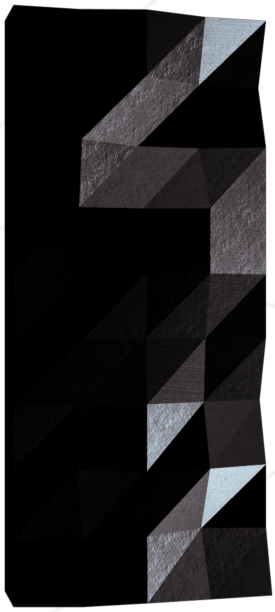


Ft_vox

Pimp my blocks

Summary: This project is the first step to the creation of your very own Voxel World!

Version: 6.1

Contents

Chapter I

Preamble

By Mike Acton on March 14, 2008 9:44 PM

One of the things we talked about this year at GDC was what we called the "Three Big Lies of Software Development." How much programmers buy into these "lies" has a pretty profound effect on the design (and performance!) of an engine, or any high-performance embedded system for that matter.

(LIE 1) SOFTWARE IS A PLATFORM

I blame the universities for this one. Academics like to remove as many variables from a problem as possible and try to solve things under "ideal" or completely general conditions. It's like old physicist jokes that go "We have made several simplifying assumptions... first, let each horse be a perfect rolling sphere..."

The reality is software is not a platform. You can't idealize the hardware. And the constants in the "Big-O notation" that are so often ignored, are often the parts that actually matter in reality (for example, memory performance.) You can't judge code in a vacuum. Hardware impacts data design. Data design impacts code choices. If you forget that, you have something that might work, but you aren't going to know if it's going to work well on the platform you're working with, with the data you actually have.

(LIE 2) CODE SHOULD BE DESIGNED AROUND A MODEL OF THE WORLD

There is no value in code being some kind of model or map of an imaginary world. I don't know why this one is so compelling for some programmers, but it is extremely popular. If there's a rocket in the game, rest assured that there is a "Rocket" class (Assuming the code is C++) which contains data for exactly one rocket and does rocketty stuff. With no regard at all for what data transformation is really being done, or for the layout of the data. Or for that matter, without the basic understanding that where there's one thing, there's probably more than one.

Though there are a lot of performance penalties for this kind of design, the most significant one is that it doesn't scale. At all. One hundred rockets costs one hundred times as much as one rocket. And it's extremely likely it costs even more than that! Even to a non-programmer, that shouldn't make any sense. Economy of scale. If you have more

of something, it should get cheaper, not more expensive. And the way to do that is to design the data properly and group things by similar transformations.

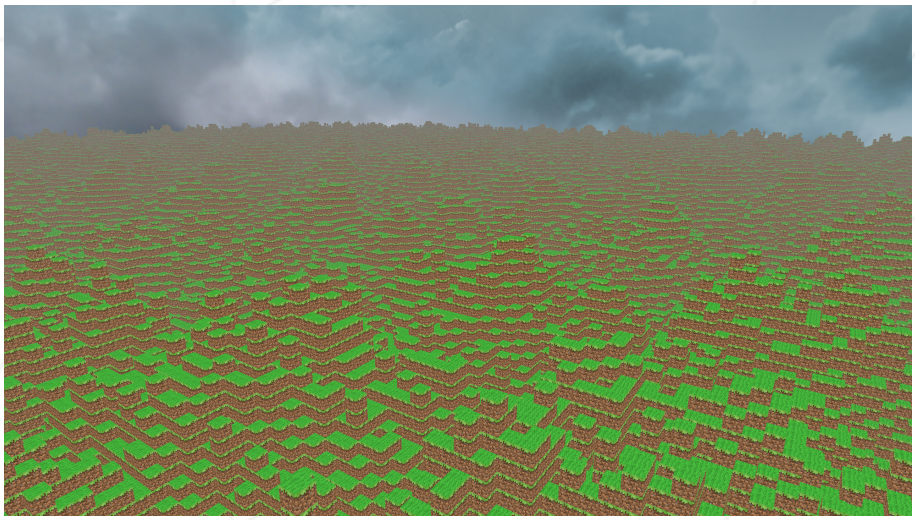
(LIE 3) CODE IS MORE IMPORTANT THAN DATA

