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	Implementing the path planner	3
2	Visualizing the updated Path planning algorithm	3
3	Realistic Farmland Terrain Simulation and Data Collection System for Agricultural Rover	3
4	Implementing AStar algorithm to the new map	3
5	Formulating Multi-Pass Grid AStar algorithm	3
6	Implementing Updated AStar algorithm to the new map	3
7	Work plan for next week	1
8	Report Writing	1
	Total hours for the week:	20

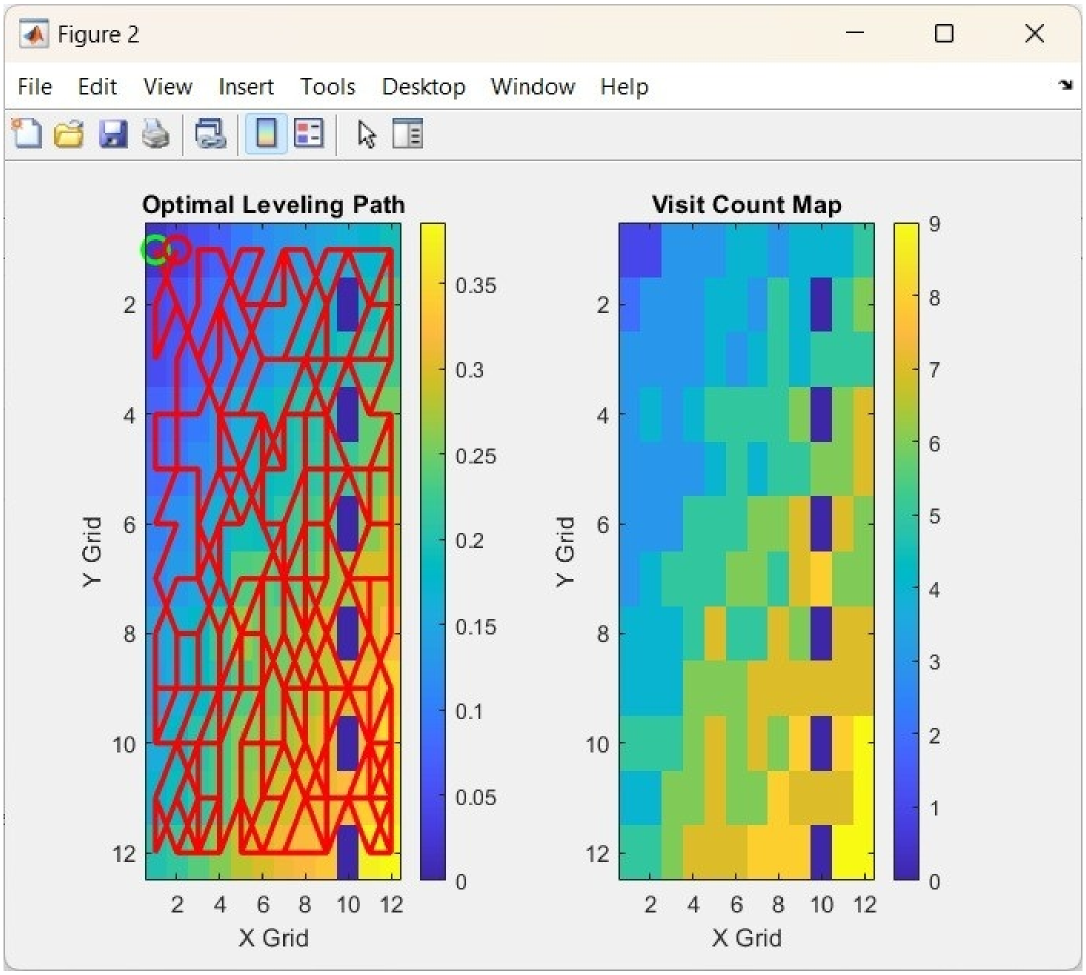
Verification Documentation:

Action Item 1: Implementing the path planner – 3 hour(s).

Project Work Summary

- Developed a height-based A* pathfinding algorithm that:
  - Generates optimal paths considering terrain elevation differences
  - Implements priority-based cell selection for multiple passes
  - Tracks visit counts to ensure complete field coverage
  - Adapts path planning based on local terrain characteristics
- Created a multi-pass optimization system that:

    - Calculates required passes for each grid cell based on height differences from target level
    - Prioritizes higher elevation areas requiring more passes
    - Ensures minimum single-pass coverage for all cells
    - Dynamically updates visit frequency during operation
- Implemented comprehensive visualization tools showing:
    - Color-coded height grid displaying terrain variations from 0.05m to 0.3m
    - Optimal path planning with start (green) and end (red) positions
    - Visit count heatmap indicating coverage frequency
    - Real-time path execution and coverage tracking



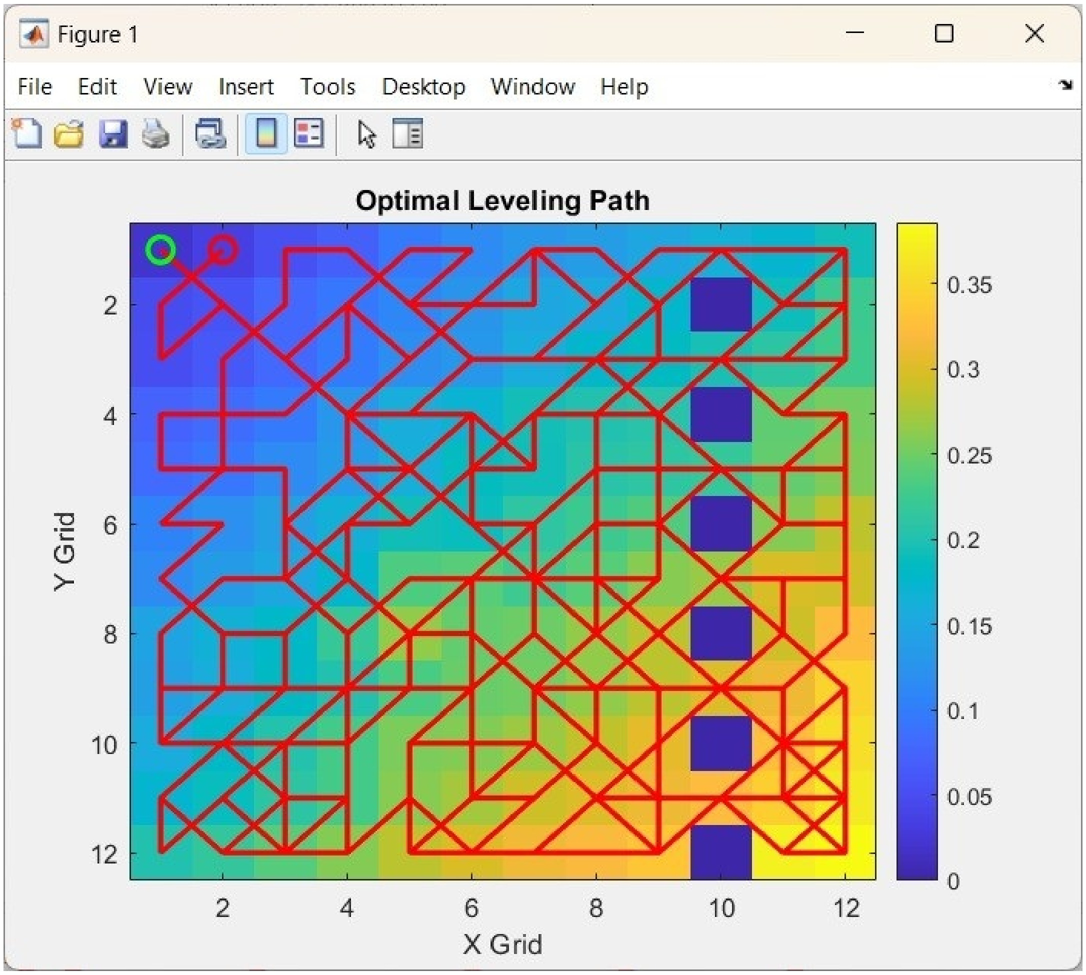


Figure 1
File Edit View Insert Tools Desktop Window Help
Optimal Leveling Path
Y Grid
X Grid
2
4
6
8
10
12
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0

