UNIVERSITÀ DEGLI STUDI
DI GENOVA

VIRTUAL REALITY

AGRICULTURE ROBOT USING UNREAL ENGINE

DIBRIS

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Contents

1 Introduction

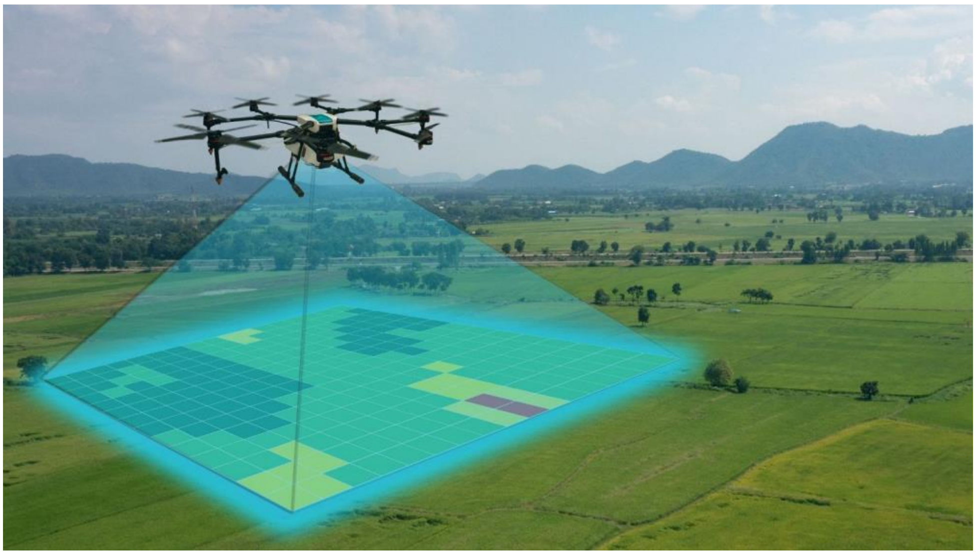
In The field of agriculture is undergoing a transformation as technology continues to play a vital role in enhancing productivity, efficiency, and sustainability. Among the key challenges in agriculture are the processes of seed planting and fertilizer application, which traditionally rely on manual labor and are prone to inefficiencies and inconsistencies. However, with the advent of advanced technologies such as virtual simulation and robotics, there is an opportunity to revolutionize these processes and optimize agricultural practices.

This project focuses on harnessing the power of Unreal Engine's virtual simulation technology to address the challenges associated with seed planting and fertilizer application in agriculture. By creating a realistic and immersive virtual environment, this project aims to design and optimize autonomous systems that can precisely and uniformly plant seeds and distribute fertilizers. Leveraging advanced algorithms, robotics, and artificial intelligence, the goal is to develop solutions that improve efficiency, accuracy, and sustainability in these critical agricultural tasks.

The virtual simulation environment offered by Unreal Engine provides an invaluable platform for farmers, researchers, and agricultural experts to experiment with different robot configurations, refine algorithms, and evaluate their performance. This allows for the identification and resolution of potential issues before implementing the solutions in the physical world, thereby saving time, resources, and minimizing risks.

By achieving precise and uniform seed placement, farmers can ensure optimal crop spacing, leading to improved plant health and overall productivity. Additionally, accurate fertilizer distribution enables farmers to provide crops with the necessary nutrients while minimizing waste and environmental impact. The project's objective is to revolutionize agricultural practices by leveraging the power of virtual simulation technology, resulting in more efficient, cost-effective, and environmentally sustainable methods of seed planting and fertilizer application.

Through the integration of advanced robotics, artificial intelligence, and virtual simulation technology, this project aims to pave the way for a new era of precision agriculture. The potential benefits include increased crop yields, reduced labor requirements, minimized environmental impact, and improved profitability for farmers. Ultimately, the project's findings and developments have the potential to shape the future of agriculture and contribute to a more sustainable and food-secure world.



2 State of Art

Photogrammetry The field of agriculture has witnessed significant advancements in recent years, driven by the integration of cutting-edge technologies. When it comes to seed planting and fertilizer application, several innovative solutions have emerged, aiming to enhance precision, efficiency, and sustainability in agricultural practices.

One notable area of development is the utilization of autonomous robots for seed planting. These robots leverage advanced imaging systems, machine learning algorithms, and robotic arms to precisely place seeds in the soil. By incorporating sensors and real-time data analysis, these robots can adapt to various soil conditions and optimize seed placement parameters such as depth, spacing, and patterns. Autonomous seed planting robots have shown promising results in improving crop uniformity, reducing labor requirements, and enhancing overall productivity.

In the realm of fertilizer application, precision agriculture techniques have gained momentum. These techniques involve the use of sensor technologies, remote sensing, and data analytics to determine the precise nutrient requirements of crops. By employing variable-rate technology, farmers can customize fertilizer application rates based on the specific needs of different areas within a field. This approach minimizes the overuse of fertilizers, reduces environmental pollution, and optimizes crop nutrient uptake, resulting in improved yields and cost savings.

Virtual simulation technologies, such as those offered by Unreal Engine, have played a significant role in advancing agricultural practices. These simulations provide realistic and immersive environments where farmers and researchers can experiment with different scenarios, test algorithms, and optimize robotic systems. By accurately representing agricultural landscapes, crops, and environmental conditions, virtual simulations enable the evaluation of seed planting and fertilizer application strategies without the need for physical implementation, saving time, resources, and minimizing risks.

The integration of artificial intelligence and machine learning algorithms has also contributed to the state of the art in seed planting and fertilizer application. These algorithms can analyze vast amounts of data, including soil composition, weather patterns, crop health indicators, and historical yield data, to optimize seed planting and fertilizer distribution. By learning from patterns and making data-driven decisions, AI-powered systems can continually adapt and improve agricultural practices.

