An Indoor Guide Robot Based on ROS

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Abstract

This project focuses on realizing a Guide Robot to help people reach a specific destination. The Guide Robot is capable of planning the path to the destination and driving to the coordinate while avoiding obstacles when requested by cellphone. Features include a practical approach to 2D mapping and path planning, a reliable implementation of obstacle detection, and a robot-sever-cellphone communication system architecture realized by HTTP protocol.

Hardware System

- Kobuki Base: implements movement instructions with odometry feedback
- Orbbec Astra 3D camera: collects environmental 3D image data (RGB, IR and depth)
- Netbook installed with ROS
- Mounting Hardware


Figure 1: Guide Bot

Robot System Architecture

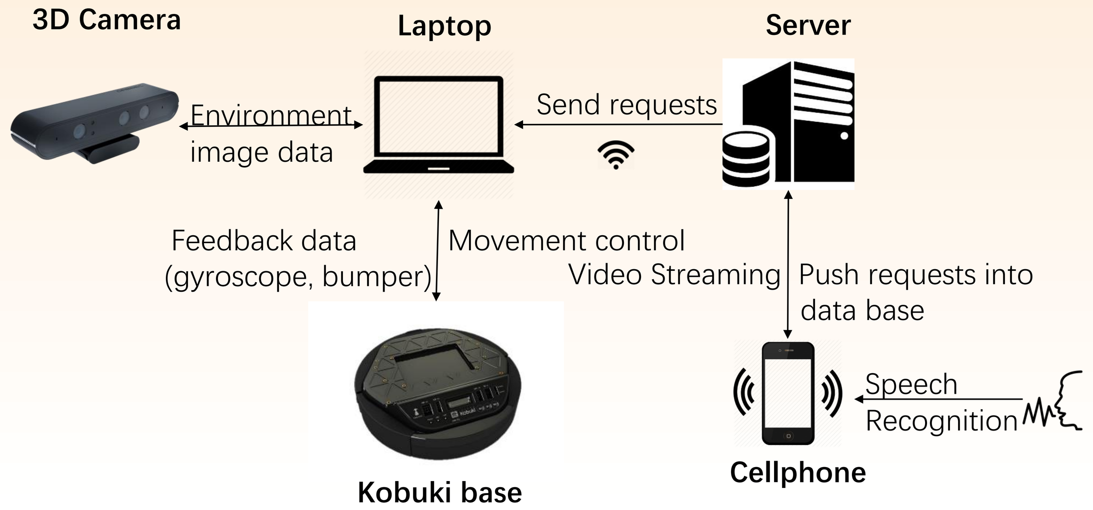

Figure 2: Robot System Architecture

Goals

Develop a robot capable of guiding customers in an unknown place with the ability to:

- Get 2D layouts of large scale unknown environments
- Autonomously navigate to the destination
- Avoid obstacles
- Handle with multiple cellphone requests
- Recognize speech requests

3D Mapping


Figure 3: Robot point of view

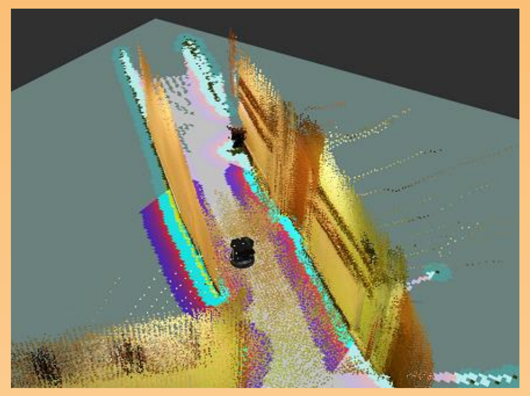
Figure 4: 3D point cloud map

Real-Time Appearance-Based Mapping

- Process visual odometry (correspondences between frames)
- Add Frames to Graph
- Merge depth images based on visual odometry
- Loop closure detection
- Project 3D cloud to 2D map

