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	Data Collection for Terrain Leveling	3
2	Literature review of Land-Leveling algorithms	3
3	Formulating an algorithm for optimal Path planning	2
4	Optimal Path Planning for Agricultural Field Leveling	2
5	Thanksgiving	3
6	Thanksgiving	3
7	Thanksgiving	2
8	Report Writing	1
9	Work plan for next week	1
	Total hours for the week:	20

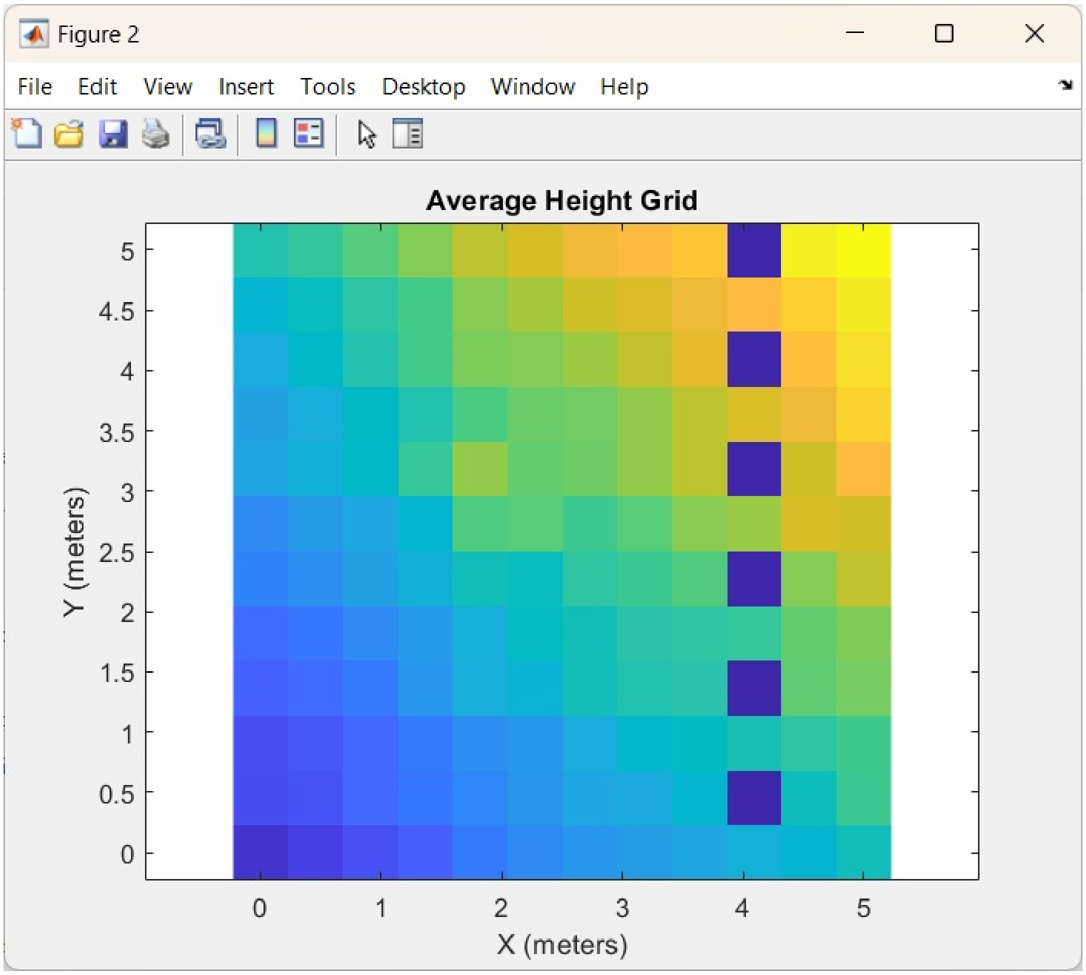
Verification Documentation:

Action Item 1: Data Collection for Terrain Leveling – 3 hour(s).

