigned int viewLoc = glGetUniformLocation(cubeshader.programid, "view");
    glUniformMatrix4fv(modelLoc, 1, GL_FALSE, glm::value_ptr(model));
    glUniformMatrix4fv(viewLoc, 1, GL_FALSE, &view[0][0]);
    cubeshader.setMat4("projection", projection);
    glBindVertexArray(VAO);
}
else {
    cubegshader.usepro();
    cubegshader.setVec3("object_color", glm::vec3(1.0f, 0.7f, 0.6f));
    cubegshader.setVec3("light_color", glm::vec3(1.0f, 1.0f, 1.0f));
```

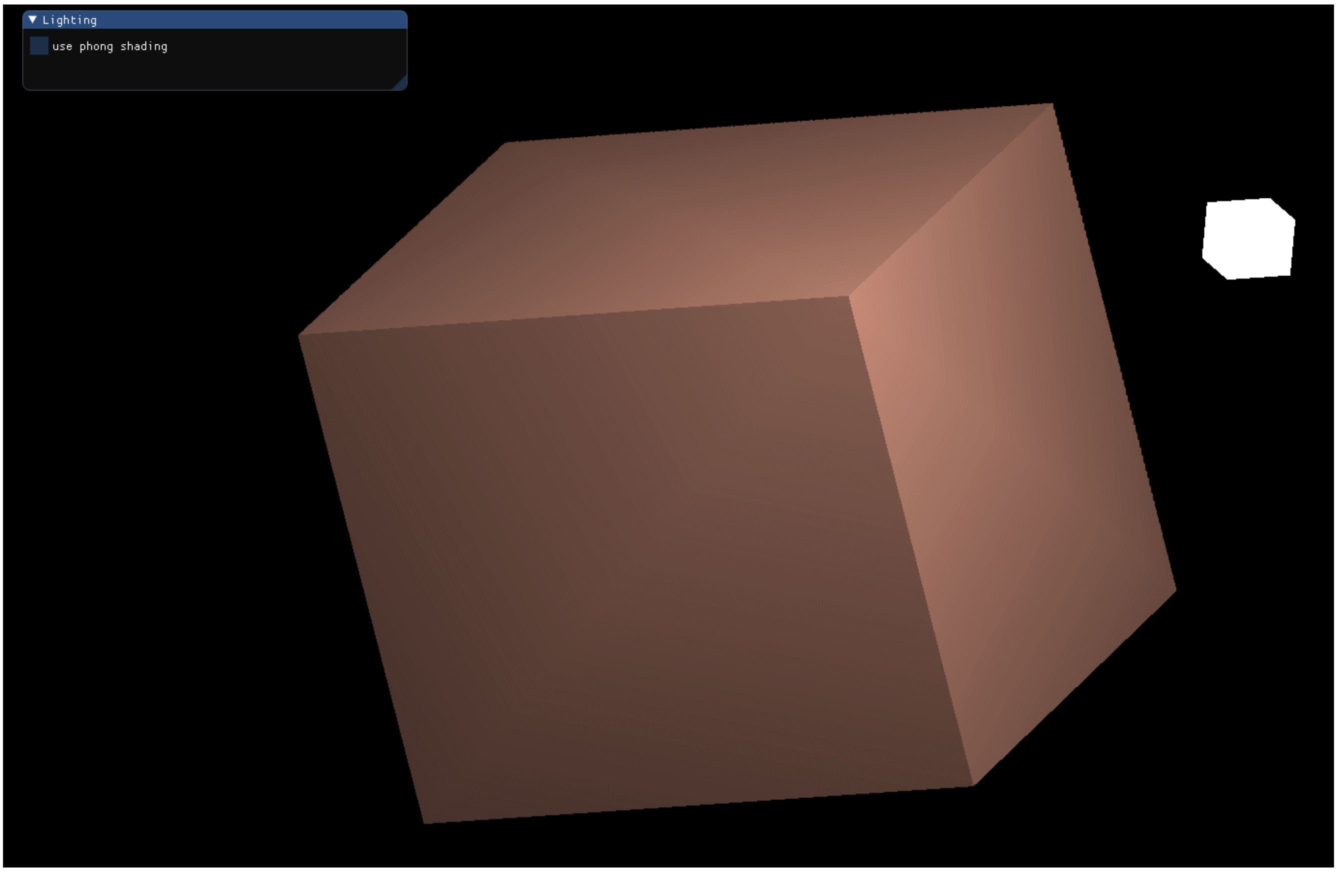
```
    cubegshader.setVec3("light_pos", lightpos);
    cubegshader.setVec3("view_pos", glm::vec3(40.0f, 0.0f, 40.0f));
    unsigned int modelLoc = glGetUniformLocation(cubegshader.programid, "model");
    unsigned int viewLoc = glGetUniformLocation(cubegshader.programid, "view");
    glUniformMatrix4fv(modelLoc, 1, GL_FALSE, glm::value_ptr(model));
    glUniformMatrix4fv(viewLoc, 1, GL_FALSE, &view[0][0]);
    cubegshader.setMat4("projection", projection);
    glBindVertexArray(VAO);
}
```

phong shading效果



gouraud shading效果





2. 使用GUI，使参数可调节，效果实时更改

- 修改phongshading.fs文件

