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	Implementing Spiral Path Planning for Agricultural Rover Simulation	3
2	Implementing and Visualizing Spiral Plowing in MATLAB Simulation	3
3	Rectangular Spiral Path Planning for Agricultural Rover Simulation	3
4	Implementing and Visualizing Rectangular Spiral Plowing	3
5	Trade study of different leveling approaches	3
6	Multi-Pass Terrain Leveling with Agricultural Rover	3
7	Work plan for next week	1
8	Report Writing	1
	Total hours for the week:	20

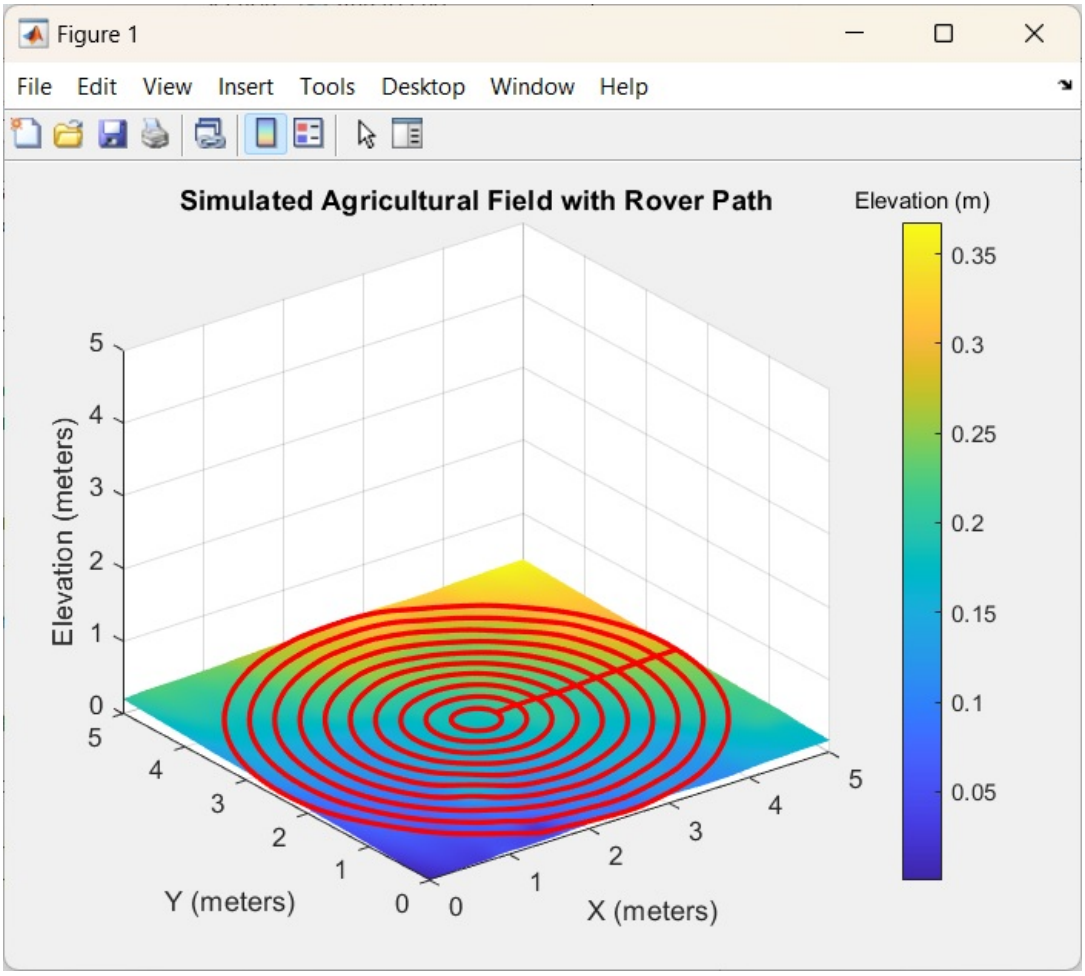
Verification Documentation:

Action Item 1: Implementing Spiral Path Planning for Agricultural Rover Simulation – 3 hour(s).

Project Work Summary

- For the previous week we used a sub optimal method for the leveling of the farm land task. Hence looked for an optimal path planning algorithm.
- Created a spiral path generation function using parametric equations, allowing the rover to cover the entire field in a continuous, inward-moving pattern.
- Utilized MATLAB's linspace function to generate a smooth, high-resolution spiral trajectory with 100 points per revolution.
- Implemented 10 spiral turns to ensure comprehensive coverage of the 5x5 meter simulated field.
- Applied scaling and offset factors to center the spiral path within the predefined field boundaries.

- Generated separate arrays for x and y coordinates of the spiral path, facilitating easy integration with the existing simulation framework.
- Incorporated logic to clip the generated path, ensuring the rover stays within the 5x5 grid boundaries throughout its trajectory.
- Interpolated the z-coordinates for the spiral path using the previously generated terrain data, allowing the rover to follow the contours of the simulated farmland.
- Visualized the planned spiral path using MATLAB's plot3 function, providing a clear representation of the rover's intended movement pattern.



Action Item 2: Implementing and Visualizing Spiral Plowing in MATLAB Simulation – 3 hour(s).

Project Work Summary

- Spiral Path Planning:
  - Implemented a spiral path planning algorithm that generates a continuous inward-moving trajectory, ensuring comprehensive coverage of the field.
  - Calculated path coordinates using parametric equations, adjusting for grid boundaries to keep the rover within the field limits.
- Dynamic Terrain Modification:
  - Introduced a plow_count matrix to track plowing frequency across the field, enabling progressive terrain modification.
  - Developed an algorithm that simulates real-time terrain modification as the rover moves, reducing terrain height towards a target level with each pass.
  - Implemented an exponential decay factor to mimic diminishing plowing effects over repeated passes, enhancing realism.
- Simulation Animation and Visualization:
  - Animated the rover's movement along the spiral path, updating its orientation based on local terrain gradients to simulate realistic navigation over uneven surfaces.
  - Updated the terrain visualization dynamically to reflect changes in elevation due to plowing, providing a visual indicator of plowing progress through colorbar updates.