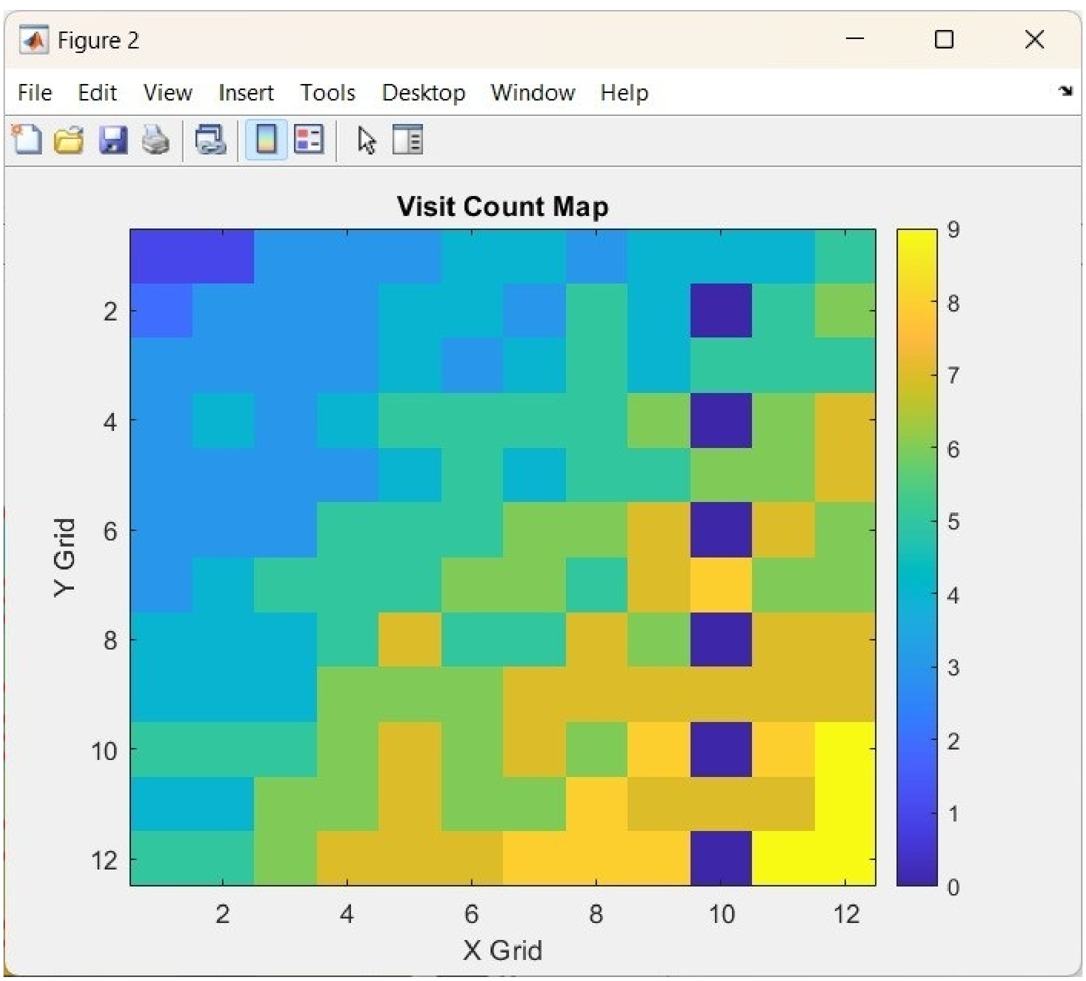
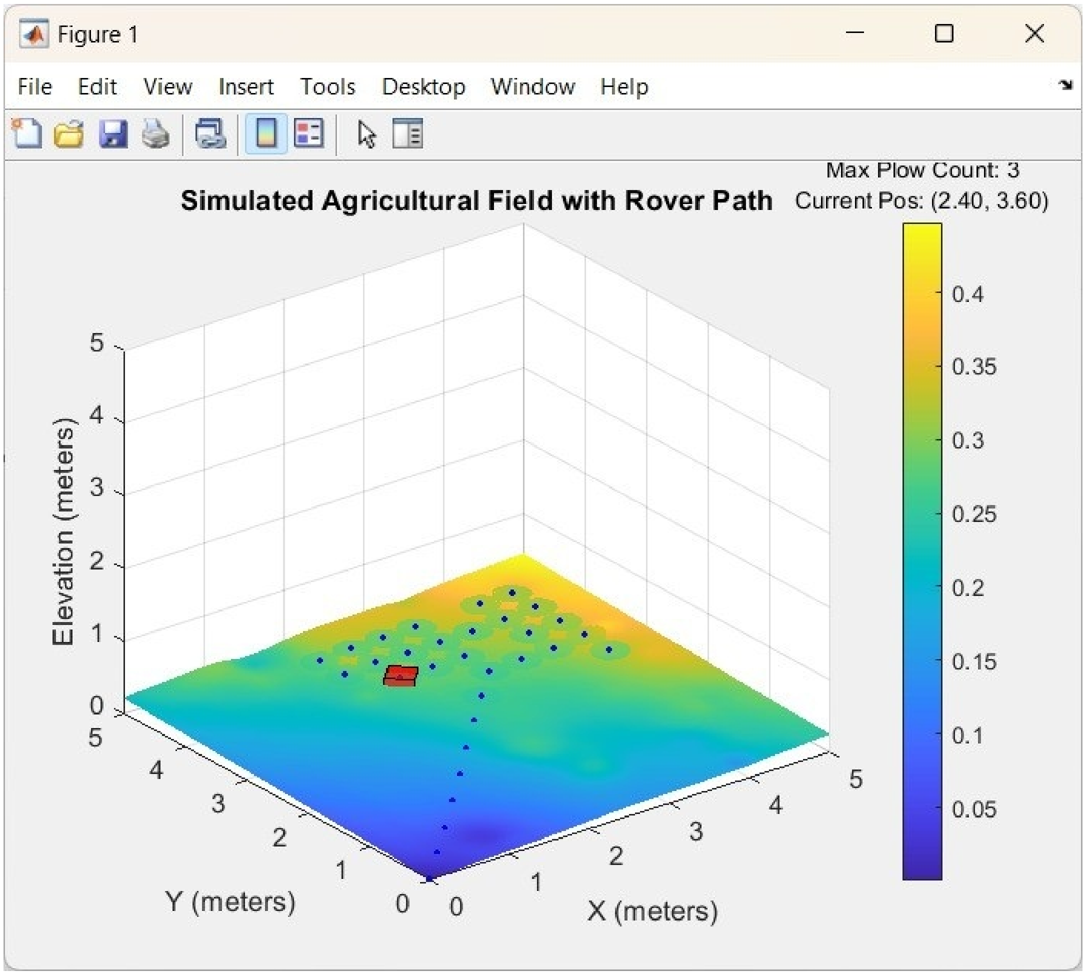


Figure 2
File Edit View Insert Tools Desktop Window Help
Visit Count Map
Y Grid
X Grid
2
4
6
8
10
12
9
8
7
6
5
4
3
2
1
0

Action Item 2: Visualizing the updated Path planning algorithm – 3 hour(s).

Project Work Summary

- Developed dual-panel visualization system that:
  - Displays color-coded height grid showing terrain variations from 0.05m to 0.3m across the 12x12 grid cells
  - Illustrates optimal leveling path with clear start position (green marker) and end position (red marker)
  - Generates real-time visit count heatmap indicating coverage frequency across the field
- Created interactive visualization features including:
  - Dynamic colorbar showing elevation scale for terrain height interpretation
  - Clear axis labeling for X and Y grid coordinates
  - Subplot organization for simultaneous display of height and coverage data
  - Path overlay showing complete rover trajectory across the field
- Implemented comprehensive data representation through:
  - Continuous color gradients from blue (low elevation) to yellow (high elevation) for intuitive height visualization
  - Distinct path marking in red for clear trajectory visualization
  - Strategic marker placement showing critical path points
  - Synchronized display of terrain characteristics and planned coverage patterns



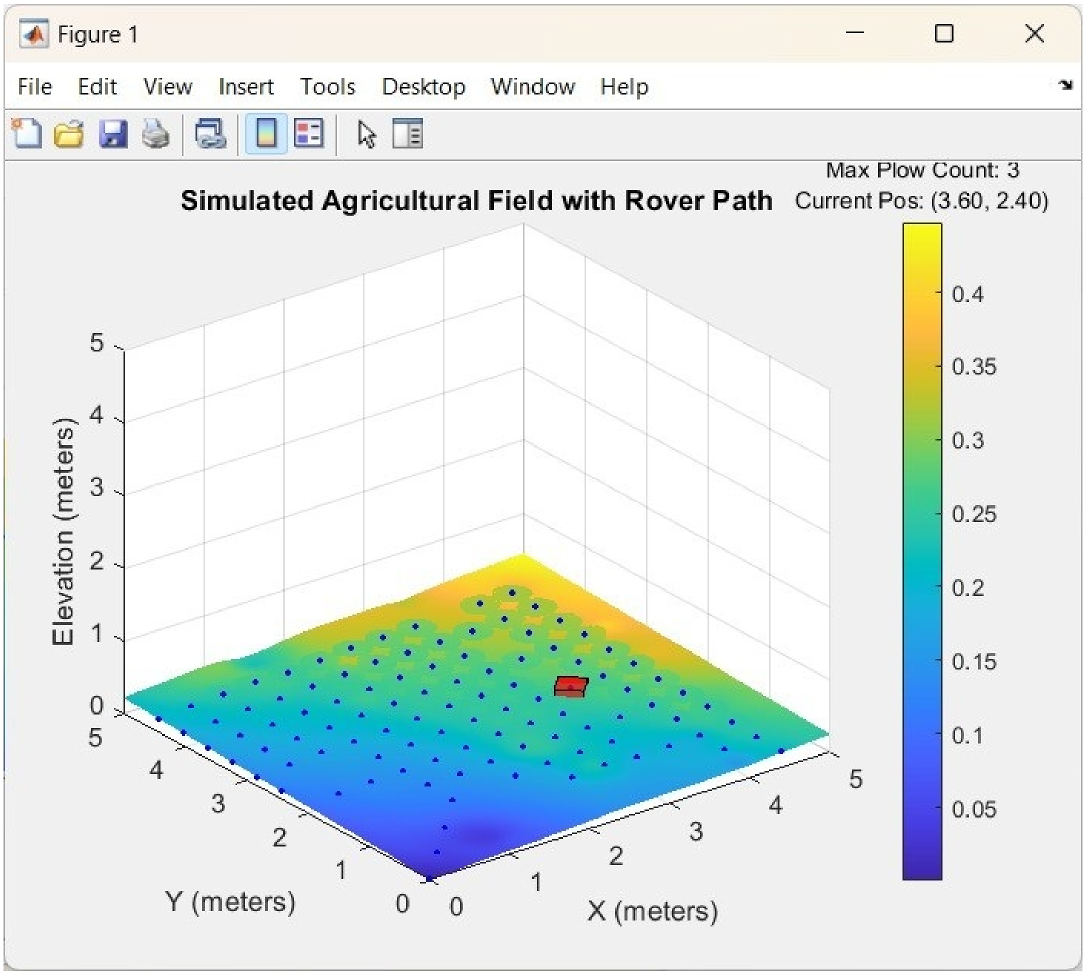


Figure 1
File Edit View Insert Tools Desktop Window Help
Max Plow Count: 3
Current Pos: (3.60, 2.40)
Simulated Agricultural Field with Rover Path
Elevation (meters)
Y (meters)
X (meters)
0 1 2 3 4 5
0.05 0.1 0.15 0.2 0.25 0.3 0.35 0.4

