Robotic Guide Dog Applied to Indoor Exploring and Navigation

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Abstract—Walking on the uneven road or passing the crossroads may be dangerous for blind or visually impaired (BVI) people. Therefore, there are many assistive equipment for BVI people to maintain their daily necessary of transportation. White canes and guiding dog are used commonly to help them avoid the obstacle or pedestrians. However, it's nearly impossible for guiding dog to identify the sigh, and these kinds of smart machine are expensive to maintain relatively. To finding the alternative solution, this paper presents an affordable, autonomous robotic guide dog equipped with LiDAR, Arduino, Raspberry pi, Webcam and Echo dot.

I. INTRODUCTION

Indoor service robot has tremendous progress in the past decade, applicated whether in family or public. However, the service robot commonly has specific task and less flexibility for more application. Educational Robot like Zenbo and Pepper feature by their great human-robot interaction. Delivery robot from Starship Technologies feature by its great navigation performance. These developments provide us a startup activation. Standing on the shoulders of these innovations above, we wish to build an indoor robotic guide dog for BVI people that can locate necessary rooms, like bathroom, gate, etc., by recognizing the Ar-tag attached on the wall.

Besides, social activities are definitely having tremendous efficient to our spirit. It is hard for BVI people to recognize their friends or family in public. Inspired by service robot mentioned above, we provide a system that could recognize the faces and compare to preset database. If friends or family of user are conformed, a notification will be sending by system through the audio assistant.

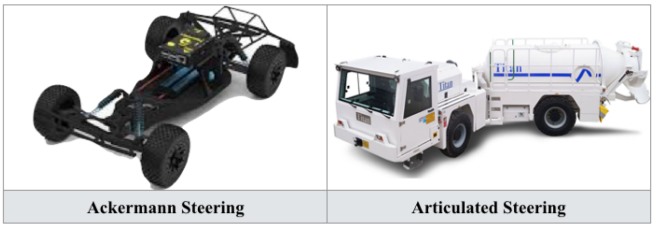
II. THE PROPOSED DESIGN

A. Robotic Guide Dog frame select

Kinematic model of robot plays an extremely important rule as controlling the robot. We wish robot would have same or even more degree of mobility compare with dog.

Unfortunately, it is impossible to reach unless we build a bionic robot. Finding alternative solutions, we propose using differential-drive type as our kinematic model.

The general kinematic model such as Ackermann steering type and Articulated Steering type are applicated in civil using and industry. Considering of degree of mobility economical option, differential-drive robot has more mobility and easier to build.



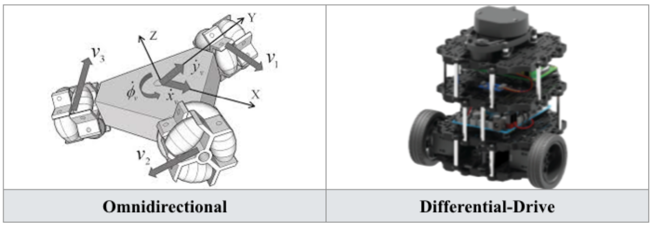


Fig. 1: Kinematic models.

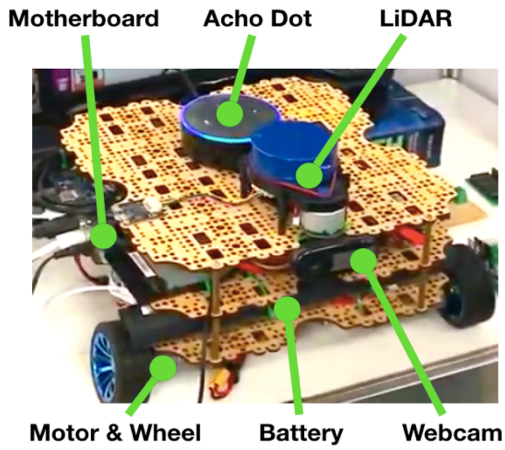


Fig. 2: There is Robotic guide dog equipped with a motherboard of Lenovo ideapad 100, one LiDAR, one Logitech c170 Webcam, one Amazon Echo Dot and a 14.8v Li-Po Battery.

