

Advanced Computer Graphics: Final Report

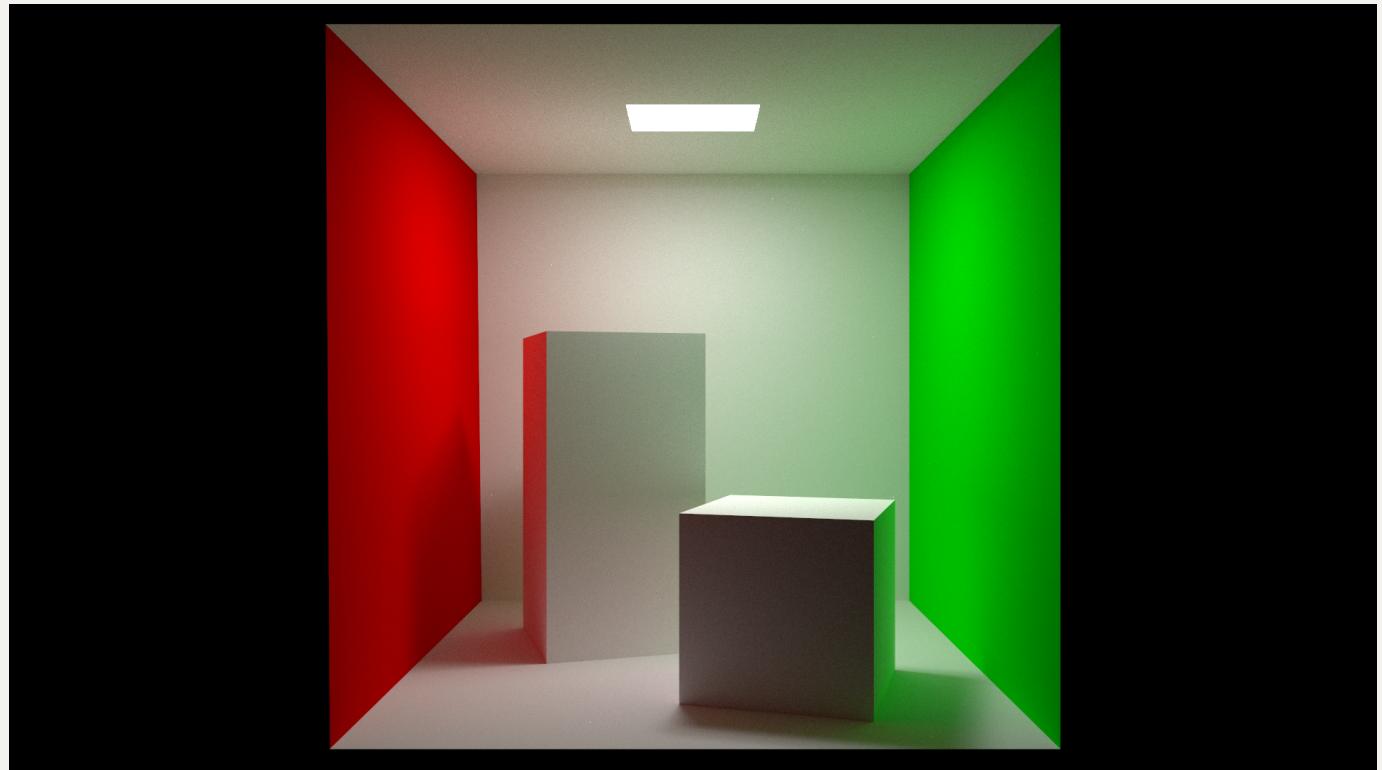
Yanpeng Wei, 2021010795

Yiyin Wang, 2020011604

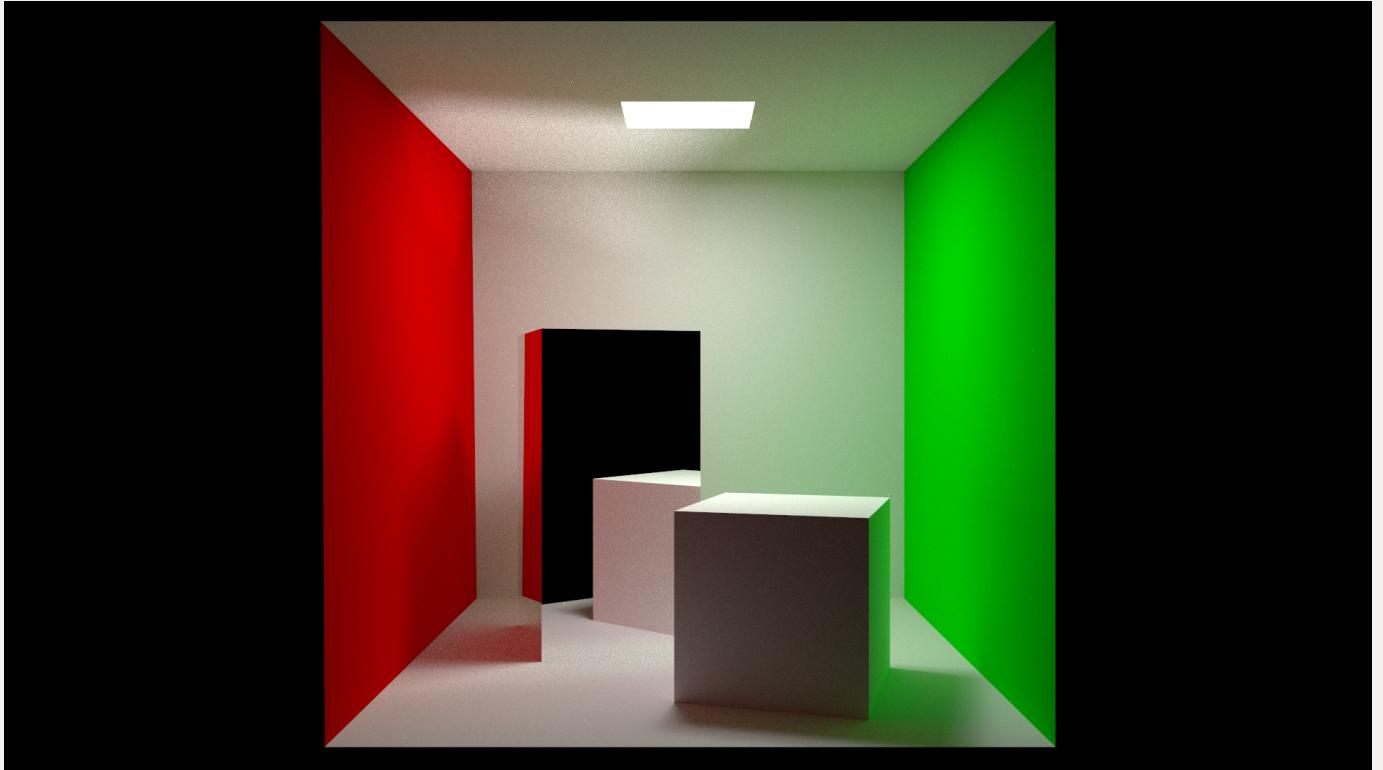
git: [altramarine/sparkium](https://github.com/altramarine/sparkium)