Project Work Summary

- The primary objective of this task is to develop an efficient data collection system for analyzing terrain characteristics before implementing any leveling algorithms.
- This collection technique will help us to develop optimal path planning and leveling strategies can be developed based on accurate terrain data.
- Implementation Details
- The data collection system operates by:

- Dividing the field into a grid based on the rover's plowing radius (0.2m), creating approximately 12x12 grid cells across the 5x5m field.
- Implementing a row-wise traversal pattern where the rover:
  - Moves along parallel lines with spacing equal to the plowing diameter
  - Alternates direction between adjacent rows to minimize travel distance
  - Collects height data at regular intervals

- Creating a height mapping system that:
  - Records average terrain height within each grid cell
  - Accounts for multiple data points within the rover's plowing radius
  - Generates a comprehensive elevation map showing terrain variations
  - 

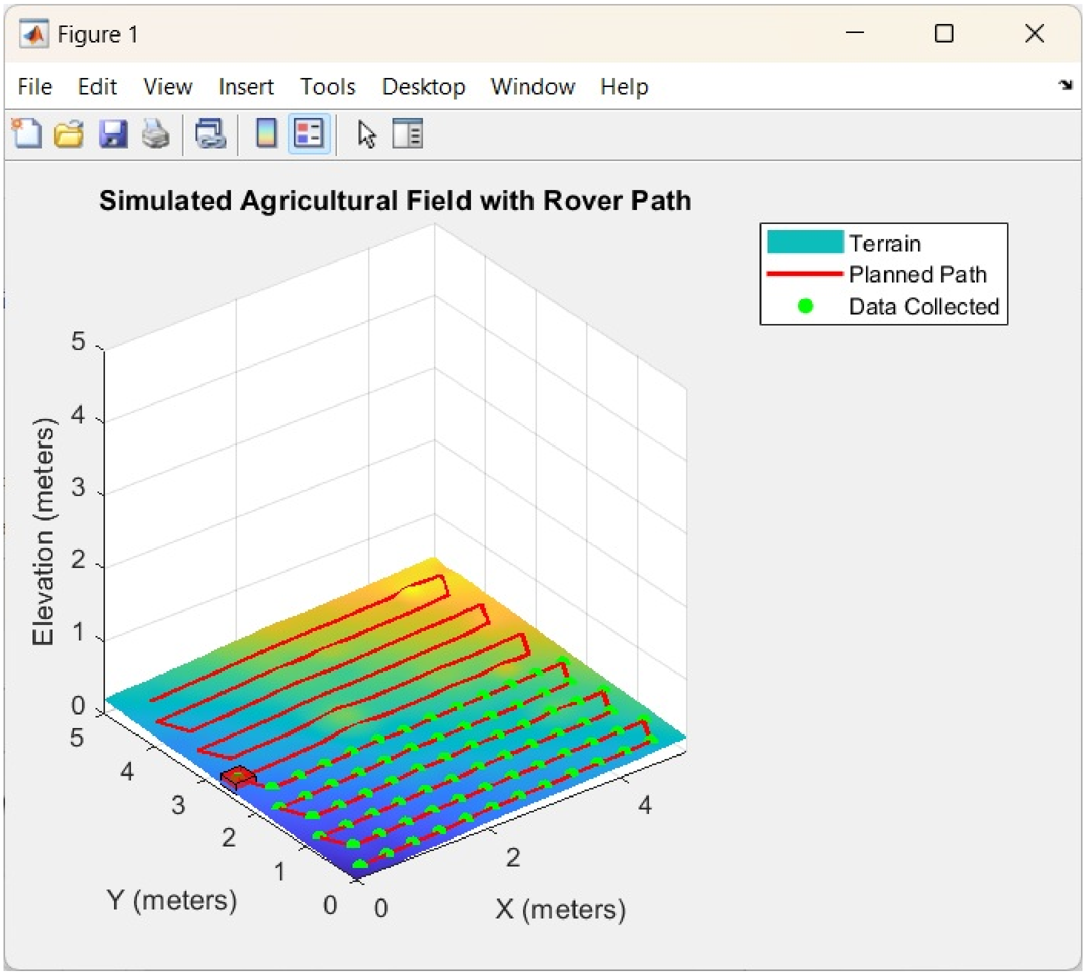
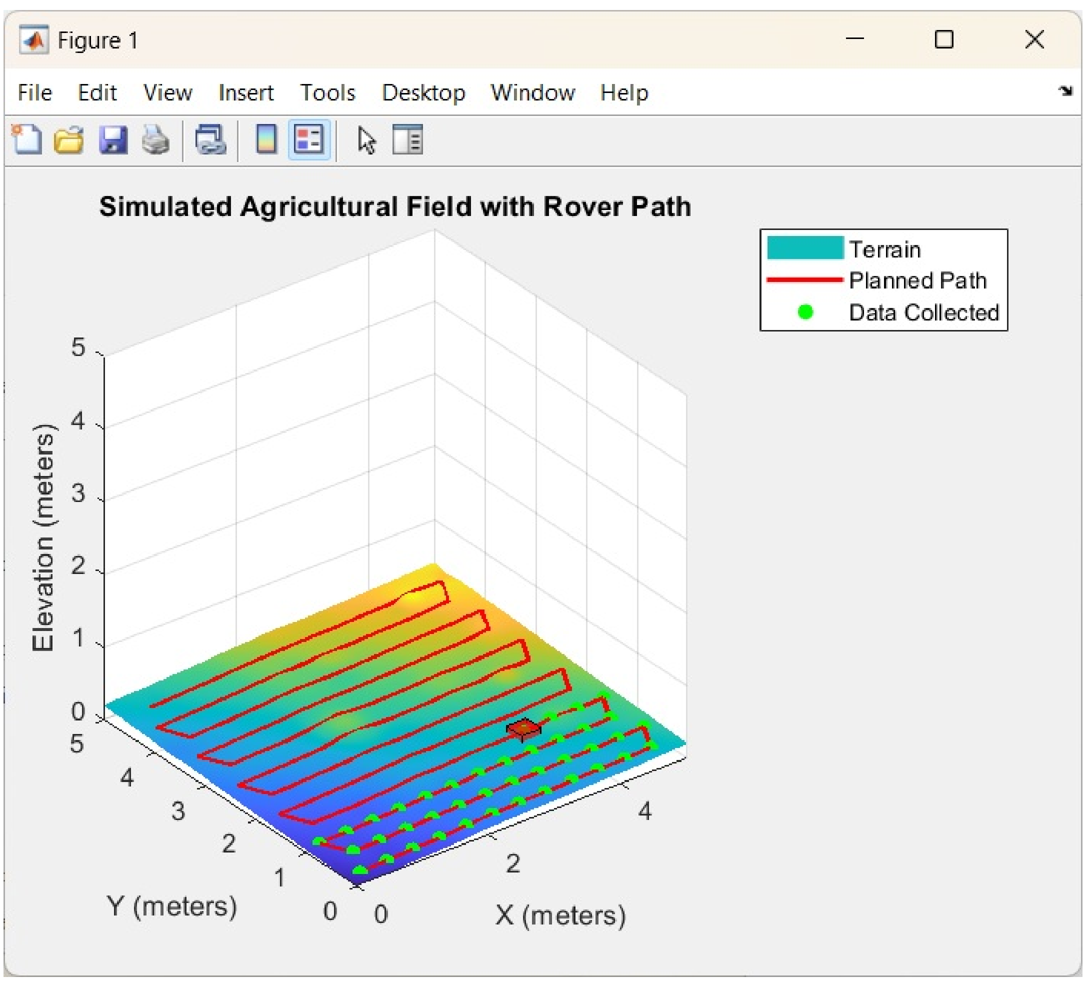
- 