```
#version 330 core
```

```
out vec4 FragColor;
//normal为法向量的参数
in vec3 objectNormal;
in vec3 Frag_pos;

uniform vec3 light_pos;
uniform vec3 view_pos;
uniform vec3 light_Color;
uniform vec3 object_Color;
uniform float aStrength;
uniform float specularStrength;
uniform float diffusefactor;
uniform int specfactor;

void main() {
    // 用光的颜色乘以一个很小的常量环境因子，再乘以物体的颜色，以获得环境光照
    //float aStrength = 0.1;
    vec3 ambient = aStrength * light_Color;

    // 把法线和方向向量都进行标准化
    vec3 norm = normalize(objectNormal);
    vec3 lightDir = normalize(light_pos - Frag_pos);
  //计算光源对当前片段实际的漫反射影响。结果值再乘以光的颜色，得到漫反射分量
    float diff = max(dot(norm, lightDir), 0.0);
    vec3 diffuse = diff * light_Color*diffusefactor;

    // 定义镜面强度变量
    //float specularStrength = 0.5;
  // 计算视线方向向量
    vec3 viewDir = normalize(view_pos - Frag_pos);
  // 计算围绕法线轴的反射向量
    vec3 reflectDir = reflect(-lightDir, norm);
  // 带入反光度进行计算
    float spec = pow(max(dot(viewDir, reflectDir), 0.0), specfactor);
    vec3 specular = specularStrength * spec * light_Color;

    vec3 result = (ambient + diffuse + specular) * object_Color;
    FragColor = vec4(result, 1.0);
}
```

- 修改GouraudShading.vs文件

```
#version 330 core
layout (location = 0) in vec3 aPos;
layout (location = 1) in vec3 aNormal;

out vec3 lighting_color;

uniform vec3 light_pos;
uniform vec3 view_pos;
uniform vec3 light_color;

