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.

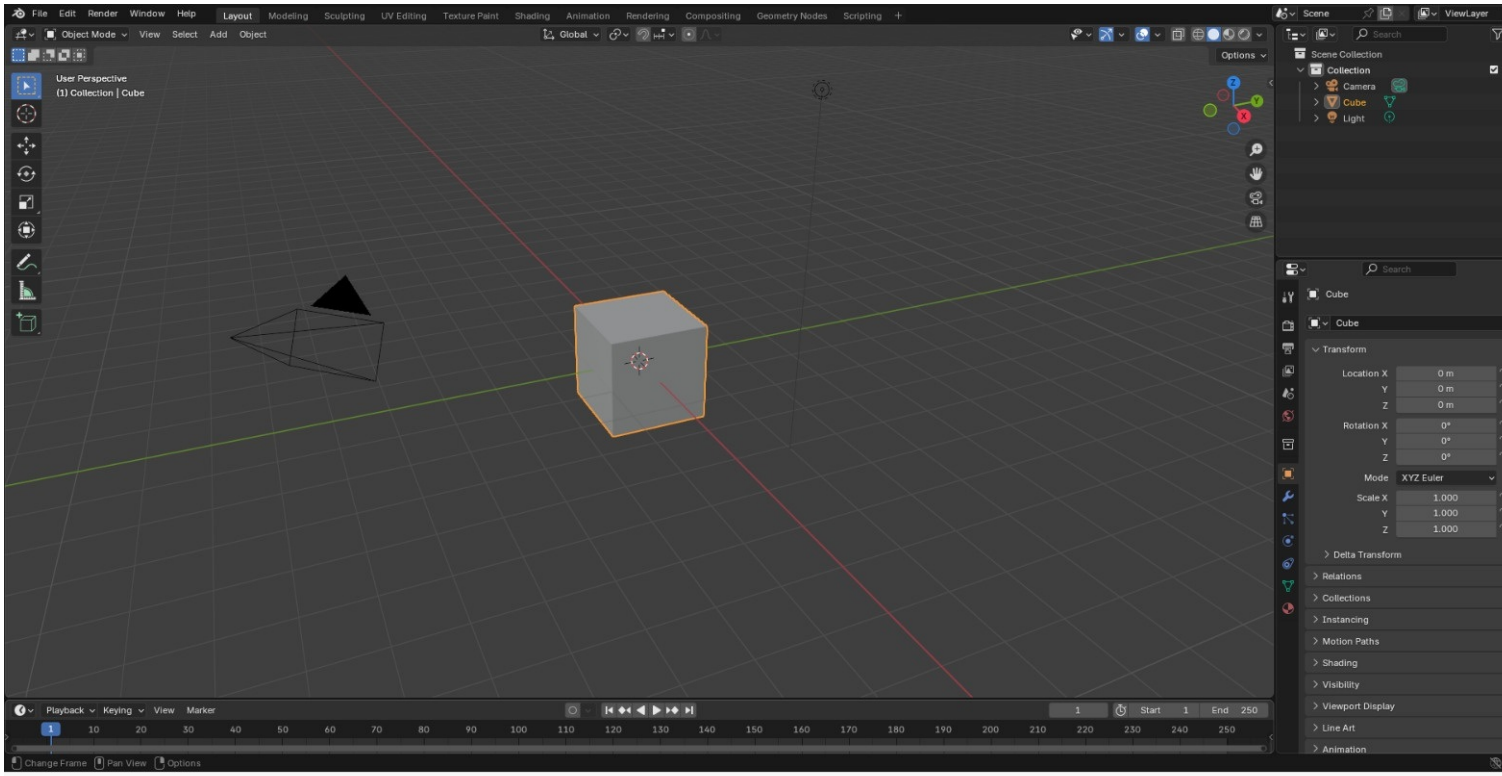
#	Action Item/ Explanation	Total Time This Week (hours)
1	Installing Blender and setting up	3
2	Creating and Sculpting Terrain in Blender	3
3	Finding suitable Soil Texture and Applying in Blender	3
4	Creating Crop rows in Blender	3
5	Procedural Generation and Blender Integration for Farmland Simulation	3
6	Exporting a Blender Map to Gazebo	3
7	Weekly Plan for Next Week	1
8	Report Writing	1
	Total hours for the week:	20

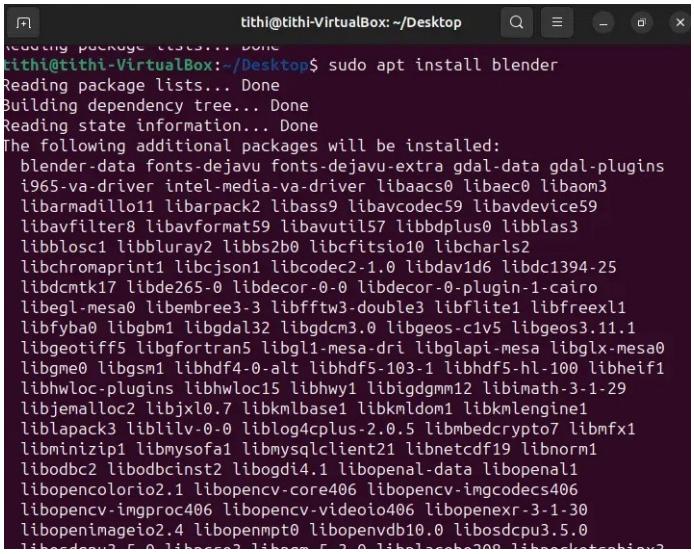
Verification Documentation:

Action Item 1: Installing Blender and setting up – 3 hour(s).

Project Work Summary

- This week, I'm working with Blender to create the simulation map for future integration with the gazebo. By creating the map with Blender it becomes flexibility to create and adjust maps as we needed, making it feasible for designing custom simulation environments.
- We constantly ran into some trouble with Husky navigating the heightmap of the virtual maize map. That's why I decided to make the map without importing and more over the map is not very realistic from the sources online and eventually get more control of the environment by creating a custom map in Blender.
- Steps to Install Blender via Terminal
  - Before installing Blender, made sure my system was up to date with the sudo update. I ran the necessary terminal commands to refresh the package list and upgrade any outdated packages.
  - Since we need the latest version directly from Blender's developers, so i explored the official Blender repository for information.
  - Once the repository was added, I installed Blender using a simple terminal command. The process was smooth, and the installation completed without issues.
  - To confirm everything worked as expected, I launched Blender from the terminal using the command blender. It opened without any issues, so we finally know the installation was successful and ready to use.
- Unlike prebuilt maps, Blender allows to create exactly what we need to tackle Husky's navigation challenges. We can tweak and adapt it for different simulations and scenaros as needed. By designing our own map, we can ensure better control over elevation and obstacles.

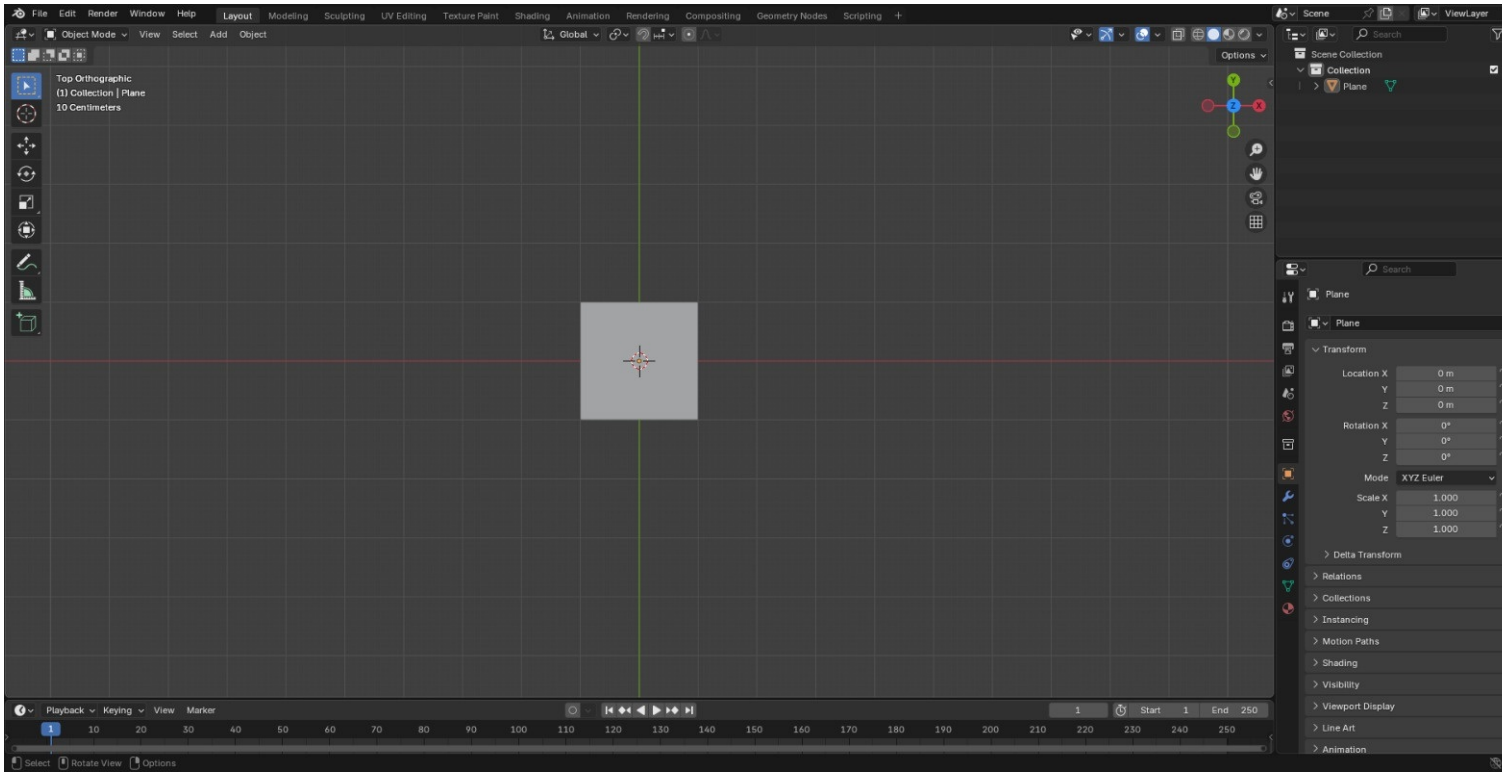




Action Item 2: Creating and Sculpting Terrain in Blender – 3 hour(s).

