Assignment 2: Transformations & Additional Primitives

1 代码实现

1.1 修改intersect函数返回法向量

```
 virtual bool intersect(const Ray& r, Hit& h, float tmin)
    {
        Ray raySphereSpace(r.getOrigin() - center, r.getDirection());
        float disRayOrigin = raySphereSpace.getOrigin().Length();

        float a =
raySphereSpace.getDirection().Dot3(raySphereSpace.getDirection());
        float b = 2 *
raySphereSpace.getDirection().Dot3(raySphereSpace.getOrigin());
        float c = raySphereSpace.getOrigin().Dot3(raySphereSpace.getOrigin()) -
radius * radius;
        float delta = b * b - 4 * a * c;
        if (delta < 0)
        {
            return false;
        }
        delta = sqrtf(delta);
        float t1 = (-b - delta) / (2 * a);
        float t2 = (-b + delta) / (2 * a);
        Vec3f p1 = r.pointAtParameter(t1);
        Vec3f p2 = r.pointAtParameter(t2);
        Vec3f n1 = p1 - center;
        Vec3f n2 = p2 - center;
        n1.Normalize();
        n2.Normalize();
        if (t1 > tmin )
        {
            if (t1 < h.getT())
            {
                h.set(t1, getMaterial(), n1, r);
                return true;
            }
        }
        else if (t2 > tmin)
        {
            if (t2 < h.getT())
            {
                h.set(t2, getMaterial(), n2, r);
                return true;
            }
```

```
        }
        return false;
    }
```

1.2 Plane类

```
class Plane :public Object3D
{
public:
    Plane(Vec3f& normal, float d, Material* m):Object3D(m),normal(normal),d(d)
    {
        this->normal.Normalize();
    }

    Plane(Vec3f a, Vec3f b, Vec3f c,Material* m):Object3D(m)
    {
        Vec3f::Cross3(normal, b - a, c - b);
        normal.Normalize();
        d = fabsf(a.Dot3(normal));
    }
    ~Plane(){}
    bool intersect(const Ray& r, Hit& h, float tmin)
    {
        if (normal.Dot3(r.getDirection()) == 0)
        {
            return false;
        }

        float t = (d - normal.Dot3(r.getOrigin())) /
normal.Dot3(r.getDirection());
        if (t>tmin)
        {
            if (t < h.getT())
            {
                h.set(t, getMaterial(), normal, r);
                return true;
            }
            //return true;
        }
        return false;
    }

private:
    Vec3f normal;
    float d;

};
```

1.3 Transform类

```
class Transform :public Object3D
{
public:
    Transform(Matrix& m, Object3D* o):transform(m),object(o)
    {
    }
    ~Transform()
    {
        delete object;
    }

    virtual bool intersect(const Ray& r, Hit& h, float tmin)
    {
        //cout << "here" << endl;
        //transform ray from world space to object space
        Matrix inverseTransform = transform;
        assert(inverseTransform.Inverse());
        Vec3f rayOriginOS = r.getOrigin();
        Vec3f rayDirectionOS = r.getDirection();

        inverseTransform.Transform(rayOriginOS);
        inverseTransform.TransformDirection(rayDirectionOS);

        float ratio = rayDirectionOS.Length();

        //store the transform ratio
        //float ratio = r.getDirection().x() / rayDirectionOS.x();
        rayDirectionOS.Normalize();
        Ray rayOS(rayOriginOS,rayDirectionOS);

        //do intersect in object space
        Hit temph(h);
        temph.set(h.getT() * ratio, h.getMaterial(), h.getNormal(), rayOS);
        if (!object->intersect(rayOS, temph, tmin*ratio))
        {
            return false;
        }

        //transform normal from object space to world space
        inverseTransform.Transpose();
        Vec3f normalWS = temph.getNormal();
        inverseTransform.TransformDirection(normalWS);
        normalWS.Normalize();
        h.set(temph.getT()/ratio,temph.getMaterial(),normalWS,r);
        return true;
    }

private:
    Matrix transform;
    Object3D* object;

};
```

