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	Simulation Optimization and Experimental Study of the Working Performance of a Vertical Rotary Tiller Based on the Discrete Element Method	3
2	Physically-Based Interactive Sand Simulation	3
3	Discrete element method simulation of disc type furrow openers in paddy soil	3
4	Install Necessary Packages and Create a Single Particle in Mayavi	3
5	Single Particle Terrain Visualization using Mayavi	3
6	3D Terrain Generation and Particle-Based Visualization using Mayavi	3
7	Next week plan	1
8	Report Writing	1
	Total hours for the week:	20

Verification Documentation:

Action Item 1: Simulation Optimization and Experimental Study of the Working Performance of a Vertical Rotary Tiller Based on the Discrete Element Method – 3 hour(s).

Research

- Simulation Optimization and Experimental Study of the Working Performance of a Vertical Rotary Tiller Based on the Discrete Element Method
- https://www.mdpi.com/2076-0825/11/12/342
- Summary of Report:

    - The study uses discrete element method (DEM) to simulate and optimize the performance of a vertical rotary tiller.
    - Researchers conducted simulation tests and soil tank experiments to analyze soil breaking effects, tool torque, and power consumption.
    - The optimal combination of operating parameters was determined through orthogonal testing and verified through physical experiments.
- Relation to Project:
    - Provides a methodology for simulating soil-tool interactions using DEM, which can be adapted for our agricultural simulation.
    - Offers insights into optimizing tiller design parameters like tool bending angle and number of tools, applicable to our rover design.
    - Demonstrates the integration of simulation results with physical experiments, a valuable approach for validating our soil-rover interaction models.
- Motivation for Research:
    - To improve the operating effect and efficiency of vertical rotary tillers through simulation-based optimization.
    - To understand the complex interactions between soil and rotary tiller blades using advanced computational methods.
    - To establish a reliable method for predicting and optimizing agricultural machinery performance before physical prototyping.

Action Item 2: Physically-Based Interactive Sand Simulation – 3 hour(s).

Project Work Summary

- https://www.researchgate.net/publication/235223044
- Physically-Based Interactive Sand Simulation
- Summary of Report:
    - The paper proposes a physically-based model for real-time, interactive simulation of sand dynamics in 3D environments.
    - It combines a discrete model for sandpile evolution with a soil-tool interaction model based on Perumpral's approach.
    - The authors implement and test their model, demonstrating its efficiency and suitability for real-time applications like driving simulators.
- Relation to Project:
    - Provides a framework for simulating sand physics in real-time, which could be adapted for use with Pygame.
    - Offers insights into handling sand-object interactions, crucial for creating realistic sand simulations.
    - Demonstrates the feasibility of integrating complex physical models into interactive graphical applications.
- Motivation for Research:
    - To develop a more physically accurate model for sand simulation that can still run in real-time.
    - To improve upon existing models by incorporating both vertical and horizontal forces in sand-object interactions.
    - To create a sand simulation model suitable for integration into demanding applications like driving simulators.

Action Item 3: Discrete element method simulation of disc type furrow openers in paddy soil – 3 hour(s).