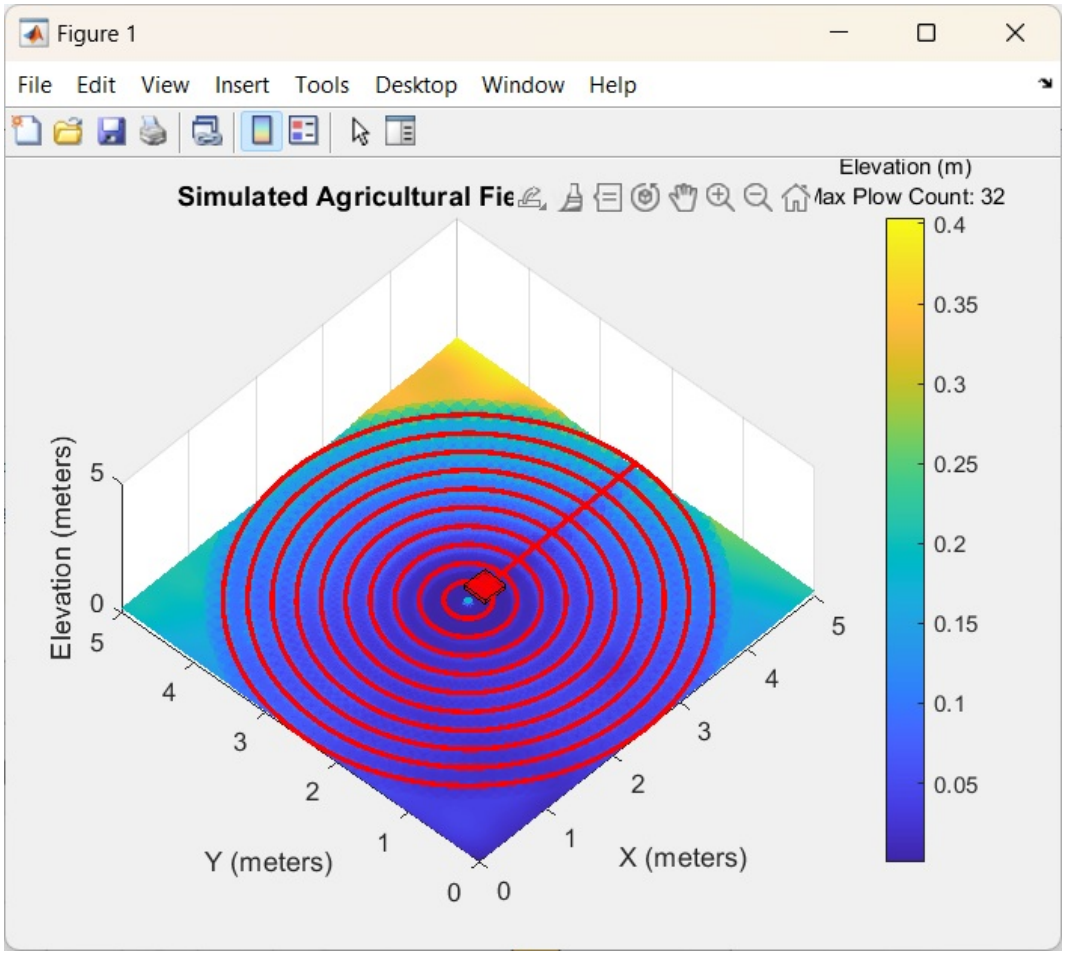


Figure 1
File Edit View Insert Tools Desktop Window Help
Simulated Agricultural Fie
Elevation (m)
Max Plow Count: 32
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
Elevation (meters)
Y (meters)
X (meters)

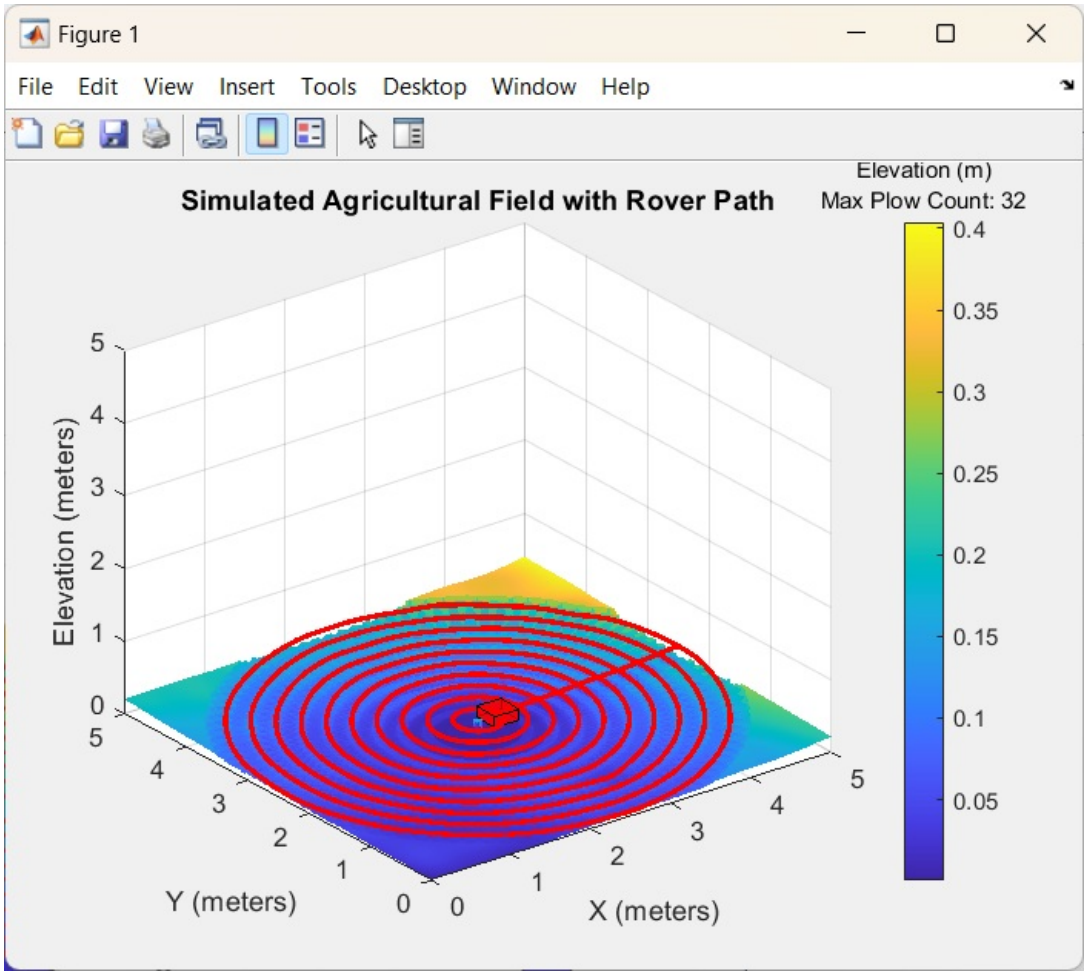


Figure 1
File Edit View Insert Tools Desktop Window Help
Simulated Agricultural Field with Rover Path
Elevation (m)
Max Plow Count: 32
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
Elevation (meters)
Y (meters)
X (meters)

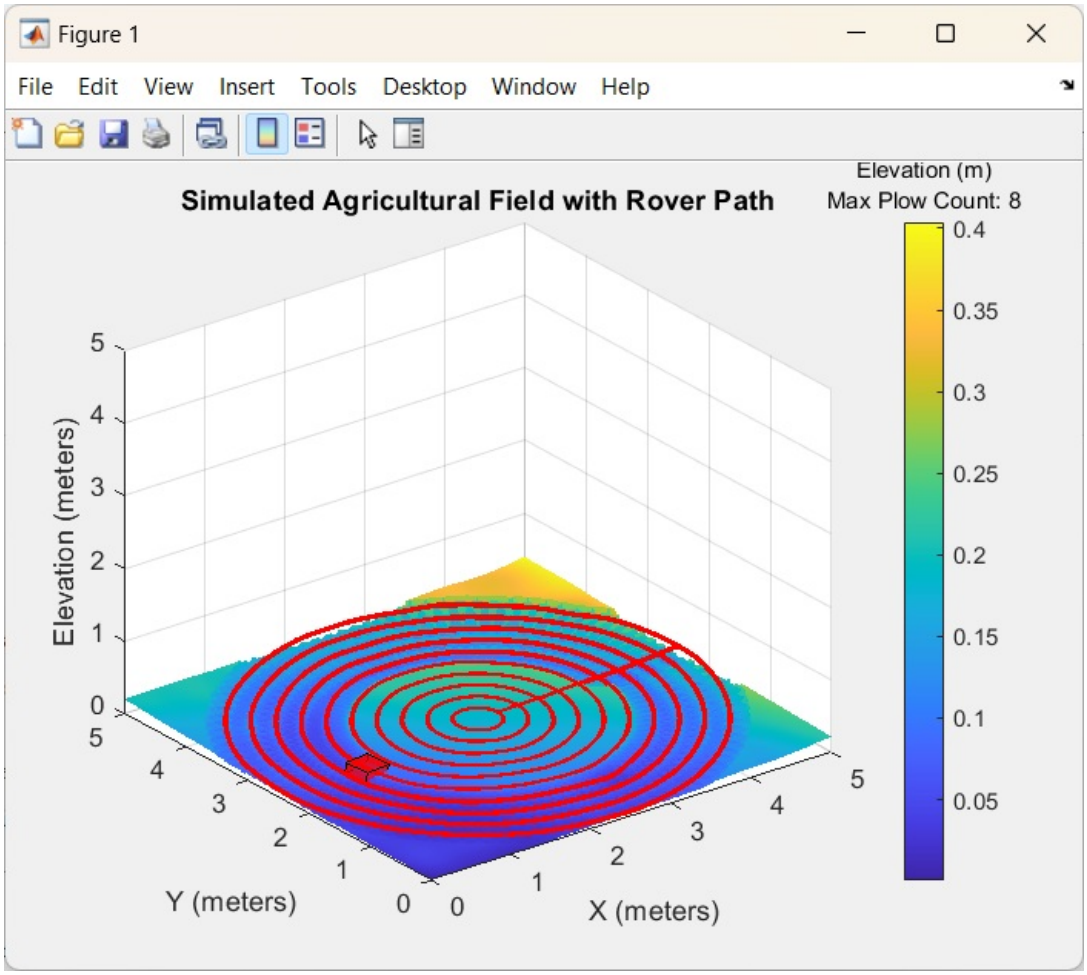


Figure 1
File Edit View Insert Tools Desktop Window Help
Simulated Agricultural Field with Rover Path
Elevation (m)
Max Plow Count: 8
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
Elevation (meters)
0 1 2 3 4 5
Y (meters)
0 1 2 3 4 5
X (meters)
0 1 2 3 4 5

