VR Smart Garden & Farm Simulator

Keith Washington, Ayesha Siddiqui, Kyle Tran

Faculty Name: Dr. Sharad Sharma, Department of Data Science, University of North Texas - Denton, Denton, TX 76205

Abstract—Traditional agricultural education faces significant challenges due to limited access to farming facilities, particularly in urban environments. This paper presents the VR Smart Garden & Farm Simulator, an immersive virtual reality application developed using Unity that allows users to explore and interact with a simulated farming environment. The application features garden plots, farm animals, interactive tools, and sensor-based events including proximity, time, and touch triggers. Users can perform farming activities such as planting, watering, harvesting crops, and interacting with AI-controlled animals. The target audience includes students, educators, and individuals interested in agriculture or VR experiences. This work demonstrates how VR technology can provide accessible, risk-free, and engaging agricultural education, addressing the gap between theoretical knowledge and practical application.

Index Terms—Virtual reality, agricultural education, Unity, simulation, NavMesh, sensor-based interaction, serious games.

I. INTRODUCTION

A. Goals and Objectives

This project aims to develop an interactive VR Smart Garden & Farm Simulator that allows users to explore and interact with a simulated farming environment. The primary objectives are:

- Create an immersive virtual farm environment with garden plots, plants, animals, tools, and farm structures.
- Enable user interactions including planting, watering, harvesting, and animal interaction.
- Demonstrate fundamental VR concepts: navigation, object interaction, environmental animation, and AI-driven character behaviors.
- Integrate sensor-based events including proximity triggers, timed events, and touch-based interactions.
- Provide an engaging educational experience that helps users understand farming processes.
- Showcase Unity as a VR development platform with C# scripting.

B. Designed Environment

The virtual environment represents a small farm and garden area. As shown in Fig. 1, the scene includes multiple garden plots for planting crops, trees and vegetation, a small shed/farmhouse structure, farm animals (chickens and cows), and interactive tools such as watering cans and baskets.

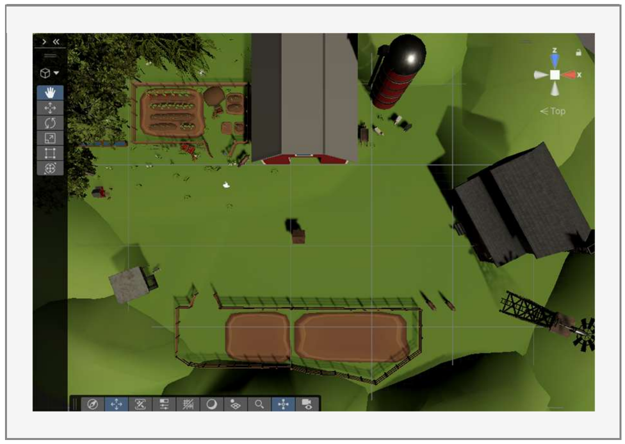

Fig. 1. Overview of the VR Smart Garden & Farm Environment showing the main farm area with garden plots, shed, and roaming animals.

Textures are applied to surfaces to represent grass, soil, wood, and natural materials, providing visual realism.

C. Target Audience and Usefulness

The target audience includes students, educators, and individuals interested in agriculture or nature-based VR experiences. The application is suitable for educational demonstrations and introductory VR training.

This application is useful because it provides a safe, repeatable, and accessible way to learn basic farming tasks without requiring physical land, seeds, or water. Studies have shown that VR can offer realistic, interactive simulations that are crucial for practical skills development [1].

II. RELATED WORK

Recent research has explored the application of VR and Extended Reality (XR) technologies in agricultural education. HoloFarm, developed by Ario et al. [1], is a VR-based farming simulation created using Unity and C# that integrates physical movement, joystick navigation, and spatial audio for crop cultivation. Evaluation with 27 urban users via the Igroup Presence Questionnaire showed strong spatial presence (M=5.59) and general presence (M=5.81).

Spyrou et al. [2] explored AI-driven Digital Twin systems embedded within gamified XR environments for viticulture and woody crop management. Their survey revealed participants are increasingly open to adopting VR combined with AI-enhanced technologies.

Choi [3] proposed a methodology for implementing serious games that integrate XR with smart farm systems, employing REST-based integration interfaces for real-time data synchronization. The study demonstrated that web-based development approaches ensure accessibility across various environments.

