Assignment 3a

CS4610

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Assignment 2b

The *purpose* of this assignment was to familiarize ourselves with the OpenGL command of the hidden surface removal, illumination, shading and texture mapping.

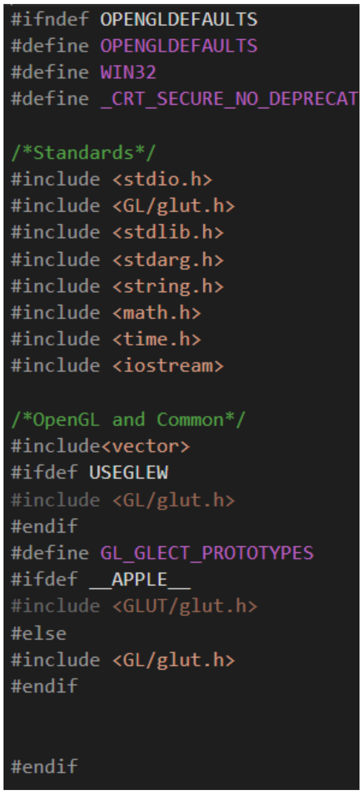
Objectives:

1. Interactively change the field of view and aspect ratio of the camera.
2. Interactively change the values of the near and far clipping plane.
3. Support for at least two light source.
4. Interactively turn light(s) on and off.
5. Support flat and Gouraud shading models. (Hint: In order to do Smooth/Gouraud shading, you need to provide the normal vector for each vertex using glNormal. The vertex normal can be computed as the average of all the faces/triangles adjacent to the current vertex as described in here).
6. Interactive change the (RGBA) values associated with the global ambient light.
7. Interactive change the (RGBA) values associated with the ambient, diffuse and specular component of the light sources.
8. Interactive change the (RGBA) values associated with the ambient, diffuse and specular material properties of the objects.

Approach: Upon loading in a .OBJ file, I scale and calculate the normal vectors for each vertex. This was probably the most challenging part of the assignment. For each vertex, I had to go through all faces to check to see if it included the vertex in question. From there, I calculated and averaged the face normal vectors. Changing the field of view and aspect ratio was pretty easy, a simple variable was used which could be inputted via the keyboard. I added in two light sources (toggle-able) being default red and green. Shading modes can be toggled as well (decided by a simple variable). All RGBA values can be adjusted, though I kept the Green and Red lights to stay primarily those colors. View Keyboard input section for more.

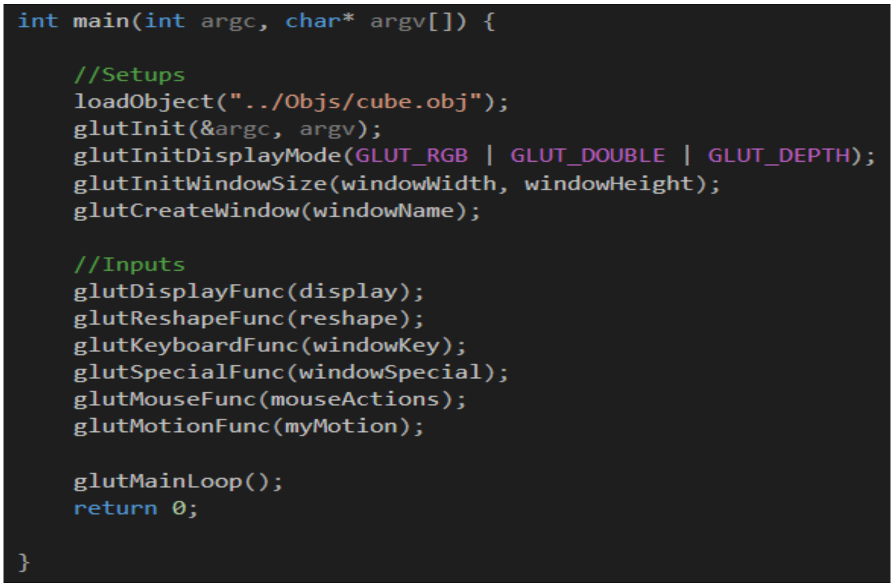
The Header File (OpenGLDefaults.h)

First and foremost, I have decided to include a header file to be used for this assignment’s, as well as future assignments’, libraries. Note this file include OpenGl basic libraries, as well as printing for debugging and math for easy/complex calculations.



```
#ifndef OPENGLDEFAULTS
#define OPENGLDEFAULTS
#define WIN32
#define _CRT_SECURE_NO_DEPRECAT

/*Standards*/
#include <stdio.h>
#include <GL/glut.h>
#include <stdlib.h>
#include <stdarg.h>
#include <string.h>
#include <math.h>
#include <time.h>
#include <iostream>

/*OpenGL and Common*/
#include<vector>
#ifdef USEGLEW
#include <GL/glut.h>
#endif
#define GL_GLECT_PROTOTYPES
#ifdef __APPLE__
#include <GLUT/glut.h>
#else
#include <GL/glut.h>
#endif


#endif
```

