Visual SLAM on Atlas

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Abstract

Simultaneous Localization and Mapping (SLAM) is a powerful method for autonomously exploring new environments, which has never been applied to humanoid robots. This project implemented SLAM on the Atlas humanoid robot, allowing it to interact with and explore novel environments. The Atlas robot was programmed to create 3 dimensional maps of environments and localize itself within them. Due to constraints in time and safety the project was conducted mostly in simulation. Both stereo cameras and LiDAR were used in experiments to identify the robot's surroundings and avoid obstacles. These sensors paired with the robot's locomotion allowed the Atlas robot to search and navigate unknown areas.

Background

Humanoid robotics research has made it possible to program and simulate a wide variety of complex human capabilities through robotics. To make humanoids interact robustly with new and altered environments, they must be able to simultaneously create a high quality 3-dimensional map of the nearby environment and localize themselves in the map.

ATLAS Robot:
- 30 degree of freedom **humanoid robot**
- stereo camera and a lidar in head

Simultaneous Localization and Mapping:
- **mapping** an environment without global **localization** information

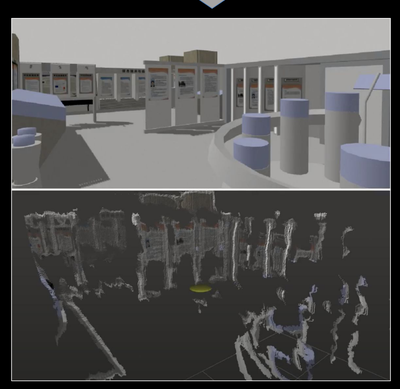
Transportable Open-Source UI and GUI for General Humanoids (TOUGH):
- provides **controllers and basic functionality** for the Atlas robot (ie balancing, walking, footstep planning, and path planning)

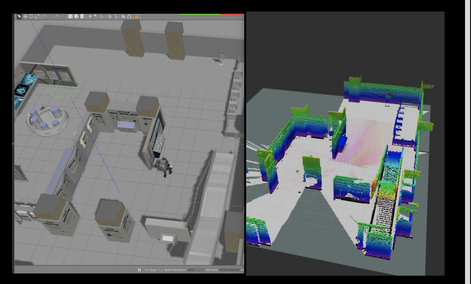
Octomap:
- Grid-based **3D mapping** for point clouds
- Calculates and published 3D and 2D **occupancy grids**

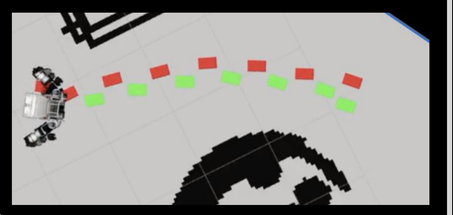
Objectives

1. Establish a method for SLAM that can be extended to all humanoid robots.
2. Identify the most capable sensors for the task at hand, and determine what kind of processing needs to occur when data is retrieved from them.
3. Use SLAM to perform informed navigation/obstacle avoidance in a simulated environment

Overview







Multisense Interface and TOUGH Library

- Lidar and Stereo Camera in robot's head
- Lidar scan takes ~30 seconds in simulation
- Gyroscope in robot's pelvis provides localization information

Point Cloud Information

- Stereo camera and lidar can create point clouds
- Point clouds passed to Octomap to create an occupancy grid

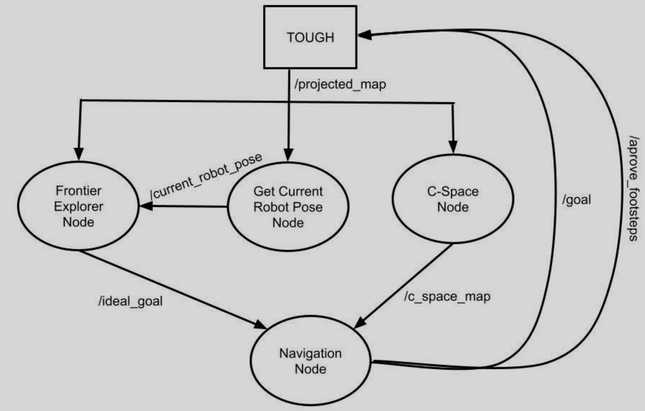
Localization and Mapping

- Octomap combines point clouds using feature detection and matching
- Octomap calculates and publishes 3D and 2D point clouds

Informed Navigation

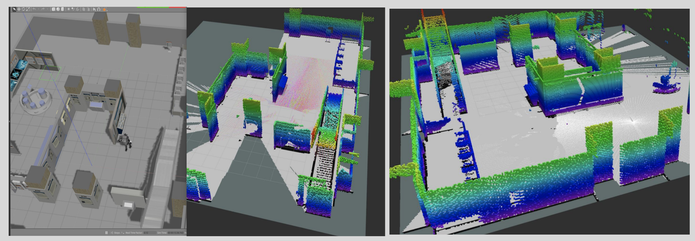
- Identify frontiers
- Choose the best frontier to explore
- Navigate to the closest walkable spot to the frontier

ROS Node Graph

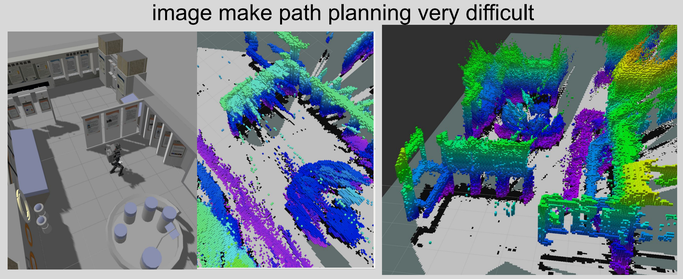


Results

Lidar Point Cloud Map: Accurate with no artifacts but slow



Stereo Camera Point Cloud Map: Fast, but many artifacts in the image make path planning very difficult



Overall Mapping Performance
- Mapping was robust and could perform closed loop mapping.
- Final lidar based maps had few artifacts and were easy to navigate

Conclusions and Recommendations

In this project, we analyzed data from the robot's sensors to create the first SLAM algorithm for the Atlas robot. Our algorithm is robust and accurate when using the lidar, and was capable of closed loop mapping.

There are several suggestions we have for future work:

- Making it transportable: the algorithm could be integrated into TOUGH and tested on more humanoid robots
- Sensor Fusion: Combining stereo camera and lidar data could create both fast and accurate mapping
- Intelligent path planning: The robot is capable of navigating 3D terrain, and path finding should be able to as well