3D Procedural Cave Generation

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**By**

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Paragraphs in red, like this one, are instructions and extra information. You must delete them before submitting your report.

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On this page (and I *really* hope this is obvious) you must replace the words “The Title Of Your Project”, “Your Full Name Here” and “202100000” with the correct information. You’d be surprised how often people forget to do this. Don’t be one of them.

You must also replace “XXXX” with the actual word count (excluding acknowledgements, abstract, table of contents, references and appendices) of your document.

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Delete these red paragraphs!

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# Project background and purpose

## Introduction

This project will focus on the procedural generation of caves within computers, it will explore methods of generating terrain in order to procedurally generate a cave system. Using a graphics API such as OpenGL in C++ to render and generate a procedural cave. It will compare different methods of procedural generation, their different purposes as well as their suitability for this project, what procedural generation is will also be researched and its differences compared to random generation.

## Objectives

This project aims to develop a working program that implements procedural terrain generation for caves and displays it through the use of a 3D environment. This will be useful as a project for developing the research of procedural generation of caves specifically rather than just procedural terrain generation in 3D. The motivation of this project is to further advance procedural generation in computer games/programs and more specifically procedural cave generation.

The primary objectives of this project are, these are sorted in order of priority, as are the secondary objectives:

* Implement procedural cave generation using Perlin Noise/L-Systems.
* Render procedurally generated cave in 3D, this includes shadows, lighting and texturing.
* Implement basic collision detection for the cave walls, floor and ceiling in order to be able to move through the cave without exiting the bounds.
* Create program with user controls in order for the 3D environment to be observed properly, allow user to change the perspective.

If there is enough time during the project, the secondary objectives:

* Create alternative first person character perspective that allows the player to walk around in the cave system.
* Implement procedural terrain generation in 3D using Cellular Automata and compare to other methods used.
* Implement procedural generation at runtime to make the 3D world “infinite” and generate as the user moves, this includes making the environment into “chunks” to aid performance.
* Add extra graphical enhancements to the 3D rendering such as more advanced lighting, advanced texturing, shadows etc.

## Scope

The purpose of this project is to delve into the 3D aspects of procedural cave generation, there is a lot of similarities between 2D and 3D procedural generation but only 3D will be involved with this project. There are also a lot of different methods of procedurally generating terrain in computer graphics, the ones being looked into with this project will be Perlin Noise, L-Systems and optionally Cellular Automata. As mentioned, this project is about procedural cave generation in 3D, normal world terrain generation is similar to cave generation, but this will not be included in the project. Procedural generation is often used in video games, this project is focused on the technical side and will not use the procedural generation to create a game.

## Deliverables

The main deliverable will be a program that implements procedural cave generation within a 3D environment that is rendered using a graphics API, it will have user input for moving around the environment. This deliverable will be met if the final program displays a procedurally generated cave within a 3D environment that can be viewed by the user, the cave must be rendered properly and use shadows and lighting to make the cave generation visible. The generated cave must be the same each time based on the same input seed; it must not be random.

## Assumptions

One of the big assumptions when starting a coding project is assuming what technology/methods can be used to achieve what you want. With this project I want to procedurally generate a 3D cave system, having superficially researched methods to do this I have assumed that the methods of generation I’ve chosen are good for my project. Further down the line I might realise that they don’t generate the kind of cave generation I want, for example I assume L-Systems Trees would help generate a tree like structure, but maybe I would need to use a different method for this.

Another big assumption is compatibility of different technology/methods, at this stage I’ve chosen what I intend to use and research further, I assume these will all work well together to create what I want. It may be that these do not work well together and/or actually conflict with each other. For example L-System Trees and Perlin Noise may not be good to use in conjunction with each other. The actual technology such as the language, 3D graphics API may also be an issue later down the line if they don’t work well together.

# Project rationale and operation

## Project benefits

What benefits will a successful project bring, and to whom? Note that this is about the project’s content and purpose, not the fact that you are doing a project for your degree.

This project, if a success, would benefit procedural generation in computers as it would help further the research on how to generate good cave systems in 3D. This would be useful for many areas of computing such as: real world use for mapping cave systems in order to visualize them virtually. It would also help with generating caves in 3D games development where procedural generation is frequently used for the game world, this could help games use better methods of generating 3D caves. Currently there are not many resources available on procedural generation for caves specifically, there is a lot for normal terrain generation, but not caves, this project could help with this problem.