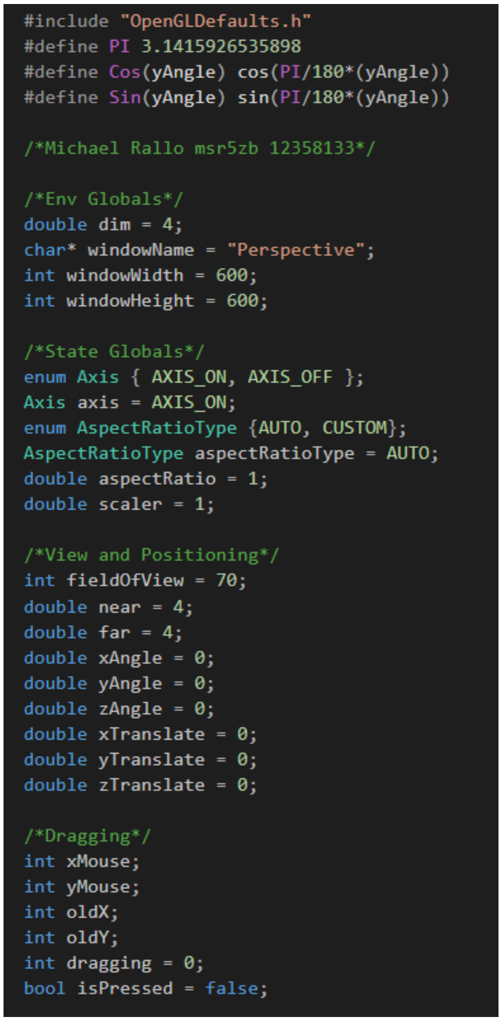
Main



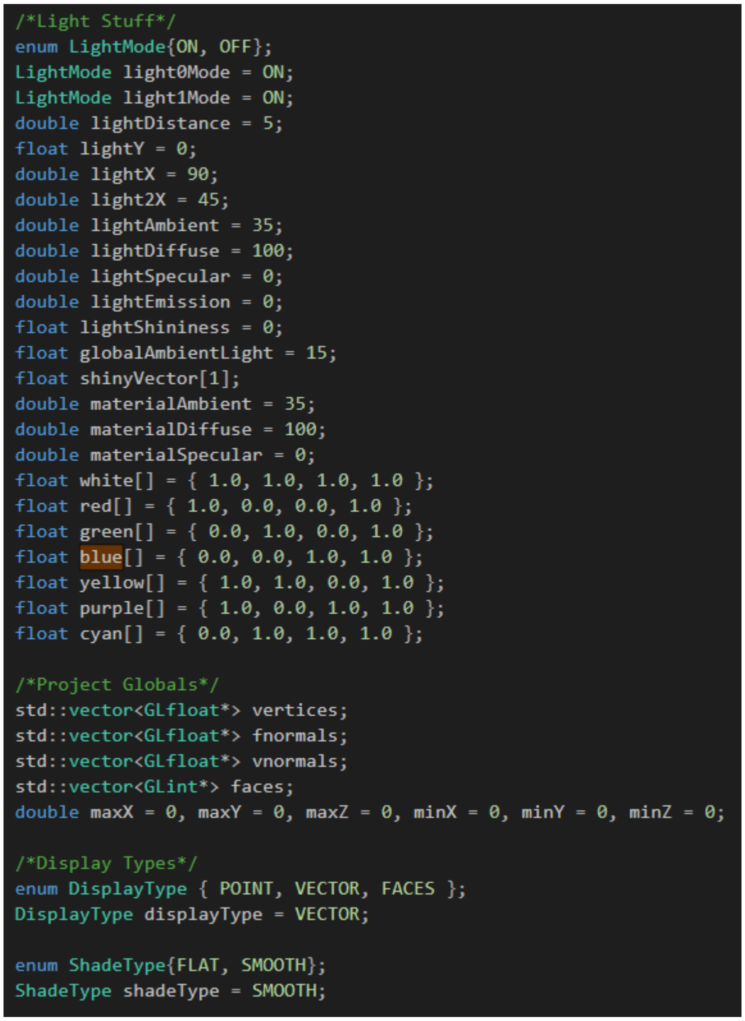
```
int main(int argc, char* argv[]) {

    //Setups
    loadObject("../Objs/cube.obj");
    glutInit(&argc, argv);
    glutInitDisplayMode(GLUT_RGB | GLUT_DOUBLE | GLUT_DEPTH);
    glutInitWindowSize(windowWidth, windowHeight);
    glutCreateWindow(windowName);

    //Inputs
    glutDisplayFunc(display);
    glutReshapeFunc(reshape);
    glutKeyboardFunc(windowKey);
    glutSpecialFunc(windowSpecial);
    glutMouseFunc(mouseActions);
    glutMotionFunc(myMotion);

    glutMainLoop();
    return 0;

}
```

Our main function is similar to that from Assignment 2a. Note by default we load in the cube object file.

Global Variables



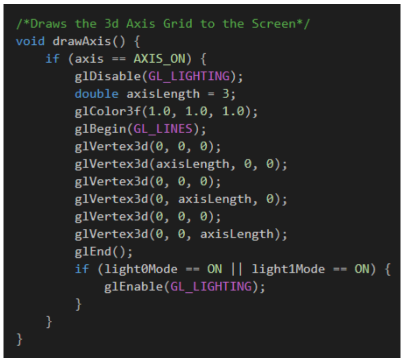
```
#include "OpenGLDefaults.h"
#define PI 3.1415926535898
#define Cos(yAngle) cos(PI/180*(yAngle))
#define Sin(yAngle) sin(PI/180*(yAngle))

/*Michael Rallo msr5zb 12358133*/

/*Env Globals*/
double dim = 4;
char* windowName = "Perspective";
int windowWidth = 600;
int windowHeight = 600;

/*State Globals*/
enum Axis { AXIS_ON, AXIS_OFF };
Axis axis = AXIS_ON;
enum AspectRatioType {AUTO, CUSTOM};
AspectRatioType aspectRatioType = AUTO;
double aspectRatio = 1;
double scaler = 1;

/*View and Positioning*/
int fieldOfView = 70;
double near = 4;
double far = 4;
double xAngle = 0;
double yAngle = 0;
double zAngle = 0;
double xTranslate = 0;
double yTranslate = 0;
double zTranslate = 0;

/*Dragging*/
int xMouse;
int yMouse;
int oldX;
int oldY;
int dragging = 0;
bool isPressed = false;
```



```
/*Light Stuff*/
enum LightMode{ON, OFF};
LightMode light0Mode = ON;
LightMode light1Mode = ON;
double lightDistance = 5;
float lightY = 0;
double lightX = 90;
double light2X = 45;
double lightAmbient = 35;
double lightDiffuse = 100;
double lightSpecular = 0;
double lightEmission = 0;
float lightShininess = 0;
float globalAmbientLight = 15;
float shinyVector[1];
double materialAmbient = 35;
double materialDiffuse = 100;
double materialSpecular = 0;
float white[] = { 1.0, 1.0, 1.0, 1.0 };
float red[] = { 1.0, 0.0, 0.0, 1.0 };
float green[] = { 0.0, 1.0, 0.0, 1.0 };
float blue[] = { 0.0, 0.0, 1.0, 1.0 };
float yellow[] = { 1.0, 1.0, 0.0, 1.0 };
float purple[] = { 1.0, 0.0, 1.0, 1.0 };
float cyan[] = { 0.0, 1.0, 1.0, 1.0 };

/*Project Globals*/
std::vector<GLfloat*> vertices;
std::vector<GLfloat*> fnormals;
std::vector<GLfloat*> vnormals;
std::vector<GLint*> faces;
double maxX = 0, maxY = 0, maxZ = 0, minX = 0, minY = 0, minZ = 0;

/*Display Types*/
enum DisplayType { POINT, VECTOR, FACES };
DisplayType displayType = VECTOR;

enum ShadeType{FLAT, SMOOTH};
ShadeType shadeType = SMOOTH;
```

For this assignment, I will be using global variables in order to change various settings (named conventionally). Note the fieldOfView, near, and far to handle clipping and camera view. Lighting variables for the lights, environment, and objects were also created. Positions for lights will also be manipulated so we can see the full effects of lighting in our program.

