Tutorial 5 – Ray Tracing

Note: while this tutorial is available after lecture 10, some questions require concepts introduced in lecture 11.

Camera

Exercise 1.

Given:

- a camera position $P = (1,2,-3)$,
- a camera target $T = (1,3,2)$
- an up-vector $\vec{u} = (0,1,0)$,
- a screen resolution of 1024x768,
- a FOV of 90 degrees.

a) Construct the camera matrix.
b) Calculate the screen corners for a screen plane at a distance of 1 from the camera.
c) Calculate the world space position for pixel (512,384).
d) Calculate the world space position for pixel (40,50).

Rays

Exercise 2.

a) How do we calculate rays for orthographic projection?
b) How do we calculate rays for perspective projection?
c) How would you generate rays for a 180 fish eye lens?
d) Explain why a ray tracer would be better suited for rendering images for the Oculus Rift than a rasterizer, if we do not consider performance.

Exercise 3.

Explain the concept of 'ray coherence'.

Intersections

Exercise 4.

What are the consequences if we allow ray/primitive intersections with a distance smaller than 0?

Exercise 5.

Given:

- an object O;
- transformation matrices M_1 and M_2;
- a ray r.

a) Suppose we want to intersect ray r twice with object O, once with O transformed by M_1, and once with O transformed by M_2. How do we calculate the intersection?
b) In the above case, how do we determine the normal at the intersection point?
c) In the above case, why should we not normalize the direction of our rays?

Exercise 6.

Let C be an axis-parallel cube in $\mathbb{R}^3$ with center $(0,0,4)$ and edge length 2. Let S be a sphere with radius 1.2 and center $(0,0,2)$. Let O be $C - S$. What is the intersection of the ray $(x, y, z) = t(0,0,1)$ with O?

Shading

Exercise 7.

Show that in case of ideal specular reflection, the reflection vector $\vec{r}$ can be calculated as

$$\vec{r} = \vec{d} - 2(\vec{d} \cdot \vec{n})\vec{n}$$

where $\vec{d}$ is the incoming direction and $\vec{n}$ is the normal vector at the intersection point.

Acceleration structures

Exercise 8.

a) Explain the difference between a spatial subdivision and an object subdivision. Give an example of both.
b) Is a nested grid a spatial subdivision or an object subdivision?
c) Is a loose octree (Google) a spatial subdivision or an object subdivision?
d) When using a kD-tree for kNN-searches (Google), is the kD-tree a spatial subdivision or an object subdivision?

Exercise 9.

Explain the limitations of the surface area heuristic.

The End

(is near)