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.

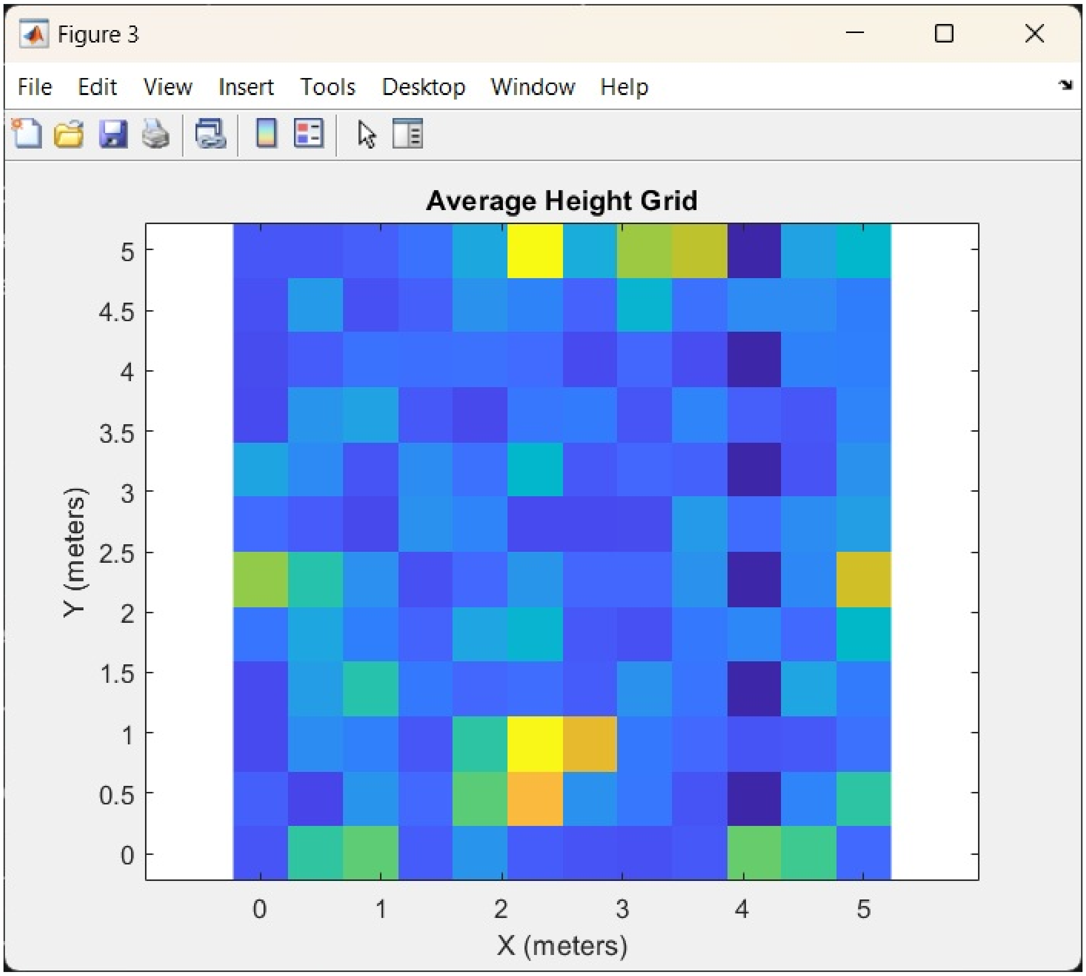
#	Action Item/ Explanation	Total Time This Week (hours)
1	Discretized grid map and enhanced simulation	3
2	Implementing the discretized map and the Astar algorithm	3
3	Enhanced the simulation	3
4	A Review of Discrete Element Method Applications in Soil–Plant Interactions: Challenges and Opportunities	3
5	Path Planning Approaches in Multi-robot System: A Review	3
6	An efficient multi-robot path planning solution using A* and coevolutionary algorithms	3
7	Work plan for next week	1
8	Report writing	1
	Total hours for the week:	20