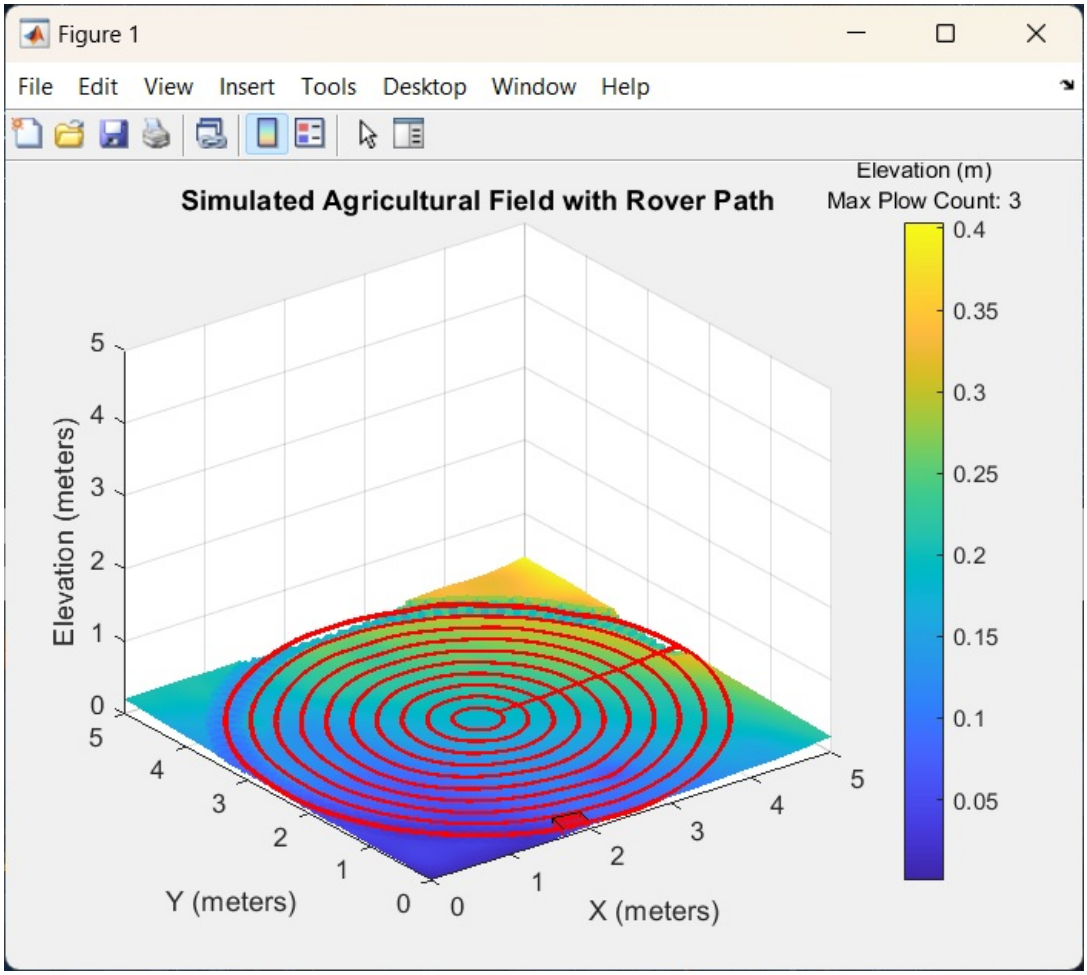


Figure 1
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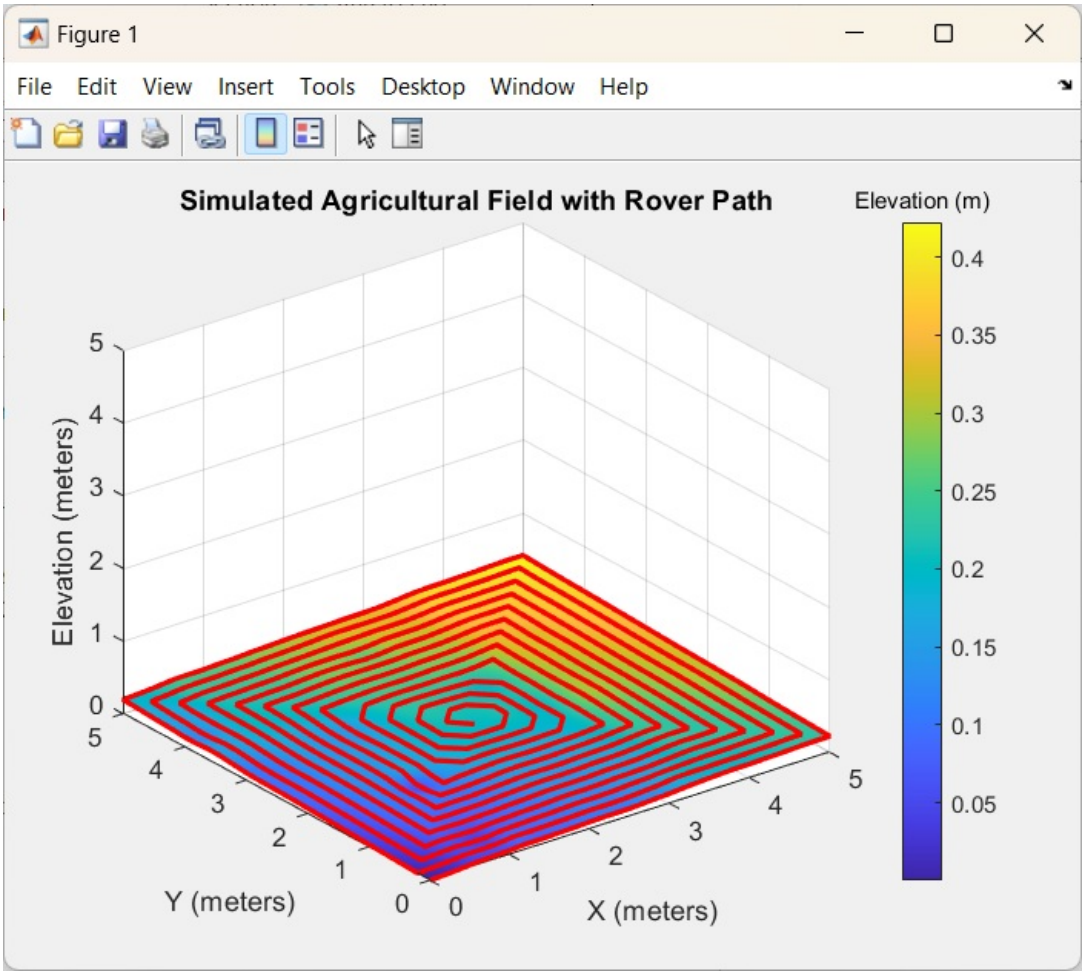
Simulated Agricultural Field with Rover Path
Elevation (m)
Max Plow Count: 3
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
Elevation (meters)
0 1 2 3 4 5
Y (meters)
0 1 2 3 4 5
X (meters)
0 1 2 3 4 5

Action Item 3: Rectangular Spiral Path Planning for Agricultural Rover Simulation – 3 hour(s).