Base

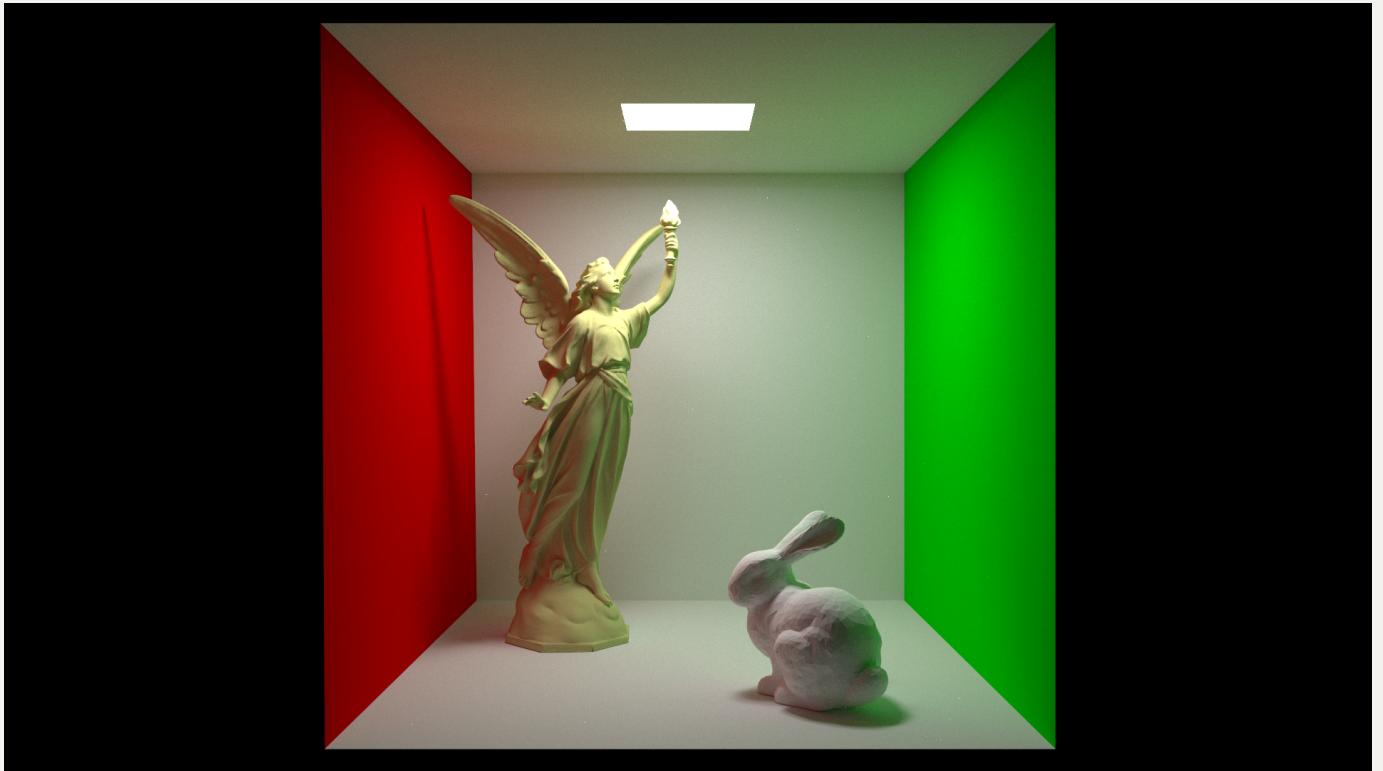
Cornell Box



Specular



Lucy & Bunny



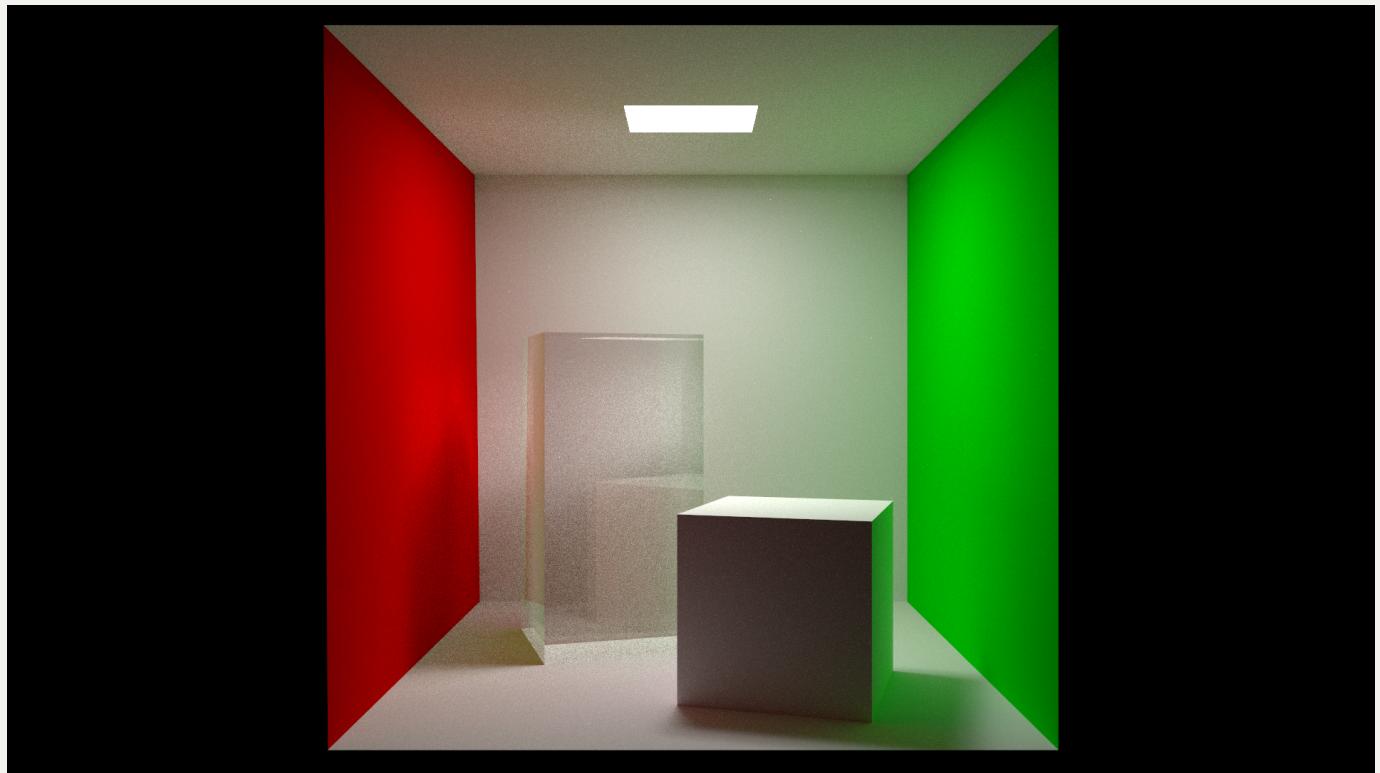
Transmissive

折射材质，默认真空折射率为 1.0, 给定 iot (Transmissive Rate), 根据 Fresnel Form 决定是否折射。

Fresnel Form 采用近似：

```
float f0 = pow((eta_i - eta_o) / (eta_i + eta_o), 2);
float fresnel = f0 + (1.0f - f0) * pow(1.0 - abs(cos_theta), 5);
```

iot = 2.0:



核心代码：

```
// hit_record.normal = hit_record_normal;
vec3 median = -dot(direction, hit_record_normal) * hit_record_normal;
vec3 proj_x = normalize(direction + median);
vec3 proj_y = hit_record_normal;
// theta: 初始角度, phi: 穿过后角度
float cos_theta = dot(hit_record_normal, direction);
float sin_theta = sqrt(1-cos_theta*cos_theta);
float sin_phi, cos_phi;
```

```

float eta_i = 1.0;
float eta_o = material.ior;
float eta = 1.0 / material.ior;
if (cos_theta < 0) {
    proj_y = -proj_y;
    cos_theta = -cos_theta;
} else{
    eta = 1.0 / eta;
    eta_i = material.ior;
    eta_o = 1.0;
}
float f0 = pow((eta_i - eta_o) / (eta_i + eta_o), 2);
float fresnel = f0 + (1.0f - f0) * pow(1.0 - abs(cos_theta), 5);
if(RandomFloat() > fresnel) {
    sin_phi = eta * sin_theta;
    cos_phi = sqrt(1-sin_phi*sin_phi);
    origin = hit_record.position;
    direction = cos_phi * proj_y + sin_phi * proj_x;
} else {
    vec3 wi = direction - 2.0f * dot(direction, hit_record.normal) *
hit_record.normal;
    // this is calculate shading
    origin = hit_record.position;
    direction = wi;
}