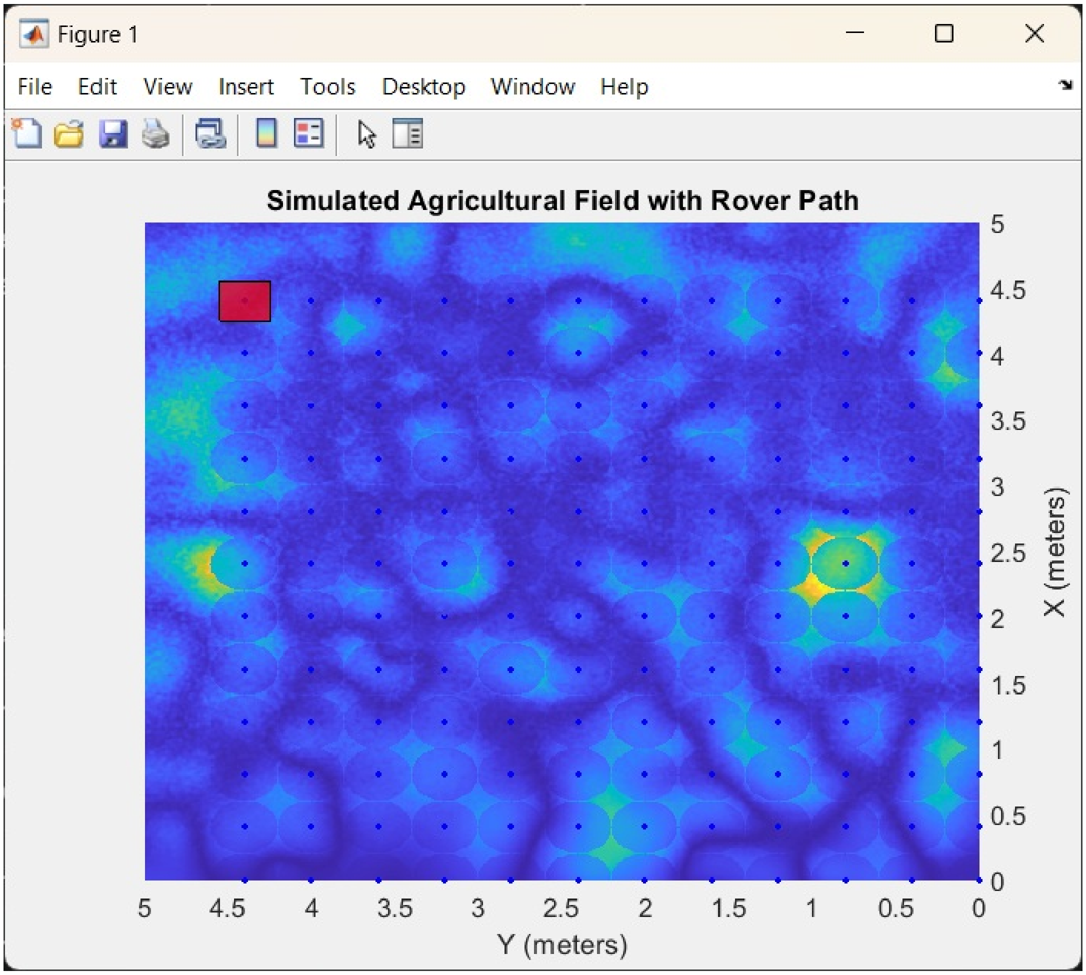
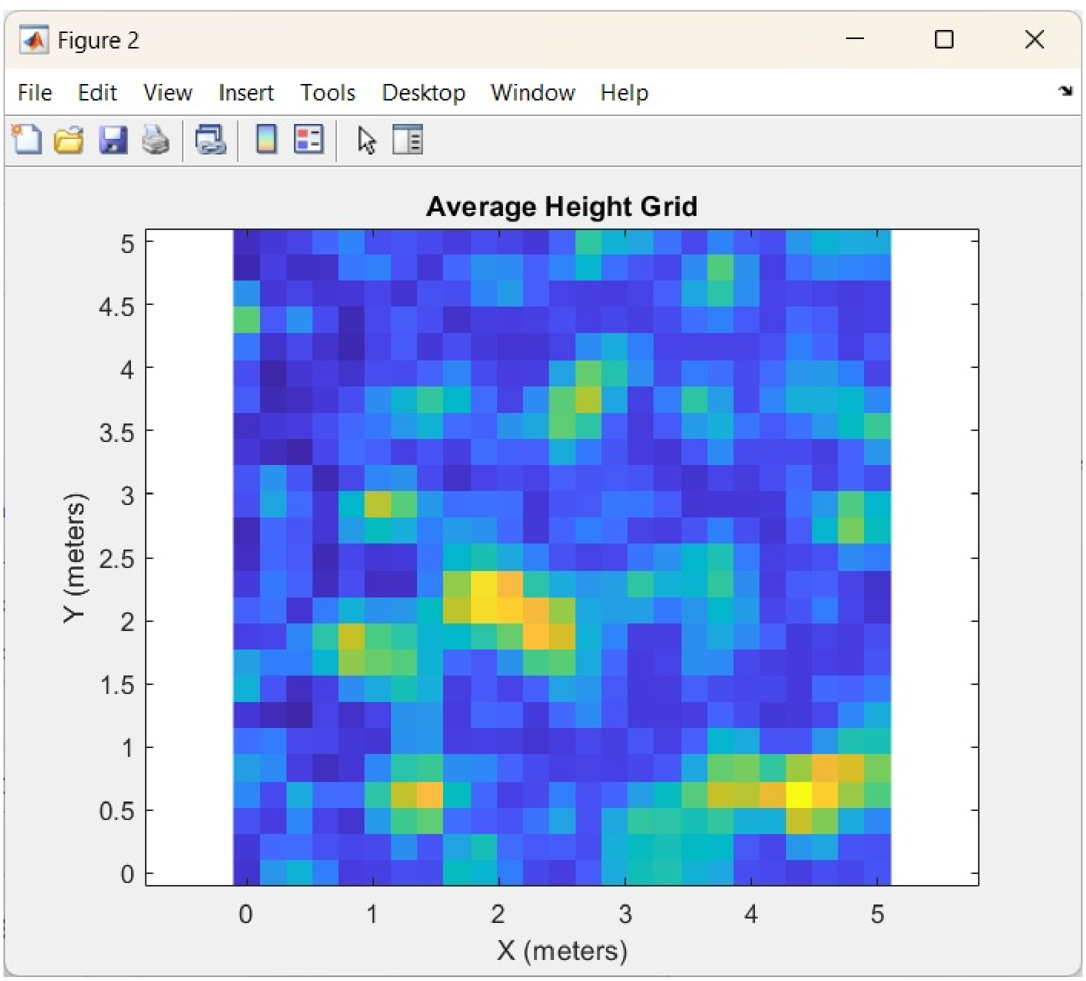
Verification Documentation:

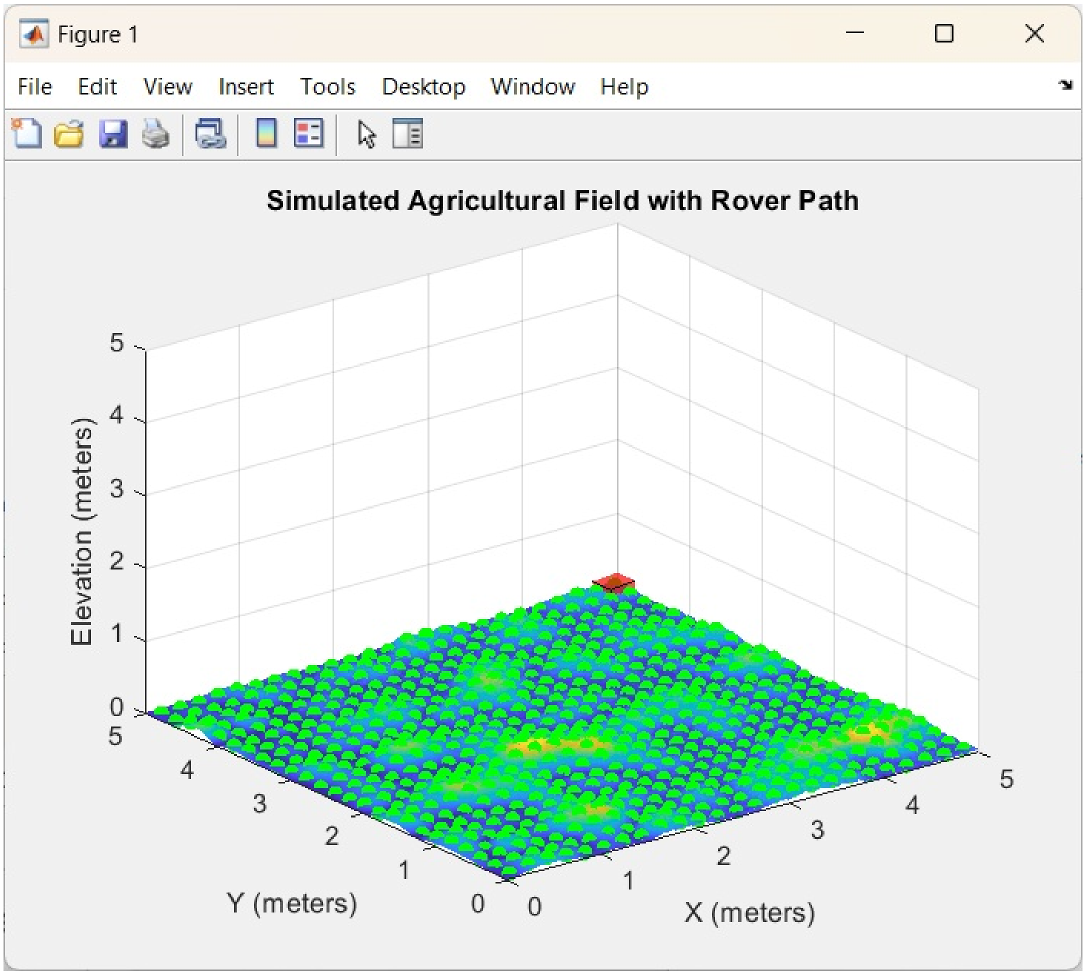
Action Item 1: Discretized grid map and enhanced simulation – 3 hour(s).

Project Work Summary

- Up until now, we used a larger grid size to discretize the entire map, which made the leveling task less efficient and left some unattended space at the intersections.
- Even after the rover covered the entire area, the farmland showed clear problems with discretization.
- To address this issue, we reduced the grid size from 0.2 m to 0.1 m, allowing for better discretization and improved performance in the leveling task.

- We then performed the regular data collection task with the changed grid size and visualized the results.
- The outcome clearly showed a more defined data collection process, with more data gathered from the map.
- 

- 
Figure 1
File Edit View Insert Tools Desktop Window Help
Simulated Agricultural Field with Rover Path
5 4.5 4 3.5 3 2.5 2 1.5 1 0.5 0
Y (meters)
X (meters)
- 
Figure 2
File Edit View Insert Tools Desktop Window Help
Average Height Grid
0 1 2 3 4 5
X (meters)
Y (meters)
5 4.5 4 3.5 3 2.5 2 1.5 1 0.5 0

