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A mobile robot that can explore, map, and navigate an unknown environment

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Presentations : https://www.youtube.com/@TejKiran/videos

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Overview

This robot was built to explore, map, navigate and manipulate objects in an environment. The robot's functionality consists of 3 major modules: a physical device, device software stack, backend server software stack.

Robot's Hardware

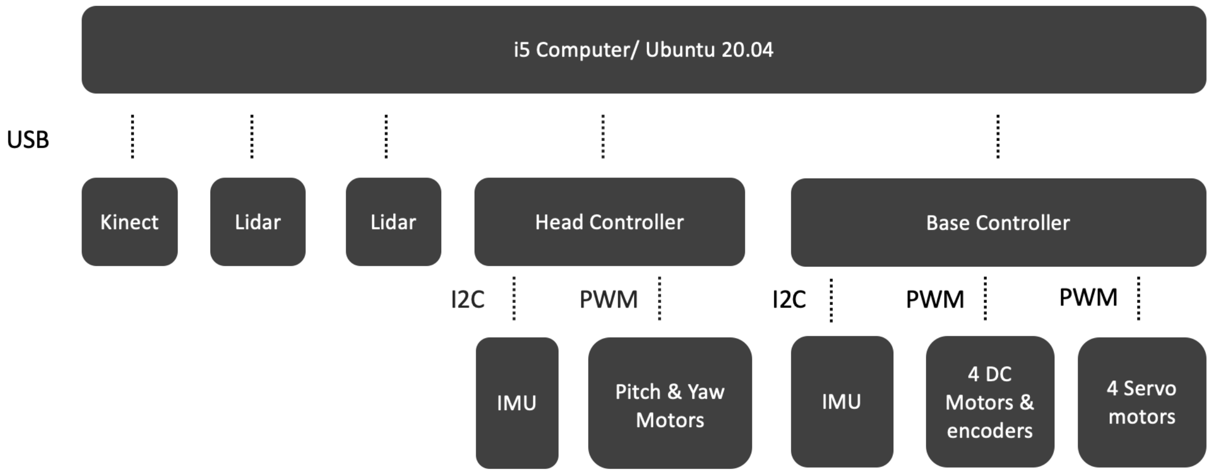
a) Robot’s Body

The Hardware consists of a base platform for navigation, a head module with 3D depth camera for spatial mapping, corresponding electronics and an on-device computer as shown below

The physical hardware is made from aluminum sheets, and stainless steel plates reworked using lathe machines and power tools.

b) Robot's Electronics

Robot's electronic communication wiring diagram is as shown below



The base controller board is mounted on the base platform and head controller is mounted on the head module. Each controller board consists of an IMU and electronics to control the motion.

A dual lidar setup is used to create a planar map of the environment. The structure of the robot obstructs the view of a single lidar. So, the depth points from two lidars mounted on the either side of the robot are combined to create the effect of a single virtual lidar that generates an unobstructed laser scan around the robot.

A Kinect camera is mounted on the head portion of the robot to create the spatial map of the environment, object recognition and 3D point cloud mapping.

All the sensors and controllers are connected to a computer mounted at the back of the robot.

c) Robot's Software stack

All controllers run software based on the Arduino stack.

The Base driver board contains in-house developed velocity kinematics to convert ROS Twist commands to 4-wheel steering angles and wheel velocities. The board also estimates the wheel odometry by considering the wheel velocities, IMU data, and the geometry of the base platform. The base platform electronics is as shown in figure below.

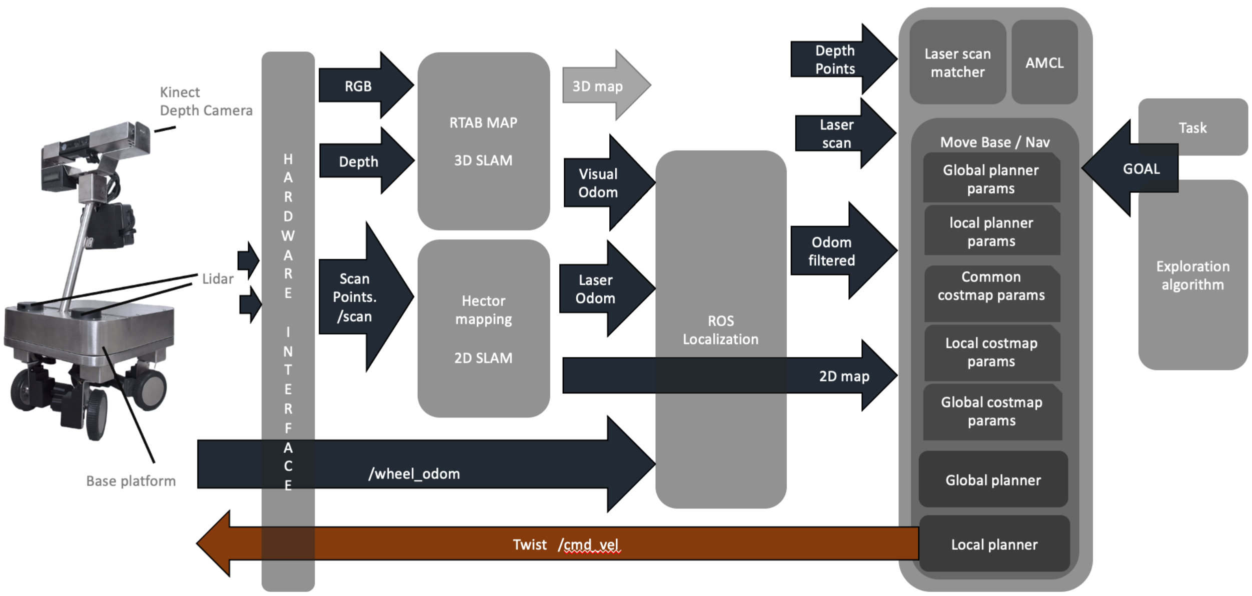
The head driver controls the pitch, yaw of the 3D camera, and reads the current camera pose using and IMU.

ROS Integration:

Recently, I've adapted the ROS into this robot. For this adaptation I've modified the controller stack to perform

- Conversion of ROS Twist commands to 4-wheel drive/steer commands
- Estimating wheel odometry using IMU planar orientation data, steering angles, and wheel velocities.

ROS Navigation Integration - Architecture diagram:



Using ROS the robot can explore an unknown environment using exploration stack and navigate to a goal in that environment.

References:

1. https://create.arduino.cc/projecthub
2. https://www.ros.org/