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SIMULATION OF DRONE IN DIFFERENT TERRAINS

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PREVIOUS WORK

- Building a custom drone on blender and importing it to UNITY
- Simulation of drone in different terrains (Urban, Rural and Forest)
- Adding sensors to the drone
- Autonomous and Manual navigation of a drone
- Obstacle avoidance using LIDAR sensor

LITERATURE REVIEW

S.No	Title	Authors	Summary	Short Comings
1	Quadcopter Simulation Model for Research of Monitoring Tasks	Ivan Berman, Artemii Zenkin & Kanstantsin Pachkousk	Description of a simulation of the drone designed to monitor a large area	Data collection, transmission for large area monitoring, lacks environmental realism, sensor accuracy.
2	Modeling and Simulation of an Octorotor UAV with Manipulator Arm	Edmundo Javier & Luis A Reyes-Osorio	Analysis of Octorotor and implementing, validating on MATLAB	Modelling, dynamics control, trajectory planning, kinematics, MATLAB.
3	Drone Simulation For Military Surveillance In the North-East of Nigeria	Dr Karim Usman & Mr. Ike Innocent	Study of simulation tools that are capable of controlling, coordinating, manipulating, detecting and tracing of drones in the North-East of Nigeria	Reconnaissance, security, monitoring, aerial imagery, intelligence gathering.
4	Simulation and Development of an Autonomous Drone for Delivery of Medicines during COVID-19	M Mamoon Khan & Qasim Ali	Development of an autonomous medicine delivery quadcopter and validate a simulator model for it and calculate its physical parameters using SolidWorks.	Aerial transportation, unmanned aerial vehicle, route optimization, medical supply chain, remote areas, emergency response.

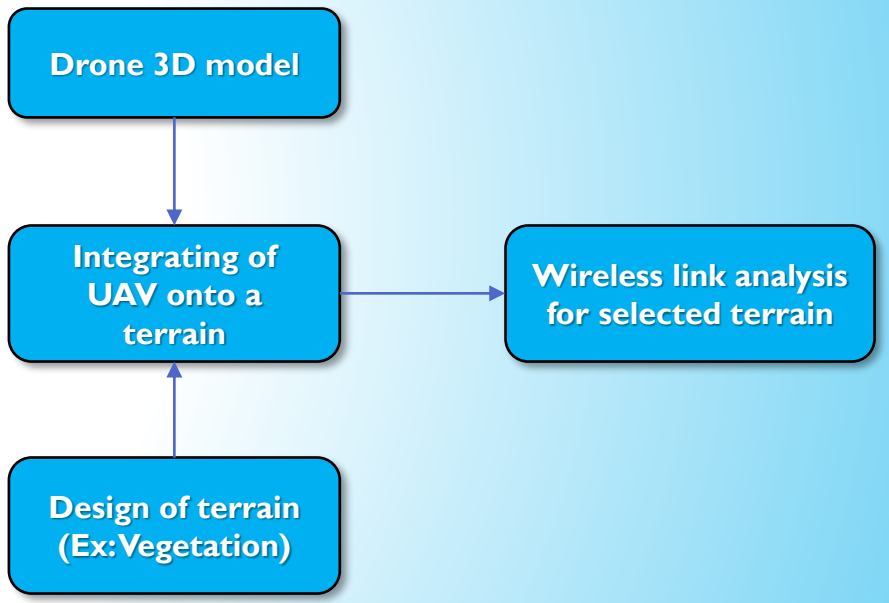
<u>Existing simulations:</u>

- [1,3,4]: 3D Drone simulations, Wireless and Wireless link analysis
- [2]: Validating only on MATLAB

NOVELTY

- Integrated Simulation helps us to recreate various environmental conditions and can study how drone functions and how it responds in those scenarios
- It is cost effective and ensures safety
- Prediction of drone's speed, battery life based on environmental conditions such as wind speed, rainy conditions
- Integrated Simulation helps us to know the function of drone before hand and helps us to make improvements
- It can accurately model sensor behaviour including LIDAR, GPS