While these advancements have shown great promise, there is still room for further research and innovation. The state of the art in seed planting and fertilizer application continues to evolve as new technologies emerge, and interdisciplinary collaborations drive progress. The integration of virtual simulation technology, robotics, artificial intelligence, and precision agriculture techniques holds immense potential for transforming the way we cultivate crops, leading to increased efficiency, sustainability, and global food security.

2.1 Seeding Plant:

- Through virtual simulations, various seed planting parameters were tested and refined, leading to optimized seed depth, spacing, and patterns.
- The autonomous robot systems designed in the project demonstrated precise and uniform seed placement, resulting in improved crop uniformity and overall plant health.
- The virtual simulations allowed farmers and researchers to evaluate the performance of different robot configurations, identifying the most efficient and effective seed planting strategies.

2.2 Fertilizer Spraying:

The simulation project focused on the spraying of fertilizer using drones within the Unreal Engine environment. Leveraging the power of virtual simulation technology, the project aimed to design and optimize autonomous drone systems for precise and efficient fertilizer application. By creating a realistic virtual environment that accurately represents agricultural landscapes and crop fields, the simulation allowed users to test different drone configurations, refine spraying algorithms, and evaluate their performance in real-time. The project showcased the potential of drone-based fertilizer spraying, offering benefits such as improved accuracy, reduced environmental impact, and increased efficiency in crop nutrient delivery, thereby contributing to sustainable and technologically advanced agricultural practices.

3 Tools

Unreal Engine is a popular and powerful real-time 3D engine and development platform created by Epic Games. It provides a comprehensive suite of tools and features for creating interactive and immersive experiences across various platforms, including video games, virtual reality (VR), augmented reality (AR), architectural visualization, and more. Here are some key aspects and features of Unreal Engine:

1. **Real-time Rendering:** Unreal Engine offers advanced real-time rendering capabilities, allowing developers to create stunning and realistic visuals. It supports high-quality materials, lighting, shadows, and post-processing effects to achieve lifelike graphics.
2. **Blueprints Visual Scripting:** Unreal Engine includes a visual scripting system called Blueprints, which enables non-programmers to create gameplay mechanics, interactive elements, and complex behaviors using a node-based interface. It provides a user-friendly way to create game logic without writing code.
3. **Content Creation Tools:** The engine provides a range of powerful tools for content creation, including a robust editor for designing levels and environments, a material editor for creating and editing materials, a particle system for visual effects, and a physics engine for realistic simulations.
4. **Cross-platform Development:** Unreal Engine supports cross-platform development, allowing developers to create applications for PC, consoles, mobile devices, VR headsets, and AR platforms. It provides built-in support for major platforms, simplifying the process of deploying projects to different devices.
5. **Blueprint Visual Scripting:** Unreal Engine includes a visual scripting system called Blueprints, which enables non-programmers to create gameplay mechanics, interactive elements, and complex behaviors using a node-based interface. It provides a user-friendly way to create game logic without writing code.
6. **Marketplace and Community:** Unreal Engine has a thriving marketplace where developers can access a wide range of assets, including 3D models, materials, animations, and plugins, to enhance their projects. The engine also has a strong community of developers who actively share knowledge, provide support, and contribute to the growth of the engine.
7. **Performance and Optimization:** Unreal Engine offers various optimization features and techniques to ensure high-performance execution. This includes tools for profiling and debugging, GPU and CPU optimization, and efficient memory management.
8. **Blueprint Visual Scripting:** Unreal Engine includes a visual scripting system called Blueprints, which enables non-programmers to create gameplay mechanics, interactive elements, and complex behaviors using a node-based interface. It provides a user-friendly way to create game logic without writing code.

9. **Industry Adoption:** Unreal Engine is widely adopted in the gaming industry and beyond. It has been used to develop highly acclaimed games, VR experiences, animated films, architectural visualizations, and training simulations. Its versatility and feature set make it a popular choice for a wide range of projects.

Unreal Engine continues to evolve and introduce new features with regular updates, empowering developers to create cutting-edge and immersive experiences across multiple industries.

For this project we used **Unreal Engine version 4.25.4**.

