## InternPro Weekly Progress Update

| Name | Email | Project Name | NDA/ Non-NDA | InternPro Start Date | OPT |
|---|---|---|---|---|---|
| Adharsh Prasad Natesan | anatesan@asu.edu | IT-Core Foundation Suriname | Non-NDA | 2024-08-05 | Yes |

### Progress

Include an itemized list of the tasks you completed this week.

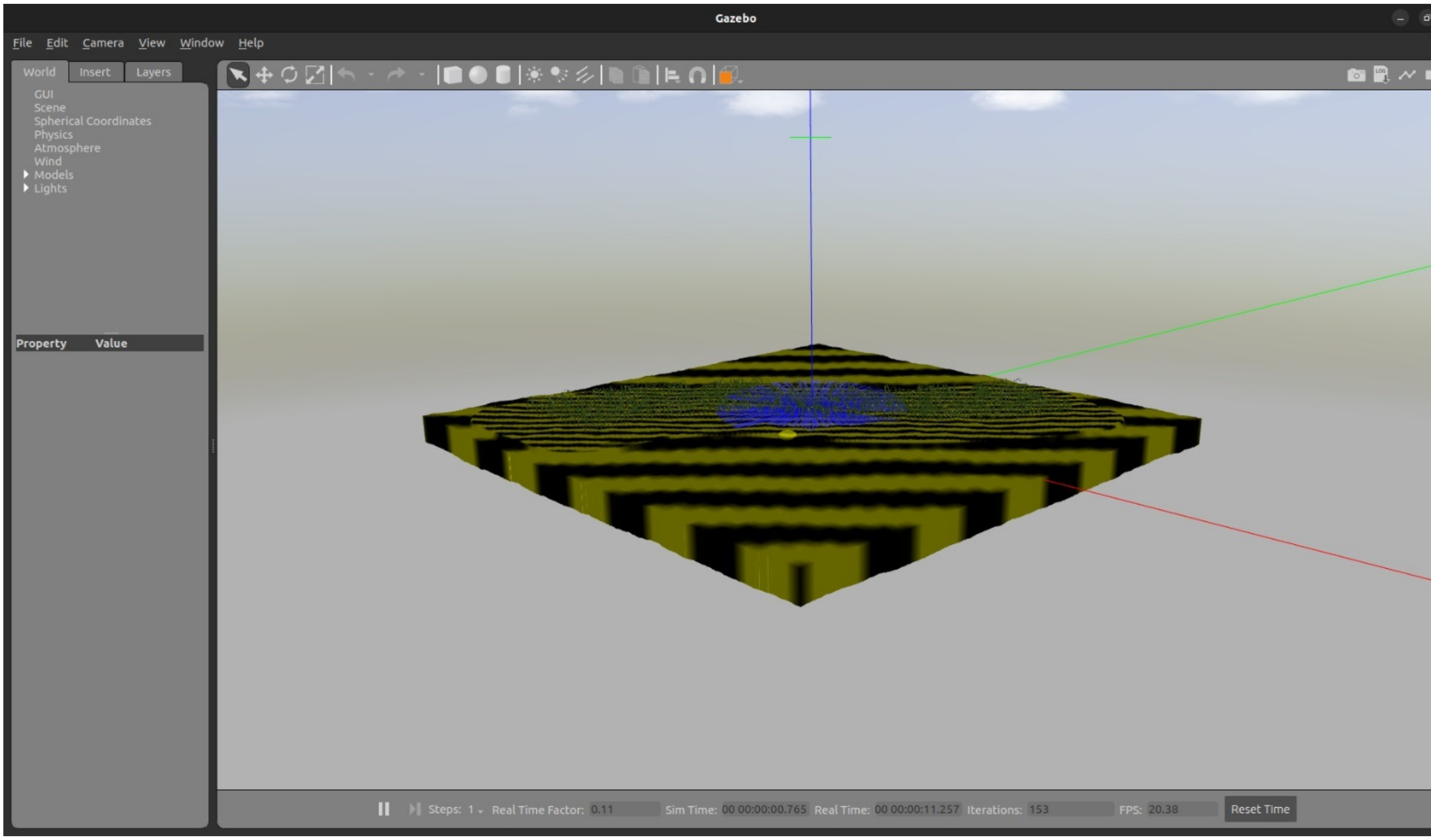
| # | Action Item/ Explanation | Total Time This Week (hours) |
|---|---|---|
| 1 | Virtual Farmland Simulation | 3 |
| 2 | Rover Integration into Virtual Farmland Simulation | 3 |
| 3 | Navigation System Implementation | 3 |
| 4 | Real-time GNSS Precise Positioning: RTKLIB for ROS | 3 |
| 5 | Rover Autonomous Navigation | 3 |
| 6 | Improving the ROS 2 Navigation Stack with Real-Time Local Costmap Updates for Agricultural Applications | 3 |
| 7 | Next week plan | 1 |
| 8 | Report Writing | 1 |
| | **Total hours for the week:** | 20 |