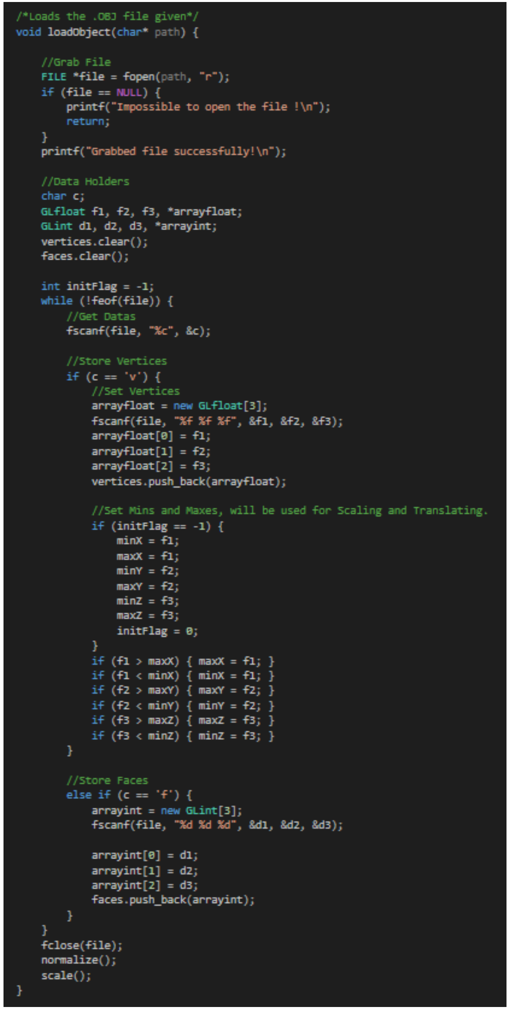
Drawing the XYZ Grid (Extras)



```
/*Draws the 3d Axis Grid to the Screen*/
void drawAxis() {
    if (axis == AXIS_ON) {
        glDisable(GL_LIGHTING);
        double axisLength = 3;
        glColor3f(1.0, 1.0, 1.0);
        glBegin(GL_LINES);
        glVertex3d(0, 0, 0);
        glVertex3d(axisLength, 0, 0);
        glVertex3d(0, 0, 0);
        glVertex3d(0, axisLength, 0);
        glVertex3d(0, 0, 0);
        glVertex3d(0, 0, axisLength);
        glEnd();
        if (light0Mode == ON || light1Mode == ON) {
            glEnable(GL_LIGHTING);
        }
    }
}
```

This is a simple function to draw a grid at the origin of our view in order for us to see the object more clearly. This can be toggled on and off with the "i" key. By default, it is on.

Loading the File (loadObject)

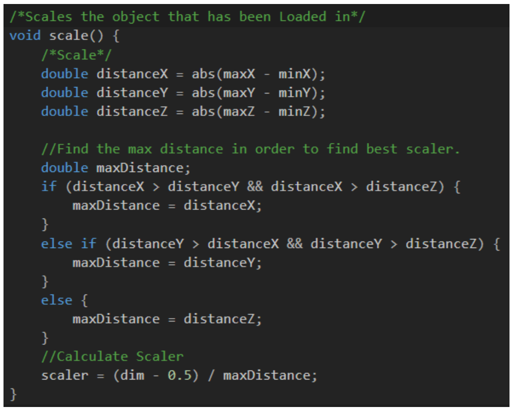


```
/*Loads the .OBJ file given*/
void loadObject(char* path) {

    //Grab File
    FILE *file = fopen(path, "r");
    if (file == NULL) {
        printf("Impossible to open the file !\n");
        return;
    }
    printf("Grabbed file successfully!\n");

    //Data Holders
    char c;
    GLfloat f1, f2, f3, *arrayfloat;
    GLint d1, d2, d3, *arrayint;
    vertices.clear();
    faces.clear();

    int initFlag = -1;
    while (!feof(file)) {
        //Get Datas
        fscanf(file, "%c", &c);

        //Store Vertices
        if (c == 'v') {
            //Set Vertices
            arrayfloat = new GLfloat[3];
            fscanf(file, "%f %f %f", &f1, &f2, &f3);
            arrayfloat[0] = f1;
            arrayfloat[1] = f2;
            arrayfloat[2] = f3;
            vertices.push_back(arrayfloat);

            //Set Mins and Maxes, will be used for Scaling and Translating.
            if (initFlag == -1) {
                minX = f1;
                maxX = f1;
                minY = f2;
                maxY = f2;
                minZ = f3;
                maxZ = f3;
                initFlag = 0;
            }
            if (f1 > maxX) { maxX = f1; }
            if (f1 < minX) { minX = f1; }
            if (f2 > maxY) { maxY = f2; }
            if (f2 < minY) { minY = f2; }
            if (f3 > maxZ) { maxZ = f3; }
            if (f3 < minZ) { minZ = f3; }
        }

        //Store Faces
        else if (c == 'f') {
            arrayint = new GLint[3];
            fscanf(file, "%d %d %d", &d1, &d2, &d3);

            arrayint[0] = d1;
            arrayint[1] = d2;
            arrayint[2] = d3;
            faces.push_back(arrayint);
        }
    }
    fclose(file);
    normalize();
    scale();
}
```

This function take the object the as a parameter and sets our global vertices and faces variables with the data the OBJ file contains. This function also sets the min/max values that will be later used for scaling/transitioning our object.

Scaling (Scale)

