Smart Robotic Assistant for Visually Impaired

Gaurao Chaudhari, Asmita Deshpande, Kaikai Liu
Department of Computer Engineering
Charles Davidson College of Engineering, SJSU
San Jose, CA, United States
Email: {gochaudhari@gmail.com, asmita.boo@gmail.com, kaikai.liu@sjsu.edu}

***Abstract*—Disabled people are in a dire need of electronic assistance. There are a couple of electronic assisting devices that bring their life to an easier turn. In this paper, we describe the design and implementation of a personal assistant robot for blind people. Visually impaired people need such personal assistant devices for they provide a real-time assistance regarding any necessary problem that blind people face. Some of those main problems are navigation in the indoors, identifying objects around unless getting a physical sense of those objects and sensing the surrounding with the distance of multiple objects. Our paper discusses the various application targeting features like using the LIDAR for local mapping, using a 3D camera for understanding the depth of the surrounding so that the person understands the distance and other information of the objects around. This design has been experimentally validated and required observations are posted in this paper.**

Keywords—mapping; localization; audio; ROS; 3D camera, create2, Roomba, face, object, depth, blind.

I. Introduction

The AFB statistics based on the National Health Interview Survey suggests that around 22.5 million American adults experience vision loss. Blindness has profound impact on a person's life, including social as well as technological challenges. Existing blind assistant systems include blind sticks, guide dogs and robots like Baxter.

Among the aids available for visually impaired, blind-stick has been the one which is used often. As per the AFB, approximately 48% of the blind use long canes to get around in the USA. Only around 3% of the visually impaired use guide dogs. Two major age groups which are affected by this disability are above age 50 and children below age 15. While the former age group comprises around 20% of world population, the number is bound to increase given the aging number of people in developing countries. Since most of the population of visually impaired people live in developing countries (90% as of 2014), it's imperative to devise a cost-effective solution.

Most of the existing aids do not make the user completely independent. Thus, we propose to use the technology advancements to overcome the shortcomings of the conventional aids and devise a smart assistant for the blind. Assistance by robots was present in industries for commercial purposes since 21st century but with the pace of time robots have marked their presence in other fields as well, most significant being the Human Robot Interaction. In [1], a Robot assisted therapy for children with autism spectrum disorder was carried out with wizard-robot and it was observed that adding learning capabilities to the robot improves user's preference of the system.

Another example is the work presented in [3], where blind stick is improved by adding electronic travel aids to help blind avoid collisions, increase safety and improve travel speed. There is no such conventional aid present for people with both visual and walking impairment which is designed in [5]. Usually, navigation while moving around in the indoor environments is one of the primary requirements for visually impaired. A shared robotic guide for the indoor navigation of the blind visitors is proposed in [2] which is trained by prior visits of the blind. Thinking about making life of blind easier by a service robot is put forth in [4].

The primary purpose of this paper is to propose a system that will assist blind in all aspects and revolutionize their life. The paper is organized as follows. In Section II, an overview of the system is described. The system implementation involving hardware and software is explained in Section III. The experimental results are presented in Section IV and the conclusion is the Section V.

II. System Overview

This system consists of different modules ranging from the one that enables the audio interface to the 3D camera module. The modules discussed in this paper are:

1) Video Processing
2) Localization and Mapping module
3) Audio processing module
4) Obstacle Detection module

All these modules have a specific output and they provide output to the decision module to decide on what to do at a time. For example, following is the prospective flow of data:

1) If the audio module speaks up it wants to travel to point B from point A.
2) The localization and mapping module comes into picture and sends the required data to the decision module.

3) The decision module in turn gets a sense of the robot coordinates and sends the direction data to the create 2 Roomba.
4) The size of motor module is not so huge, so it is not considered as a significant sized module. But, the decision module sends the direction and speed command to the motor module.

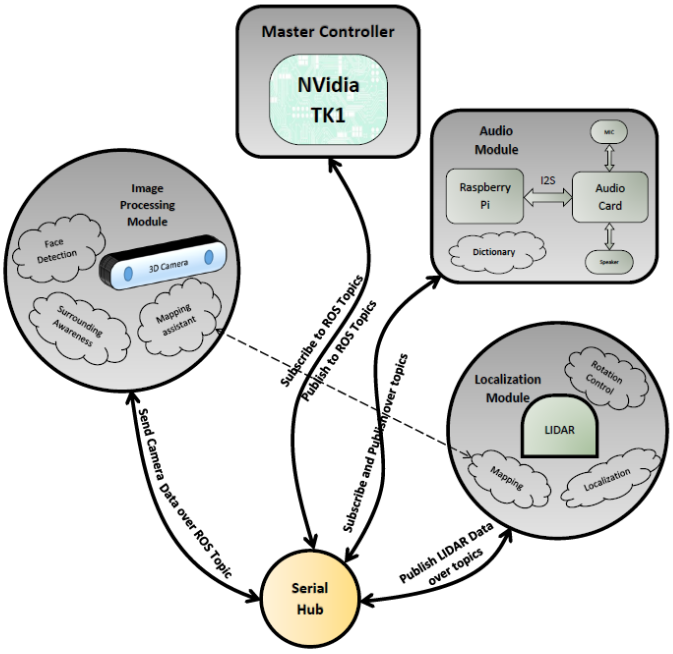

Fig.1 Project Architecture

This is the basic structure of the entire project. All the communications in this project is done using ROS libraries. ROS publisher and subscriber are the important communication basics of the sending and receiving of data.

