GPU Accelerated Method for Constructing and Rendering Trees
-
Project Proposal

Thomas Mcloughlin

registration: 100203952

1 Introduction

Generating natural environments can be costly. Creating and rendering realistic models of trees can be challenging. The aim of this project is to investigate approaches for creating and rendering trees to be used in a real-time graphics application. A key reason for wanting to include trees in computer generated environments is that trees, and other foliage, are what give life to that environment, a forest is not a forest without the trees and having an easy method of including trees in a landscape will mean that making that landscape more realistic and engaging is easier.

2 Description of Project

2.1 Aims

The aim of this project is to create an OpenGL module for constructing and rendering trees for use in 3D environments such as games. The trees that are constructed should: be rendered at least in 30fps (ideally 60fps), the module should take input from the user allowing them to vary the appearance of the trees that are generated so that the trees do not all look the same and the rendering process should make effective use of the GPU to be as efficient as possible.

2.2 Motivation

The motivation for creating this project is to make the addition of trees into a 3D environment easier to allow for the creation of better looking environments without needing to spend as much time modeling certain assets.
The natural growth patterns of trees can be represented quite well algorithmically so I would argue that using an algorithm to produce tree models will also result in a more realistic looking model than one created manually while taking less time and effort.

2.3 Understanding of Issues and Problems

The issues and problems that this project would aim to solve would revolve mainly around the difficulties of producing realistic looking trees manually and then having to insert them into your scene.

The user could choose to either make their own trees or acquire premade assets:

- If they decide to produce their own trees it would take a long time to model a realistic tree and it is also very hard to make a realistic looking model.

- If they decide to use premade assets it may cost money to acquire decent assets and it might not be possible to find the kind of specific tree they want.

My solution would help solve these problems by allowing an automatic construction for the trees to avoid any modeling by the user and, by including modifiable parameters the user can tweak, they could produce many different looking trees for their scene.

3 Preliminary Work to Identify Resources

3.1 Market Analysis

The following section details some of the existing software solutions available for producing 3d models of trees.

3.1.1 SpeedTree 3D Vegetation Modeling

SpeedTree IDV Inc. (2017) is an advanced software suite that is used for large projects in the game and film industry. It allows for extremely detailed foliage generation, not limited to trees, and allows for very minute detail manipulation for the generated plants. This includes factors such as tree bark colour and texture, and the size, shape and scattering of leaves across branches.

3.1.2 The Grove 3D Tree Growing Software

The Grove F12 (2014) is a detailed simulated method of constructing trees with a multitude of factors that come into play with the growth of the tree. The Grove uses a different method than might be assumed for typical construction of trees. Rather than construct trees in one state, by that I mean that you construct the tree as you would want to display it, The Grove gives you a set of many parameters that you can tweak and you then grow a tree, by adding years to its life and tweaking the parameters you construct the tree you want. This includes modifying the weight of branches, the flow of sugar and hormones within the tree, growing towards light sources, growing around or avoiding buildings and many others.

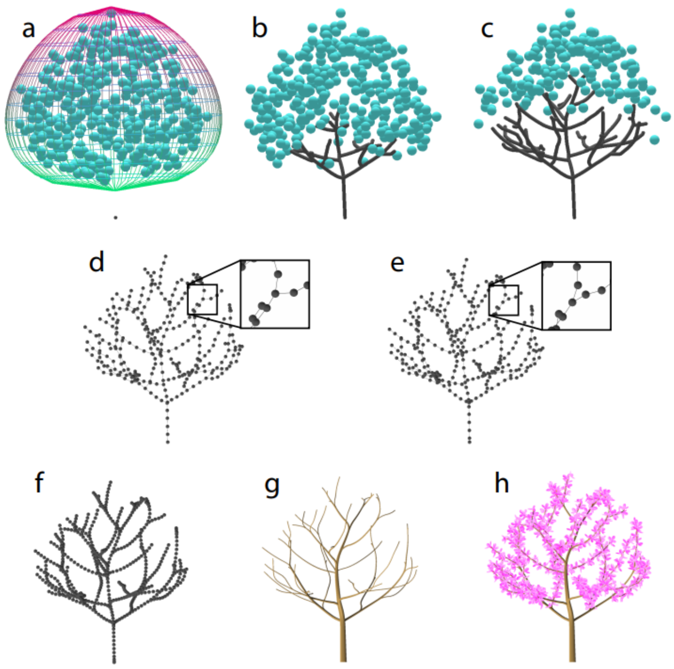
3.2 Method Analysis

This section contains reviews of some methods used for constructing trees found in literature and how they relate to the aims of my project.

3.2.1 Modeling Trees with a Space Colonization Algorithm

The paper Adam et al. (2007) is a wealth of knowledge on the construction of trees. It includes a well written and explained method for constructing trees and provides many links to other relevant papers that relate to various aspects of the tree construction. The main method they describe involves creating a three-dimensional *envelope* of the tree crown that you want to produce. You then give a set of *attraction points* which the paper states as user inputted but I think could be randomly generated using a noise algorithm. The tree *skeleton* then grows, from a given root point, into the envelope and towards the attraction points which produces branches within the given space. Once the skeleton is produced it can be used as a base to apply thickness to the trunk and branches.