Project Work Summary

- Now we need to start work on to building the custom terrain in Blender to add our husky to the map and the gazebo. By designing the terrain from scratch, we can have a better control over the map and ensure that we can meets Husky's requirements while also making it adaptable for future applications. Blender gives that flexibility to sculpt realistic environments, making it a great tool for this task.
- Steps to Create the Terrain
  - Setting Up the Scene
    - Started by preparing the workspace in Blender:
    - Removed the default cube to clear the scene (Shift + A → Delete).
    - Added a new plane to serve as the base for the farmland (Mesh → Plane).
    - Scaled up the plane (S → 15) to give myself enough space to design a large, realistic farmland.
  - Subdividing the Plane
    - To make sure the terrain had enough detail for sculpting:
      - Entered Edit Mode (Tab) and selected the plane.
      - Right-clicked and chose "Subdivide" to increase the number of cuts.
      - Added many the cuts until the number of subdivides are 200, ensuring there was enough geometry to sculpt fine details later.
- Sculpting the Farmland
  - With the subdivided plane ready, then we switched to Sculpt Mode (Ctrl + Tab → Sculpt Mode).
  - Shaping the Terrain, I used various sculpting tools to shape the farmland:
    - Draw Brush to created hills and elevated areas.
    - Flatten Brush to smoothen out certain sections to form flat, farmable land.
    - Dyntopo (Dynamic Topology) to add finer details, ensuring small bumps and indentations were accurately represented.
    - Scrape Brush to added natural imperfections and subtle variations in elevation to make the terrain look more realistic.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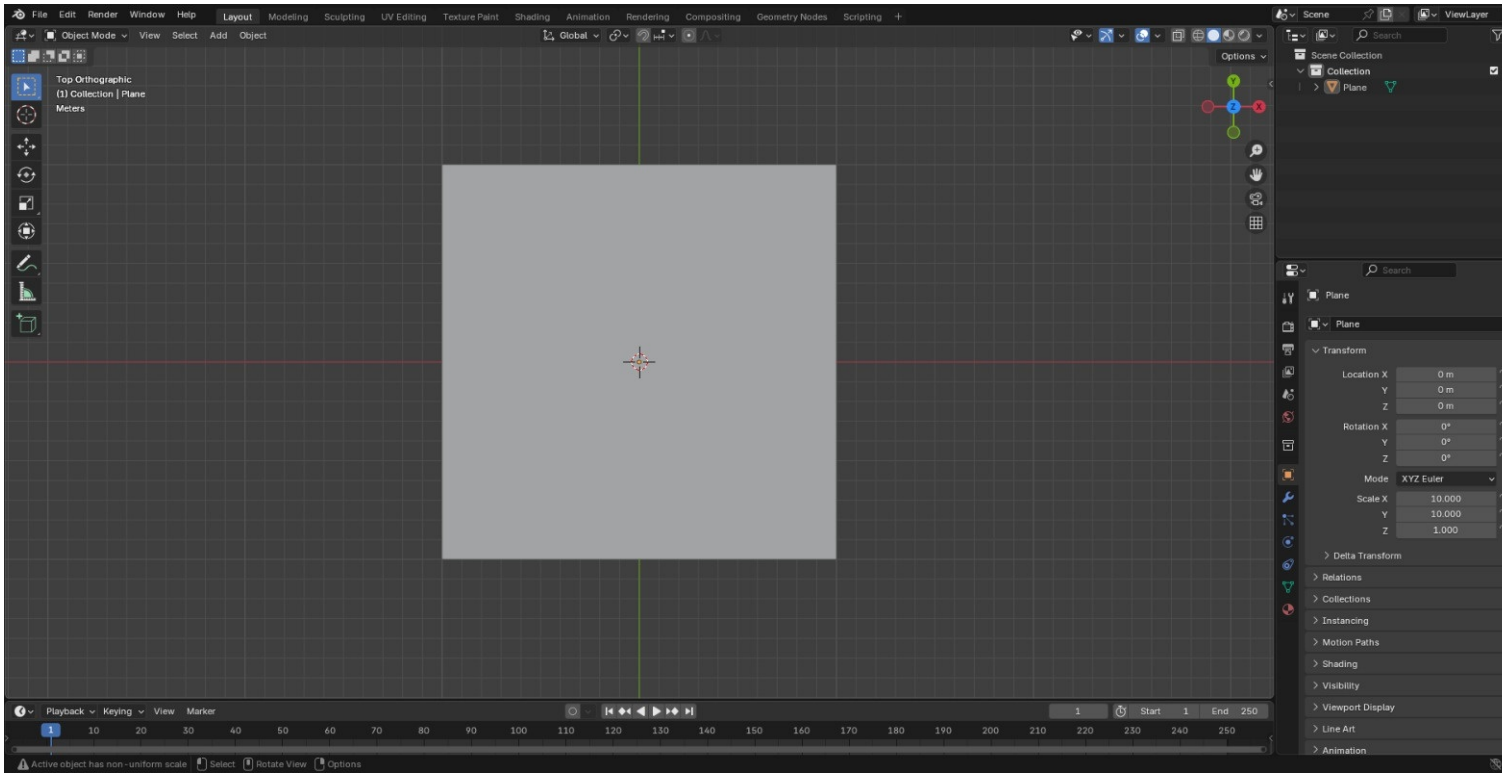
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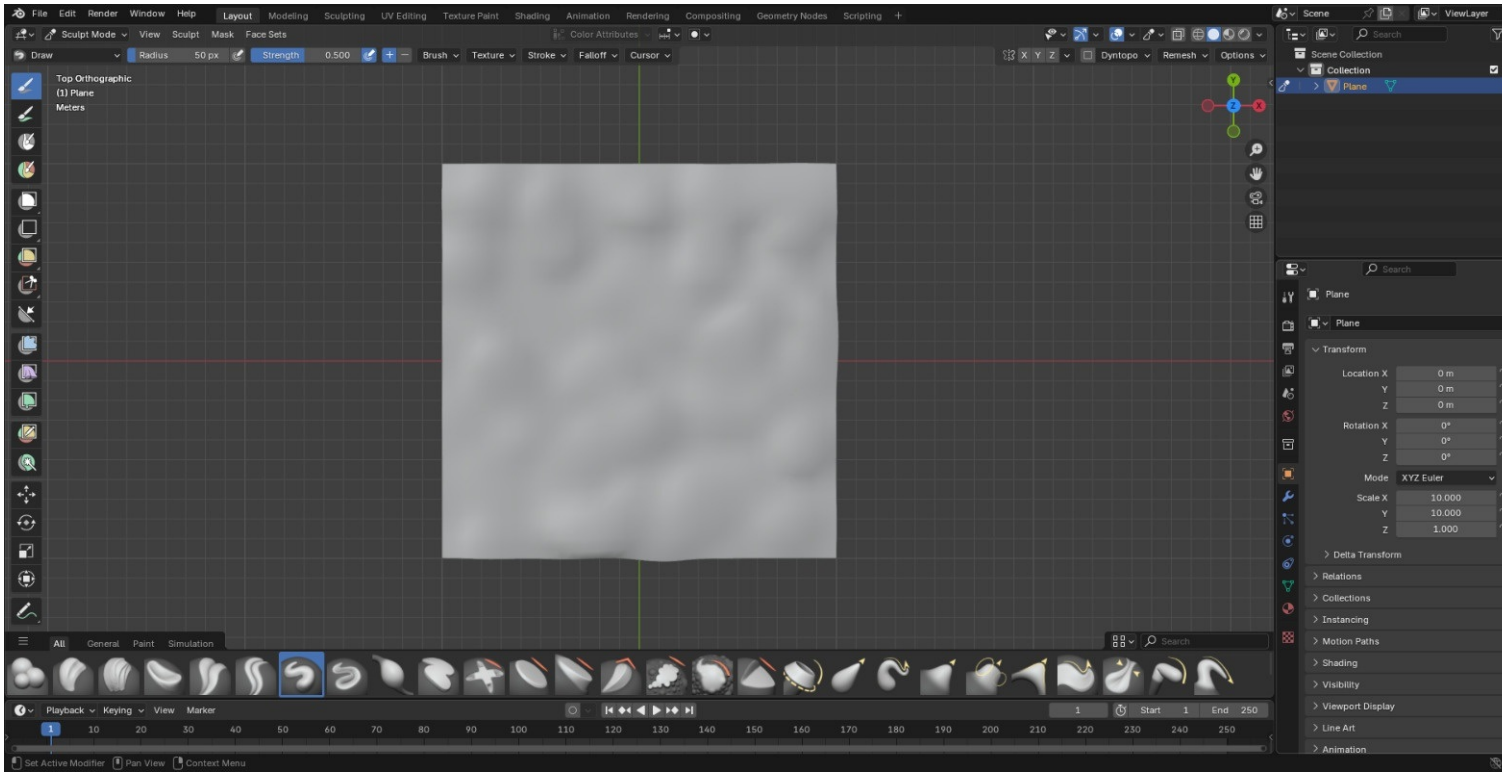
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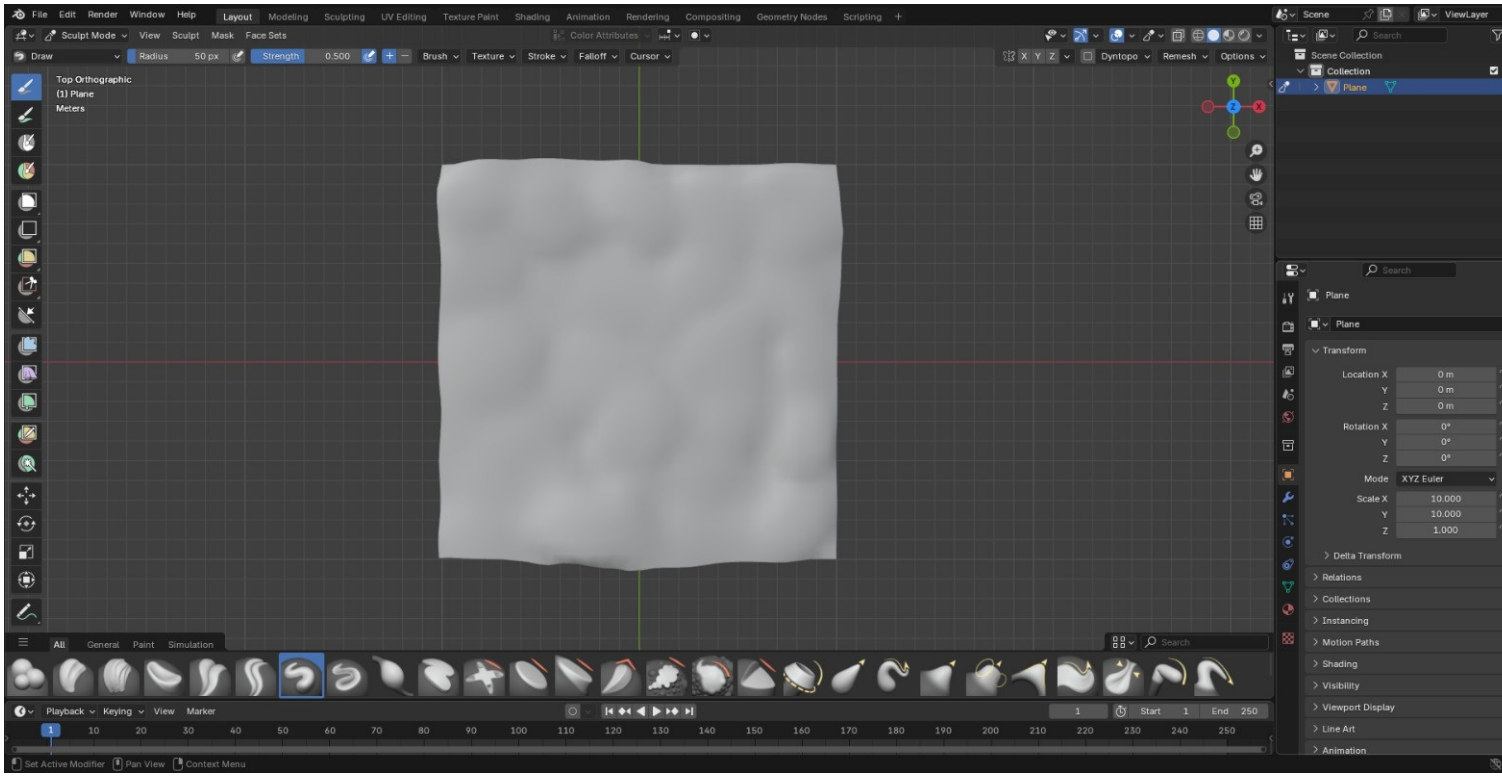
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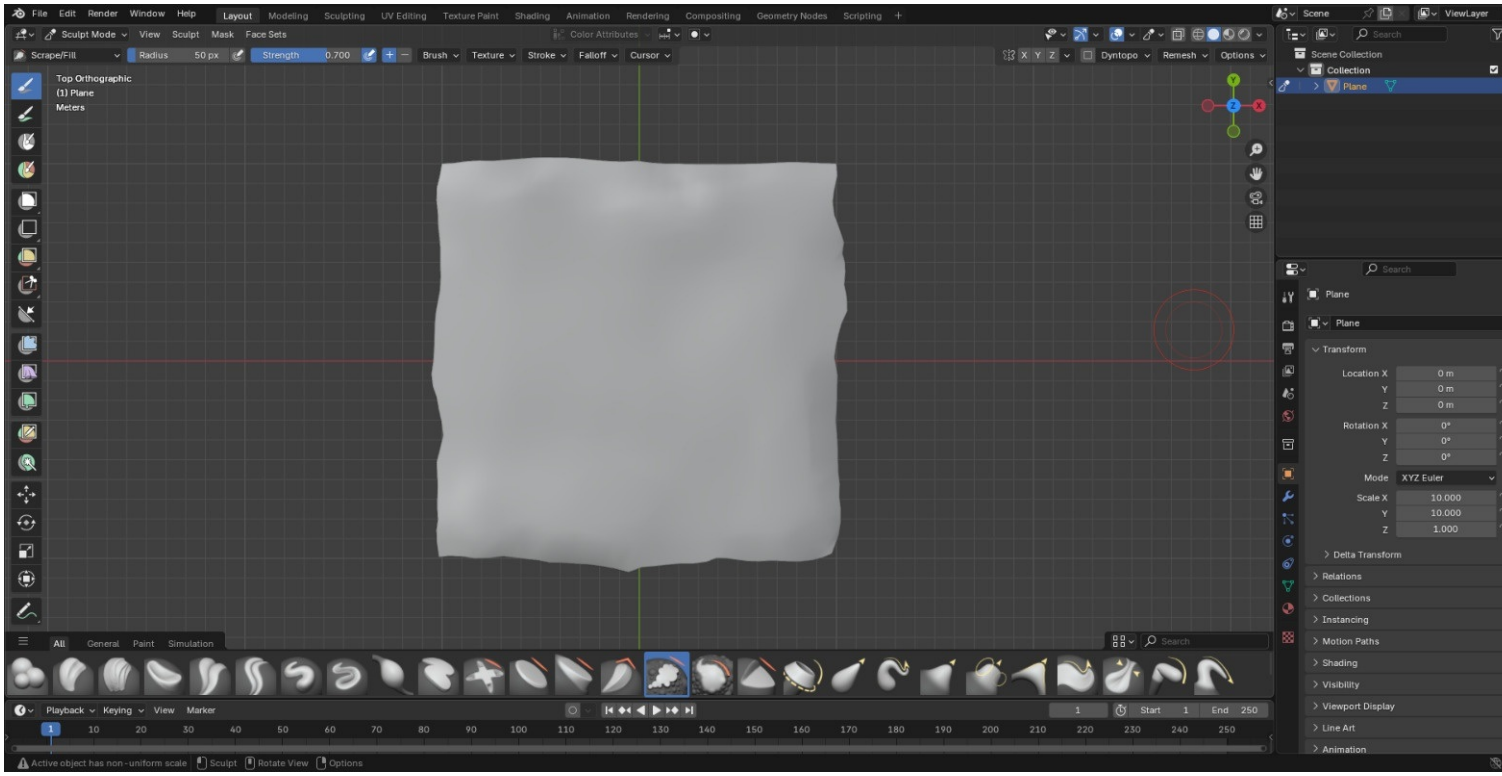
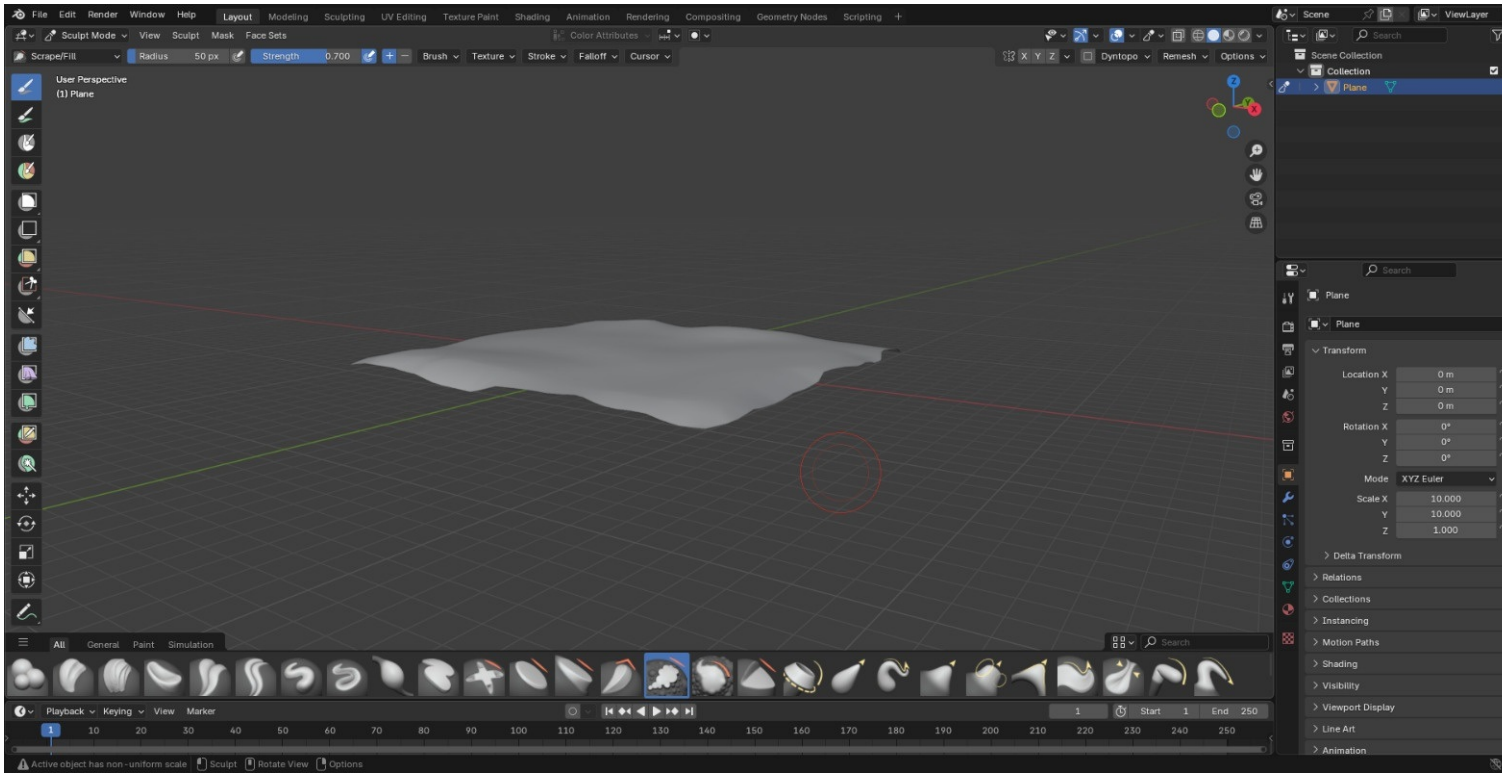
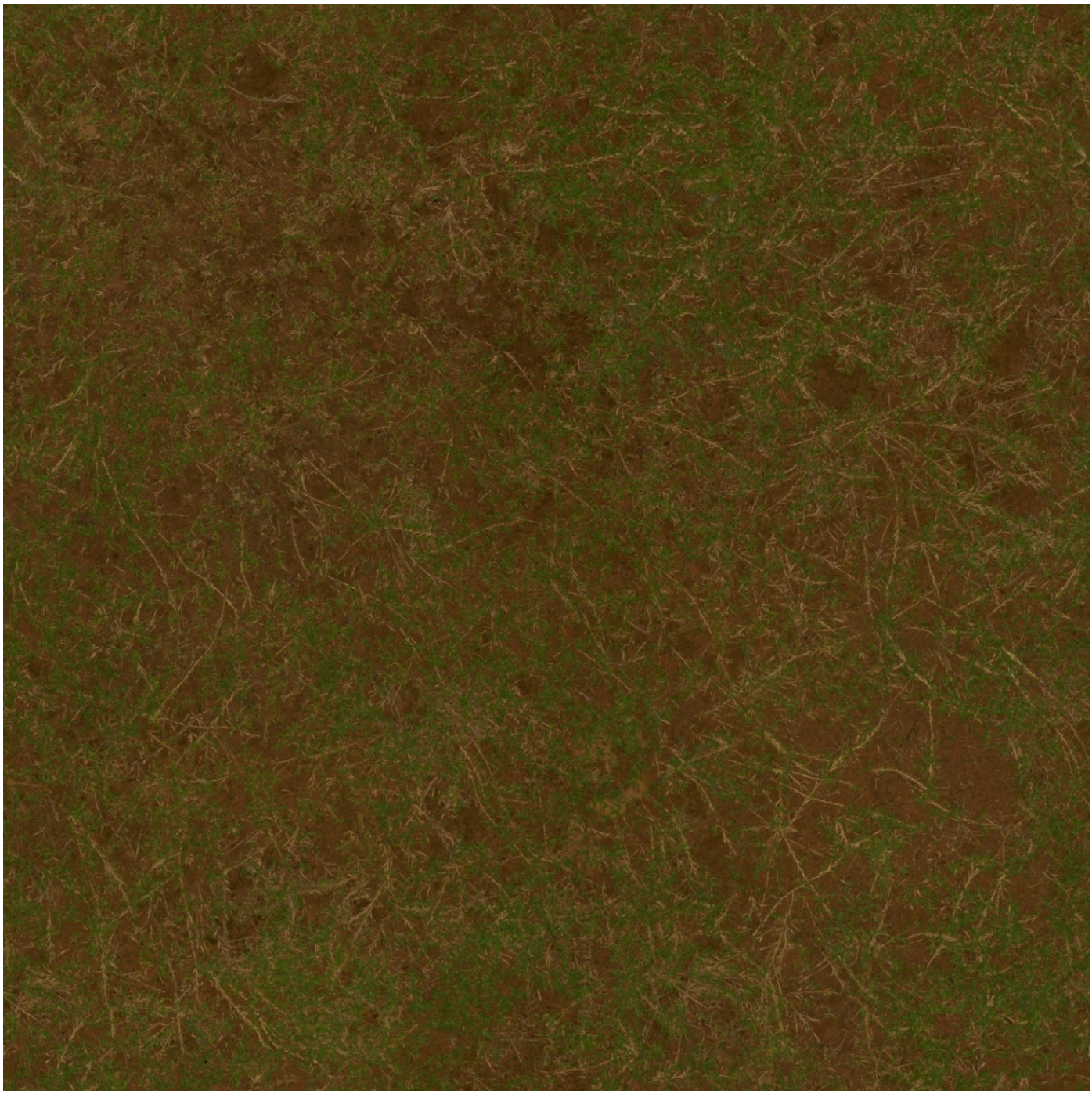