Project Work Summary

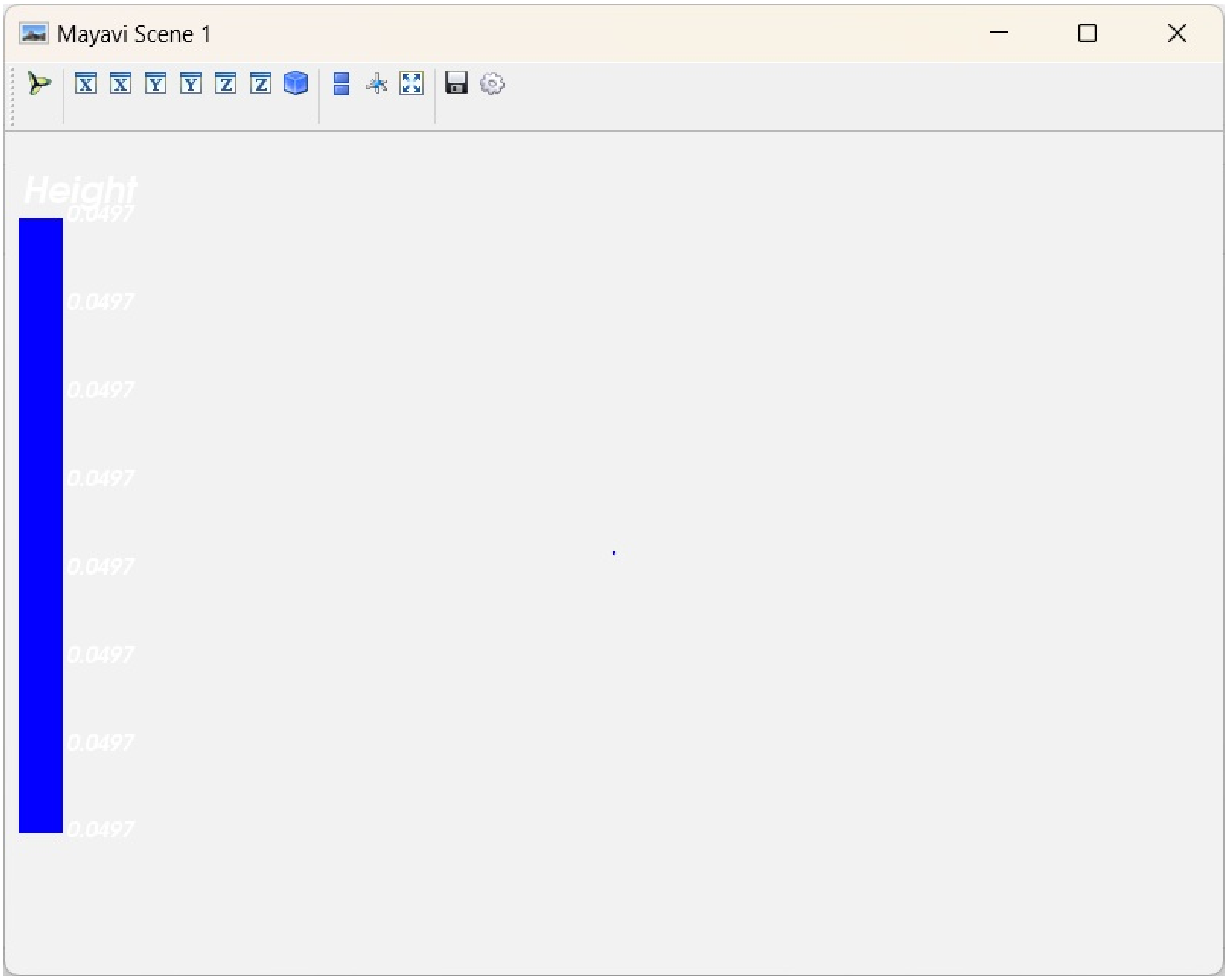
- Discrete element method simulation of disc type furrow openers in paddy soil
- https://www.semanticscholar.org/paper/Discrete-element-method-simulation-of-disc-type-in-Ahmad-Qiu/1db28433a74183649e3e059f767995ec7aff24dd
- Summary of Report:
    - The study used discrete element method (DEM) to simulate and evaluate the performance of disc furrow openers in paddy soil.
    - Three types of furrow openers were simulated: notched, toothed, and double disc.
    - The Hertz-Mindlin contact model with bonding was used to simulate soil moisture and cohesion between particles.
- Relation to Project:
    - Provides a methodology for simulating soil-tool interactions in paddy soil using DEM, which can be adapted for our agricultural simulation.
    - Offers insights into modeling different types of disc furrow openers, which could inform our rover design for various soil conditions.

    - Demonstrates the use of EDEM software for 3D DEM simulation, a potential tool for our project.
- Motivation for Research:
    - To develop a more accurate simulation model for disc furrow openers in paddy soil conditions.
    - To understand the effects of different opener designs on soil disturbance and draft force.
    - To validate the use of DEM for simulating narrow tillage tools in cohesive soils, addressing a gap in previous research which focused mainly on wide tools in cohesionless soils.

Action Item 4: Install Necessary Packages and Create a Single Particle in Mayavi – 3 hour(s).