Research has shown that immersion and interactivity in VR environments heighten critical learning variables [4]. When applied to farming education, VR can simulate realistic farm settings where learners interact with virtual crops, livestock, and machinery, increasing engagement and receptiveness to complex agricultural concepts.

Liew et al. [5] examined the role of NPCs in digital learning environments. Pavlenko et al. [6] examined gamification approaches in precision farming through the Farming Simulator case, demonstrating that game-based learning can stimulate awareness of agricultural practices. Yoo [7] explored 3D virtual space agriculture education games based on historic environment simulation and guiding NPCs.

Unlike existing systems, our project integrates three types of sensors (proximity, time, and touch) with AI-based animal behavior and multiple interactive farming activities in a single accessible simulator designed for desktop VR interaction.

III. IMPLEMENTATION

A. System Architecture

Fig. 2 illustrates the system architecture showing user interaction with the Unity client.

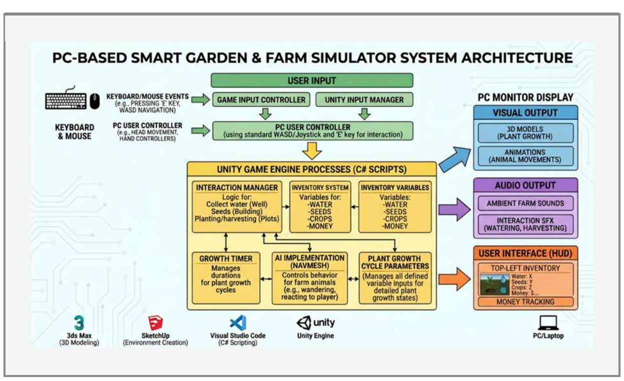

Fig. 2. System architecture showing user input through First Person Controller, processing through Unity's C# scripts, and output via visual, audio, and UI elements.

B. Modeling Phase

The virtual environment was constructed using Unity's Terrain tool for the ground base. 3D models were created using SketchUp and 3ds Max, with additional assets obtained from the Unity Asset Store. The environment includes:

- Terrain: Grass and soil textured ground with elevation variations.
- Structures: Wood-textured shed/farmhouse.
- Plants: Low-poly trees, shrubbery, and growable crops.
- Animals: Chickens and cows with basic rigging for animation.
- Tools: Watering can and harvest basket.

Textures including grass, soil, wood, and leaf materials were applied to surfaces to enhance visual realism.

C. Exporting to Unity Phase

All 3D models were exported as .fbx or .obj files and imported into Unity 2022 LTS. Materials and textures were reassigned within Unity using the Universal Render Pipeline (URP) for optimized rendering.

D. Scripting and Behaviors Phase

C# scripts were written using Visual Studio Code to implement interactions, sensor triggers, animations, and AI behaviors. The NavMesh system was baked to enable animal navigation.

IV. FUNCTIONALITY

A. Vision: Textures and 3D Models

Detailed textures and 3D models create a visually engaging environment. Fig. 3 shows the textured terrain and plant models.

Fig. 3. Textured terrain with grass and soil materials, garden plots, and plant models.

B. Sound

Ambient farm sounds (birds, wind) play continuously. Interaction sounds including water splashing, animal noises, and harvest sounds are triggered during user actions.

C. Animation

The project implements three animated object types:

- Farm animals walking using NavMesh navigation.
- Plant growth scaling after watering (triggered by timer).
- Environmental animations (leaves moving, grass swaying).

D. Interactivity

Five interactive events are implemented (see Fig. 4):

- Collecting water — Press ‘E’ near the well to fill water supply.
- Collecting seeds — Press ‘E’ near the farm building to pick up seeds.
- Planting seeds — Press ‘E’ at a garden plot with seeds in inventory.
- Harvesting crops — Press ‘E’ at a mature plant to collect crops.
- Opening farm gate — Press ‘E’ near the gate to open or close it.

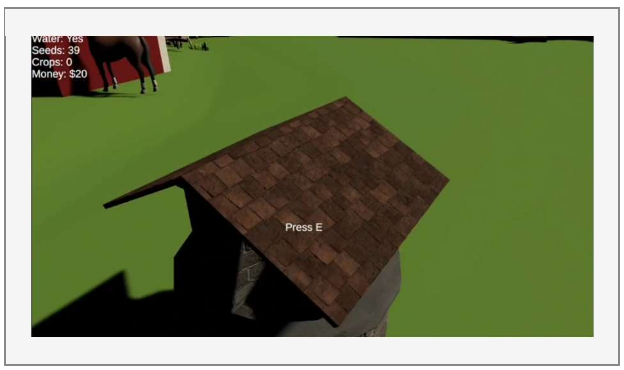

Fig. 4. Player interaction at the well to collect water (Press E).