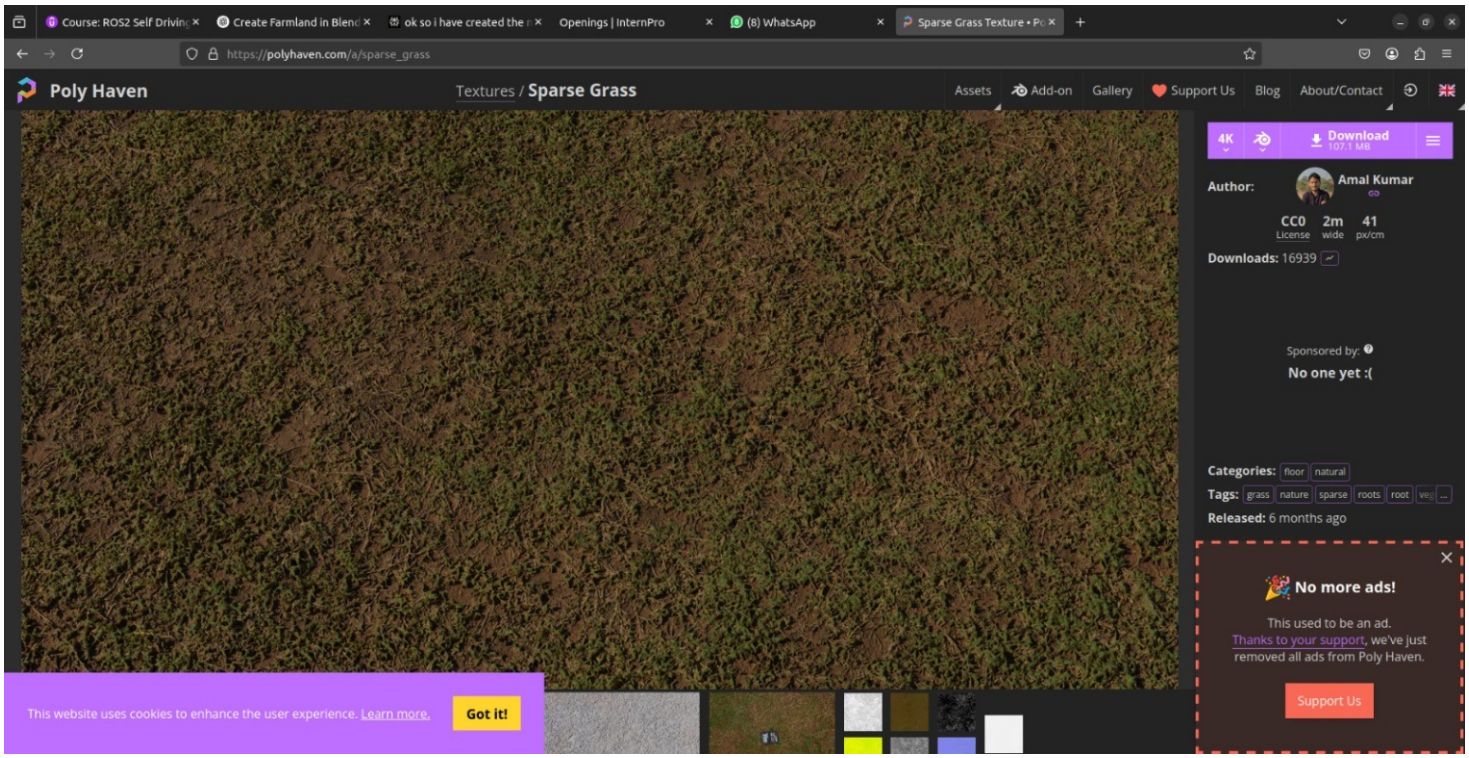


Action Item 3: Finding suitable Soil Texture and Applying in Blender – 3 hour(s).

Project Work Summary

- After sculpting the terrain for the custom map, the next step was to add a realistic soil texture. This was important to both make visual appeal and also to make the environment feel more immersive in the Gazebo simulation. A well-textured landscape enhances realism, making it easier to test Husky's navigation effectively.
- Finding the Right Soil Texture
  - Researching Texture Sources
    - Started by looking for high-quality PBR (Physically Based Rendering) textures that would make the terrain look as realistic as possible. After exploring different options, found the Poly Haven that contains a lot of resource that are free with high-quality textures designed for 3D environments.
  - Choosing the Best Texture
    - On Poly Haven's website, I browsed through their terrain textures, found the soil and ground textures. I was looking for something that closely resembled a real farmland surface that contains a mix of soil with sparse patches of grass for a natural look.
  - Downloading the Texture
    - SetOnce I found the perfect soil texture, I downloaded the full texture set, which included:
      - Base Color Map to define the surface's main color and appearance.
      - Normal Map to add fine surface details like bumps and grooves.
      - Roughness Map to control how shiny or matte the surface appears.
      - Displacement Map to create additional depth by adjusting the surface elevation.
  - Organizing Files