### Verification Documentation:

Action Item 1: Virtual Farmland Simulation – 3 hour(s).

### Project Work Summary

- Created a virtual 3D maize field using pre-existing models for the farmland and gazebo tool, creating a scaled representation of real-world crop spacing and terrain variations.
- Installed essential robotics navigation packages and sensor libraries compatible for the map through ros specifications and farm environment constraints.
- Programmed with ros to generated a customizable farmland map with adjustable parameters for row spacing, plant density, and obstacle distribution to match agronomic realities.
- Modified the simulation framework to incorporate the rover's 3D model at a strategic entry point, ensuring proper alignment with crop rows and field boundaries.
- Removed the irrelevant parts of the map for better visualization and clear simulation of the turtlebot in the map.

- 

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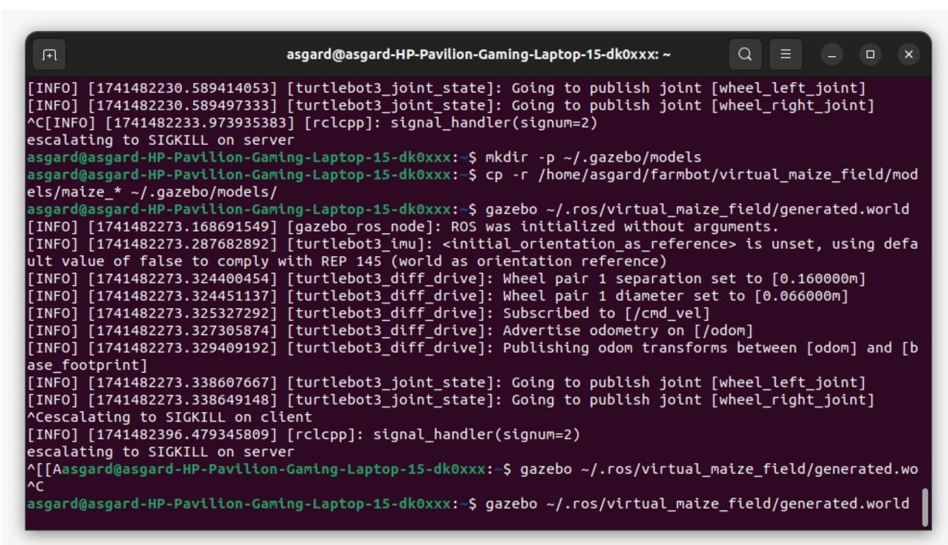
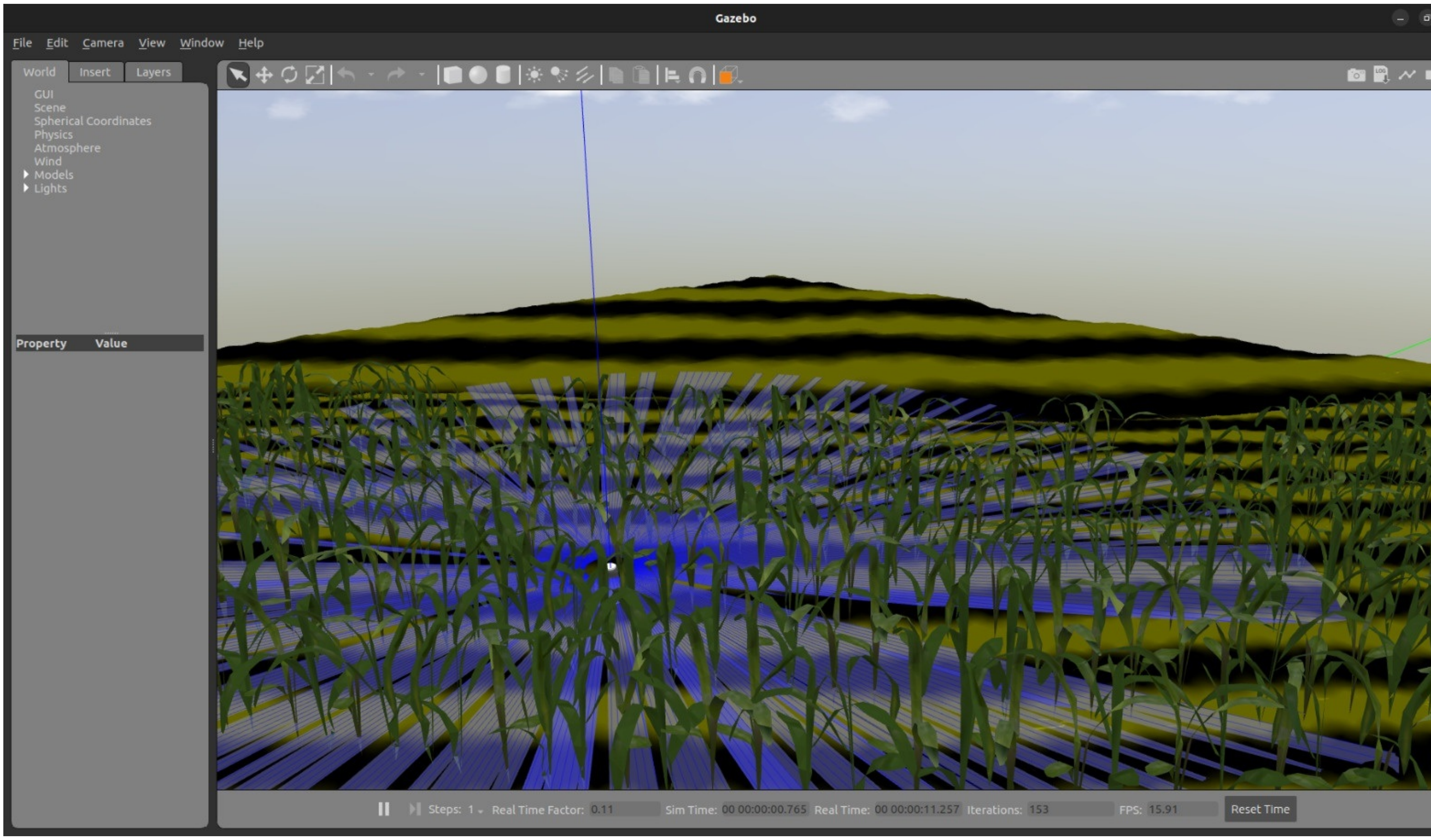
Action Item 2: Rover Integration into Virtual Farmland Simulation – 3 hour(s).

### Project Work Summary

- Building upon our previous work on creating the map, we then focused on integrating the TurtleBot3 into our simulated 3D farmland environment.
- Began by setting up the Gazebo environment with the necessary dependencies installed, including the TurtleBot3 packages and ROS 2 Humble.
- Cloned the relevant github page for creating the farmland and edited the generated.world file to include the TurtleBot3 model.
- To ensure realistic interaction with the environment, we adjusted the wheel friction and collision properties of the TurtleBot3 model.
- Finally, we verified the integration by running the generate world file in terminal and observing the TurtleBot3's movement within the maize field environment.