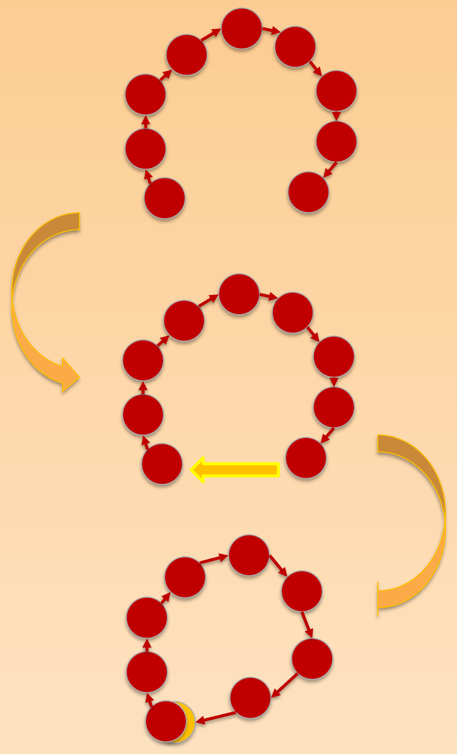
Figure 5: Graph SLAM

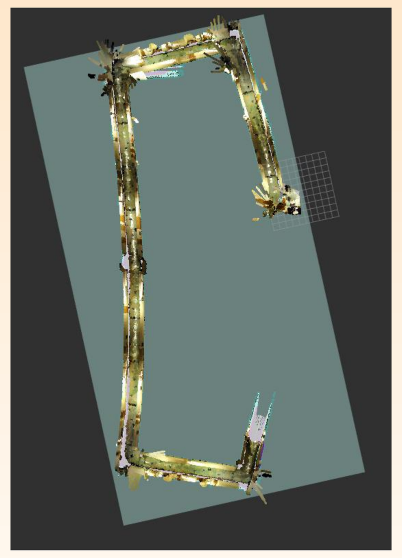
Figure 6: 3D map before loop closure

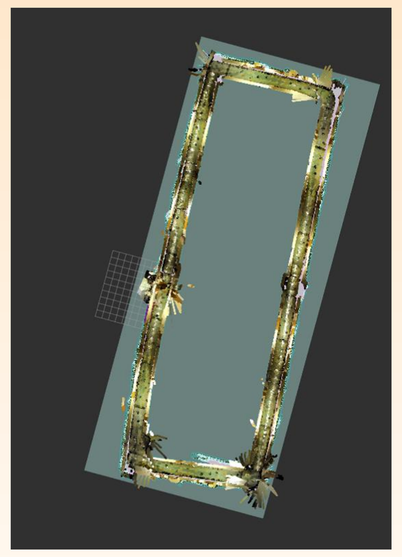
Figure 7: 3D map after loop closure

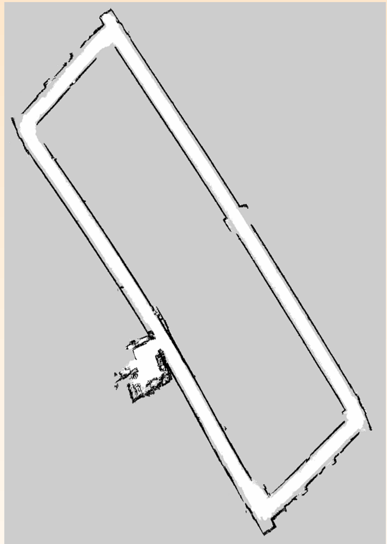
Figure 8: 2D projection map

Path Planning (Global planner)

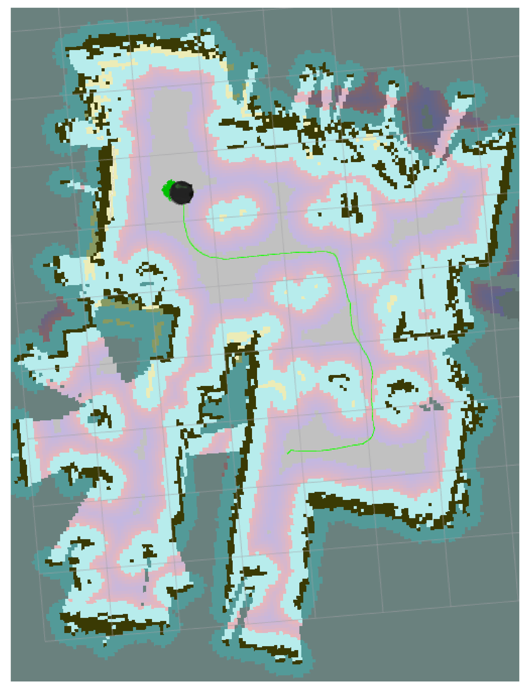
Figure 9: Robot path planning

Using its camera information, Guide Bot can intelligently plan paths.

