Sahayak - An Autonomous COVID Aid Bot

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Abstract

The COVID-19 pandemic has posed many new challenges, among them is a need to reduce person-to-person contact in hospitals and quarantine facilities. Developing an autonomous robot for hospital environments is a potential to reduce the risk of infection. This work proposes a general framework for developing medical assistive robots capable of delivering food and medicine to patients and facilitating teleconferencing with doctors. The ideas presented here have been validated extensively in simulated environments using a Navigation Stack for autonomous mobility, while a teleoperated prototype was deployed at AIIMS Nagpur, India.

INTRODUCTION

Healthcare workers are expected to wear uncomfortable and bulky PPE kits for long periods to treat patients infected with highly communicable diseases.There is an acute need for a technological solution that can protect these frontline healthcare workers.We present Sahayak, a COVID Aid Bot that can perform routine tasks, thereby reducing the spread of diseases among the medical personnel [1]. The key contributions of this work are as follows:-

- We present the system architecture of a telepresence robot that can be used for distant consultation and to deliver food and medicines. A prototype based on this design is currently deployed at AIIMS Nagpur, India.
- We open-source the design and framework of Sahayak that can be used to test complex algorithms for autonomous navigation in a hospital environment[2].

MECHANICAL DESIGN

Hospital environments have narrow passages and sharp turns that require precise maneuvers. Considering these constraints and feedback from the doctors, a 4-wheel drive design was adopted. Sahayak is driven by four planetary DC geared motors. It has heavy-duty disc wheels, a payload capacity of 20 Kg, and a 20Ah lithium-ion battery. Fig. 1(b) illustrates the sensor stack deployed on this robot.

(a) Former Version of Sahayak

(b) CAD Model of the Autonomous Version

Figure 1. Mechanical Design of Sahayak

AUTONOMOUS NAVIGATION

Autonomous Navigation consists of several cohesive modules, as indicated in Fig 2. Visual Odometry was computed through 3D-2D and 3D-3D motion estimation methods by using a sparse optical flow-based feature tracking approach [3]. This odometry information was fused with the IMU readings using an Extended Kalman Filter (EKF). Alternatively, odometry from the RPLiDAR was calculated through an incremental laser scan matcher.

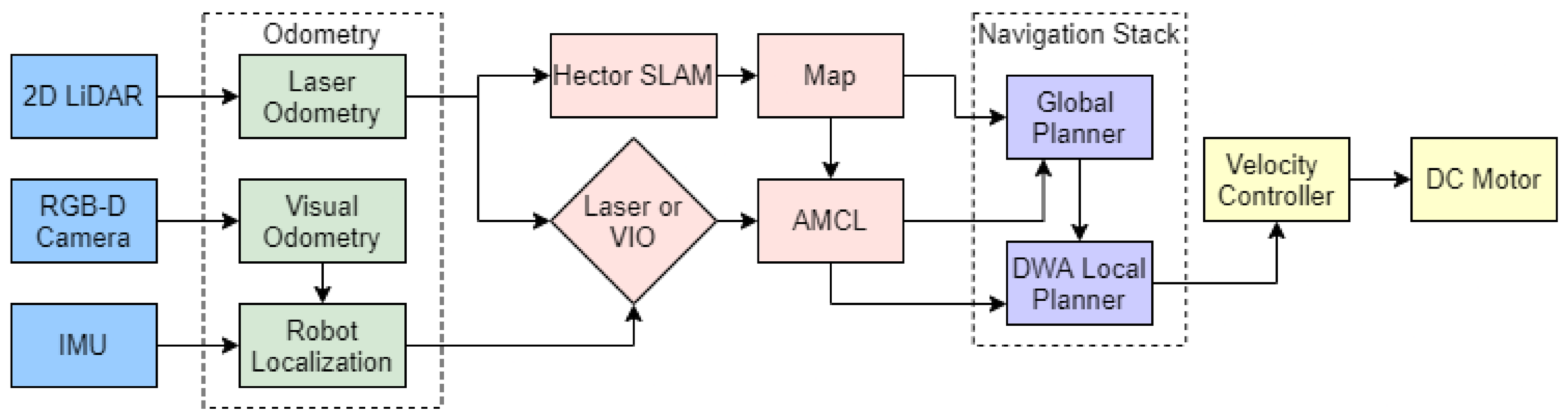

Figure 2. Overview of Autonomous Navigation Pipeline

The environment was mapped using Real-Time Appearance-Based (RTAB) mapping [4]. Hector SLAM [5] and GMapping [6] were used to generate a 2D occupancy grid for the locomotion of the robot.The robot was localized on a pre-built map using Adaptive Monte Carlo Localization (AMCL). Point-to-point navigation was achieved through a Global Planner, and a Dynamic Window Approach (DWA) based Local Planner.