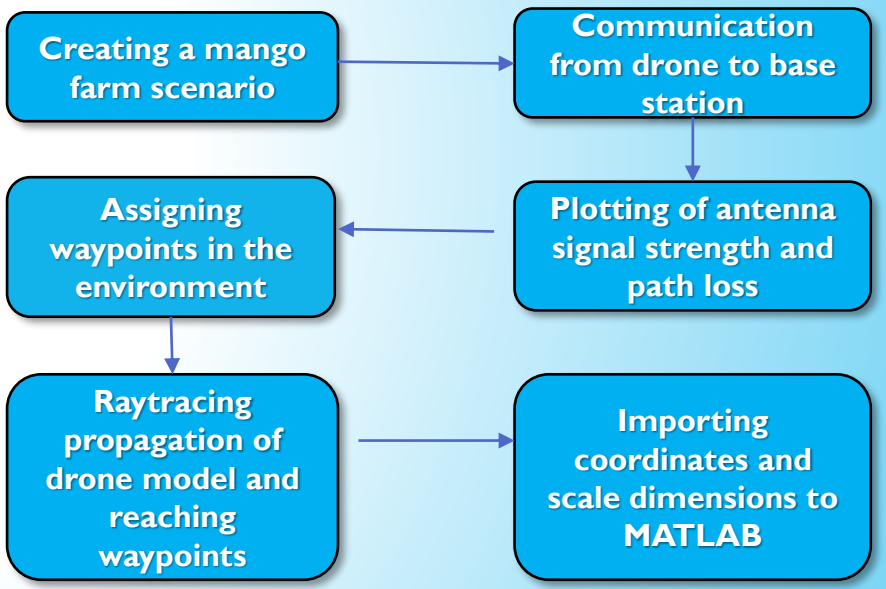
Integral Simulation Framework



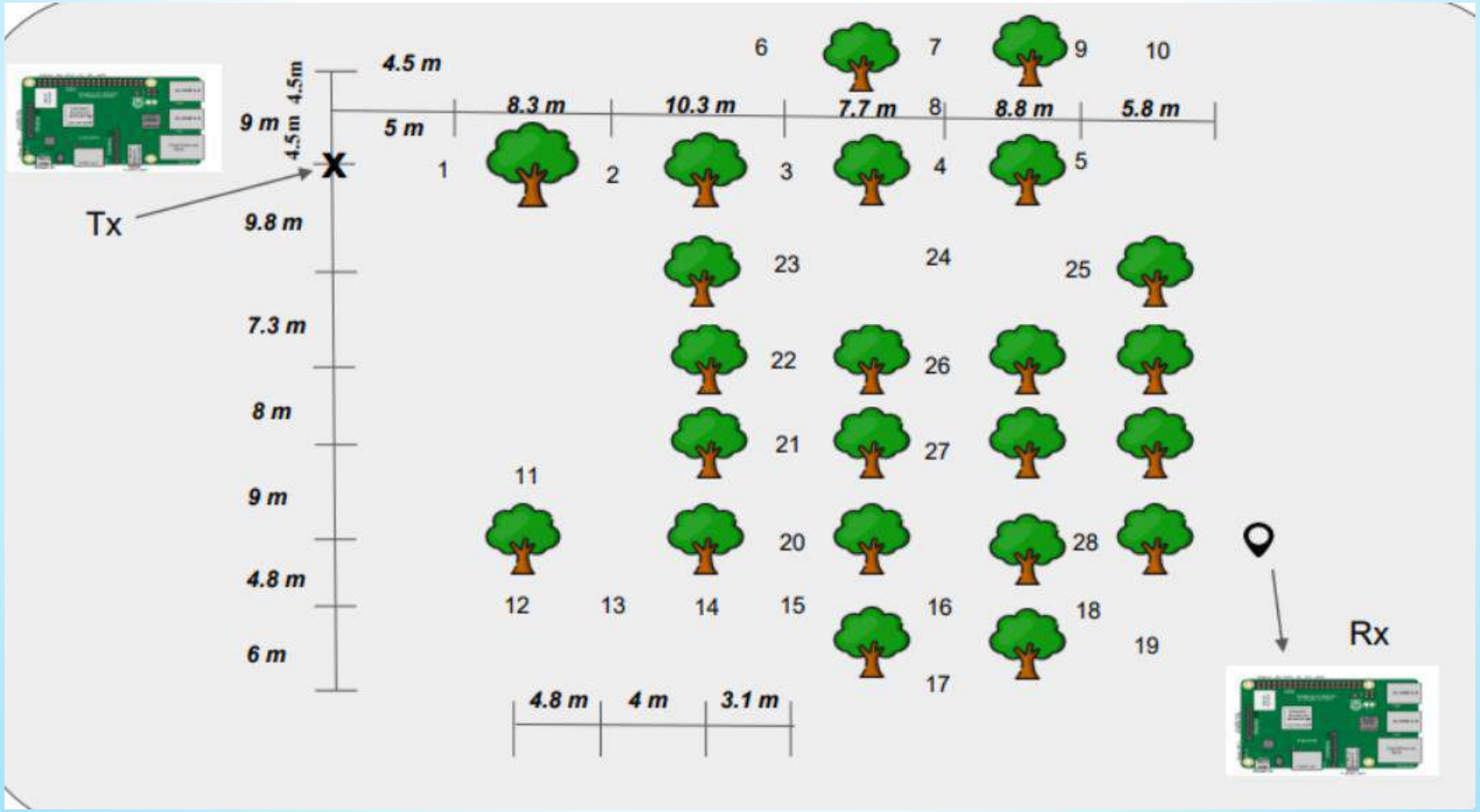
CURRENT PROGRESS
CASE STUDY-1: UAV WIRELESS LINK ANALYSIS IN VEGETATION TERRAIN

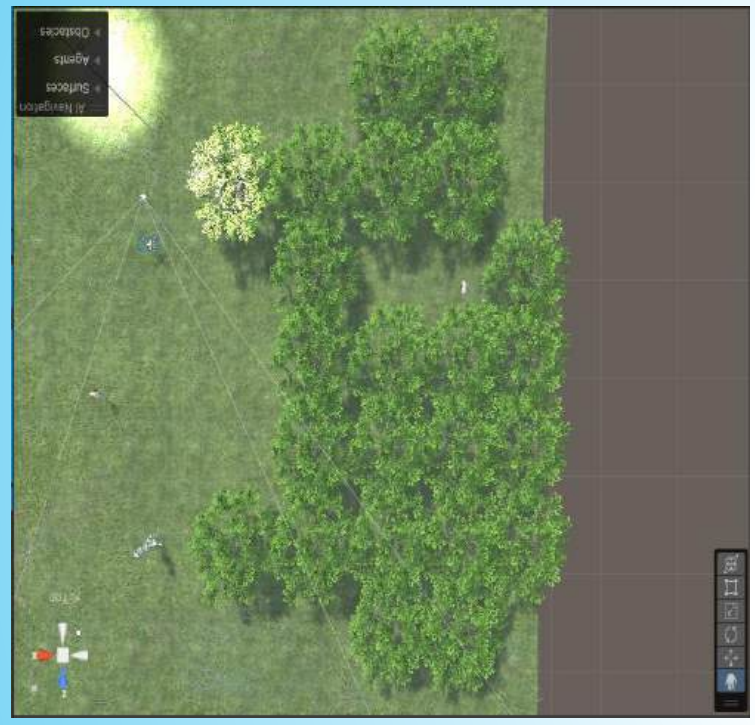
- Created a scenario based on the measurements taken physically from the mango farm near the campus
- Implementation of a base station and transmitted signals between drone and base station
- Finding antenna signal strength in the coverage map and detects the path loss
- Navigation of a drone with the help of ray tracing propagation model
- Sending frames and video from drone camera to the base station
- Importing co-ordinates and scaling dimensions of the entire scenario to MATLAB.