- The black plate is the robot footprint
- The green line is the path from the current position to the goal

Localization

Adaptive Monte Carlo localization:

- Uses a particle filter to track the pose of a robot against a known map
- The green arrows are a set of vectors representing the uncertainty of robot pose.
- The particle filter narrows the set into a smaller particle set when the robot moves and integrates the data from camera.


Figure 10: AMCL pose before movement

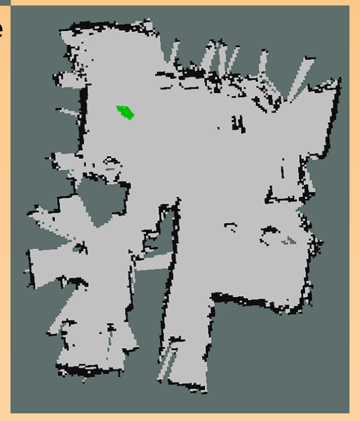
Figure 11: AMCL pose after movement

Obstacle Detection (Local planner)

Guide Bot has the capability to determine the existence and location of obstacles it cannot cross.

- The yellow grid cells represent obstacles
- The blue and purple cells represent virtual inflation, to keep the robot a safe distance from obstacles

When the global path enters into the obstacle origin, the base controller will adjust the global path due to the local obstacle map and determines the orientation and velocities of the robot base to avoid obstacles.

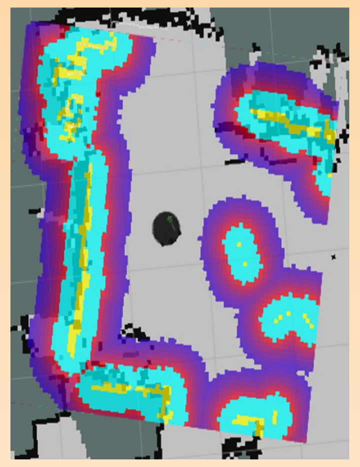
Figure 12: Local obstacle map

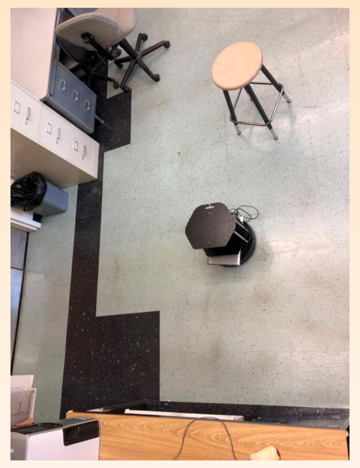
Figure 13: Robot position

Cellphone User Interface

The Cellphone User Interface affords the ability to request tasks to the Guide Bot through a Web App. It is programmed with Javascript, HTML, CSS, PHP, and Google speech recognition library. The Web App allows user selecting their destination by touching on the screen or voice input. The requests would be stored in the server database and be sent to the robot one by one after each task.

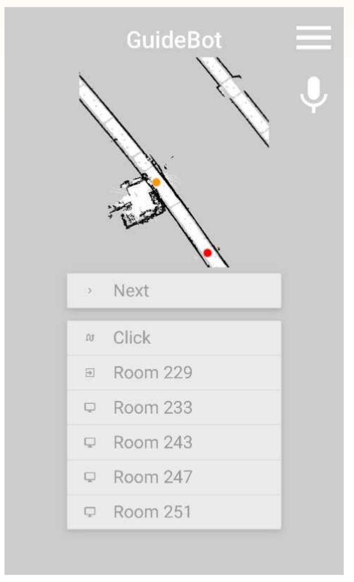

Figure 14: Web App interface

References

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- Brock, Oliver, and Oussama Khatib. "High-speed navigation using the global dynamic window approach." Robotics and Automation, 1999. Proceedings. 1999 IEEE International Conference on. Vol. 1. IEEE, 1999.
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