uniform mat4 model;
uniform mat4 view;
uniform mat4 projection;
uniform float aStrength;
uniform float specularStrength;
```

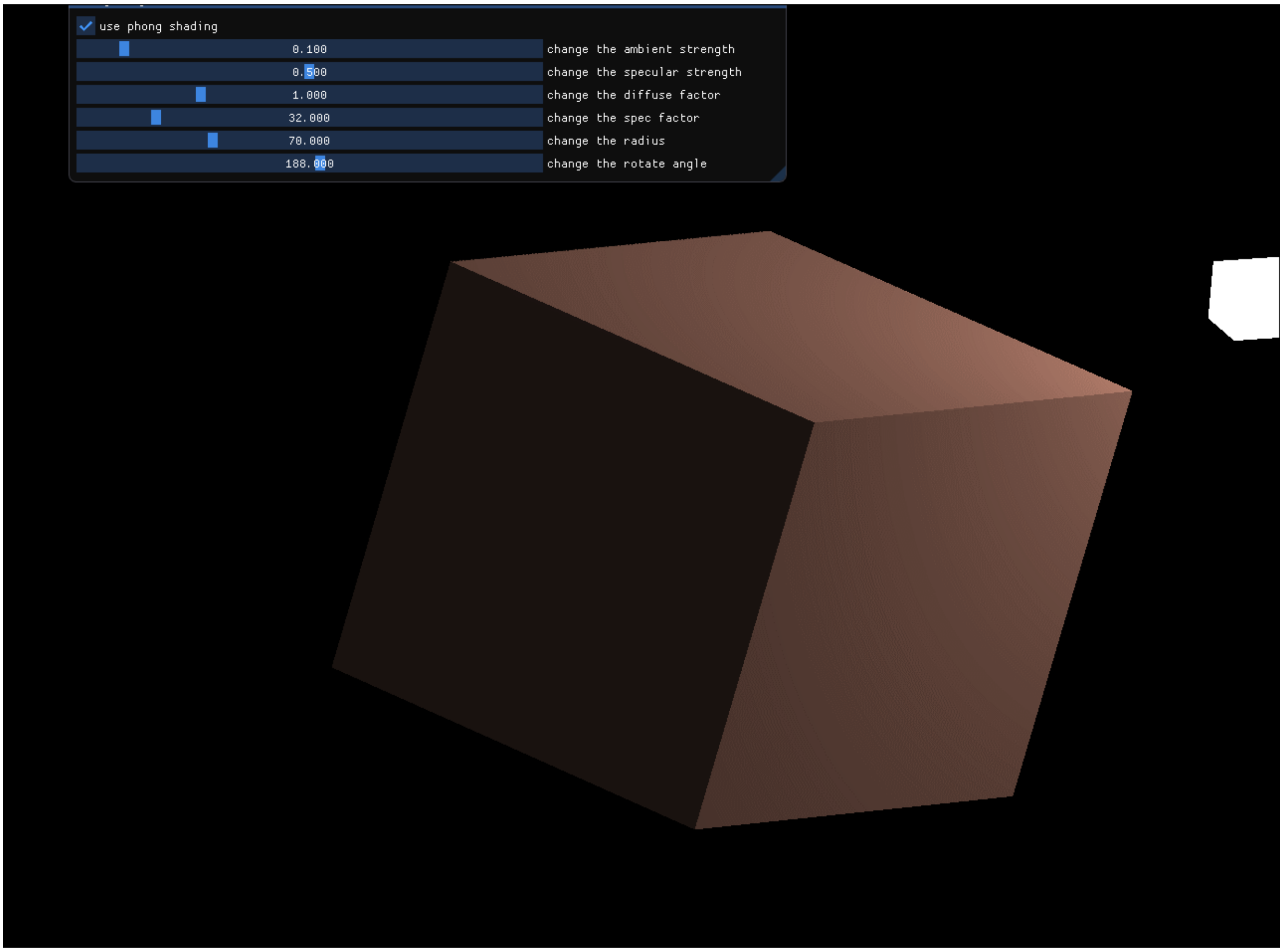
```
uniform float diffusefactor;
uniform int specfactor;


void main() {
    gl_Position = projection * view * model * vec4(aPos, 1.0);

    //使用法线矩阵将法向量转换为世界空间坐标
    vec3 Position = vec3(model * vec4(aPos, 1.0));
    vec3 Normal = mat3(transpose(inverse(model))) * aNormal;

    // 用光的颜色乘以一个很小的常量环境因子，再乘以物体的颜色，以获得环境光照
    // float ambientStrength = 0.1;
    vec3 ambient = aStrength * light_color;

    // 把法线和方向向量都进行标准化
    vec3 norm = normalize(Normal);
    vec3 lightDir = normalize(light_pos - Position);
    //计算光源对当前片段实际的漫反射影响。结果值再乘以光的颜色，得到漫反射分量
    float diff = max(dot(norm, lightDir), 0.0);
    vec3 diffuse = diff * light_color*diffusefactor;

     // 定义镜面强度变量
    //float specularStrength = 1.0;
    // 计算视线方向向量
    vec3 viewDir = normalize(view_pos - Position);
    // 计算围绕法线轴的反射向量
    vec3 reflectDir = reflect(-lightDir, norm);
    // 带入反光度进行计算
    float spec = pow(max(dot(viewDir, reflectDir), 0.0), specfactor);
    vec3 specular = specularStrength * spec * light_color;
    // 计算光照颜色
    lighting_color = ambient + diffuse + specular;
}
```

- 添加GUI

```
//通过IMGUI来改变的部分参数
bool use_phong = true;
float aStrength = 0.1f;
float specularStrength = 0.5f;
float diffusefactor = 1.0f;
float specfactor = 32;
float radius = 70.0f;
float rotate = 188.0f;