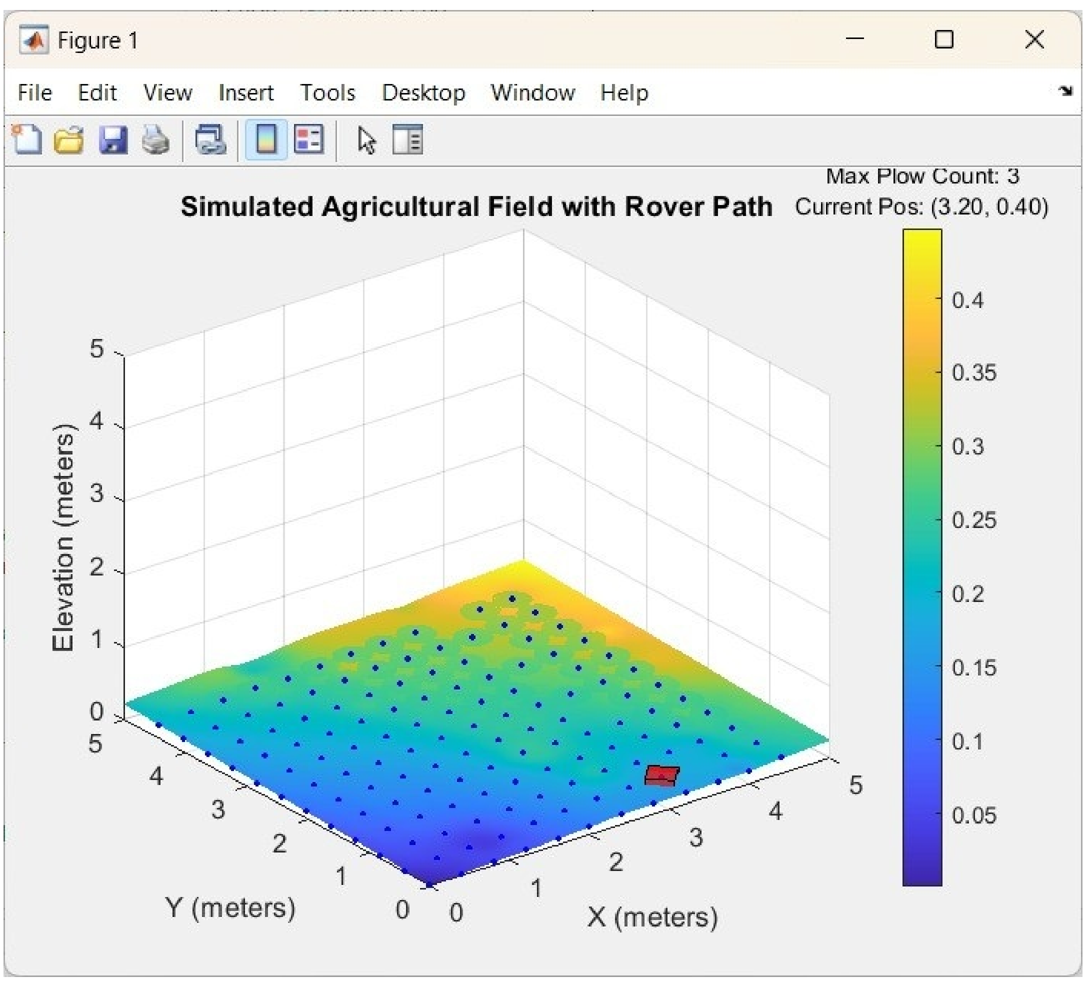


Figure 1
File Edit View Insert Tools Desktop Window Help
Max Plow Count: 3
Current Pos: (3.20, 0.40)
Simulated Agricultural Field with Rover Path
Elevation (meters)
Y (meters)
X (meters)
0 1 2 3 4 5
0.05 0.1 0.15 0.2 0.25 0.3 0.35 0.4

Action Item 3: Realistic Farmland Terrain Simulation and Data Collection System for Agricultural Rover – 3 hour(s).

Project Work Summary

- In this task, we focused on developing a realistic farmland terrain simulation and implementing a data collection system for our agricultural rover in MATLAB.
    - Terrain Generation:
        - Created a 5x5 meter high-resolution grid using meshgrid.
        - Generated a base sinusoidal terrain with varying amplitude and frequency.
        - Added random bumps to increase realism and terrain complexity.
        - Applied Gaussian smoothing for smooth transitions between terrain features.
    - Rover Simulation:
        - Defined rover dimensions and created a 3D model using vertices and faces.
        - Implemented a function to generate the rover's 3D structure.
        - Created a visual representation of the rover using MATLAB's patch function.
    - Path Planning:
        - Developed a row-wise path planning algorithm for the rover.
        - Calculated grid resolution based on the rover's plow radius.
        - Generated separate arrays for x and y coordinates of the path.
        - Interpolated z-coordinates for the path using the terrain data.
    - Data Collection:
        - Implemented a system to collect height data as the rover moves along its path.
        - Created an average height grid to store collected data.
        - Utilized a circular mask to simulate the rover's plow area for data collection.
    - Visualization:
        - Plotted the 3D terrain using MATLAB's surf function.
        - Visualized the planned path and the rover's movement in real-time.
        - Created a dynamic legend to display current rover position and data collection status.
        - Generated a final plot showing the average height grid of collected data.
    - Rover Movement Simulation:
        - Calculated 2D gradients for realistic rover orientation on the terrain.
        - Implemented forward, right, and up vector calculations for rover positioning.
        - Applied rotation and translation to the rover model for accurate visualization.
- This task significantly enhanced our agricultural rover simulation by introducing a more realistic terrain model and implementing a data collection system. These improvements provide a solid foundation for future development of terrain leveling algorithms and more complex path planning strategies.

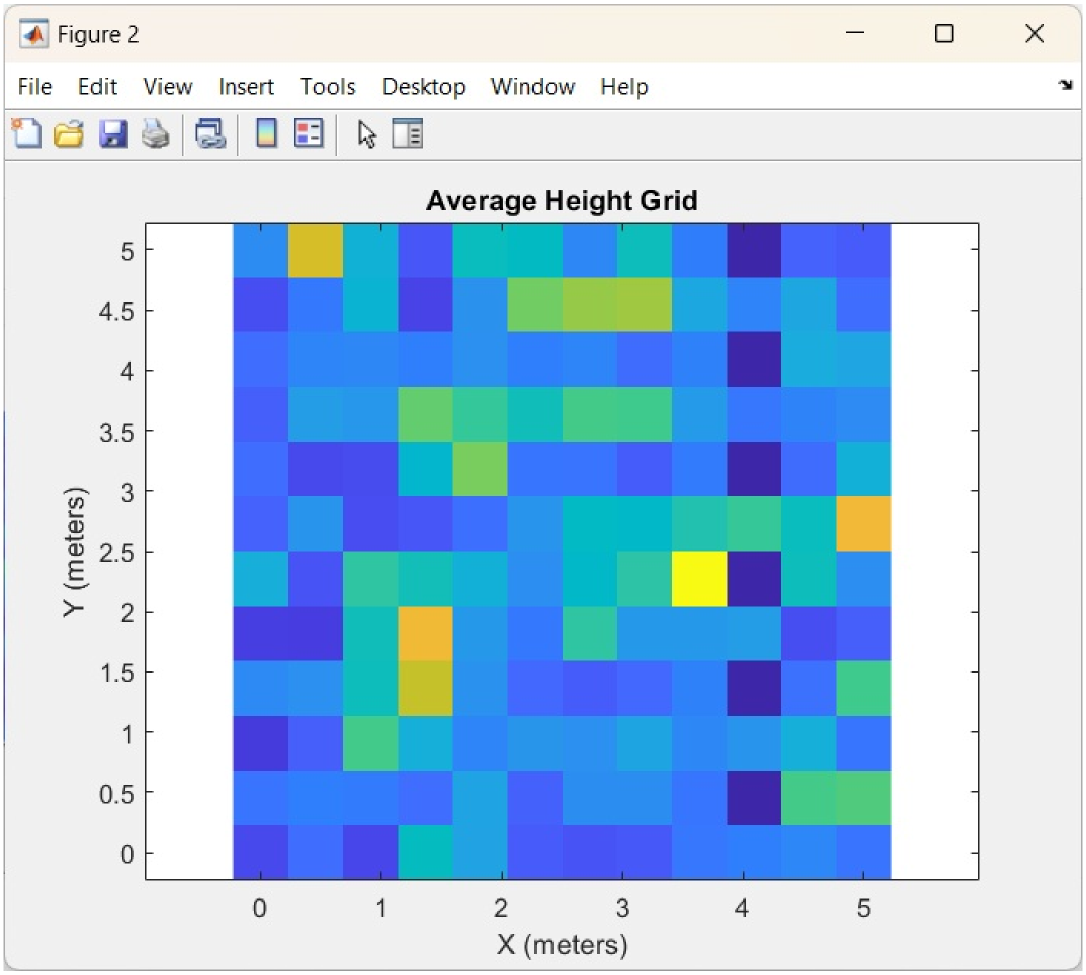


Figure 2
File Edit View Insert Tools Desktop Window Help
Average Height Grid
Y (meters)
X (meters)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5