1.4 Triangle类

使用三角形重心坐标系求交

```
class Triangle :public Object3D
{
public:
    Triangle(Vec3f& a, Vec3f& b, Vec3f& c, Material* m) :Object3D(m), a(a),
b(b), c(c)
    {
        Vec3f::Cross3(normal, b - a, c - b);
        normal.Normalize();
    }
    ~Triangle() {};
    bool intersect(const Ray& r, Hit& h, float tmin)
    {
        Vec3f Ro = r.getOrigin();
        Vec3f Rd = r.getDirection();
        float detA = Matrix::det3x3(a.x() - b.x(), a.x() - c.x(), Rd.x(),
                        a.y()-b.y(),a.y()-c.y(),Rd.y(),
            a.z() - b.z(), a.z() - c.z(), Rd.z());
        float detBeta= Matrix::det3x3(a.x() - Ro.x(), a.x() - c.x(), Rd.x(),
            a.y() - Ro.y(), a.y() - c.y(), Rd.y(),
            a.z() - Ro.z(), a.z() - c.z(), Rd.z());
        float detGamma = Matrix::det3x3(a.x() - b.x(), a.x() - Ro.x(), Rd.x(),
            a.y() - b.y(), a.y() - Ro.y(), Rd.y(),
            a.z() - b.z(), a.z() - Ro.z(), Rd.z());

        float detT= Matrix::det3x3(a.x() - b.x(), a.x() - c.x(), a.x()-Ro.x(),
            a.y() - b.y(), a.y() - c.y(), a.y()-Ro.y(),
            a.z() - b.z(), a.z() - c.z(), a.z()-Ro.z());

        float beta = detBeta / detA;
        float gamma = detGamma / detA;
        float t = detT / detA;
        if (t > tmin && beta>0 && gamma > 0 && beta + gamma < 1)
        {
            if (t < h.getT())
            {
                h.set(t, getMaterial(), normal, r);
                return true;
            }
            //return true;
        }
        return false;
    }

private:
    Vec3f a;
    Vec3f b;
    Vec3f c;
    Vec3f normal;

};
```

1.5 透视相机类

假设virtual screen与center的距离为1，求出其他参数

```
class PerspectiveCamera :public Camera
{
public:
    PerspectiveCamera()
    {
        assert(0);
    }
    PerspectiveCamera(Vec3f center, Vec3f& direction, Vec3f& up, float
angle):center(center),direction(direction),up(up),angle(angle)
    {
        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();
        virtualScreenSize = 2 * tanf(angle / (float)2);
        this->tmin = 0;
    }
    ~PerspectiveCamera() {}
    Ray generateRay(Vec2f point)
    {
        float pointX, pointY;
        point.Get(pointX, pointY);

        Vec3f rayOrigin = center;
        Vec3f rayDirection = direction+(pointX - 0.5) * virtualScreenSize *
horizontal + (pointY - 0.5) * virtualScreenSize * up;
        rayDirection.Normalize();
        //cout << "Origin: " << origin<<endl;
        return Ray(rayOrigin, rayDirection);
    }

    virtual float getTMin() const
    {
        return tmin;
    }


private:
    Vec3f center;
    Vec3f horizontal;
    Vec3f up;
    Vec3f direction;
    float angle;
    float virtualScreenSize;
    float virtualScreenDistance = 1;
    float tmin;

};
```

1.6 渲染法向量函数

```
    void normalShader(char* outputFile)
    {
        Image outputImage(width, height);
        for (int i = 0; i < width * height; i++)
        {
            int x = i % width;
            int y = i / width;
            Vec3f N = hits[i].getNormal();
            Vec3f depthColor(fabsf(N.x()), fabsf(N.y()), fabsf(N.z()));
            outputImage.SetPixel(x, y, depthColor);
        }
        outputImage.SaveTGA(outputFile);
    }
```

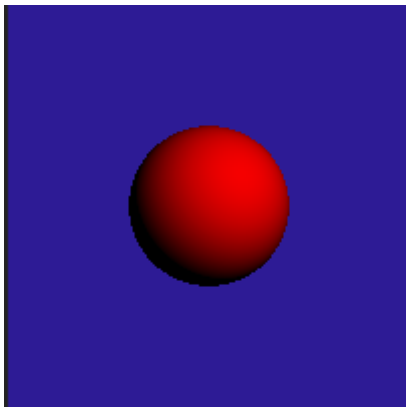
1.7 添加diffuse shading

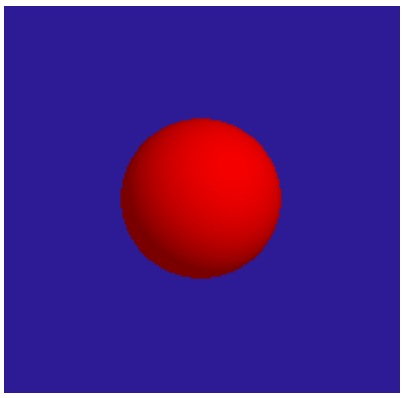
```
 void diffuseShader(char* outputFile,bool shadeBack)
    {
        Image outputImage(width, height);
        for (int i = 0; i < width * height; i++)
        {
            int x = i % width;
            int y = i / width;
            if (hits[i].getT() == INFINITY)
            {
                outputImage.SetPixel(x, y, scene->getBackgroundColor());
                continue;
            }
            Vec3f N = hits[i].getNormal();
            //cout << "N: " << N << endl;
            //if shade back
            if (shadeBack && rays[i].getDirection().Dot3(N) > 0)
            {
                N.Negate();
            }
            //no shade back and ray inside object
            if (!shadeBack && rays[i].getDirection().Dot3(N) > 0)
            {
                outputImage.SetPixel(x, y, Vec3f(0,0,0));
                continue;
            }
            Vec3f objectColor = hits[i].getMaterial()->getDiffuseColor();
            Vec3f ambientColor = scene->getAmbientLight() * objectColor;
            Vec3f diffuseColor(0,0,0);
            for (int i = 0; i < scene->getNumLights(); i++)
            {
                Vec3f L;
                Vec3f lightColor;
                scene->getLight(i)-
>getIllumination(hits[i].getIntersectionPoint(), L, lightColor);
                float temp = L.Dot3(N);
                if (temp < 0)
```

```
                    temp = 0;
                diffuseColor += temp * lightColor * objectColor;
            }
            Vec3f pixelColor =ambientColor+diffuseColor;
            outputImage.SetPixel(x, y, pixelColor);
        }
        outputImage.SaveTGA(outputFile);
    }
```