E. Character Behaviors

Farm animals utilize Unity's NavMesh system for autonomous navigation. Fig. 8 shows the baked NavMesh area and animal movement paths.

F. Sensors

Three sensor types are implemented using Unity's trigger colliders:

- Proximity Sensor: Player enters trigger zone near interactive objects (well, seed source, garden plots, gate) to enable context-sensitive Press E interactions.
- Time Sensor: A timer triggers plant growth after the planting action is performed at a garden plot.
- Touch Sensor: Player collides with animal → animal sound plays.

G. Player Controller

A First Person Controller (FPSController) provides WASD movement and mouse look. Fig. 5 shows the controller hierarchy and components.

Fig. 5. First Person Controller in Unity hierarchy showing camera, movement, and interaction scripts.

H. AI Implementation

Animals demonstrate wandering behavior using NavMesh. The AI chooses random destinations within the navigable area and updates when the destination is reached.

I. User Interface Elements

The application features a persistent heads-up display (HUD) in the top-left corner of the screen that tracks four inventory values in real time: Water, Seeds, Crops, and Money. These values update immediately as the player collects resources or sells crops, providing continuous feedback on game state without interrupting gameplay. There is no separate start or main menu screen; the simulation begins immediately on launch.

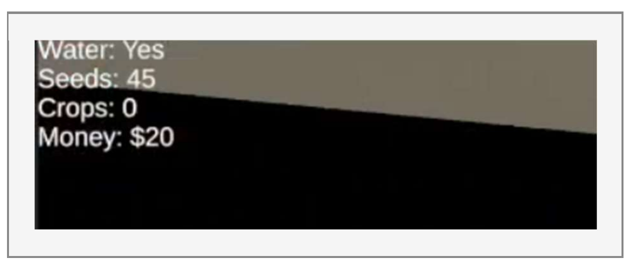

Fig. 6. Persistent HUD in the top-left corner displaying player inventory: Water, Seeds, Crops, and Money.

V. CONCLUSION

We successfully implemented a VR Smart Garden & Farm Simulator featuring interactive terrain, plants, animals, a well-based water collection system, seed pickup, garden plot planting, crop harvesting, gate interaction, animated animal movement, three sensor types, a first-person controller, and a persistent HUD inventory display.

This application is useful because it provides accessible, engaging agricultural education without requiring physical resources. VR is the appropriate technology because it offers immersive, hands-on interaction that mimics real-world actions better than traditional screen-based learning.

The target users include students, educators, and VR enthusiasts. Benefits include safe repetition of tasks, low cost compared to physical farms, and immersive learning experiences.

A. Problems Encountered

- NavMesh baking errors when terrain was modified.
- Plant growth timer resetting incorrectly on repeated trigger events.
- Audio clipping during rapid successive interactions.

B. Future Work

- Meta Quest hardware integration for untethered VR.
- Multi-user support for collaborative farming.
- More complex AI behaviors (flee, follow, feeding).
- ChatGPT integration for voice interaction with NPCs.
- Additional crop varieties and growth stages.

ACKNOWLEDGMENT

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APPENDIX: USER MANUAL

How to Use the Application

1. Run the Unity build executable. The simulation begins immediately on launch.
2. Use WASD keys to move, mouse to look around.
3. Approach the well and press E to collect water.
4. Approach the farm building and press E to collect seeds.
5. Walk to a garden plot and press E to plant a seed (requires seeds in inventory).
6. Wait for the plant to grow (time-based trigger).
7. Return to the mature plant and press E to harvest the crop.
8. Monitor your Water, Seeds, Crops, and Money totals in the HUD (top-left corner).
9. Approach the gate and press E to open or close it.

Software and Hardware Used

Category	Items
Software	Unity 2022 LTS, Visual Studio Code, SketchUp, 3ds Max, Unity Asset Store
Hardware	Windows PC, keyboard, mouse, standard monitor display

Additional Screenshots

Fig. 7. Garden plot before watering showing small plant.

Fig. 8. Garden plot after watering showing mature plant ready for harvest.

Fig. 9. Chicken roaming near the shed along NavMesh path.