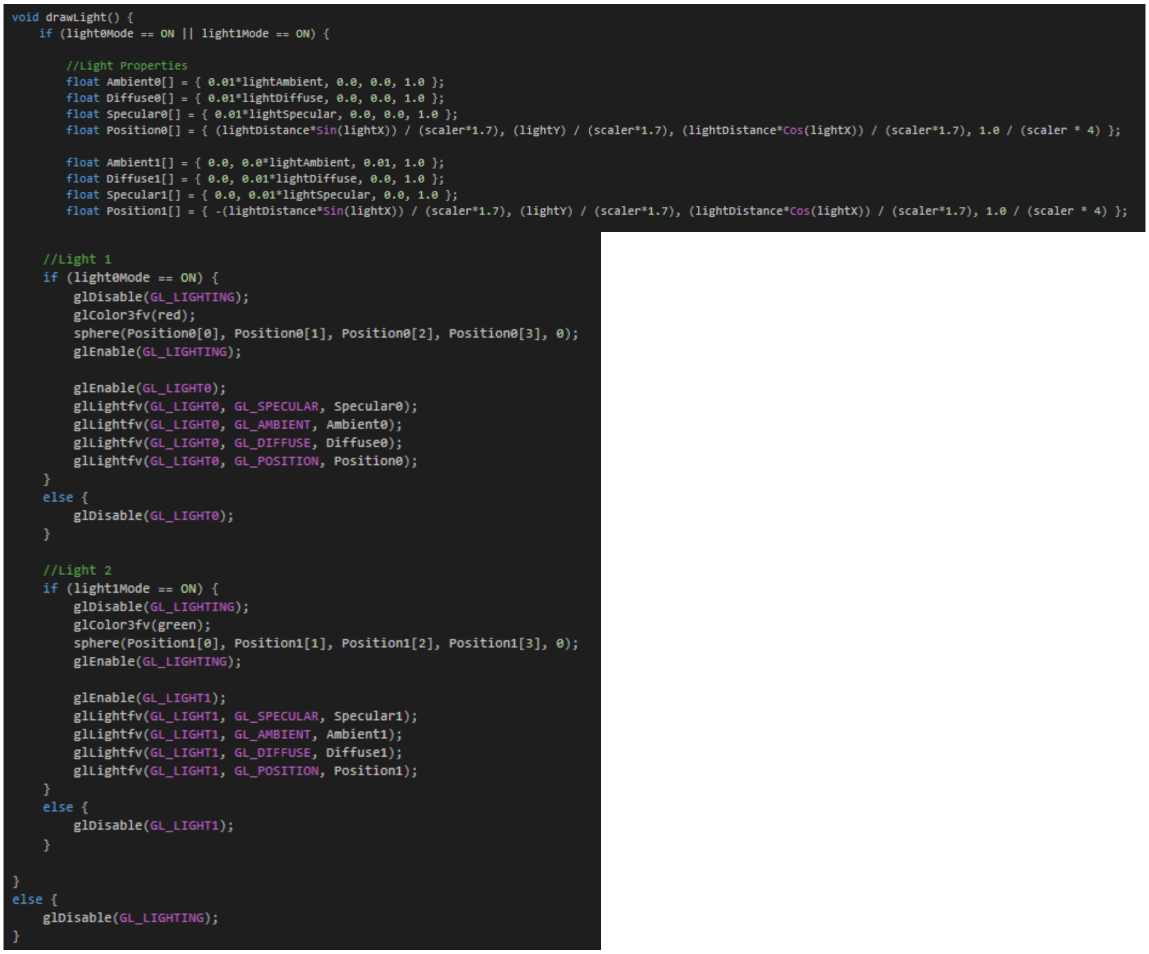
This scale method finds the greatest distance between the X, Y, and Z axis and uses that as a scaler for this Object. The reason we use the longest distance is so that we can scale everything equally whilst still being in our view.



```
/*Scales the object that has been Loaded in*/
void scale() {
    /*Scale*/
    double distanceX = abs(maxX - minX);
    double distanceY = abs(maxY - minY);
    double distanceZ = abs(maxZ - minZ);

    //Find the max distance in order to find best scaler.
    double maxDistance;
    if (distanceX > distanceY && distanceX > distanceZ) {
        maxDistance = distanceX;
    }
    else if (distanceY > distanceX && distanceY > distanceZ) {
        maxDistance = distanceY;
    }
    else {
        maxDistance = distanceZ;
    }
    //Calculate Scaler
    scaler = (dim - 0.5) / maxDistance;
}
```

LightSources

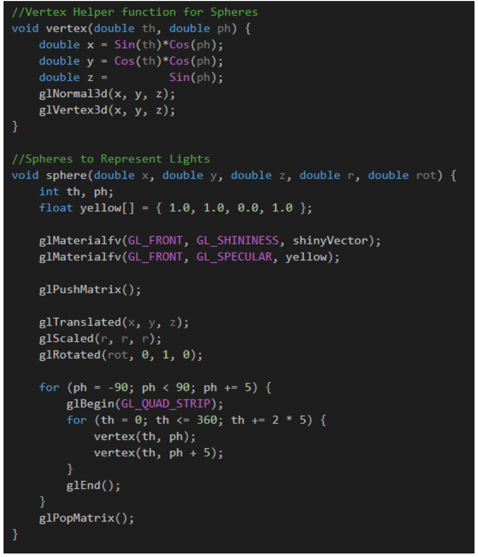
This is our function to create our light sources. Note to adjustable RGBA values for each light. Also note how we use the scalar on the light source to keep a constant size throughout objects. Light Sources are toggle-able as well.



```
void drawLight() {
    if (light0Mode == ON || light1Mode == ON) {

        //Light Properties
        float Ambient0[] = { 0.01*lightAmbient, 0.0, 0.0, 1.0 };
        float Diffuse0[] = { 0.01*lightDiffuse, 0.0, 0.0, 1.0 };
        float Specular0[] = { 0.01*lightSpecular, 0.0, 0.0, 1.0 };
        float Position0[] = { (lightDistance*Sin(lightX)) / (scaler*1.7), (lightY) / (scaler*1.7), (lightDistance*Cos(lightX)) / (scaler*1.7), 1.0 / (scaler * 4) };

        float Ambient1[] = { 0.0, 0.0*lightAmbient, 0.01, 1.0 };
        float Diffuse1[] = { 0.0, 0.01*lightDiffuse, 0.0, 1.0 };
        float Specular1[] = { 0.0, 0.01*lightSpecular, 0.0, 1.0 };
        float Position1[] = { -(lightDistance*Sin(lightX)) / (scaler*1.7), (lightY) / (scaler*1.7), (lightDistance*Cos(lightX)) / (scaler*1.7), 1.0 / (scaler * 4) };

    //Light 1
    if (light0Mode == ON) {
        glDisable(GL_LIGHTING);
        glColor3fv(red);
        sphere(Position0[0], Position0[1], Position0[2], Position0[3], 0);
        glEnable(GL_LIGHTING);

        glEnable(GL_LIGHT0);
        glLightfv(GL_LIGHT0, GL_SPECULAR, Specular0);
        glLightfv(GL_LIGHT0, GL_AMBIENT, Ambient0);
        glLightfv(GL_LIGHT0, GL_DIFFUSE, Diffuse0);
        glLightfv(GL_LIGHT0, GL_POSITION, Position0);
    }
    else {
        glDisable(GL_LIGHT0);
    }

    //Light 2
    if (light1Mode == ON) {
        glDisable(GL_LIGHTING);
        glColor3fv(green);
        sphere(Position1[0], Position1[1], Position1[2], Position1[3], 0);
        glEnable(GL_LIGHTING);

        glEnable(GL_LIGHT1);
        glLightfv(GL_LIGHT1, GL_SPECULAR, Specular1);
        glLightfv(GL_LIGHT1, GL_AMBIENT, Ambient1);
        glLightfv(GL_LIGHT1, GL_DIFFUSE, Diffuse1);
        glLightfv(GL_LIGHT1, GL_POSITION, Position1);
    }
    else {
        glDisable(GL_LIGHT1);
    }

}
else {
    glDisable(GL_LIGHTING);
}
```

