Cover Letter

Dear OSCAR Review Committee,

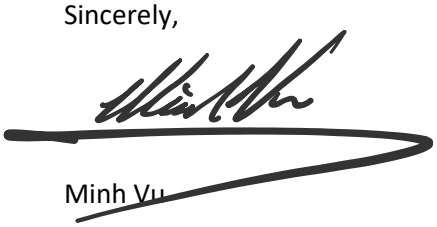
Throughout high school, I have endeavored on numerous projects that allowed me to combine my creative and problem-solving nature. Many of these projects were focused on graphic design, robotics, and game development. They all share a visual feedback loop, something that allowed me to recognize and identify problems and effectively improve the project. This experience was revitalized when I started my final project in *HNRS 122: Expression in Video Games* with Dr. Jan Allbeck. The assignment was to design a video game, which encompassed story, gameplay, visuals, levels, and characters.

My game, *Uniquest*, was centered on the concepts of planetary-scale exploration, colonization, resource management, and worlding building. The course's final project required two levels to be designed, each with one of two themes: clarity or mystery. I considered illustrating the levels on paper, but I felt that that route wouldn't fully encompass the spherical nature of the planet levels nor would it correctly display my vision. In order to solve this problem, I took to learning 3D modeling through Blender and integrated it with a game engine, Unity, to create a functioning game demo. I thoroughly enjoyed learning the tools, and it inspired me to keep learning about game development. You can view the demo here: https://minhd-vu.github.io/Uniquest/docs/index.html.

I would like to continue the development of *Uniquest* and explore the possibilities of procedurally generating planets and simulating biospheres. While I manually created two planets in Blender for my final project, to achieve my goal of an almost limitless universe, I would have to turn to procedural generation in order to efficiently design new planets for players to interact with. Furthermore, biosphere simulation would encompass the planet's response to the player's actions.

I believe that this research opportunity would give me an in-depth introduction to computer graphics, which I hope to explore further in my education. I am currently majoring in computer science, but I hope to tailor my senior computer science electives towards computer graphics and game programming. Hopefully, the collective of senior courses, research experiences, and extracurricular organizations will narrow my desired career and/or graduate school plans. I believe that engaging in a research project related to those fields would provide me with appropriate exposure along with invaluable experiences.

Sincerely,



Minh Vu

Introduction

Procedural generation is the process of utilizing computer software in order to create content autonomously (with or without human interaction). Many aspects of games can be procedurally generated, such as levels, maps, terrains, textures, rules, items, quests, stories, characters, etc. (Shaker et al. 1). A benefit of procedural generation is that it reduces the cost of assets and human resources (Shaker et al. 2). I plan to use procedural generation in my research project to model planets and ecosystems while having them coherently respond to human/player interaction.

Procedurally generated content has a vast array of applications and therefore, there is little specificity regarding the topic I wish to pursue. From a preliminary search of scholarly research on procedural generation, some key topics included procedurally generated terrains, generating planet shaped objects, and ecosystem modeling; however, the implementation of these into one entity remains unaddressed in academia.

Of the resources I found that detailed procedurally generated planets, the planets generated are dull, comprising of one or two environmental elements (e.g. soil and water). There is little expansion into vegetation, wildlife, or ecosystems (Watkins ch. 9). I hope to bridge the gap in scholarly conversation around procedurally generated planets and ecosystem simulation.

Beyond the information found in scholarly sources, it seems that there are various sources, such as YouTube videos, online articles, and published games, that provide insight into bits and pieces of what I hope to accomplish. I hope to research and compile the various external sources in order to produce a comprehensive architecture and system for procedurally generating planets.

Overall, my research proposal addresses how procedurally generated planets and ecosystems can be seamlessly and attractively implemented using a game engine. Game engines are software development environments that allow developers to create games. They allow for ease of integration between code and assets (such as art and 3d models). For the majority of the research project, I will be programming the algorithm to generate procedural planets while defining their interactions with ecosystems.

The project can be tailored toward educational purposes. For example, in environmental studies or biology class students may learn about the effects of deforestation's effects on ecosystems in real-time through the visual representations presented in the project. Additionally, the project could be extended by future researchers to make ecosystems more realistic by introducing more accurate simulation variables.

