Ray Tracing

Introduction

In this report for Project 5, we delve into the advanced aspects and applications of Ray Tracing-2, building upon the foundational principles covered earlier in the course to explore how this sophisticated rendering technique can enhance realism in computer graphics.

Checkpoint 4

Recursion and Reflection:

When the depth is greater than zero, indicating that the ray can still be traced recursively, the direction of the reflected ray (D_{reflect}) is computed. This is calculated using the formula:

$$D_{\text{reflect}} = \text{ray\_dir} - 2 \times (\text{ray\_dir} \cdot \text{hit\_norm}) \times \text{hit\_norm}$$

This reflects the incoming ray off the surface at an angle equal to the angle of incidence. To avoid self-occlusion, the origin of the reflected ray (reflect_orig) is slightly offset along the hit normal. The reflected ray is then recursively traced by calling the RT_trace_ray unction, and its color contribution (L_{reflect}) is computed. Finally, this reflected light's contribution to the final color is added, scaled by the reflectivity (k_r) of the surface.

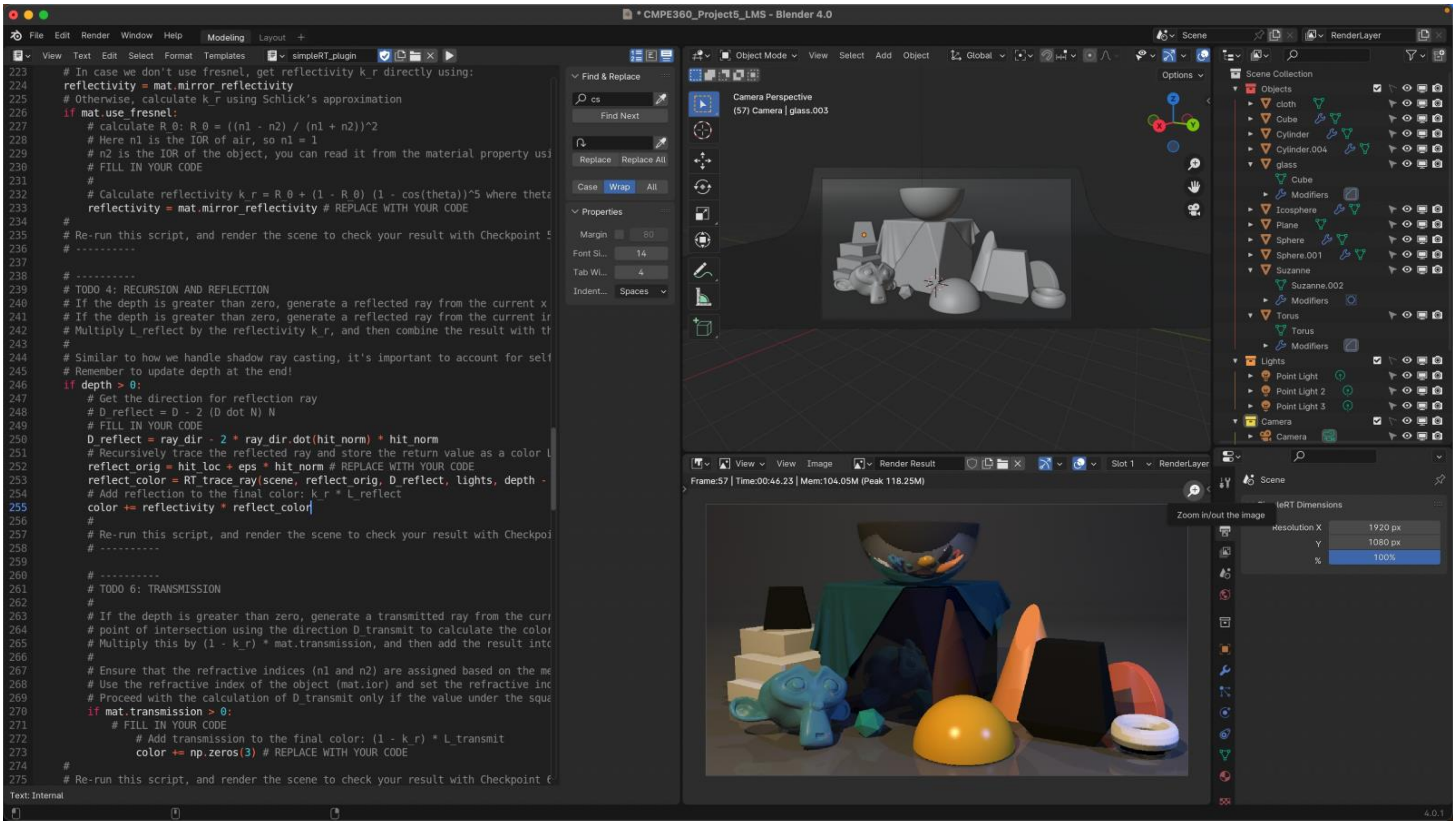

Figure 1: Checkpoint 4: Reflections Screenshot

Figure 2: Checkpoint 4: Reflections Output

Checkpoint 5

Fresnel Effect:
The Fresnel effect calculates how reflectivity changes with the angle of incidence. If Fresnel effect is not used, reflectivity (k_r) is directly taken as the mirror reflectivity of the material. If Fresnel effect is used, Schlick's approximation is applied to calculate k_r.

