InternPro Weekly Progress Update

Name	Email	Project Name	NDA/ Non-NDA	InternPro Start Date	OPT
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Progress

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

#	Action Item/ Explanation	Total Time This Week (hours)
1	Report Writing	1
2	Weekly plan for next week	1
3	Give the rover more dimensions of freedom and rover more realistic movement	3
4	Exploring other variations for the design of realistic farm land	3
5	Create a path to mimic the ploughing action in the farm land	3
6	Research paper on Energy Efficient Path Planning	3
7	Mobile Robotics in Agricultural	3
8	Review paper on Path Planning for Agricultural Ground Robots	3
	Total hours for the week:	20

Verification Documentation:

Action Item 1: 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.

Action Item 2: Weekly plan for next week – 1 hour(s).

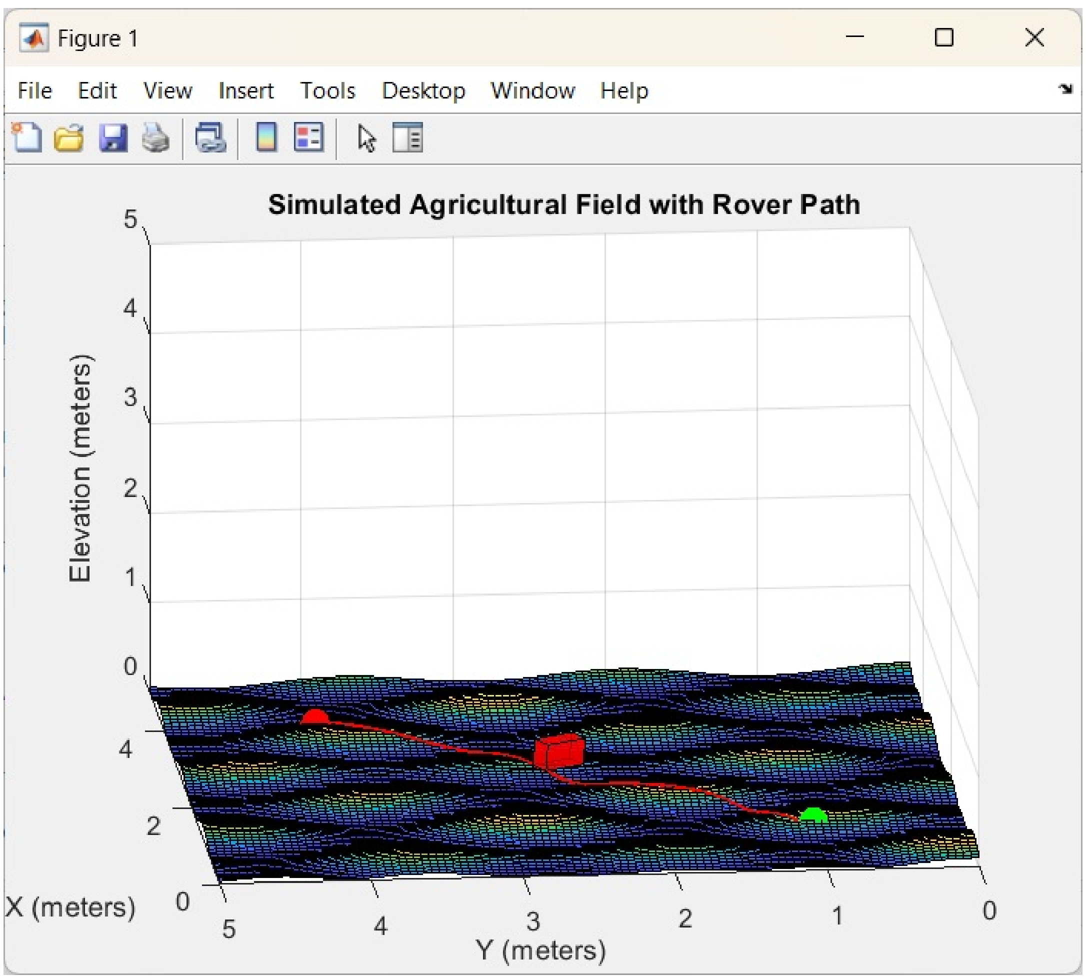
Project Work Summary

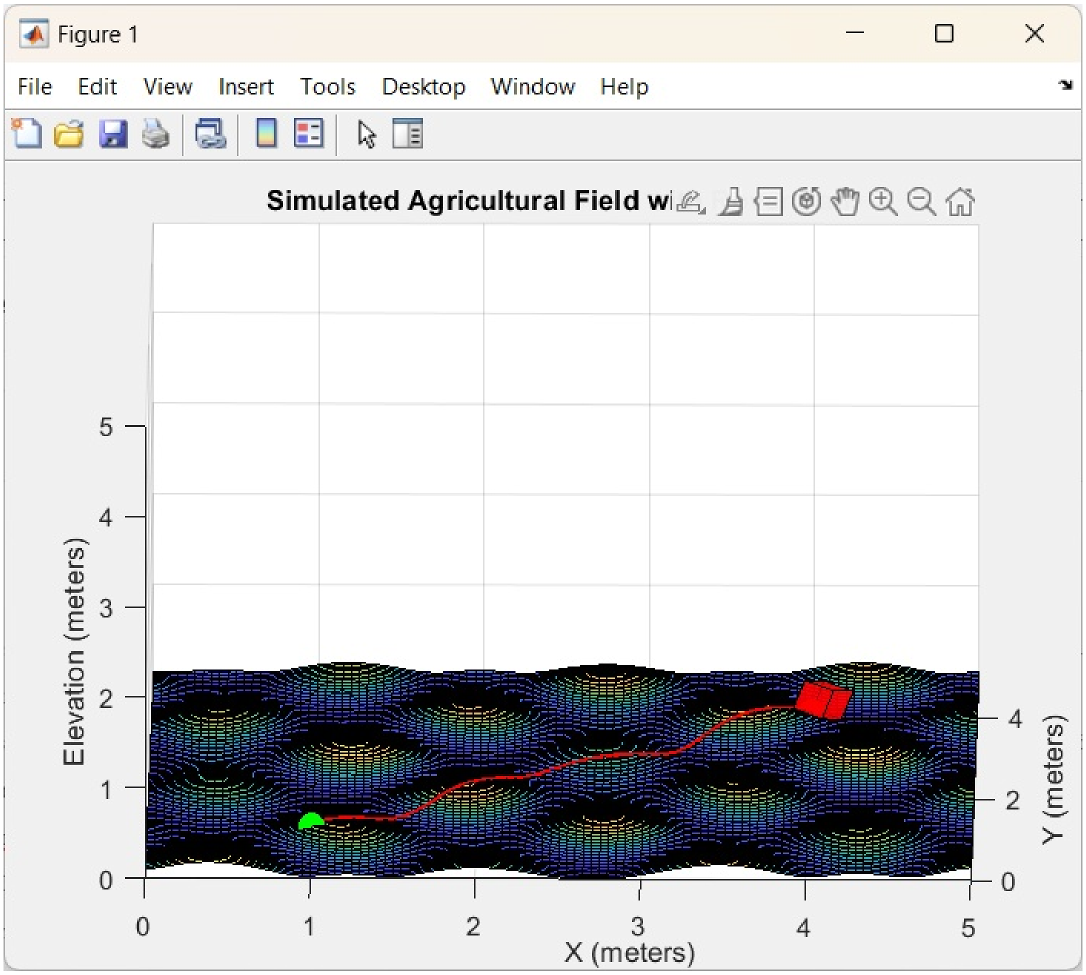
- For the upcoming week, we will focus on enhancing our MATLAB simulation with more advanced features and realistic models for the agricultural rover project.
- We plan to implement a GNSS simulation module that incorporates typical inaccuracies and signal drift, providing a more realistic representation of the rover's positioning system in field conditions.
- We will research and implement an advanced path planning algorithm, such as A* or RRT (Rapidly-exploring Random Trees), to improve the rover's navigation capabilities in complex terrain with obstacles.
- Our simulation will be expanded to include virtual sensors like LiDAR and cameras. We'll develop basic algorithms to process this simulated sensor data for improved terrain mapping and obstacle detection.

Action Item 3: Give the rover more dimensions of freedom and rover more realistic movement – 3 hour(s).

Project Work Summary

- Building upon our previous work on terrain modeling and basic rover movement, we focused on enhancing the realism of the rover's maneuvering in our simulated 3D farmland environment using MATLAB.
- We utilized our established 5x5 meter grid terrain, which was generated using a combination of sine waves and smoothed with a Gaussian filter.
- To improve the rover's movement, we implemented a more sophisticated orientation algorithm that calculates the local surface normal at each point along the path using the gradient of the terrain.
- This approach allows the rover to adjust its orientation in all three dimensions (pitch, roll, and yaw) based on the local slope, ensuring it remains tangential to the terrain surface as it moves.
- We used MATLAB's gradient function to determine the surface normals and created a local coordinate system for the rover at each point along its path.
- The resulting visualization demonstrates how the rover now "hugs" the terrain more realistically, tilting and rotating to match the undulations of the farmland.
- This enhancement provides a more accurate representation of how an actual agricultural rover would navigate through a field with varying elevations and depressions.