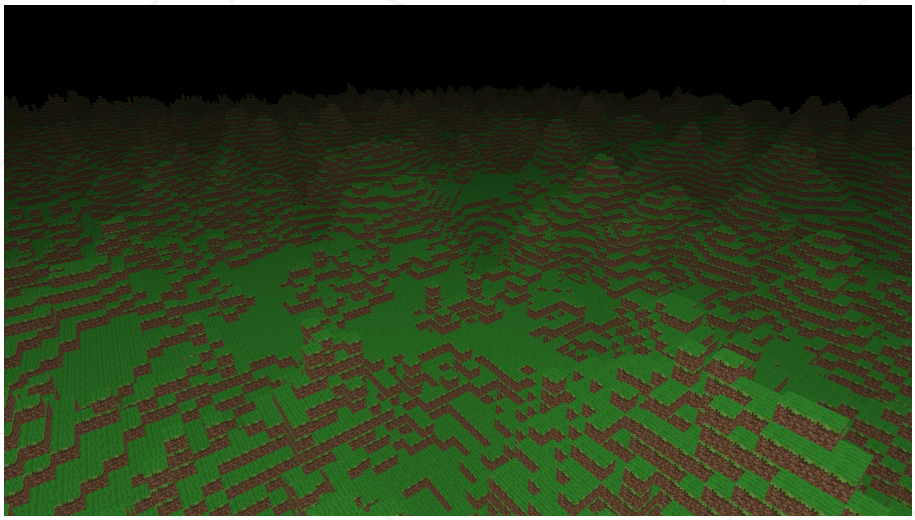
This is the biggest lie of all. Programmers have spent untold billions of man-years writing about code, how to write it faster, better, prettier, etc. and at the end of the day, it's not that significant. Code is ephemeral and has no real intrinsic value. The algorithms certainly do, sure. But the code itself isn't worth all this time (and shelf space! - have you seen how many books there are on UML diagrams?). The code, the performance and the features hinge on one thing - the data. Bad data equals slow and crappy application. Writing a good engine means first and foremost, understanding the data.

Chapter II

Introduction

Welcome to the beautiful world of voxels, where you will use all the benefits of the abstraction "the whole world is a 3 dimensions grid" in order to display a daunting number of things on a screen, travel in a gigantic procedural universe and a completely malleable playground. What are voxels?





Chapter III

Objectives

This project aims to confront you to a graphic project that will be extremely demanding in terms of optimization. You will have to study the characteristics of the voxel worlds, and use them along your infographics knowledge to display a lot of elements on screen. Thus, you will have to study different algo/opti to obtain a SMOOTH render (there are many of them). You will also have to manage your memory and data structures properly to be able to travel in a very, very large universe. Once you have achieved that, you will be ready to get to the next level with the project ft_minecraft, which will be even more demanding.

Chapter IV

General instructions

- You're free to use your language, but keep an eye on its performances. (If you can't choose, c/c++/rust are suggested).
- You must work directly with the APIs (OpenGL, OpenCL, Vulkan, Metal, or WebGPU). You cannot use higher-level libraries built on top of them.
- You can use a library to load 3D objects and pictures, a windowing library and a mathematics library for your matrix/quaternions/vectors calculations. You must not push them in your repo. Instead, you must write your own download/install scripts.
- The render should always be SMOOTH. This means if your assessor considers your game offers an unpleasant visual experience, he can give you a 0.
- Any crash (Uncaught exception, segfault, abort ...) will disqualify you.
- Your program must be able to run for hours without eating the whole memory or slowing down. Manage your RAM as well as VRAM very carefully.
- Your program will have to run in full screen mode. Reduce the default frame buffer is prohibited.

