Pathfinding for Snow Blowing

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Introduction

The research that the ACT LAB is doing under Professor Nora Ayanian and Eric Ewing is Multi-Robot Path Finding, or multi-agent path finding (MAPF). This is similar to warehouse problems where there are robots transferring goods to one location and then to the other without running into other robots and completing the task in time.

Amazon is a leading example in this field as they solve & use this exact solution in their warehouses.

To actually test this out, ACT Lab uses drones to simulate the environment.

Figure : act.usc.edu

Our Approach

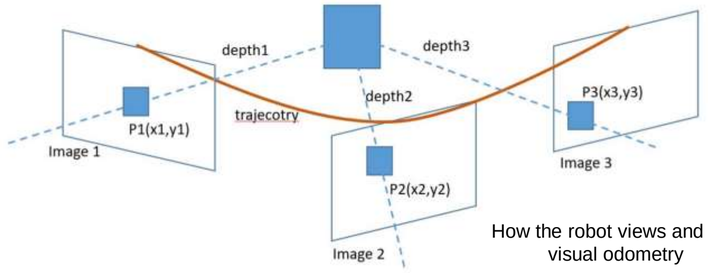
We are solving this problem using the JetSon Nano. First, we broke this down into many smaller problems. The parts we solved were collision avoidance, scanning QR codes, visual odometry, snow depth approximation.

Collision Avoidance uses PyTorch models relying on object identification using jetbot camera. By detecting lines/objects, collision avoidance was used as a safety measure.

QR Codes were used for localization and for path planning, adjusting/replanning.

Snow depth approximation systems rely heavily upon camera usage. While a common way to approach this problem would be by having set markers, we approached this mathematically using height and proportions to estimate depth.

Similar to collision avoidance, visual odometry can be used as a backup safety system but here, we used visual odometry for planning & can be built on for SLAM.



How the robot views and uses visual odometry

Figure 2: Check citations

Figure 3: Vrinda Bansal JetBot camera vision of the driveway with snow and three QR Codes

Problem

We've heard of automatic vacuums, but what about automatic snow blowers? Snow blowing adds to the the current lawn mowing problem.

We developed solutions to problems such as the original path-planning whilst keeping in mind snow density, snow height, being able to keep track of its position with possibly hard to access markers hidden under the snow and depositing the snow in a feasible manner for a driveway.

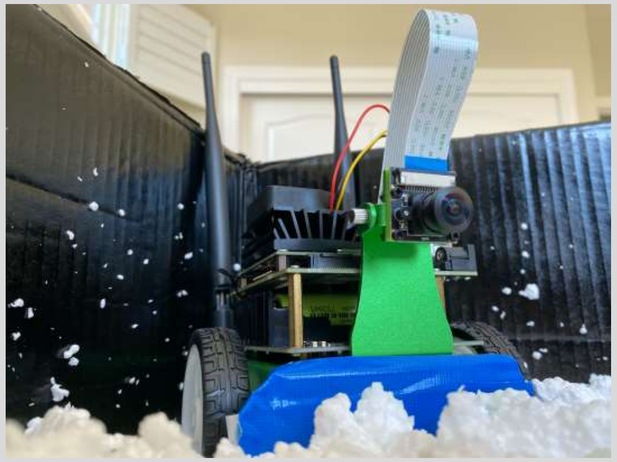


Figure 1: Vrinda Bansal Jetbot with snow blower attachment in snow setup

Our Results

While we aimed to implement security systems such as collision avoidance, our current model has put a hold on utilizing that system. Currently, our robot is successful using the qr codes with a finite state automata algorithm.

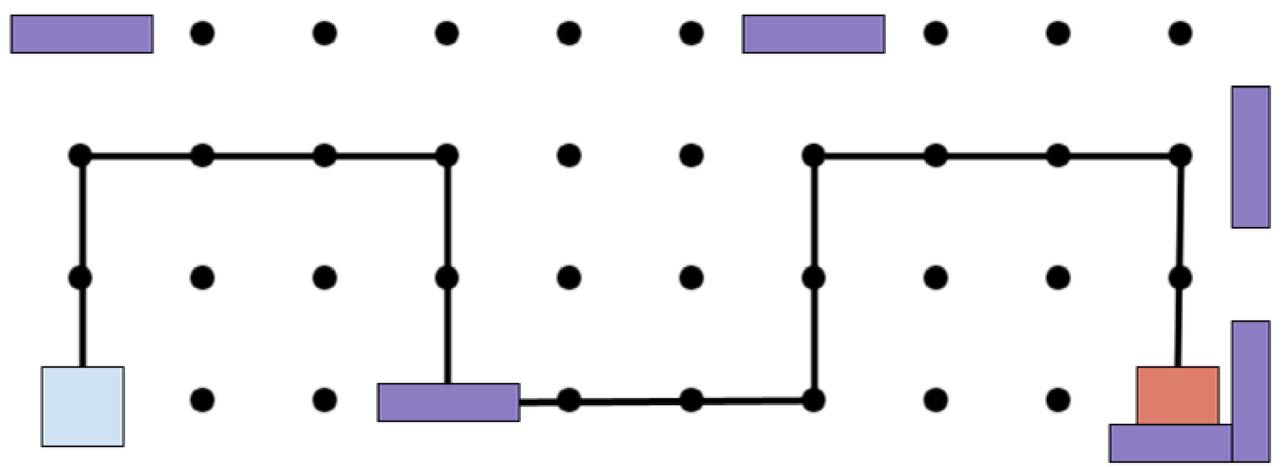


Figure 4: Vrinda Bansal

Planning of the route from the robot. Blue square is the starting point. Purple rectangles are the QR Codes placement. Black line is the planned route after analysis. Red box is the goal/ending position.

In the end, the system using an efficient zig-zag type pattern path allowed it to shovel off the snow easily, saving battery and time rather than physically scouting out the area first.

We have also implemented a version of visual odometry which is what makes the QR Code system work successfully and solves the SAPF problem (single-agent path-finding).

Skills Learned

In research skills, I learned how to analyze research papers & create scholarly knowledge. From my lab, mentor and professor I learned PyTorch, Open CV, machine learning, planning algorithms like A* & depth for search/breadth for search algorithms using nodes.

Acknowledgements

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Papers Used/Cited

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