        - Saved all the textures in a dedicated folder on my farmland directory. A clean workflow helps when working with multiple assets in Blender.
- Applying the Texture in Blender
    - Switching to the Shading Workspace
        - With the terrain ready, I moved to Blender’s Shading tab to start applying the textures.
    - Creating a New Material
        - Selected the terrain mesh and created a new material in the Material Properties panel. This would serve as the base for my soil texture.
    - Setting Up the Node Network
        - Using Blender’s Shader Editor, I built a material network to apply the texture properly:
            - Base Color Texture → Connected to the Base Color input of the Principled BSDF shader.
            - Normal Map → Linked through a Normal Map node to add realistic surface bumps.
            - Roughness Map → Connected to the Roughness input to adjust surface reflectivity.
    - Adding Noise for More Realism
        - To make the soil look more natural and less uniform, I added some variation:
            - Inserted a Noise Texture node (Shift + A → Texture → Noise Texture).
            - Mixed it with the Base Color using a MixRGB node to create subtle variations in soil color.
            - Adjusted the scale and detail parameters to enhance the effect.
- 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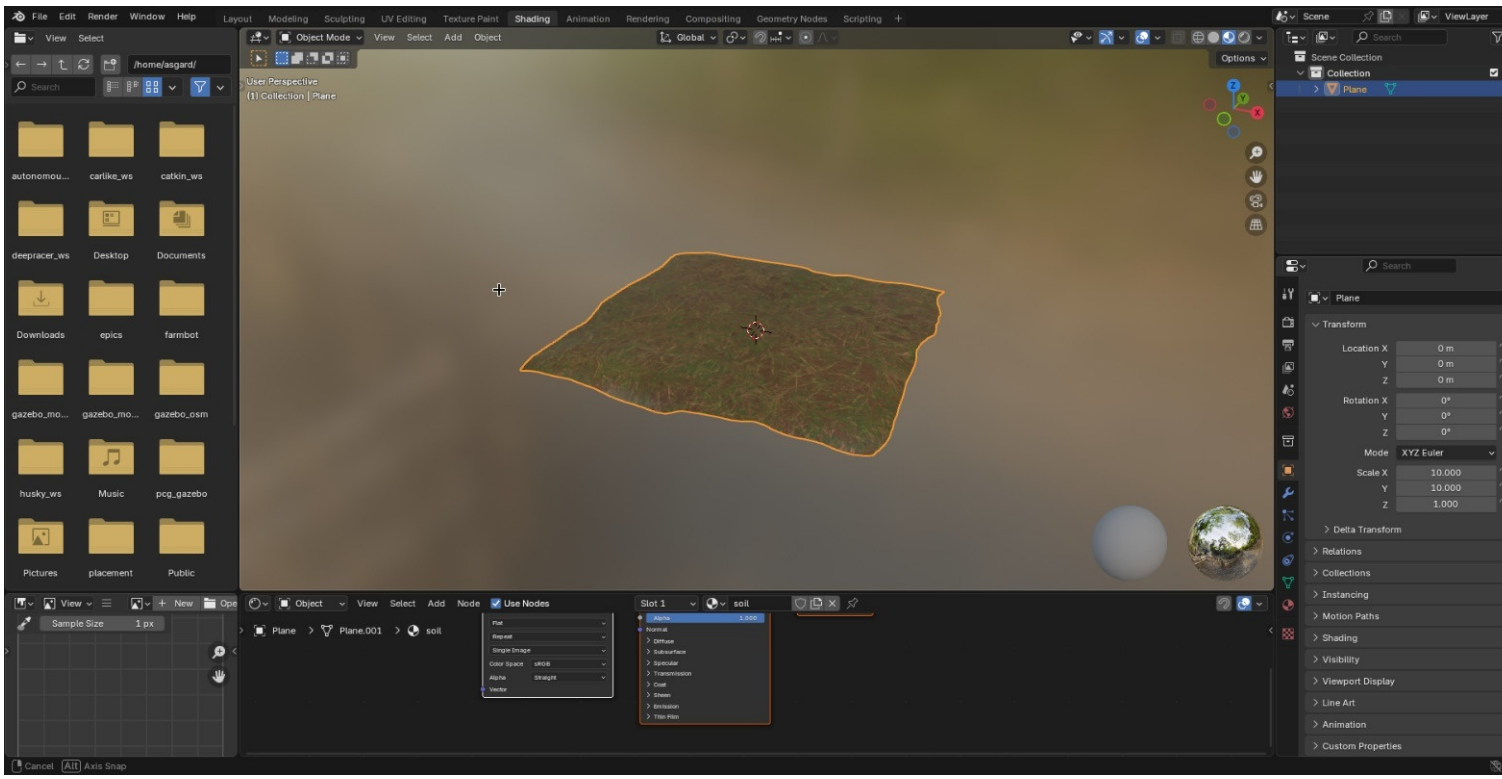
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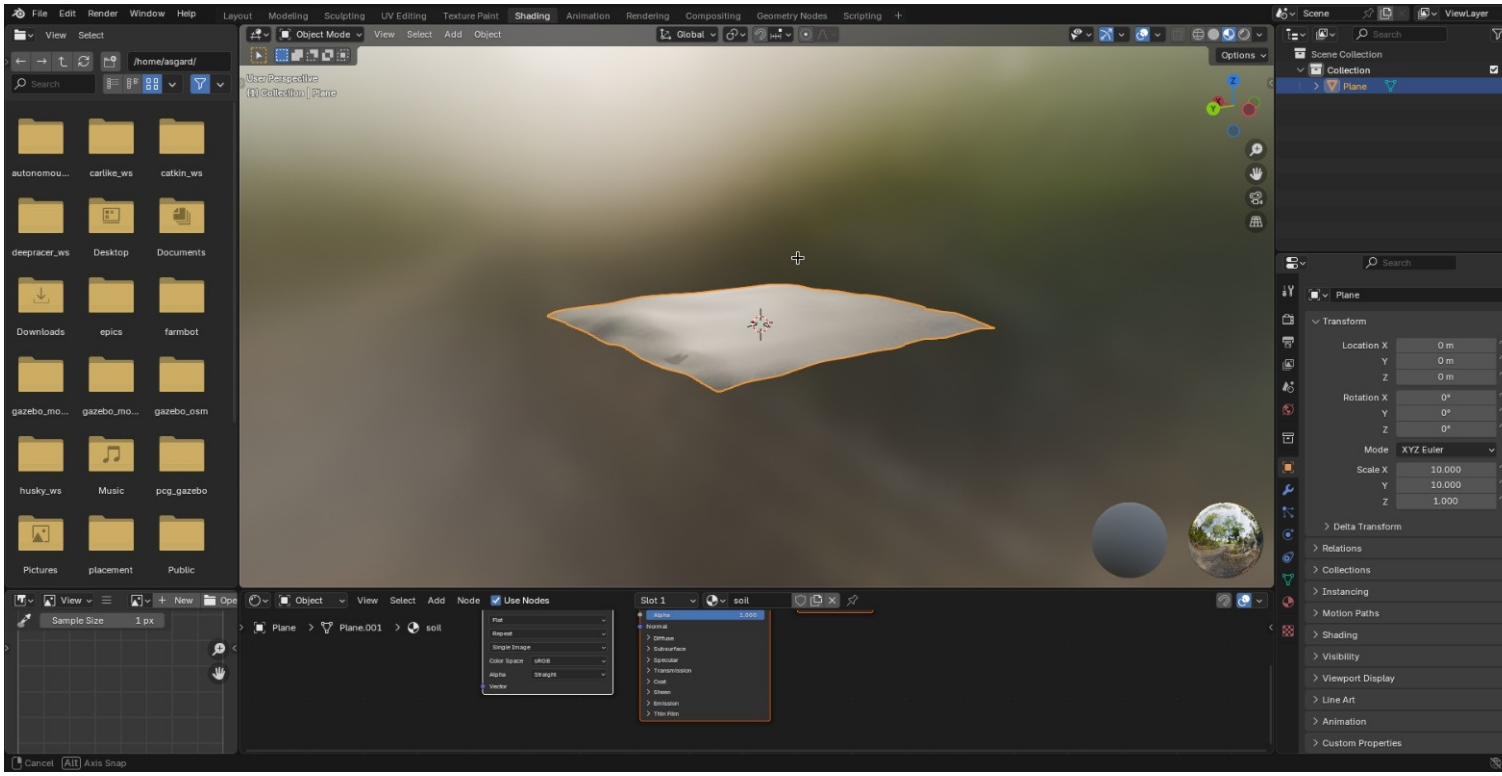
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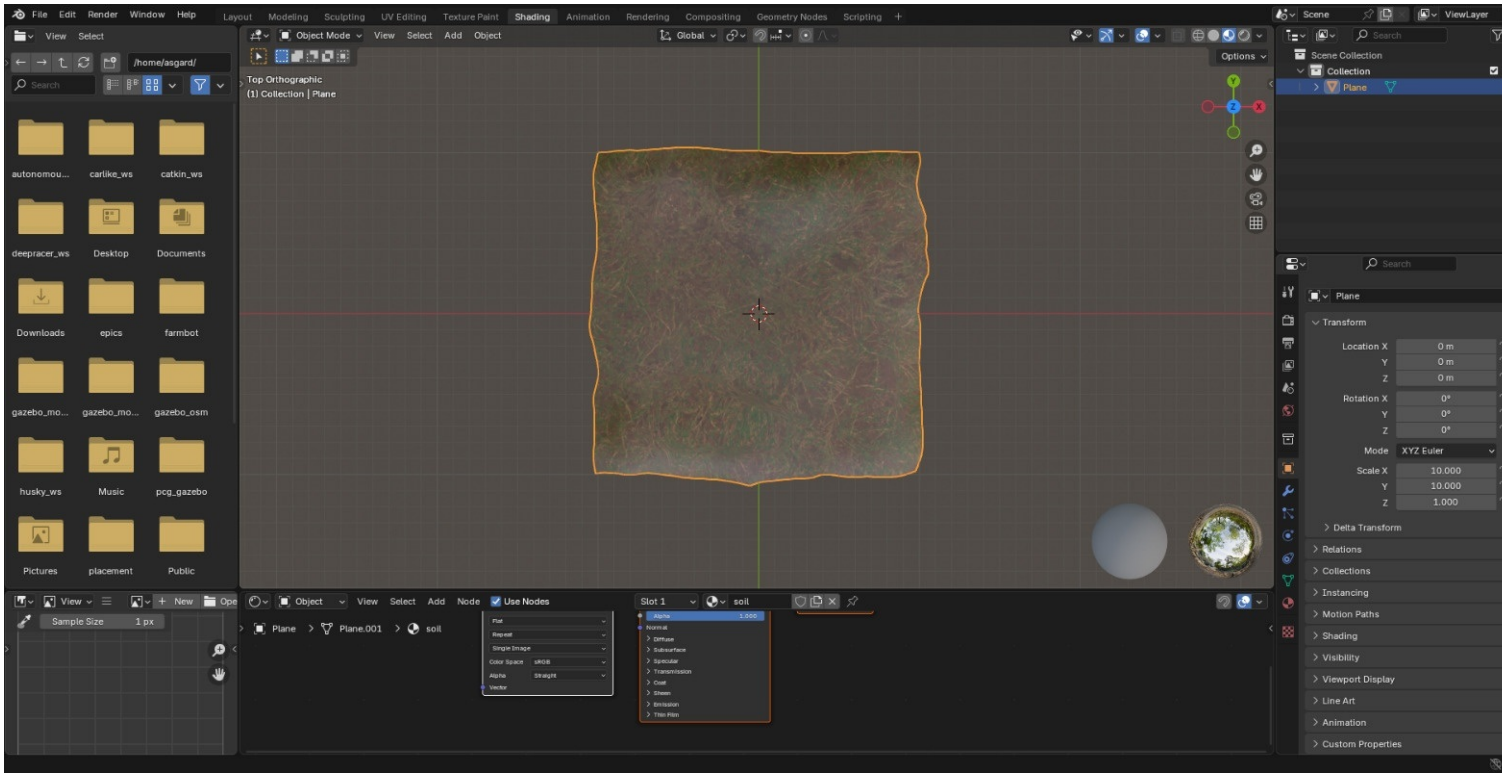
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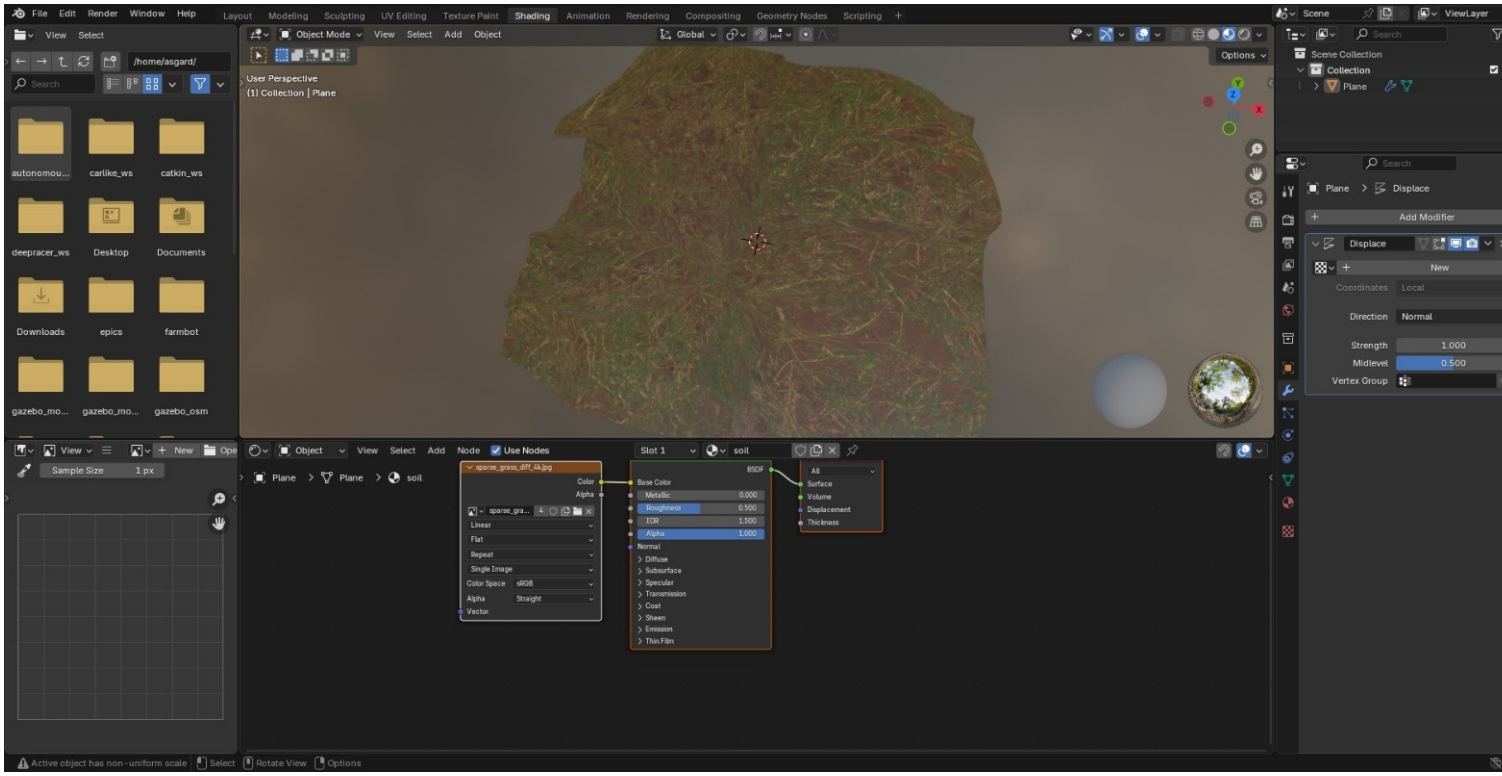
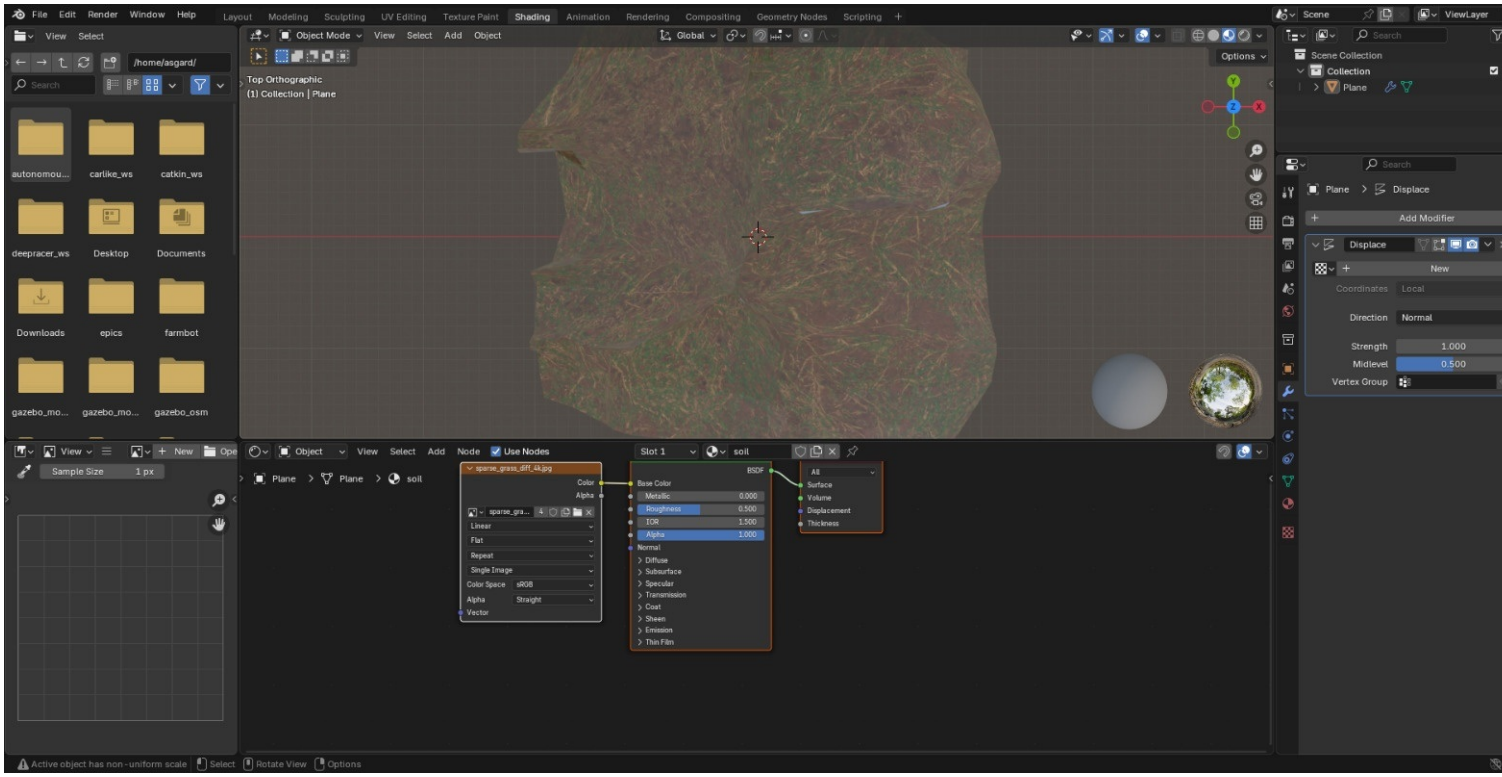