Block Diagram

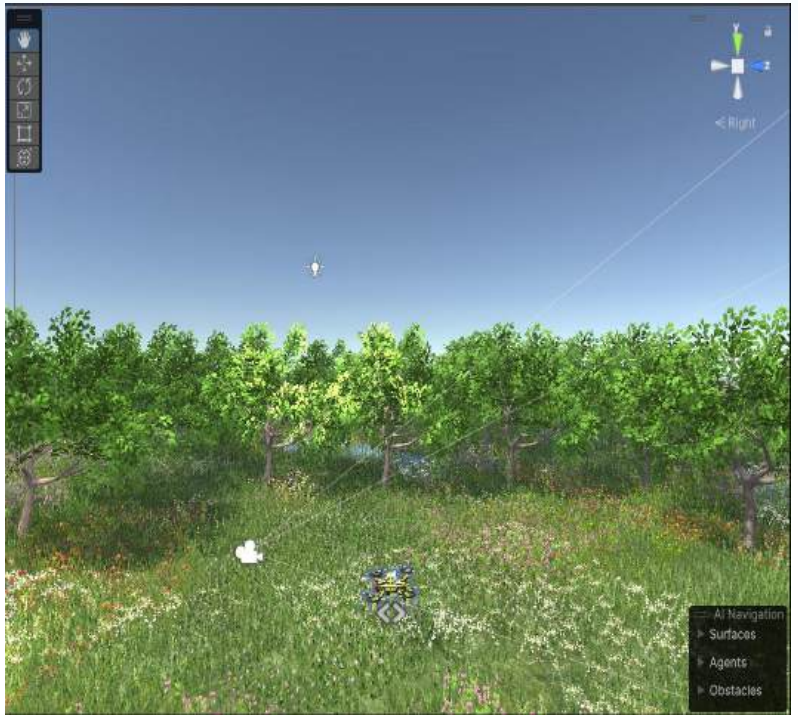


MANGO FARM SCENARIO IN UNITY



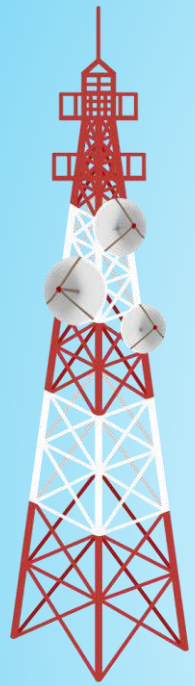


Top View



Overall view

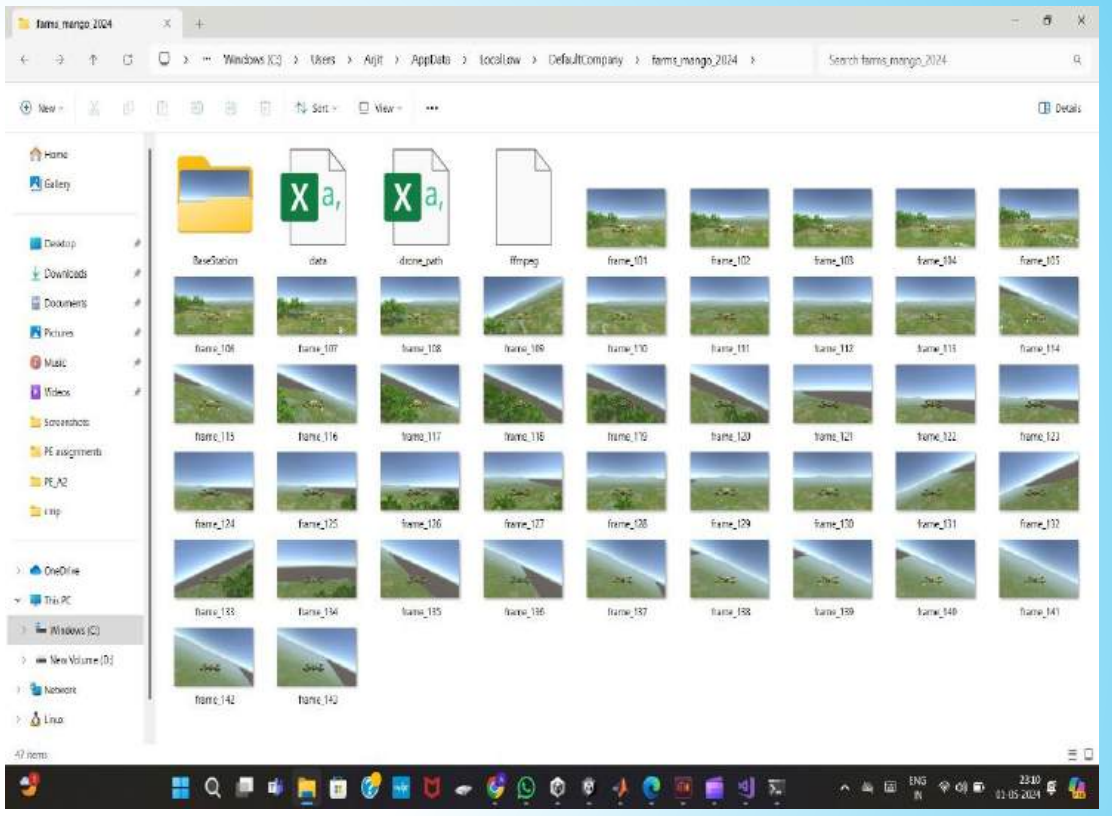
Drone near the
Base station



OPERATION OF BASE STATION

- With the help of C# we can get the frames of the path travelled by the drone and it is encoded into a video using FFMPEG and sends it to the base station
- Here base station acts like a receiver
- It analyzes images captured by the drone to extract valuable insights.
- Base stations manages the storage and displays the data in the form of csv files, disseminates the data collected during drone operations.