```

微表面模型： cook-torrance brdf

具体公式见 [链接](#)，加入了 α 参数作为粗糙度， $k = \frac{\alpha^2}{2}$ 。效果见自定义场景。

核心代码，F0 直接利用了 albedo:

```

vec3 calculate_brdf(vec3 n, vec3 wi, vec3 wo, float D, vec3 h, float
alpha, vec3 F0) {
    // float roughness = alpha;
    // float k = pow(roughness + 1.0f, 2) / 8.0f;
    float k = (alpha * alpha) / 2.0f;
    float G_i = dot(n, wi) / (dot(n, wi) * (1.0f - k) + k);

```

```

float G_o = dot(n, wo) / (dot(n, wo) * (1.0f - k) + k);
vec3 fresnel = F0 + (vec3(1.0f) - F0) * pow(1.0f - dot(h, wi),
5.0f);

float G = G_i * G_o;

// if(alpha == 0.0f) {
//   return fresnel * D * dot(wi, n);
// }

// if(dot(n, wi) < 0.0f || dot(n, wo) < 0.0f) return 0.1f;
return (fresnel * G * D / (4.0f * dot(n, wi) * dot(n, wo))) *
dot(wi, n);

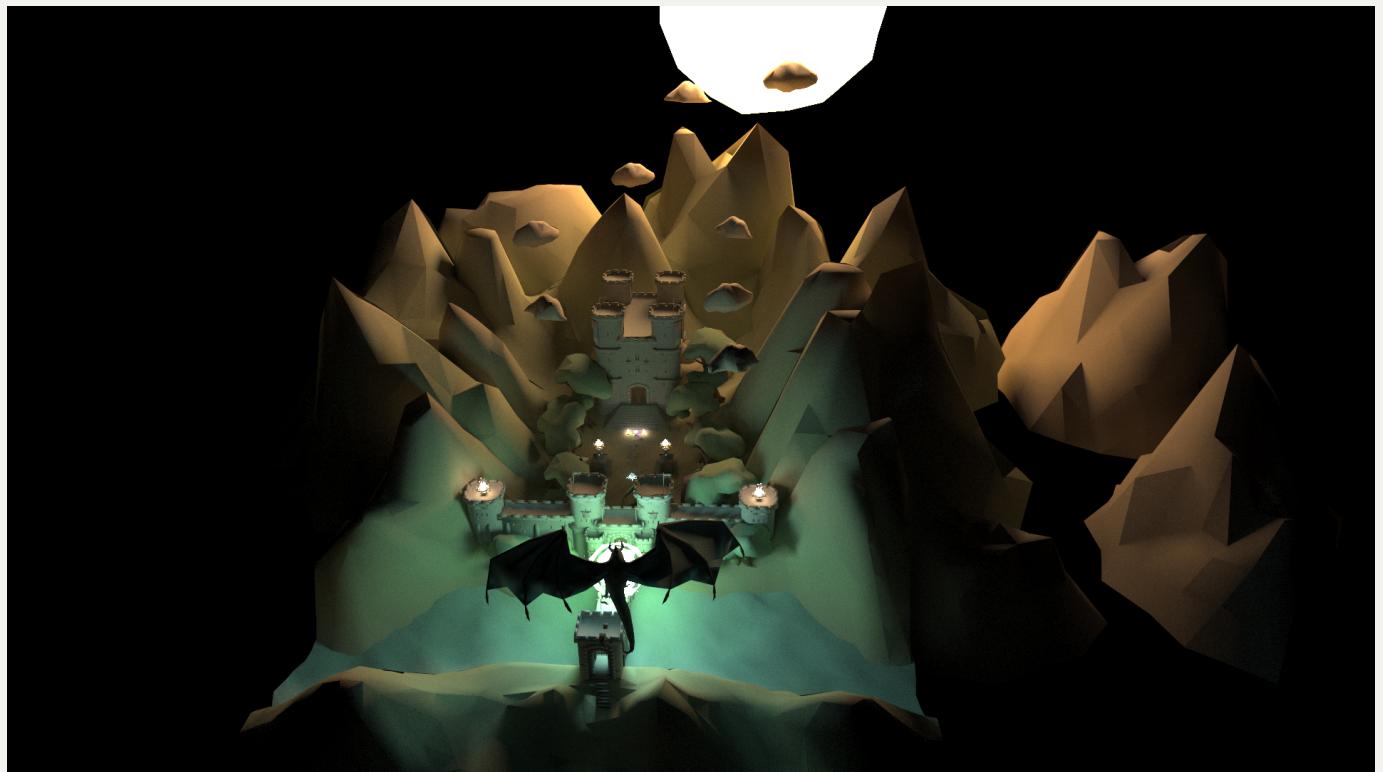
}

```

Texture

实现了发光贴图和颜色贴图。

同时，我们将一个同时有两种贴图的同一物体放在了一个场景，用于展示：



(整个场景只有一个 object，见 `new_copy.xml`)

核心代码：

```

if (material.material_type != MATERIAL_TYPE_EMISSION) {
    vec3 emission = material.emission *
        vec3(texture(texture Samplers[material.emission_texture_id], hit_rec
ord.tex_coord));
    if(emission != vec3(0.0f)) {
        radiance += throughput * emission * material.emission_strength;
        break;
    }
}