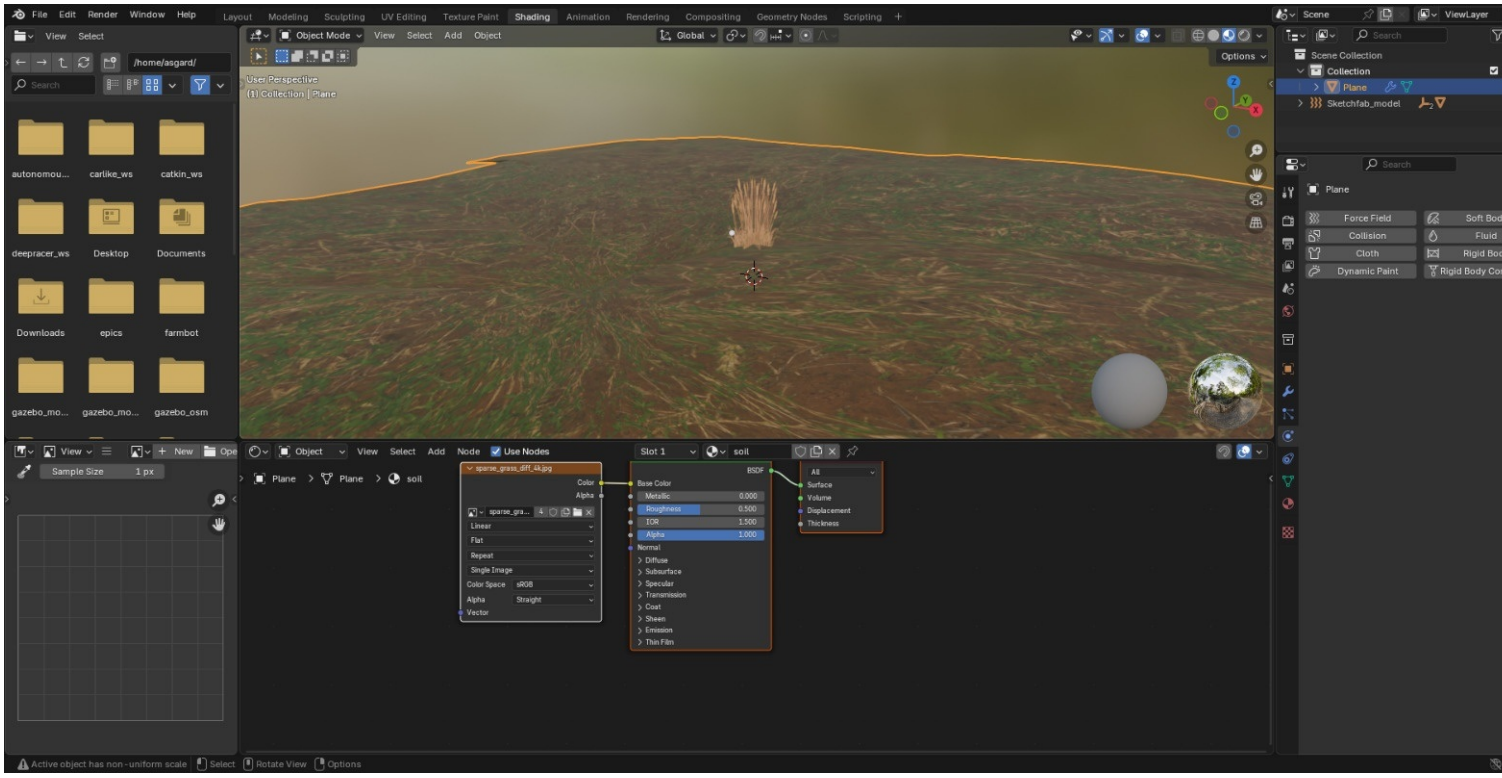


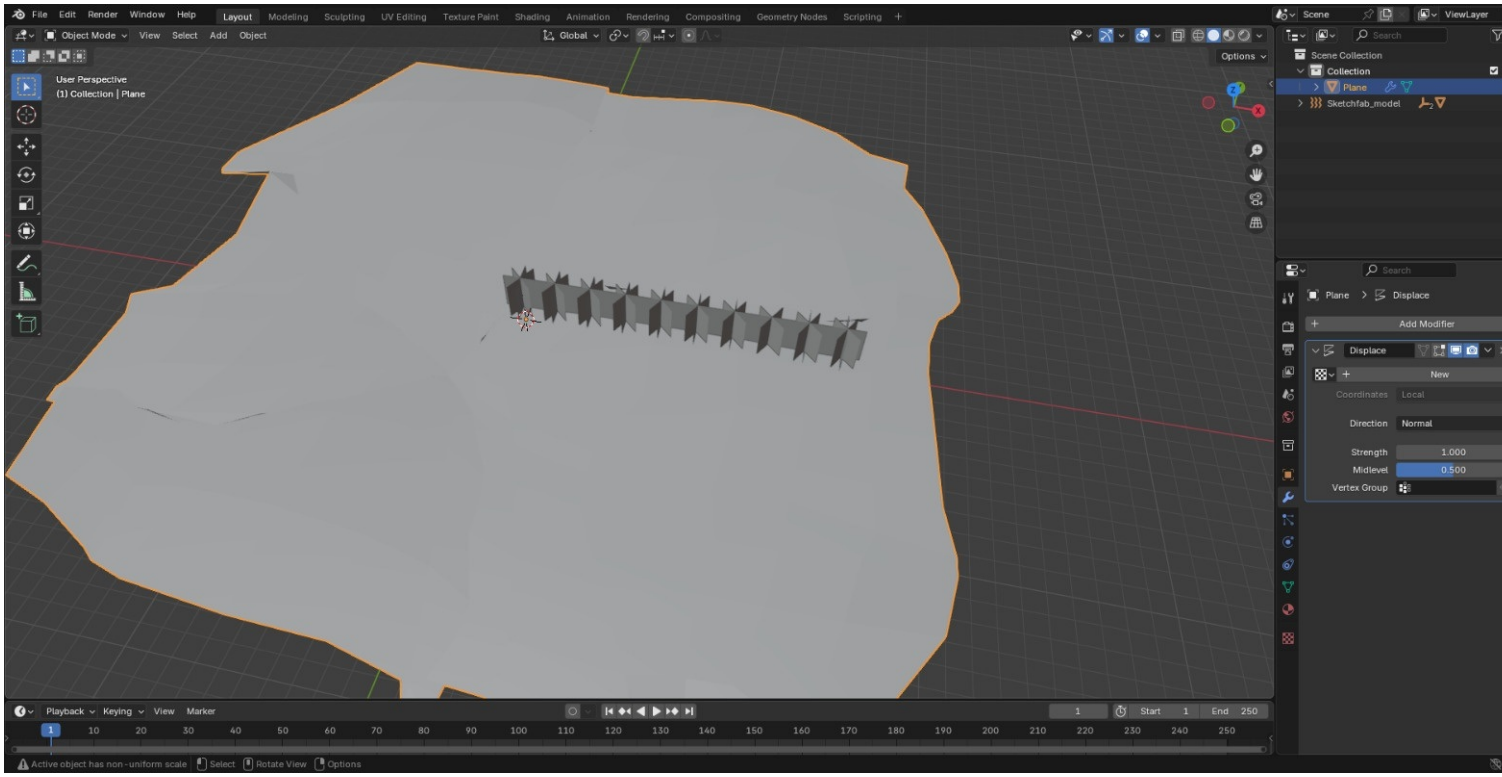
Action Item 4: Creating Crop rows in Blender – 3 hour(s).

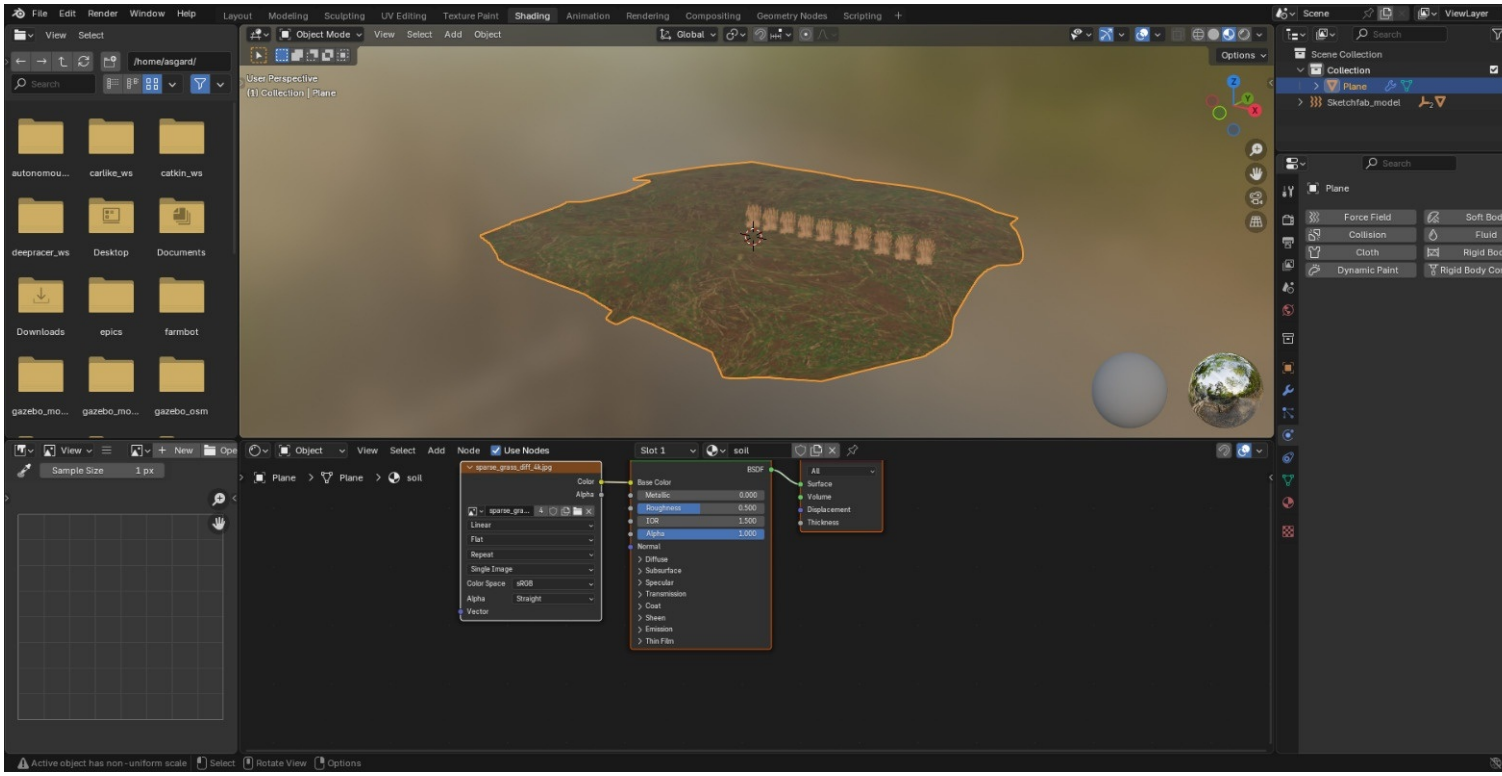
Project Work Summary

- To make the farmland look more realistic for Gazebo simulations, I worked on adding furrows (plowed fields) and crops (wheat) in Blender. This step not only improves the visual accuracy of the environment but also ensures that Husky's navigation is tested in a setting that mimics real-world conditions.
- Creating Furrows (Plowed Fields)
  - Preparing the Terrain
    - I started by selecting the sculpted farmland terrain and applied a Displacement Modifier to add the furrow details.
  - Generating the Furrow Pattern
    - To create the characteristic ridges and grooves of a plowed field, I used one of two approaches:
      - Custom Height Map: I designed a black-and-white height map with wavy lines—white areas representing raised ridges and black areas forming the grooves.
      - Pre-made Textures: As an alternative, I searched for seamless furrow textures from resources like Poly Haven or OpenTopography.
- Applying the Displacement Modifier
  - Loaded it as a texture in the Displacement Modifier.
  - Adjusted the Strength to control the depth of the furrows and fine-tuned the Midlevel to set the base elevation.
  - Increased subdivisions to ensure smooth and realistic furrow shapes.
- This gave the farmland a properly plowed appearance, making it more suited for an agricultural simulation.
- Adding Crops (Wheat)
  - Finding the Right Wheat Model

        - To add wheat crops, I searched for low-poly wheat models on Sketchfab, ensuring compatibility with Gazebo for real-time simulation. I found the "Wheat Field" model by Buncic, which featured both ripe and green wheat variations. I downloaded the model in FBX/OBJ format and saved it locally.
    - Importing and Adjusting the Wheat Model
        - Imported the wheat model into Blender (File → Import → FBX/OBJ).
        - Scaled it to match the terrain's dimensions.
        - Optimized the geometry if needed, reducing complexity for better performance in Gazebo.
    - Distributing the Wheat Using a Particle System
        - To spread the wheat across the farmland, I used Blender's Particle System:
        - Selected the terrain and added a new Particle System.
        - Assigned the wheat model as the particle object.
        - Tweaked the settings to make it look more natural:
            - Density: Controlled how closely crops were spaced (e.g., 0.5 for sparser fields).
            - Scale Randomness: Added slight variations (0.2–0.5) to make the wheat look less uniform.
            - Rotation: Enabled Random and Dynamic rotation to mimic the effects of wind.