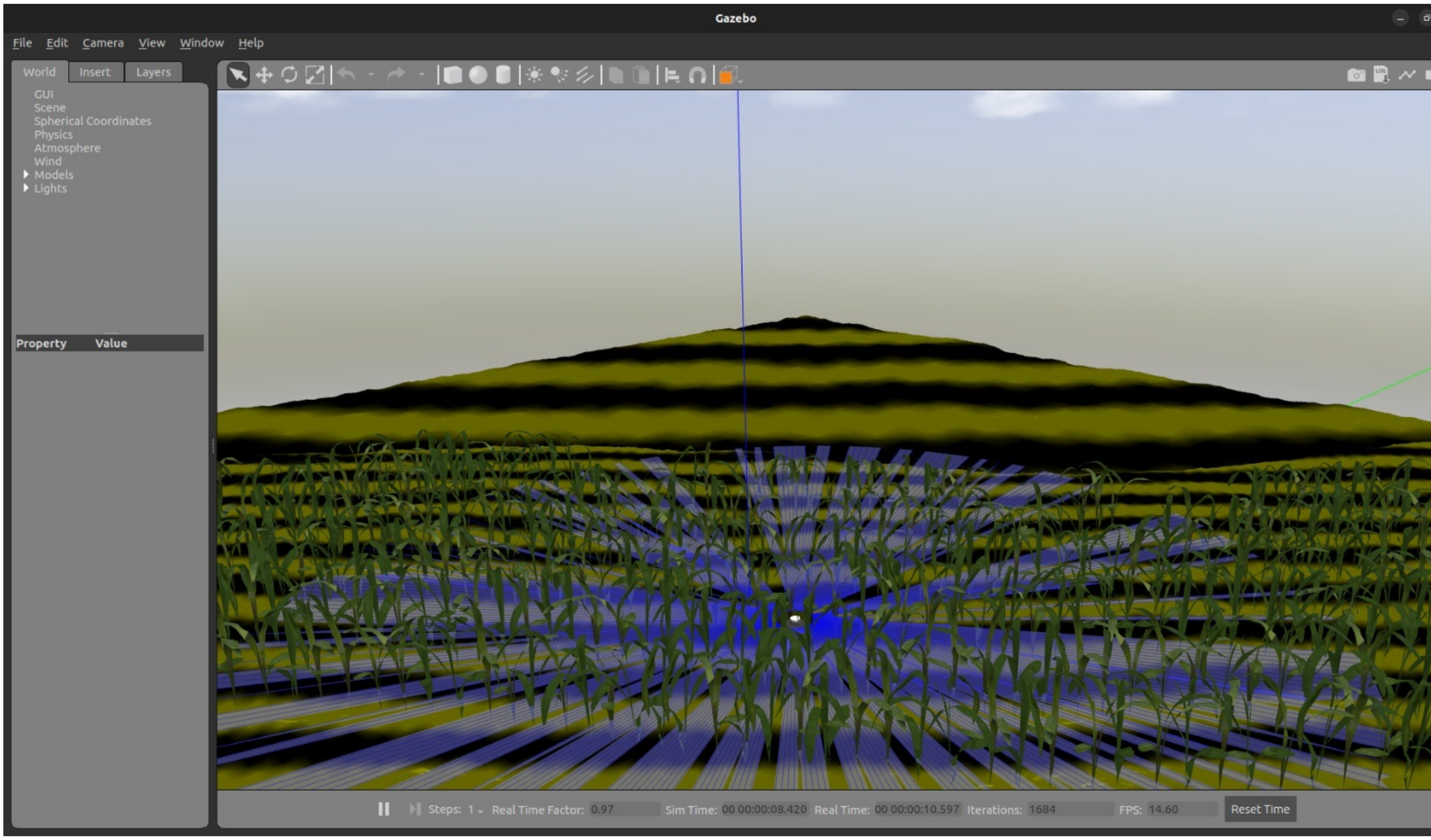
- 




Action Item 3: Navigation System Implementation – 3 hour(s).