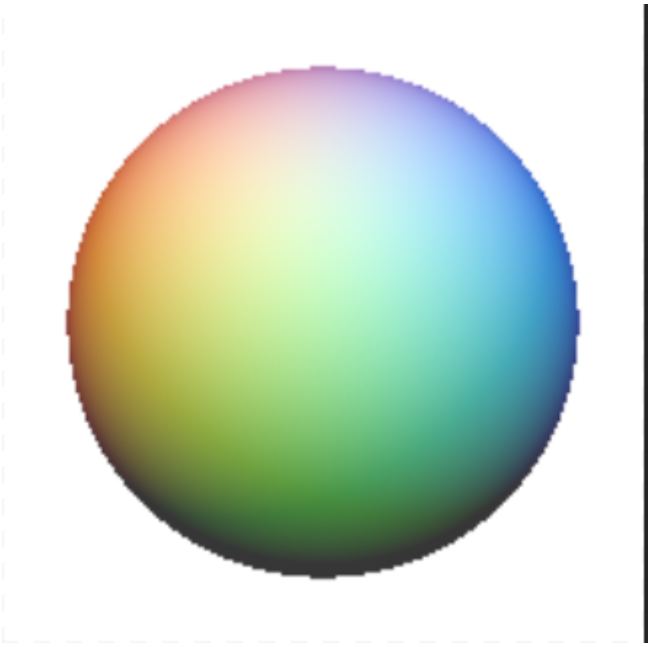
2 实验结果

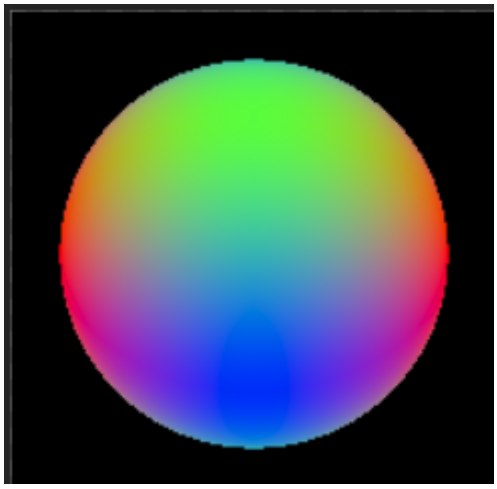
```
raytracer -input scene2_01_diffuse.txt -size 200 200 -output output2_01.tga
raytracer -input scene2_02_ambient.txt -size 200 200 -output output2_02.tga
```



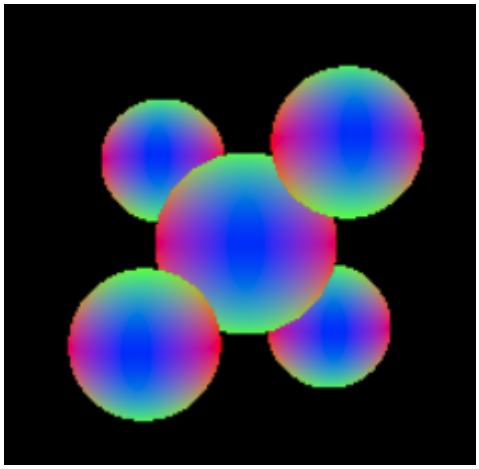


```
raytracer -input scene2_03_colored_lights.txt -size 200 200 -output
output2_03.tga -normals normals2_03.tga
```