EXPERIMENTS AND SIMULATION RESULTS

The odometry of the bot was determined through 3D-2D, 3D-3D motion estimation (the results are as shown in Fig.4)and Incremental Laser Scan Registration matching.

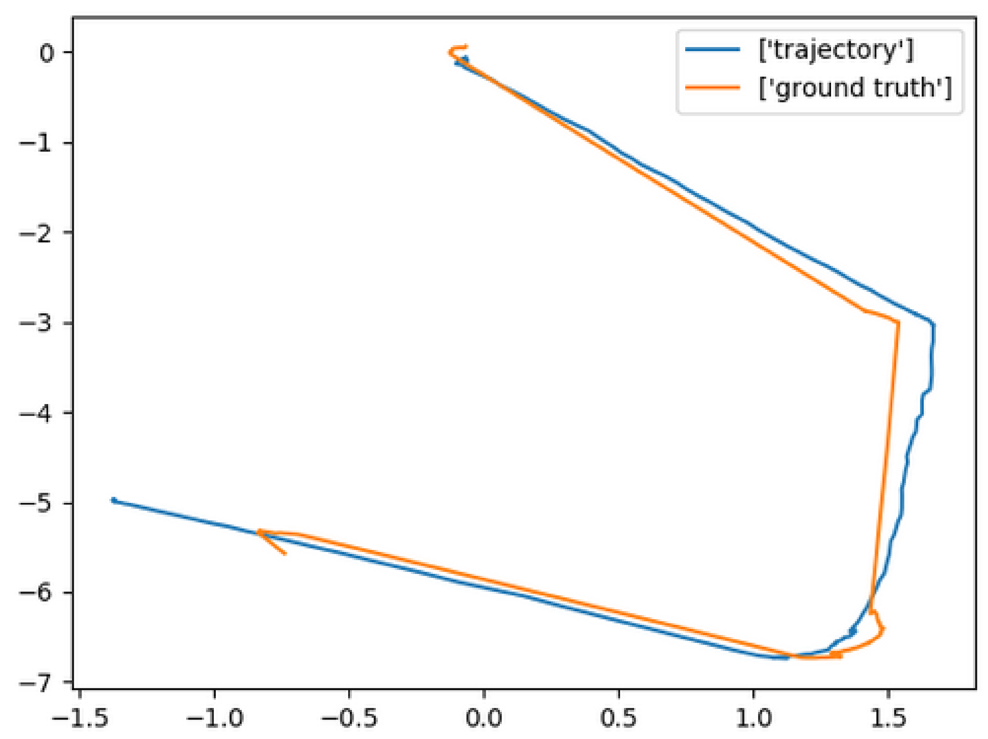

Figure 3. Motion Estimation Using Visual Odometry

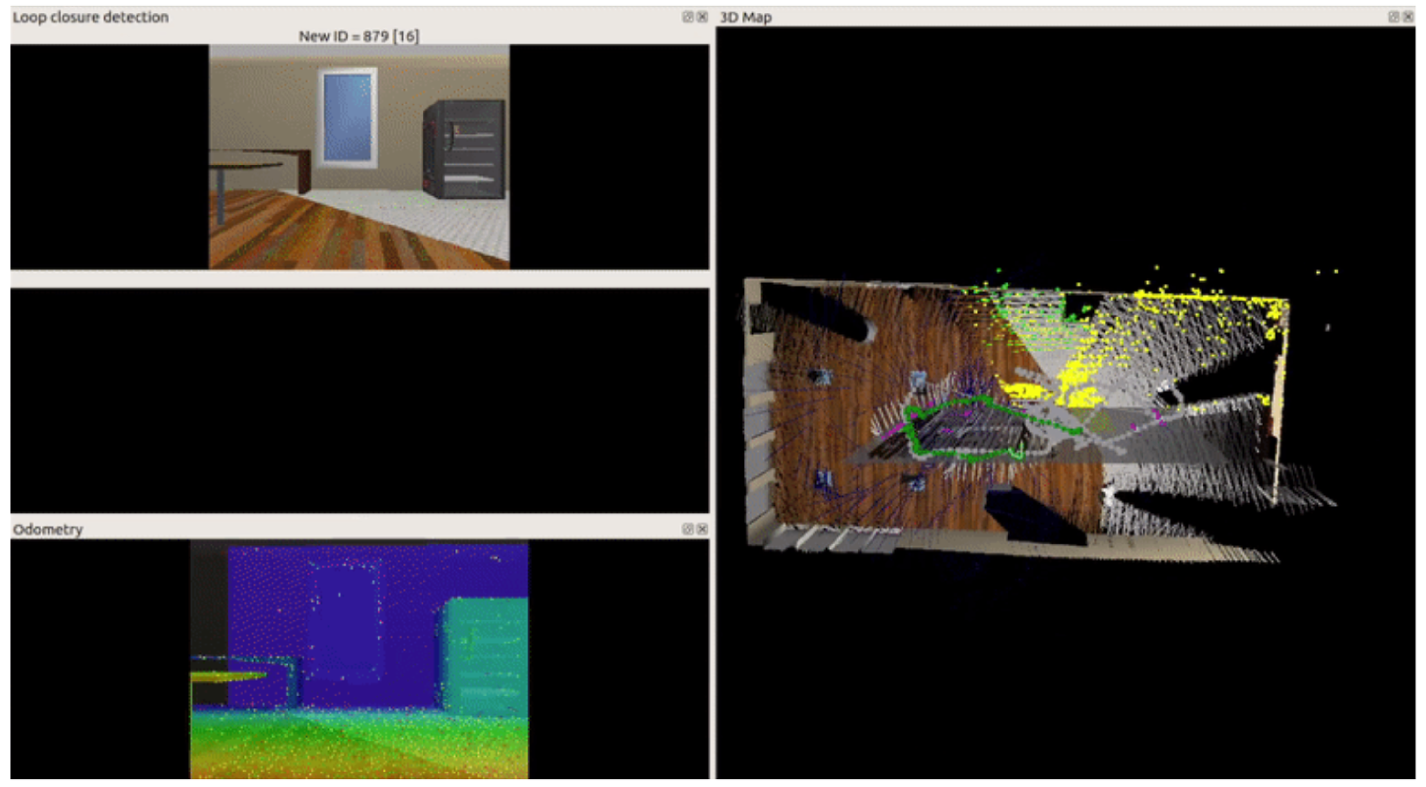