LightSource Spheres

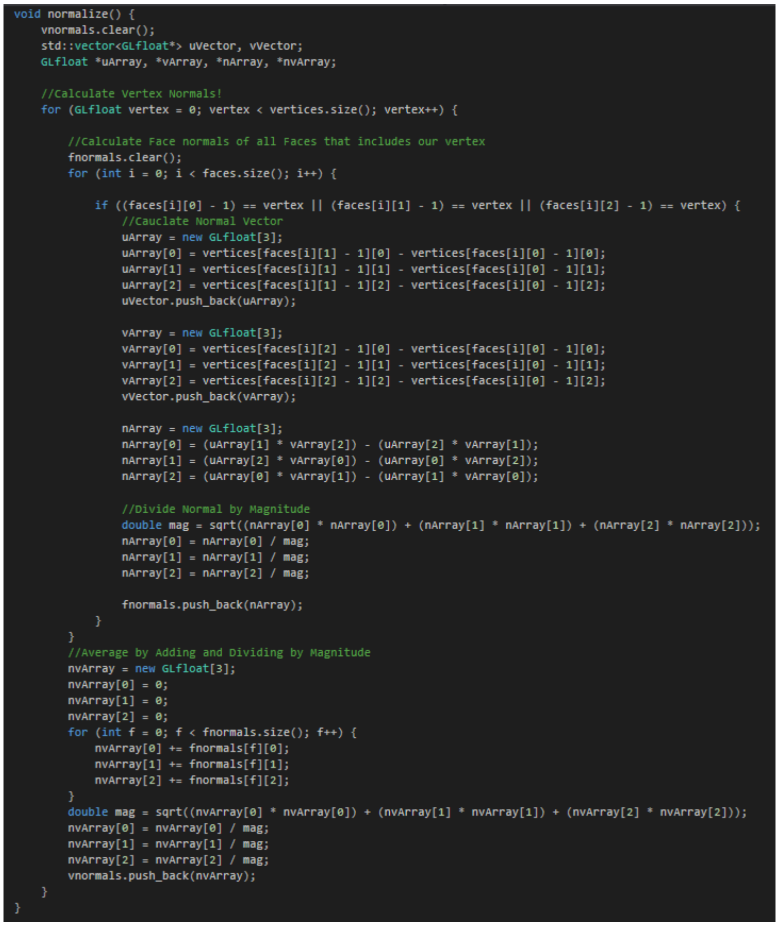
This function simply puts a sphere where the light source radiates from.



```
//Vertex Helper function for Spheres
void vertex(double th, double ph) {
    double x = Sin(th)*Cos(ph);
    double y = Cos(th)*Cos(ph);
    double z =         Sin(ph);
    glNormal3d(x, y, z);
    glVertex3d(x, y, z);
}

//Spheres to Represent Lights
void sphere(double x, double y, double z, double r, double rot) {
    int th, ph;
    float yellow[] = { 1.0, 1.0, 0.0, 1.0 };

    glMaterialfv(GL_FRONT, GL_SHININESS, shinyVector);
    glMaterialfv(GL_FRONT, GL_SPECULAR, yellow);

    glPushMatrix();

    glTranslated(x, y, z);
    glScaled(r, r, r);
    glRotated(rot, 0, 1, 0);

    for (ph = -90; ph < 90; ph += 5) {
        glBegin(GL_QUAD_STRIP);
        for (th = 0; th <= 360; th += 2 * 5) {
            vertex(th, ph);
            vertex(th, ph + 5);
        }
        glEnd();
    }
    glPopMatrix();
}
```

Normal Vectors

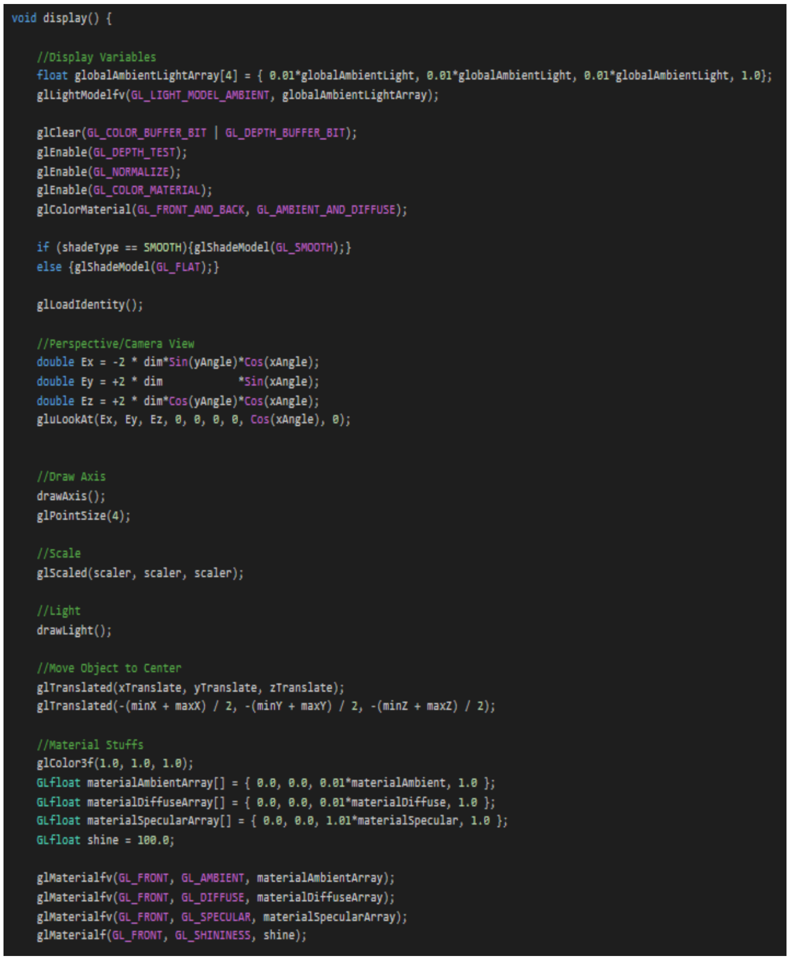
As described above, this is our ‘normalize’ function that calculates the normal vectors for all vertexes.