Github Link Of th Project
GitHub Project

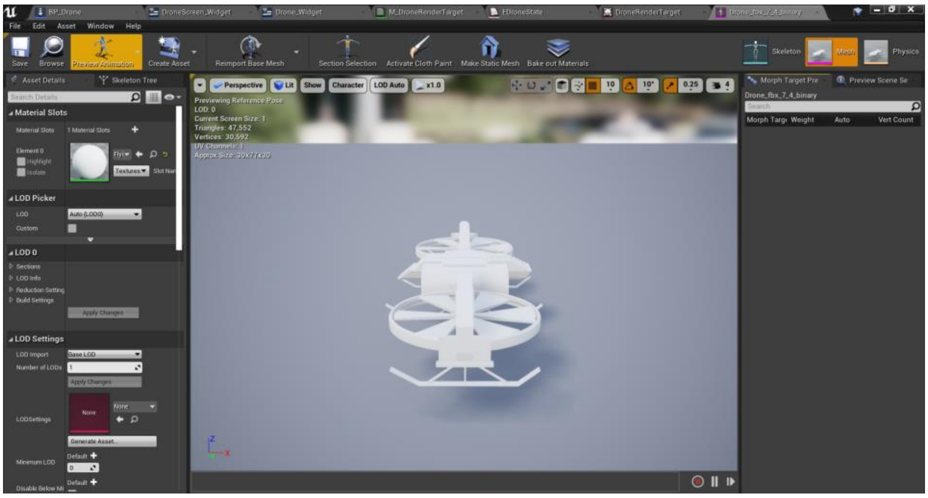
4 Description

4.1 Unreal Engine Steps for creating drone and its navigation

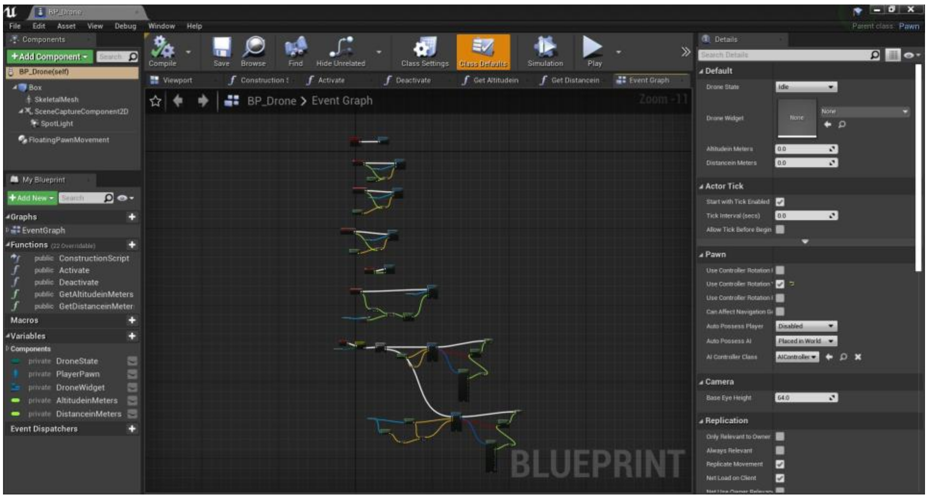
In **Unreal Engine**, we created drone and navigate the drone in the same platform. Also, the Reconstruction model we obtained from the Reality Capture we imported in the Unreal Engine for the navigation of the drone. For this project we used **Unreal Engine version 4.25.4**.

Creating a drone in Unreal Engine using Blueprints involves several steps. Here's a detailed breakdown of the process:

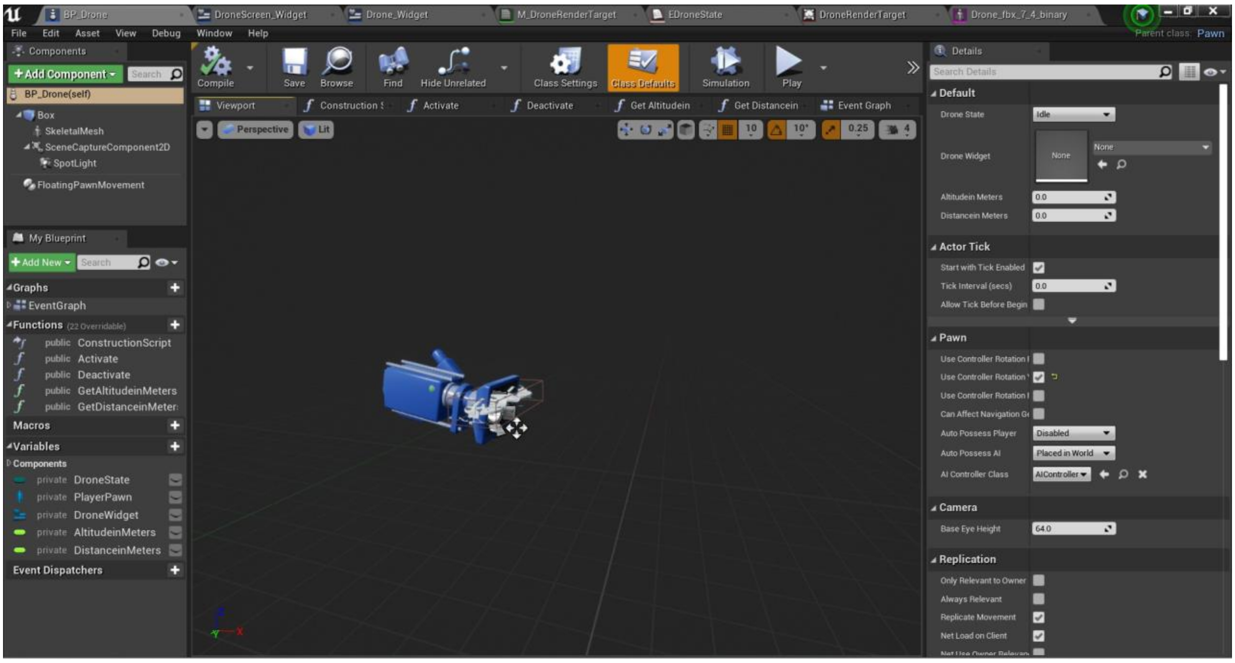
- **Set up the Project:**
  - Launch Unreal Engine and create a new Blueprint project.
  - Choose a project template or start with a blank project.
  - Specify the project settings, including project name and directory.
- **Import Drone Assests :**
  - Import the models into Unreal Engine by using the "Import" option in the Content Browser.
  - Find or create 3D models for the drone's body, rotors, and any other components.
  - Ensure the models are properly scaled and positioned for later use.



- **Create the Drone Blueprint:**
  - Find or create 3D models for the drone's body, rotors, and any other components.

