RISE:2016
RESEARCH, INNOVATION AND SCHOLARSHIP EXPO

Graduate
Category: Engineering and Technology
Degree Level: Ph.D.
Abstract ID #1268

Northeastern University
RIVeR

3D Path Planning for a Mobile Manipulator in Cluttered Environments

Maozhen Wang

Abstract

We present our work on 3D path planning for a mobile robot in unknown and cluttered environments. This research is motivated by use-cases for a remotely operated mobile robot in applications ranging from disaster response to sample acquisition to environment monitoring. There is a trained human operator in the loop controlling the robot, but the uncertain and densely structured environments pose operational challenges.

Introduction

Hardware Platform

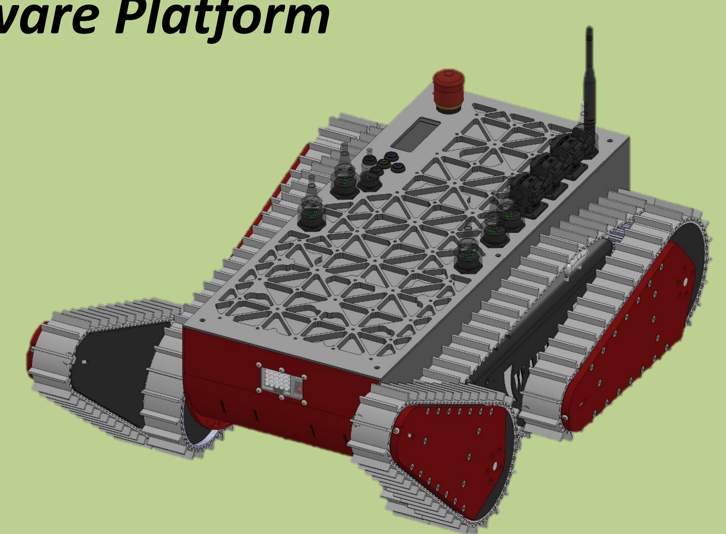
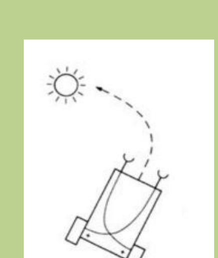


Figure 1: Mobile Manipulator

The hardware platform is composed of a tracked rover with four flippers which enable the robot to crawl over and under obstacles, climb stairs and traverse various terrain including sand, gravel, muck, snow, and ice.