ImGui_ImplOpenGL3_NewFrame();
ImGui_ImplGlfw_NewFrame();
ImGui::NewFrame();
ImGui::Begin("Lighting");
ImGui::Checkbox("use phong shading", &use_phong);
ImGui::SliderFloat("change the ambient strength", &aStrength, 0.0f, 1.1f);
ImGui::SliderFloat("change the specular strength", &specularStrength, 0.1f, 0.9f);
ImGui::SliderFloat("change the diffuse factor", &diffusefactor, 0.3f, 3.0f);
ImGui::SliderFloat("change the spec factor", &specfactor, 0.0f, 200.0f);
ImGui::SliderFloat("change the radius", &radius, 60.0f, 95.0f);
ImGui::SliderFloat("change the rotate angle", &rotate, 0.0f, 360.0f);
```

- 实时更新

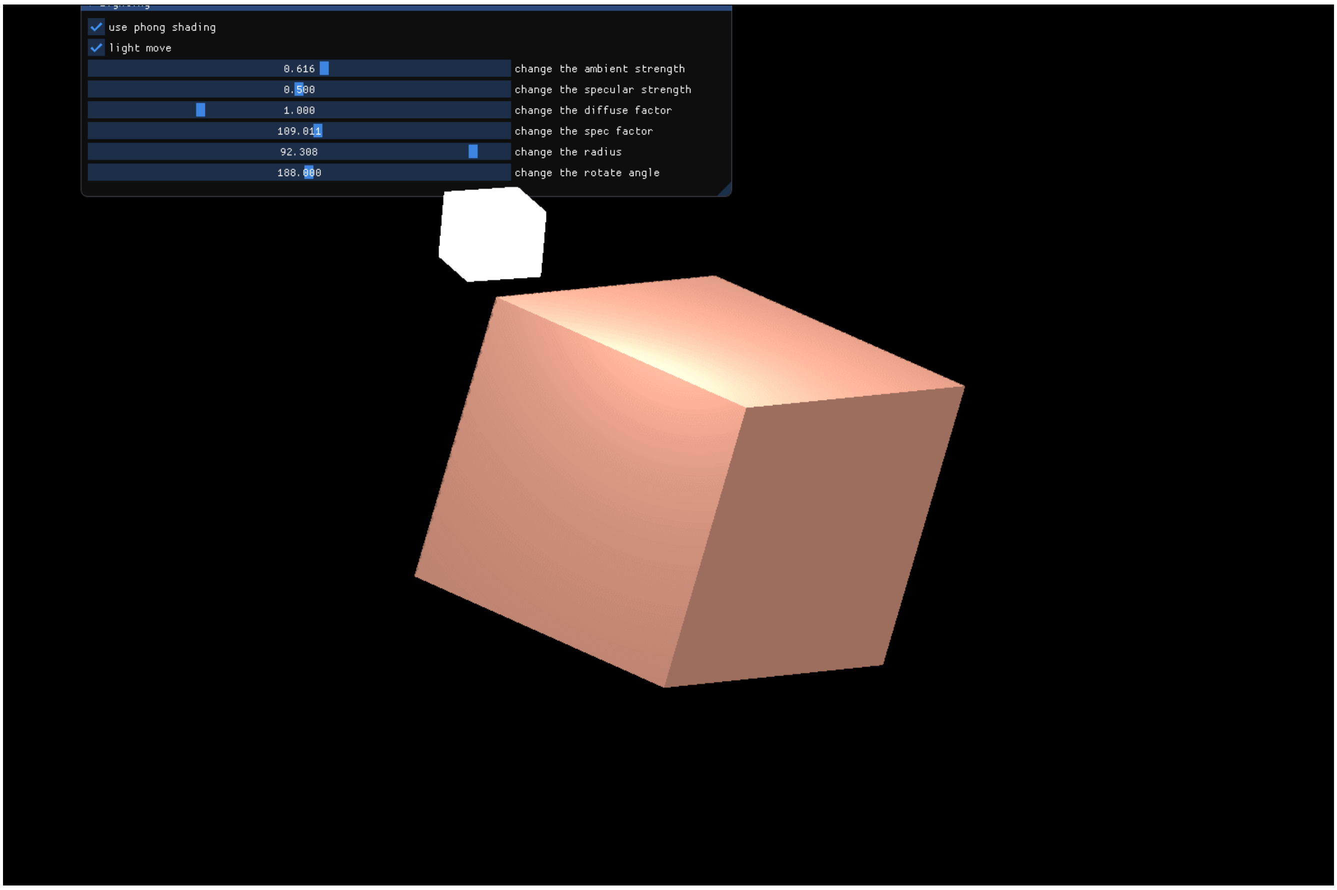
```cpp
//按照单位矩阵对三个变换矩阵进行初始化
viewpos = glm::vec3(sin(rotate)*radius, 0.0f, cos(rotate)*radius);
glm::mat4 model = glm::mat4(1.0f);
glm::mat4 view = glm::mat4(1.0f);
glm::mat4 projection = glm::mat4(1.0f);
model = glm::translate(model, cubepos);
model = glm::rotate(model, glm::radians(90.0f) * 20, glm::vec3(1.0f, 1.0f, 0.0f));
view = glm::lookAt(viewpos, glm::vec3(0.0, 0.0, 0.0), glm::vec3(0.0f, 1.0, 0.0f));
projection = glm::perspective(glm::radians(45.0f), (float)SCR_WIDTH / (float)SCR_HEIGHT, 0.1f,
100.0f);
//新建着色器类
myshader cubeshader("phongshading.vs", "phongshading.fs");
myshader cubegshader("GouraudShading.vs", "GouraudShading.fs");
myshader lightshader("newshader.vs", "newshader.fs");
if (use_phong) {
    cubeshader.usepro();
    cubeshader.setVec3("object_Color", glm::vec3(1.0f, 0.7f, 0.6f));
    cubeshader.setVec3("light_Color", glm::vec3(1.0f, 1.0f, 1.0f));
    cubeshader.setVec3("light_pos", lightpos);
    cubeshader.setVec3("view_pos", viewpos);
    cubeshader.setFloat("aStrength", aStrength);
    cubeshader.setFloat("specularStrength", specularStrength);
    cubeshader.setFloat("diffusefactor", diffusefactor);