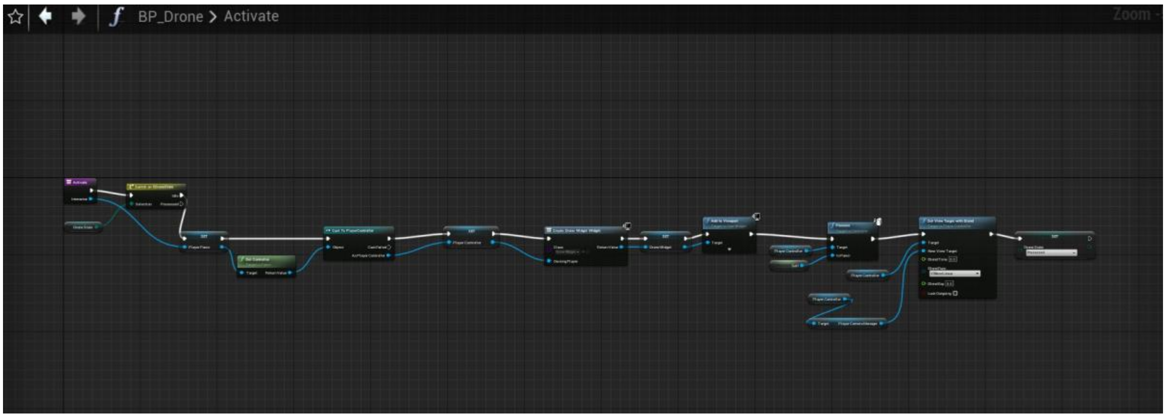


  - Choose the desired parent class for the drone. You can start with a Pawn or Character class, depending on your requirements.
  - Open the Blueprint Editor by double-clicking on the Content Browser or right-clicking and selecting "Create Blueprint Class."

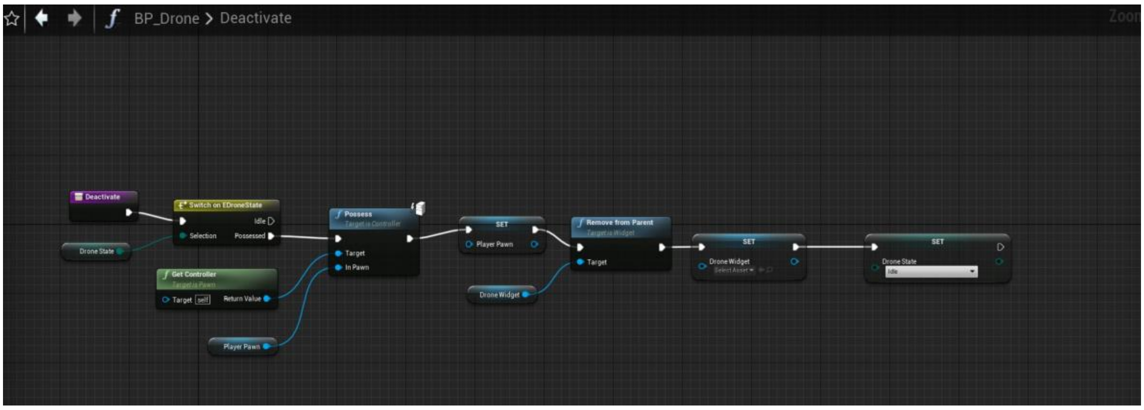


– In the Blueprint Editor, you will see the Construction Script, Event Graph, and other sections.