Project Work Summary

- In this task, we focused on developing an efficient rectangular spiral path planning algorithm for our agricultural rover simulation in MATLAB.
- Defined parameters for a 5x5 meter grid and adjustable step size to control path density.
- Implemented a rectangular spiral generation algorithm that creates concentric rectangles moving inward from the field edges to the center.
- Utilized dynamic boundary management to progressively reduce the size of each rectangular loop.
- Generated separate arrays for x and y coordinates of the path, facilitating integration with the existing simulation framework.
- Incorporated logic to ensure the path stays within the defined field boundaries throughout its trajectory.
- Interpolated z-coordinates for the path using the previously generated terrain data, allowing the rover to follow the contours of the simulated farmland.



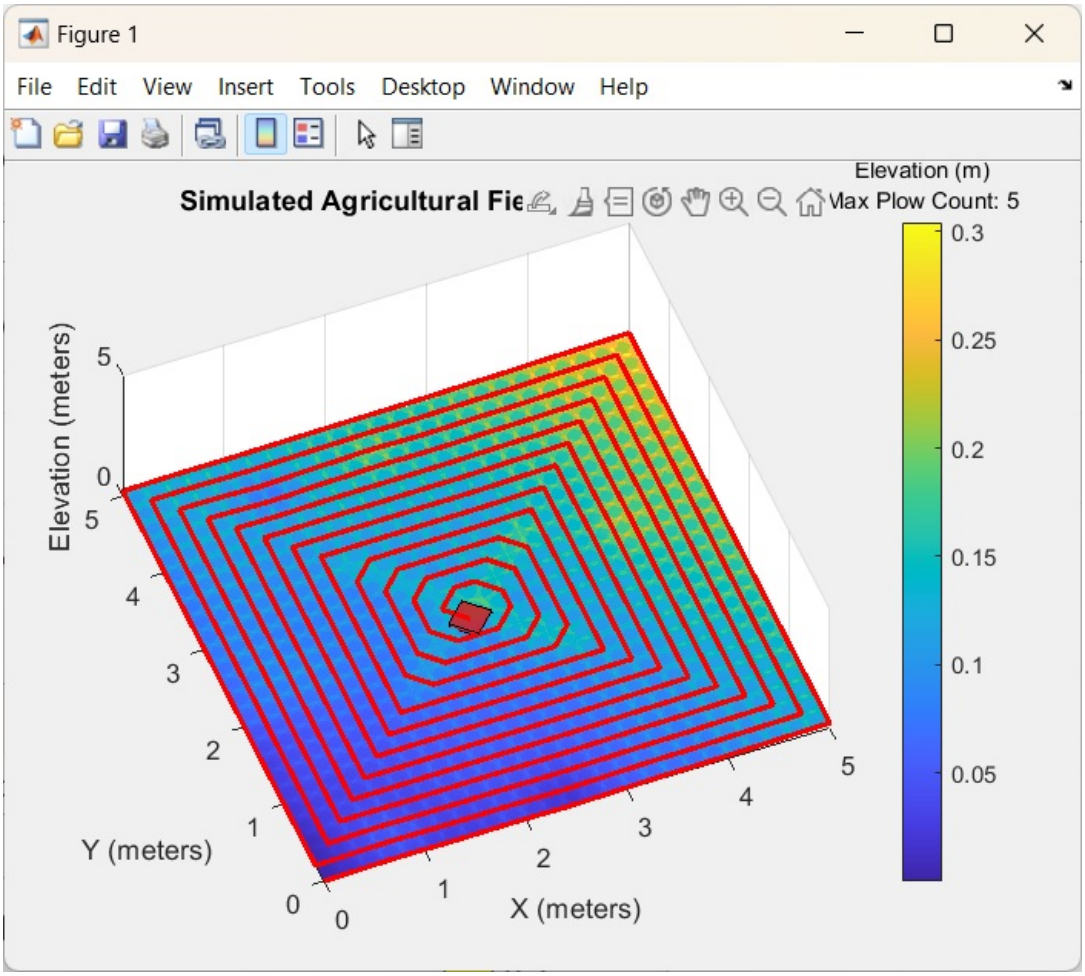
Action Item 4: Implementing and Visualizing Rectangular Spiral Plowing – 3 hour(s).

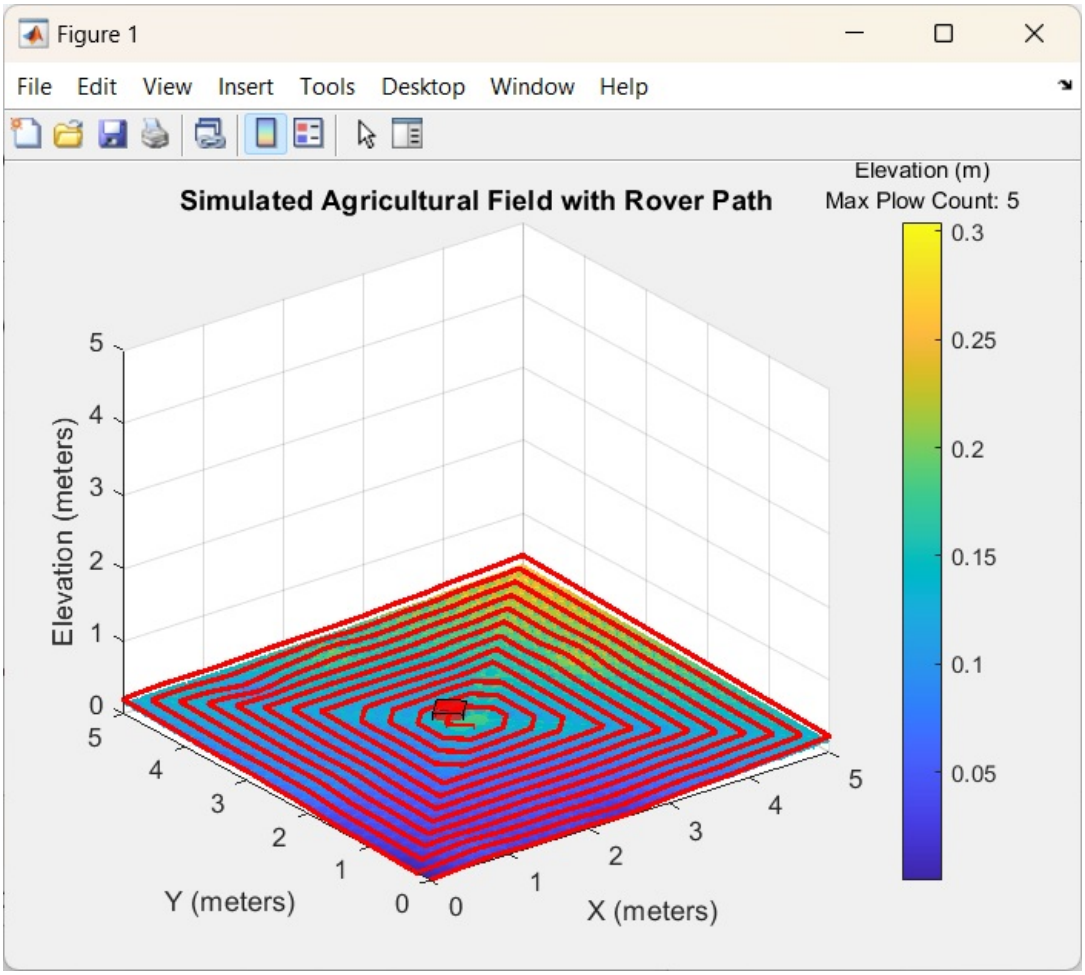
Project Work Summary

- Updated the rover animation to follow the new rectangular spiral path, adjusting its orientation based on local terrain gradients.
- Enhanced the terrain modification visualization to reflect real-time changes as the rover moves along the rectangular spiral.
- Implemented dynamic updating of the terrain surface plot to show progressive field flattening during plowing.
- Updated the colorbar to display the maximum plow count across the field, providing a visual indicator of

plowing progress.