Project Work Summary

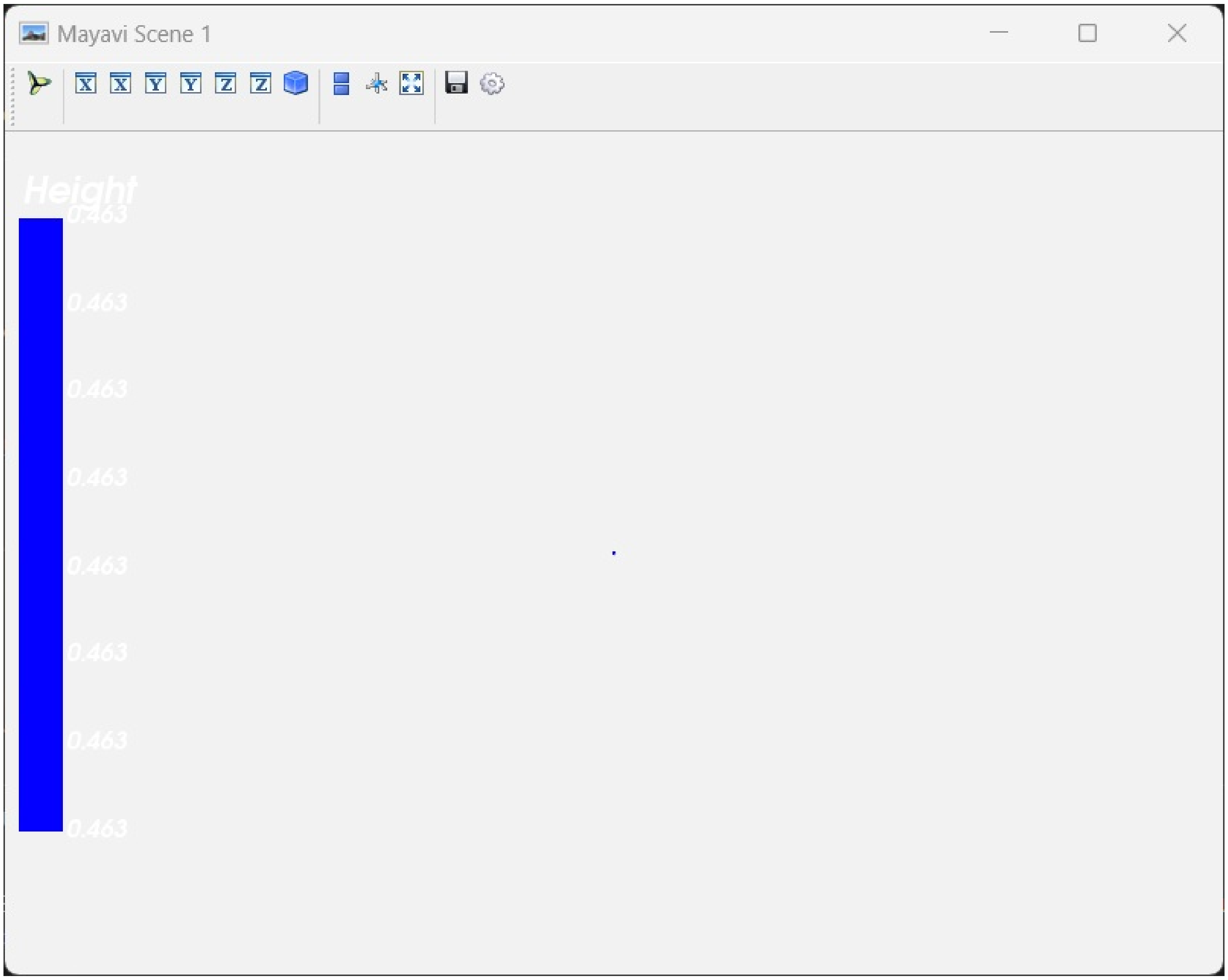
- Package Installation:
    - Open a terminal or command prompt
    - Run the following command to install the required packages
        - pip install mayavi numpy vtk
    - Verify the installation by importing the packages in a Python interpreter
- Create a Single Particle Visualization:
    - Open a new Python file
    - Import necessary modules:
      ```python
      from mayavi import mlab
      import numpy as np
      ```
      - Create a simple 3D point:
      ```python
      x, y, z = 0, 0, 0
      ```
      - Visualize the point using Mayavi:
      ```python
      mlab.figure()
      mlab.points3d(x, y, z, scale_factor=0.2)
      mlab.show()
      ``
      ```



Action Item 5: Single Particle Terrain Visualization using Mayavi – 3 hour(s).