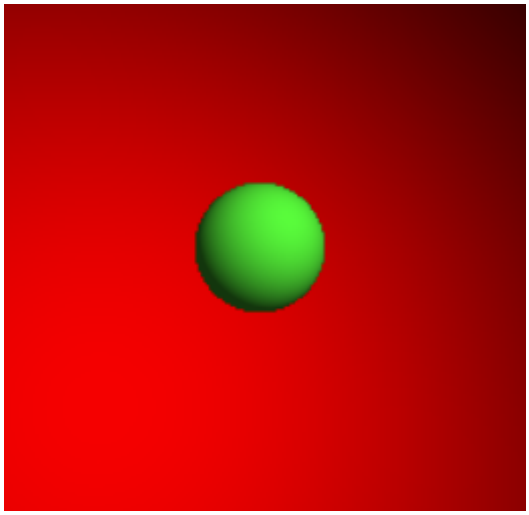


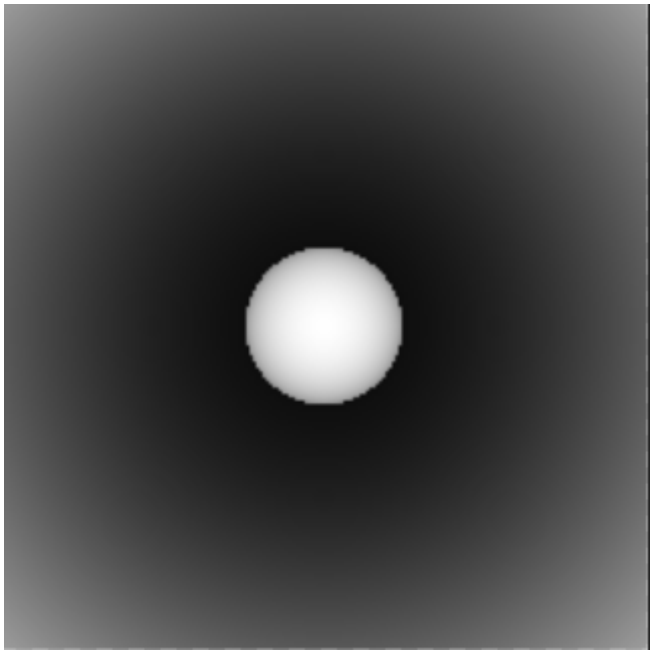


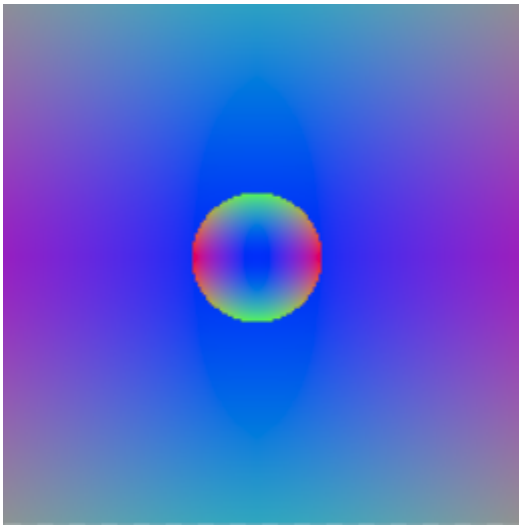
```
raytracer -input scene2_04_perspective.txt -size 200 200 -output output2_04.tga
-normals normals2_04.tga
```

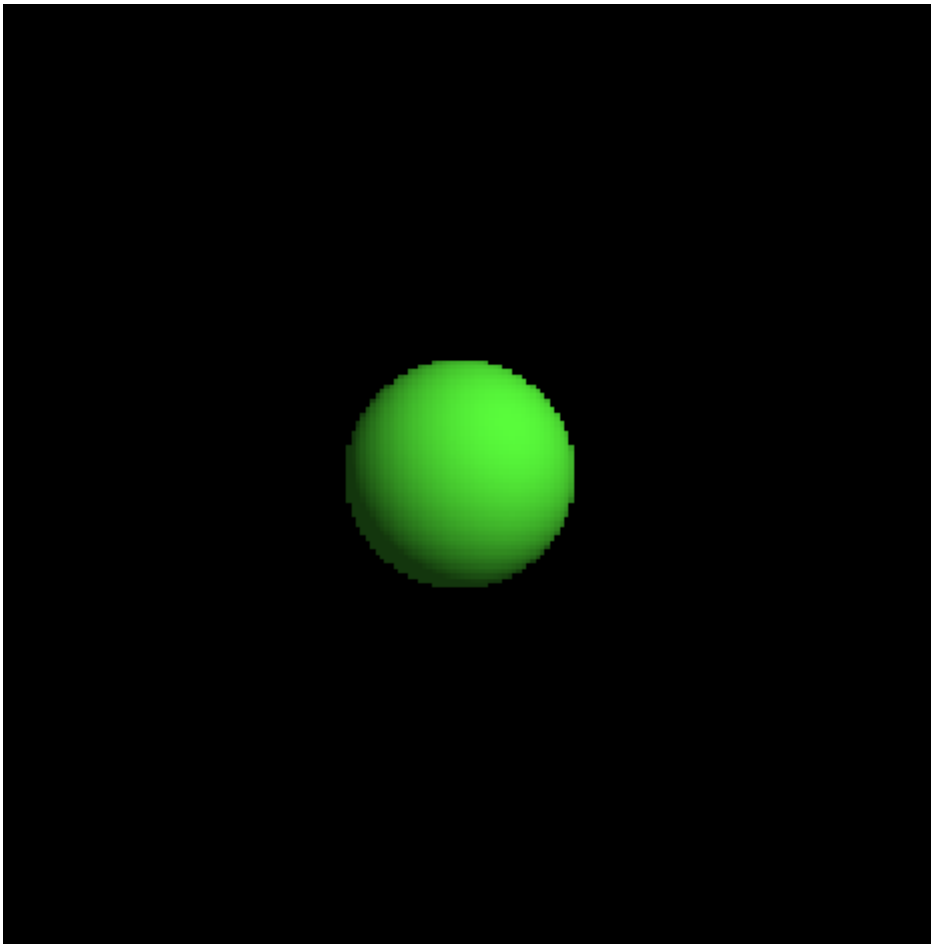


```
raytracer -input scene2_05_inside_sphere.txt -size 200 200 -output
output2_05.tga -depth 9 11 depth2_05.tga -normals normals2_05.tga -shade_back
raytracer -input scene2_05_inside_sphere.txt -size 200 200 -output
output2_05_no_back.tga
```