$$R_0 = \left(\frac{1 - \text{mat.ior}}{1 + \text{mat.ior}}\right)^2$$

The Fresnel reflectivity (k_r) is then given by:

$$k_r = R_0 + (1 - R_0) \times (1 - \cos(\vartheta))^5$$

where ϑ is the angle of incidence, calculated using the dot product of the hit normal and the negative ray direction.

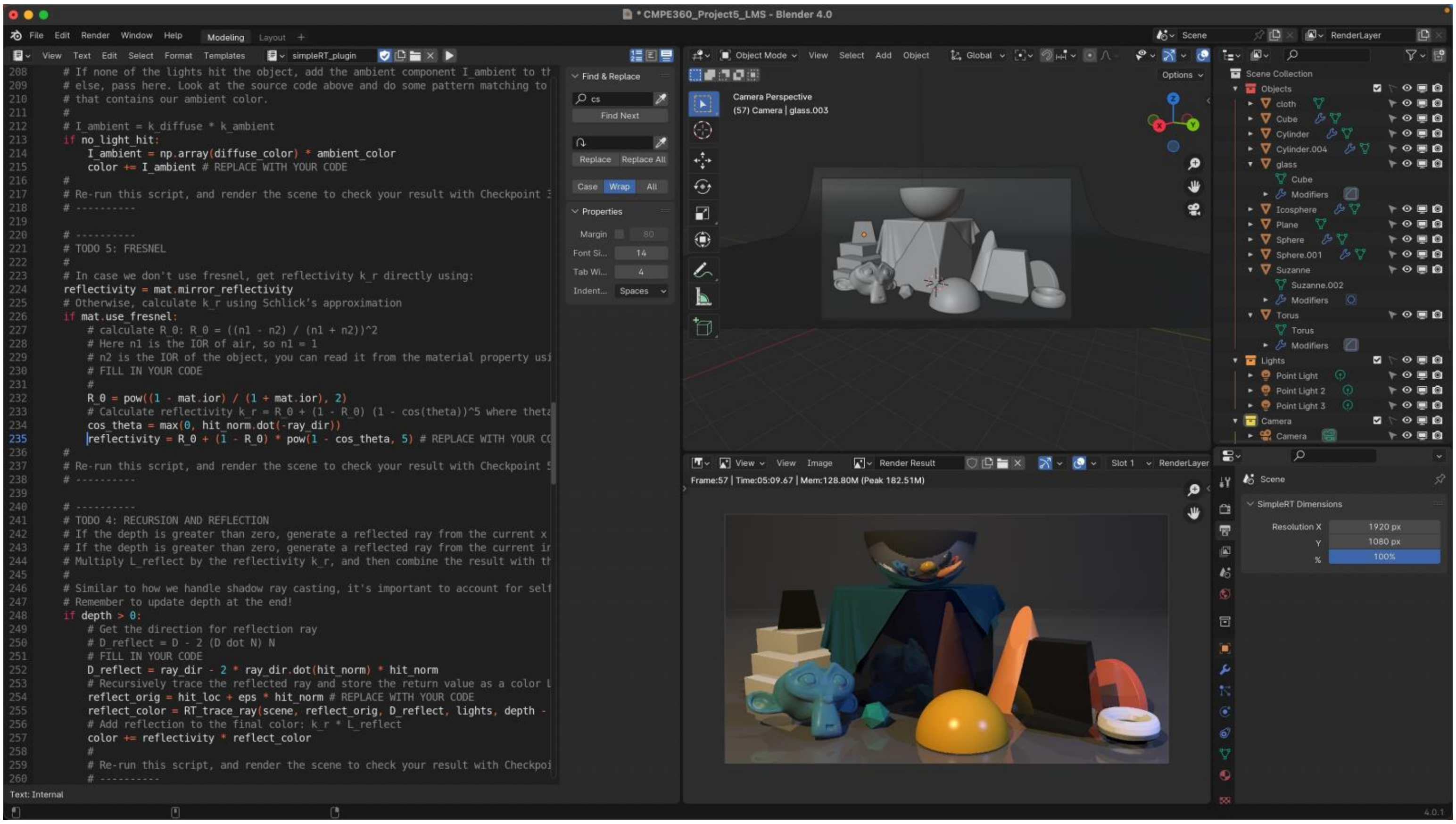

Figure 3: Checkpoint 5: Fresnel Screenshot

Figure 4: Checkpoint 5: Fresnel Output

Checkpoint 6

Transmission:
This part handles the transmission (or refraction) of the ray through a transparent material. Based on Snell's law, the refractive indices of air ($n1$) and the material ($n2$) are used. If the ray is inside