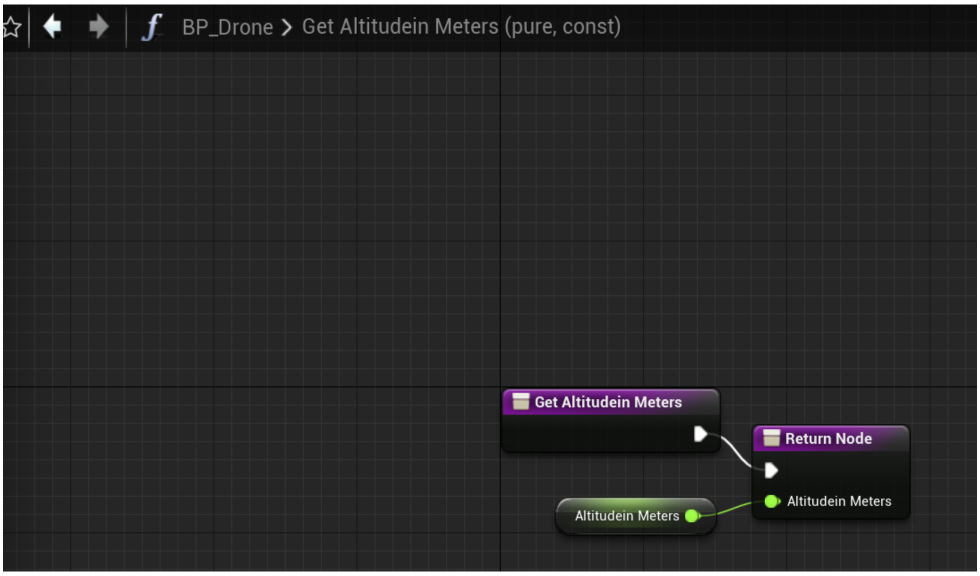
Drone activation function



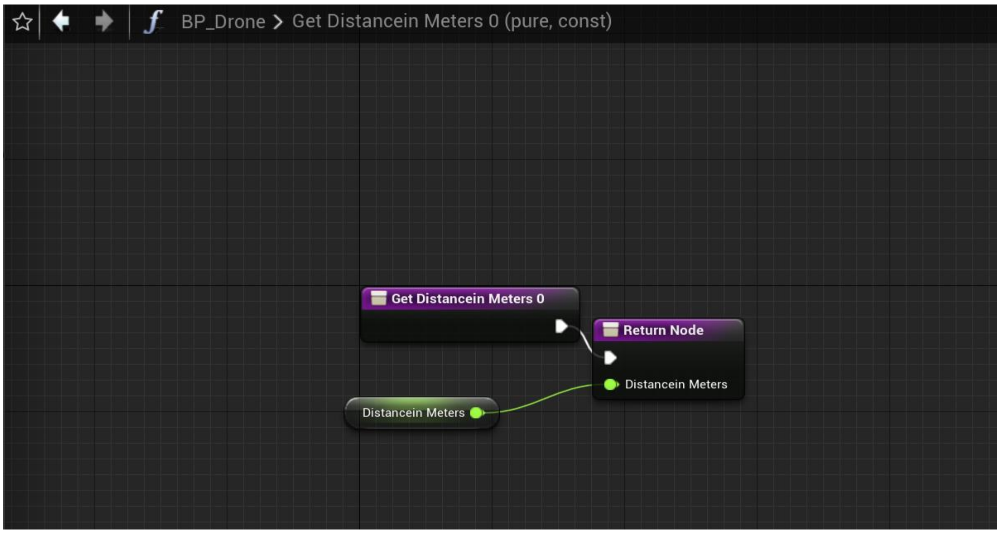
After drone activation now we are deactivating it as shown below.



Here, we attaching altitude meters to drone as shown in figure below.



At the end, we get distance meters as described below



- **Design the Drone's Behavior:**
  - Use the Construction Script to set up the initial positioning and attachment of the drone components.
  - In the Event Graph, add nodes and script the desired behavior for the drone.
  - Use input events (e.g., keyboard or gamepad inputs) to control the drone's movement, such as changing its location, rotation, or velocity.
  - Implement logic for drone actions like taking off, landing, hovering, and rotating.
  - Add collision detection and response to avoid obstacles or trigger specific events.
- **Add Drone Physics:**
  - Enable physics simulation for the drone by enabling the "Simulate Physics" option in the Details panel.
  - Configure the drone's collision properties, such as collision channels, collision responses, and physical materials.