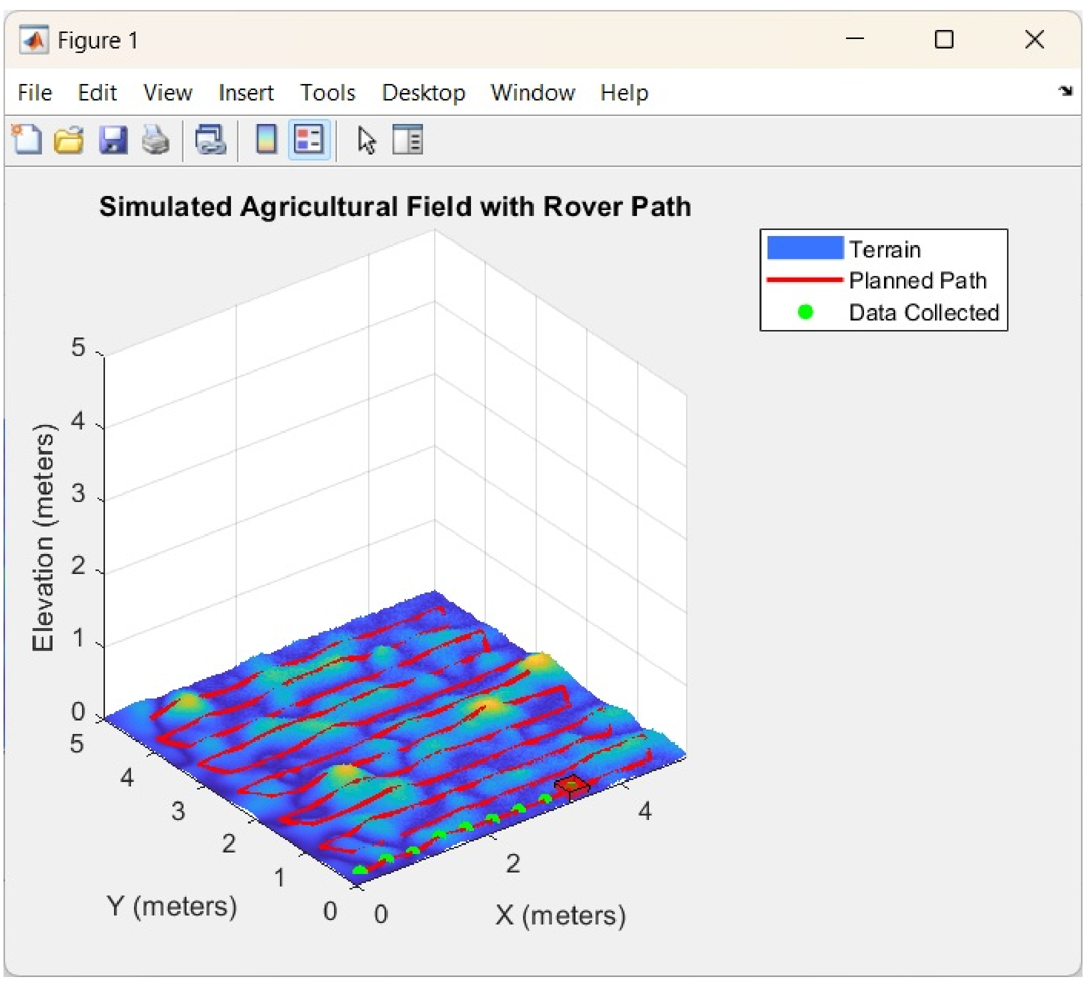
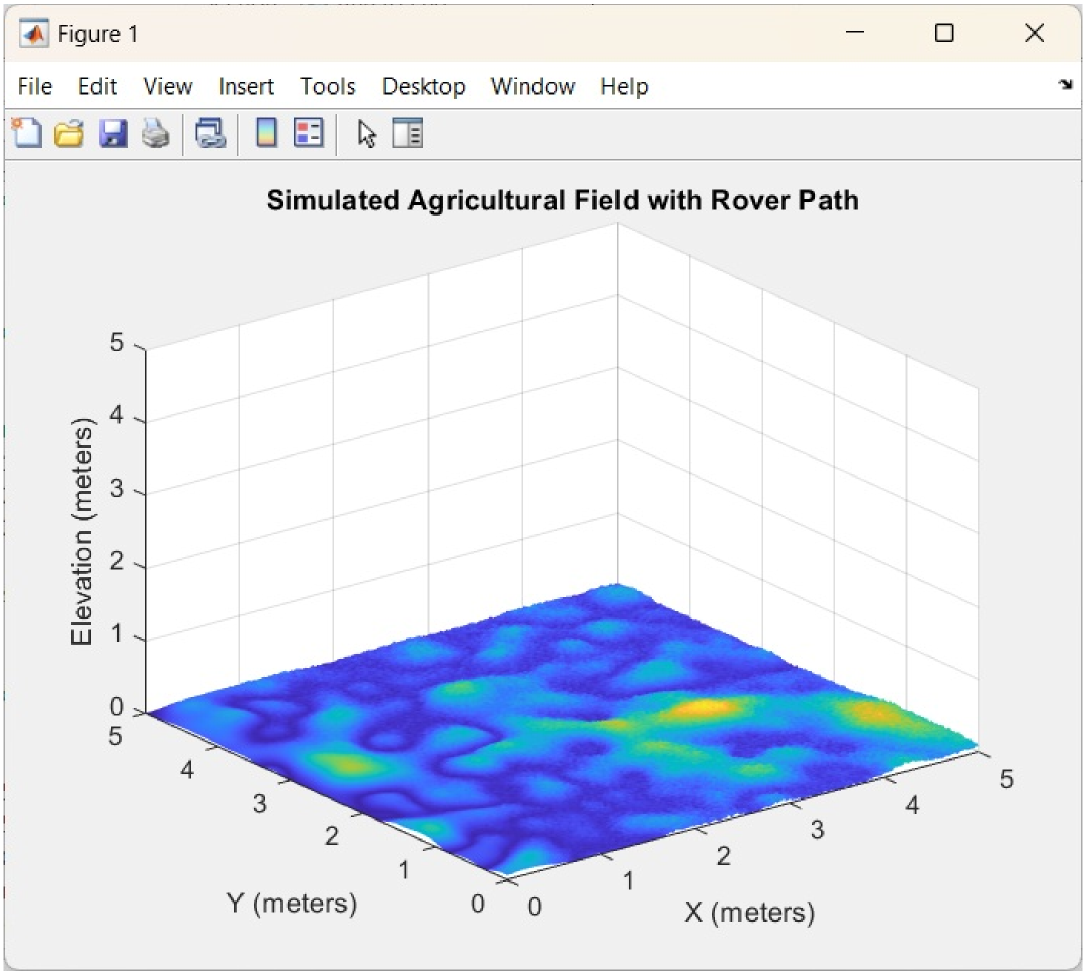


Figure 1
File Edit View Insert Tools Desktop Window Help
Simulated Agricultural Field with Rover Path
Terrain
Planned Path
Data Collected
Elevation (meters)
Y (meters)
X (meters)



Action Item 4: Implementing AStar algorithm to the new map – 3 hour(s).

Project Work Summary

- In this task, we developed and implemented a comprehensive terrain leveling system using A* pathfinding algorithm and grid-based data collection for optimal agricultural field leveling.
- A* Algorithm Implementation
  - Developed a modified A* pathfinding algorithm incorporating height-based cost functions
    - Implemented priority-based cell selection for multiple passes based on terrain elevation
    - Created adaptive visit tracking system ensuring complete field coverage
    - Integrated real-time path adjustment based on terrain characteristics
    - Developed cost functions considering height differences, visit counts, and movement efficiency
  - Rover Simulation Development
    - Created visualization system showing rover movement along optimal paths
    - Implemented dynamic terrain modification based on plowing passes
    - Developed real-time height data collection during rover traversal
    - Added progressive terrain leveling with adjustable reduction factors
    - Integrated visit count tracking for monitoring coverage completeness
  - Grid-Based Data Representation
    - Divided 5x5m field into grid cells based on rover's plowing radius (0.2m)
    - Created height mapping system showing terrain variations from 0.05m to 0.3m
    - Implemented visualization tools showing:
    - Color-coded height grid displaying terrain variations
    - Visit count heatmap indicating coverage frequency
    - Real-time path execution and coverage tracking
    - Generated comprehensive elevation maps for analyzing leveling effectiveness
- The system successfully creates efficient paths ensuring complete field coverage while automatically determining optimal number of passes for different terrain heights, representing a significant improvement over previous fixed-pattern approaches.