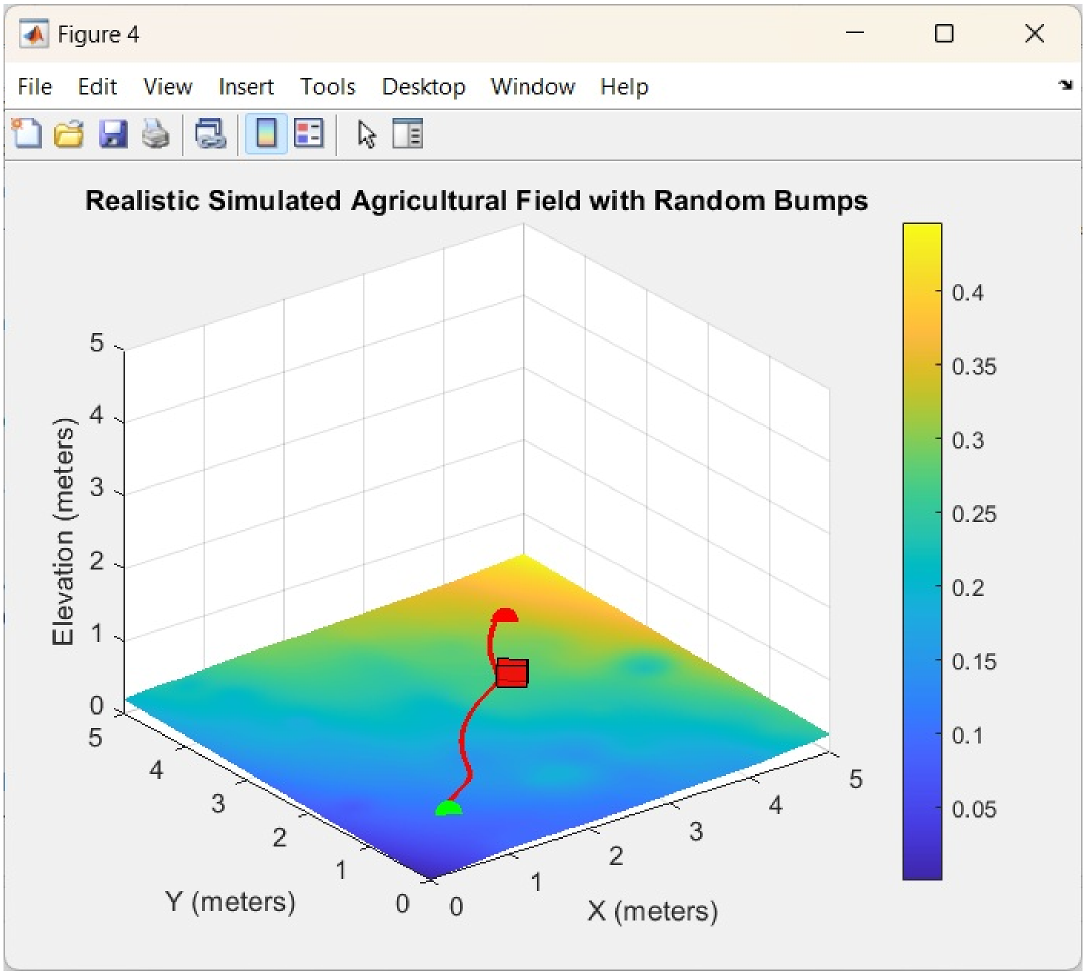




Action Item 4: Exploring other variations for the design of realistic farm land – 3 hour(s).

Project Work Summary

- Building upon our previous work on terrain modeling and rover simulation, we focused on enhancing the realism of our simulated farmland environment in MATLAB to better match the scale of our 30x30x15 cm agricultural rover.
- We refined our established 5x5 meter grid terrain, maintaining its overall dimensions while introducing more realistic and randomized features.
- We implemented a multi-layered approach to terrain generation, combining multiple octaves of random noise to create a natural-looking base landscape.
- This method produces subtle variations that more accurately represent the micro-topography of real agricultural fields.
- To further enhance realism, we introduced randomly placed bumps of varying heights (0.5 to 3 cm) and widths (10 to 30 cm) across the terrain, simulating the irregular surface features commonly found in farmlands.
- We maintained the gentle slopes across the field to represent natural gradients, and applied a slight Gaussian filter to smooth out overly sharp transitions, resulting in a more organic-looking landscape.
- The terrain's height variations were carefully scaled to maintain a maximum elevation change of about 20 cm, ensuring compatibility with our rover's dimensions.