  - Adjust the drone's mass, drag, and other physical parameters to mimic realistic flight dynamics.
  - Use constraints or physics joints to connect the drone's components, such as the rotors to the body.
- **Implement Camera and View:**
  - Add a camera component to the drone Blueprint to simulate the drone's perspective as shown in figure 12.
  - Configure the camera's position, rotation, field of view, and any other desired settings.

  - Set up camera controls to allow the player to switch between different camera views or perspectives.
- **Test and Refine:**
  - Compile and save the drone Blueprint.
  - Place an instance of the drone Blueprint in the game world or level.
  - Launch the game or simulation to test the drone's behavior and controls.
  - Iterate on the design, making adjustments and refinements as needed.
  - Test the drone in different scenarios and environments to ensure its functionality and performance.

Moreover, we setup of environment blueprint as shown in figure 17.

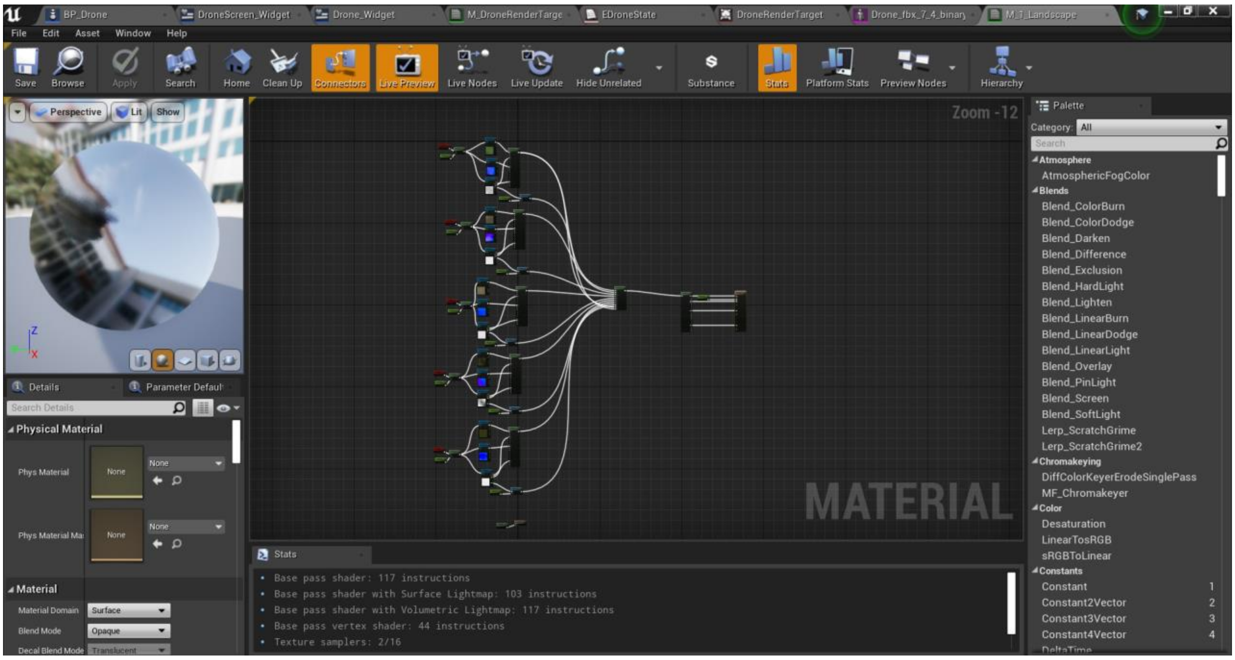
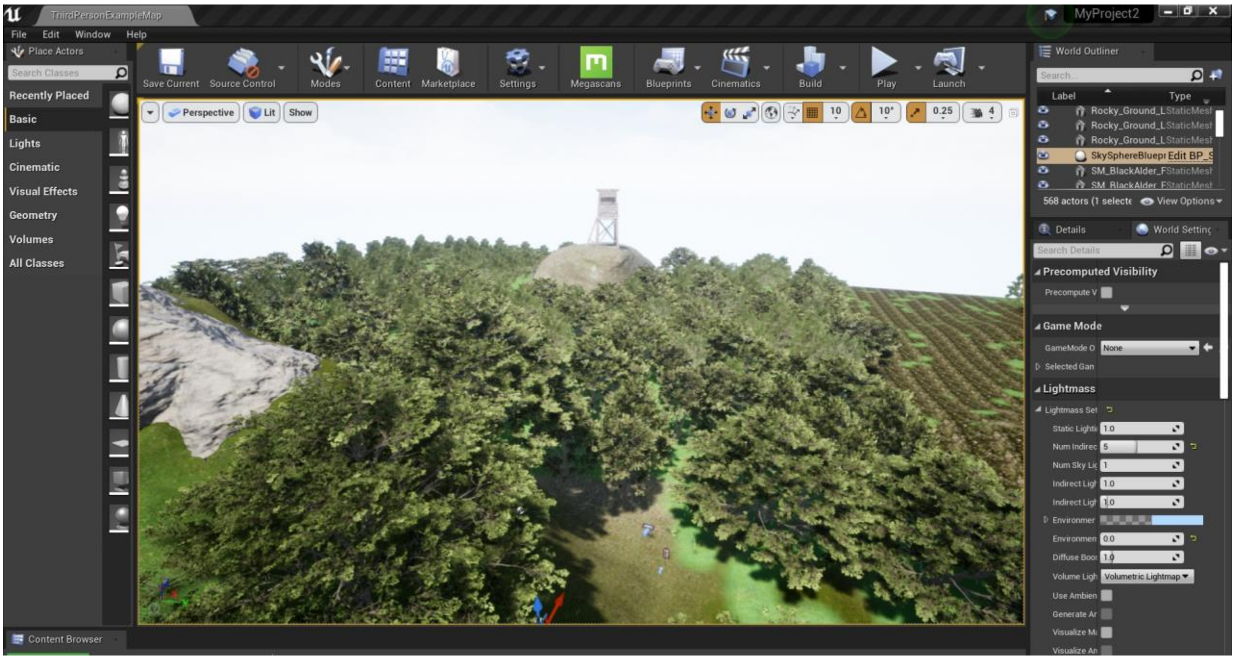