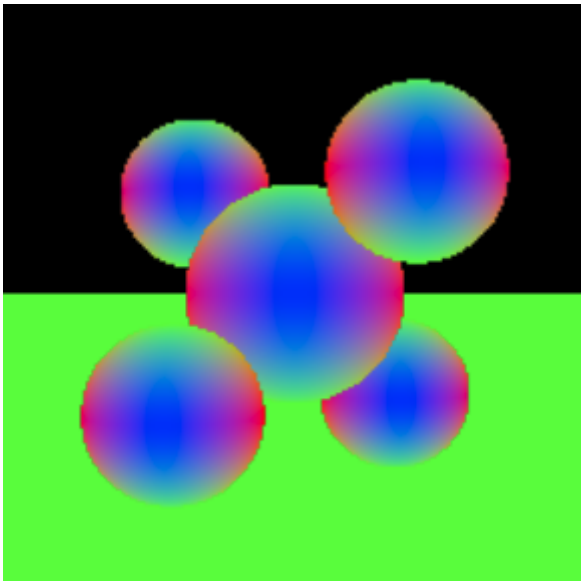




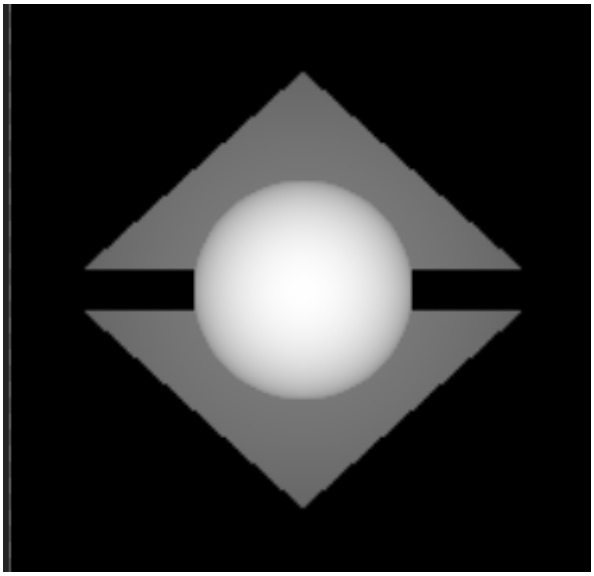


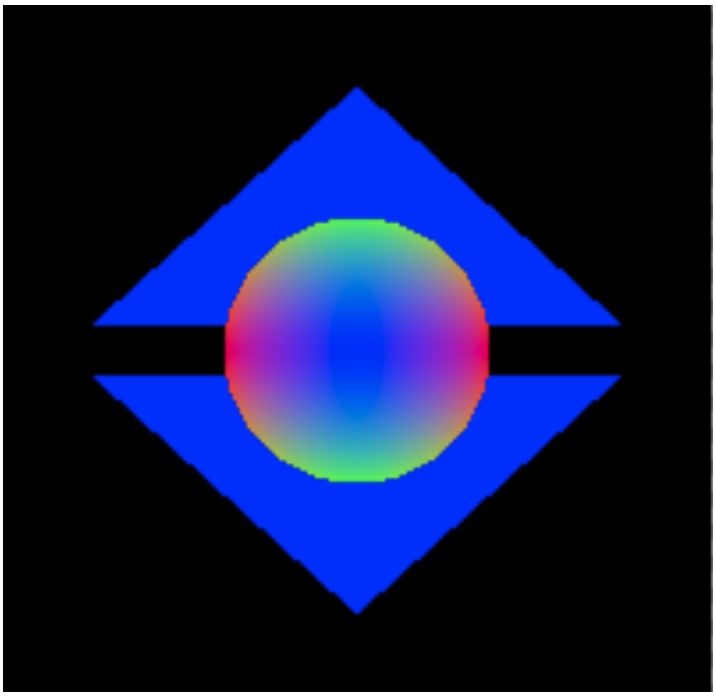


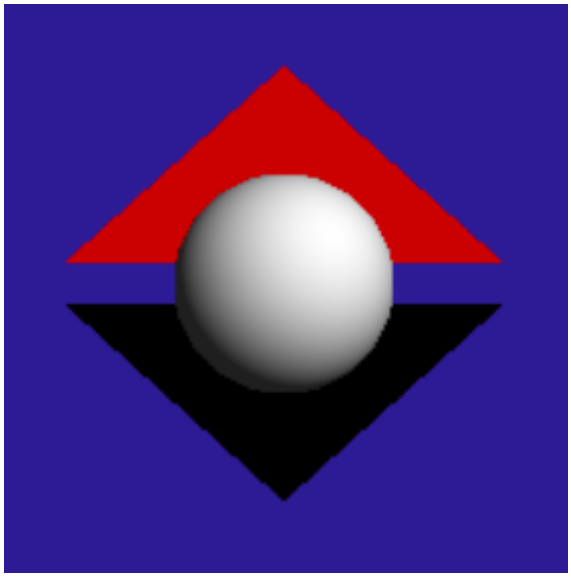
```
raytracer -input scene2_06_plane.txt -size 200 200 -output output2_06.tga -depth
8 20 depth2_06.tga -normals normals2_06.tga
```



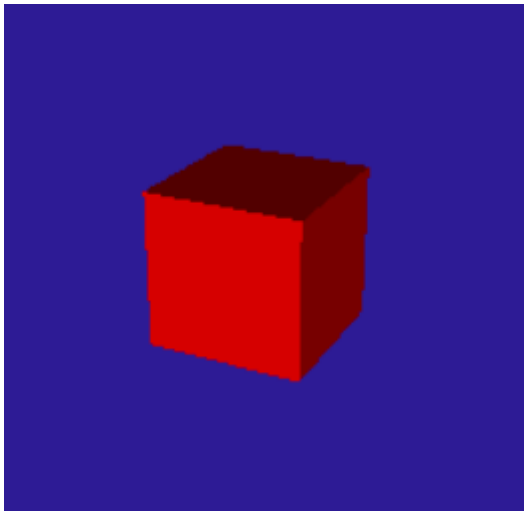
```
raytracer -input scene2_07_sphere_triangles.txt -size 200 200 -output
output2_07.tga -depth 9 11 depth2_07.tga -normals normals2_07.tga -shade_back
raytracer -input scene2_07_sphere_triangles.txt -size 200 200 -output
output2_07_no_back.tga
```