- 

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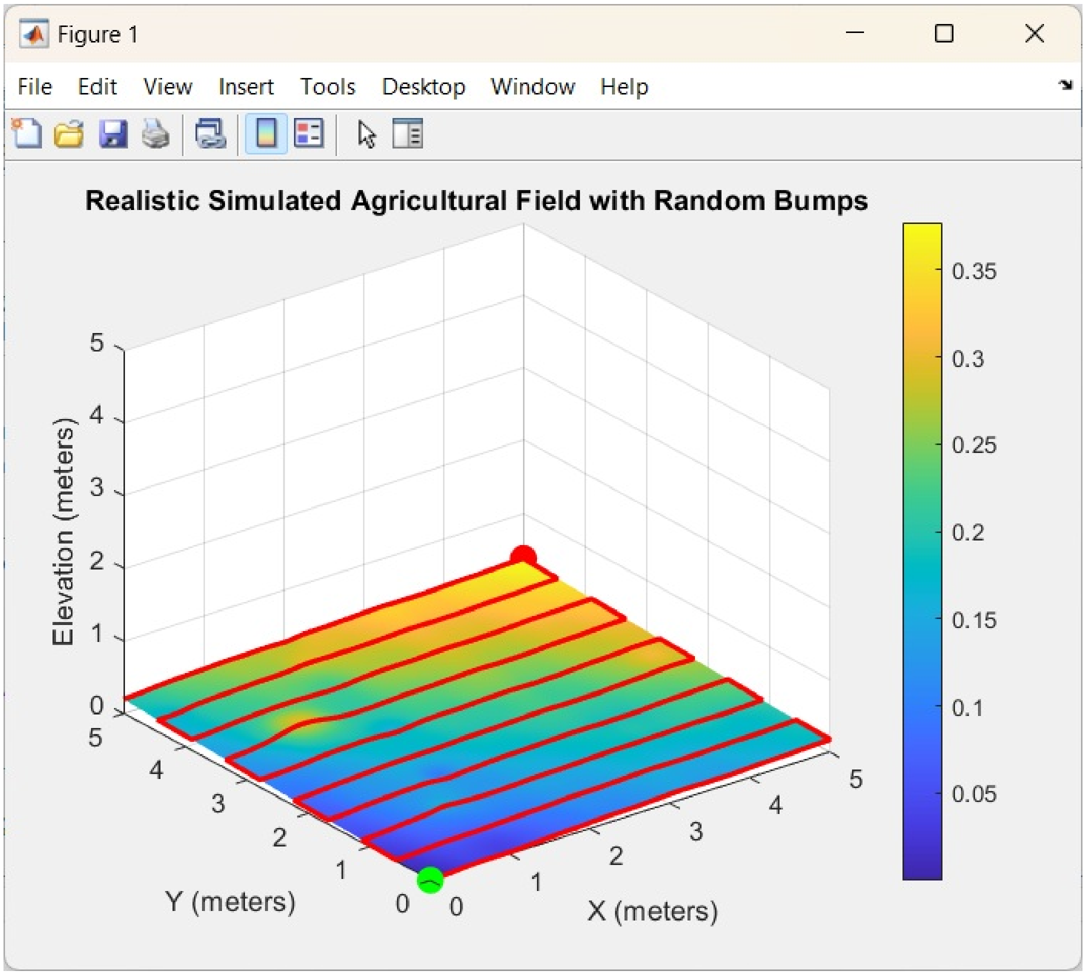
Action Item 5: Create a path to mimic the ploughing action in the farm land – 3 hour(s).

Project Work Summary

- Building upon our previous work on terrain modeling and rover simulation, we focused on implementing a realistic plowing pattern for the agricultural rover in our simulated farmland environment using MATLAB.
- We utilized our enhanced 5x5 meter grid terrain, which was generated using multiple octaves of random noise and augmented with randomly placed bumps to create a more realistic representation of an agricultural field.
- We developed a path planning algorithm that simulates a plowing action, creating a zigzag pattern that covers the entire field from one corner to the diagonally opposite corner.
- This approach mimics real-world agricultural practices, where machinery moves in parallel lines across a field.
- We implemented this pattern using a series of straight-line paths with U-turns at the field edges, adjusting the number of rows to control the density of the plowing pattern.
- The algorithm projects this zigzag path onto the 3D terrain surface using MATLAB's interp2 function, ensuring that the rover follows the contours of the land while maintaining the overall plowing pattern.
- This method results in a path that realistically adapts to the terrain's elevations and depressions while systematically covering the entire field.