Manual navigation of a drone

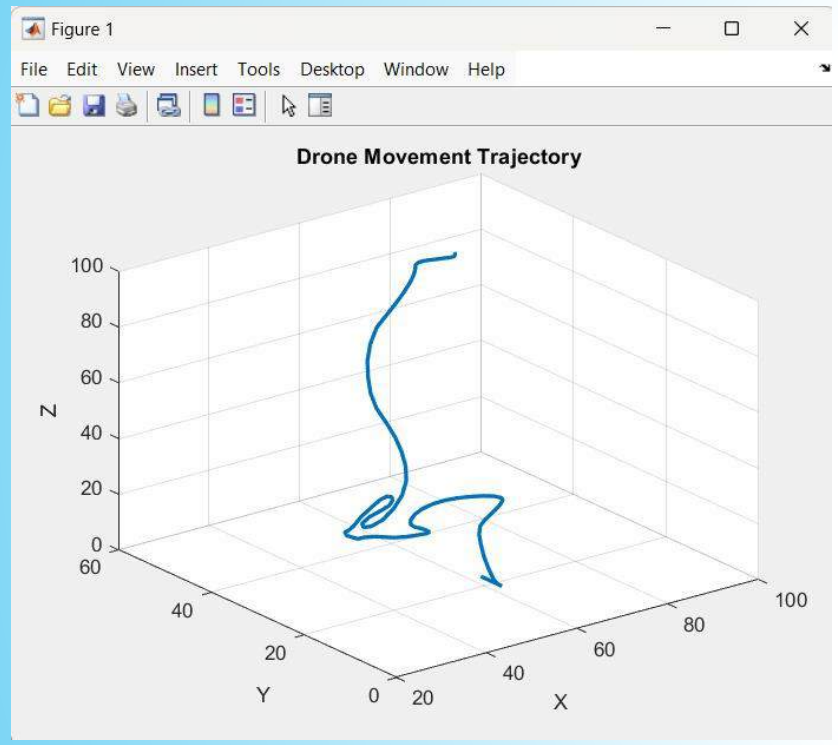


Data received to the Base Station

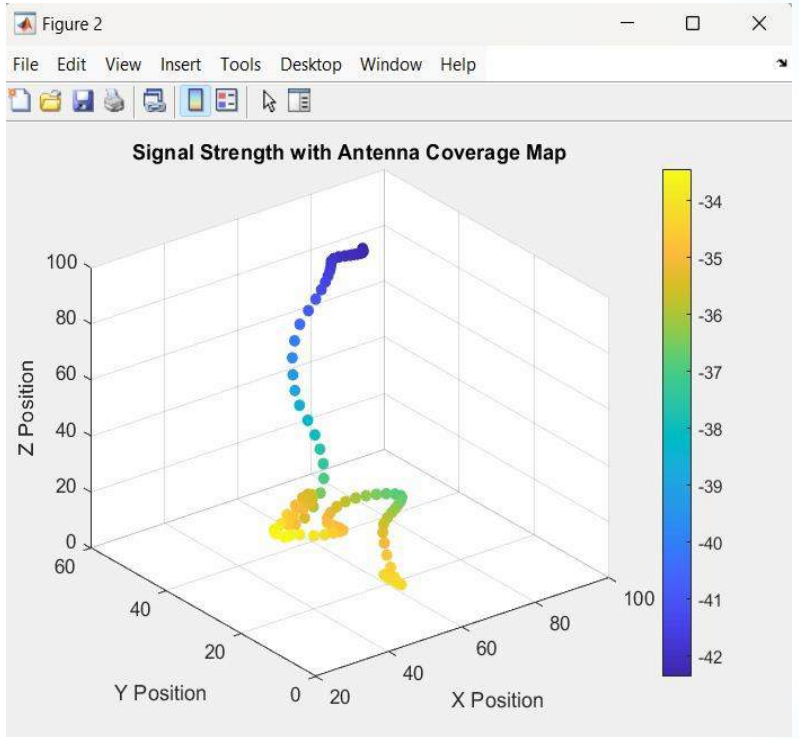
PATH LOSS

- The signal gets weaken when the drone travels away from the base station because of which the signal strength decreases .
- This loss occurs due to various factors including distance, obstacles and frequency of the signal.
- Unity sends drone position and environmental data to MATLAB which calculates path loss and provides feedback.
- In unity the maximum distance we have given with which drone can navigate is 50 units