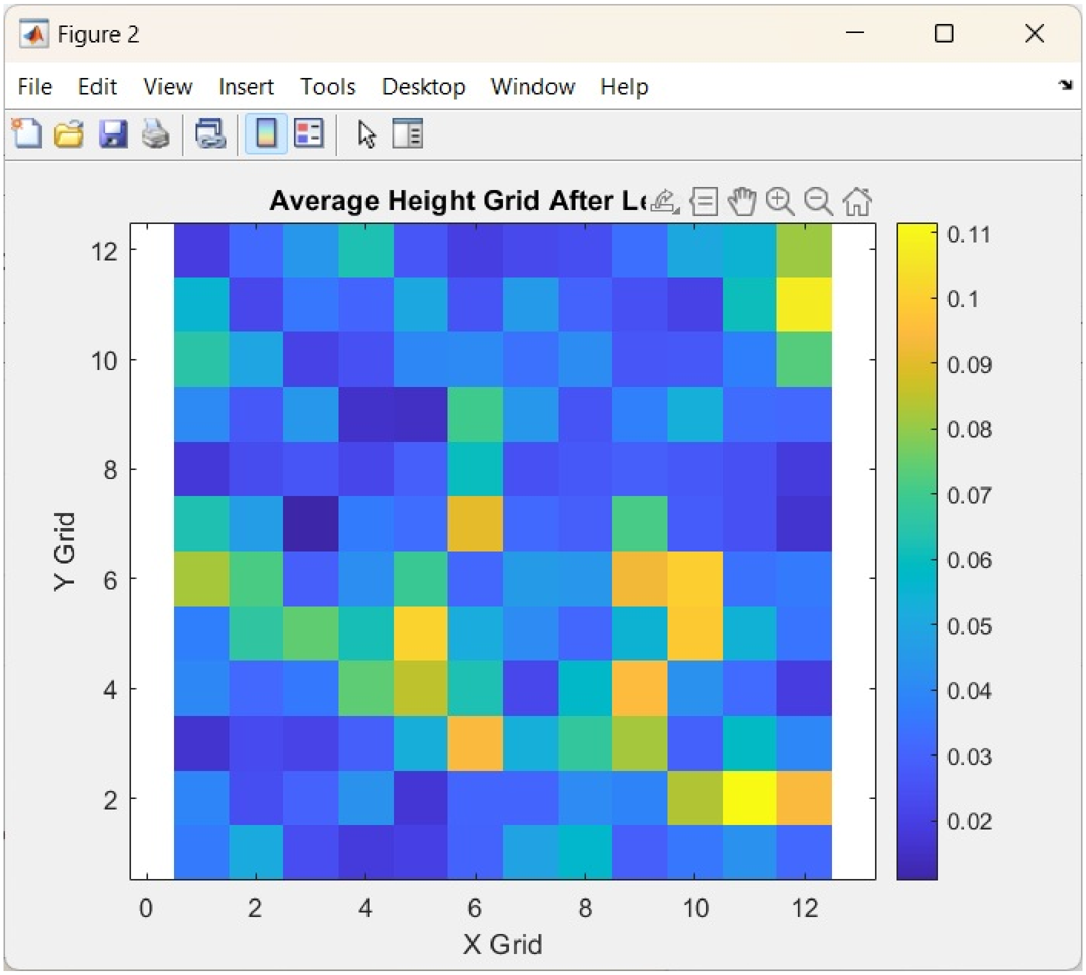
- 

Figure 2
File Edit View Insert Tools Desktop Window Help
Average Height Grid After L
Y Grid
X Grid
0 2 4 6 8 10 12
2 4 6 8 10 12
0.11 0.1 0.09 0.08 0.07 0.06 0.05 0.04 0.03 0.02

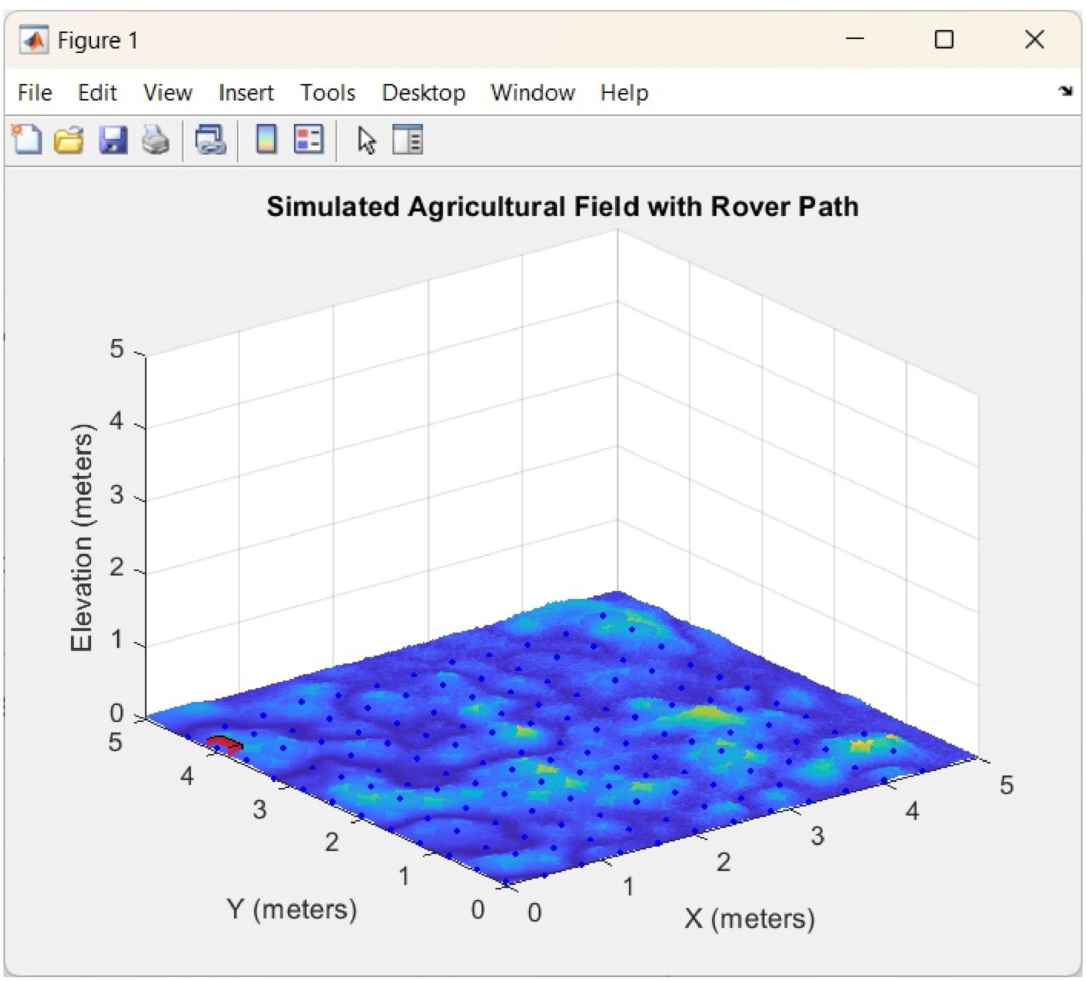
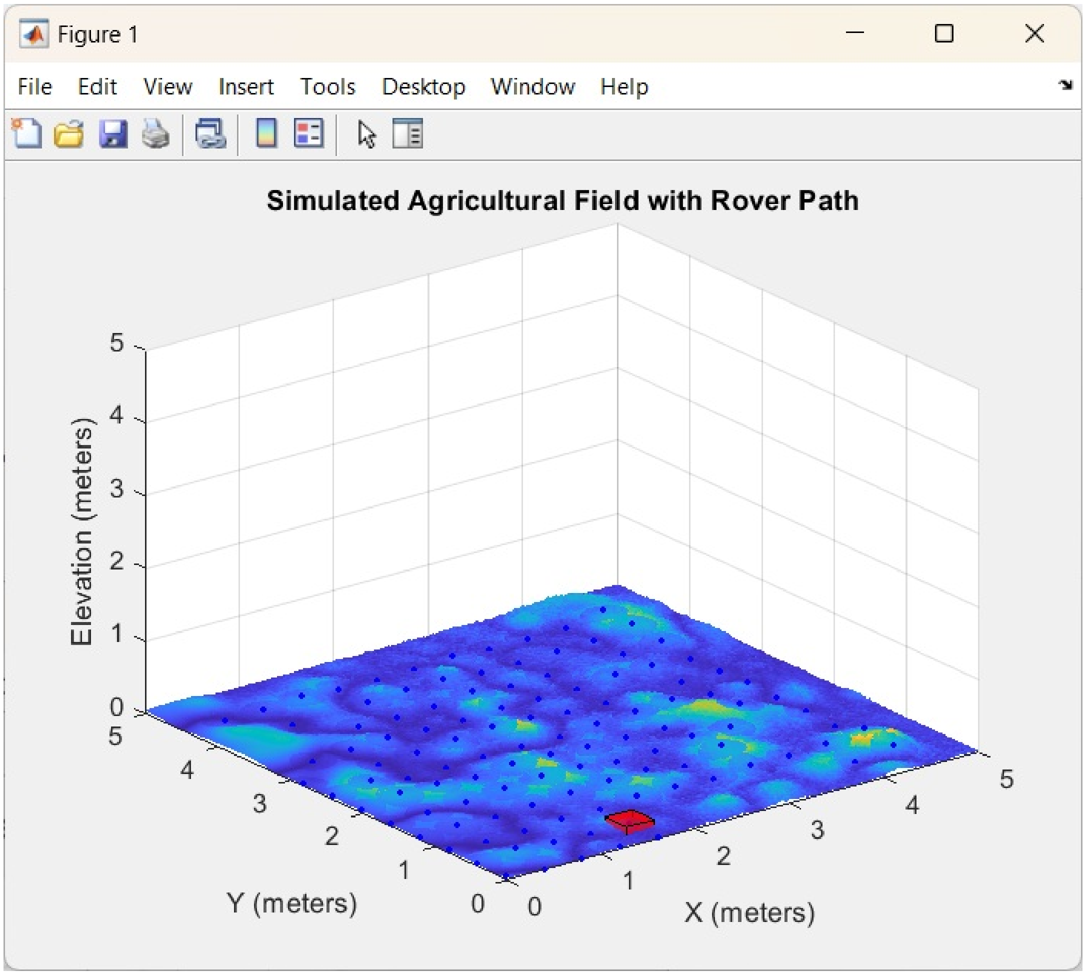
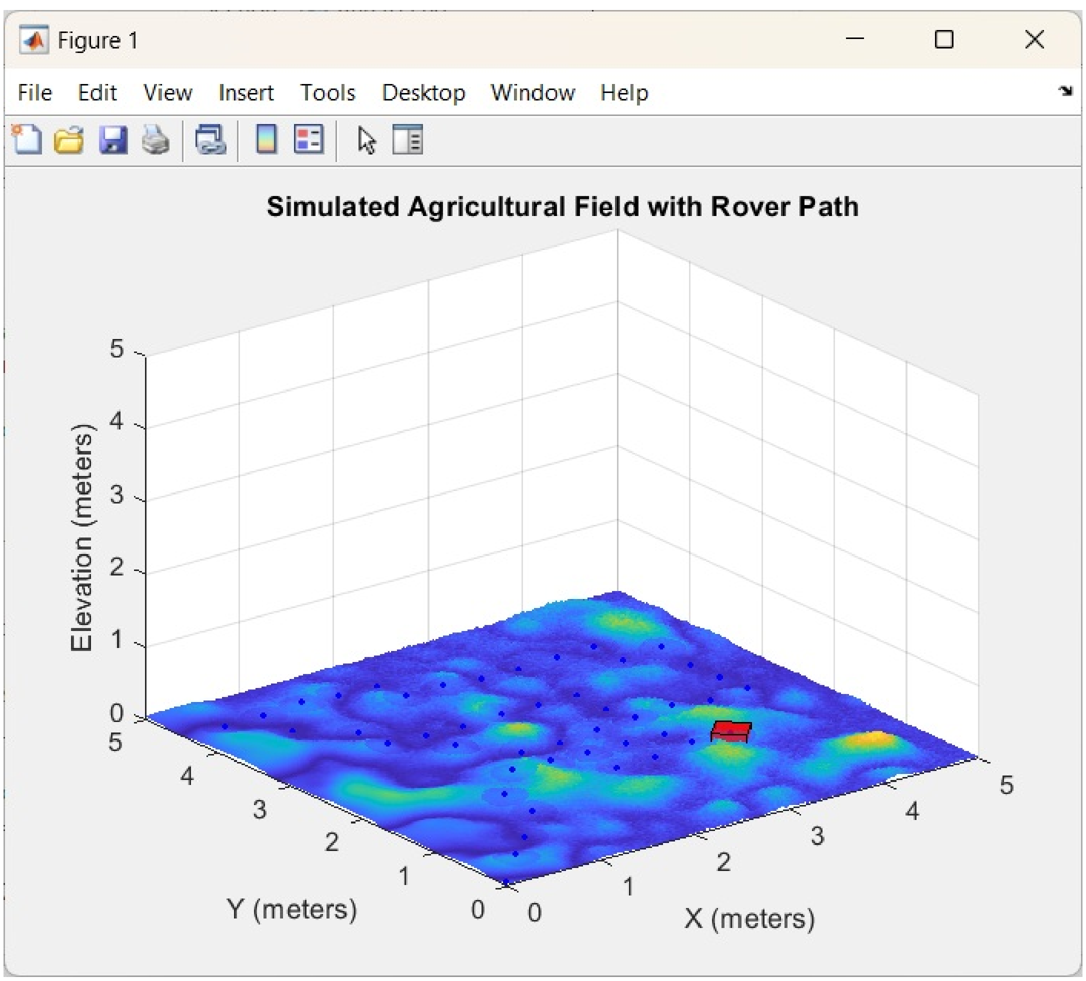
- 