- 
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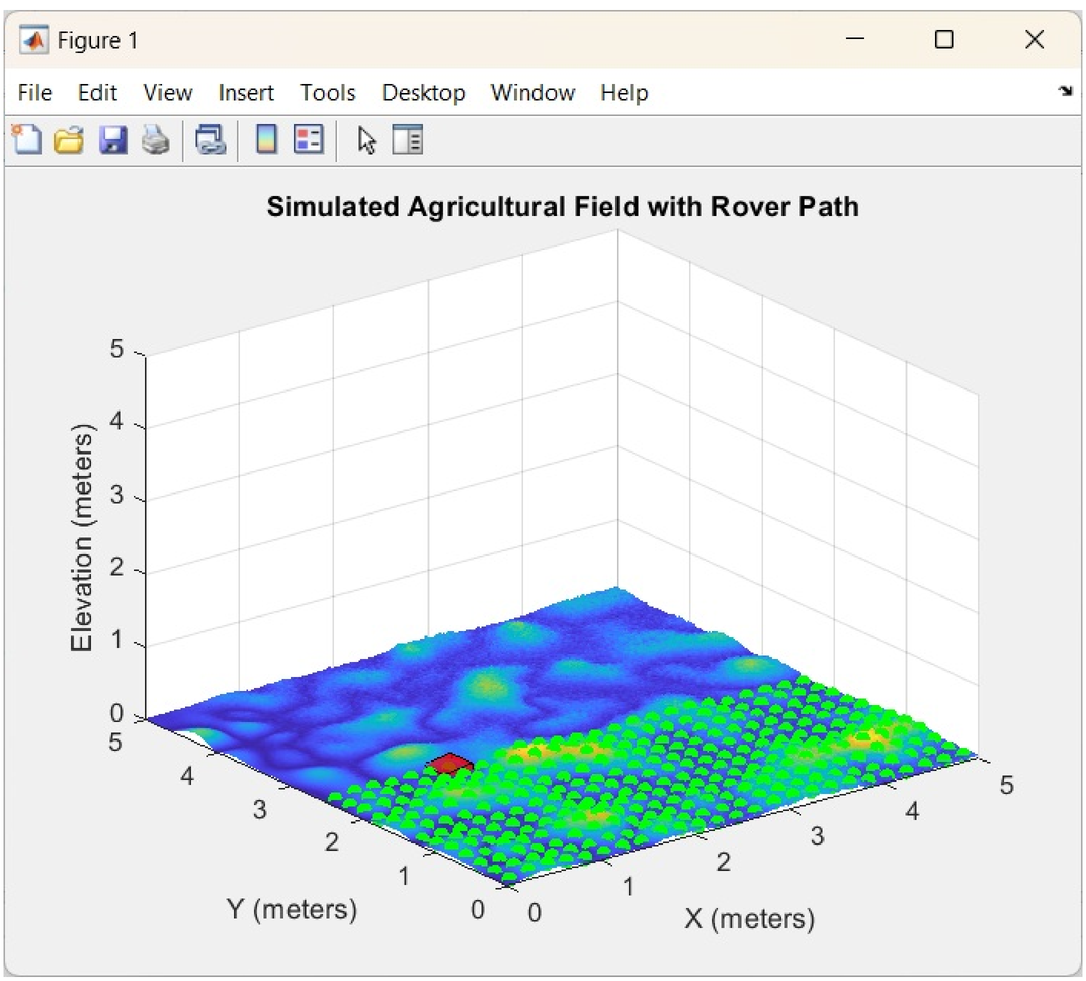
- 
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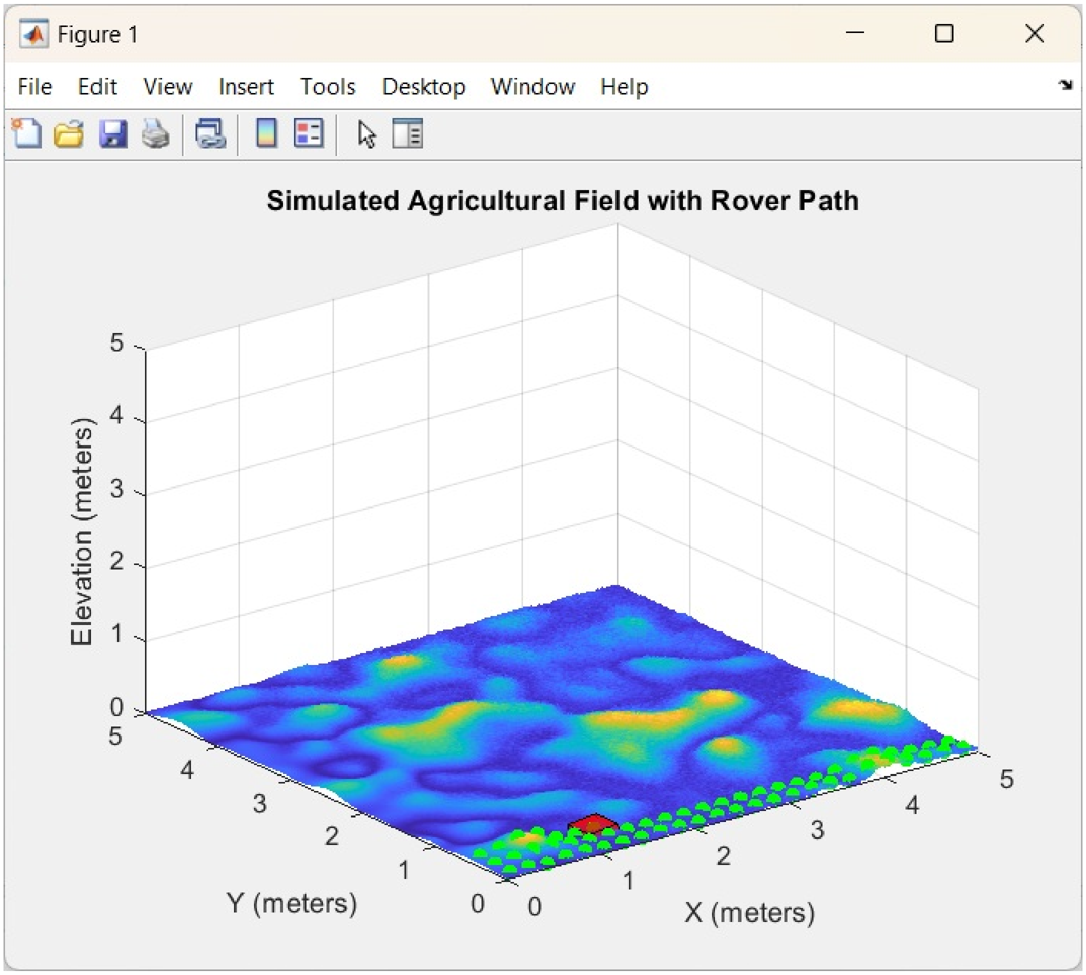
- 

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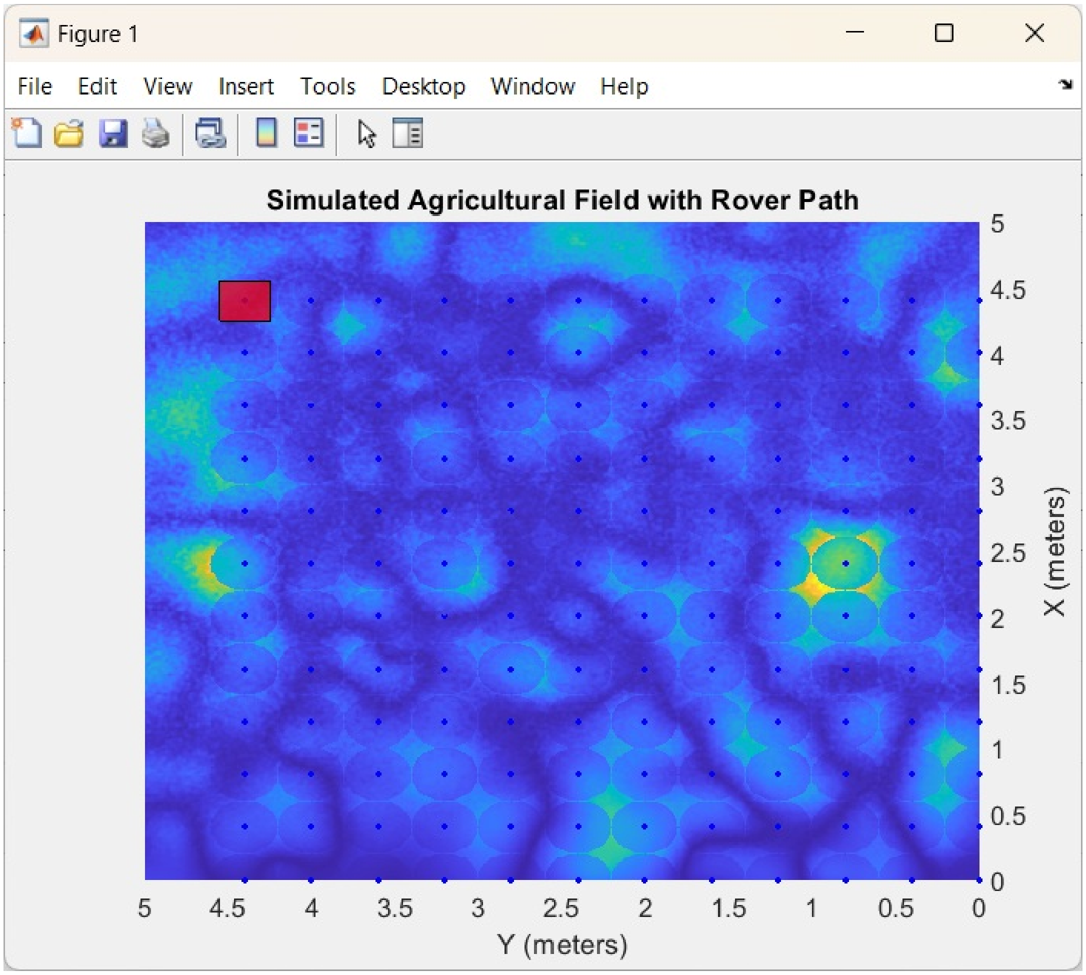
Action Item 2: Implementing the discretized map and the Astar algorithm – 3 hour(s).