    cubeshader.setInt("specfactor", int(specfactor));
    unsigned int modelLoc = glGetUniformLocation(cubeshader.programid, "model");
    unsigned int viewLoc = glGetUniformLocation(cubeshader.programid, "view");
    glUniformMatrix4fv(modelLoc, 1, GL_FALSE, glm::value_ptr(model));
    glUniformMatrix4fv(viewLoc, 1, GL_FALSE, &view[0][0]);
    cubeshader.setMat4("projection", projection);
    glBindVertexArray(VAO);
}
else {
    cubegshader.usepro();
    cubegshader.setVec3("object_color", glm::vec3(1.0f, 0.7f, 0.6f));
    cubegshader.setVec3("light_color", glm::vec3(1.0f, 1.0f, 1.0f));
    cubegshader.setVec3("light_pos", lightpos);
    cubegshader.setVec3("view_pos", viewpos);
    cubegshader.setFloat("aStrength", aStrength);
    cubegshader.setFloat("specularStrength", specularStrength);
    cubegshader.setFloat("diffusefactor", diffusefactor);
    cubegshader.setInt("specfactor", int(specfactor));
    unsigned int modelLoc = glGetUniformLocation(cubegshader.programid, "model");
    unsigned int viewLoc = glGetUniformLocation(cubegshader.programid, "view");
    glUniformMatrix4fv(modelLoc, 1, GL_FALSE, glm::value_ptr(model));
    glUniformMatrix4fv(viewLoc, 1, GL_FALSE, &view[0][0]);
    cubegshader.setMat4("projection", projection);
    glBindVertexArray(VAO);
}
//绘制三十六个顶点
glDrawArrays(GL_TRIANGLES, 0, 36);
```



3. 当前光源为静止状态，尝试使光源在场景中来回移动，光照效果实时更改。

> 让光源的位置随着时间不断变化

```
bool light_move = false;
ImGui::Checkbox("light move", &light_move);
if (light_move) {
    lightpos.x = sin(glfwGetTime())*0.6f;
    lightpos.z = cos(glfwGetTime())*0.3f;
    lightpos.y = cos(glfwGetTime())*0.3f;
}
```


use phong shading
light move
0.616
change the ambient strength
0.500
change the specular strength
1.000
change the diffuse factor
109.011
change the spec factor
92.308
change the radius
188.000
change the rotate angle