Figure 1
File Edit View Insert Tools Desktop Window Help
Simulated Agricultural Field with Rover Path
Elevation (meters)
0 1 2 3 4 5
Y (meters)
0 1 2 3 4 5
X (meters)
0 1 2 3 4 5

- 
Figure 1
File Edit View Insert Tools Desktop Window Help
Simulated Agricultural Field with Rover Path
Elevation (meters)
Y (meters)
X (meters)
0 1 2 3 4 5

- 
Figure 1
File Edit View Insert Tools Desktop Window Help
Simulated Agricultural Field with Rover Path
Elevation (meters)
Y (meters)
X (meters)
0 1 2 3 4 5

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Action Item 5: Formulating Multi-Pass Grid AStar algorithm – 3 hour(s).

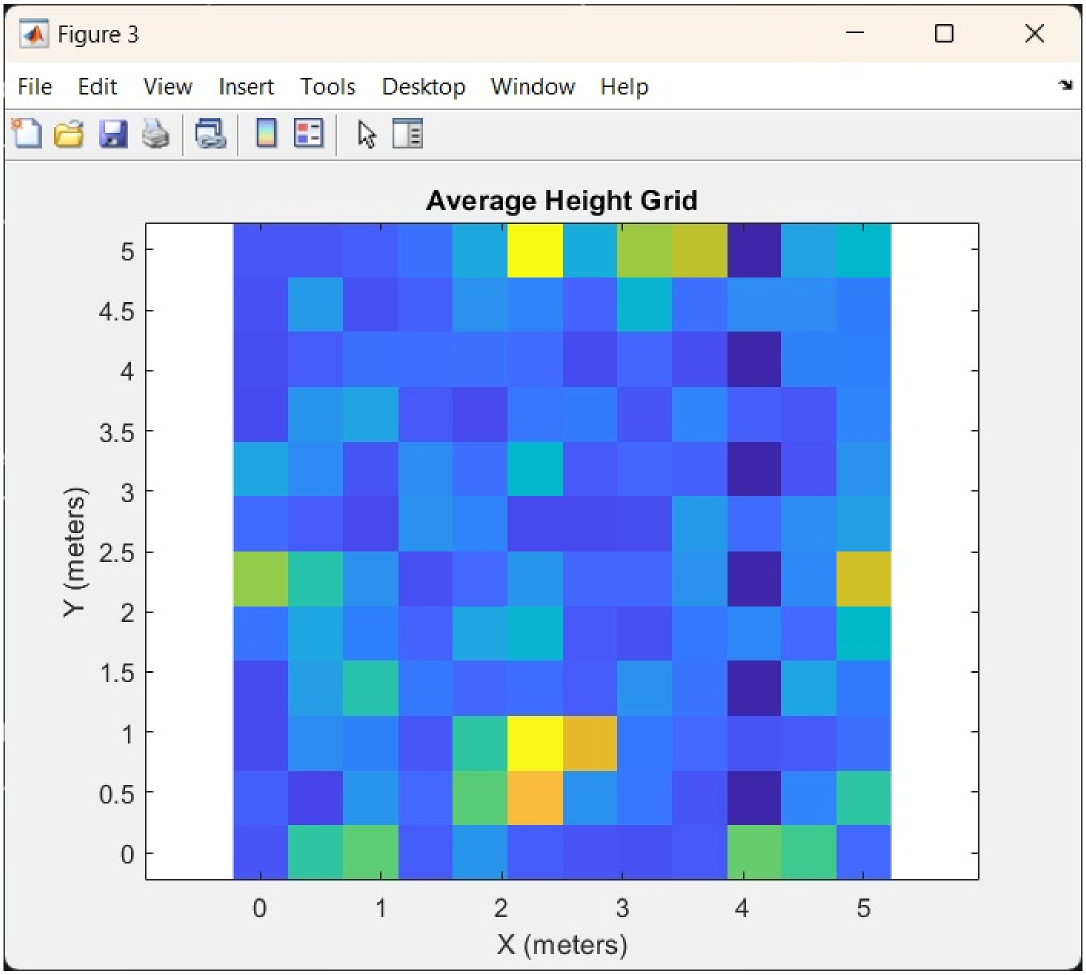
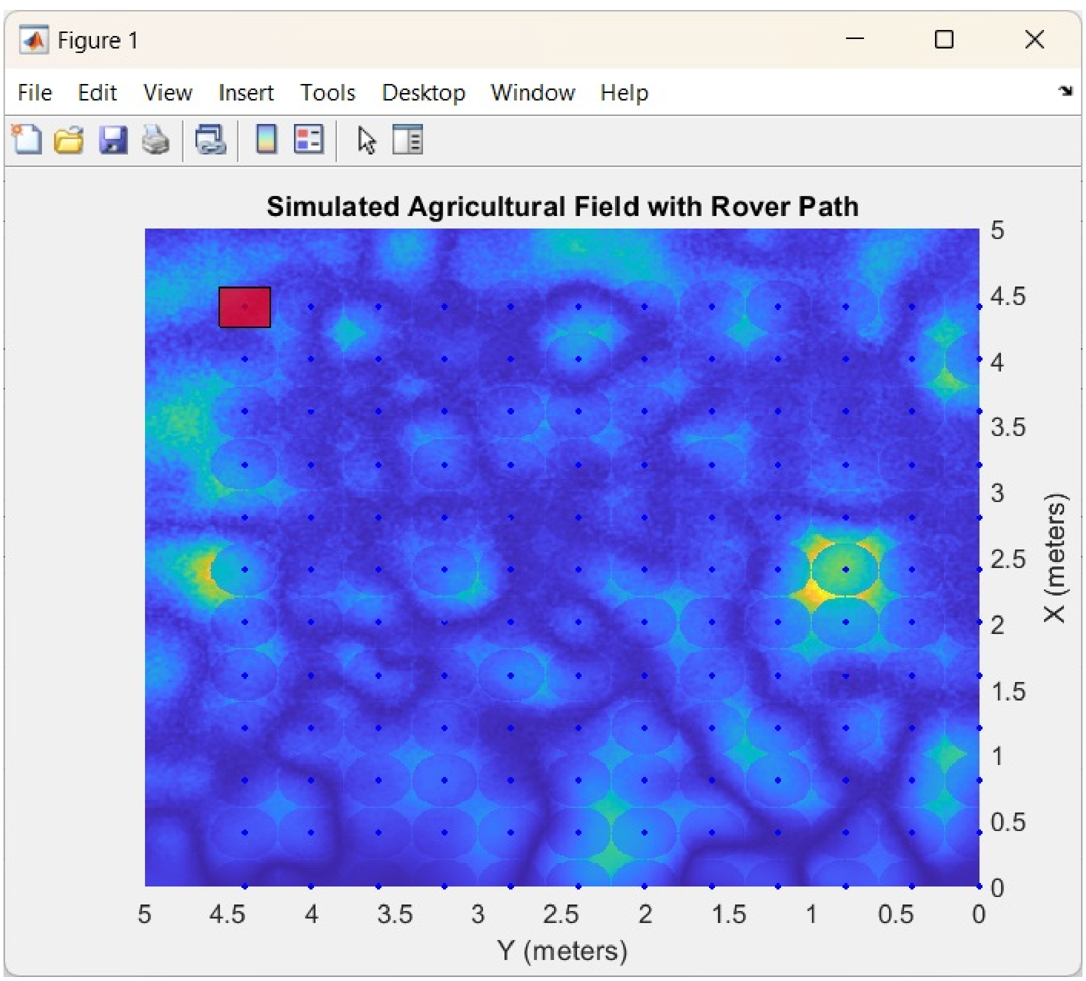
Project Work Summary

