International Journal of Business and Management Technology in Society
Available at https://journal.its.ac.id/index.php/ijbmts/

Design of Green House Information System using Virtual Reality

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Article History
Received : 2024-11-23
Revised : 2025-02-06
Accepted : 2025-04-08
Published: 2026-01-12

Keywords:
Virtual reality, Greenhouse, Information System, Agriculture

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Paper type:
Research paper

Cite this article:
Suhendi., Muksin, L., Maulana, R., Kautsasr, F. R. & Ridhwan, F. A. (2023). I*nternational Journal of Business and Management Technology in Society,* 1(2), 118-125.

Abstract

Purpose – The aim of this research is to create a hydroponic greenhouse that can be viewed virtually.

Methodology – The research method used is the multimedia development life cycle (MDLC) with stages of concept, design, asset creation, asset assembly, internal testing, and distribution for limited testing.

Findings – The findings obtained were successful in creating a hydroponic greenhouse application.

Originality – The originality of this research is the application of hydroponic greenhouses that can be enjoyed virtually by students and the public.

Research limitations – The research limitations in this study are the VRBox tool which is still limited because it still uses Google Cardboard in terms of VR features.

Practical Implications – This research is expected to have implications for application in schools to view hydroponic greenhouse rooms virtually.

Social Implications – The social implications of this research are that it is useful for students and the community to see hydroponics virtually.

Introduction

Elementary school, and secondary school students, farmers, and youth organizations have been introduced to farming using a hydroponic system in a greenhouse (Kavga et al., 2021; Patil et al., 2018; Waluyo et al., 2021). As in schools in general, the teacher only explains in front of the class, verbally describing the shape and workings of the hydroponic system and the greenhouse model farmhouse. Visually, students usually see through their books or pictures given by the teacher. Hydroponic plant cultivation using a greenhouse itself is not often found in Indonesia. This makes students unfamiliar with hydroponics and greenhouses. Palajar can only see and study forms of hydroponics and greenhouses via the Internet. To make it easier for students to learn hydroponics and greenhouses, a Virtual Reality greenhouse was created for cultivating plants. With this, it becomes easier for teachers to teach because they don't need to install original greenhouse and hydroponic circuits, but students can still understand this lesson easily.

ISSN 3025-4256

Hydroponic plant cultivation using a greenhouse itself is not often found in Indonesia. This makes students unfamiliar with hydroponics in a greenhouse. Palajar can only see and study the form of a hydroponic greenhouse via the Internet. To make it easier for students to learn about hydroponic greenhouses, a Virtual Reality Hydroponic Green House was created. Virtual Reality is an application of multimedia technology that has the advantage of describing a situation or an object. In virtual reality, a simulation of hydroponic plant cultivation in a greenhouse will be shown. Each object is given information regarding the name, function or explanation of the object's work area. This also makes it easier for teachers to provide examples for understanding. This research focuses on a topic of discussion on creating a greenhouse design for cultivating hydroponic plants using the DFT (Deep Flow Technique) Hydroponic system and using Virtual Reality technology to display a virtual visualization of a greenhouse

Literature Review

Virtual Reality is an application of multimedia technology that has the advantage of describing a situation or an object where the visualization displayed can not only be displayed from one point of view but can be seen from all angles, because it has 3 visual dimensions so that users can interact with it. an environment simulated by a computer (Garnham, 2019; Larsen et al., 2018; Linowes, 2018; Sherman, 2003; Vagg, 2018, 2018; Valle, 2019). Hydroponics or tirta tani is a method of cultivating plants using water without using soil media with an emphasis on meeting the nutritional needs of plants. The water requirement for hydroponics is less than the water requirement for soil cultivation. Hydroponics uses water more efficiently, so it is suitable for applications in areas that have limited water supplies (Hanum, 2008; Sathyanarayana et al., 2022). According to Nelson in 1978, a Green House is a building for cultivating plants, which has a roof and wall structure that is translucent. The light needed by the plants can enter the greenhouse while the plants are protected from unfavorable environmental conditions, namely air temperatures that are too low, rainfall that is too high, and winds that are too strong (Countryside et al., 2018).

