On Demand Texturing and Interactivity with Generative AI and Neural Radiance Field (NERF)-like models

Group Members:
Brendan Bain: bbain7@uwo.ca
Brandon Nathan Marks: bmarks7@uwo.ca
David Alter: dalter4@uwo.ca

Supervisor:
Dr. Brent Davis
Department of Computer Science and Psychiatry

4470Y Software Maintenance and Configuration Management
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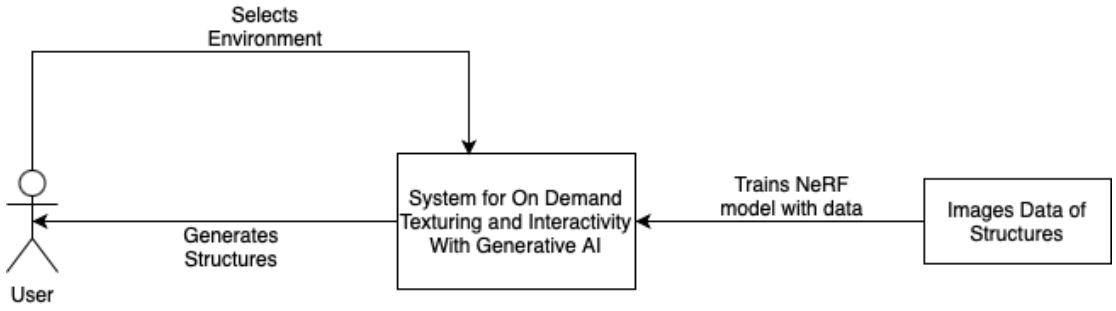
Progress Report 1

Overall Project Description

Modern advances in generative AI are supercharging many fields, including the fields of virtual, augmented and extended reality (VR, AR, XR). One of the labour intensive activities in game creation is the generation and detailing of virtual worlds. New technologies such as neural radiance fields (NeRFs) models show promise in allowing objects from the real world to be mimicked in these spaces with little effort, and may even be doable from within the headsets themselves.

In this project, we will learn about the foundations of these new technologies, beginning with basic concepts such as marching cubes and NeRF models, and implementing them into a software system. The goal is to allow the user to generate different structure types and objects in a real-time virtual reality environment using the Meta Quest 3 VR headset. The NeRF models which we will be using will be trained on images of structures such as houses, buildings, or trees. Our research findings, as well as any systems built, may be used by the Nomad XR company, which focuses on combining aspects of AI and XR, as well as exploring the potential of virtual and augmented reality by developing frameworks for indie game studios.

Context Diagram



Project Goal and Objectives

GOAL: To create a system that is capable of generating structures at runtime that look appropriate in the surrounding virtual environment, and mimic real-life objects.

OBJECTIVES:

O1: Have the project setup with a blank VR scene

O2: Create a generic wireframe representing structure and implement marching cubes algorithm to add mesh

O3: Have a trained NeRF model that generates a structure

O4: Have the NeRF model generate all structure types

O5: Optimise performance considering headset specifications

O6: Have the model working with the Meta Quest 3 Headset

O7: Add collision to the outside of a structure

O8: Add collision to the inside of a structure

O9: Have the NeRF model generate all structure types with collision
O10: Use a heuristic to make sure the structure is navigable by an avatar

SIGNIFICANCE: This project can help streamline the model-building process for VR environments by automating key aspects and reducing the manual workload for game developers. Not only can this accelerate the development cycle, but it can also mitigate burnout by sparing developers from repetitive and time-consuming tasks. The objectives of this project are meant to divide our work into manageable portions that build off of each other. Each objective in this project can be seen as a prototype of the system as it develops. By the final objective, all features will have been implemented.

Project Roles

1. **Brendan -** Project Manager

keep track of everything, who-does-what, project status, monitors progress, coordinates the team, etc. Ensures development tools are available to the team. Collaboratively decides on the logistics of work operations (where, which machines, etc.). Collaboratively sets internal meetings dates and times.

2. **Brandon -** Lead Technology(tools) Specialist

Lead Requirements Analyst, Lead Architect, Lead Tester & Quality Controller, Lead technology (tools) specialist. If someone is “Lead” in an area then one or more others are seconding the lead (as “watchdog”) to help ensure system quality

3. **David -** Documenter

prepares diagrams, refines documents, prepares presentations, demos, etc. Obtains base information from project members.

System Requirements

Feature 1: Virtual Reality Headset Compatibility

- **QR 1.1**: The system is compatible with the Meta Quest 3 headset and performs as expected in a real-time virtual reality environment.

Feature 2: Multiple Types of Structures to Generate

- **FR 2.1**: Given a user selection/environment, the system will generate the specified/appropriate structure, the structures generated can be in the form of a house, building, tree, ect.

Feature 3: Rendering of Objects

- **FR 3.1**: When a user looks in the direction of a particular structure, that structure should appear as rendered in the virtual reality environment.
- **FR 3.2**: Given that a user looks at a particular structure, that structure should appear to be its specified size.

Feature 4: Multiple Structure Interaction Types

- **FR 4.1**: The system should be capable of generating background structures without collisions with any other objects. Background structures are objects that are not meant to be interacted with.
- **FR 4.2**: The system should be capable of generating decoration structures, these structures may collide with other objects but are not meant to be interacted with.
- **FR 4.3**: The system should be capable of generating traversing structures, these are structures that are meant to be interacted with, such as buildings that you are able to walk into.