- Developed an adaptive height-based path planning system that:
  - Calculates required passes based on height differences from target level
  - Implements priority-based cell selection for multiple passes
  - Ensures complete field coverage through visit count tracking
  - Dynamically updates path planning based on leveling progress
- Created a multi-objective optimization framework that:
  - Balances height differences, visit requirements, and path efficiency
  - Adapts cost functions based on remaining passes needed
  - Implements progressive terrain modification tracking
  - Optimizes coverage patterns for efficient leveling
- Mathematical Formulation
  - State Space:
    - S = {(i,j) | 0 ≤ i,j < N} where N is grid dimension
- Required Passes Calculation:
  - required_passes(i,j) = ceil((height_grid(i,j) - target_height) / leveling_per_pass)
- Cost Function:
  - f(n) = g(n) + h(n) + terrain_cost(n)
  - where:
    - g(n) = path_cost from start to current node
    - h(n) = manhattan_distance to goal
    - terrain_cost(n) = w1*height_diff + w2*visit_penalty + w3*movement_cost
    - height_diff = |current_height - target_height|
    - visit_penalty = visits / (required_passes - visits + 0.1)
    - movement_cost = base_cost + gradient_penalty
- Optimization Goal:
  - minimize Σ(terrain_cost) while ensuring: visit_count(i,j) ≥ required_passes(i,j) ∀ i,j

Action Item 6: Implementing Updated AStar algorithm to the new map – 3 hour(s).

Project Work Summary

- Implemented a priority-based A* pathfinding algorithm that:
  - Calculates required passes for each grid cell based on height differences from target level
  - Dynamically adjusts path planning based on remaining required passes
  - Ensures complete field coverage through visit count tracking
  - Optimizes path selection using Manhattan distance heuristics
- Created an adaptive cost function system that:
  - Combines base movement cost, height differences, and visit penalties
  - Prioritizes cells requiring more passes based on current height
  - Implements distance-weighted penalties to optimize path efficiency
  - Adjusts costs dynamically based on remaining required visits
- Developed comprehensive path planning features including:
  - Priority-based cell selection favoring higher elevation areas
  - 8-directional neighbor exploration for flexible path generation
  - Dynamic path segmentation for efficient coverage
  - Visit count tracking to ensure adequate passes for leveling
- The algorithm successfully generates efficient paths that ensure complete field coverage while automatically determining optimal number of passes for different terrain heights, representing a significant improvement over previous fixed-pattern approaches by reducing overall path length and optimizing leveling effectiveness.

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

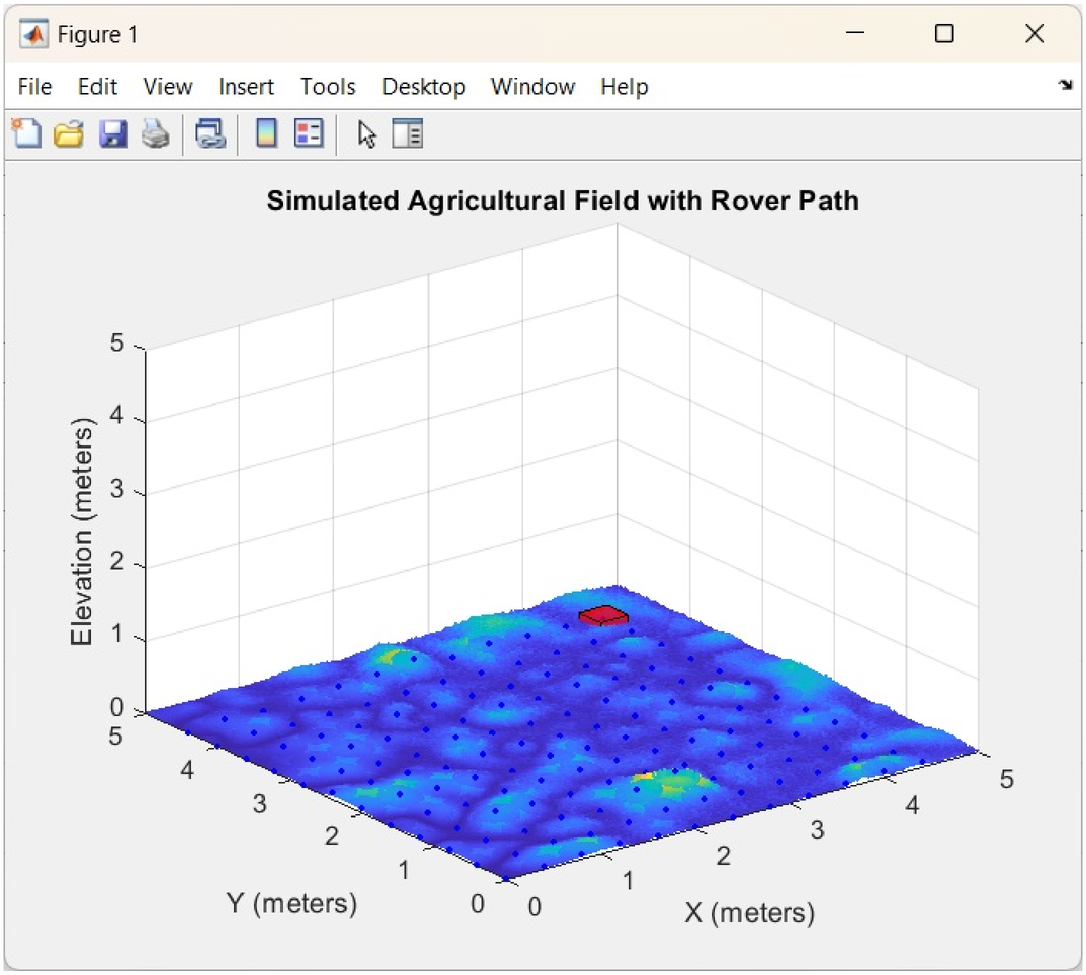
- 

Figure 1
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Simulated Agricultural Field with Rover Path
Elevation (meters)
Y (meters)
X (meters)

