Immersive and Interactive Virtual Geographic Environments

PREPARED FOR

CS 46X

PREPARED BY

GROUP 10

Seaside Tsunami Simulation

Abstract

While there are many modern tools that can be used to simulate complex weather systems and disaster scenarios, oftentimes it can be difficult for geographic researchers to display the results of their work in a way that can be understood and significantly impact the average viewer. As such, this project was created to help bridge that gap between geographical data and its realistic visualization, and successfully identifies a realistic and scalable workflow that produces accurate, real-time simulations of diverse environmental conditions.

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1 Background

The virtual geographic environment (VGE) is a geographic analysis tool that helps geographic researchers and scientists analyze data and solve geographic problems. Geography is the science that studies all the physical features of the earth. Our geographic scientists have been trying to solve geographic problems, like tsunami and wildfire, by studying and analyzing the pattern of geographic features.

There are several geographic analysis tools like the map and GIS system (H.Lin, 2013), that were developed during different stages of geographic study. The map is the fundamental tool that describes the general picture and basic features of a place for scale sizes, from a small town to a whole planet. The GIS system is an upgraded tool that builds based on maps and more geographic datasets. The GIS system can help geographic researchers to analyze data with existing geographic data and functions. However, the existing tools are not quite friendly enough for its users and audiences. The 2D visualization is limited and hardly understandable without a comprehensive knowledge of the GIS system.

In the past few years, the VGE has been proposed as a new geographic analysis tool because of 3D visualization, which enhances the user experience in understanding the geographic content. However, there are many different data formats and analyzing tools that need to be integrated. Thus, our project partner Dr. Raffaele de Amicis, an OSU professor who has been researching visualizing GIS data into 3D virtual environments, has proposed this project.

2 Vision Statement

Our goal for this project and our project partner Dr. de Amicis is to help geographical scientists visualize their research in a realistic virtual geographic environment with real geographic datasets. The visual experience will be improved due to the usage of realistic visualization techniques and the efficient ingestion of real geographic datasets. The improved visual experience will help the geographic storytellers present their content and attract the audience. The time cost of geographic visualization will be reduced due to the generated and scalable workflow from this project, and will save time for further research.

2.1. Central Hypothesis

Growth hypothesis:

The users will adopt the workflow of this project because of the realistic and immersive landscape generated from a real geographic dataset. Geographic storytellers will use this VGE tool to narrate their stories with a better visual experience.

Value hypothesis:

The virtual geographic environment will be beneficial to geographic scientists to make a comprehensive analysis of data and a deep-level understanding of their research.

2.2 Requirements

Functional requirements:

- The system must take real geographic data.
- The system must visualize data into a 3D virtual geographic terrain.
- The visualization must be done through the Unreal Engine.

Non-functional requirements:

- The virtual geographic terrain should be as realistic as possible.
- The virtual geographic environment should be as personal as possible.

3 Prioritized Project Constraints

Time:

Our full development timeline is about 6 months, the rest of the academic year. While this is a development cycle of decent length, we cannot afford to waste time during development. All members of the team have other classes and responsibilities that they need to take care of in between working on this project. We will use Asana and the Scrum methodology to help with our time management. Most classes recommend 3 hours of study time for each hour of class time. So each of us should be responsible for at least three hours of development time each week to this class. Other than VR hardware we will not need to allocate any time to acquiring equipment or materials.

Resources:

Our group has access to a multitude of resources. Unreal Engine is the main software component for our project, and GIS data is freely available from the USGS. Those two elements make up the middleware of our project. In order to deliver past the basic deliverables, we will need VR headsets to test the program in VR. This will require a budget of about $300 per person, or $900 dollars in total. For any disaster simulation and destructive environments, we may need to purchase dynamic terrain middleware, however we could also program those functions ourselves if time allows.