Figure 1: Key steps of the proposed method

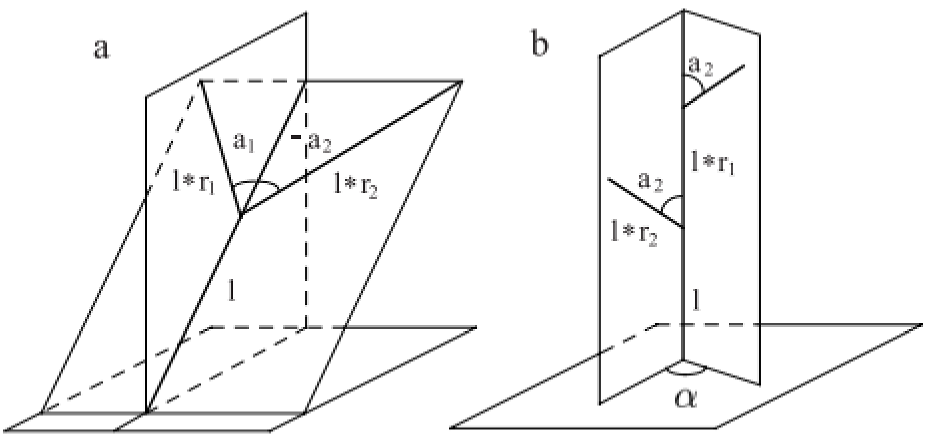


This is a very basic overview of course and I will research further into this method once I am sure of the scope and aim of the project. Whether I use this method or not however, I believe that this paper and it's references will be of great use moving forward.

3.2.2 The Algorithmic Beauty of Plants

This book Przemysław and Aristid (1990) provides many insights into the algorithmic construction of plants. After a brief look through it seems that the most relevant section will be chapter 2 "Modeling of trees" which puts forward a method of generating branches through a *mother branch* having two *daughter branches* that split off from it. These daughter branches are shortened using constant ratios with repect to the mother branch and are angled from the mother branch using constant *branching angles*. The mother branch and daughter branches are contained in the same *branch plane*.

Figure 2: Proposed tree geometry



This book was co-authored by Przemysław Prusinkiewicz who was also a co-author of the space colonization paper I referenced previously. It seems that his research into the 3D construction of plants will be useful while researching for this project. Once I am sure of the direction I'm taking the project I will read into this book more closely to glean more details that could aid my progress.

4 Proposed Approaches

My chosen approach for implementation will be using C++ to create an OpenGL module that can then be used as part of an existing OpenGL project.
At this early stage of the project I am unsure of the exact algorithmic method I will be using but I know the general process I will likely follow.
The tree trunk and branches will need to use some sort of random walk algorithm that takes into account the length and angle of growth of the parent branches. Some unit of randomness will have to be used to help produce realistic looking trees while following this process. Considering that I hope to create trees that will be seen to have grown around obstacles the random walk will also have to take obstacles into account and have a method to avoid them.
After the trunk and branches are fully constructed I will need a method of applying a correct thickness of the branches to the skeleton that I constructed using the random walk. I am currently unaware of whether it will be more beneficial to add thickness to the branches as the tree is constructed or if it will be easier to add after the entire skeleton is finished.
After the branches are finished completely I will need a method of adding leaves to the tree. Due to leaves only growing on further out branches I will need to have some method of distinguishing between the trunk of the tree and the branches. I don't know yet how I will add the leaves specifically. The likely approach would be to add a premade leaf model to parts of the branch using a chosen algorithm to decide their distribution. I have yet to fully understand the algorithms suggested in the paper I mentioned earlier Adam et al. (2007) but I will continue to research the possible methods.

5 Risks, Mitigation and Contingency Planning

Possible risks that could arise during this project are:

- Loss of workstation (Laptop or PC). This will me mitigated through the use of version control for both the codebase and report.
- Deletion of codebase from Github. This will be mitigated by having a secondary physical backup of the codebase, allowing for it to be used as a contingency plan in the event of the code being deleted.
- Scope creep is mitigated in the planning stage. I will follow a solid plan that will allow me to reach realistic goals without the project getting away from me.