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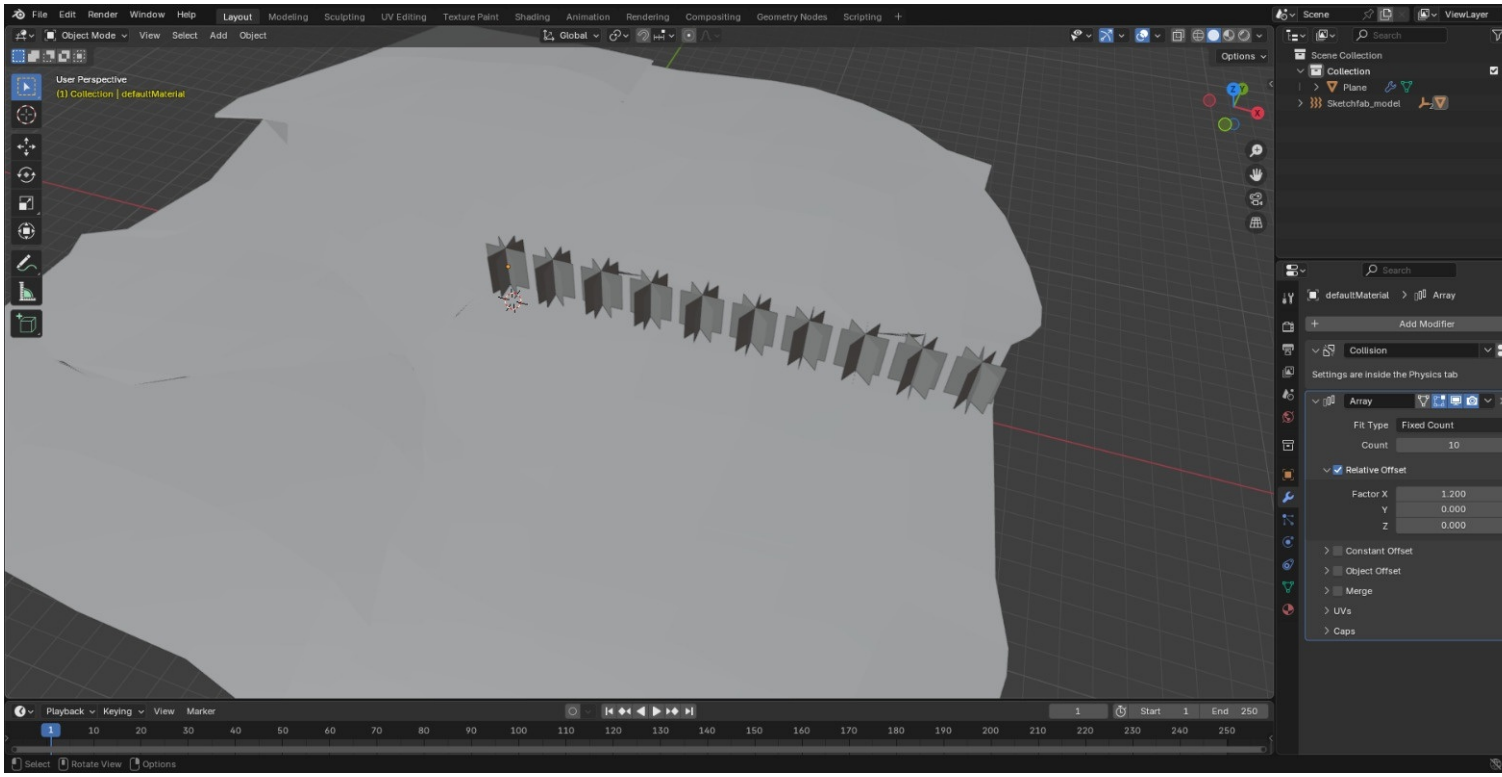
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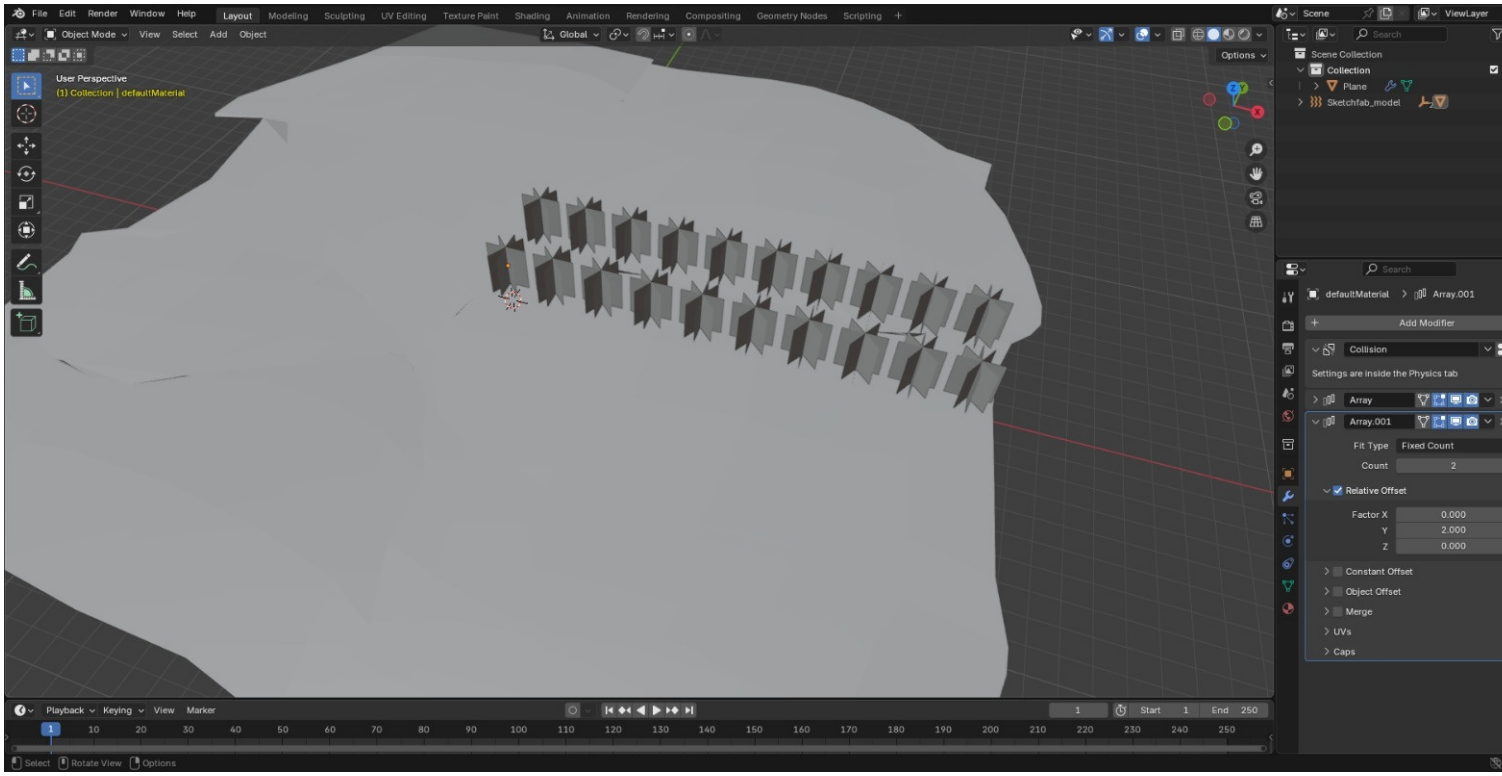
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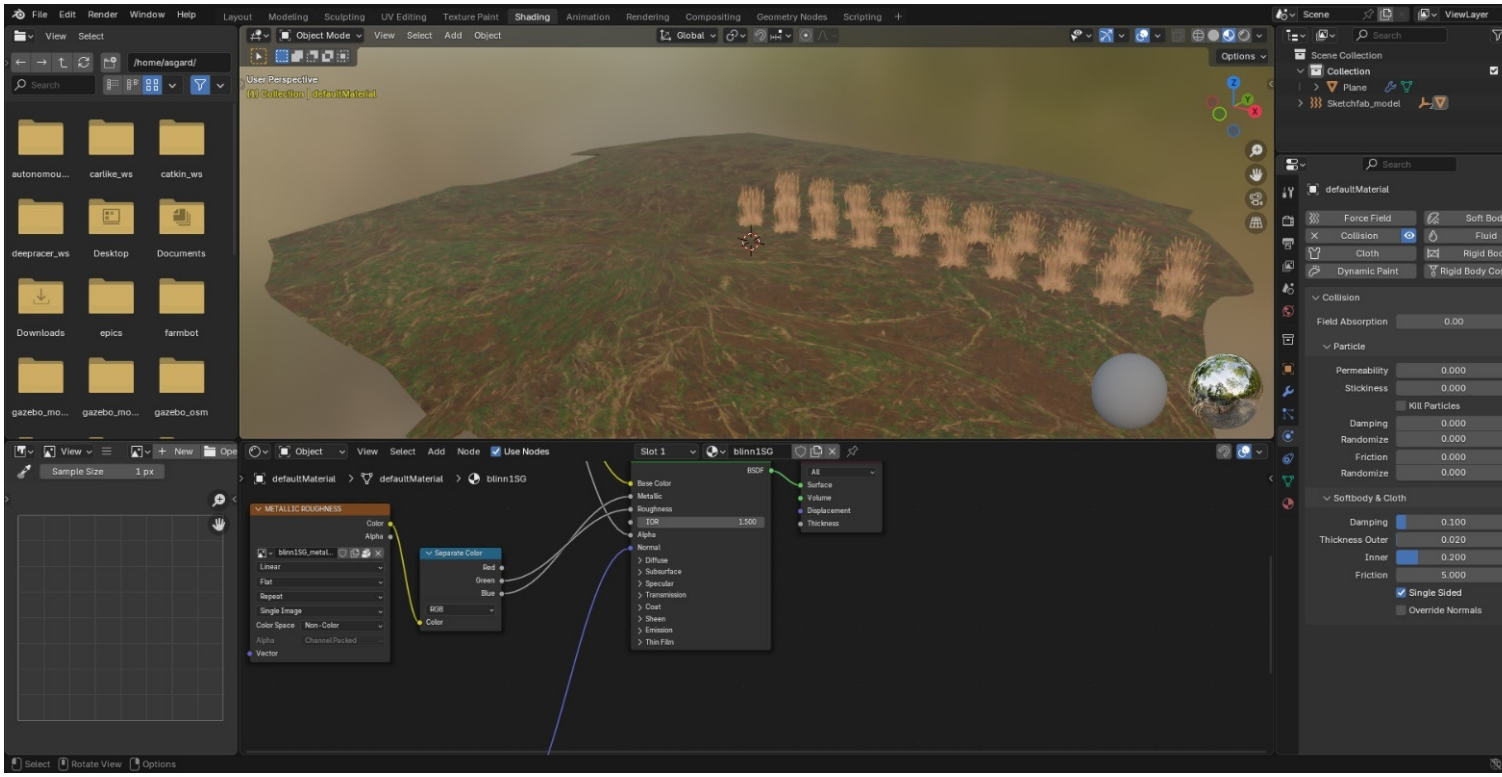
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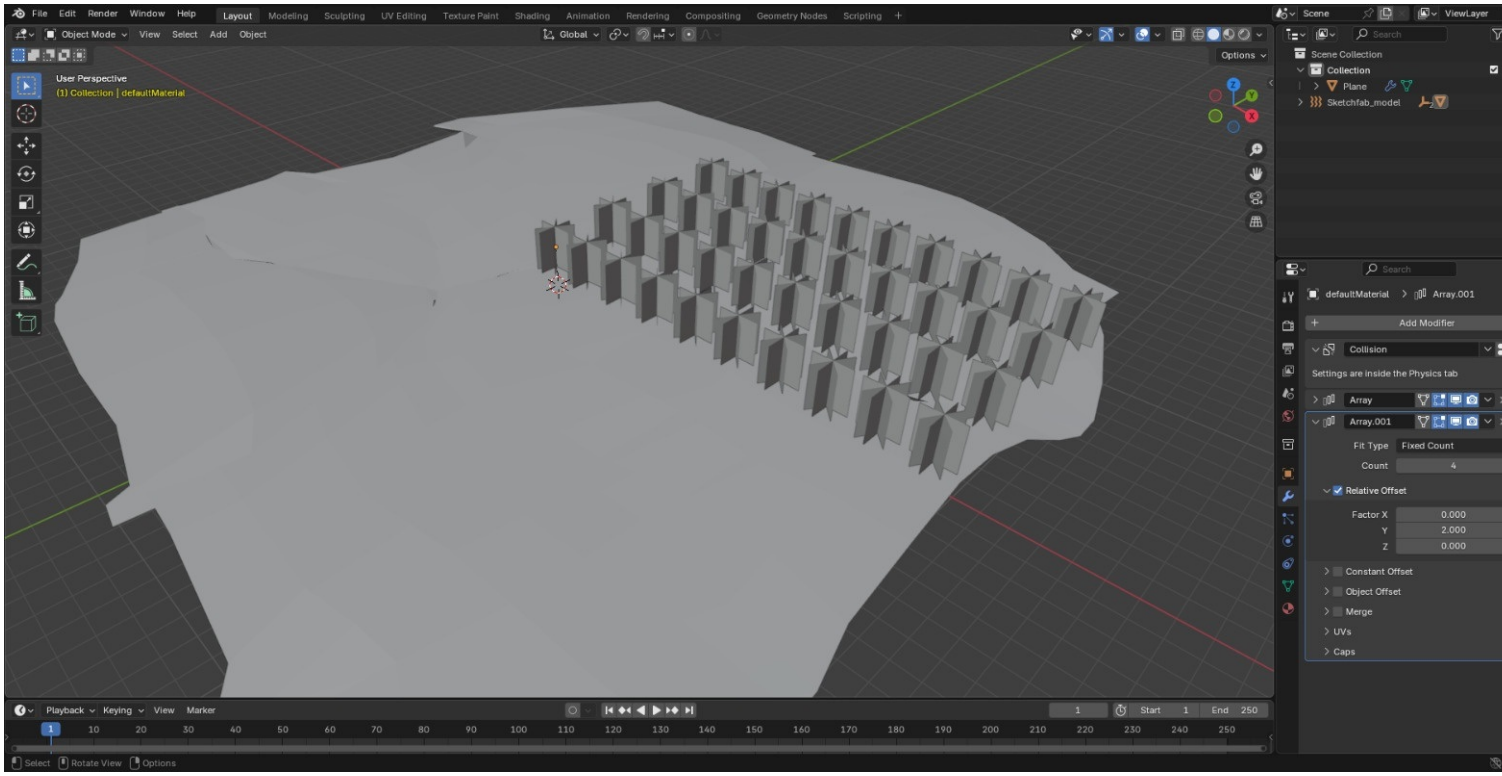
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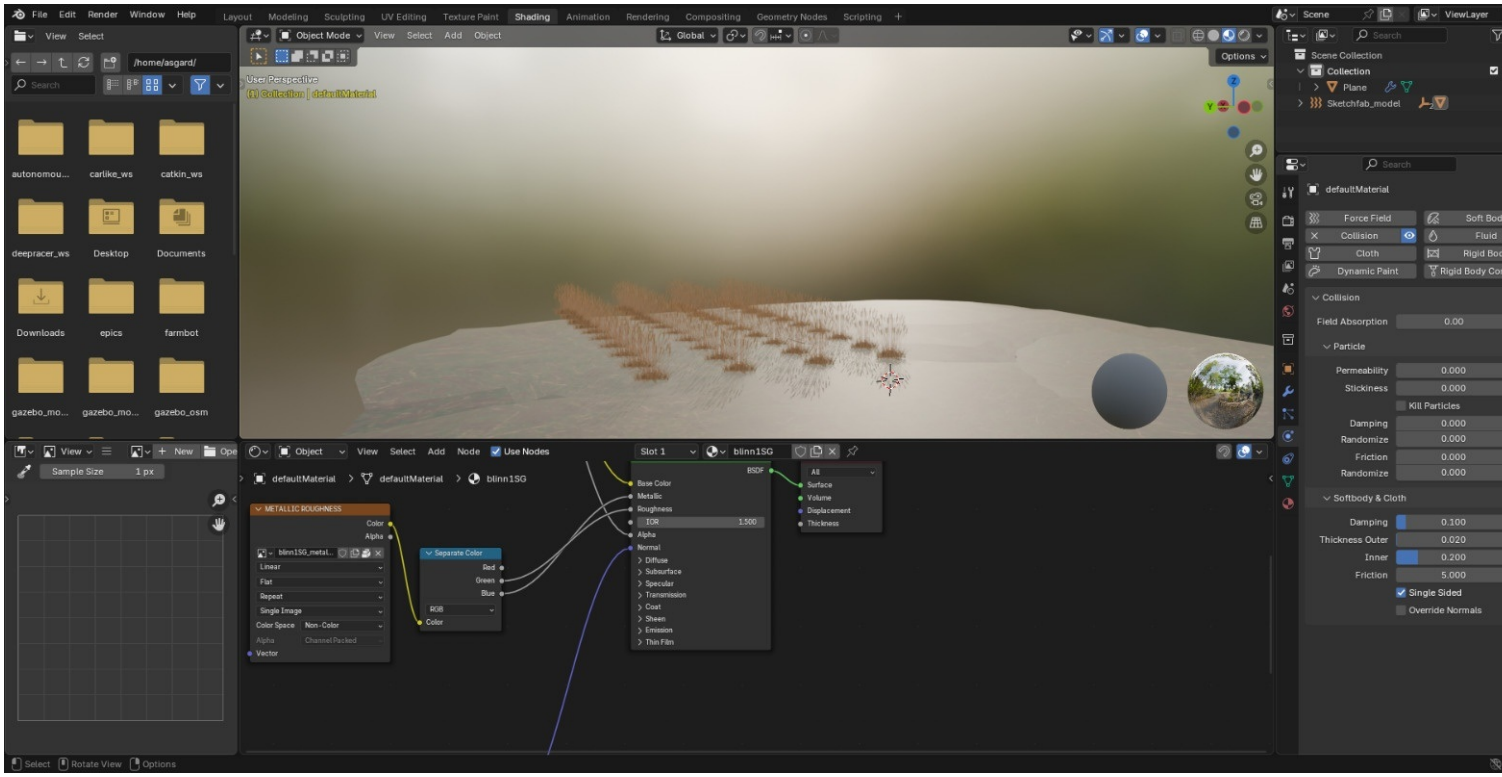
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Kill Particles
Damping
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Randomize
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Friction
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Randomize
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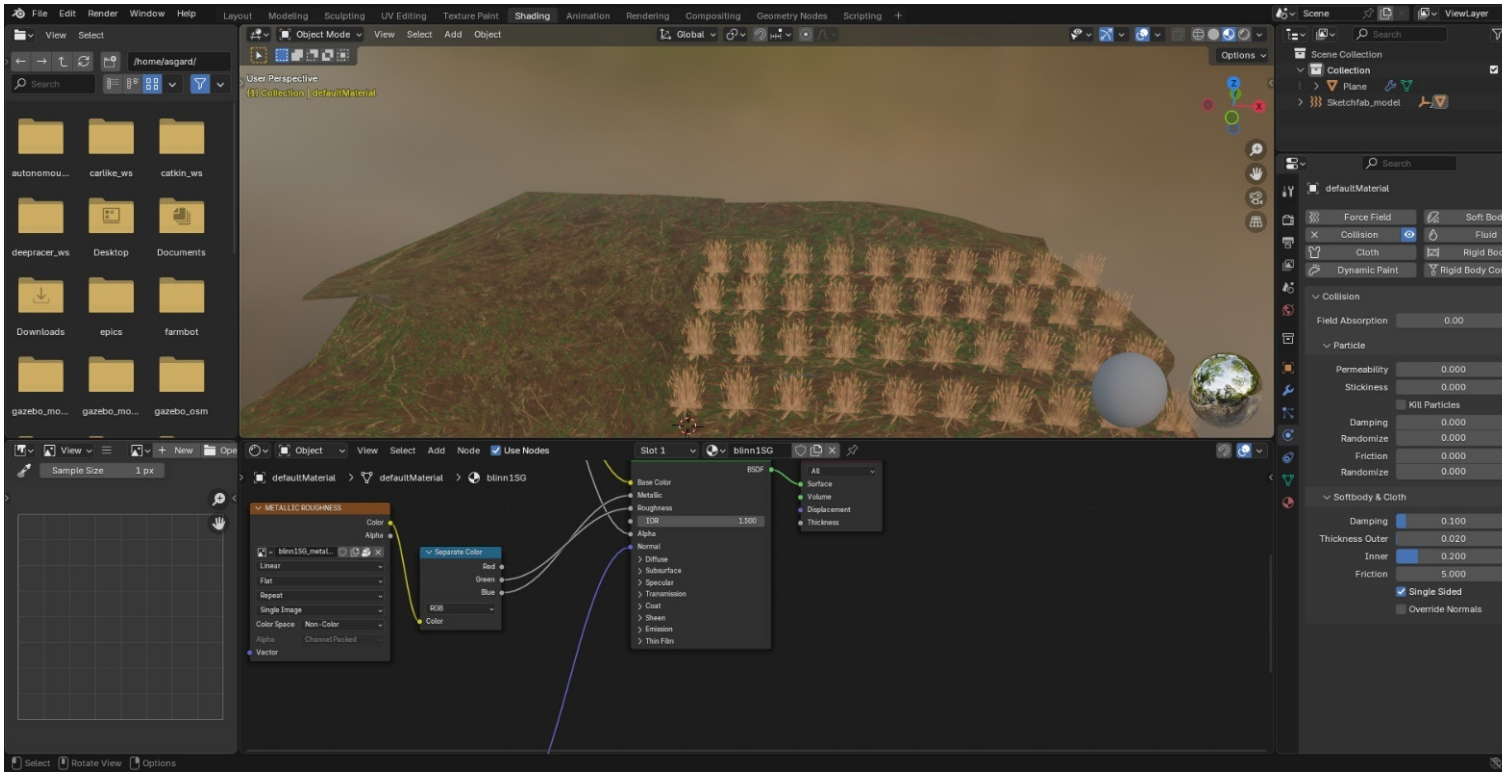
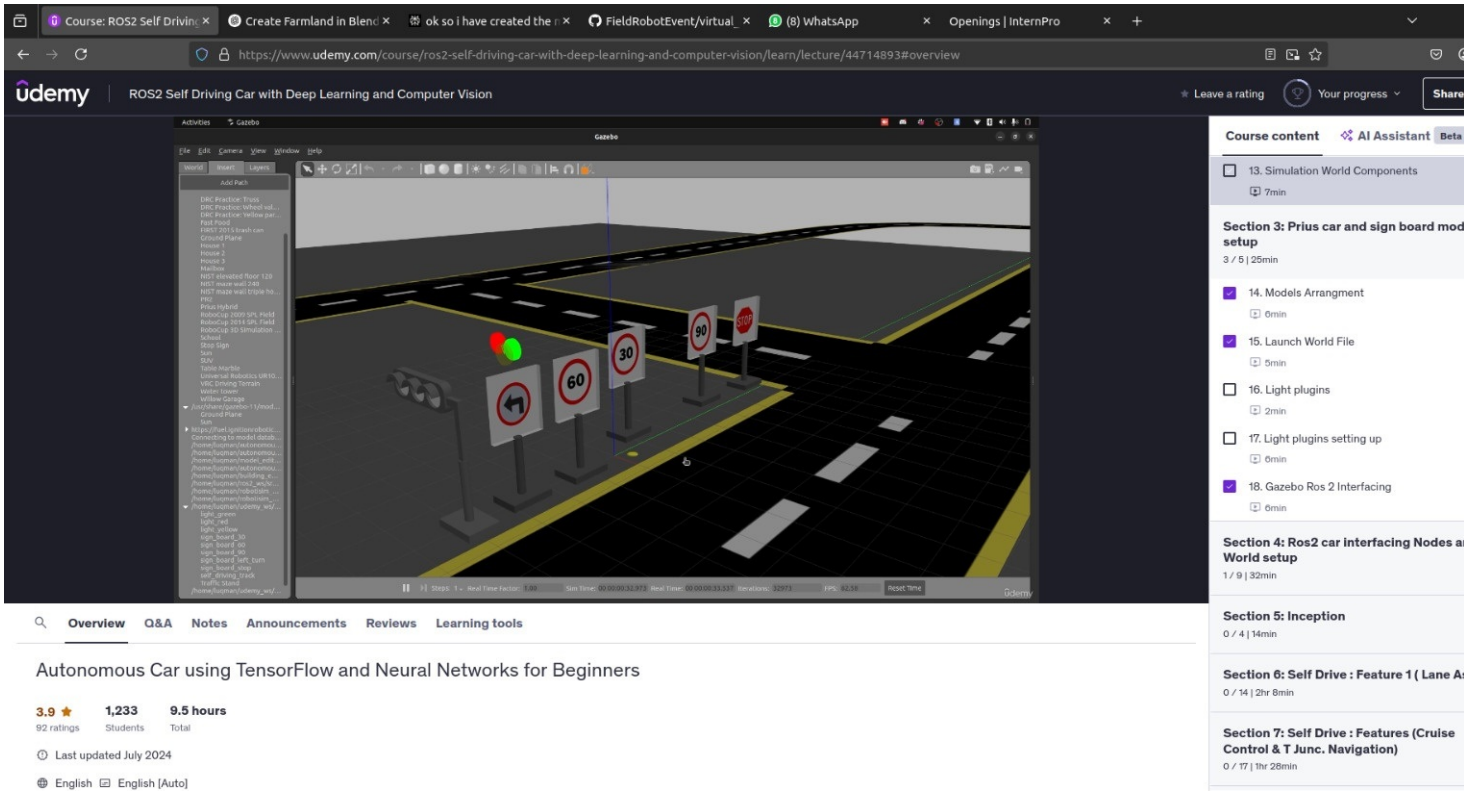


