# Lab 2: Raytracing

DH2323 (DGI17)

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## Overview

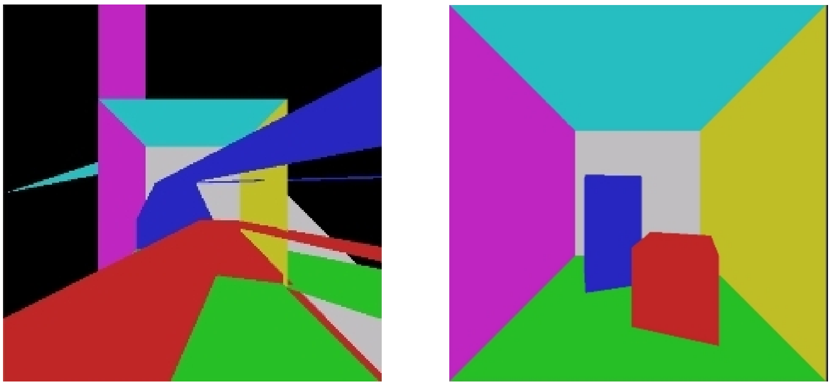
We completed all the given tasks and implemented Cramer's rule as an optimization for the ray-triangle intersection solver.

## Tracing Rays

The instructions up to and including section 3 where quite hand-holdy (e.g copy-pastable code for ray-triangle intersection) and the only real issue we had was caused by a typo in checking whether or not the ray had struck the actual triangle and not just the triangle plane (Figure 1a).

We didn't switch to using Cramer's rule for the intersection solver until much later. Some of our experiences from implementing Cramer's rule can be found later in this document.

After locating and fixing the typo we arrived at the expected result (Figure 1b).



(a) With typo

(b) Without typo

Figure 1: Tracing rays

## Moving the Camera

We initially added camera movement by simply adding or subtracting constant-valued vectors to the camera position vector. We then consulted Wikipedia for the standard

$R_y$ rotation matrix and added controllable yaw, after which we changed our movement to adding or subtracting the appropriate column vectors of the rotation matrix as instructed.

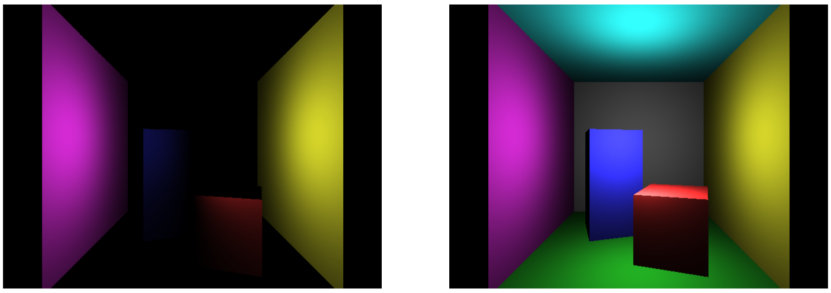
The fact that GLM/GLSL matrix types take arguments as column vectors as opposed to row vectors was and still is a source of confusion. There is some kind of cognitive struggle between wanting to set the arguments to the columns of the matrix we want (so we get the exact matrix, but it looks wrong in the code) and accepting that if we just enter the arguments as rows we get the transpose (so it looks right, but isn't). It is also surprisingly difficult to find material on the method of extracting the camera heading from the row vectors (column vectors of the transpose) of the rotation matrix.

Mikael experimented with adding pitch and roll to the camera and quickly found himself looking at YouTube videos explaining ”Gimbal Lock” and subsequently abandoned the attempt. The idea of trying quaternions for camera rotation came up but was never attempted.

## Illumination

We had two issues getting the initial lighting to work. The first issue was caused by not clamping the factor involving the dot product to a non-negative range which resulted in ”negative” lighting manifesting in the scene. This was resolved by reading the given formula properly and applying the `max` function as instructed. The second issue was caused by a bizarre typo in calculating the dot product itself (an extra asterisk after the `n.y` term):

```
float dot = r.x*n.x + r.y*n.y* + r.z*n.z;
```



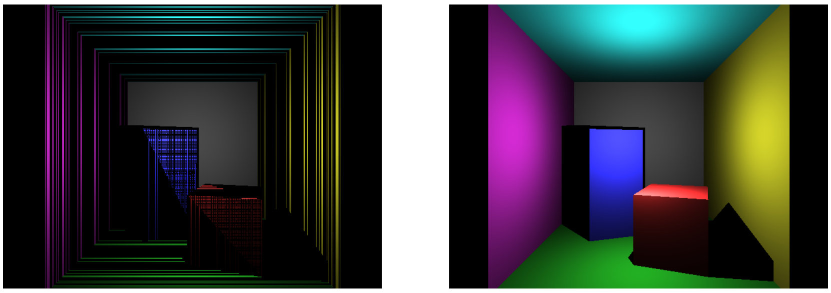
(a) With typo

(b) Without typo

Figure 2: Direct lighting

## Shadows

We had what is likely to be a very common issue implementing shadows: shadow test rays that instantly intersect with the geometry from which it was to originate. A friend of ours taking the same course ran into the same issue and Mikael has a vague recollection of seeing an old discussion about it on KTH social. We solved the issue by moving the new ray ever so slightly in the intended direction before sending it off.



(a) Instant intersection

(b) Problem solved

Figure 3: Shadow problems

## Cramer's rule

The main problem we experienced with implementing Cramer's rule were the myriad of variables involved. To spare some of our sanity we wrote down a general form of the rule (this is still in the code as a comment) and used search-and-replace to slot in the actual variable names.

At the moment we are seeing a performance increase (in FPS) of about 32% from using Cramer's rule. This could probably be optimized further using some faster algorithm for computing determinants.

## Result

Our resulting image is fairly close to the final image in the instructions document:

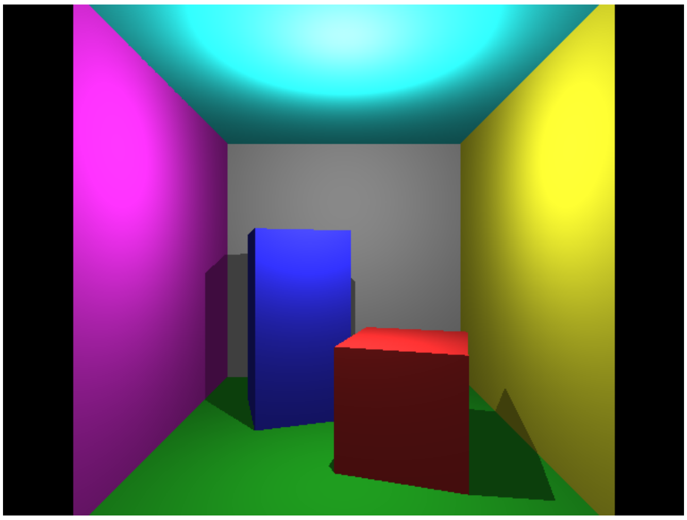


Figure 4: Final output

## Contributions

All tasks except for the optimization using Cramer's rule were completed as a joint effort. Mikael implemented Cramer's rule.