Scope:

The minimum deliverable for this project will be as follows:

1. A repeatable method to create 3D models from GIS/LIDAR data
2. A repeatable method to import the 3D model into Unreal Engine
3. Procedural generation of POI (Points of Interest) based on GIS/LIDAR data

Additional features that would be added if minimum deliverables are added:

1. VR support
2. AI roaming agents representing pedestrians
3. Dynamic Lighting (Night/Day) Cycle
4. Environmental Sounds
5. Weather
6. Destructive environments
7. Disaster Simulation

4 Scope

1.1 Process Flows

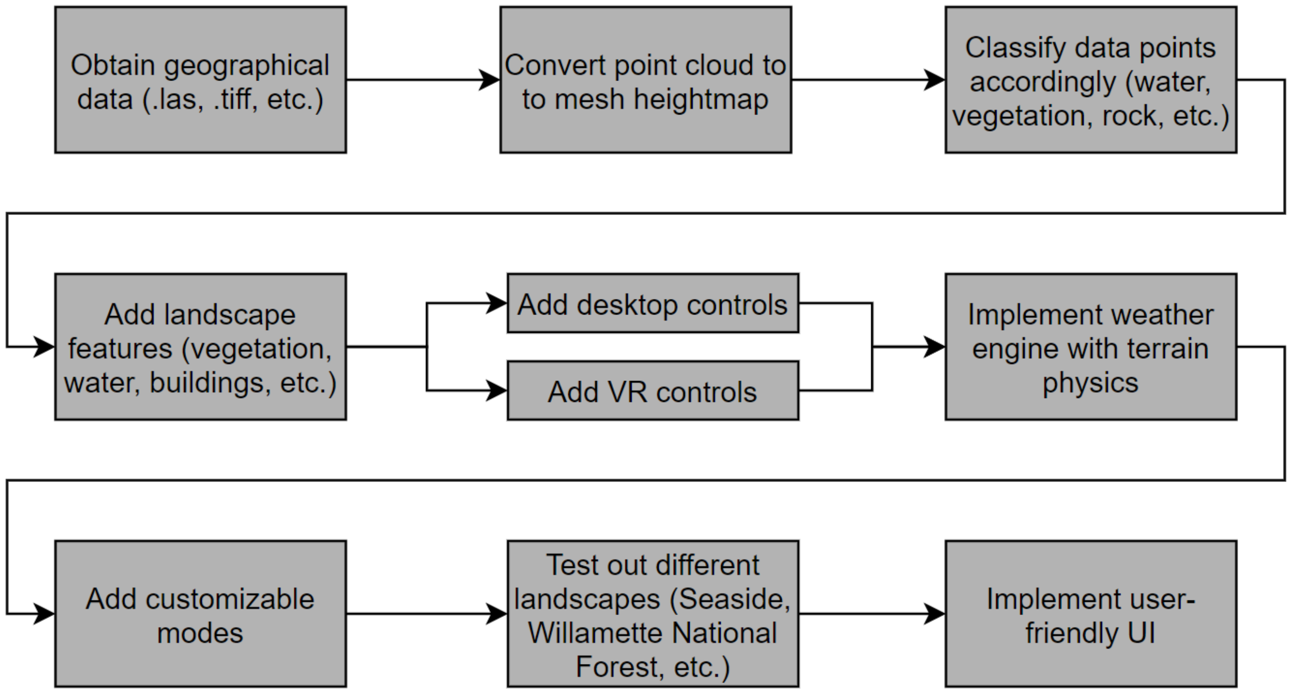

Figure 1: process workflow for completing this project

1.2 User Stories (Epics and Features)

- As a civil engineer, Dr. Daniel Cox wants to visualize disaster simulations in order to predict, prevent, and mitigate future natural disasters. For example, this project could be used to visualize how a tsunami would affect the coast of Seaside, Oregon, thus identifying where structural weak points are.
- As a research biological scientist, Dr. John Kim wants to visualize national forests under climate change conditions in order to further help communicate climate change impacts on forests. This is traditionally done with 2-dimensional maps, and a 3D immersive VR experience would more clearly visualize its effects. For example, this project could be used to visualize how the Willamette National Forest would change by 2100, and identifying how the climate would need to change by then in order to prevent that.