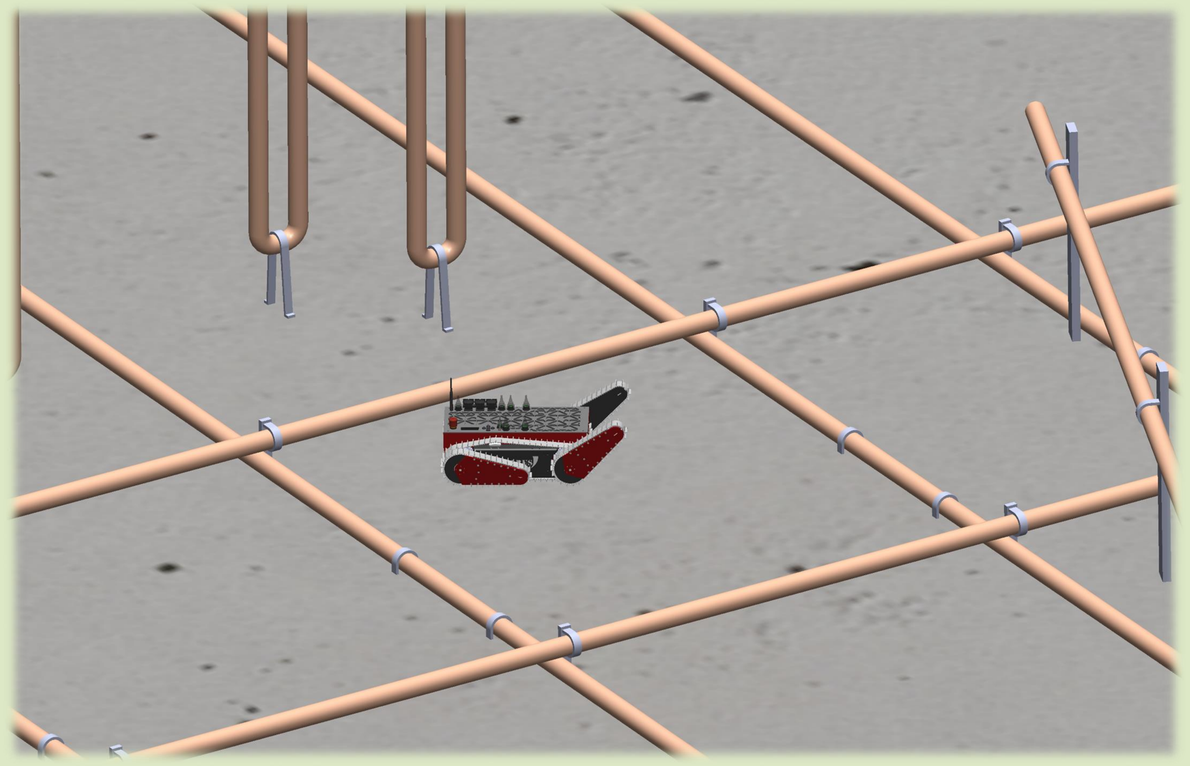
Driving with Tentacles

Our work extends a path planning method named "driving with tentacles" (Hundelshausen, 2008) to 3D navigation. The core of this method is using a set of precalculated trajectories to find out driving options for robots, which is similar to insects using their antennae.

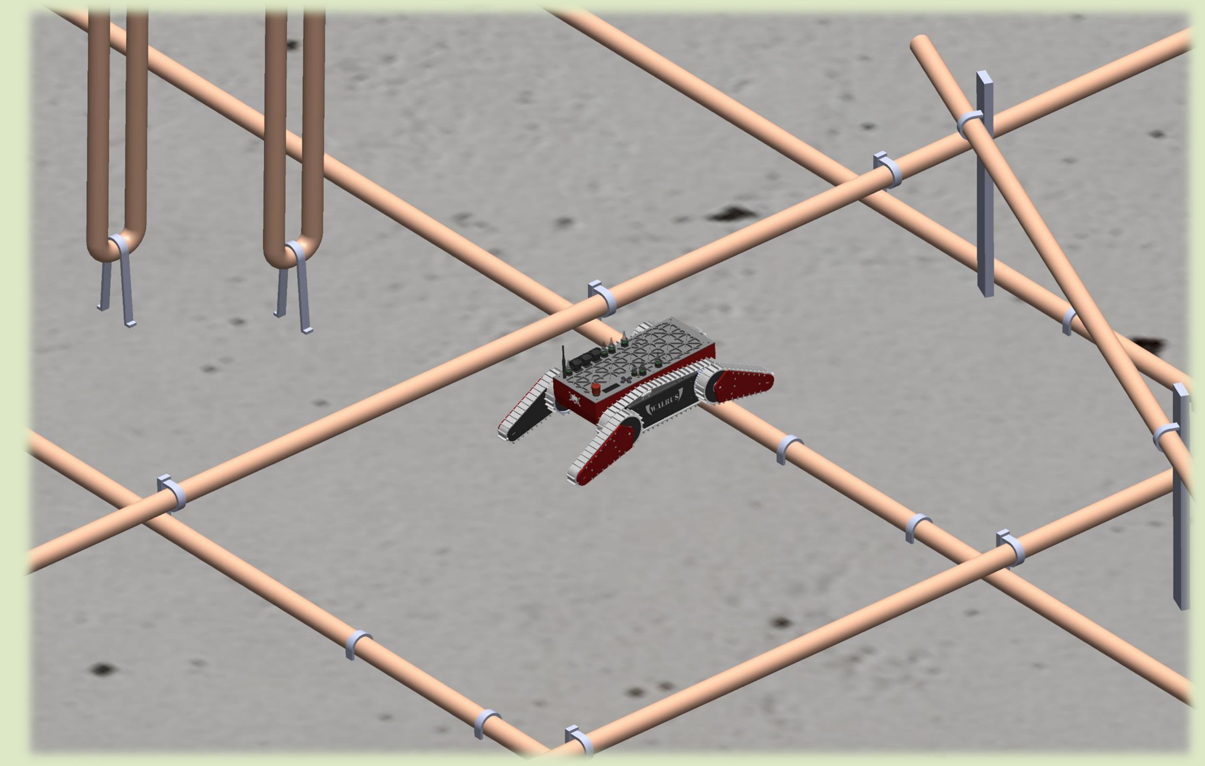


Aim

The purpose of this research is enabling a mobile robot to navigate autonomously in an unknown and cluttered environment. The robot should have the ability to detect obstacles, classify obstacles by evasive strategy and take right configuration to perform evasion.