Fig shows the entire working module of this project. There are different modules which are communicating with the USB hub and in turn with each other using the publishing and subscribing model of ROS.

The system runs on GPU platform of NVidia TX1. NVidia TX1 handles the video processing, mapping and localization along-with an interface to the create 2 Roomba. Raspberry Pi 3 handles the audio and deals with the listening and speaking part. All the commands are processed in the Raspberry Pi and the language dictionary processes the input speech and converts them into keywords.

III. System Implementation

This section of the paper describes the implementation of the entire system. To start with some description on the implementation part, it consists of several modules as it is described in the system overview.

The system was developed as described on two different hardware platforms. One is NVidia Jetson TX1 and the other one is Raspberry Pi 3. They both have two different usages. Following are the details of the development environment on the NVidia TX1 which was used for Video Processing, Mapping and Localization, obstacle avoidance and handling of Create 2.

The software platform used for the development of the software for all this was done on Ubuntu Linux 16.04. The coding was done in C++ entirely with some files in Python. These Python executables was only needed for driving the interface between TX1 and create 2. Catkin as a package manager and workspace handler was used to run the ROS projects. These packages are created in catkin and the IDE used for this process is Qtcreator which retrieves the cmake project in Qt workspace. This are small details about the development environment.

Following is the description of each module and its implementation in detail.

1) Video Processing module

This module deals with the processing of video and processing of images from the video. All the features developed on the Video processing module are then send as messages which are transmitted to the decision module which then decides upon the received data and sends that to the motor module. Following are the features that are developed on the Video module.

a) Face Recognition
   i) Face recognition is implemented using Haar Cascades and we have used the internal face detection library to achieve the face detection.
   ii) Both the left and right cameras are used to detect the faces and the number of faces counted.
   iii) This counted faces are sent continuously over to the decision module.
   iv) The decision module sends the number of faces detected to the audio module continuously over a duration of 10 seconds.

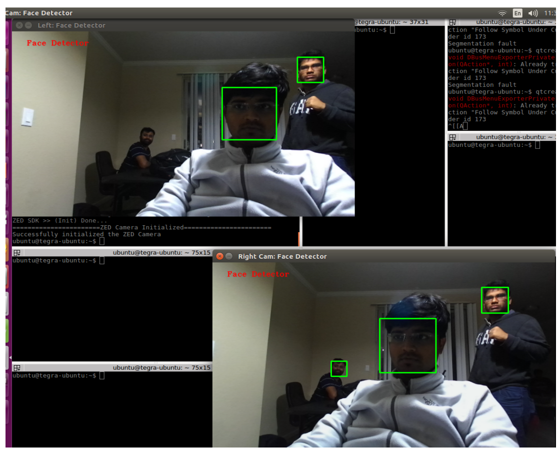

Fig.2 Multiple face detector

b) Object Recognition
Object detection is done using image color segmentation. This segmentation is then used with erosion and dilation to get a proper form of the objects from the video.
The objects detected from this image are not necessarily accurate and exact objects. There can be some discrepancy in the detection.

c) Depth analysis of the objects around
The depth of the surrounding environment is done using the ZED camera. This camera directly provides the depth map with the SDK. This depth map is overlapped on the image and the distance of objects are detected.

2) Mapping and Localization module

Mapping and localization is achieved using SLAM method. Specifically, Hector SLAM is used to achieve the final mapping of the 2D surrounding. This 2D mapping is then sent to the decision module which decides where to turn the robot in the map.

A laser LIDAR along with motors is used to sense the surrounding. The motors are rotated from -45deg to +45deg. The total 90deg of sensor data is then analyzed for the obstacles in that surrounding. If there are any obstacles in an interval of 10ms in between the angles of -45deg to 0deg then there is an obstacle in the left side and if there is any significant obstacle in 0deg to 45deg, there is an obstacle in right side.

3) Audio Processing module

All the input audio is processed in the audio module. These are then converted to keywords which are then sent again to the decision module. The decision module controls the final output of the robot system.