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)

- 

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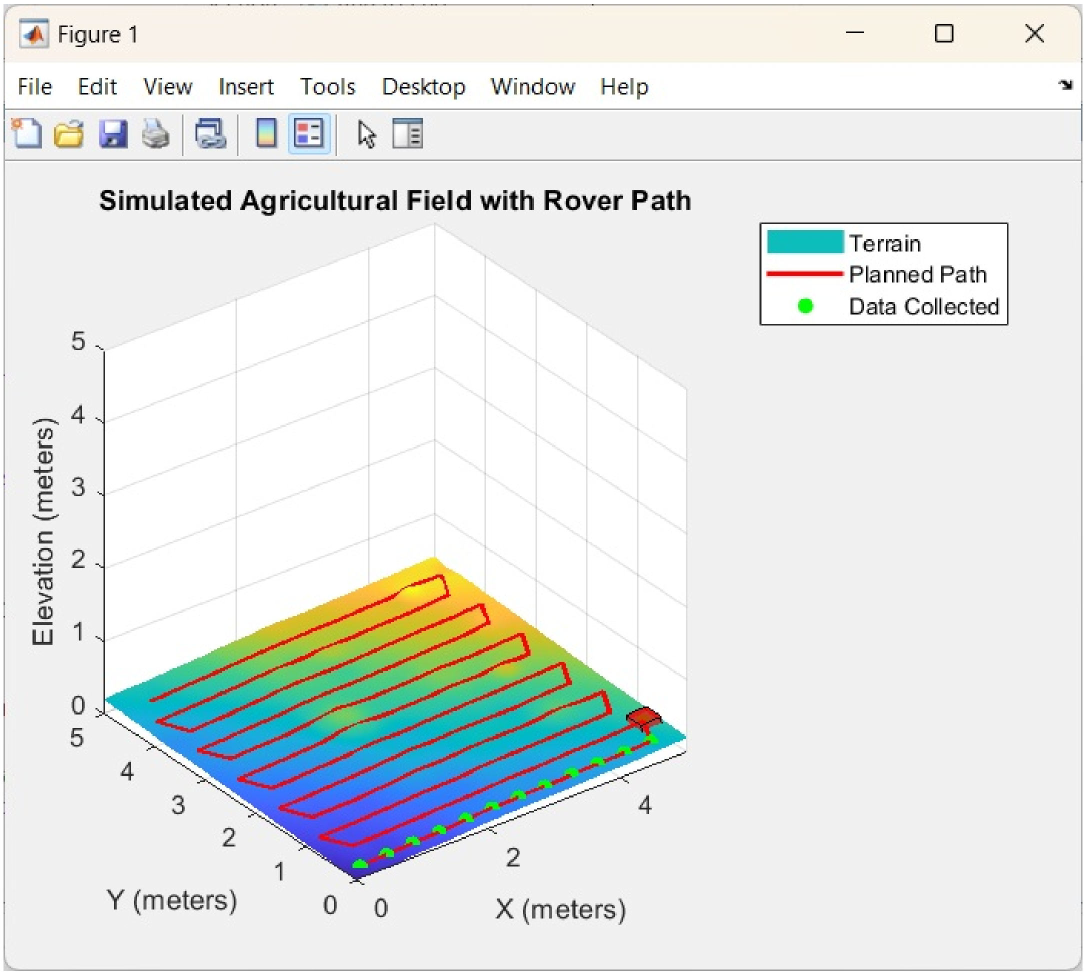
- 

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Action Item 2: Literature review of Land-Leveling algorithms – 3 hour(s).

Research

- https://www.sciencedirect.com/science/article/pii/S0168169924002928?ref=pdf_download&fr=RR-2&rr=8ea8b31e388b1b32
- A review of global precision land-leveling technologies and implements: Current status, challenges and future trends
- Summary of Report
  - The paper primarily focuses on hardware implementations and machinery aspects of land leveling, but contains some relevant algorithmic insights for our project.
    - Algorithmic Components:
      - Height control algorithms primarily use bang-bang, PID control, and fuzzy control methods1
      - Adaptive control systems that adjust based on terrain characteristics
      - Real-time data collection and processing for terrain mapping
    - Control Methods:
      - Laser-controlled systems use three key components: transmitter, receiver, and control terminal1
      - GNSS-controlled systems focus on 3D topographical measurement
      - Both systems aim to maintain constant leveling depth while adapting to terrain
    - Path Planning:
      - Systems must consider field boundaries and optimal coverage patterns
      - Multi-pass strategies for areas requiring significant leveling
      - Dynamic path adjustment based on real-time terrain data
- Relation to Project
  - The paper proposes ways to implement the optimal algorithm for leveling the farmland from the literature.
  - Our approach to discretize the entire farm land into small grids aligns with the propose approach in the paper.
  - The authors also propose a need to implement adaptive control based on collected height data.
  - The paper also propose that we should consider multi-pass optimization for efficient leveling.
- Motivation for Research

- Technical Gaps:
  - Current systems focus on hardware rather than algorithmic optimization
  - Limited research on optimal path planning for leveling
  - Need for more efficient multi-pass strategies
- Project Alignment:
  - Our simulation can test various algorithmic approaches
  - Can develop more sophisticated control methods
  - Opportunity to optimize leveling patterns
- Future Development:
  - Need to focus on algorithmic efficiency
  - Potential for machine learning integration
  - Opportunity to develop new path planning strategies

Action Item 3: Formulating an algorithm for optimal Path planning – 2 hour(s).