Perceiving the environment



Crawling over obstacles

Method

Modification of 2D Tentacle

To employ the tentacle method for 3D path planning, a 3D occupancy grid will be generated. Each grid will have two values to express the absolute Z-coordinate, Zmax and Zmin. Shown in Figure 1.

One tentacle will be determined as drivable or not based on Zmin and Zmax. Zmin determines whether the robot can go below the obstacle and Zmax determines the possibility of crawling over the obstacle.

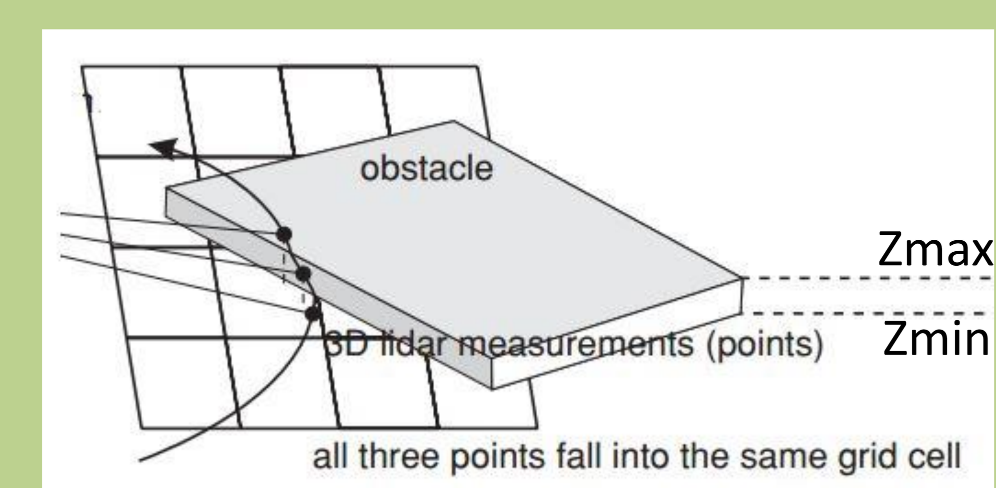


Figure 2: Occupancy Grid

Progress

Path Planning Process

Construct Occupancy Grid → Generate Tentacles → Tentacle Selection → Flippers Configuration → Tentacle Execution

References:

1. F. von Hundelshausen, M. Himmelsbach, F. Hecker, A. Mueller and H. Wuensche, "Driving with tentacles: Integral structures for sensing and motion", Journal of Field Robotics, vol. 25, no. 9, pp. 640-673, 2008.
2. F. Colas, S. Mahesh, F. Pomerleau, Ming Liu and R. Siegwart, "3D path planning and execution for search and rescue ground robots", 2013 IEEE/RSJ International Conference on Intelligent Robots and Systems, 2013.

Acknowledge:

Thanks the support from Dr. Taskin Padir and my colleagues in the lab.

Progress

Tentacles

- The tentacles are generated based on the speed of the robot. 4 sets of tentacles to represent the speed range 0 to 2m/s.
- Each set contains 81 tentacles.