Project Work Summary

- This simulation creates a 3D visualization of a single particle on a generated terrain using Mayavi.
- Terrain Generation:
  - 10x10 meter grid is created to represent the terrain.
  - The terrain height is generated using a combination of sinusoidal variations and random noise to simulate a realistic, uneven surface.
  - A custom terrain_height function calculates the height at each point using sine and cosine functions, with added randomness for natural variation.
- Particle Placement:
  - A single particle is randomly placed within the 10x10 meter grid.
  - The particle's z-coordinate (height) is determined by the terrain_height function at its x and y position.
- Visualization:
  - The simulation uses Mayavi to create a 3D visualization of the terrain and particle.
  - A Mayavi figure is created with a light gray background and dimensions of 800x600 pixels.
  - The particle is represented as a 3D point, with its color corresponding to its height.
  - A colorbar is added to provide a visual reference for the height values.
- View Configuration:
  - The 3D view is set with specific azimuth, elevation, and distance parameters for optimal visualization.
  - This ensures a clear perspective of the terrain and particle placement.
- Execution:
  - The simulation generates the terrain and places the particle.
  - Mayavi renders the 3D visualization, showing the particle's position on the terrain.
  - The plot is displayed, allowing for interactive exploration of the 3D scene.
- This simulation serves as a foundation for more complex terrain and multi-particle simulations, demonstrating basic 3D visualization techniques using Mayavi.



Citations:
[1] https://ppl-ai-file-upload.s3.amazonaws.com/web/direct-files/28784843/9a4a086b-60dd-462c-822f-2ec475ac8ec7/468865d1-5f83-4c47-9ae6-455f69c96d2e-3.pdf
[2] https://ppl-ai-file-upload.s3.amazonaws.com/web/direct-files/28784843/61c52662-d813-4cf5-a867-eb681a549a91/1e018810-9860-42fb-85b9-aba7854da4d0-1.pdf
[3] https://ppl-ai-file-upload.s3.amazonaws.com/web/direct-files/28784843/34ad1890-5fb6-49f5-8c51-eb9848014155/008ba589-9951-4733-9c63-63f0296d5edb-1.pdf

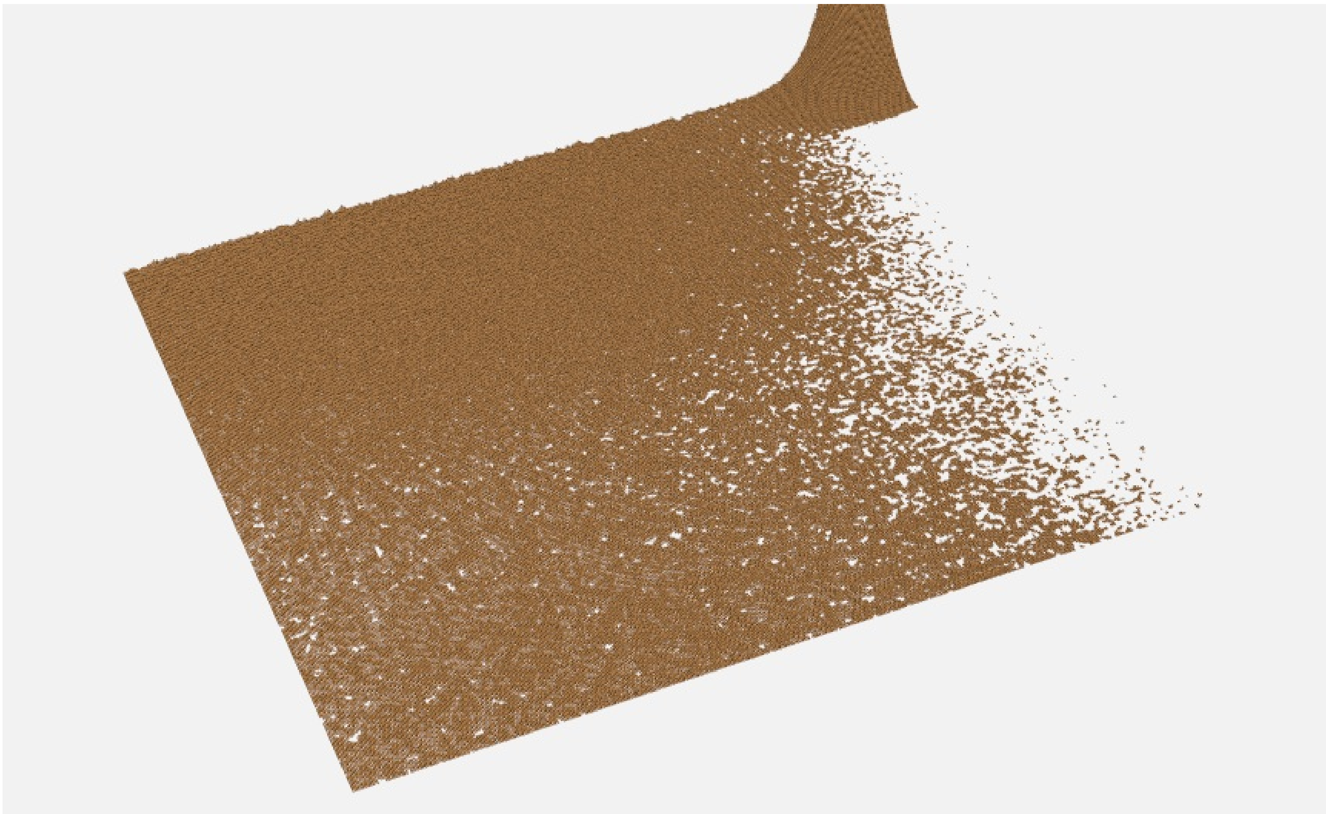
Action Item 6: 3D Terrain Generation and Particle-Based Visualization using Mayavi – 3 hour(s).