Creating 3D assets in Virtual Reality for the Greenhouse theme in this research using Blender, an open source 3D computer graphics software (Bruno et al., 2020; Carruth et al., 2020; Shan & Sun, 2021; Slob et al., 2023). This software is used to create animated films, visual effects, 3D printed models, interactive 3D applications, and video games. Blender has several features including 3D modeling, texturing, bitmap image editing, stitching, fluid and smoke simulation, particle simulation, animation, video editing, digital sculpting, and rendering (Ahmed, 2022). To create Greenhouse virtual reality, Unity Game Engine software was used, a game development tool that has good rendering quality and working methods, making it an intuitive tool for 2D and 3D creation. For an indie developer, unity offers a solution to the cost and time constraints of game creation, creating something they love that can run on multiple platforms. Unity 3D can be used on Microsoft Windows and MAC, and the resulting games can be run on several OS including Windows, MAC, iPhone, Android. To create Greenhouse virtual reality, Unity Game Engine software is used, which is a game development tool that has good rendering quality and working methods, making it an intuitive tool for 2D and 3D creation. For an indie developer, unity offers a solution to the cost and time constraints of game creation, creating something they love that can run on multiple platforms. Unity 3D can be used on Microsoft Windows and MAC, and the resulting games can be run on several OS including Windows, MAC, iPhone, Android. The results of 3D simulations can also be used in the

agricultural sector, such as to design plant picking machines. The use of virtual reality is also used in Colombia to analyze efficiency, costs and social impact (Ahmed, 2022; Calvo, 2018).

Research Methods

The research methods section describes the main stages and procedures of the research to investigate a research problem and the rationale for the application of specific procedures or techniques used to identify, select, process, and analyze information applied to understand the main problem of the research. In detail, research methods must be explaining the methods used, the influences that determined your approach, and why you chose samples, etc. This section must focus to answers about collected or generated data, and the process to analyze data with the relevant analytical tools. The writing should be direct and precise and always written in the past tense.

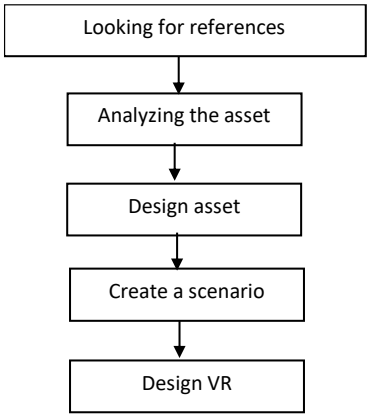

Figure 1. Research methods

This research was carried out by taking the first step, namely looking for references regarding greenhouses and hydroponics for agriculture. Next, this is done by analyzing the asset requirements for the greenhouse. After the analysis is carried out, the next step is to design the asset using Blender software. The next step is to create a scenario so that the user or player carries out activities to explore the greenhouse room. After the assets and scenarios are designed, a virtual reality application is designed using Unity 3D. The final process is inserting the script into the asset so that players interact with the panorama.

Results and Discussion

Looking for references related to designing an agricultural greenhouse theme into virtual reality consisting of theories related to greenhouses in general to accommodate the results of plant cultivation using the DFT hydroponic concept. Another reference is how to create 3D assets using Blender related to DFT hydroponic assets. Likewise for looking for references regarding the application of 3D assets that have been created into Unity 3D software. The Unity used in this research uses Unity 2018 because the cardboard hardware used is from Google Cardboard because the price is affordable for school children.

Analysis of the assets needed for a simple greenhouse theme consisting of a DFT hydroponic circuit such as pipe media, tables, fertilizer storage racks, and iron circuits for the greenhouse. The following is a table of assets needed for a plant cultivation greenhouse.