Furthermore, I expect to not only research how to create procedural generated planets, but I hope to expand it to make a functioning game, which incorporates exploration, resource management, and world-building. Therefore, this research proposal aims to address a research question while function as a creative project.

Process

To adequately address the research question and accomplish my goals, I will have to be thoroughly versed in 3D game engines and modeling applications. There are three main game engines that I wish to explore: Unity, Godot, and Unreal Engine 4. Upon researching the differences and advantages of each, I will then determine an engine that will best suit my needs for the research project. I will attempt to create procedurally generated planets in each engine and select the engine is the most pragmatic in continuing the research project.

The procedurally generated planets should be diverse, attractive, and realistic to an extent. The planet should encompass ecosystems, various terrains, and codependent wildlife. Because planets can encompass a multitude of entities and sub-entities, the organization of the project is imperative. Planets will be subdivided into terrain and ecosystem.

Terrain will have factors such as altitude and material. Altitude will determine the magnitude of mountainous regions on the planet and the overall shape of the planet. The material will define the physical characteristics of the elements on the planet. For example, one material could be dirt, a fertile resource, capable of supporting plant life, another material could be sand, a rather infertile, but structurally capable material. Terrain will be generated following a set of rules. These rules will be material dependent and somewhat follow the laws of physics. For example, one rule could be that water must touch the sand before it can touch the soil.

Ecosystems will generate a variety of wildlife, which will be broadly categorized into static and dynamic entities. Static entities will generally not move but can grow, such as trees and bushes. Dynamic entities, however, can move and interact with both static and dynamic entities. They will compete for resources, therefore simulating an ecosystem. In terms of interaction, I hope to design the relationships in a way such that they may be able to model natural selection, aggression, and mutation.

The research project will strive to combine the planets and ecosystems into numerous, unique, procedurally generated environments. I will begin by researching the various methods for implementing procedurally planets with ecosystems, and upon reaching this research checkpoint, I will select the most viable method, and through informed trial and error, I will begin implementing it.

Once the core of the game has been created (i.e. planets can be generated with ecosystems), I plan to implement objectives, player-planet interaction, and overall make the simulation feel more like a game. Players should be able to explore from planet to planet by traveling through their spaceship. Players should have the ability to interact with their environment. For example, gathering trees may allow the player to construct buildings; however, deforestation will devastate the local ecosystem, potentially exterminating wildlife.

The goal of the procedurally generating planets is not to create a self-sustaining planet, but rather being able to generate a planet that could expedite the time and resources associated with creating 3D planet assets by artists. Furthermore, the simulation aspect of the research project attempts to add diversity and player-planet interaction to the game—a planet-sized sandbox.

Timeline

Week 1	Research and Planning: Procedurally Generated Planets Compile the various sources detailing how to construct procedurally generated planets. Compare and contrast the various methodologies and choose the most optimal choice for the research project. Plan a course of action for the desired game engine and ensure that the plan includes modularity and scalability for additional features in the later weeks of the research.
Week 2-3	Execution: Procedurally Generated Planets After initial planning has concluded, a game engine will be chosen to continue with the rest of the research. Implement the system for procedurally generating diverse and attractive planets.
Week 4	Research and Planning: Ecosystems Research and compile the varying methodologies for implementing ecosystems and choose the most optimal choice. Plan the integration into the already developed procedurally generated planets, and devise solutions for project restructuring if necessary.
Week 5-6	Execution: Ecosystems Implement ecosystems which include interdependent plant and wildlife.
Week 7	Research and Planning: Game Features Create a manageable plan for additional features that would allow the procedurally generated planets and ecosystems to feel more game-like (e.g. resource management, population control, planet manipulation, etc.)
Week 7-8	Execution: Game Features Implemented the desired game features.
Week 9	Quality Assurance Ensure that the game is polished to a point where the game's core mechanics do not compromise the feel of the game and that there is a seamless experience while playing the game.
Week 10	Poster Creation, Research Summarization, Presentation

Expected Outcomes

The research project will hopefully fill the gap in scholarly conversation over combining procedurally generated planets with ecosystems. The procedurally generated planets have applications in exploring how species may interact with one another and may prove to be a useful model upon extension by further research. Moreover, games that plan on using procedurally generated planets will have a concrete preestablished basis and may extend the research. Being able to model, modify, and acquire real-time feedback will allow future researchers, developers, and students the opportunity to better understand ecosystems and the influence of different environments.

