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.

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.

Path Planning Process
Construct Occupancy Grid → Generate Tentacles → Tentacle Selection → Flippers Configuration → Tentacle Execution

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.

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.

References:

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