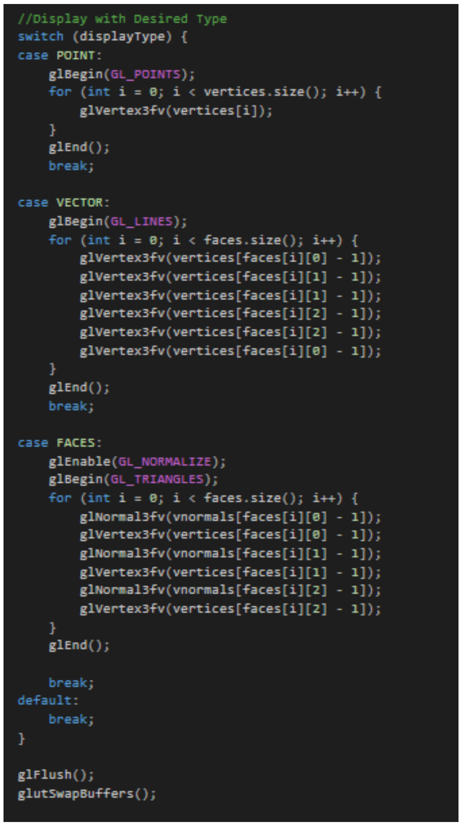
```
void normalize() {
    vnormals.clear();
    std::vector<GLfloat*> uVector, vVector;
    GLfloat *uArray, *vArray, *nArray, *nvArray;

    //Calculate Vertex Normals!
    for (GLfloat vertex = 0; vertex < vertices.size(); vertex++) {

        //Calculate Face normals of all Faces that includes our vertex
        fnormals.clear();
        for (int i = 0; i < faces.size(); i++) {

            if ((faces[i][0] - 1) == vertex || (faces[i][1] - 1) == vertex || (faces[i][2] - 1) == vertex) {
                //Cauclate Normal Vector
                uArray = new GLfloat[3];
                uArray[0] = vertices[faces[i][1] - 1][0] - vertices[faces[i][0] - 1][0];
                uArray[1] = vertices[faces[i][1] - 1][1] - vertices[faces[i][0] - 1][1];
                uArray[2] = vertices[faces[i][1] - 1][2] - vertices[faces[i][0] - 1][2];
                uVector.push_back(uArray);

                vArray = new GLfloat[3];
                vArray[0] = vertices[faces[i][2] - 1][0] - vertices[faces[i][0] - 1][0];
                vArray[1] = vertices[faces[i][2] - 1][1] - vertices[faces[i][0] - 1][1];
                vArray[2] = vertices[faces[i][2] - 1][2] - vertices[faces[i][0] - 1][2];
                vVector.push_back(vArray);

                nArray = new GLfloat[3];
                nArray[0] = (uArray[1] * vArray[2]) - (uArray[2] * vArray[1]);
                nArray[1] = (uArray[2] * vArray[0]) - (uArray[0] * vArray[2]);
                nArray[2] = (uArray[0] * vArray[1]) - (uArray[1] * vArray[0]);

                //Divide Normal by Magnitude
                double mag = sqrt((nArray[0] * nArray[0]) + (nArray[1] * nArray[1]) + (nArray[2] * nArray[2]));
                nArray[0] = nArray[0] / mag;
                nArray[1] = nArray[1] / mag;
                nArray[2] = nArray[2] / mag;

                fnormals.push_back(nArray);
            }
        }
        //Average by Adding and Dividing by Magnitude
        nvArray = new GLfloat[3];
        nvArray[0] = 0;
        nvArray[1] = 0;
        nvArray[2] = 0;
        for (int f = 0; f < fnormals.size(); f++) {
            nvArray[0] += fnormals[f][0];
            nvArray[1] += fnormals[f][1];
            nvArray[2] += fnormals[f][2];
        }
        double mag = sqrt((nvArray[0] * nvArray[0]) + (nvArray[1] * nvArray[1]) + (nvArray[2] * nvArray[2]));
        nvArray[0] = nvArray[0] / mag;
        nvArray[1] = nvArray[1] / mag;
        nvArray[2] = nvArray[2] / mag;
        vnormals.push_back(nvArray);
    }
}
```

Display

Our display function has been updated to only handle perspective camera view. Important variables are also set here (depending on flags set). One of which is the Shadetype(GL_SMOOTH/GL_FLAT). Also notice the adjusted material values put in place for the objects to be created.

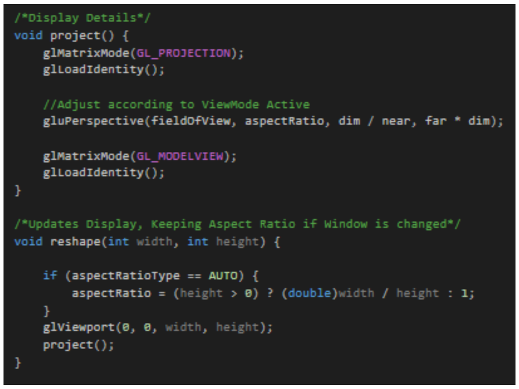


```
void display() {

    //Display Variables
    float globalAmbientLightArray[4] = { 0.01*globalAmbientLight, 0.01*globalAmbientLight, 0.01*globalAmbientLight, 1.0};
    glLightModelfv(GL_LIGHT_MODEL_AMBIENT, globalAmbientLightArray);

    glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);
    glEnable(GL_DEPTH_TEST);
    glEnable(GL_NORMALIZE);
    glEnable(GL_COLOR_MATERIAL);
    glColorMaterial(GL_FRONT_AND_BACK, GL_AMBIENT_AND_DIFFUSE);

    if (shadeType == SMOOTH){glShadeModel(GL_SMOOTH);}
    else {glShadeModel(GL_FLAT);}

    glLoadIdentity();

    //Perspective/Camera View
    double Ex = -2 * dim*Sin(yAngle)*Cos(xAngle);
    double Ey = +2 * dim           *Sin(xAngle);
    double Ez = +2 * dim*Cos(yAngle)*Cos(xAngle);
    gluLookAt(Ex, Ey, Ez, 0, 0, 0, 0, Cos(xAngle), 0);


    //Draw Axis
    drawAxis();
    glPointSize(4);

    //Scale
    glScaled(scaler, scaler, scaler);

    //Light
    drawLight();

    //Move Object to Center
    glTranslated(xTranslate, yTranslate, zTranslate);
    glTranslated(-(minX + maxX) / 2, -(minY + maxY) / 2, -(minZ + maxZ) / 2);

    //Material Stuffs
    glColor3f(1.0, 1.0, 1.0);
    GLfloat materialAmbientArray[] = { 0.0, 0.0, 0.01*materialAmbient, 1.0 };
    GLfloat materialDiffuseArray[] = { 0.0, 0.0, 0.01*materialDiffuse, 1.0 };
    GLfloat materialSpecularArray[] = { 0.0, 0.0, 1.01*materialSpecular, 1.0 };
    GLfloat shine = 100.0;

    glMaterialfv(GL_FRONT, GL_AMBIENT, materialAmbientArray);
    glMaterialfv(GL_FRONT, GL_DIFFUSE, materialDiffuseArray);
    glMaterialfv(GL_FRONT, GL_SPECULAR, materialSpecularArray);
    glMaterialf(GL_FRONT, GL_SHININESS, shine);
```



```
//Display with Desired Type
switch (displayType) {
case POINT:
    glBegin(GL_POINTS);
    for (int i = 0; i < vertices.size(); i++) {
        glVertex3fv(vertices[i]);
    }
    glEnd();
    break;

case VECTOR:
    glBegin(GL_LINES);
    for (int i = 0; i < faces.size(); i++) {
        glVertex3fv(vertices[faces[i][0] - 1]);
        glVertex3fv(vertices[faces[i][1] - 1]);
        glVertex3fv(vertices[faces[i][1] - 1]);
        glVertex3fv(vertices[faces[i][2] - 1]);
        glVertex3fv(vertices[faces[i][2] - 1]);
        glVertex3fv(vertices[faces[i][0] - 1]);
    }
    glEnd();
    break;

case FACES:
    glEnable(GL_NORMALIZE);
    glBegin(GL_TRIANGLES);
    for (int i = 0; i < faces.size(); i++) {
        glNormal3fv(vnormals[faces[i][0] - 1]);
        glVertex3fv(vertices[faces[i][0] - 1]);
        glNormal3fv(vnormals[faces[i][1] - 1]);
        glVertex3fv(vertices[faces[i][1] - 1]);
        glNormal3fv(vnormals[faces[i][2] - 1]);
        glVertex3fv(vertices[faces[i][2] - 1]);
    }
    glEnd();

    break;
default:
    break;
}

glFlush();
glutSwapBuffers();
```