```

Multiple Importance Sampling

我们对于粗糙平面，我们利用 cosine-weighted sampling，对于微表面模型，我们使用 GGX sampling。

directly sampling the light:

```

int n_lights = int(light_sources[0]);
if(n_lights != 0 && (material.material_type ==
MATERIAL_TYPE_LAMBERTIAN || material.material_type ==
MATERIAL_TYPE_PRINCIPLED)) {
    int r = RandomInt(n_lights) + 1;
    int face_cnt = light_sources[2 * r + 1];
    int obj = light_sources[2 * r];
    int faceid = RandomInt(face_cnt);
    // vec3 v1, v2, v3;
    ObjectInfo obj_info = object_infos[obj];
    Vertex nd0 = GetVertex(obj_info.vertex_offset +
    indices[obj_info.index_offset + faceid * 3 + 0]),
        nd1 = GetVertex(obj_info.vertex_offset +
    indices[obj_info.index_offset + faceid * 3 + 1]),
        nd2 = GetVertex(obj_info.vertex_offset +
    indices[obj_info.index_offset + faceid * 3 + 2]);
    vec3 d = vec3(RandomFloat(), RandomFloat(), RandomFloat());
    while(d.x + d.y + d.z == 0.0f) {
        vec3 d = vec3(RandomFloat(), RandomFloat(), RandomFloat());
    }
    d /= d.x + d.y + d.z;
}

```

```

d /= d.x + d.y + d.z;
vec3 pt = d.x * nd0.position + d.y * nd1.position + d.z *
nd2.position;
vec3 N = cross(nd1.position - nd0.position, nd2.position -
nd0.position);
float S = length(N) / 2.0f;
N = normalize(N);
vec3 Origin = hit_record.position;
vec3 wi = normalize(pt - hit_record.position);
if(dot(wi, N) > 0.0f) {
    N = -N;
}
TraceRay_0(Origin, wi);
if(ray_payload.t < 0.0f) {

} else {
    Material light_m = materials[hit_record_0.hit_entity_id];
    if(hit_record_0.hit_entity_id == obj && light_m.material_type ==
MATERIAL_TYPE_EMISSION) {
        vec3 radiance_dir = light_m.emission *
light_m.emission_strength
            * max(0.0f, dot(hit_record.normal, wi)) // cosine
            * dot(N, -wi) // cosine
            * S / pow(length(hit_record_0.position - Origin), 2)
            * n_lights * face_cnt;
        vec3 L_direct = throughput * (material.albedo_color / PI) *
texture(texture Samplers[material.albedo_texture_id], hit_record.
tex_coord) * radiance_dir;
        if(material.material_type == MATERIAL_TYPE_PRINCIPLED) {
            if(dot(hit_record.normal, wi) > 0) {
                float DD = D_alpha(wi, hit_record.normal, normalize(wi -
direction), material.alpha);
                vec3 wo = -direction;
                vec3 h = normalize(wi + wo);
                if(material.alpha == 0.0f) h = hit_record.normal;
                L_direct = throughput *
texture(texture Samplers[material.albedo_texture_id], hit_record.
tex_coord) * radiance_dir *