Figure 4. Motion Estimation Using Visual Odometry

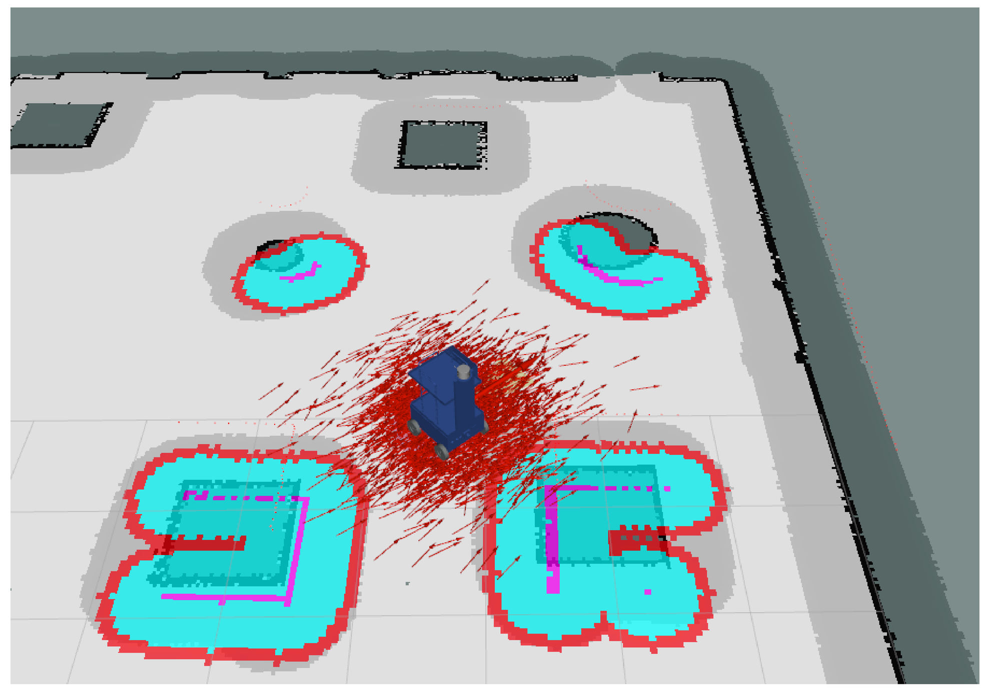

Figure 5. Cost Map with AMCL

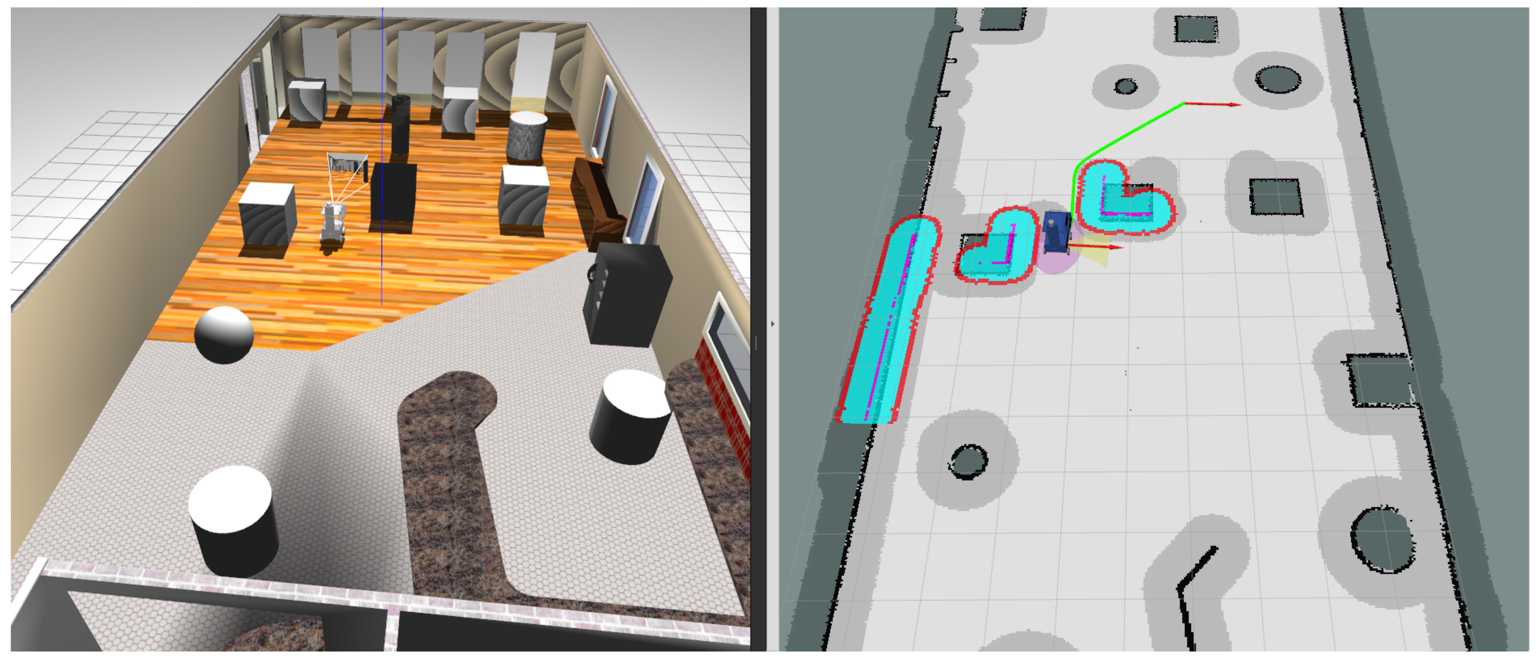

Figure 6. Path Planning

We have experimented mapping with RTAB Map, Hector SLAM and GMapping which was used for path planning and for AMCL as shown in fig.5 and fig. 6.

CONCLUSION AND FUTURE WORKS

We present the design of an autonomously navigating robot that can be deployed at hospitals to reduce the contact between healthcare workers and patients. Future works will involve provisions for Dynamic Obstacle Avoidance and solutions for the Global Localization problem.

References

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