Reshape



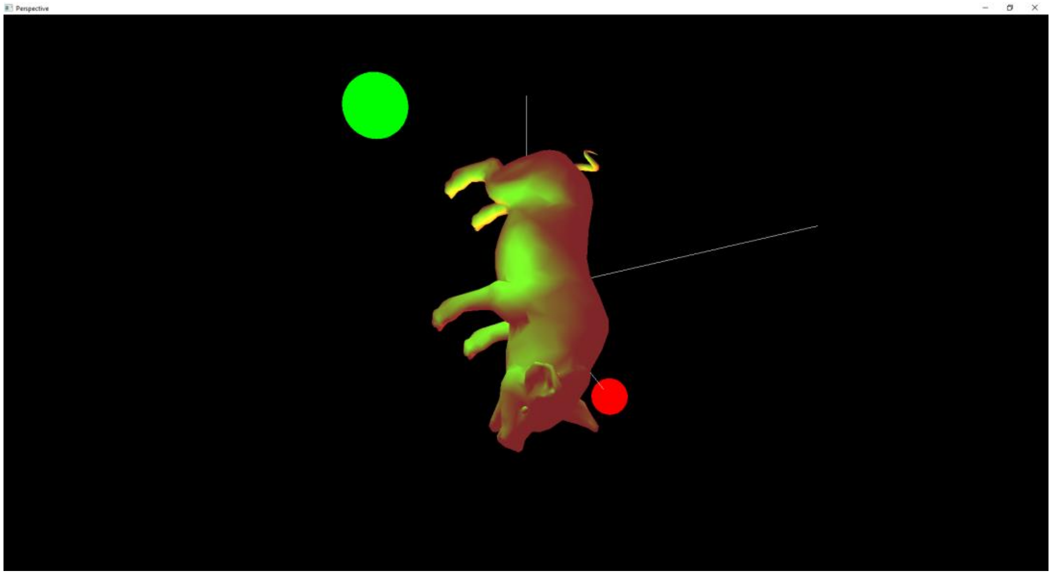
```
/*Display Details*/
void project() {
    glMatrixMode(GL_PROJECTION);
    glLoadIdentity();

    //Adjust according to ViewMode Active
    gluPerspective(fieldOfView, aspectRatio, dim / near, far * dim);

    glMatrixMode(GL_MODELVIEW);
    glLoadIdentity();
}

/*Updates Display, Keeping Aspect Ratio if Window is changed*/
void reshape(int width, int height) {

    if (aspectRatioType == AUTO) {
        aspectRatio = (height > 0) ? (double)width / height : 1;
    }
    glViewport(0, 0, width, height);
    project();
}
```

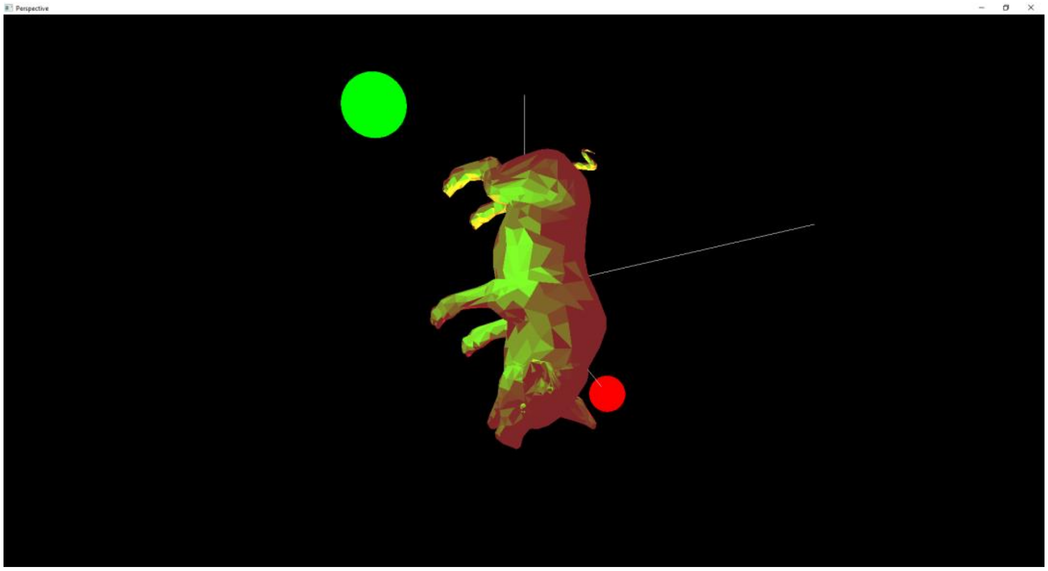
Our reshape function is still very basic and has been redesigned to only handle projection/perspective mode rather than offering an orthographic option. Also note the Aspect Ratio Adjustability.