## Project operation

How will you operate the project? Will you use a particular methodology for it and for any software or other development? How will you measure the success of your choice?

For project management I will use the waterfall model to keep it more simple, as it’s a one person project less management is needed in terms of assigning tasks/meetings etc. I will make a Gantt chart of tasks in order of priority, it’ll be more or less spending time on each task and then seeing if more/less time was needed and then planning for the next task. I will measure the success of the project by evaluating the final product against the SMART objectives defined in this document, if most of the primary objectives are complete then it is a success, if the secondary objectives are started then even more of a success. I will also measure how well the tasks were completed as part of the project planning process.

## Options

What options are available to you for the tools, techniques and design parameters of your project? How will you evaluate them and make the best selection?

Procedural generation in 3D is quite a common feature in video games as well as real world visualisations, this means that there are a lot of options for tools/techniques. For my project I will choose the best techniques by researching what each technique does and whether it is applicable for my use case. As for tools, they are less related to the use case and more about which one is the best, the big thing for this project in tools is rendering the 3D graphics, I’d need to choose the best graphics API and then a language that can use that API.

For procedural generation techniques there are a lot of techniques available, L-System Trees, Simplex Noise, Perlin Noise/Worms, Cellular Automata, Accidental Noise etc.

For tools there are also a lot of options, graphic APIs include OpenGL, DirectX, Vulkan and more, OpenGL. There is also the programming language to consider, C++ is very common in computer graphics, however C#, python etc can also be used, as can many other languages.

## Risk analysis

What risks might affect the outcome of your project or its stakeholders? How severe are they, and what steps will you take to mitigate against them?

With a project over this period of time there are a number of risks associated with it, below is my analysis of those risks and mitigations against them. The table displays the risks and the raw impact of this risk, after the mitigation the likelihood and severity make up an impact of that risk with the mitigation in place.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **ID** | **Risk** | **Raw Risk** | **Mitigation** | **Likelihood** | **Severity** | **Impact** |
| 1 | Hard drive disk failure | 10 | Use version control and make development environment available from more than one computer. | 3 | 1 | 3 x 1 = 3 |
| 2 | Illness | 4 | Have extra time in project in case issues happen along the way, don’t fill up whole timeline with tasks. | 3 | 2 | 3 x 2 = 6 |
| 3 |  |  |  |  |  |  |
| 4 |  |  |  |  |  |  |

## Resources required

What resources will you need for the project? Are any non-standard? Are they already available? What effect will it have if they are not available or are delayed, and how would you manage that?

As this is a widely researched topic there are a lot of technical resources already available as well as research available. In terms of technology the main ones necessary are a graphics API and a graphics framework. They are both readily available and can just be downloaded of the internet, OpenGL is the graphics API that will be used and GLFW is the framework, these are both pretty standard and easy to access. If they for some reason are not available the project can use an alternative API/framework, there are many available out there.

# Project methodology and outcomes

## Initial project plan

## Tasks and milestones

Present a realistic task list for the entire project, broken down to a suitable level of detail. Indicate milestones against which progress can be monitored. Make sure you include all the deliverables you mentioned earlier.

Delete the red paragraphs and replace this one with your content (use the “Normal” paragraph style).

## Schedule Gantt chart

Present a Gantt chart showing a schedule for all tasks, milestones and deliverables. Show dependencies amongst tasks. If you are intending to use SCRUM or other agile methods, be sure to go to the lectures involving project planning. Your time plan should cover the entire period of your project (and will therefore include the PDD preparation as a task and the PDD itself as a deliverable).

Delete the red paragraphs and replace this one with your content (use the “Normal” paragraph style).

## Project control

How will you manage the project day-to-day? How will its performance be monitored? How will you judge if it has been successful?

Delete the red paragraphs and replace this one with your content (use the “Normal” paragraph style).

## Project evaluation

How will you evaluate the project’s artefacts and overall outcomes? What user evaluation will you do? Do not underestimate the importance of this, and include clear details of how you will do the evaluation.

Delete the red paragraphs and replace this one with your content (use the “Normal” paragraph style).

# References

List any sources you have used for your background and introduction here. Make sure you use the proper referencing format.

Delete the red paragraphs and replace this one with your content (use the “Normal” paragraph style).

# Appendix a

You may use one or more appendices to add useful reference information which may be relevant to other sections of the report. Do not use appendices simply as a way of writing more than will fit into the main document word count. If you don't need any appendices, then delete this whole section

Delete the red paragraphs and replace this one with your content (use the “Normal” paragraph style).