- Integrated the new path visualization with existing terrain modeling and rover movement systems for a comprehensive simulation.
- Ensured smooth transitions between straight segments and corners of the rectangular spiral path in the animation.
- It is interesting to note how the colour map scale changed from 0.4 to 0.35 and eventually 0.3, suggesting that the rover is leveling the surface properly.



- 
Figure 1
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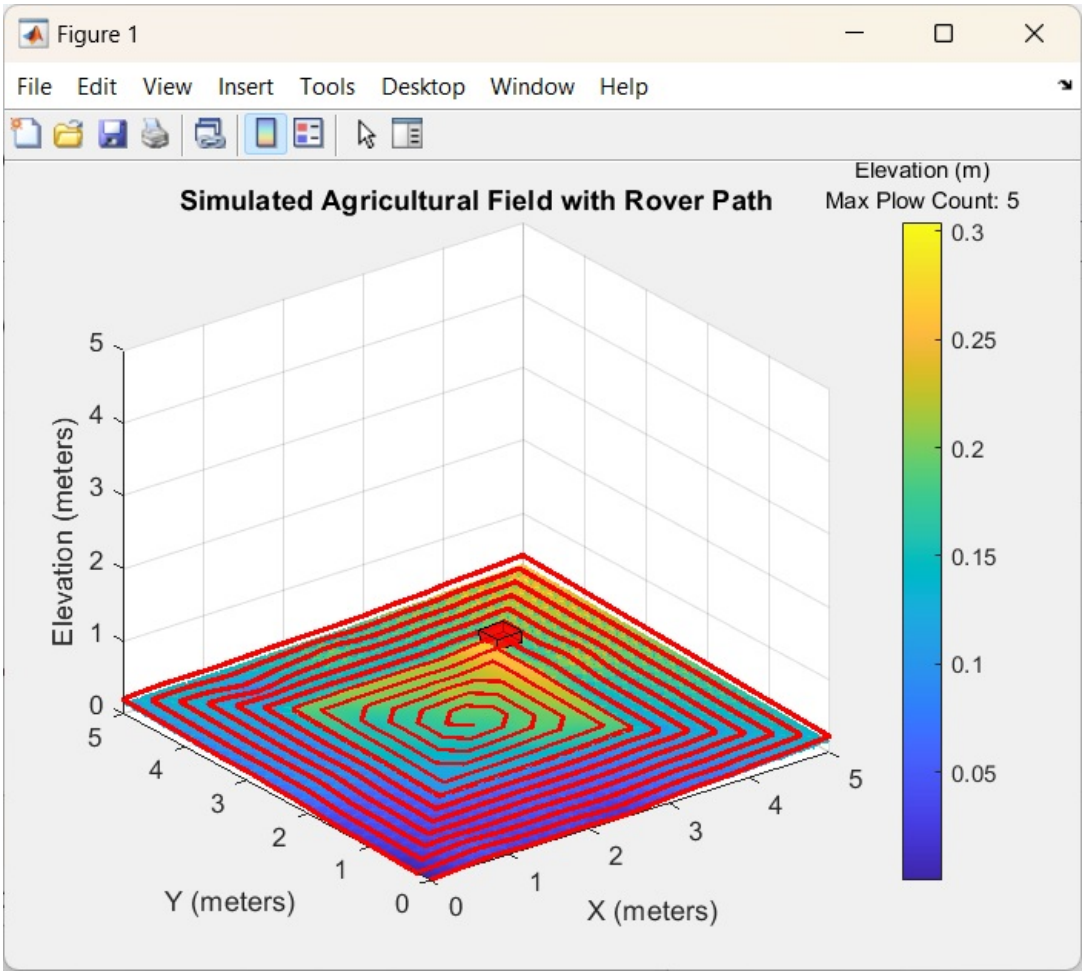
Simulated Agricultural Field with Rover Path
Elevation (m)
Max Plow Count: 5
0.3
0.25
0.2
0.15
0.1
0.05
Elevation (meters)
Y (meters)
X (meters)
- 
Figure 1
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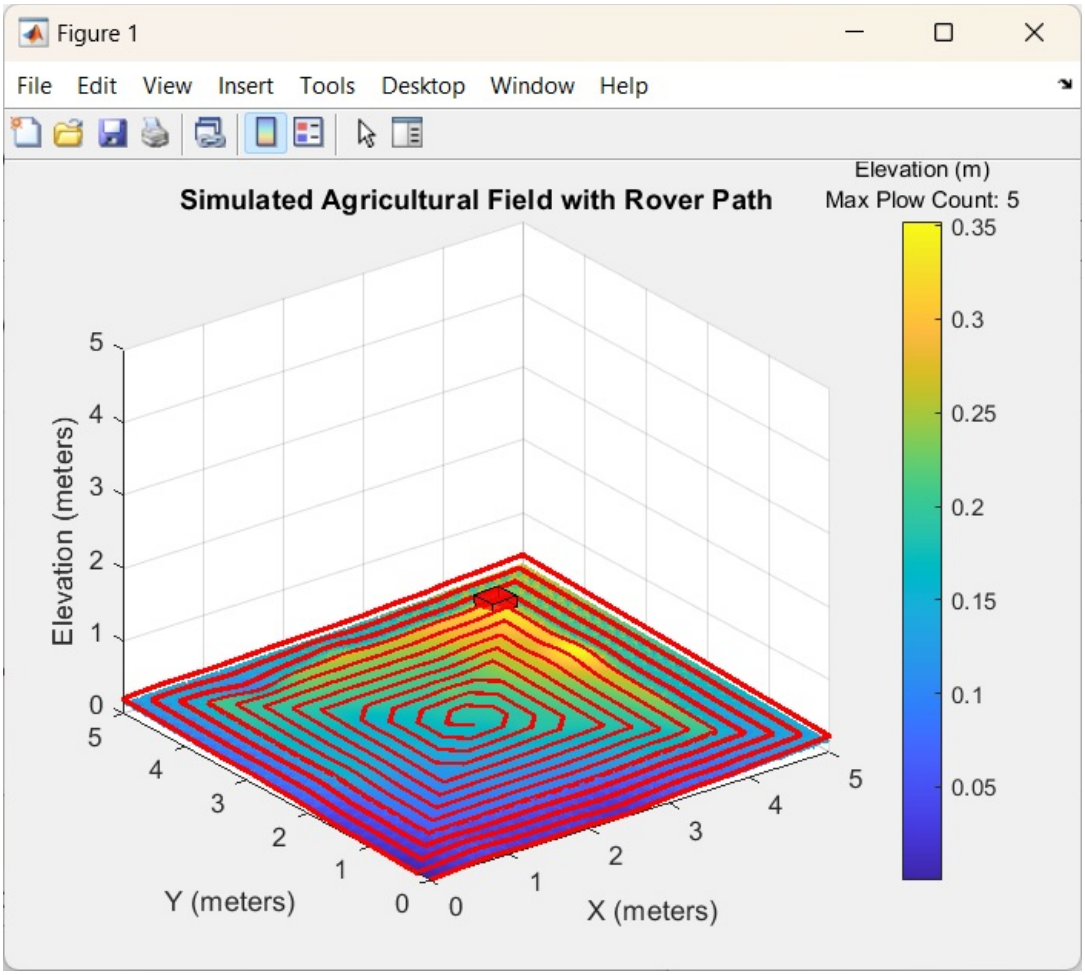
Simulated Agricultural Field with Rover Path
Elevation (m)
Max Plow Count: 5
0.3
0.25
0.2
0.15
0.1
0.05
Elevation (meters)
Y (meters)
X (meters)