5 Iteration Plan and Estimate

Due to the development team's lack of experience with Unreal Engine, visualizing geographical data, and using VR headsets, project development will take more time than usual in order to account for time spent learning new skills. Keeping this in mind, the goals of this years Sprints will be as follows:

1. Learn to create landscapes in Unreal Engine and how to categorize points within the geographical data set (such as vegetation, water, roads, etc.)
2. Import the classified data sets into Unreal Engine with all the necessary objects (buildings, vegetation, etc.), and learn how to implement VR with Unreal Engine.
3. Add photorealistic lighting and effects, and create controls for both desktop and VR modes. Also, learn about how to implement weather and physics engines in the project.
4. Implement the relevant weather and physics systems, and gain access to more geographical data sets for more testing.
5. Prepare more geographical data sets for the project, and start a portfolio showcasing the project's features. In addition, learn about how menus and UI's work with Unreal Engine.
6. [stretch goal] Implement a user-friendly interface in which the user can input a classified geological data set and see the corresponding visualizations.
7. [stretch goal] Clean up project, and learn about how to implement the data preprocessing into Unreal Engine itself (as opposed to using other softwares beforehand). Also, learn about how to process other data formats (such as .laz, .tiff, etc.).
8. [stretch goal] Implement more acceptable data sets, such as .laz, .tiff, etc. Prepare project for official beta release.

6 Report of Alpha Functionality

6.1 Ibrahim Mahmoud

An undergraduate senior majoring in computer science with an emphasis on artificial intelligence and computer graphics, Ibrahim's primary focus is to implement the physics simulations and graphics in Unreal Engine. Given that the current goal is simulating a tsunami, and that he has had no prior experience with Unreal Engine, he has spent most of his time learning about what the software is capable of as well as the physics behind ocean waves. Specific tasks include:

- Learning about and testing Unreal Engine's new Water plugin
- Learning about and implementing Gerstner waves
- Learning about and implementing a realistic ocean shader
- Learning about how materials and blueprints communicate with each other
- Learning about the Cascade particle system
- Learning about linear wave theory and tsunami physics
- Converting GeoTiff files into an image format Unreal Engine accepts
- Mapping height maps and satellite images onto generated landscapes

6.2 Zachary Morello

Zachary Morello is an undergraduate student majoring in computer science with an emphasis in simulations. Zachary Morello's main focus is to implement procedural texturing, mesh generation, and the illusion of a living world. To achieve the illusion of a living world, he has started work on AI pathfinding agents to populate the Seaside, Oregon simulation. Specific tasks include:

- Learning ArcGIS Pro's interface.
- Understanding GeoTiff file formats
- Creating base-map textures for Seaside, Oregon's mesh
- Learning about options in crowd simulation for Unreal Engine
- Generating procedural foliage and objects across the Seaside, Oregon landscape
- Applying high resolution procedural color - based texturing across a satellite image of Seaside, Oregon
- Creating intelligent AI agents that convincingly represent Seaside, Oregon pedestrians
- Building navigation meshes for AI agents to traverse across

6.3 Wanying Lu

Wanying Lu is a undergraduate senior and is studying for a bachelor's degree in computer science at Oregon State University. In this capstone project, her current main goal is to integrate Unreal Engine 4 with CityEngine, which generates buildings and streets with real-world geographic datasets. She spends most of her time exploring CityEngine and other geographic tools to meet the specified goal. Specific tasks include:

- Learning Geographic Information System (GIS) datasets
- Learning how to get access to real-world datasets
- Learning how to implements building and street generation in CityEngine
- Import given heightmap, building footprints, and street networks into CityEngine
- Generate buildings and streets in CityEngine
- Shape buildings and streets with CityEngine rules
- Align buildings and street shapes to Seaside terrain
- Export shape model from CityEngine to UE4 supported format (.udatasmith)
- Enable UE4 plugin, Datasmith Importer, to allow importing .udatasmith models
- Import generated models into UE4 and align them to the eam project
- Learning about how to retexture imported models with high-quality textures in UE4

7 References

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