Action Item 5: Procedural Generation and Blender Integration for Farmland Simulation – 3 hour(s).

Research

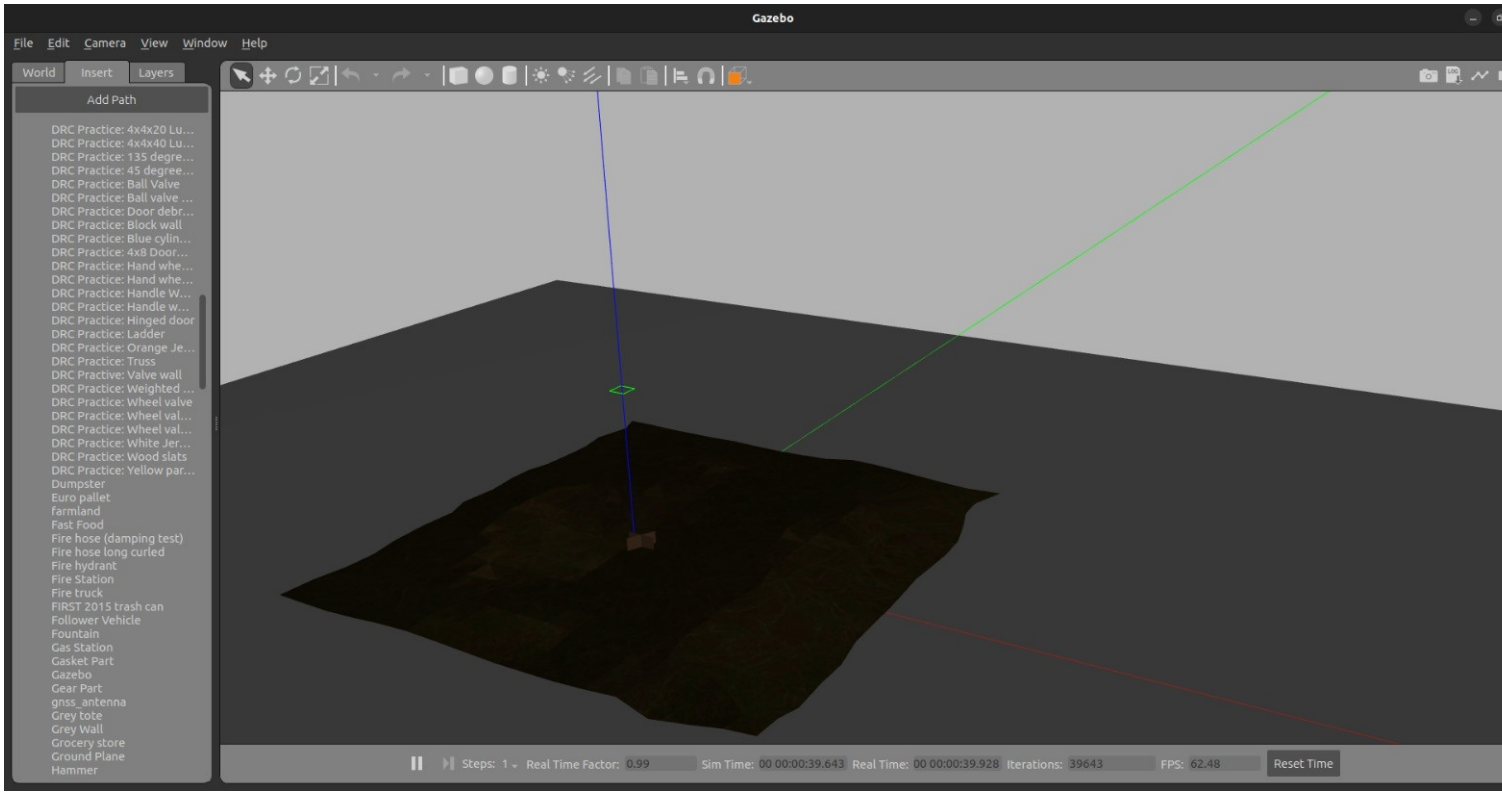
- https://github.com/FieldRobotEvent/virtual_maize_field
- Procedural Generation and Blender Integration for Farmland Simulation
- Summary of Report
  - The generate_world.py script automates farmland creation by defining parameters like: Row length (default: 12m), Plant spacing (0.13–0.19m) and Ground elevation (up to 0.2m). To add realism, the script introduces randomized plant placement errors (±0.02m) and holes in crop rows, mimicking real-world inconsistencies. This removes the need for manual design, making robotic simulation setup much more efficient.
  - The tool offers granular control over the environment: Row Design: Rows can be straight, curved, or sinusoidal, with curvature adjustable up to 1.57 rad. Ground Features: Users can set ditch depths (0.3m), headland size (2m), and ground resolution (0.02m/pixel) to create irrigation channels and field boundaries. Vegetation & Obstacles: Plants can have randomized heights (0.3–0.6m), and extra elements like weeds or litter (e.g., nettles, coke cans) can be added to test navigation in cluttered fields.
  - The generated worlds are fully compatible with ROS 2 Humble, supporting both Gazebo Classic and Ignition Gazebo. The package includes pre-configured launch files (e.g., jackal_simulation.launch), making it easy to integrate Clearpath Jackal and other agricultural robots for navigation testing.
- Relation to Project
  - Previously, designing a virtual farmland required manually sculpting terrain and placing crops in Blender, which was time-consuming. With this tool, I could automate base map generation, creating randomized rows, holes, and elevation changes instantly. For example: Using fre21_task_2, I generated straight rows with holes. The fre22_task_navigation preset added curved rows and obstacles, perfect for testing Husky's path-planning algorithms.
  - While the procedural tool created a solid base, I imported the .world file into Blender to refine details like: Adding furrows using displacement modifiers for a more natural plowed look. Manually adjusting crop placements to test specific navigation scenarios.
  - This package's native ROS 2 support solved previous integration challenges I faced with ROS 1-based worlds. I could directly spawn the Husky robot into the generated world using robot_spawner.launch, streamlining navigation algorithm testing.
- Motivation for Research
  - Creating farmland in Blender manually takes hours—this tool cuts setup time by 90%. I could iterate quickly to test different layouts, such as: Dense maize fields (--plant_spacing_max 0.19, --rows_count 8) generated in under 10 seconds. Sparse crop environments to evaluate Husky's pathfinding in open fields.
  - By tweaking parameters like: ground_ditch_depth 0.3, I simulated challenging terrains with deeper ditches, testing Husky's slope-handling capabilities. weed_types dandelion, I introduced random obstacles, helping refine Husky's obstacle detection accuracy.
  - With the terrain automatically generated, I could spend more time improving navigation algorithms rather than manually modeling environments. Predefined configurations like fre22_task_mapping_mini served as benchmark test worlds, while Blender allowed fine-tuning for more complex features like textured furrows.