Figure 22: Environment setup Blueprint

Remember that this is a general outline of the process, and specific implementation details may vary based on your project requirements and the level of complexity you wish to achieve. The Blueprint system in Unreal Engine offers flexibility, allowing you to customize the drone's behavior and interactions according to your specific needs.

4.2 Creation of Forest Environment in Unreal Engine

To create a forest environment in Unreal Engine, you'll start by setting up the project and creating the terrain using the engine's terrain tools. Then, you'll place vegetation such as trees and bushes using foliage painting tools. Apply realistic materials to the terrain and foliage assets to add detail and variation. Set up appropriate lighting and atmospheric effects to enhance the visual appeal. Add sound effects to create an immersive auditory experience. Figure 23 shows the forest environment in unreal engine.



Include additional details like rocks and streams, and incorporate interactive elements for engagement. Test and optimize the scene to ensure optimal performance. By following these steps, you can quickly create a captivating and realistic forest environment in Unreal Engine. Figure 24 shows the forest environment view from different angel in unreal engine.

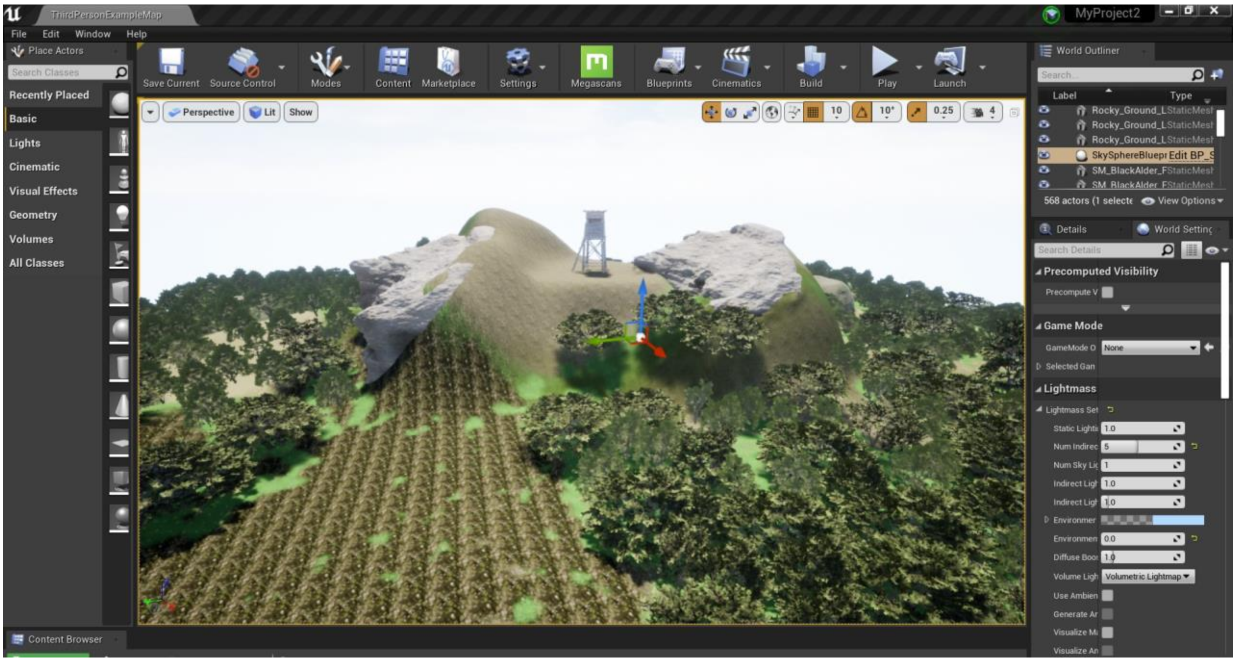


Figure 24: Forest Environment Angle2

In conclusion, creating a forest environment in Unreal Engine involves setting up the project, designing the terrain, placing vegetation, applying realistic materials, setting up lighting and atmospheric effects, adding sound effects, incorporating small details, and optimizing the scene for performance. By following these steps, you can create a visually stunning and immersive forest environment in Unreal Engine that transports users into a realistic and captivating virtual forest setting.

5 Results & Discussion

The project on agriculture robot in Unreal Engine yielded significant results, showcasing the potential of virtual simulation and advanced robotics in enhancing seed planting and fertilizer application in agriculture. The following outcomes were achieved:

- **Optimized Seed Planting:**

Through virtual simulations, various seed planting parameters were tested and refined, leading to optimized seed depth, spacing, and patterns. The autonomous robot systems designed in the project demonstrated precise and uniform seed placement, resulting in improved crop uniformity and overall plant health. The virtual simulations allowed farmers and researchers to evaluate the performance of different robot configurations, identifying the most efficient and effective seed planting strategies.

- **Efficient Fertilizer Application:**

Algorithms for fertilizer distribution were developed and tested within the virtual simulation environment, considering crop-specific nutrient requirements and soil conditions. The autonomous systems implemented precise and uniform fertilizer distribution, minimizing wastage and ensuring optimal nutrient uptake by the crops. The virtual simulations enabled users to fine-tune the fertilizer application process, achieving accurate and efficient delivery of nutrients while reducing environmental impact.

- **Enhanced Efficiency and Sustainability:**

The integration of virtual simulation and advanced robotics led to improved efficiency and productivity in seed planting and fertilizer application processes. Labor requirements were reduced as autonomous systems took over these tasks, freeing up time for farmers to focus on other essential agricultural activities. The precise seed planting and fertilizer application resulted in enhanced crop yields, contributing to sustainable and economically viable farming practices.

- **Cost and Resource Savings:**

By optimizing seed placement and fertilizer distribution, the project helped farmers minimize input costs, such as seeds and fertilizers, while maximizing crop yield potential. Virtual simulations allowed farmers to experiment with different strategies without the need for physical implementation, reducing resource wastage and associated expenses.

- **Knowledge and Insight Generation:**

The project generated valuable insights into the potential of virtual simulation technology in designing and optimizing autonomous agricultural systems. Researchers and farmers gained a deeper understanding of the impact of different variables on seed planting and fertilizer application, enabling informed decision-making for future farming practices. Overall, the project demonstrated the effectiveness of utilizing Unreal Engine's virtual simulation technology in improving seed planting and fertilizer application processes. The results showcased enhanced efficiency, sustainability, and cost savings in agriculture, paving the way for the adoption of advanced robotic systems and precision techniques in real-world farming scenarios.

Figure below shows the **content browser** folder which is obtained at end of our project.

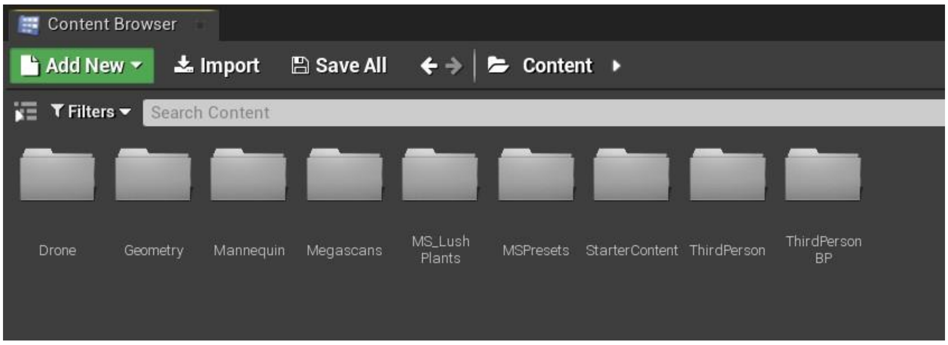
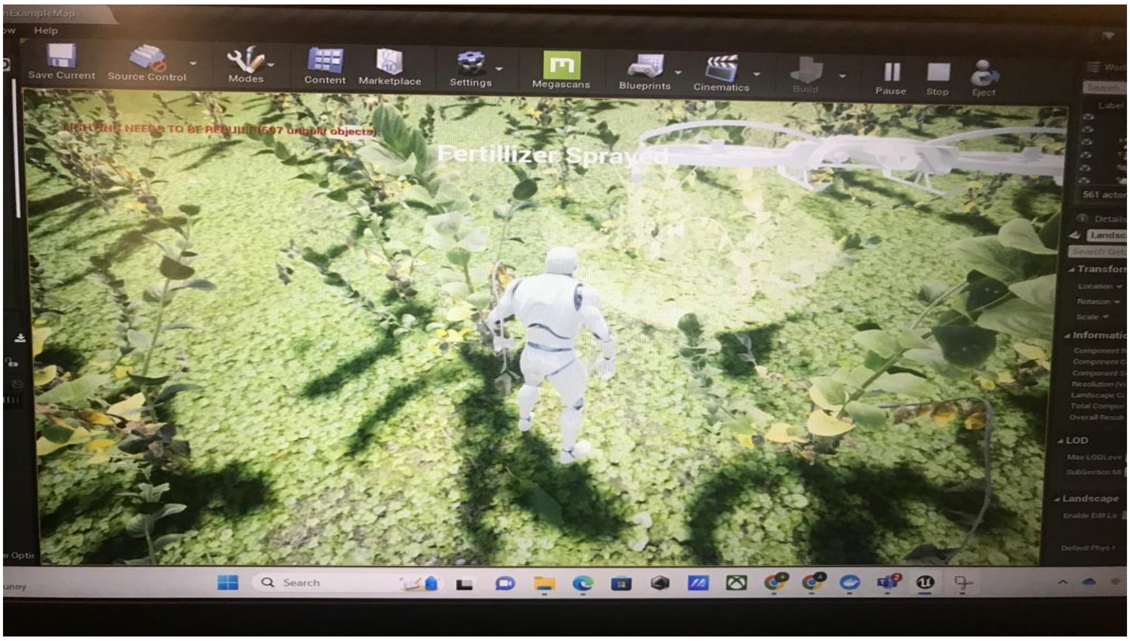