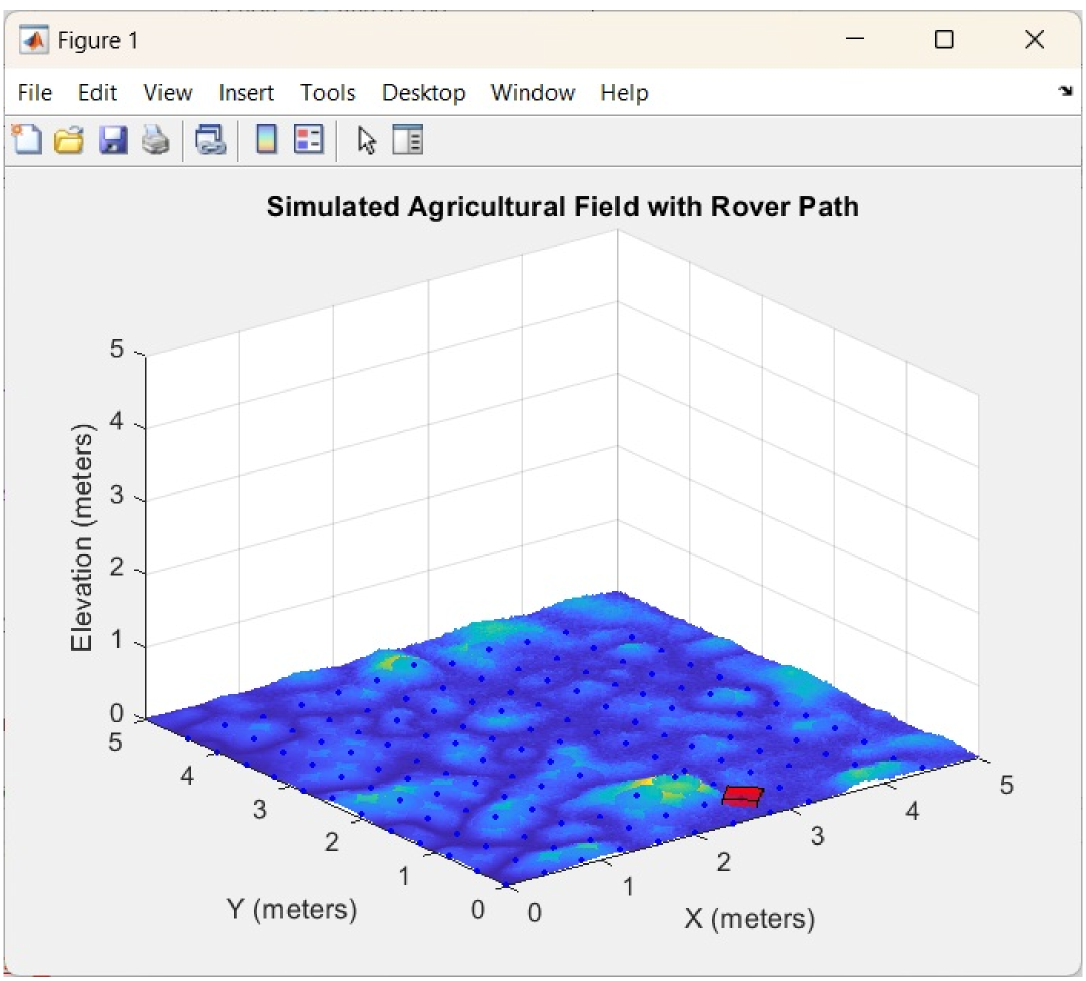
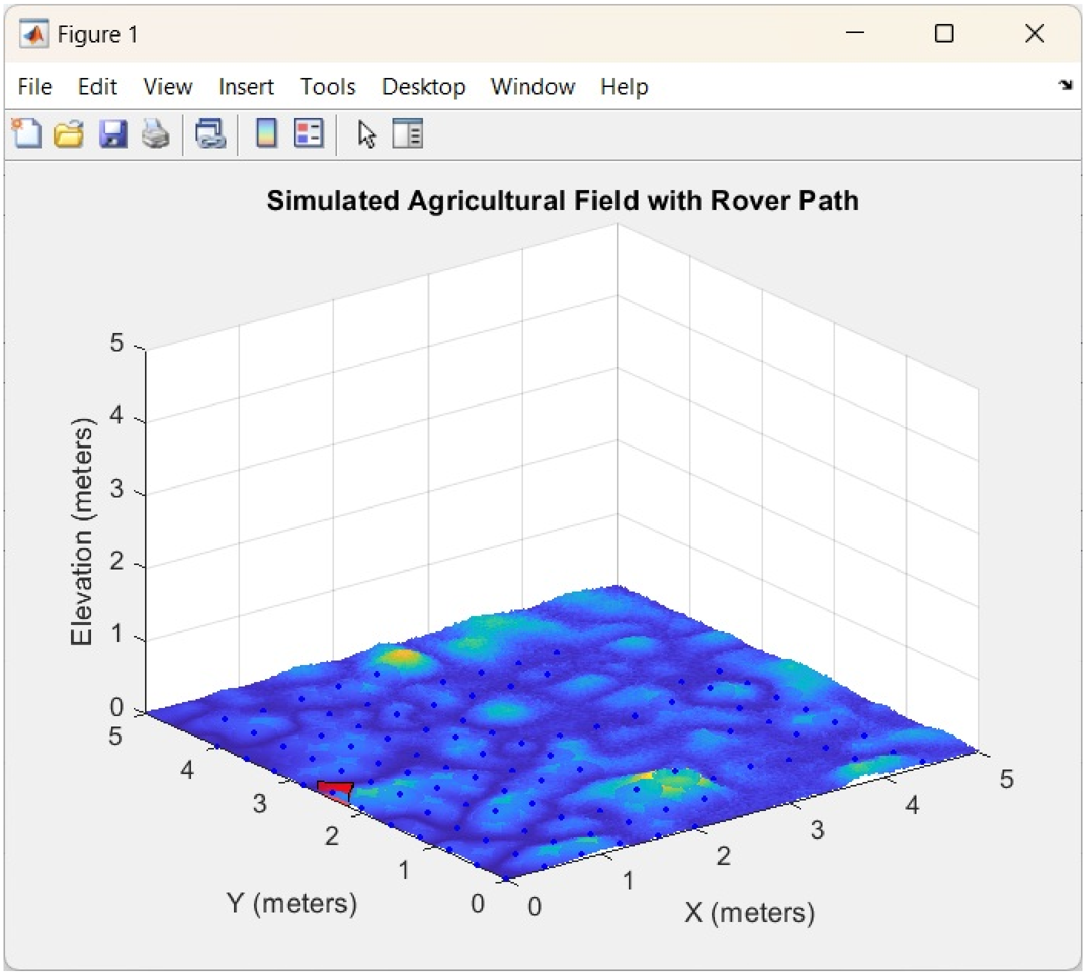
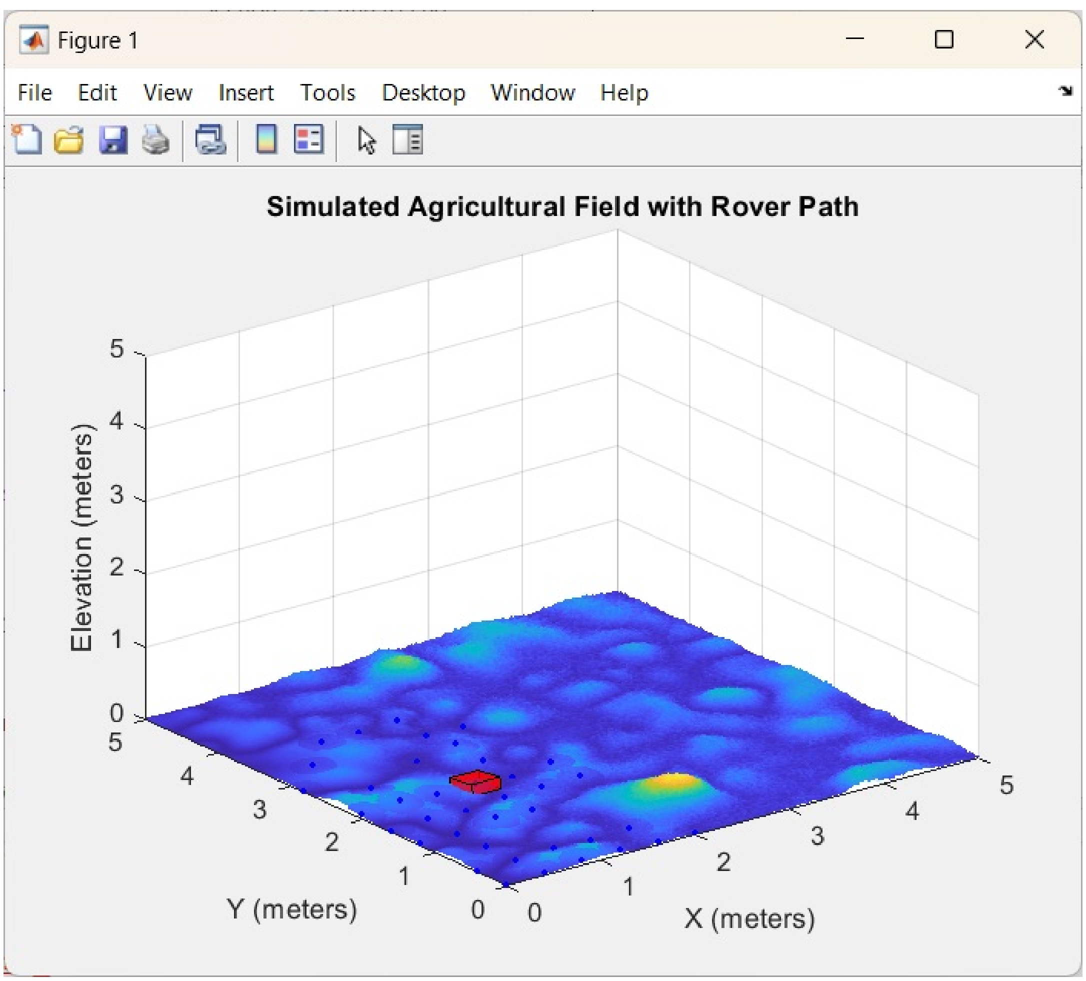
- 

Figure 1
File Edit View Insert Tools Desktop Window Help
Simulated Agricultural Field with Rover Path
Elevation (meters)
Y (meters)
X (meters)

- 
Figure 1
File Edit View Insert Tools Desktop Window Help
Simulated Agricultural Field with Rover Path
Elevation (meters)
Y (meters)
X (meters)
0 1 2 3 4 5

- 
Figure 1
File Edit View Insert Tools Desktop Window Help
Simulated Agricultural Field with Rover Path
Elevation (meters)
Y (meters)
X (meters)
0 1 2 3 4 5

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

Project Work Summary

- Grid Resolution Enhancement
  - Modify grid dimensions to match rover's effective plowing area:
    - Adjust grid size from current 25x25 to 12x12 based on the 5x5m field and 0.2m plow radius
    - Implement proper coordinate transformation between grid indices and actual field coordinates
- Plowing Pattern Optimization
  - Redesign rover's leveling effect simulation:
    - Replace circular plowing area with rectangular or square pattern matching grid cells
    - Implement complete coverage within each grid cell
    - Add overlap between adjacent cells to ensure uniform leveling
- Coverage Verification
  - Develop monitoring system to:
    - Track actual area leveled versus planned coverage
    - Verify leveling effectiveness at grid boundaries
    - Identify any gaps in coverage between grid cells

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.