Drone path during manual navigation



Change in signal strength w.r.t distance



Dimensions and coordinates of trees in unity

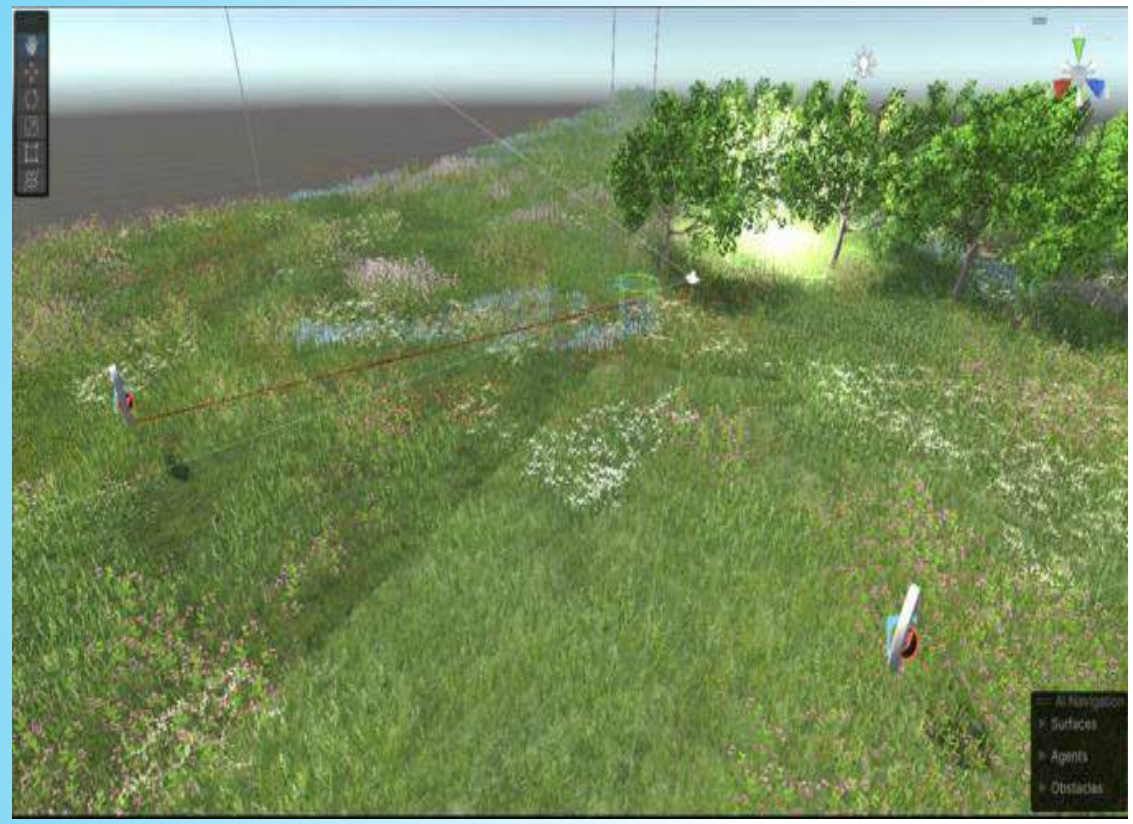
```
>> part1
Data from CSV file:
    {'Tree Number'}    {'Dimensions'}    {'Scale'}

    1.0000    2.9000    3.8800   35.6000    3.0000    3.0000    3.0000
    2.0000    2.9000    3.8800   27.7000    3.0000    3.0000    3.0000
    3.0000   27.4500    3.8800   20.2000    3.0000    3.0000    3.0000
    4.0000   10.2000    3.8800   11.8000    3.0000    3.0000    3.0000
    5.0000   10.2000    3.8800    2.9000    3.0000    3.0000    3.0000
    6.0000   10.2000    3.8800   35.6000    3.0000    3.0000    3.0000
    7.0000   27.4500    3.8800   44.1000    3.0000    3.0000    3.0000
    8.0000   27.4500    3.8800   11.8000    3.0000    3.0000    3.0000
    9.0000   10.2000    3.8800   51.9000    3.0000    3.0000    3.0000
   10.0000   18.4500    3.0000   51.9000    3.0000    3.0000    3.0000
   11.0000   27.4500    3.8800   27.7000    3.0000    3.0000    3.0000
   12.0000   18.4500    3.8800   44.1000    3.0000    3.0000    3.0000
   13.0000    2.9000    3.8800   20.2000    3.0000    3.0000    3.0000
   14.0000   18.4500    3.8800    2.9000    3.0000    3.0000    3.0000
   15.0000   36.7500    3.8800   44.1000    3.0000    3.0000    3.0000
   16.0000   27.4500    3.8800   35.6000    3.0000    3.0000    3.0000
   17.0000   18.4500    3.8800   35.6000    3.0000    3.0000    3.0000
   18.0000   10.2000    3.8800   44.1000    3.0000    3.0000    3.0000
   19.0000   18.4500    3.8800   27.7000    3.0000    3.0000    3.0000
   20.0000   18.4500    3.8800   11.8000    3.0000    3.0000    3.0000
   21.0000   10.2000    3.8800   27.7000    3.0000    3.0000    3.0000
   22.0000   36.7500    3.8800   11.8000    3.0000    3.0000    3.0000
   23.0000    2.9000    3.8800   44.1000    3.0000    3.0000    3.0000
```