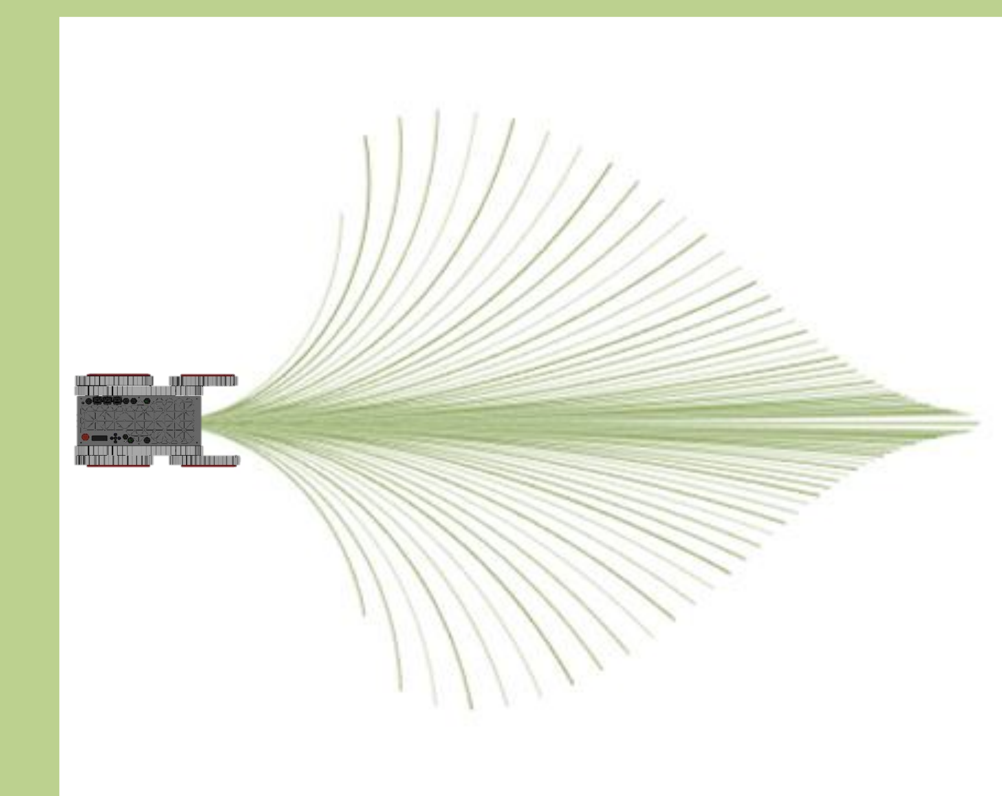


Figure 3: Tentacle Set at 1m/s

- One tentacle is drivable if Zmin is greater than 9'' and Zmax is less than 16''.
- One tentacle will be chosen to execute based on the clearance, flatness and robot orientation.

Flipper Configuration

The flippers of the robot will be configured using the geometric information so that the flippers will lie as much as possible on the surface.

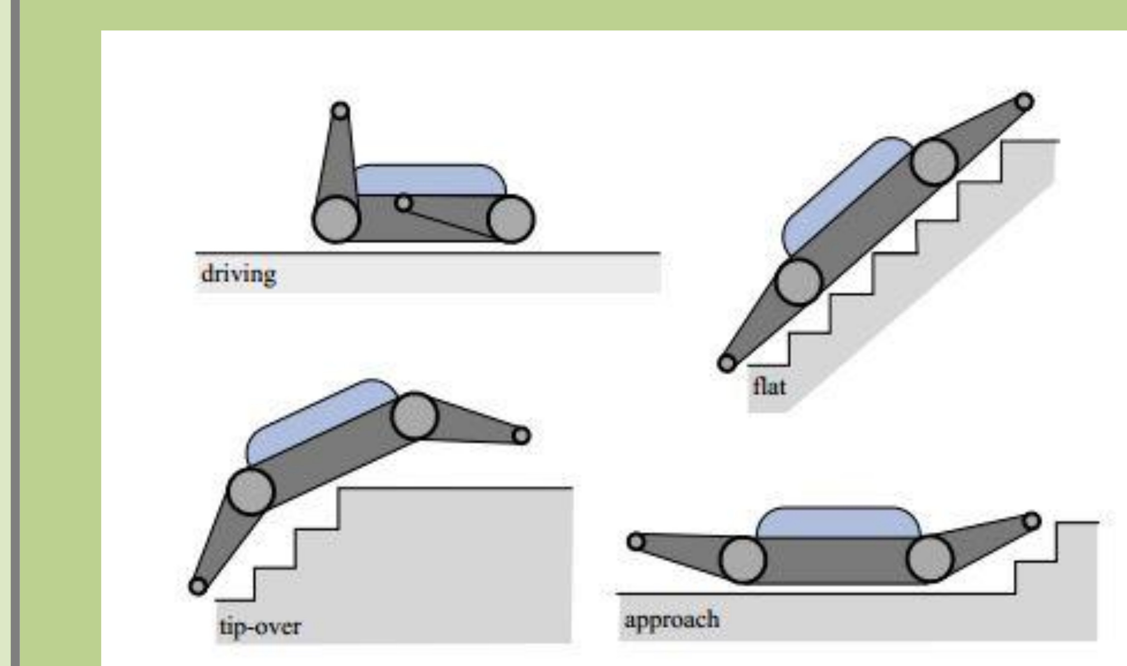


Figure 4: Flipper Configurations (Colas, 2013)

Conclusion

- This research introduces a 3D path planning method extended from a 2D method known as "Driving with Tentacles".
- Our future work includes building the manipulator, running simulations for various scenarios to test our method.