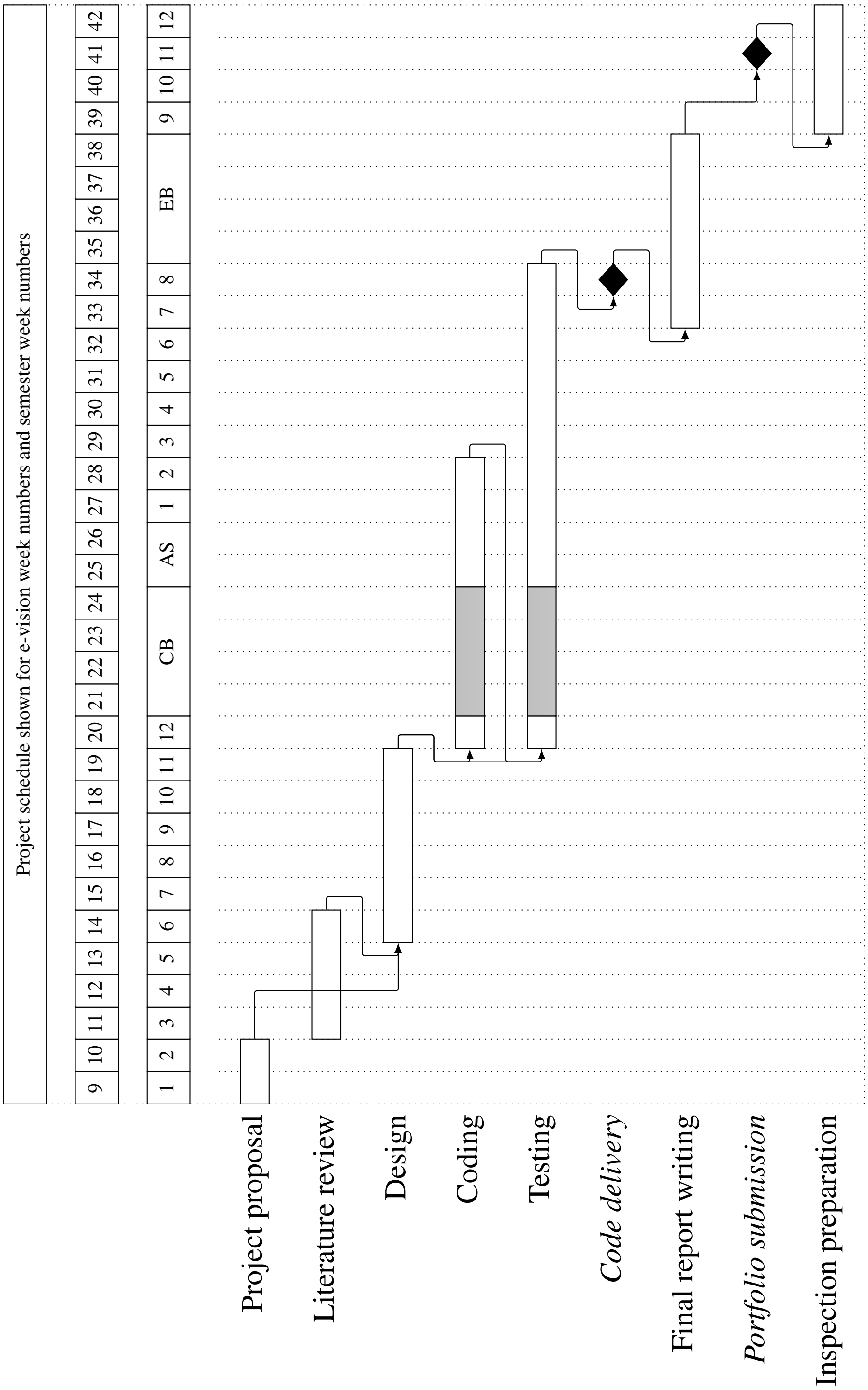


Figure 3: Project Gantt chart

References

Adam, R., Brendan, L., and Przemyslaw, P. (2007). Modeling trees with a space colonization algorithm. *http://algorithmicbotany.org/papers/colonization.egwnp2007.large.pdf*.

F12 (2014). 3d tree growing software - the grove. *https://www.thegrove3d.com/*.

IDV Inc. (2017). Speedtree – 3d vegetation modeling and middleware. *https://store.speedtree.com/*.

Przemysław, P. and Aristid, L. (1990). The algorithmic beauty of plants. *http://algorithmicbotany.org/papers/#abop*.

Project proposal

Description of project: aims, motivation, understanding of issues, problems	First	2.1	2.2	3	Fail
Resources, references: evidence of preliminary work to identify key resources, initial reading	First	2.1	2.2	3	Fail
Proposed approaches: relevance, suitability, appropriateness	First	2.1	2.2	3	Fail
Risks: identification, suitable contingency planning	First	2.1	2.2	3	Fail

Quality of writing

Clarity, structure correctness of writing	First	2.1	2.2	3	Fail
Presentation conforms to style	First	2.1	2.2	3	Fail

Workplan

Measurable objectives : appropriate, realistic, timely	First	2.1	2.2	3	Fail
Gantt chart: legibility, clarity, feasibility of schedule	First	2.1	2.2	3	Fail

Comments

Supervisor: Dr. Stephen Laycock

Markers should circle the appropriate level of performance in each section. Report and evaluation sheet should be collected by the student from the supervisor.