Tabel 1. Greenhouse asset

No	Asset Name	Function
1	Pipe gully	Plant media
2	Gully table	Holds the planting medium
3	Water pipe	For water channels
4	Fiberglass Reinforced Polyester	Greenhouse covering material
5	Iron frame	For strengthening walls and roofs of greenhouses
6	Light	Night lighting and plant light enhancement

The virtual reality scenario created in this research uses a greenhouse panorama. The main actor is the user who walks around the greenhouse room who can press information buttons using a raycaster. If you touch the information button, text information will be displayed and if you want to delete the information, you have to touch the button again. Hydroponic installations have 2 types, namely NFT (Nutrient Film Technique) and DFT (Deep Flow Technique). In this project, DFT type hydroponics is used. DFT hydroponics requires plant roots to always be submerged in water. This hydropnic also requires a Green House which functions to avoid and manipulate environmental conditions in order to create the desired environmental conditions for maintaining plants.

Greenhouse Plan Design

The first greenhouse building made was a building frame using light steel material. On the roof there is ventilation. The covering material for the greenhouse building is made of Fiberglass Reinforced Polyester which covers all the walls of the greenhouse building. Meanwhile, the door is made to protrude inward. The Green House frame is then covered with transparent Fiberglass Reinforced Polyester material and the Greenhouse base uses rocky material.

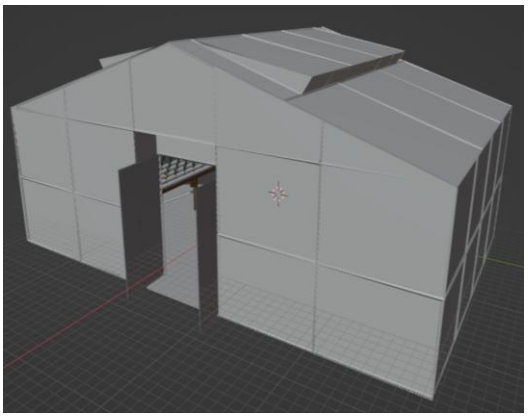

Figure 2. Design the shape of the greenhouse design

Figure 2. The greenhouse uses a gable roof so that when it rains the water quickly flows down. The grille holes in the greenhouse roof are made for air circulation and wire mesh is installed to prevent plant pests from entering. The greenhouse door is made for human circulation to carry out plant care in the greenhouse. The greenhouse building frame material is made of iron, while the greenhouse building cover is made of fiberglass reinforced polyester so that it is durable in hot and cold weather.

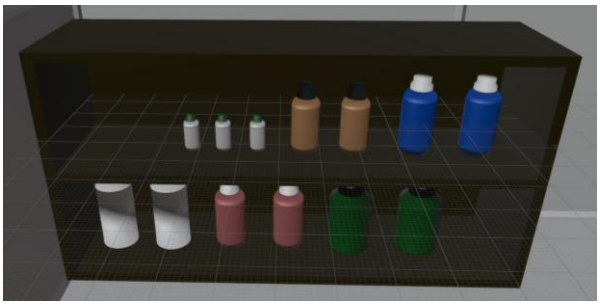

Figure 3. Shelves for storing fertilizer

Figure 3 explains the design of lamps and shelves for storing fertilizer in the greenhouse building. Lights and fertilizer racks are part of the accessories in greenhouse buildings in general. There are many more accessories in greenhouse buildings so that these accessories become complementary contents in greenhouse buildings.

The hydroponic design adapts to the DFT system installation design. The pipes are parallel, not tilted like the NFT system. Consists of 5 large pipes as a place for water to flow. In the large pipe there are 10 holes and a netpot for plants to grow. Large pipes are connected to small pipes using T-connector pipes and L-connector pipes. The beginning and end of the pipes are in the reservoir. In the reservoir there is a water machine as a driver to channel nutrient water to the plants. The water machine is connected to a pipe that leads to the top, connected to a large pipe for the plants, then to a medium pipe at the bottom to be channeled back to the tank. At the end of the pipe there is a tap to regulate the water that comes out. These hydroponic pipes are supported using an iron table with 6 legs whose length adjusts to the length of the pipe. while his height is less than 1 meter. Pipes, iron tables and reservoirs are combined into a hydroponic installation. One hydroponic installation can only be planted with one type of plant. There are 3 types of plants designed. Leeks with straight, hollow plant stems. Lettuce with lots of curly leaves stacked together. Finally mustard greens with a combination of stems and leaves.