- 
Figure 1
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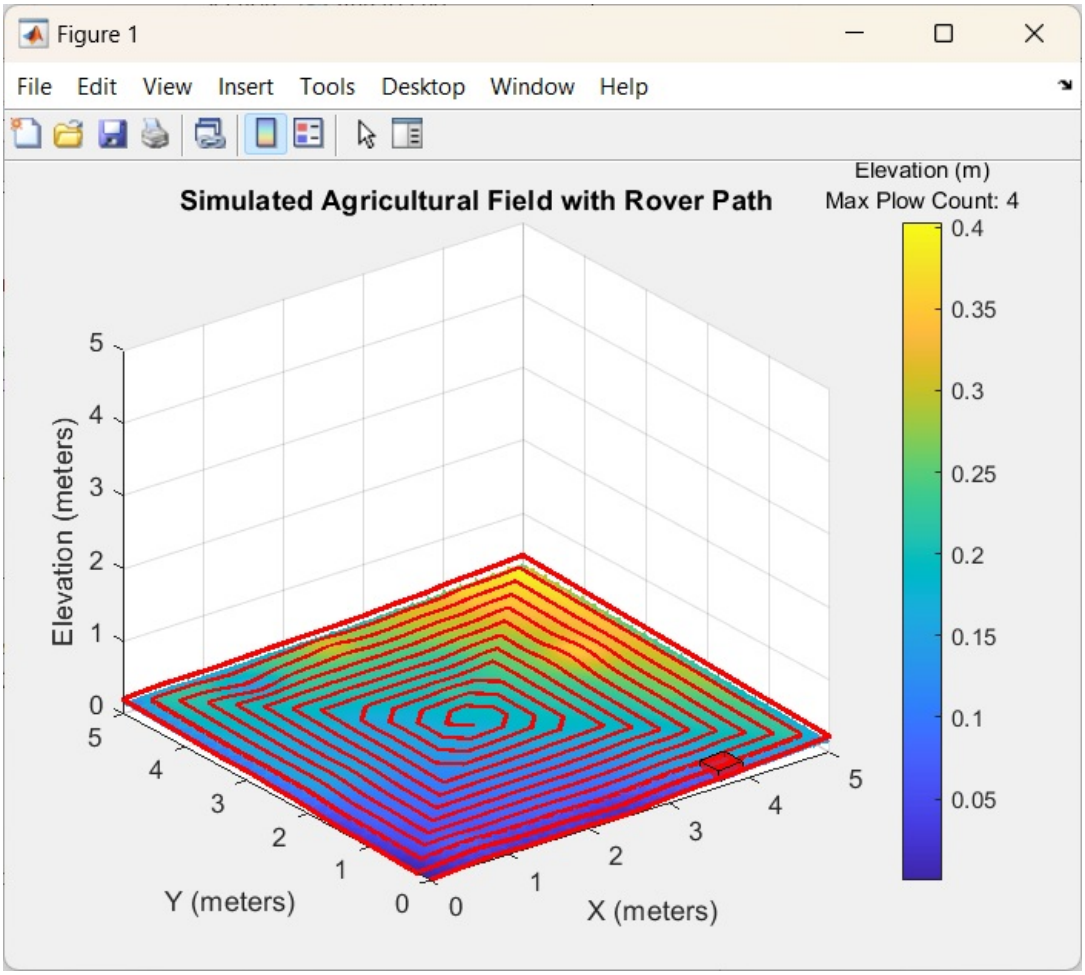
Simulated Agricultural Field with Rover Path
Elevation (m)
Max Plow Count: 5
0.35
0.3
0.25
0.2
0.15
0.1
0.05
Elevation (meters)
Y (meters)
X (meters)
- 
Figure 1
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Simulated Agricultural Field with Rover Path
Elevation (m)
Max Plow Count: 4
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
Elevation (meters)
Y (meters)
X (meters)

-

Action Item 5: Trade study of different leveling approaches – 3 hour(s).

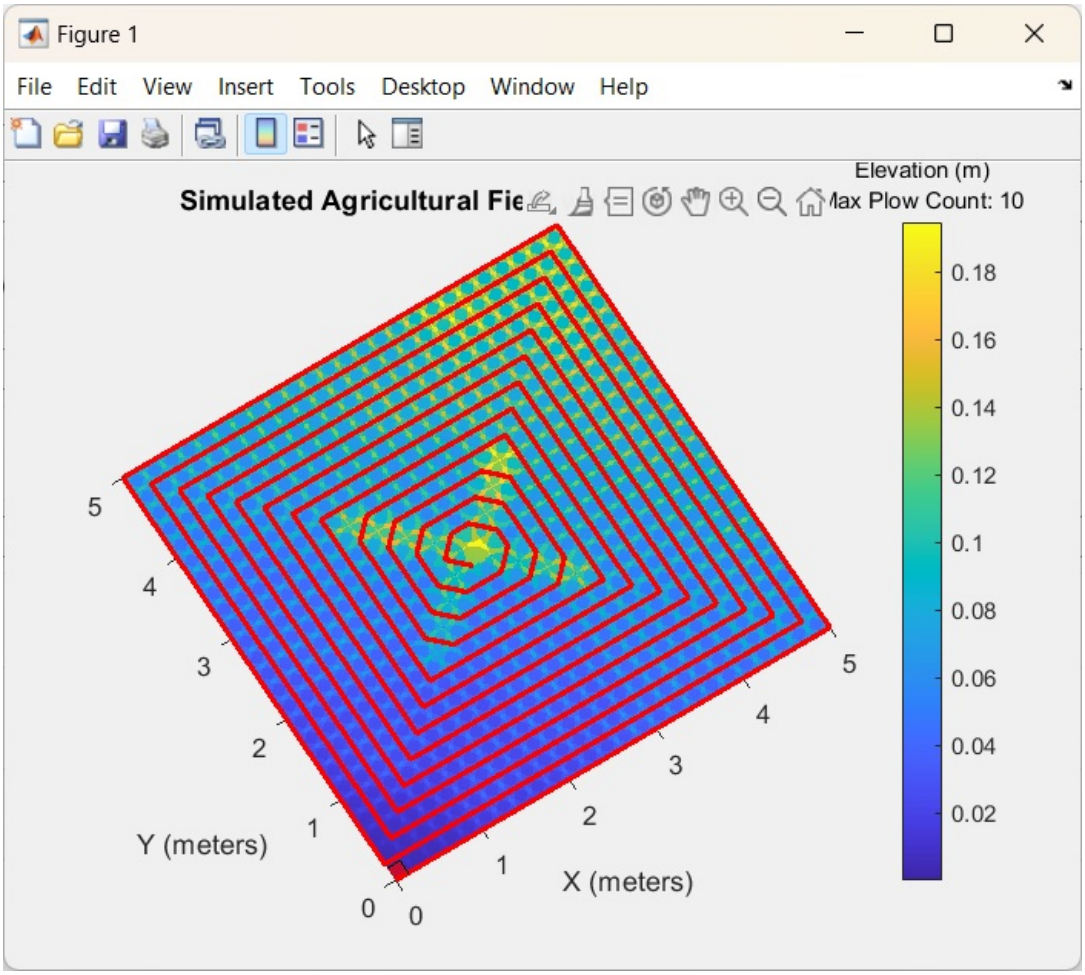
Project Work Summary

- Pattern Characteristics Analysis
  - Documented the geometric differences between approaches:
    - Rectangular: Sharp 90-degree turns with uniform parallel lines
    - Circular: Smooth continuous curves with varying path density
- Field Coverage Evaluation
  - Examined edge and corner treatment effectiveness
  - Analyzed path overlap patterns and field utilization
  - Studied terrain modification uniformity
- Implementation Considerations
  - Compared path planning complexity between approaches
  - Assessed computational requirements for path generation
  - Evaluated control system demands for each pattern
- This comparative analysis provides valuable insights for optimizing agricultural rover operations, highlighting the tradeoffs between implementation simplicity, coverage efficiency, and operational effectiveness of different plowing patterns.
- I have also attached the Link for the trade study between these two approaches of leveling the farm land.

Action Item 6: Multi-Pass Terrain Leveling with Agricultural Rover – 3 hour(s).