Project Work Summary

- Using the newly discretized map, we implemented the A* algorithm for the updated grid assignments, and the path was extracted.
- With finer discretization, we observed that the A* algorithm generates more intricate and complex paths for rover travel compared to the previous version.
- We then simulated the rover along the new path and visualized the leveling task.
- The results clearly showed that with the discretized map, we covered more of the map area, and the leveling process encompassed almost all of the farmland.
- This improved discretization led to more comprehensive coverage and a more effective leveling operation across the entire agricultural field.

- 
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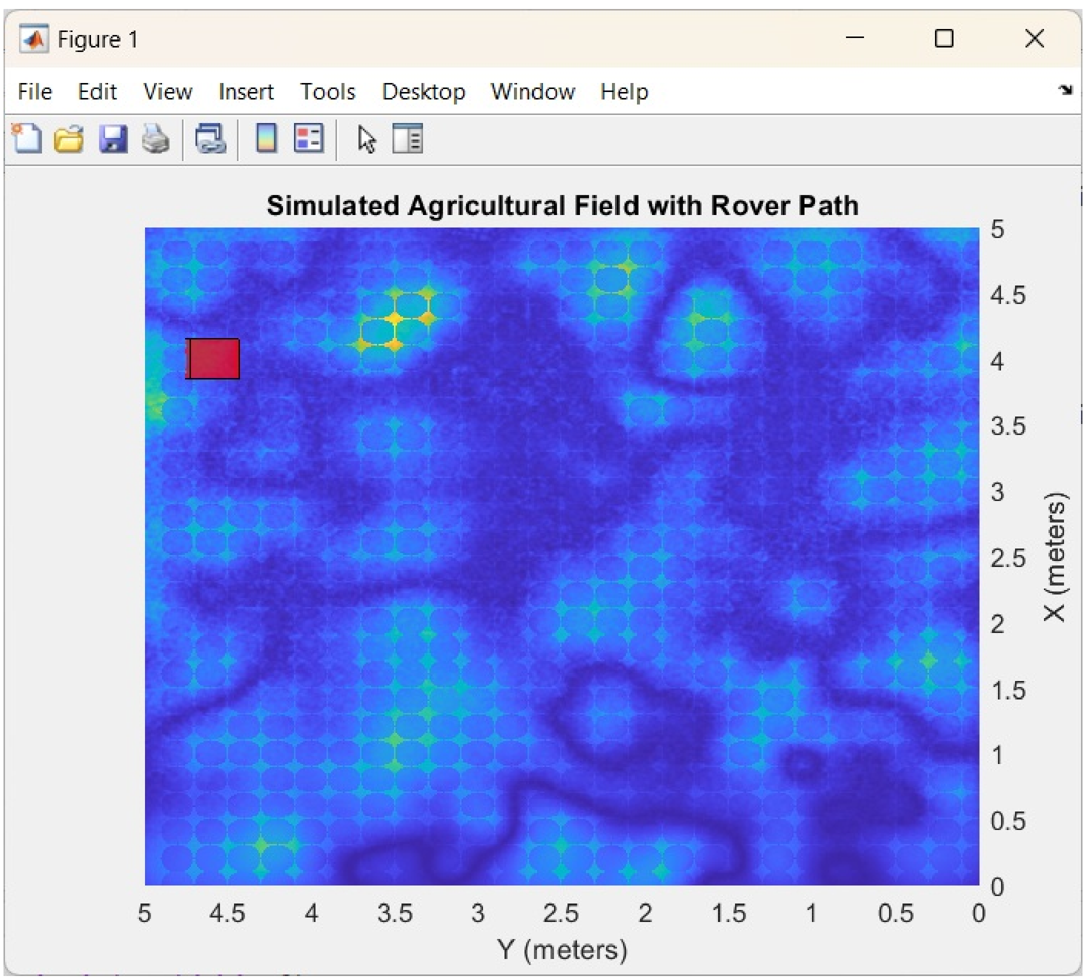
- 
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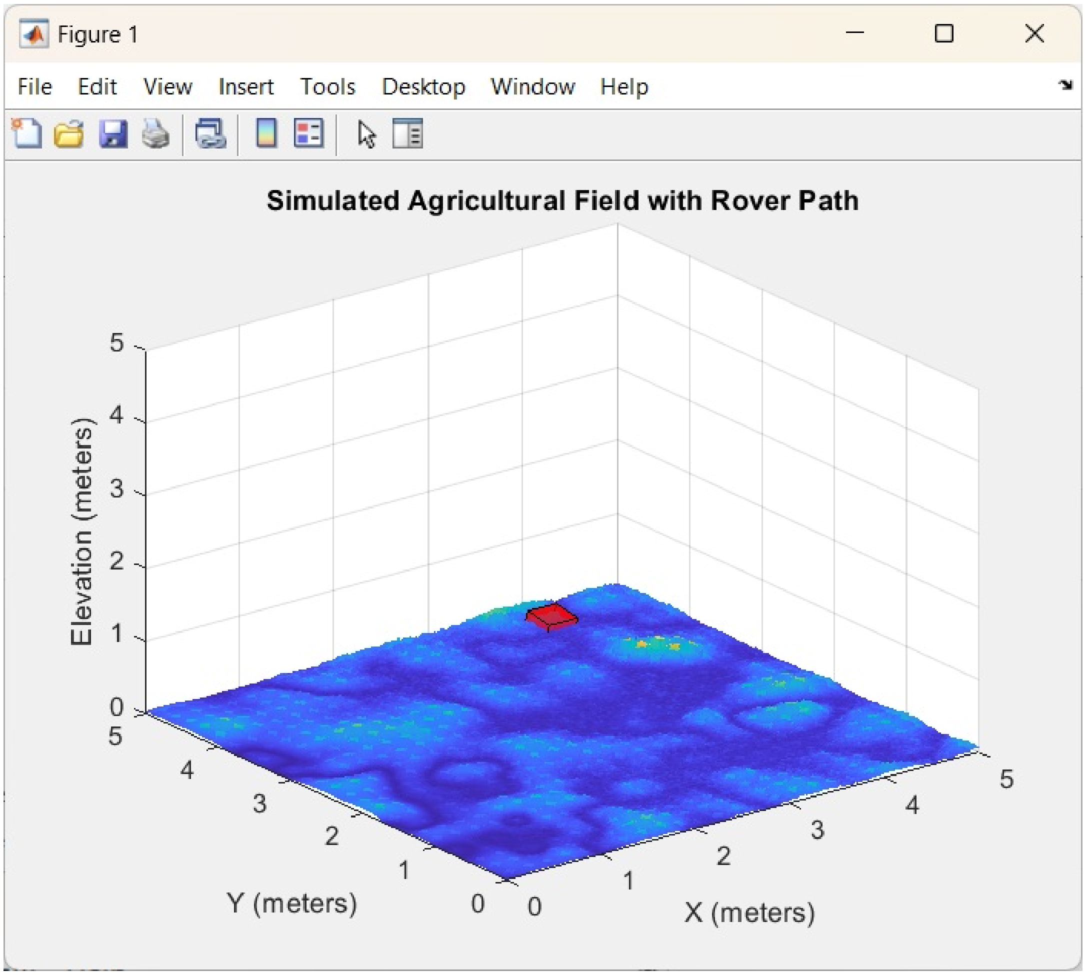
- 
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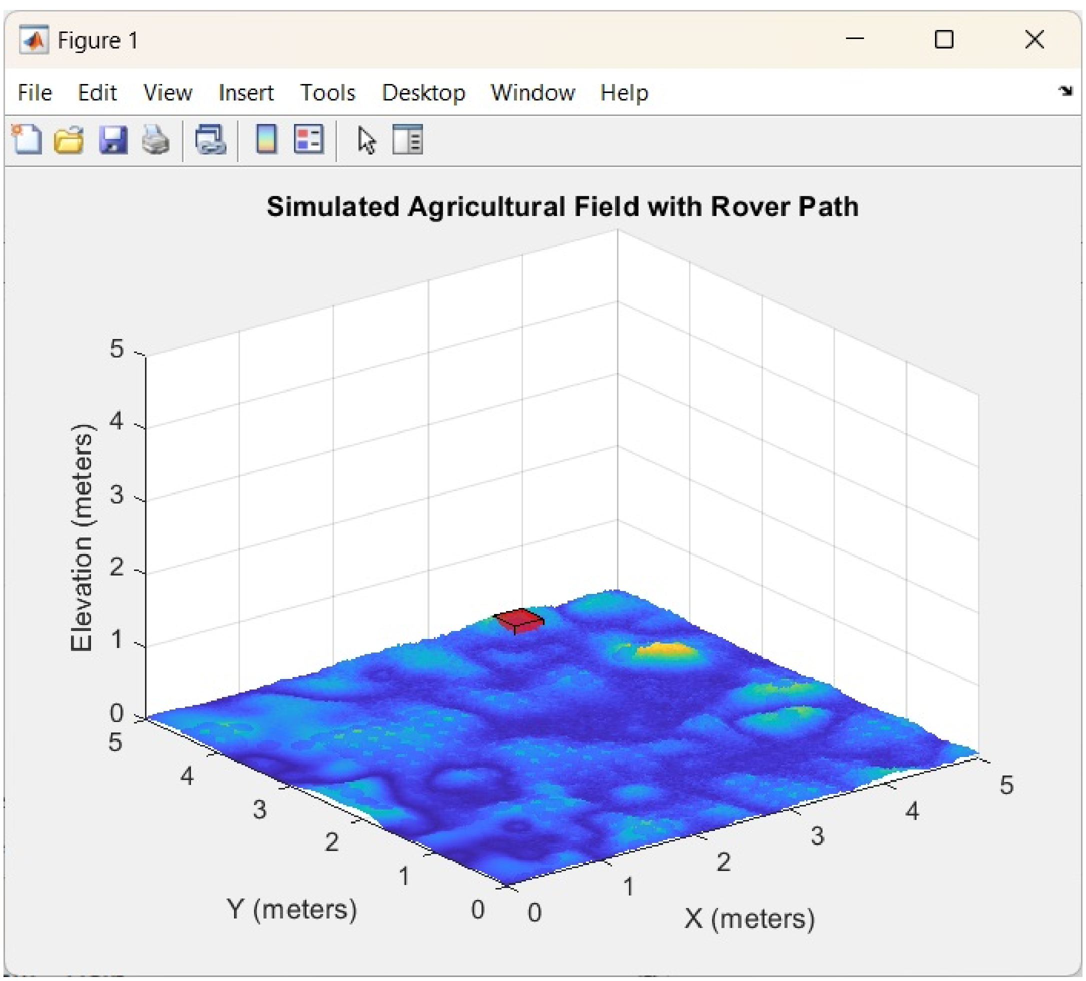
- 
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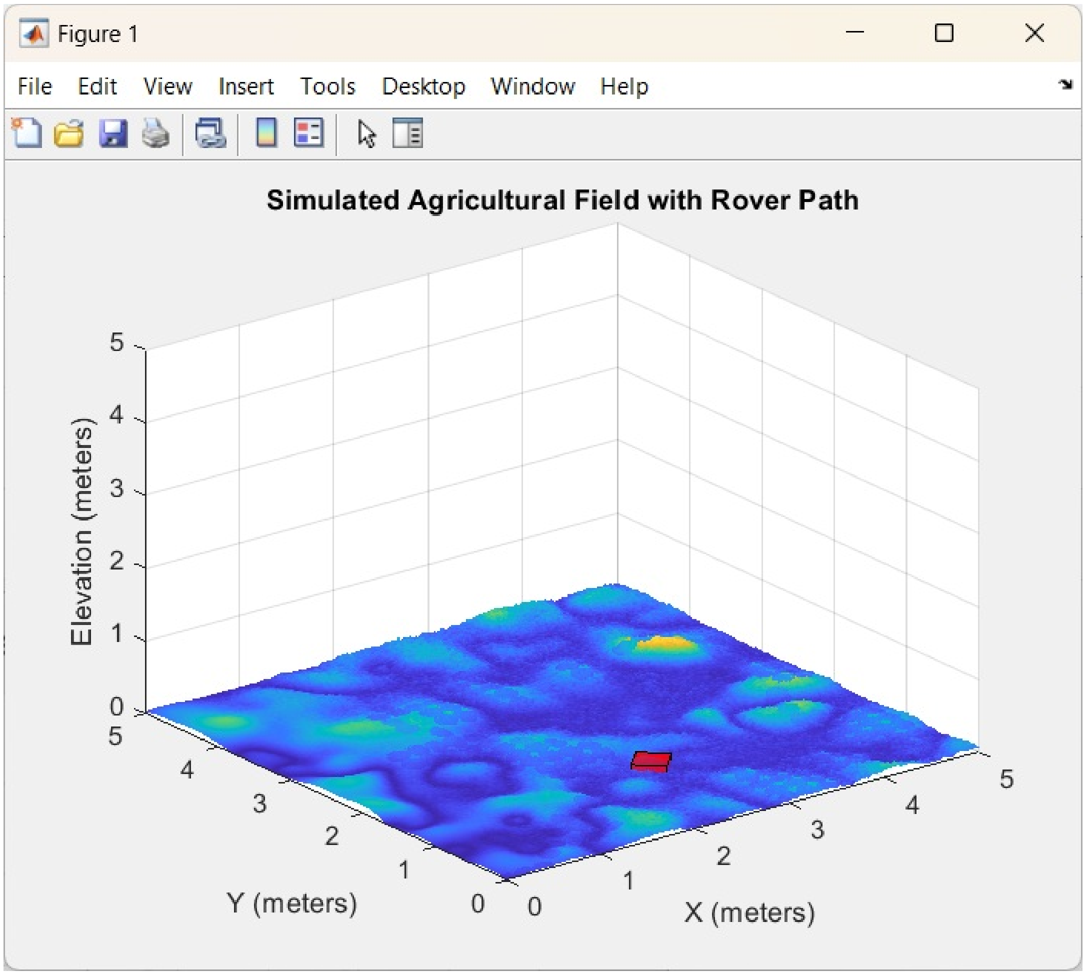
- 