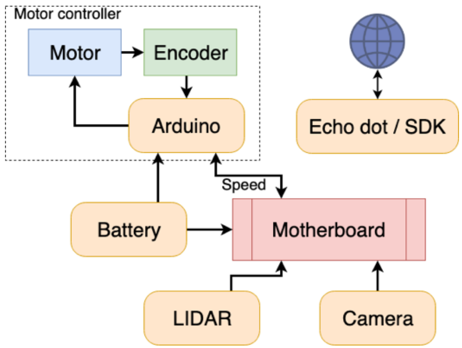


Fig. 3: Hardware structure

B. Propose system

We wish to make portable hardware on robotic guide dog rather a higher compute performance pc connects to it. By using the motherboard of laptop, we could embed it on robotic guide dog and get more flexible to upgrade when necessary.

The proposed robotic guide dog showed in Fig1 and the structure in Fig2. It has one LiDAR, one Logitech c170 Webcam, one Amazon Echo Dot, motor controller and a 14.8v Li-Po Battery.

In the robot, we set up a centralized system with six passive nodes and one core node showed in Fig. 4. Then, core node will choose which node be opened depend on which mode we choose.

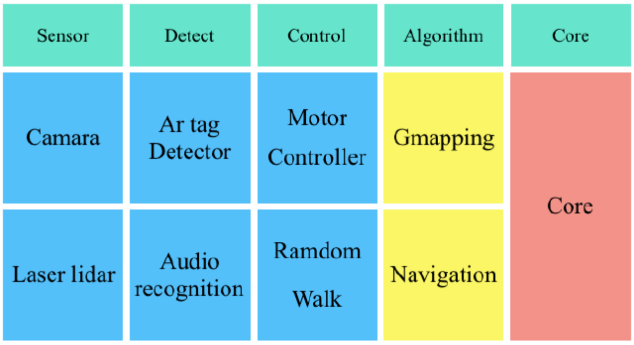


Fig. 4: System structure

C. Simulation

To simulate real indoor environment in virtual environment, Gazebo was used to be as physics engine. We first create a one floor house with furniture and ar-tags on the wall as the specific locations in virtual environment.

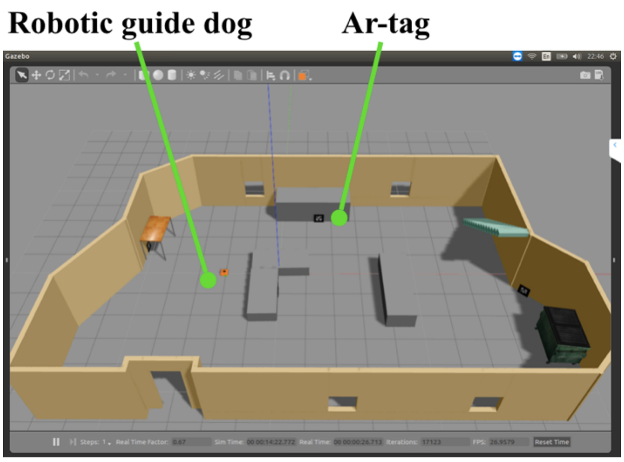


Fig. 5: Virtual environment in Gazebo.

D. Simultaneous localization and mapping (SLAM)

SLAM play an important rule for robotic guide dog to recognizing the environment. Recently Rao-Blackwellized particle filters [1] had made a great contribute as effective means to solve the SLAM problem.

By using laser scanners such as LiDAR or RGB-D camera to scan the features of environment, we simply create the map in RVIZ, a visualization widget tool.

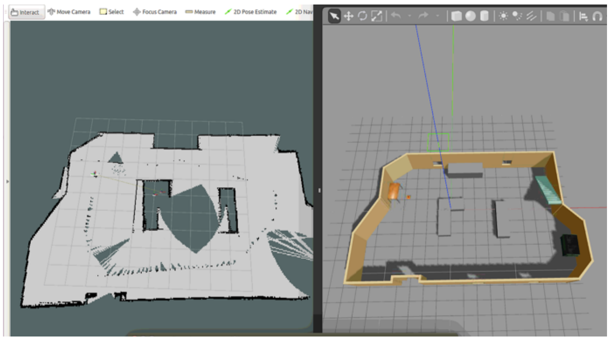


Fig. 6: SLAM.

E. Navigation

Navigation was a critical problem for mobile robot. However, indoor navigation [2] have tremendous progress in past decade. By using two-dimensional CostMap in Global Planner and Local Planner, we simply creating the trajectory of the robot.