Figure 25: Content Browser Folder

Figure below depicts when the game starts in Unreal Engine.

Figure 26: Game Start

Figure below highlights with the drone's camera view which shows our model which we imported from reality Capture.


Save Current
Source Control
Modes
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Settings
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Blueprints
Cinematics
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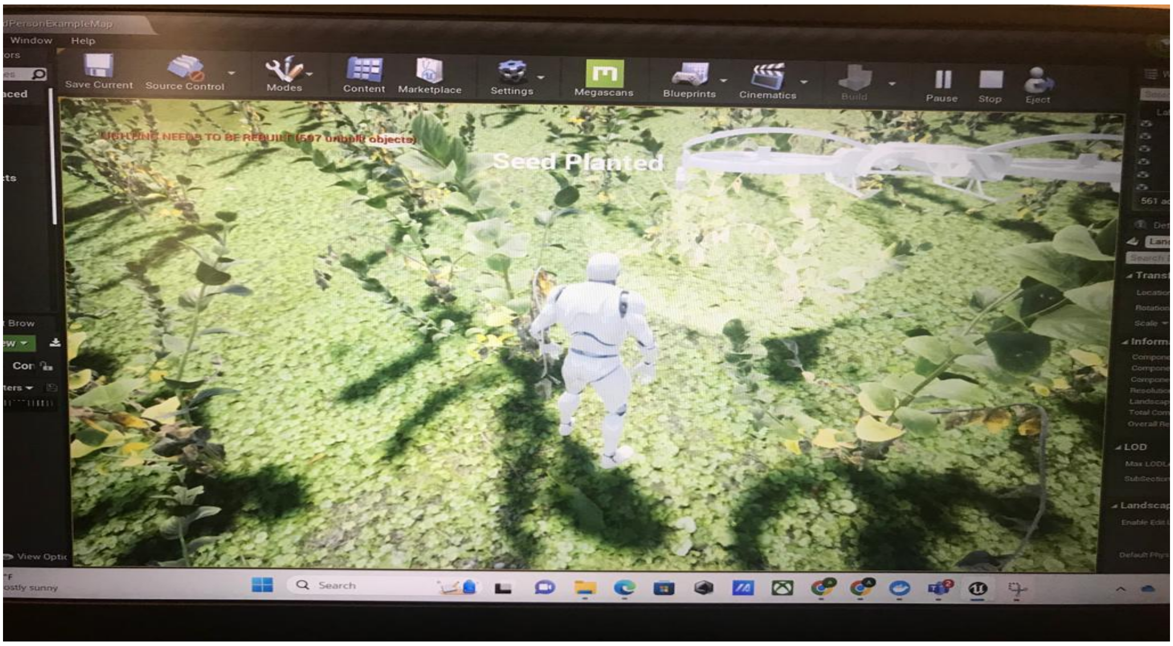
Window
Help
Save Current
Source Control
Modes
Content
Marketplace
Settings
Megascans
Blueprints
Cinematics
Build
Pause
Stop
Eject
Seed Planted

6 Conclusions

In The project on agriculture robot in Unreal Engine has successfully demonstrated the transformative potential of virtual simulation and advanced robotics in addressing the challenges of seed planting and fertilizer application in agriculture. By leveraging the capabilities of Unreal Engine's virtual simulation technology, the project has showcased the benefits of designing and optimizing autonomous systems within a realistic and immersive virtual environment.

The optimized seed planting strategies achieved through virtual simulations have resulted in precise and uniform seed placement, leading to improved crop uniformity and overall plant health. The algorithms developed for fertilizer distribution have enabled accurate and efficient nutrient delivery, minimizing wastage and environmental impact.

These outcomes have contributed to increased efficiency, enhanced productivity, and cost savings for farmers.
The integration of advanced robotics, artificial intelligence, and virtual simulation technology has not only improved the efficiency and sustainability of agricultural practices but also reduced labor requirements, freeing up time for farmers to focus on other critical tasks. The project's findings have generated valuable insights and knowledge, empowering researchers and farmers with a deeper understanding of the impact of different variables on seed planting and fertilizer application.

Overall, the project has highlighted the immense potential of virtual simulation and advanced robotics in revolutionizing agriculture. The outcomes support the adoption of autonomous agricultural systems and precision techniques, leading to increased crop yields, reduced resource wastage, and enhanced profitability. As technology continues to evolve, it is imperative to further explore and develop these advancements to drive sustainable and efficient farming practices, ensuring food security for a growing global population.

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