IV. Experimental Results/Evaluations

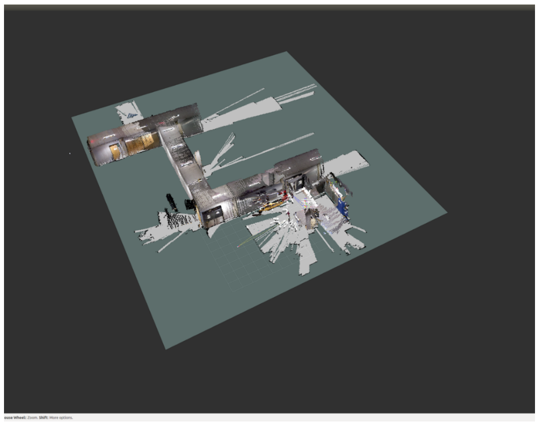

Fig.3 3D map

The above image shows the 3D map of the surrounding computed using Point Cloud. It describes how the Video processing module can map the surrounding of the system and generate the map that explains the depth of the environment.

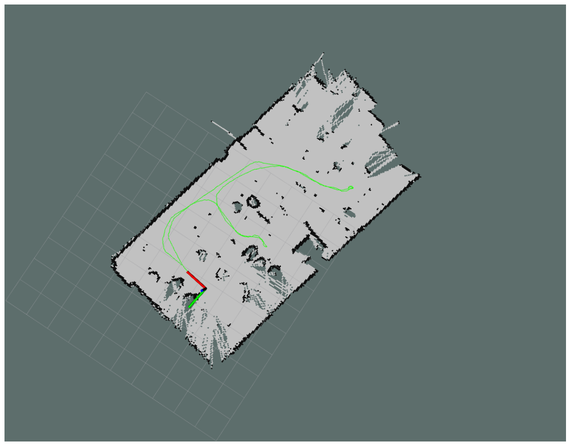

Fig. 4 2D map of Lab 1

The above and below images are 2D maps generated by RP LIDAR over Robot Operating System using Rviz visualization software. From the images, one can observe that the entire laboratory is scanned from end to end where black borders define the walls and green path describes the movement of the system around the laboratory.

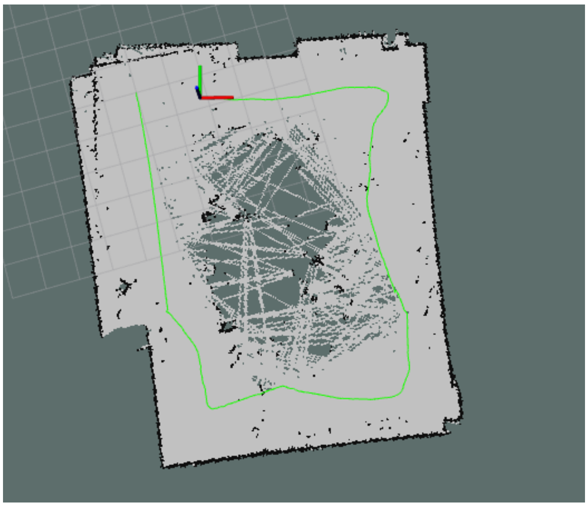

Fig. 5 2D map of Lab 2

For the Obstacle detection module, LIDAR lite v3 Laser Rangefinder is being used. The algorithm is designed such that within a specified range of distance, if an obstacle is present then the Master controller is notified with the message "obstacle detected". Also, the sensor scans the surrounding with an angular displacement of about -45 degrees to 45 degrees with the help of servo motor HS422.

With the help of audio processing module, audio commands like 'forward', 'backward', 'start' and 'stop' can be given to the system and it moves accordingly on reception of the commands. Moreover, the system can give audio notifications like how many faces are being detected of the persons in front of it, processed by the video processing module.

V. CONCLUSION

The system presented in this paper will aid the blind. It will guide the person to a destination with ongoing interaction in the form of voice commands about the obstacles like persons or other things coming in front of it. It will reach the destination under the commands it will get from the master controller. The information about the area mapped around the system is fed to the master controller by the navigation and mapping module. In this way, the assistant would be useful especially for indoor environments.

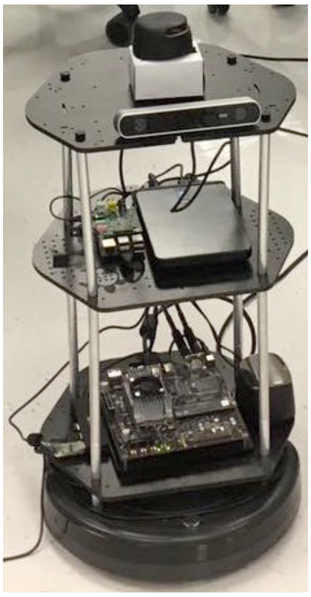

Fig 6. Blind robotic assistant

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