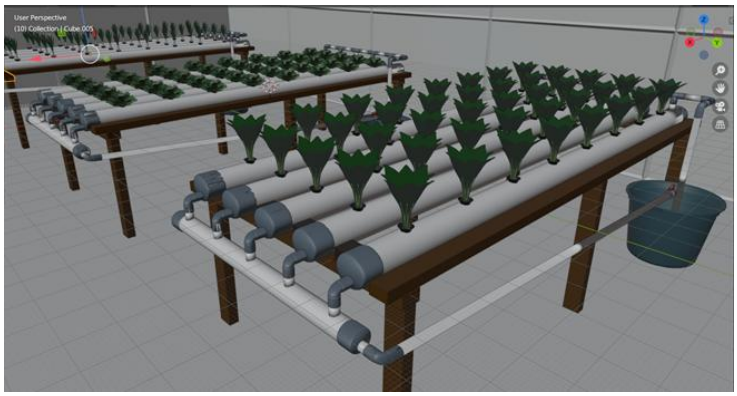

Figure 4. DFT hydroponic design results

Figure 4 shows that there are pipes installed to channel water to each plant's gully pipe to get nutrients. Because the DFT model is water will pool in the pipe to provide nutrients. Lighting will be obtained from the greenhouse walls which are transparent and can reduce excessive heat from the sun.

Figure 5. The greenhouse building looks from the outside

Figure 5 explains that the greenhouse building has transparent covering walls made of Fiberglass Reinforced Polyester so that light can enter to illuminate the room where the plants are. Iron frames are located around the greenhouse building to strengthen the greenhouse structure.

Scenario Player

The results of designing player scenarios for greenhouse buildings produce player interaction with the virtual reality panorama in the greenhouse room, namely that players can walk into the greenhouse room. Players can search for information about the elements in the greenhouse by pressing the menu button via Raycaster.

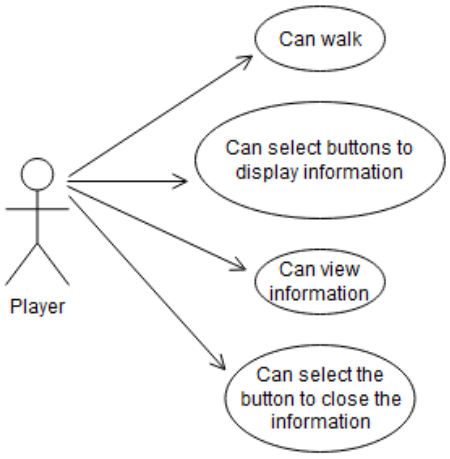

Figure 6. Player activities in the greenhouse

Player activity in the greenhouse room in Figure 6 explains that the player is an actor who can carry out walking activities by selecting and closing information via buttons. This activity helps players get information about the contents in the greenhouse room.

VR test results

The results of testing the VR greenhouse design were carried out internally from the researcher's side before being tested by respondents. The test results can be seen in table 2 below.

Tabel 2. The results of testing the VR greenhouse

No	Testing Items	Test Result	
		Succeed	Not successful
1	Player can walk	√	
2	Player can touch all buttons	√	
3	Players can see information	√	
4	Player can close the information	√	

The conclusion results from the testing in table 2 above were found to be successful for the 4 activities in the VR greenhouse. So it can be continued for testing on respondents to see the impact.

Conclusion

The conclusion of this research was the success of designing a virtual reality application according to the scenario that had been designed. It was found that the results of application testing from researchers were able to run as expected. Future research will conduct trials on respondents, namely middle school students, to see the impact of this VR greenhouse application.

Acknowledgements

The research team would like to thank LPPM STT Terpadu Nurul and STT Terpadu Nurul Fikri as funding sponsors for this research.

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