Overall, the research project will strive to be able to procedurally produce small scale planets that have a multitude of materials, life, and planet-wildlife interaction. For example, on such a planet may be comprised of most of the frozen water, land may be relatively flat, and vegetation may be near non-existent, while other planets may have fluid oceans, active and diverse wildlife, but maybe mountainous and untraversable towards the poles.

Furthermore, there will be a written comparison detailing the trial and error associated procedurally generating planets and the most effective methods used. It will help guide the scholarly community in reproducing the project and aid in the future extension of modeling more accurate biospheres. Additionally, if the game is in a ready state, I plan on publicly releasing the playable version on itch.io and/or Steam. Otherwise, the research project will be published on GitHub and readily accessible for future research.

Works Cited

Shaker, Noor., et al. *Procedural Content Generation in Games*. Springer International Publishing, 2016, doi:10.1007/978-3-319-42716-4.

Watkins, Ryan. *Procedural Content Generation for Unity Game Development: Harness the Power of Procedural Content Generation to Design Unique Games with Unity*. Packt Publishing, 2016.

Budget

I hope to engage in an intensive USRP over the summer. As compared to a traditional USRP, the additional time will be necessary for completing the research project. Planets are complex entities, and procedurally generating them and combining them with dynamic ecosystems will prove a challenge; therefore, the time allocation will favor that of an intensive USRP.

My supply budget will be primarily allocated towards the purchase of assets to expedite the research project and meet my expected outcomes in a timely manner. Generally, I will purchase assets that would be necessary to complete the project that would otherwise be unfeasible to create myself. For example, if I required some 3D models for a game, such as an array of buildings, depending on my progress thus far, I would consider purchasing art assets to keep my project on track. Similarly, if there was something that would be too time-consuming to program, such as a more optimal lighting architecture, I would consider purchasing the asset. Additionally, the budget might also be allocated to contract artists and sound designers to create resources that would be considered outside the scope of the research project.

Here are the budget breakdown and some examples that I might consider purchasing throughout the research project.

Description	**Price**	**Source**
Low Poly Nature Package • 350 nature-related assets that encompass four seasons.	$20.99	https://assetstore.unity.com/packages/3d/environments/low-poly-nature-package-87956
Low Poly Animated People • 36 unique animated characters	$12.00	https://assetstore.unity.com/packages/3d/characters/humanoids/low-poly-animated-people-156748
Low Poly Animated Animals • 24 unique animated animals	$30.00	https://assetstore.unity.com/packages/3d/characters/animals/low-poly-animated-animals-93089
Space Skyboxes & Planets • 12 unique skyboxes	$89.99*	https://assetstore.unity.com/packages/3d/environments/sci-fi/space-skyboxes-planets-156674
Low Poly Ultimate Pack • Numerous 3D models that might prove useful in production.	$30.00	https://assetstore.unity.com/packages/3d/props/low-poly-ultimate-pack-54733
A* Pathfinding Project Pro • Used for dynamic entity navigation	$100.00*	https://assetstore.unity.com/packages/tools/ai/a-pathfinding-project-pro-87744
Behavior Designer - Behavior Trees for Everyone • AI supplement	$80.00*	https://assetstore.unity.com/packages/tools/visual-scripting/behavior-designer-behavior-trees-for-everyone-15277
DoozyUI: Complete UI Management System	$65.00	https://assetstore.unity.com/packages/tools/gui/doozyui-complete-ui-management-system-138361
	TOTAL	$157.99-$427.98*

Asterisks (*) indicate that there is a free alternative (or contingent upon self-implementation). Overflow budget may be used on contractors or assets that may be needed later.