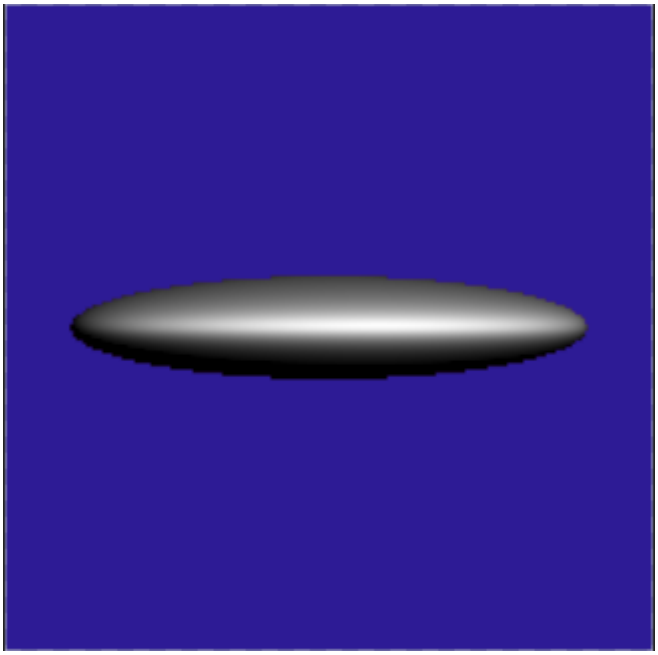


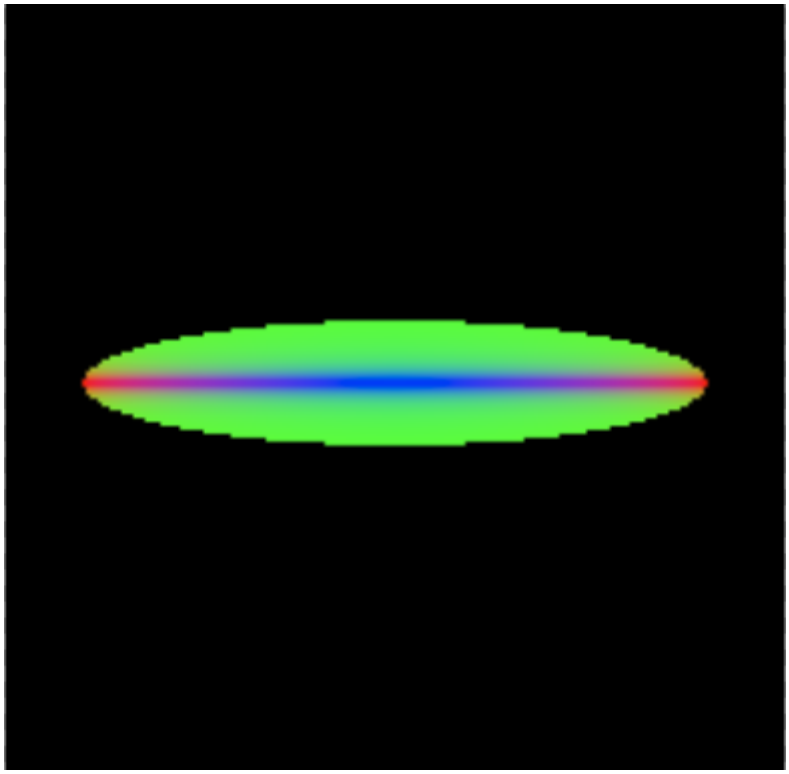


```
raytracer -input scene2_08_cube.txt -size 200 200 -output output2_08.tga
raytracer -input scene2_09_bunny_200.txt -size 200 200 -output output2_09.tga
raytracer -input scene2_10_bunny_1k.txt -size 200 200 -output output2_10.tga
```

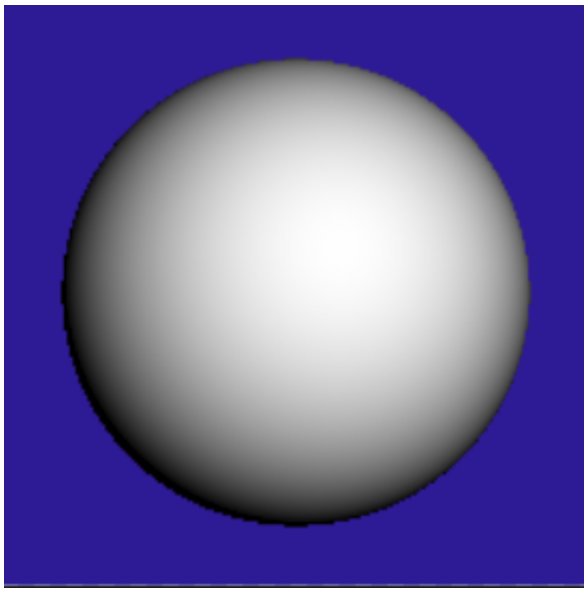


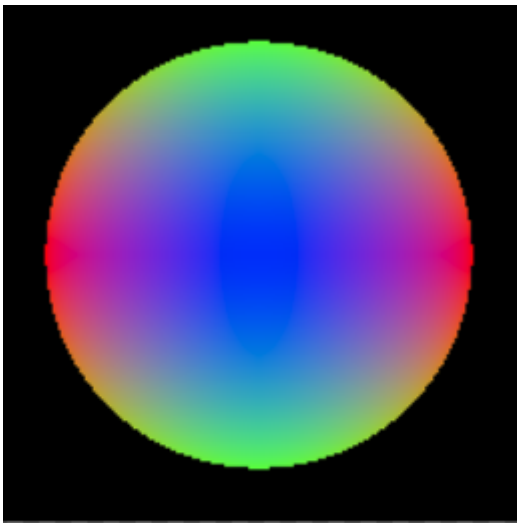
```
raytracer -input scene2_11_squashed_sphere.txt -size 200 200 -output
output2_11.tga -normals normals2_11.tga
```