```

```

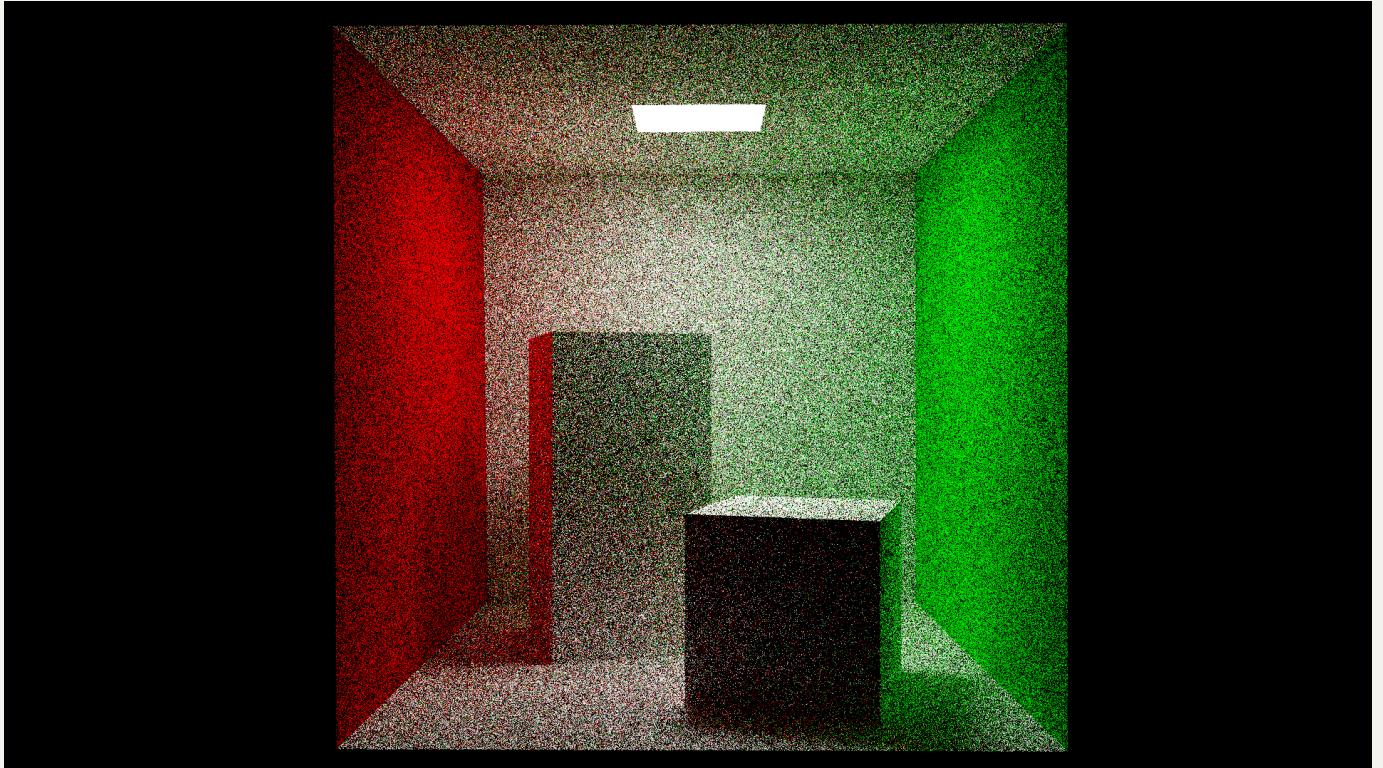
        calculate_brdf(hit_record.normal, wi, wo, DD, h,
material.alpha, material.albedo_color) / dot(hit_record.normal, wi);
    } else
        L_direct = vec3(0.0f);
}

float sampling_the_light_pdf = dot(N, -wi) // cosine
    * S / pow(length(hit_record_0.position - Origin), 2)
    * n_lights * face_cnt;
if(sampling_the_light_pdf != 0.0f) {
    sampling_the_light_pdf = 1.0f / sampling_the_light_pdf;
}
// if(sampling_the_light_pdf != 0.0f)
if(material.material_type == MATERIAL_TYPE_LAMBERTIAN)
    radiance += L_direct * get_pdf_ratio(Origin, wi,
hit_record.normal, -direction, 0);
else
    radiance += L_direct * get_pdf_ratio_principled(Origin, wi,
hit_record.normal, -direction, material.alpha, 0);
}
}
}

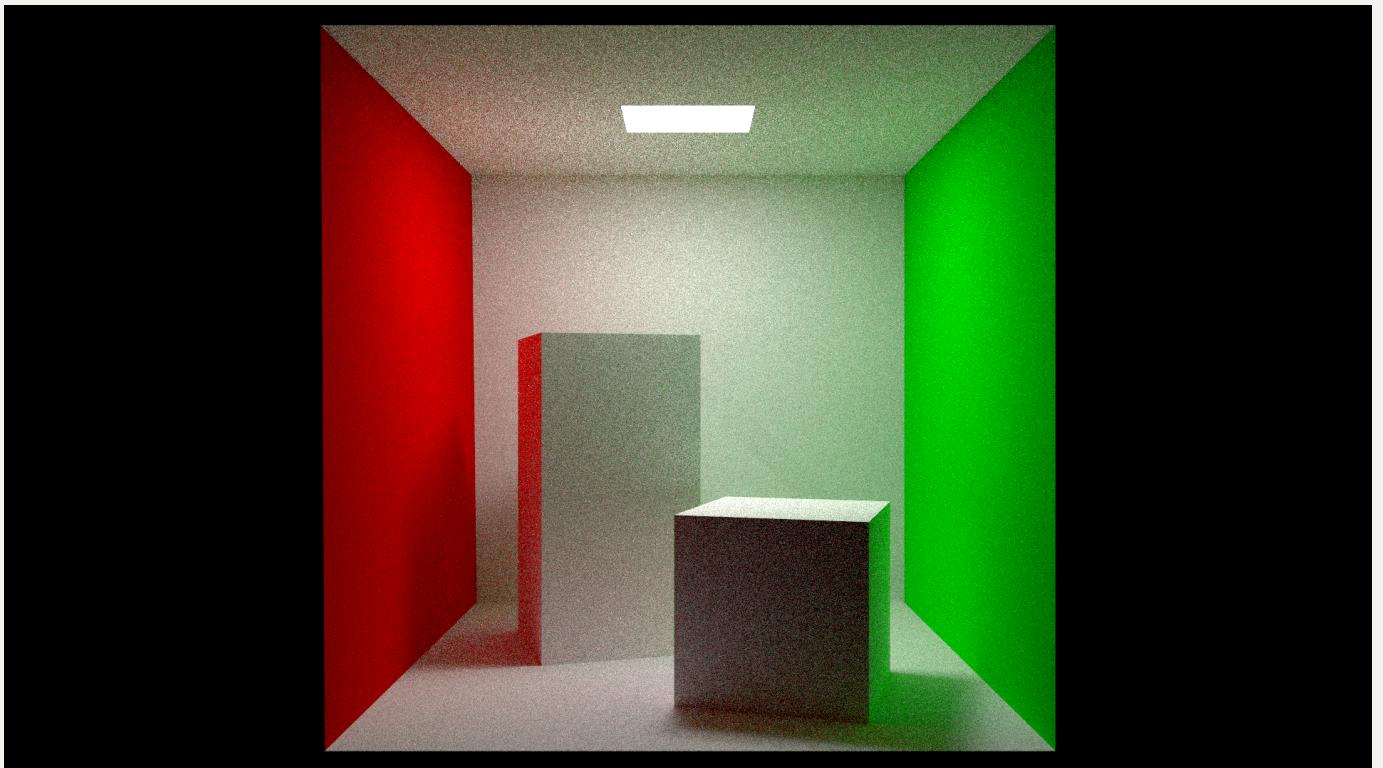
```