Project Work Summary

- This task involves creating a realistic 3D terrain simulation using Mayavi, with the following key components:
- Terrain Generation
  - Create a 5x5 meter terrain grid with high resolution (0.01m spacing)
  - Generate terrain height using sinusoidal variations with random amplitude and frequency
  - Add Gaussian bumps for additional texture and realism
  - Apply Gaussian filtering for terrain smoothing
- Particle-Based Representation
  - Represent the terrain using particles with a specified radius
  - Fill the terrain height with particles, creating a volumetric representation
  - Generate millions of particles to achieve high detail
- Visualization
  - Use Mayavi to create a 3D visualization of the particle-based terrain
  - Set up a Mayavi figure with specific size and background color
  - Render particles as 3D points with appropriate scaling and color
  - Configure the view angle for optimal terrain visualization
- Key Features
  - High-resolution terrain generation (500x500 grid points)
  - Realistic terrain features using combined sinusoidal and Gaussian bump patterns
  - Volumetric particle representation for enhanced depth perception

- Customizable particle size and color for different soil types
- 3D interactive visualization using Mayavi

- Implementation Details
  - Utilize NumPy for efficient terrain generation and particle creation
  - Employ SciPy's Gaussian filter for terrain smoothing
  - Use Mayavi's points3d function for rendering millions of particles efficiently
  - Implement view angle settings for proper 3D perspective
- This simulation provides a foundation for further agricultural robotics research, allowing for the study of soil interactions, path planning, and multi-robot coordination in a realistic 3D environment.



Action Item 7: Next week plan – 1 hour(s).

Project Work Summary

- Soil Interaction Model Design
  - Develop a particle-based soil representation using NumPy and SciPy for more realistic soil deformation simulation
  - Implement a soil compaction prediction algorithm that calculates stress distribution based on rover weight and wheel configuration
  - Create a database of soil properties for different soil types (e.g., clay, silt, sand, loam) to enable adaptive soil type modeling
- Path Planning Algorithm Enhancement
  - Integrate terrain characteristics and soil properties into the existing A* algorithm for more efficient path planning
  - Implement a dynamic obstacle avoidance system to handle unexpected objects or changes in the terrain
  - Develop an energy efficiency optimization component for the path planning algorithm
- Multi-Robot Coordination System
  - Design a task allocation system that optimizes workload distribution among multiple rovers
  - Implement a real-time communication protocol for data sharing between robots
  - Create an adaptive decision-making mechanism that responds to changing environmental conditions and task priorities
- Visualization and Simulation Improvements
  - Enhance the 3D visualization of the terrain and rovers using advanced rendering techniques in Pygame or consider transitioning to a 3D engine like Panda3D
  - Implement more realistic physics for rover-terrain interactions, including wheel sinkage and soil displacement

- Develop a user interface for real-time monitoring and control of multiple rovers
- Performance Optimization
  - Optimize the particle simulation code to handle a larger number of particles for increased realism
  - Implement parallel processing techniques to improve simulation speed and efficiency
  - Develop a more efficient data structure for storing and updating terrain information
- These tasks aim to advance the agricultural simulation by focusing on realistic soil modeling, improved path planning, multi-robot coordination, enhanced visualization, and overall system optimization.

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. Total hours : 20