### Project Work Summary

- Following the successful integration of the TurtleBot3, we developed a ROS 2 node to enable the rover to move from one point to another within the simulated farmland. Here's how we implemented this:
- We created a new ROS 2 node named field_navigator.py to publish velocity commands to the TurtleBot3 created in the map through generated.world file.
- Although we didn't implement a complex path planning algorithm for this task,  the TurtleBot3 was programmed to move forward at a constant speed (0.2 m/s) for a specified duration (5 seconds)
- We implemented the node using Python and tested it in the Gazebo simulation environment. The TurtleBot3 successfully moved from its initial position to a target point, demonstrating basic navigation capabilities.
- Future enhancements could include integrating more sophisticated path planning algorithms (e.g., A* or RRT*) to navigate through complex field geometries and around obstacles.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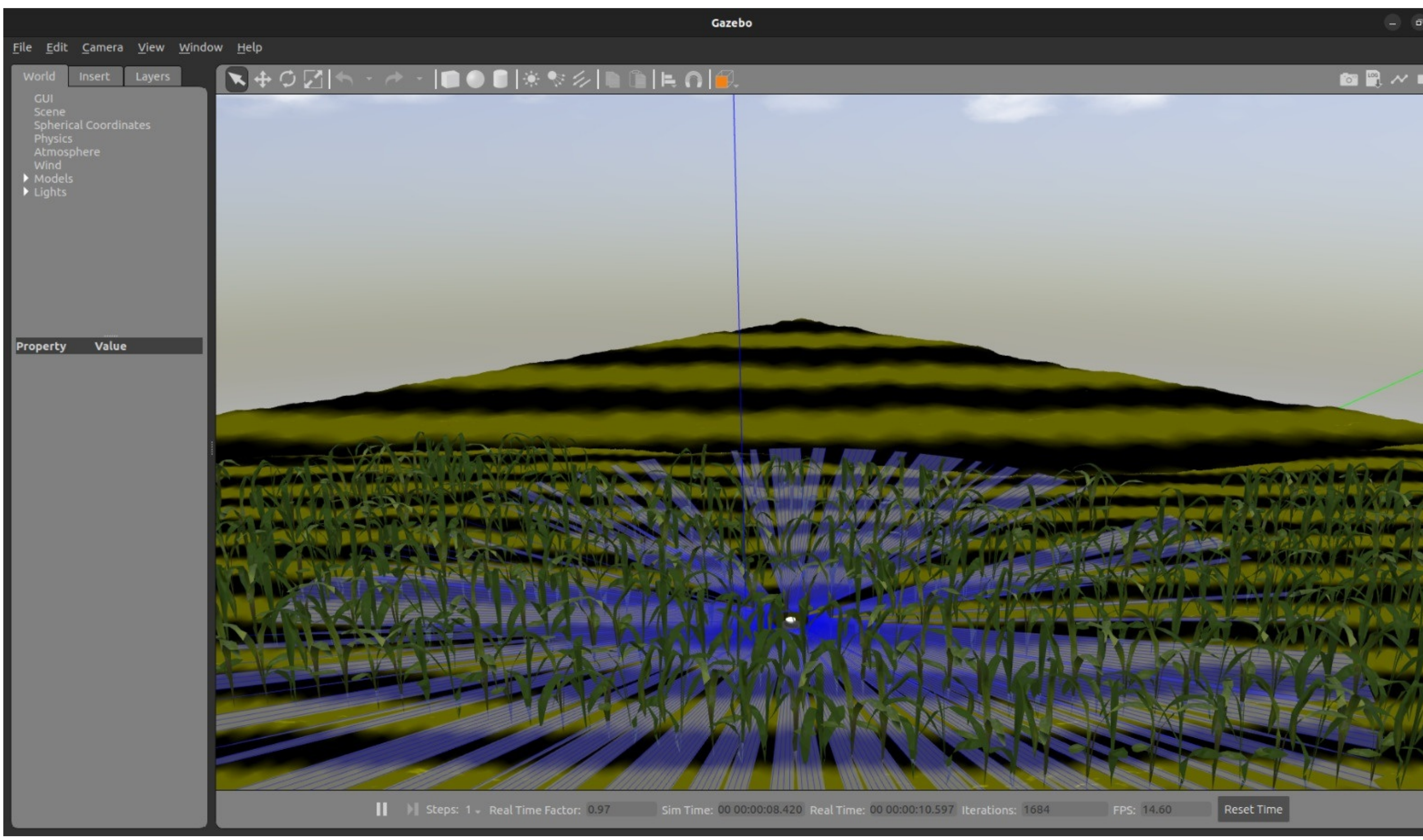
Models
Lights
Property Value
Steps: 1
Real Time Factor: 0.97
Sim Time: 00 00:00:08.420
Real Time: 00 00:00:10.597
Iterations: 1684
FPS: 14.60
Reset Time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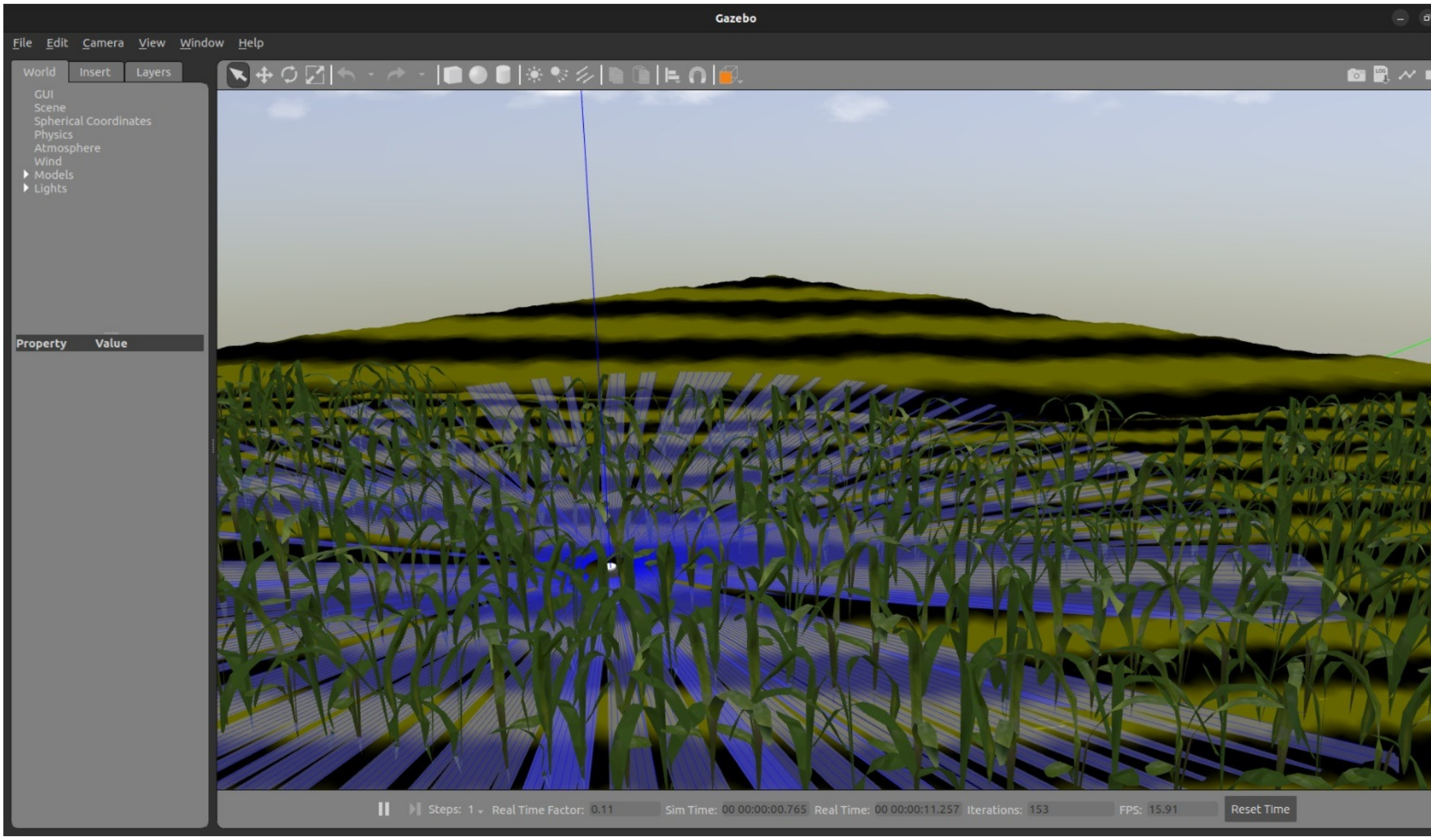