Project Work Summary

- Path Planning Enhancement
  - Developed a bi-directional rectangular spiral algorithm
  - Implemented path reversal functionality for double coverage
  - Maintained precise tracking of rover position from perimeter to center and back
- Terrain Modification System
  - Enhanced the plowing mechanism to support multiple passes over the same path
  - Implemented progressive terrain leveling with each pass
  - Tracked cumulative plowing effect through plow count matrix
- Visualization Improvements
  - Updated real-time visualization to show incremental terrain changes
  - Enhanced color mapping to reflect multiple plowing passes
  - Implemented dynamic elevation tracking across repeated coverage
- Performance Optimization
  - Calibrated plowing depth for optimal terrain leveling
  - Adjusted rover speed for consistent soil manipulation
  - Fine-tuned the step size for precise path following
- It is also note worthy that now the z axis maximum perturbations is near 0.18, which is half of what we got when single pass leveling was done.

- 
Figure 1
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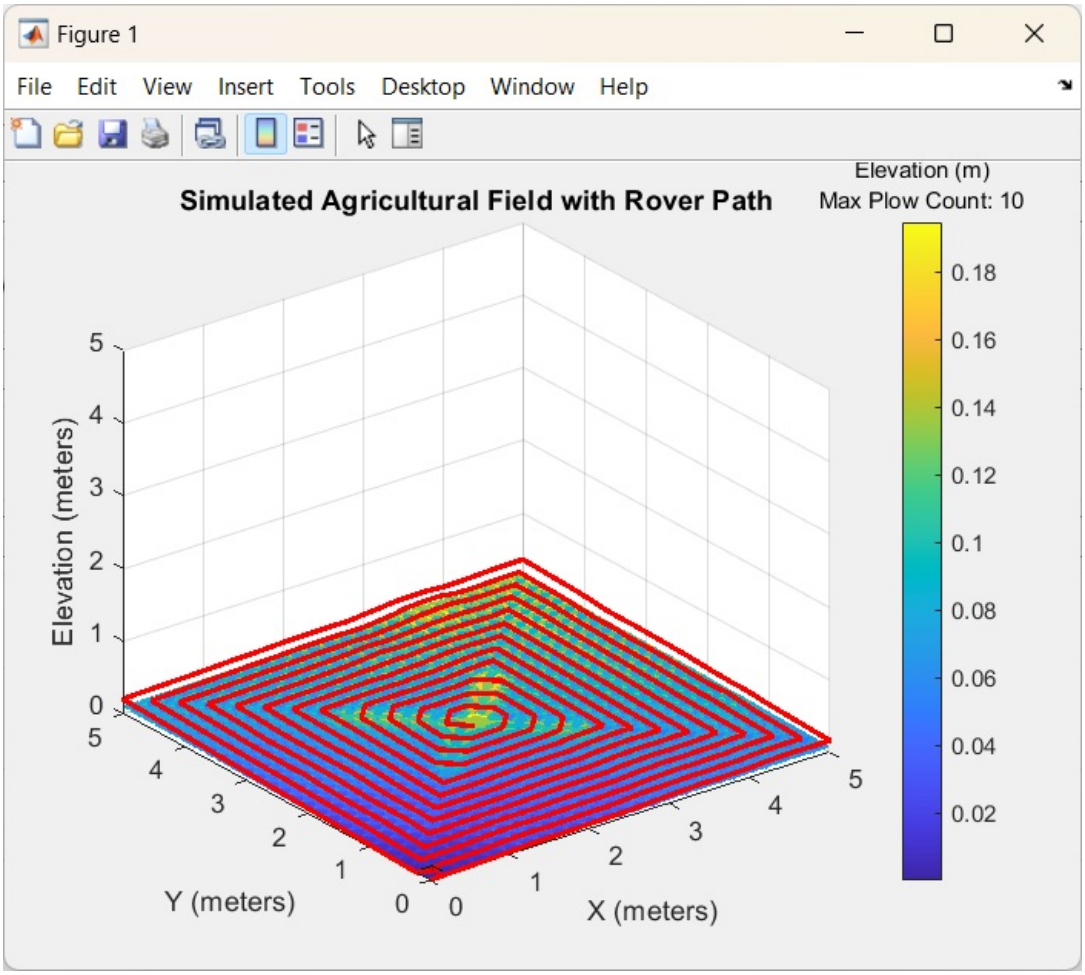
Simulated Agricultural Fie
Elevation (m)
Max Plow Count: 10
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
Y (meters)
X (meters)
0 1 2 3 4 5
- 
Figure 1
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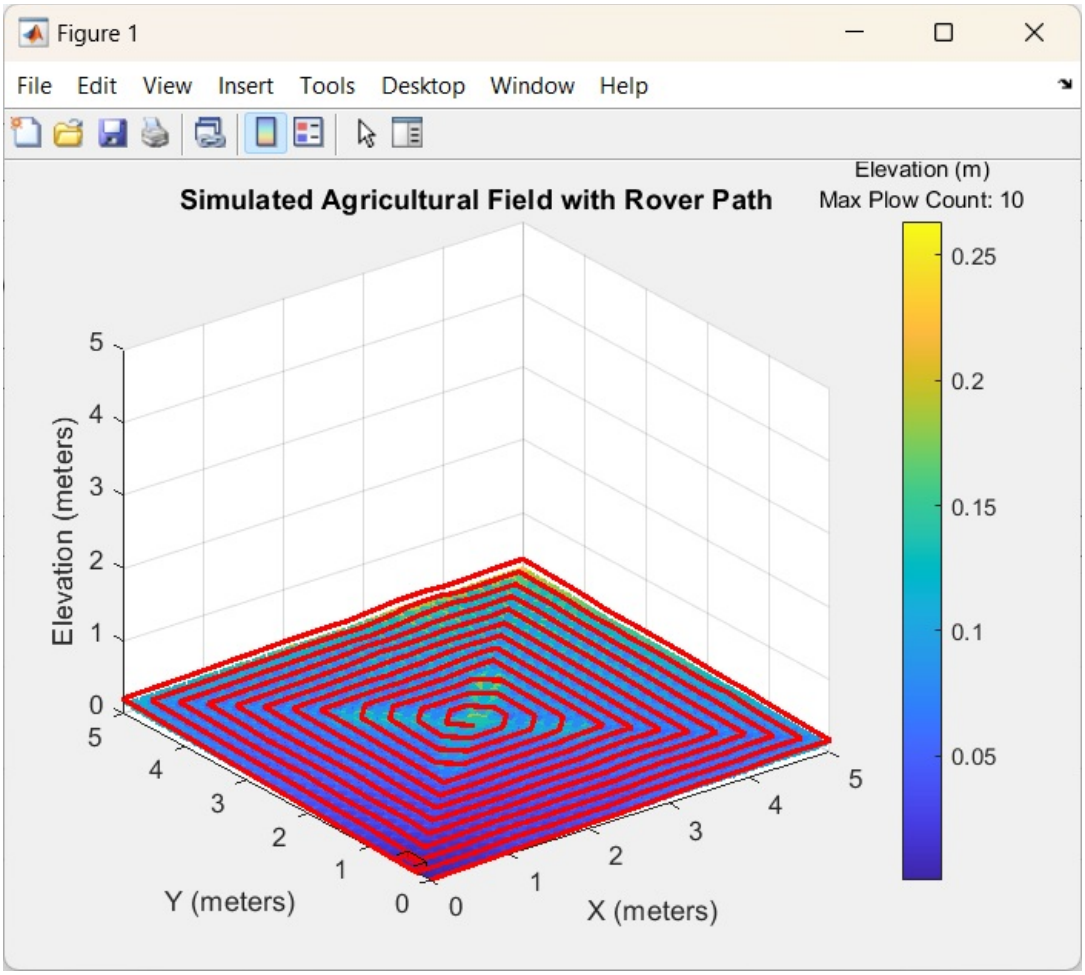
Simulated Agricultural Field with Rover Path
Elevation (m)
Max Plow Count: 10
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
Elevation (meters)
Y (meters)
X (meters)
0 1 2 3 4 5