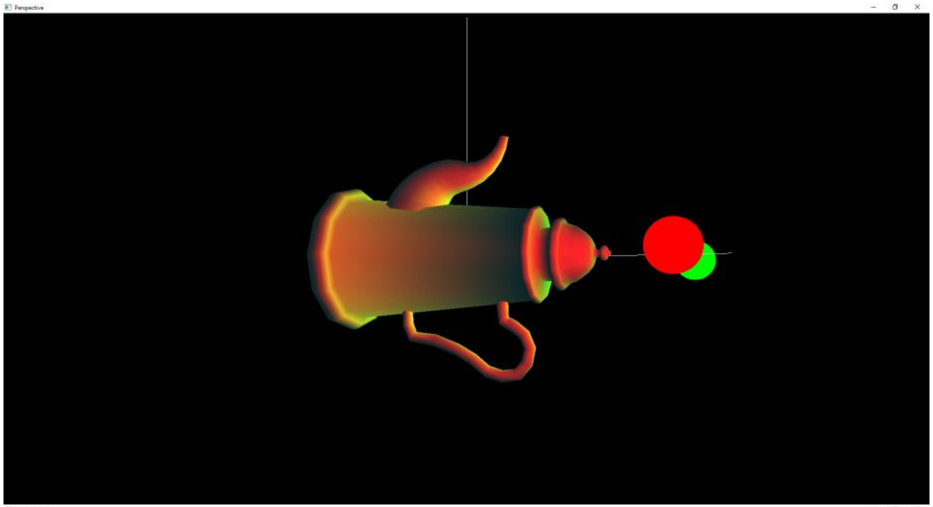
Keyboard Input
Key: Esc exits the program.
Keys: 1,2,3 loads in different Objects.
Keys: a,s,d changes display type.
Key: i toggles the XYZ grid.
Keys: +,- Zooms In/Out (field of view).
Keys: b,B Scales Objects.
Keys: t,T Changes the Aspect Ratio.
Keys: g,G controls the clipping range for the near value.
Keys: f,F controls the clipping range for the far value.
Keys: l,L toggles lights 1 and 2.
Keys: <,> rotates the lights.
Keys: [,],{,} moves lights.
Keys: o,O adjusts the Global Ambience.
Keys: h,H adjusts lightAmbient.
Keys: j,J adjusts the lightDiffuse.
Keys: k,K adjusts the lightSpecular.
Keys: n,N adjusts the materialAmbient.
Keys: c,C adjusts the materialDiffuse.
Keys: v,V adjusts the materiaSpecular.
Key: q toggles the ShadeType.
Keys: x,X,y,Y,z,Z Translates objects.
Key: r resets the object.
Arrow Keys adjusts/rotates object/view incrementally.
Click and Drag to Rotate Object, further you drag quicker it rotates.

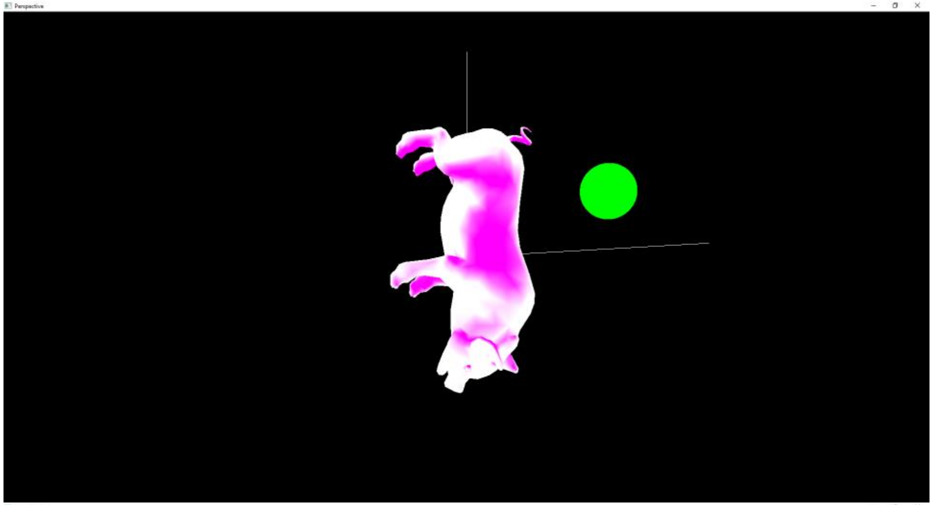
The Output

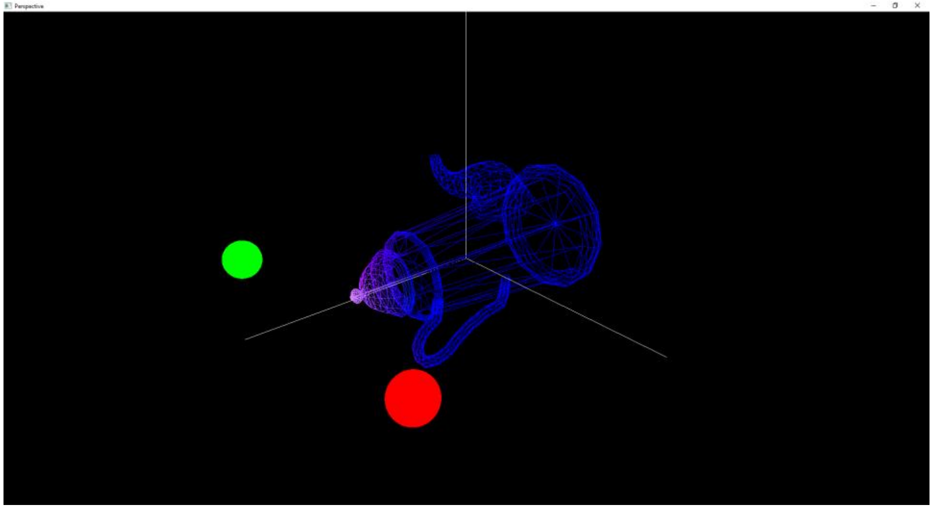
The following are samples of outputs. Note how the Spheres represent the lightsources. Also note how the smoothing technique drastically affects how our objects looks. Adjusting the ambience, diffuse, and specular yields us very creative and interesting results as well!











The only issue I ran into is the loadtime when calculating the normal vectors for each vertex, though this may not be able to be helped.