Action Item 4: Real-time GNSS Precise Positioning: RTKLIB for ROS – 3 hour(s).

### Project Work Summary

- http://journals.sagepub.com/doi/full/10.1177/1729881420904526
- Real-time GNSS Precise Positioning: RTKLIB for ROS
- Summary:
  - The paper introduces rtkrcv_ros, a ROS package that integrates RTKLIB's real-time kinematic (RTK) GNSS capabilities for precise positioning.
  - Centimeter-Level Accuracy is proposed to be achieved using dual-antenna setups and moving-baseline RTK modes, suitable for the medium scale agricultural farm.
  - ROS Compatibility: Offers ROS-native features like topic publishing for position/velocity and service controls for control and command over the rover.
- Relation to Your Project:
  - Enables sub-meter positioning crucial for crop-row navigation in medium scale fields, ensuring accurate fertilizer application or selective harvesting.
  - The paper solves GNSS Signal loss issues under crop canopies via observation synchronization, maintaining continuous navigation.
  - Velocity Data: Provides velocity information for dynamic path correction on uneven terrain, enhancing navigation stability.
- Motivation for Research:
  - GNSS is essential for outdoor robots but lacks precision without RTK techniques and this new integration addresses helps mitigating the error.
  - RTKLIB is open-source ros package, making it easy to simulate and apply for hardware and precise positioning affordable for agricultural applications.
  - The ROS integration allows combining GNSS with other sensors (LiDAR, vision) for robust navigation systems.