Chapter V

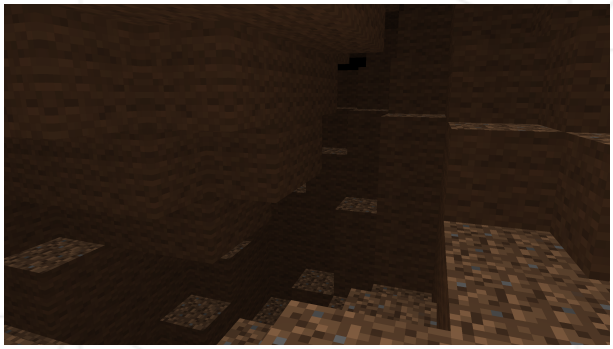
Mandatory part

V.1 The world

You must be able to create a very large procedural world. For this project, user should be able to visit at least 16384*256*16384 cubes (256 is the height).

`The ft_minecraft project will be WAY bigger !`

Some cubes may be empty, others can have different types, like grass, ground, sand, etc...
Except for the empty cubes, they will all be opaque but will have their own textures.
You must implement a method to generate terrains such as hills, mountains or caves when the user goes underground. This generation has to be determinist, which means the same seed will spawn the exact same map.
The terrain should have a remotely natural topography, with hills and/or mountains, caves and so on... A simple rand() will not be tolerated.
Each visited piece of terrain must be saved in the memory up to some limit you will set yourself and after which you can start deleting cubes from the memory.



V.2 Graphic rendering

Cubes must be displayed on screen.
In open areas (i.e. when the player's view is not obstructed by walls, caves or dense terrain), your engine must render at least 160 cubes in the player's field of vision. This distance is measured from the camera outward and represents the minimum viewing distance under normal conditions. The first image in the introduction corresponds to a distance of 320 cubes, for reference.
Of course, occluded cubes (e.g., fully hidden behind others) do not need to be drawn. You must implement proper frustum culling and visibility optimization.

Each cube must be textured, and you must have at least 2 different textures and 2 different types of cubes. Make sure the FoV is always filled with various elements. The user should never feel lost or confused when scanning the ground level.
Again, render must be smooth. Avoid the freeze frames at all costs.
FoV must be 80 degrees.
To make it a little nicer, you will set up a skybox. Don't leave any artefact on its junctions.

`If you want your render to run smooth, you should manage the workload so it is equally shared between the CPU and the GPU.`

V.3 The camera

If we can travel in your game, this would make for a nice touch. You must configure a nice little camera. The mouse must be able to control it on 2 axis at least and you will set 4 keys that will make it go forth, back, right and left in according to the camera rotation. Of course, the user must be able to keep going if he keeps pressing a key. The camera speed should be set around 1 cube/second, but for the evaluation, you will create a key that will multiply this speed by 20.

V.4 To sum it up:

- A gigantic terrain made of textured cubes of different types.
- A luxurious FOV.
- An advanced procedural generation offering a natural face to the terrain (hills, mountains, caves, lakes...).
- An intuitive camera.
- A skybox.

Chapter VI

Bonus part

I bet you're dying to add physics, a player, green explosive monsters that will ruin hours of painstaking work. But this will come with the ft_minecraft project. Right now, you will only focus on the technical side.

- Your engine must dynamically manage the render distance to preserve a smooth and fluid display at all times.
  However, even in extreme cases (e.g. high-speed movement, heavy terrain generation, or low performance conditions), the render distance must **never drop below 14 cubes** in any direction from the player.
  In open areas, the visible distance should normally reach or exceed 160 cubes, as required in the mandatory part.
- A fps counter is displayed.
- Render is smooth and doesn't freeze, event at x20 speed.
- Being able to delete blocks with the mouse.
- Having a lot of different biomes.

`The bonus part will only be assessed if the mandatory part is PERFECT. Perfect means the mandatory part has been integrally done and works without malfunctioning. If you have not passed ALL the mandatory requirements, your bonus part will not be evaluated at all.`

Chapter VII

Submission and peer-evaluation

Turn in your assignment in your `Git` repository as usual. Only the work inside your repository will be evaluated during the defense. Don't hesitate to double check the names of your folders and files to ensure they are correct.