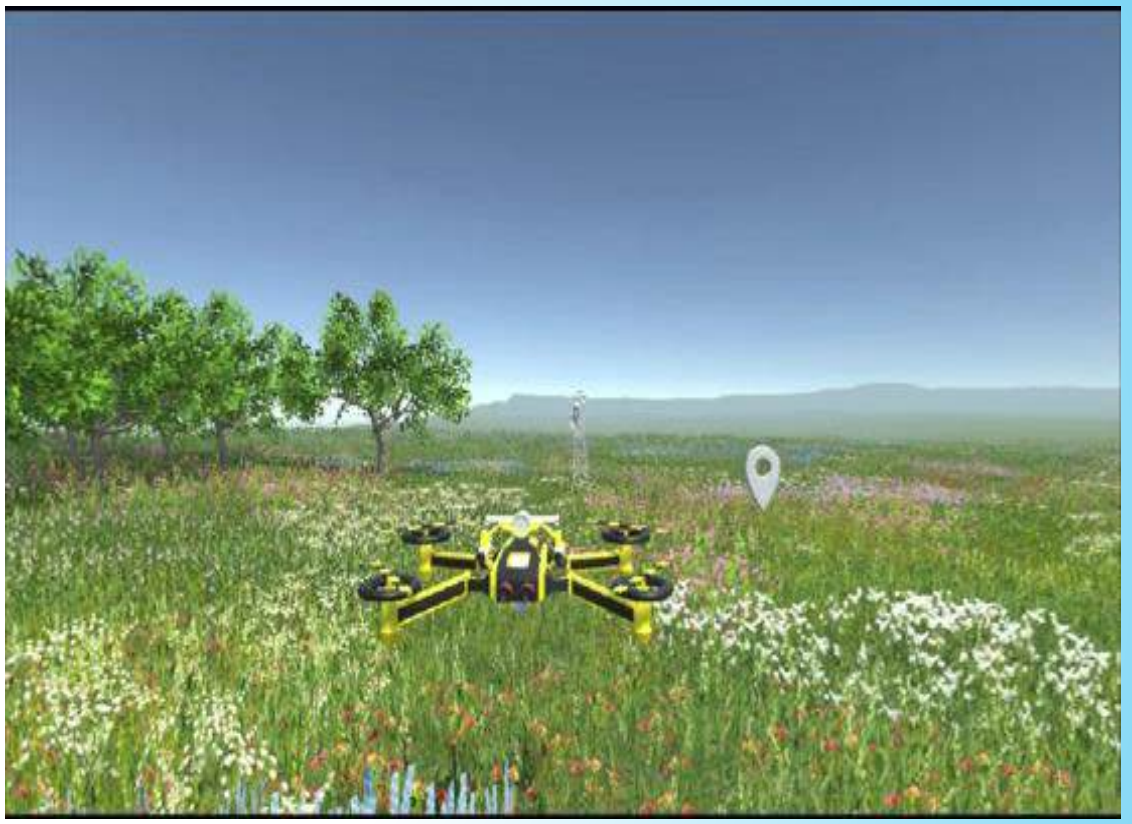
- Yellow indicates strong signal strength
- Green indicates moderate signal strength
- Blue indicates weak signal strength

RAY TRACING

- We use unity ray cast functionality to simulate the emission and detection of rays from the drone
- The ray casts detects the obstacles and the drone avoids them if there are any
- Based on waypoints we assign the drone reaches the destination safely
- Ray casting is an efficient technique compared to other collisions detection methods to avoid every obstacle present in the scenario



Drone following the ray casting propagation model



Drone avoiding the obstacles on its way to waypoint

FURTHER DEVELOPMENTS

- Integration of Google maps using map APIs to retrieve map data and overlay it into UNITY
- Incorporating weather variations, wind speed factors, lighting conditions, and other environmental factors for better simulation
- Comparing experimental results with the simulation results in calculating the varying signal strength between drone and the base station
- Extracting objects and their properties to MATLAB for better analysis and improving simulation results.

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THANK YOU!