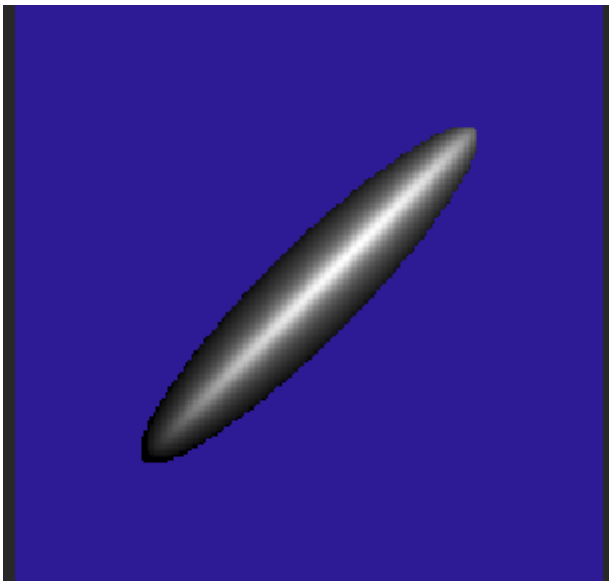


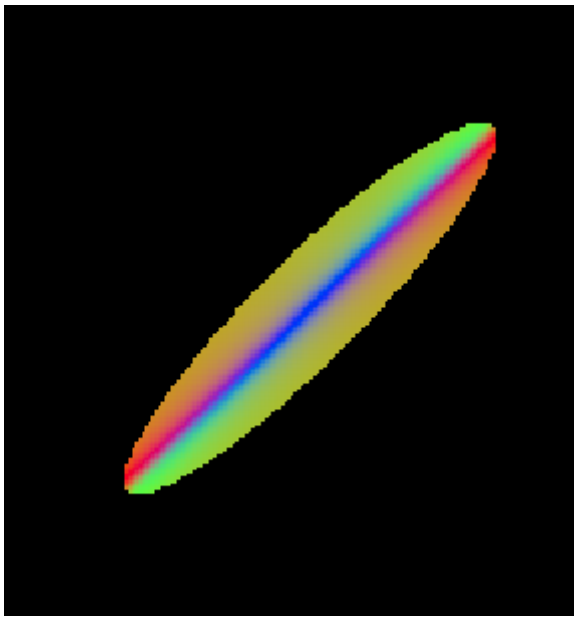
```
raytracer -input scene2_12_rotated_sphere.txt -size 200 200 -output
output2_12.tga -normals normals2_12.tga
```



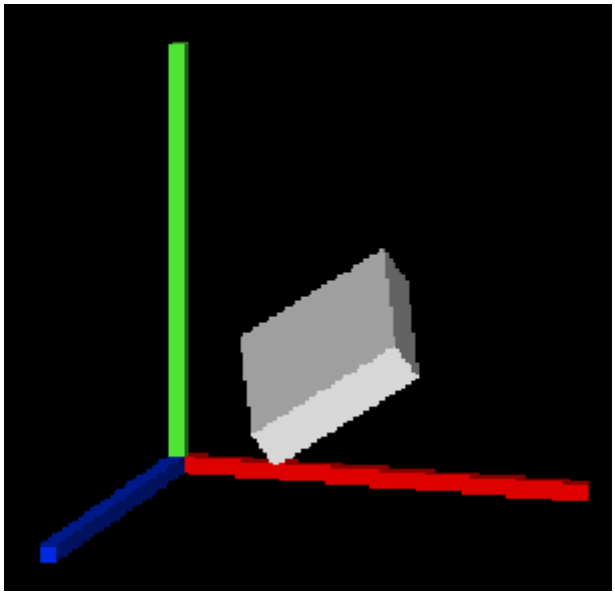


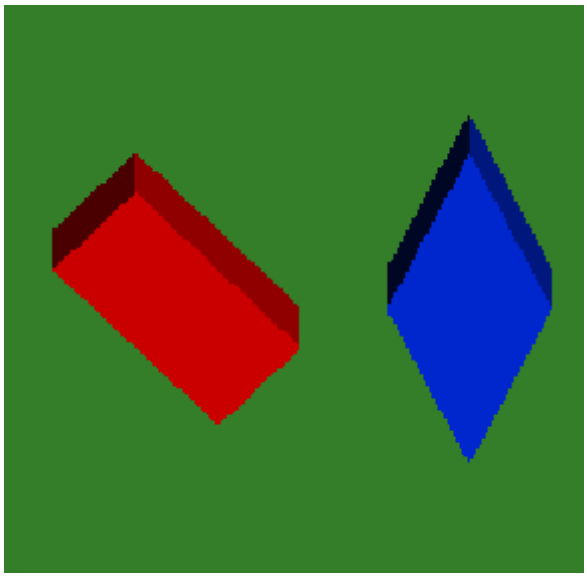
```
raytracer -input scene2_13_rotated_squashed_sphere.txt -size 200 200 -output
output2_13.tga -normals normals2_13.tga
```





```
raytracer -input scene2_14_axes_cube.txt -size 200 200 -output output2_14.tga
raytracer -input scene2_15_crazy_transforms.txt -size 200 200 -output
output2_15.tga
```





```
raytracer -input scene2_16_t_scale.txt -size 200 200 -output output2_16.tga -
depth 2 7 depth2_16.tga
```