James’ Guide to Software Rendering

Episode 1: Why does dividing by z make 3d graphics?

Over the years I have tried to make a whole host of 3d apps and, because I’m an engineer at heart, I wondered how 3d graphics work. I’ve even made a few basic software renderers over the years. At the time, I never really understood why the various tricks that created the pretty shapes on the screen worked. That was when I was a teenager.

For some reason I’ve come back to this over the last year. This time round I spent a while really digging into the theory. This is my effort to explain what I’ve learned.

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| **Buyer Beware**  I am not a mathematician. I am a hobby programmer whose main job is being a doctor. Take what you read below with appropriate caution! |

# My Assumptions

1. You are a programmer, preferably one who is familiar with C/C++
2. You remember your GCSE (high school?) maths; preferably a bit of A-level maths too
3. You have a bit of experience with simple 3d graphics, probably with OpenGL or Direct X

If that’s not you, you might find this a bit difficult. Sorry, I’m not sure what I can do about that.

# Step 1: Some basic definitions

My 3d world is made up of shapes. The various bits of those shapes are defined by their coordinates in the world. Those coordinates are 3d Cartesian coordinates; that is, they have an x, a y, and a z part.

I call the space in which my shapes live “World Space”.

My screen is a 2d world. The physical screen on the laptop on which I’m writing this 1920 units wide, by 1080 units tall. My virtual screen has no limits however. It’s still 2d, and coordinates on it are defined by an x and a y part, but there are no limits on how big the numbers can be. My physical screen just shows a little window onto this.

I’m going to call this flat space “Screen Space”.

I want to draw my world on my screen. The question I’m going to address today is a very basic one: if I have a coordinate in “World Space”, how to I figure out where it goes in “Screen Space”.

# Step 2: a picture of where my two worlds meet

Before you look at the picture you need to imagine the scene. You are sat in front of a window. Behind the window is the scene. You want to draw the scene on the glass. The picture below is looking at you, and the window, from the side.

This picture shows my “World Space” from a side-on view. Upwards is y and rightwards is z. The origin (y = 0, z = 0) is where the X is.