- 
Figure 1
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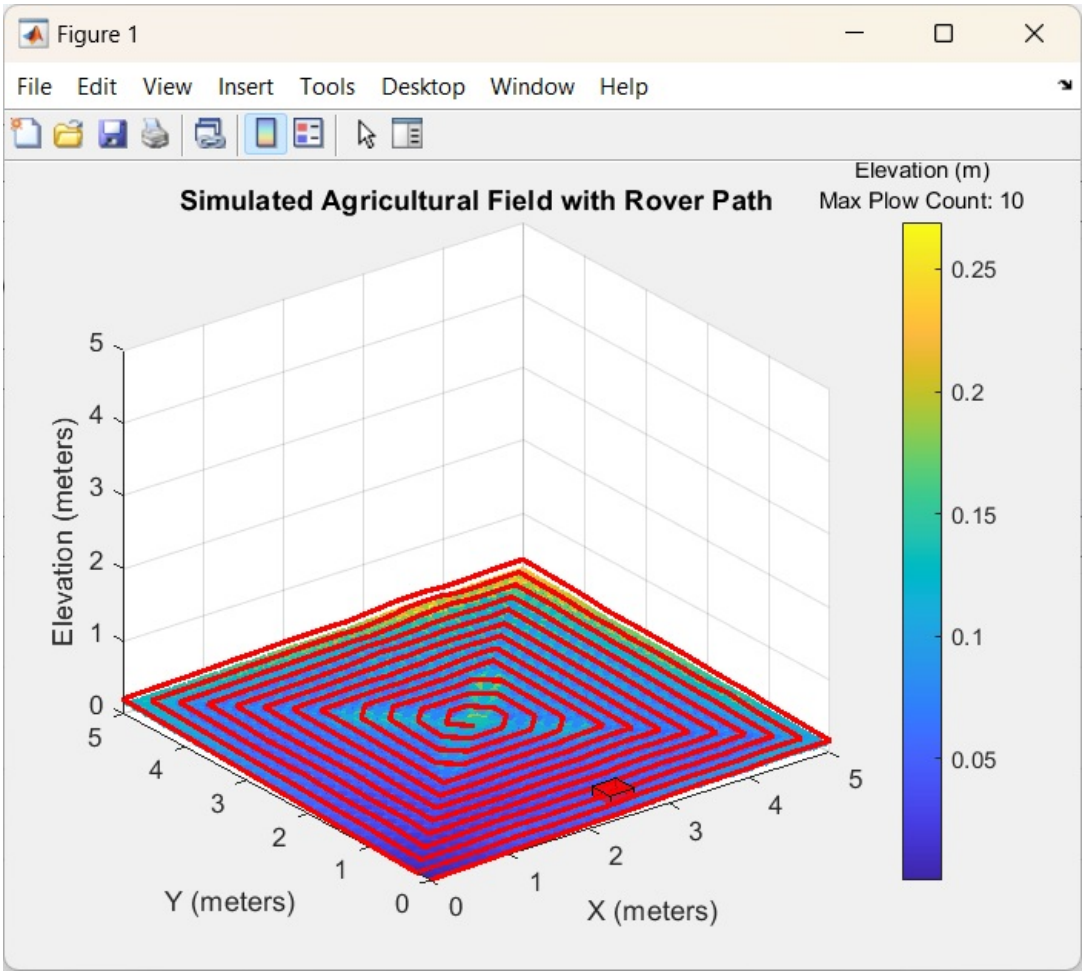
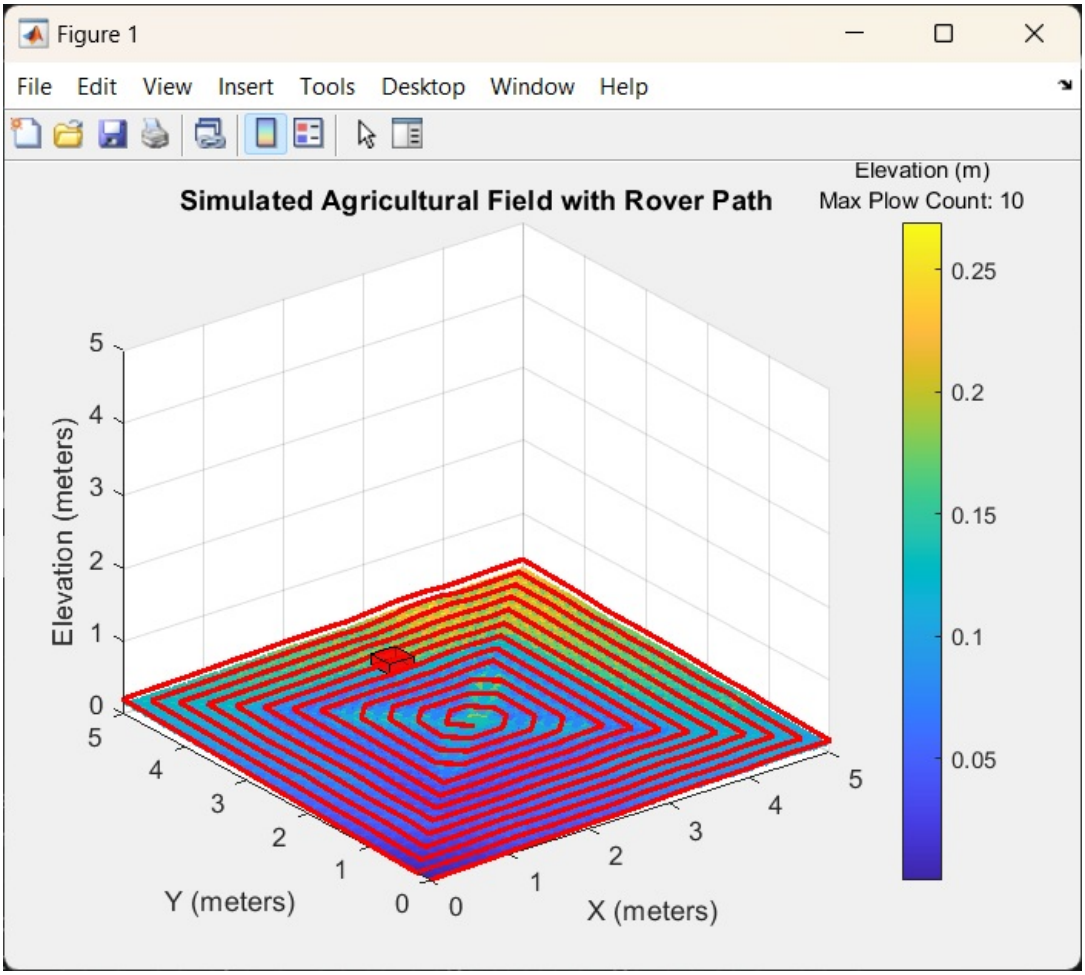
Simulated Agricultural Field with Rover Path
Elevation (m)
Max Plow Count: 10
0.25
0.2
0.15
0.1
0.05
Elevation (meters)
Y (meters)
X (meters)
- 
Figure 1
File Edit View Insert Tools Desktop Window Help
Simulated Agricultural Field with Rover Path
Elevation (m)
Max Plow Count: 10
0.25
0.2
0.15
0.1
0.05
Elevation (meters)
Y (meters)
X (meters)



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

Project Work Summary

- Algorithm Enhancement
  - Implement adaptive plowing depth based on terrain characteristics
  - Develop intelligent path adjustment to minimize overlap while maintaining coverage
  - Create a hybrid pattern that combines benefits of both rectangular and circular approaches
- Simulation Improvements
  - Add realistic soil physics modeling including:
  - Soil composition variations
- Rover Capabilities
  - Design obstacle avoidance system for real-world applications
  - Add dynamic speed control based on terrain difficulty
  - Implement energy consumption modeling
  - Develop multi-rover coordination algorithms
- Validation and Testing
  - Create benchmark metrics for plowing quality
  - Design test scenarios with varying field conditions

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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