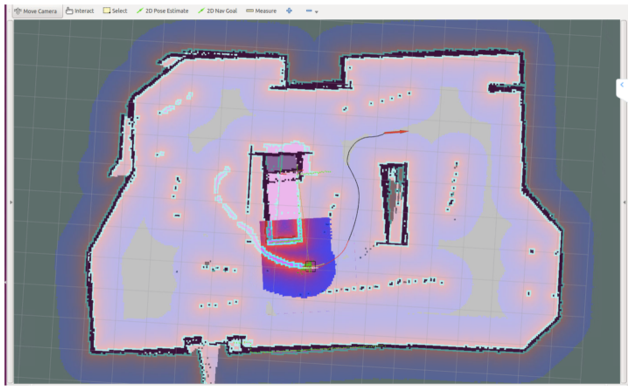


Fig. 7: Navigation visualization.

F. Ar-tag Localization

To make robotic guide dog recognized the specific locations such as bathroom, living, gate, etc., we attach Ar-tag markers on the well as labels for robot. They are encoded binary data by a two-dimensional grid, and it is easy to recognize by a mono-camera and save the location in parameter server. After we calibrate our mono-camera, the distances between markers and camera are calculable.

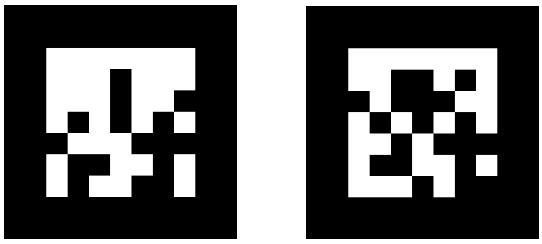


Fig. 8: Ar-tag Markers.

G. Audio Assistant

We deployed Amazon Echo Dot device as robotic guide dog's controller. The functions behind the Alexa audio system are pre-setting by user in cloud. In the "Alexa Skill Kit", we can add intents which could be regular commands or state information. When intense are triggered by user, a message of intent will be sand to local server. On the robot, we make a script to receive triggered intense from local server and connect it to "Alexa Skill Kit" by ngrok. In addition, user could also get daily information and entertainments from native Alexa service.

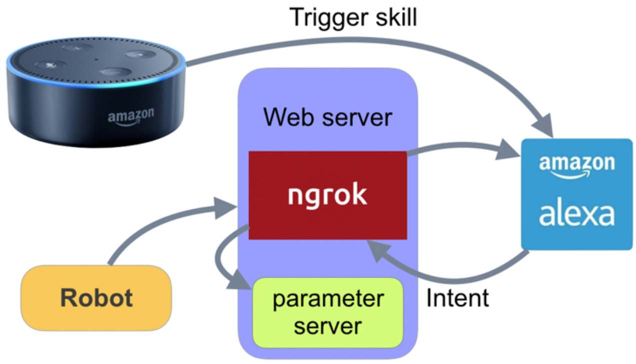


Fig. 9: Official Amazon Echo Dot developing structure.

H. Facial Recognize System

In face recognize system, we use "AWS Rekognition" service as our face detector. AWS Rekognition is a deep learning-based visual analysis service that provide us an easy way to deploy and apply in our robot by using AWS SDK. On our robot, the camera capture one image per second and transmit to AWS. Then AWS Rekognition compare the faces in image with pre-store faces images in AWS storage. After robot receive result data, robot show each faces id, name and pose in visualize software and notify the user.

III. EXPERIMENTAL RESULTS

According the describe above, we built a robotic guide god and tested at the basement with no obstacle. The robot completed the task well. After real testing, we decide to test in virtual environment with furniture and ar-tag makers. As predicted, the robot hit no obstacles, but still remain the problem in SLAM. In the simulation, robot guide dog hangs out around to scan the features of environment and detected the ar-tag markers. The insufficient features of environment cause map broken.

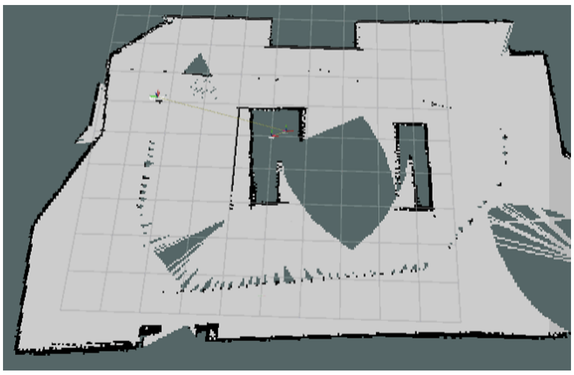


Fig. 10: Broken Map

Communicate with AWS take parts of network traffic and cause network congestion. In order to reduce the dependence on network speed, we propose a salutation by detect faces in image and compress image before transmit data to AWS.

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