Action Item 5: Rover Autonomous Navigation – 3 hour(s).

### Project Work Summary

- https://strathprints.strath.ac.uk/61247/
- Autonomous Navigation with ROS for a Mobile Robot in Agricultural Fields
- Summary:
  - ROS-Based Navigation Architecture: Describes a modular ROS system with nodes for localization, perception, planning, and control, designed for agricultural robots.
  - Combines wheel odometry with visual odometry using RTAB-MAP for improved localization accuracy in featureless fields and hence provides a Sensor Fusion approach.
  - Implements simplified algorithms for efficient navigation through open spaces like farm fields and proposed effective path planning.
- Relation to Your Project:
  - Addresses complex agricultural challenges like wheel slippage and actuator delays common in muddy farmland, ensuring reliable movement.
  - The paper proposed integrating GNSS data with existing ROS nodes for enhanced positioning and navigation, effectively an modular approach.
  - Uses cost effective hardware approach to keep costs low for medium and small level farming.
- Motivation for Research:
  - Farmers require affordable, reliable robots for monitoring and intervention tasks, further reinforcing Autonomous Farming Needs.
  - The paper addresses existing navigation systems struggle in featureless outdoor environments; this work addresses those limitations.
  - The modular ROS architecture leads to other future upgrades for tasks like harvesting and crop treatment.

Action Item 6: Improving the ROS 2 Navigation Stack with Real-Time Local Costmap Updates for Agricultural Applications – 3 hour(s).

### Project Work Summary

- https://arxiv.org/abs/2407.18535
- Title: Improving the ROS 2 Navigation Stack with Real-Time Local Costmap Updates for Agricultural Applications
- Summary:
  - The paper presents a lightweight approach to improve outdoor robot navigation by integrating real-time local costmap updates.
  - Uses a depth camera for pixel-level classification to correct costmaps, enabling safe traversal of areas like tall grass.
  - Demonstrates effectiveness on a Clearpath Husky robot, showing improved navigation capabilities in challenging outdoor conditions.
- Relation to Your Project:
  - Addresses issues with tall grass or weeds being misclassified as obstacles by LiDAR sensors and address the real world complexities.
  - Combining this approach with precise GNSS positioning could enhance navigation reliability in complex agricultural environments.
  - Real-Time Adaptability allows for dynamic adjustments to navigation plans based on real-time sensor data.
- Motivation for Research:

- Standard ROS navigation stacks struggle with outdoor obstacles and changing conditions and hence understanding those challenges is needed.
- The approach is tailored to agricultural environments, where robots must navigate through diverse terrain and vegetation.
- Improves the feasibility of autonomous farming tasks by enhancing robot adaptability to real-world condition

Action Item 7: Next week plan – 1 hour(s).

### Project Work Summary

- Develop a ROS 2 node that publishes velocity commands to move the robot forward in a simulated maize field environment. This ensures that the robot can communicate with Gazebo and execute basic movements.
- Add collision component to the map creation to the robot model and adjust the ground plane's friction properties to prevent wheel slippage on soft soil or uneven terrain.
- Replace the `burger` model with `waffle` rover and integrating additional sensors like a RealSense depth camera for enhanced obstacle detection.
- Update navigation for the rover to account for the energy efficient movement in the farmland, ensuring smooth navigation through tight spaces between crop rows.
- Configure the Navigation2 stack with local and global costmaps for agricultural environments, using SLAM-generated maps to navigate through the farm efficiently.

Action Item 8: Report Writing – 1 hour(s).

### Project Work Summary

- Created word document layout to write contents of the weekly progress.
- Created relevant subsections in the epicspro website and documented 20 hours of weekly progress.
- Collected relevant documents research papers, relevant links and company's objective from their portal.

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