Feature 5: Performance Optimization

- **QR 5.1**: Optimise system performance considering the specifications of the VR headset in use (Meta Quest 3).
- **QR 5.2**: The system as well as the environment running it should not drop below 60fps.

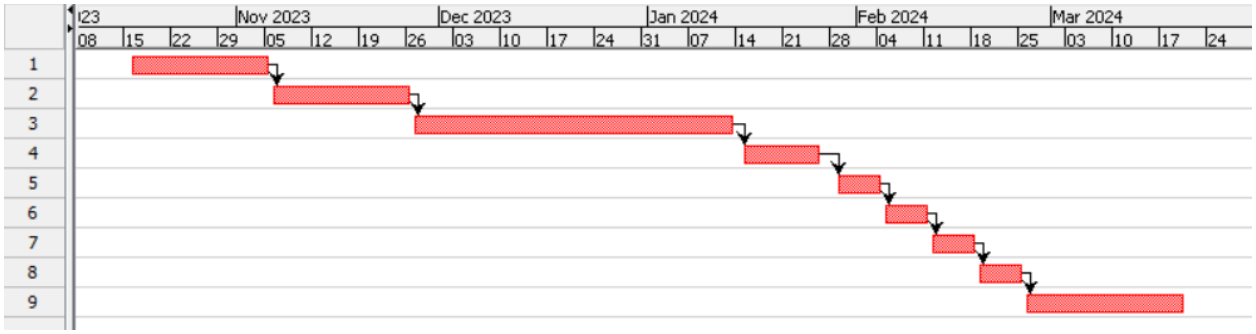
Feature 6: Scalability

- **QR 6.1**: Design the system to handle varying levels of complexity and scale for different virtual reality environments.

Project Plan and Tracking (Brendan)

The features being worked on in a given iteration can be found in the chart below under the “Objectives Addressed” column.

	Name	Duration	Start	Finish
1	Have the project setup with a blank VR scene	21 days?	16/10/23 8:00 AM	05/11/23 5:00 PM
2	Create a generic wireframe representing structure and implement marching cubes	21 days?	06/11/23 8:00 AM	26/11/23 5:00 PM
3	Have a trained NeRF model that generates a structure	36 days?	27/11/23 8:00 AM	13/01/24 5:00 PM
4	Have the NeRF model generate all structure types	12 days?	15/01/24 8:00 AM	26/01/24 5:00 PM
5	Optimise performance considering headset specifications	7 days?	29/01/24 8:00 AM	04/02/24 5:00 PM
6	Have the model working with the Meta Quest 3 Headset	7 days?	05/02/24 8:00 AM	11/02/24 5:00 PM
7	Add collision to the outside of a structure	7 days?	12/02/24 8:00 AM	18/02/24 5:00 PM
8	Add collision to the inside of a structure	7 days?	19/02/24 8:00 AM	25/02/24 5:00 PM
9	Have the NeRF model generate all structure types with collision	24 days?	26/02/24 8:00 AM	20/03/24 5:00 PM



All development has a hard deadline of March 20th 2024. There will be minimal development between December 8th - January 8th due to exams and winter break, so iteration 3 has been extended.

Spreadsheet

4470FeaturesPR1

Feature ID	Objectives Addressed	Requirements	Tasks	Agent	Status
1: Virtual Reality Headset Compatibility	O1, O2	ALL the requirements	Setup necessary development tools		
			Create project repository		COMPLETE
			Test version control		
			Create VR compatible project		
2: Multiple Types of Structures to Generate	O3, O4	ALL the requirements	Build foundational knowledge of NeRFs		
			Gather and clean image data of structures (city building, house, tree)		
			Select NeRF model		IN PROGRESS
			Train NeRF model on all 3 types of structures		
			Verify structures are generated correctly		
			Develop UI for		

			structure selection		
			Verify selections produce correct structure		
3: Rendering of Objects	O6	ALL the requirements	Develop code for scene manager		
			Implement dynamic loading		
			Test rendering using different view angles		IN PROGRESS
			Test rendering of scene using Meta Quest 3 headset		
4: Multiple Structure Interaction Types	O7, O8, O9	ALL the requirements	Develop code for adding collision to an object		
			Apply collision to a generated structure manually for blocking purposes		
			Develop code for adding collision to a structure at the time it is generated		NOT STARTED
			Develop code for adding collision to the inside of a structure		
			Develop code for adding collision to the inside of a structure at run time		
5: Performance Optimization	O5	ALL the requirements	Analyse system to gain an understanding of which components are the most resource intensive		
			Optimise any		NOT

			algorithms that can be optimised		STARTED
			Lower poly count of structure without sacrificing substantial quality		
6: Scalability	O5	ALL the requirements	Maintain good coding practices		
			Maintain low coupling and high cohesion		IN PROGRESS
			Optimise performance		
			Test with large scenes		

https://www.matthewtancik.com/nerf
https://github.com/kwea123/nerf_pl/blob/master/README_mesh.md
Neural Sparse Voxel Field
https://github.com/facebookresearch/NSVF?tab=readme-ov-file#dataset