对于 MIS，我们会统计 directly sampling 和当前sample 方式的 pdf ratio w_1, w_2 ，最终会按 $w_i^2/(w_1^2 + w_2^2)$ 分配光源的贡献。

50ssp, without MIS:



50ssp, with MIS:



可以看到，收敛更快（我们同时可以从Specular里看出，因为镜面反光没有 Importance Sampling）

动态模糊

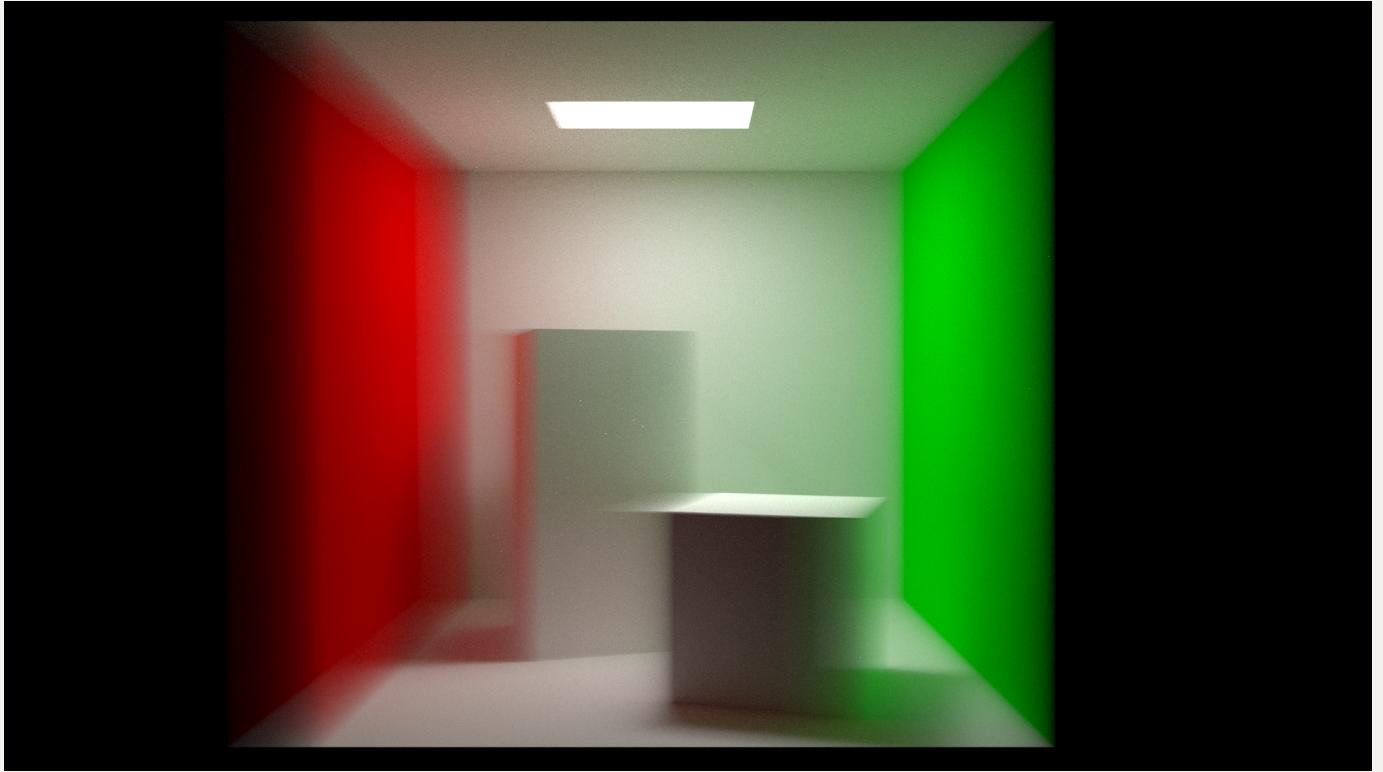
设置了相机的动态模糊，更改相机的速度和remain_time，随机函数并没有使用泊松分布：

```
float RandomPoisson(float n){  
    int t = 0;  
    while(t < 10){  
        float m = RandomFloat();  
        if(m < 0.3){  
            break;  
        }  
        t++;  
    }  
    float f = t + RandomFloat();  
    return (f / 11) * n;  
}
```

核心代码（在景深的基础上）：

```
vec3 camerail_speed = vec3(0.0,0.0,0.0);  
// vec3 camerail_speed = vec3(7.5,0.0,0.0);  
float remain_time = 10.0;  
remain_time = remain_time * length(camerail_speed);  
camerail_speed = normalize(camerail_speed);  
  
float pre_time = RandomPoisson(remain_time);  
vec4 origin = camera_to_world * vec4(o_, 1) - vec4((pre_time *  
camerail_speed).xyz, 0.0f);
```