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Action Item 6: Research paper on Energy Efficient Path Planning – 3 hour(s).

Research

- https://www.sciencedirect.com/science/article/abs/pii/S0921889023000052
- Energy efficient path planning for autonomous ground vehicles with ackermann steering
- Summary of Report
  - The paper proposes an energy efficient path planning method for autonomous ground vehicles with Ackermann steering.
  - The authors develops an energy cost model based on vehicle kinematics and motor power consumption.
  - The paper mainly uses A* search algorithm with energy-aware motion primitives to find energy-efficient paths for the methodology.
  - Demonstrates effectiveness through simulations and real vehicle tests, showing energy savings of up to 26.9% compared to distance-optimal paths.
- Relation to Project
  - The research paper is applicable to agricultural robotics using autonomous ground vehicles for tasks like precision farming.
  - The paper also provides a framework for energy-efficient navigation in outdoor environments for the agricultural application.
  - This methodology could help extend operating time of battery-powered agricultural robots between recharges.
- Motivation for Research
  - Autonomous ground vehicles have limited on-board power in challenging environments like agriculture.
  - Energy-efficient path planning can allow vehicles to perform more tasks with limited power.
  - Few existing studies on energy-efficient planning for Ackermann steering vehicles, which are common in real-world applications.
  - This paper is relevant for agricultural robotics applications as it addresses energy-efficient path planning for autonomous ground vehicles operating in outdoor environments with limited power.

Action Item 7: Mobile Robotics in Agricultural – 3 hour(s).

Research

- https://www.mdpi.com/2076-3417/10/10/3453
- Mobile Robotics in Agricultural Operations: A Narrative Review on Planning Aspects
- Summary of Report
    - The paper provides a comprehensive review of mobile robotics applications in agriculture, focusing on planning aspects.
    - Examines terminology, technical aspects, and fundamental planning attributes for autonomous agricultural operations.
    - The author identifies seven key planning attributes for mobile robots in agricultural environments.
    - Discusses challenges and opportunities for implementing mobile robotics in various agricultural scenarios.
- Relation to Project
    - The paper directly addresses methodologies for path planning for agricultural robotics applications.
    - The author also offers insights into the complexities of autonomous navigation in agricultural environments.
    - The article provides a framework for understanding different planning aspects relevant to agricultural robots.
- Motivation for Research
    - This paper is relevant for agricultural robotics applications as it addresses energy-efficient path planning for autonomous ground vehicles operating in outdoor environments with limited power.
    - The lack of consistent terminology and definitions in the field of agricultural robotics.
    - Need for a comprehensive understanding of planning attributes for autonomous agricultural operations
    - Growing importance of mobile robots in optimizing labor-intensive and resource-demanding agricultural tasks

Action Item 8: Review paper on Path Planning for Agricultural Ground Robots – 3 hour(s).

Research

- https://www.mdpi.com/2071-1050/14/15/9156
- A Comprehensive Review of Path Planning for Agricultural Ground Robots
- Summary of Report
    - Provides a systematic literature review of path/trajectory planning for agricultural ground robots and various path planning techniques used in different agricultural applications.
    - Analyzes trends, challenges, and future directions in agricultural robot path planning and covers both point-to-point and coverage path planning approaches.
    - Discusses applications in vineyards, orchards, greenhouses, and crop fields and evaluates algorithms like A*, RRT, genetic algorithms, and particle swarm optimization.
- Relation to Project
    - Offers comprehensive overview of path planning methods for agricultural robots and highlights key considerations for developing effective navigation systems.
    - Identifies gaps and opportunities for further research in this area, provides context on challenges specific to agricultural environments.
    - Compares pros and cons of different path planning approaches and discusses integration with positioning systems and sensors.
- Motivation for Research
    - This paper is relevant for agricultural robotics applications as it addresses energy-efficient path planning for autonomous ground vehicles operating in outdoor environments with limited power.
    - Growing global population necessitates increased agricultural productivity and labor shortages driving need for automated agricultural systems.
    - Precision agriculture requires advanced navigation and path planning capabilities, aims to improve efficiency and sustainability of farming operations
    - Addresses need for autonomous navigation in complex, unstructured environments and supports development of multi-robot systems for large-scale farms