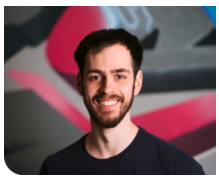
Autonomous Pickup of Bagged Soil Samples

Master's Project Thesis Mechatronics and Automation Spring Semester 2026

Student



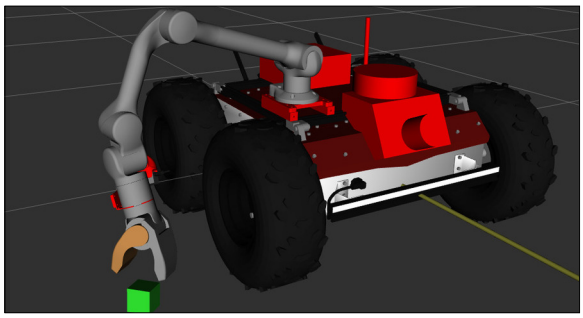
Jonas Scholz

Definition of Task: The objective of this project is to integrate a Unitree Z1 Pro robotic arm with the Husarion Panther mobile platform to create an autonomous mobile manipulator capable of performing complex tasks in dynamic environments. The Z1 Pro is equipped with an eye-in-hand camera for object detection and perception-guided manipulation, and the entire architecture is integrated via Robot Operating System 2 (ROS 2). A secondary objective is to implement an initial soil sample collection use case. In this scenario, samples previously extracted are scattered across a field with roughly known coordinates. The manipulator must then navigate autonomously to the target region, execute a search algorithm and collect the samples.

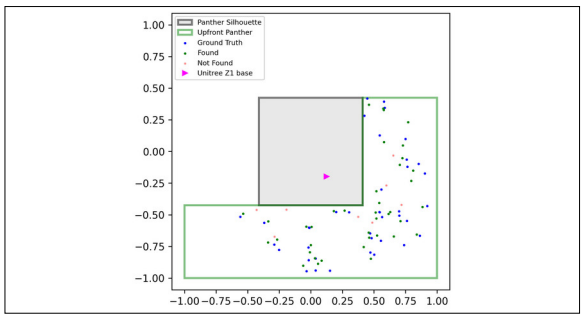
Result: To facilitate sample collection, a modified greedy search algorithm was developed. This algorithm samples and evaluates multiple candidate camera postures using a custom scoring function, iterating N times or until the search area reaches 99% coverage. This function evaluates the newly covered area with each iteration, penalising excessive translational and rotational camera displacement while rewarding overlap with previously searched regions, thus ensuring efficient robotic arm movements. The soil sample, simulated using a cube with ArUco markers, is dynamically added to the planning scene upon detection. A combination of marker-based localisation and efficient point cloud filtering determines the cube's precise pose. The estimated marker coordinates define a narrow bounding box that aggressively filters the camera's point cloud data to minimise computational overhead. Finally, the pick-and-place task is planned using the MoveIt Task Constructor (MTC). Rather than using rigidly hardcoded trajectories, the MTC defines the task via distinct stages and constraints, maximising operational flexibility.

Conclusion: The initial iteration was evaluated in a simulated environment. The results demonstrate that the proposed algorithm efficiently explores the target area. The combination of stochastic spatial sampling and the multi-objective scoring function successfully balances coverage metrics with movement efficiency. This inherent randomness provides an operational advantage: if a target is occluded, subsequent attempts naturally explore the workspace from different angles. Under current testing conditions, samples located in the robot's primary frontal workspace are detected in the first iteration 85% of the time.

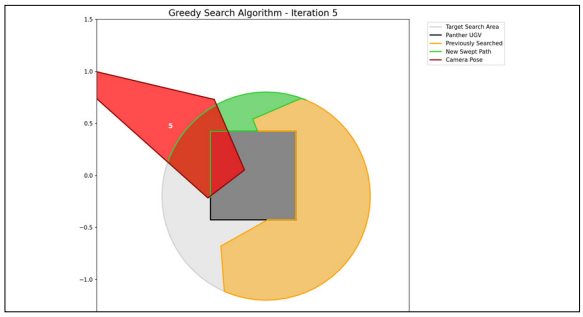
The Panther Mobile Manipulator is picking up the soil sample dummy.
Own presentment



This is the resulting scatter plot of numerous tests.
Own presentment



The plot illustrates how the search algorithm works.
Own presentment



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Subject Area
Mechatronics and Automation, Software and Systems, Mechanical Engineering