cornell-box, speed = (7.5, 0, 0), remain_time = 10.0



景深 & 抗锯齿

景深可以修改 aperture。

效果见自定义场景。

核心代码:

```
for (int i = 0; i < guo.num_samples; i++) {  
    InitRandomSeed(uint(pixelCenter.x), uint(pixelCenter.y),  
                  guo.accumulated_sample + i);  
  
    // vec4 origin = camera_to_world * vec4(0, 0, 0, 1);  
    // vec4 target = screen_to_camera * vec4(d.x, d.y, 1, 1);  
    // vec4 direction = camera_to_world * vec4(normalize(target.xyz),  
    0);  
    vec2 pixelPoint = vec2(gl_LaunchIDEXT.x + RandomFloat(),  
                          gl_LaunchIDEXT.y + RandomFloat());  
    vec2 inUV = pixelPoint / vec2(gl_LaunchSizeEXT.x,  
                                 gl_LaunchSizeEXT.y);  
    vec2 d = inUV * 2.0 - 1.0;  
    vec3 o_ = vec3(RandomInCircle() * guo.aperture, 0); // origin
```

```

vec3 t_ = vec3(screen_to_camera * vec4(d.x, d.y, 1, 1)); // target
vec3 f_ = normalize(t_) * guo.focal_length; // focal
vec3 d_ = normalize(f_ - o_); // direct
vec4 origin = camera_to_world * vec4(o_, 1);
vec4 direction = camera_to_world * vec4(d_, 0);
imageStore(accumulation_color, ivec2(gl_LaunchIDEXT.xy),
           imageLoad(accumulation_color, ivec2(gl_LaunchIDEXT.xy)) +
           vec4(SampleRay(origin.xyz, direction.xyz), 1.0));
imageStore(accumulation_number, ivec2(gl_LaunchIDEXT.xy),
           imageLoad(accumulation_number, ivec2(gl_LaunchIDEXT.xy)) +
           1.0);
}

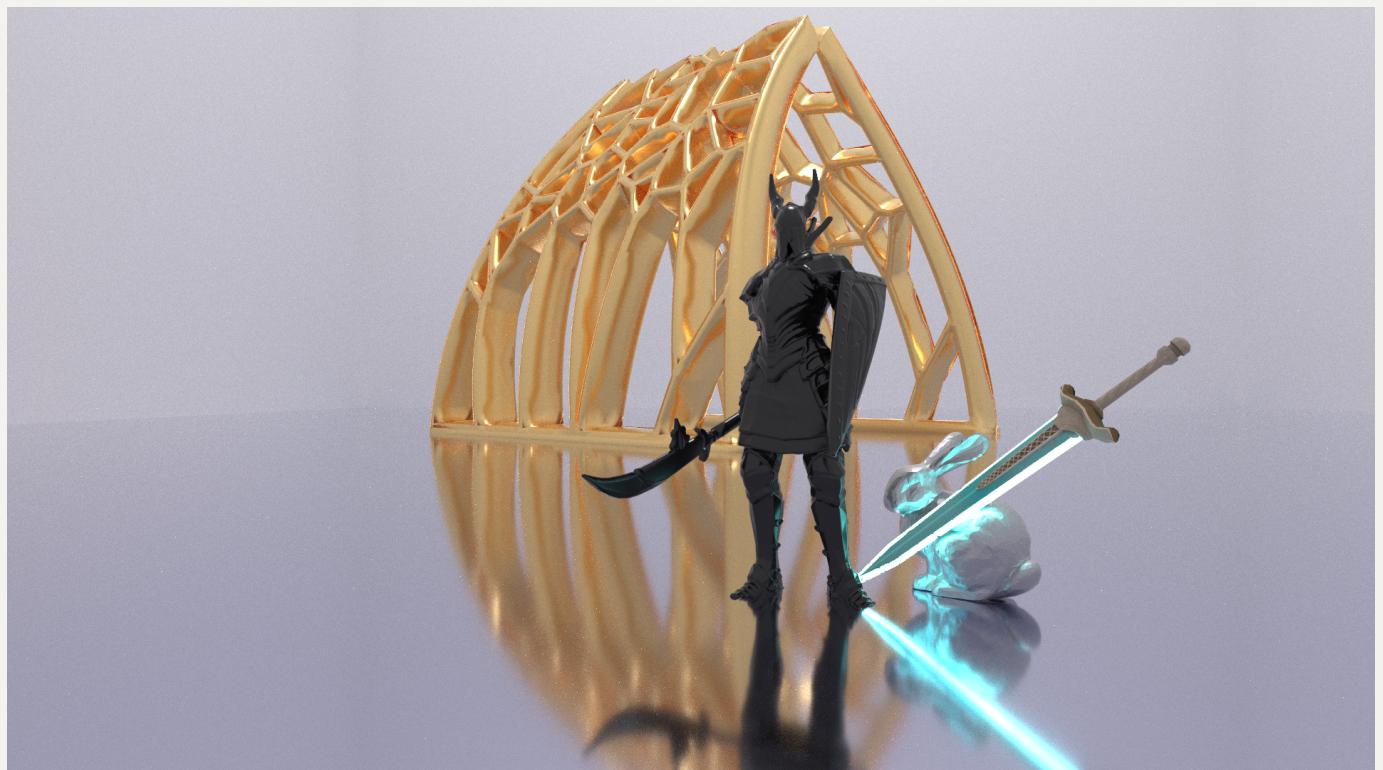
```

自定义场景

```

arch: F0 = "1.00 0.71 0.29", alpha = 0.1
knight: F0 = "0.05 0.05 0.05", alpha = 0.05
Bunny: F0 = "0.56 0.57 0.58", alpha = 0.2
ground: alpha = 0.01

```



加入景深:

```
<aperture value="0.2"/>  
<focal_length value="44"/>
```



分工情况

完成部分

分工

Base

自定义场景

投射材料

微表面模型

Texture

MIS

动态模糊

景深 & 抗锯齿