Project Work Summary

- Problem Formulation
  - Now that we have the variation of farmland heights data stored, we need to use the data to come up with an algorithm effectively plan an path planning algorithm to effectively level the ground.

1. State Space:
   - Grid representation: 12x12 cells (based on rover's plow radius of 0.2m)
   - Each cell (i,j) contains height value h(i,j) ranging from 0.1m to 0.3m
   - Target height (h_target) = mean height across all cells
2. Cost Function
   C(i,j) = w_1* |h(i,j) - h_target| + w_2*E(i,j) + w_3*D(i,j) $$
   1. Where:
      - |h(i,j) - h_target|: Height difference from target
      - E(i,j): Energy cost for movement
      - D(i,j): Distance from current position
      - w_1, w_2, w_3: Weighting factors
3. Constraints:
   - Maximum height adjustment per pass: ±0.05m
   - Grid boundary: 0 ≤ i,j < 12
   - Movement: Adjacent cells only
4. Optimization Goal:
   1. Minimize the total cost function while achieving uniform height:
      1. min(sum(sum(C(i,j))))

Action Item 4: Optimal Path Planning for Agricultural Field Leveling – 2 hour(s).

Project Work Summary

- Developed a grid-based height mapping system that divides the 5x5m field into cells based on the rover's plowing radius (0.2m), creating a detailed terrain height representation.
- The height grid clearly shows variations from 0.05m to 0.3m across the field.
- Implemented a modified A* pathfinding algorithm with:
  - Custom cost functions incorporating height differences, visit counts, and movement costs
  - Priority-based cell selection favoring areas requiring more passes
  - Dynamic path adjustment based on real-time leveling progress
  - Multi-pass optimization for areas with higher elevation
- Created an adaptive visit tracking system that:
  - Calculates required passes based on height differences from target level
  - Ensures complete field coverage with at least one pass per cell
  - Prioritizes higher elevation areas for multiple passes
  - Updates visit counts dynamically during operation
- Integrated visualization tools showing:
  - Real-time path planning and execution
  - Current rover position and completed paths
  - Visit count heatmap indicating coverage frequency
  - Height grid displaying terrain variations

Action Item 5: Thanksgiving – 3 hour(s).

Thanksgiving holiday and corresponding hours entry to complete the 20 hours per week, so that I could submit my progress.

Action Item 6: Thanksgiving – 3 hour(s).

Thanksgiving holiday and corresponding hours entry to complete the 20 hours per week, so that I could submit my progress.

Action Item 7: Thanksgiving – 2 hour(s).

Thanksgiving holiday and corresponding hours entry to complete the 20 hours per week, so that I could submit my progress.

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.

Action Item 9: Work plan for next week – 1 hour(s).

Project Work Summary

- Algorithm Optimization
    - Implement height-based cost function refinements:
        - Adjust weights for different terrain characteristics
        - Fine-tune the balance between visit frequency and height differences
        - Optimize the priority calculation for multi-pass coverage
        - Path Planning Enhancements:
        - Develop smoother transitions between grid cells
        - Implement dynamic replanning based on real-time leveling progress
        - Create efficient turning patterns at grid boundaries
- Path Planner Implementation
    - Develop height-based A* pathfinding algorithm:
        - Generate optimal paths considering terrain elevation differences
        - Implement priority-based cell selection for multiple passes
        - Track visit counts to ensure complete field coverage
        - Create multi-pass optimization system:
        - Prioritize higher elevation areas requiring more passes
    - Visualization Development
        - Implement comprehensive visualization tools:
            - Create color-coded height grid displaying terrain variations (0.05m to 0.3m)
            - Show optimal path planning with start (green) and end (red) positions
            - Generate visit count heatmap indicating coverage frequency