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X (meters)
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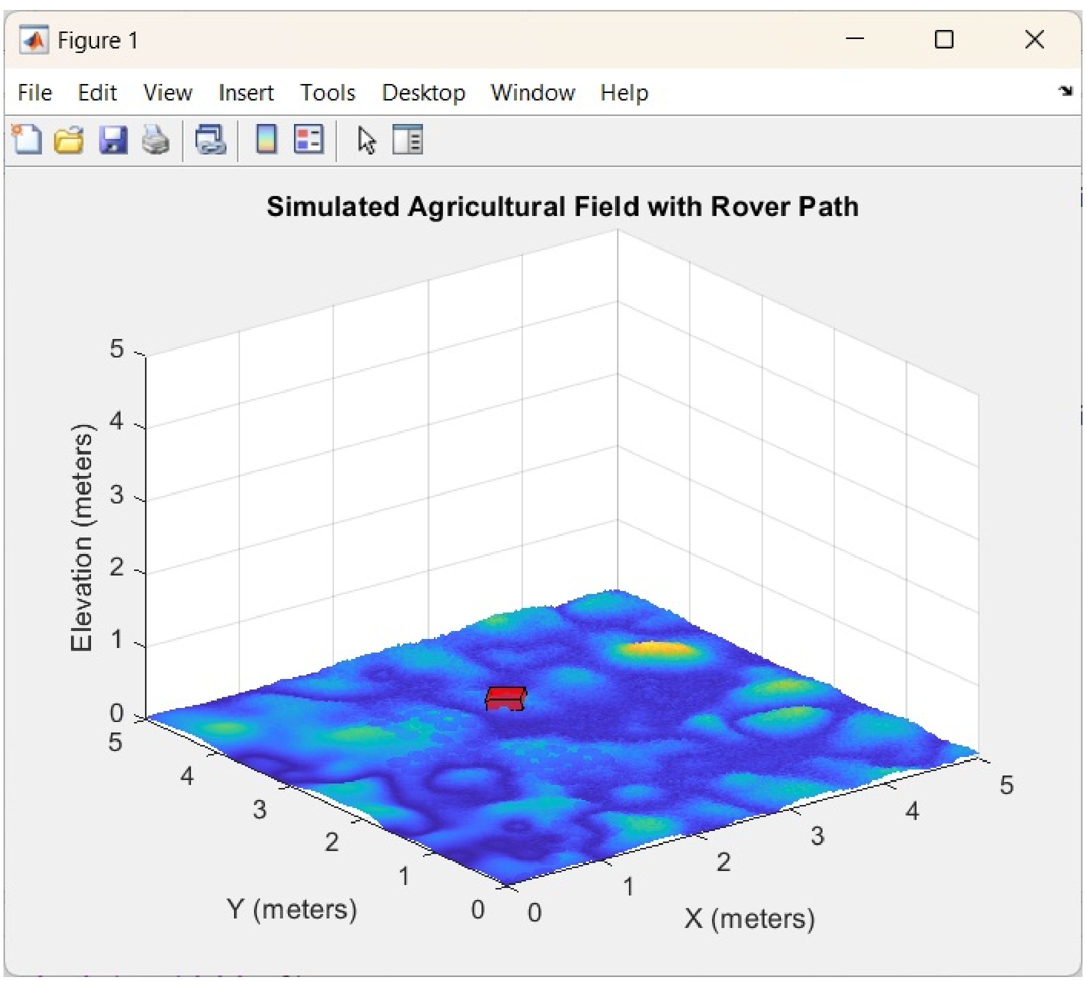
- 

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Action Item 3: Enhanced the simulation – 3 hour(s).