Action Item 6: Exporting a Blender Map to Gazebo – 3 hour(s).

Project Work Summary

- After finalizing the farmland terrain in Blender, the next step was to export it to Gazebo while ensuring all dependencies—such as wheat, grass, and textures—were properly integrated. This setup allows Husky to navigate the map in simulation without rendering or pathing issues.
- Steps to Export and Import the Map
  - Apply Transforms in Blender
    - Before exporting, I selected the entire terrain model (press A) and applied all transformations (Ctrl + A → All Transforms). This step resets the model's scale, rotation, and location to default values, preventing unexpected behavior in Gazebo.
  - Export as Collada (.dae)
    - Used File → Export → Collada (.dae).
    - Enabled Include UV Textures and Include Material Textures to ensure all texture paths were embedded.
    - Saved the .dae file in a dedicated folder along with all texture files (e.g., soil, grass, wheat).
  - Create Model Files
    - To make the terrain compatible with Gazebo, I created two key files:
    - Model Config File (model.config) – Includes metadata like the map name, version, author, and description, helping Gazebo recognize the model.
    - SDF File (model.sdf) – Defines the terrain's geometry, textures, and dependencies (such as wheat and grass models). The <mesh> tags reference the .dae file, while <pose> values ensure proper alignment in the simulation.


Gazebo
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Dumpster
Euro pallet
farmland
Fast Food
Fire hose (damping test)
Fire hose long curled
Fire hydrant
Fire Station
Fire truck
FIRST 2015 trash can
Follower Vehicle
Fountain
Gas Station
Gasket Part
Gazebo
Gear Part
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Grey tote
Grey Wall
Grocery store
Ground Plane
Hammer
Steps: 1 Real Time Factor: 0.99 Sim Time: 00 00:00:39.643 Real Time: 00 00:00:39.928 Iterations: 39643 FPS: 62.48
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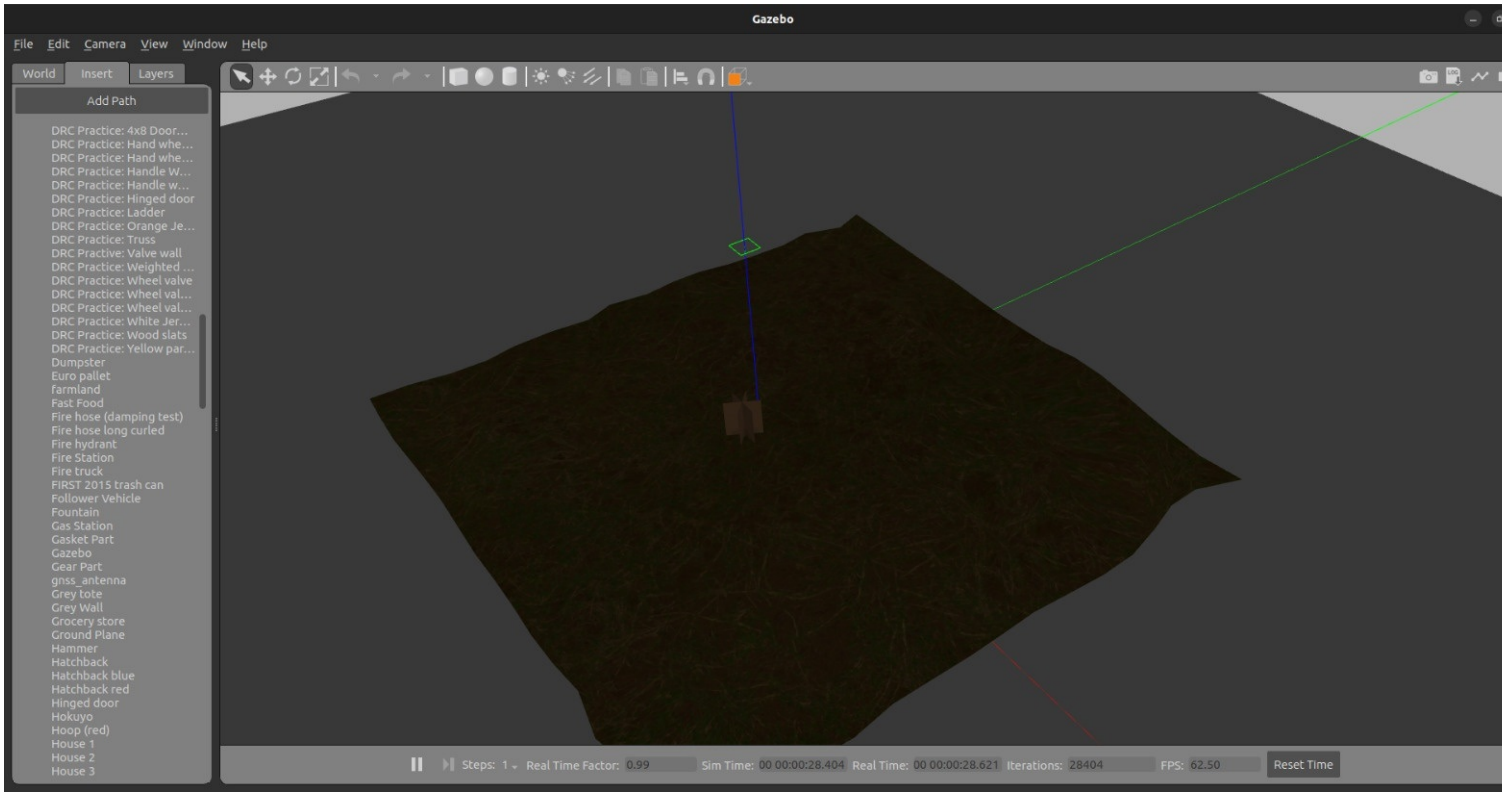
Gazebo
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Dumpster
Euro pallet
farmland
Fast Food
Fire hose (damping test)
Fire hose long curled
Fire hydrant
Fire Station
Fire truck
FIRST 2015 trash can
Follower Vehicle
Fountain
Gas Station
Gasket Part
Gazebo
Gear Part
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Grey tote
Grey Wall
Grocery store
Ground Plane
Hammer
Hatchback
Hatchback blue
Hatchback red
Hinged door
Hokuyo
Hoop (red)
House 1
House 2
House 3
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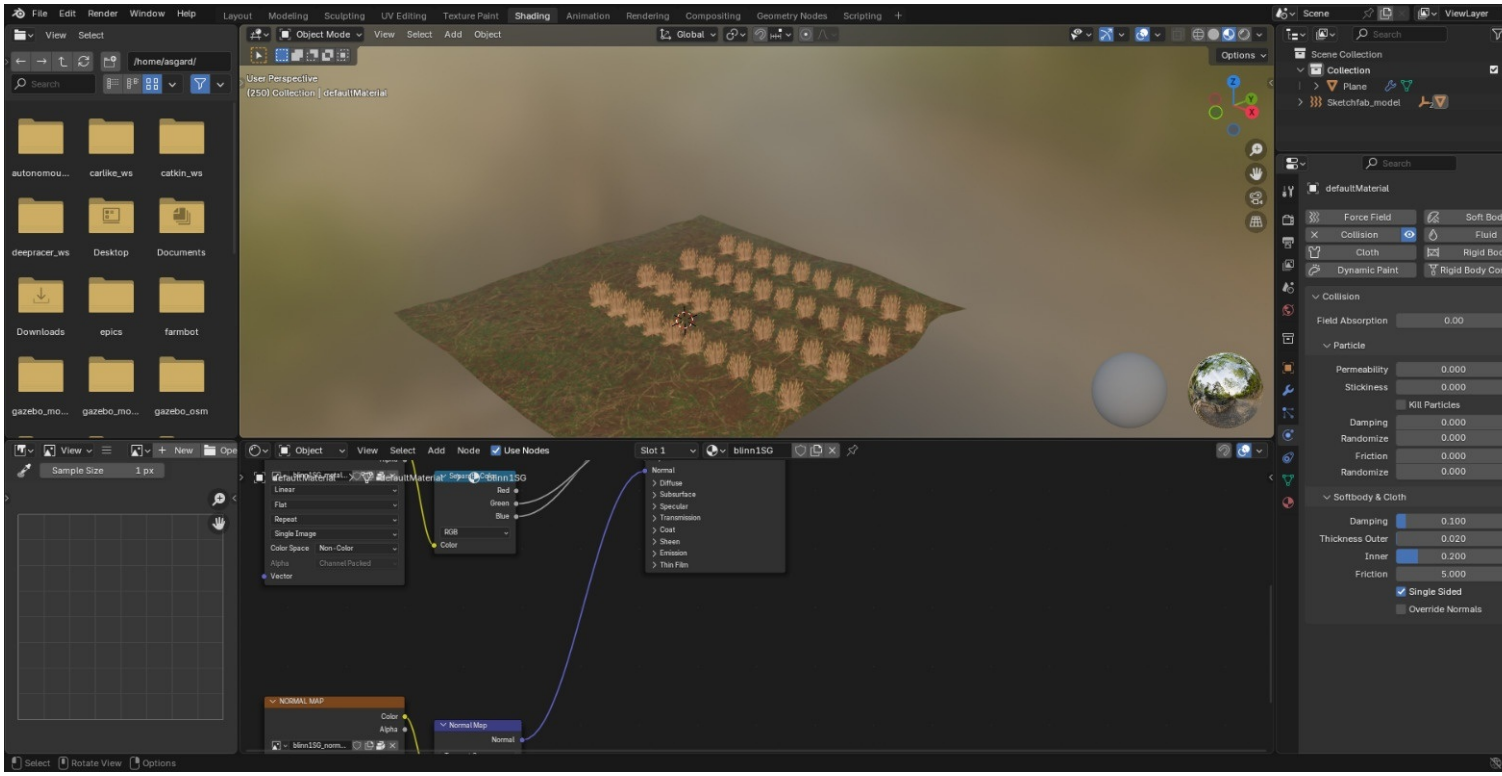
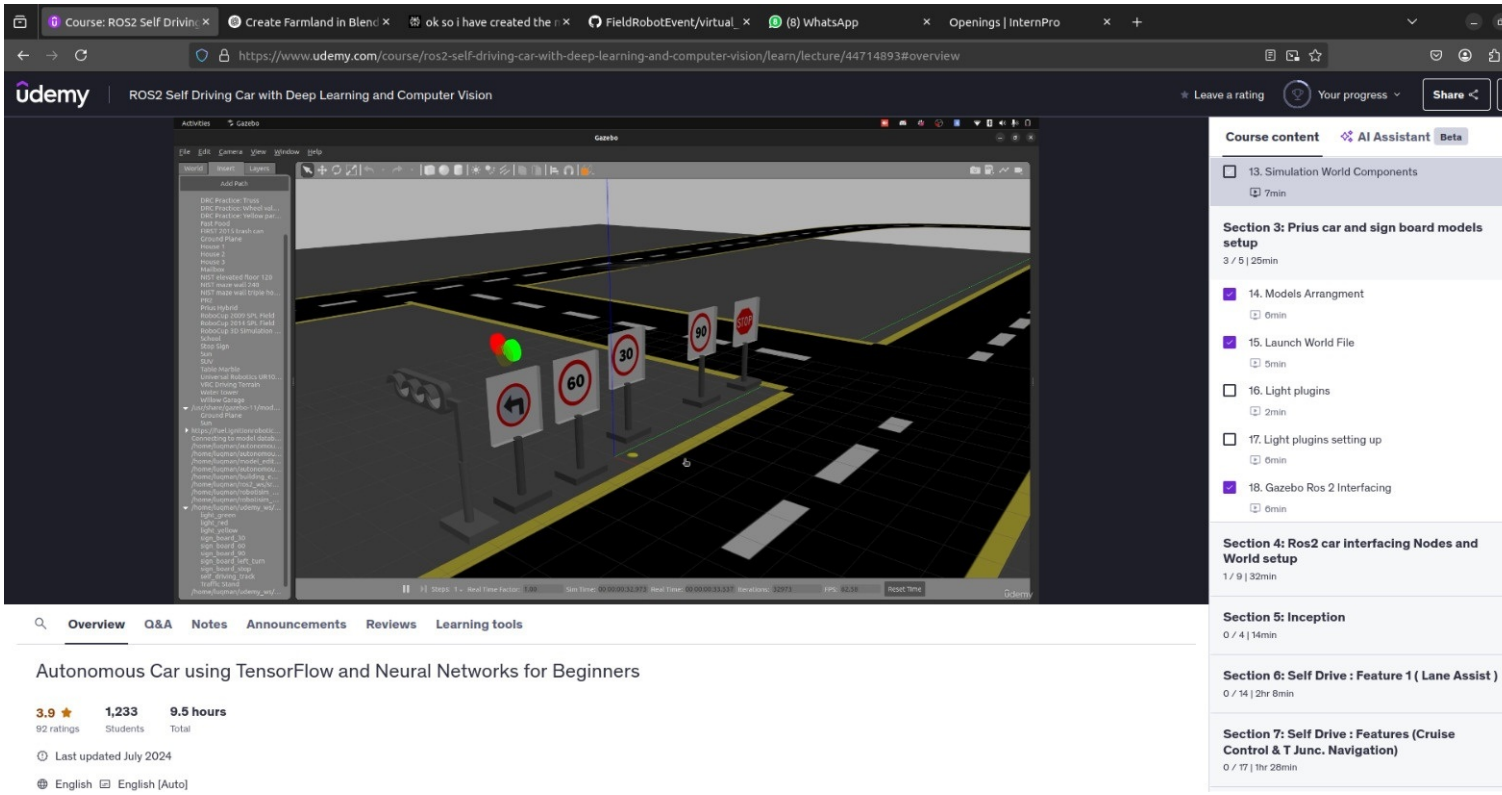


Action Item 7: Weekly Plan for Next Week – 1 hour(s).

Project Work Summary

- Update the map further to make sure the crops created in the blender translates properly to the gazebo map.
- Refine the husky_mover.py script in the husky_control package to improve navigation efficiency in the FarmWithCropRow.world.
- Update Husky's SDF model and crop collision properties to prevent unrealistic interactions.
- Test Husky's ability to traverse corner-to-corner in procedurally generated maps.
- Configure Nav2 and test SLAM-based navigation using the husky_cartographer_navigation package.



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.