the object, $n1$ and $n2$ are swapped. The ratio of these indices (η) is calculated, and the sine of the transmitted angle squared ($\sin^2(t)$) is derived from it. If there's no total internal reflection (checked using $\sin^2(t) < 1$), the direction for the transmitted ray (D_{transmit}) is calculated. The origin for the transmission ray is offset to avoid self-occlusion. The transmitted ray is then recursively traced, and its color contribution (L_{transmit}) is added to the final color, weighted by $(1 - k_r)$.

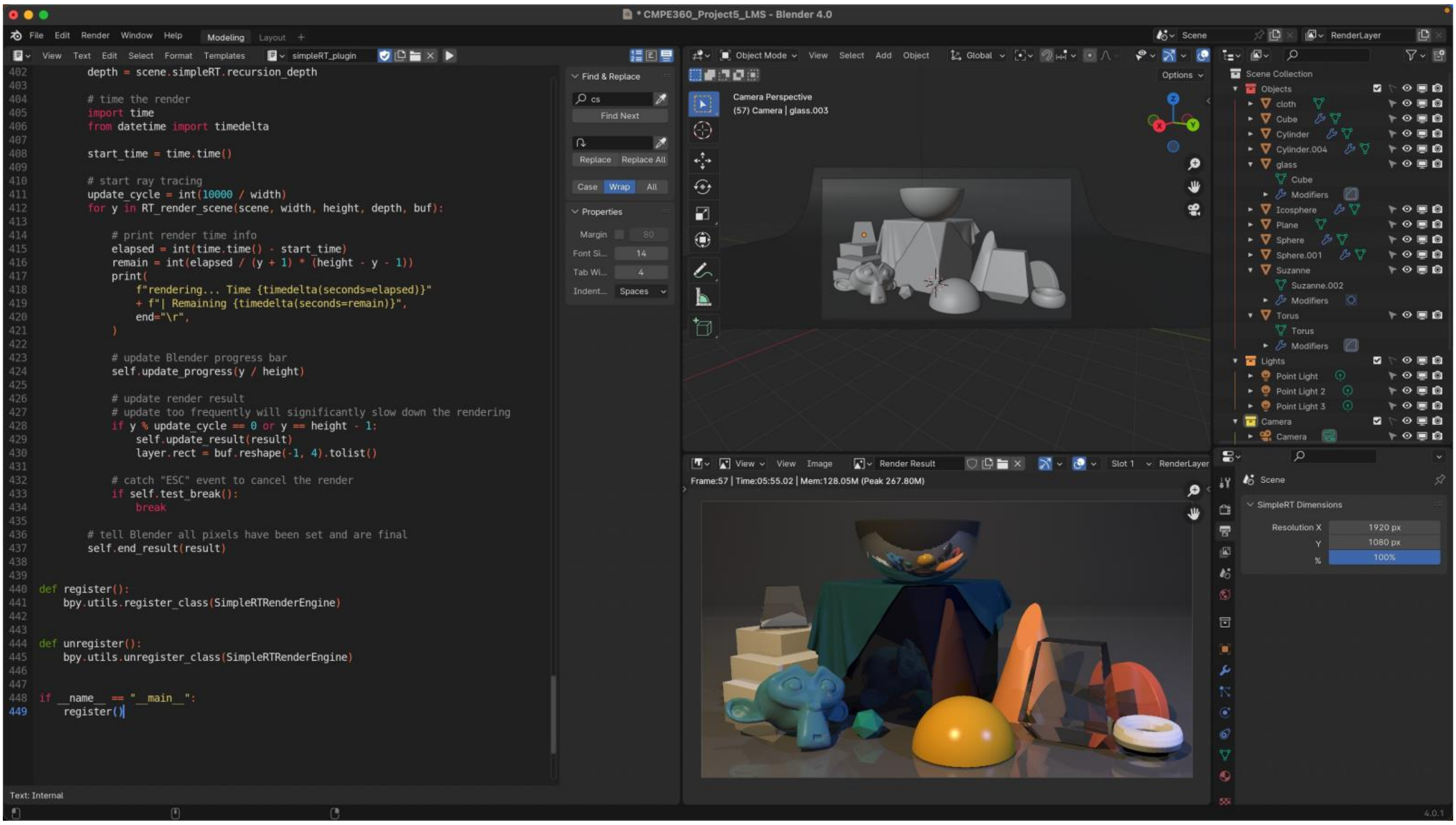

Figure 5: Checkpoint 6: Transmission Screenshot

Figure 6: Checkpoint 6: Transmission Output