Project Work Summary

- **Path Interpolation:**
  - Apply multiple passes of Gaussian smoothing (`imgaussfilt`) to reduce terrain roughness and create more gradual transitions in height variations.
  - The terrain is smoothed twice to ensure a consistent, smooth surface for the rover to navigate.
- **Reduced Visualization Update Frequency:**
  - Interpolate the rover's path using spline interpolation to generate more evenly spaced waypoints. This reduces sharp changes in direction and ensures a smoother motion trajectory.
  - The path is interpolated to 500 points, providing a finer resolution for the rover's movement.
- **Enhanced Terrain Modification:**
  - The rover's orientation and movement along the path are calculated more smoothly by using interpolated path coordinates, ensuring gradual transitions in the rover's position and rotation.
- **Orientation and Movement Adjustments:**
  - Implement a mechanism to reduce the frequency of plot updates during animation (plot updates are made every 5 frames). This reduces computational overhead and makes the simulation more responsive.

Action Item 4: A Review of Discrete Element Method Applications in Soil–Plant Interactions: Challenges and Opportunities – 3 hour(s).

Research

1. Link to Article: https://www.mdpi.com/2077-0472/13/2/305
Title of the Article: Simulating Soil–Disc Plough Interaction Using Discrete Element Method–Multi-Body Dynamic Coupling

Summary of Report:
• The study modeled the interaction between soil and a one-way modified disc plough using the discrete element method (DEM)
• DEM-MBD coupling was used to predict the rotational speed of the disc plough
• The model was validated using field experiments, showing good agreement between simulated and measured results

Relation to Project:
• Provides a validated methodology for simulating soil-tool interactions using DEM
• Demonstrates the effectiveness of coupling DEM with multi-body dynamics for agricultural tool simulations
• Offers insights into predicting tool performance parameters like rotational speed and soil disturbance

Motivation for Research:
• To develop accurate simulation methods for optimizing agricultural tool design
• To reduce the need for extensive field testing by providing reliable virtual prototyping tools
• To better understand the complex interactions between soil and tillage implements

Action Item 5: Path Planning Approaches in Multi-robot System: A Review – 3 hour(s).

Research

- https://onlinelibrary.wiley.com/doi/full/10.1002/eng2.13035
- Path Planning Approaches in Multi-robot System: A Review
- Summary of Report:
  • This review article categorizes and analyzes path planning approaches for multi-robot systems, focusing on classical, heuristic, and artificial intelligence-based methods.
  • The paper examines recent publications, evaluating approaches based on static and dynamic scenarios, real-time experiments, and simulations involving hybrid solutions.
  • It highlights the increasing use of hybrid approaches in dynamic environments, particularly in heuristic and AI-based methods, and the growing implementation of AI-based approaches in real-time applications.
- Relation to Project:
  • Provides a comprehensive overview of current path planning techniques for multi-robot systems, which is directly relevant to developing efficient multi-robot coordination strategies.
  • Analyzes the strengths and limitations of various algorithms, helping researchers select appropriate approaches for specific application needs in multi-robot systems.
  • Highlights the trend towards hybrid solutions and AI-based methods, indicating promising directions for future research in multi-robot path planning.
- Motivation for Research:
  • The increasing complexity of multi-robot applications necessitates more advanced and adaptive path planning techniques to ensure efficient and collision-free operation.
  • There is a growing need to understand and compare different path planning approaches to overcome limitations such as high processing costs and susceptibility to local optima.
  • The research aims to bridge the gap between simulation and practical implementation of path planning algorithms in real-world multi-robot scenarios.

Action Item 6: An efficient multi-robot path planning solution using A* and coevolutionary algorithms – 3 hour(s).

Research

- https://content.iospress.com/articles/integrated-computer-aided-engineering/ica220695
- An efficient multi-robot path planning solution using A* and coevolutionary algorithms
- Summary of Report
  - The paper proposes an efficient multi-robot path planning solution using A* and coevolutionary algorithms for controlled environments like warehouses and virtual labs.
  - The approach combines A* for initial optimal routes, an A*-based alternative search, and a coevolutionary optimization process to find collision-free paths for multiple robots.
  - Experiments show the method outperforms previous approaches and can solve complex scenarios where other algorithms like M* and WHCA fail to find solutions.
- Relation to Project
  - The proposed solution addresses multi-robot path planning in grid-based environments, which is directly applicable to warehouse automation and logistics projects.
  - The method can handle a higher number of robots and more complex scenarios compared to existing approaches, enabling more efficient warehouse operations.
  - The algorithm's ability to find collision-free paths in real-time makes it suitable for implementation on edge computing devices in industrial settings.
- Motivation for Research
  - Existing multi-robot path planning approaches often rely on local sensory systems and on-the-fly decision making, which may be unnecessary in controlled environments.
  - There is a need for efficient collision-free path planning solutions that can be pre-computed for simpler robots in industrial plants and virtual labs.
  - The research aims to improve upon previous work by reducing computational costs and handling a larger number of robots in complex scenarios.

Action Item 7: Work plan for next week – 1 hour(s).

Project Work Summary

- Setup and Initial Implementation
  • Set up the development environment with MATLAB
  • Implement the basic A* algorithm for a single robot
  • Create a simple grid-based terrain representation
- Multi-Robot Extension
  • Extend the A* algorithm to handle multiple robots
  • Implement collision avoidance between robots
  • Test the multi-robot pathfinding on a simple terrain

- Visualization and Testing
  - Create a visualization module to display robot movements and terrain changes
  - Implement comprehensive testing scenarios
  - Debug and refine the algorithm based on test results

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.