Robotic Assistance in Indoor Navigation for People Who are Blind

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***Abstract*—In this paper, we describe the process of making a robot useful as a guide robot for people who are blind or visually impaired. For this group, the interactive audio feature of a robot assumes a very high level of importance. We have introduced some features that will help to make the robot sound natural and be more comfortable. We first addressed the question of the speaker placement to help the user determine the size and distance of the robot. After the initial meeting, user data will be retained by the robot so that their communication evolves with every interaction. The robot will also ask the users if they need to take a rest after a specified interval depending upon the user's age and the distance they need to cover. The next time they visit, all this information will be used to make the interaction more natural and customized for each individual user.**

Keywords—mobile robot, navigational assistance, blind, low vision, audio interaction

I. Introduction

In recent years, people who are blind or low vision have been assisted by well-trained dog-guides, white canes, and wearable technology [1]. These techniques have been proven effective in helping their users to avoid obstacles, informing them about changes in their surroundings, and giving them a greater degree of independence.

A key aspect of our envisioned approach is that these robots will stay within the building and be shared by visitors who need them. This transfers the cost from users to building operators and increases feasibility. However, sharing the robot across users creates an opportunity for easy interaction customization and learning of user preferences.

While doing so, we have tried to make the human-robot interaction a comfortable experience for the user. It has been equipped with interactive features that make the interaction with the robot as friendly and convenient as possible.

I. Physical Features

We wanted to provide assistance using a small mobile robot (Pioneer 3DX) outfitted with a way for users to hold onto the robot. Exploration of different forms and mechanisms with blind and low vision users in simulated guidance experiences led to a harness similar to a dog-guide. We carried out user tests to determine the appropriate handle to ensure the user's comfort. The users were given a choice from models like a shopping-cart, a psuedo upper arm/elbow shape [2], and the D-handle. They were also asked to comment on various materials options. From their feedback we identifed a wooden D-handle as the best choice. The D-handle is stable because of the short arm length. It is horizontal and perpendicular to the robot's travelling direction. Wood was the preferred material because the metal handle was too cold to touch.

Fig. 1. The Pioneer 3DX robot equipped with a wooden harness

The shaft was attached to a pivot point with springs, thus providing a small degree of flexibility. Furthermore, two 20 pound weights and a steel block mounted on top of the P3DX robot. The pivot joint and weights keep the robot stable so it will not tip over when someone pulls or pushes it. Figure 1 below shows the proof-of-concept design with these options.

II. Interactive Features

A. Sound Generation for Identifying the Robot's Location

During the user study, a few users requested for periodic sound generation from the robot. This would help them in locating its position and also give them a perception of its size. As a result, we began research on the best approach for such a feature. This section details important considerations identified by this effort.

The human ear can detect the source of sound based on direction and distance. The direction is determined by two different methods – one for the horizontal plane and one for the vertical plane along the midline of a person's head [3]. The difference in frequency of sound helps in determining the source of the sound. For the user to get a good idea about the robot's size and distance, we need to identify the appropriate location for positioning the source of sound [4]. We will be exploring options such as speakers placed on the handle of the robot and those placed on its deck.

B. Speech for User-Robot Interaction

For audio interaction we have opted to use simple text-to-speech (TTS) software installed on the robot's laptop. Modern TTS software are more natural in their tone and modulation than older versions. We examined a number of TTS options and selected based on the variety of voices available, quality of sound, etc. Festival TTS software was chosen [5].

A variety of voices with differing gender, ages, and nationalites are available in the software. We will give users the ability to choose the one they prefer. We expect the robot will be deployed in busy locations, so users may prefer voices which can be heard in crowded environments.

C. Retaining User Information for Evolving HRI

Good assistants remember the people they help, so we have equipped our robot with a database for user information. When a user gets help from the robot for the first time an account will be created with basic personal information obtained during the interaction (eg. name, age, gender, destination, etc).

We plan to obtain this information through an accessible Android app [6] being developed by the team. This information could be obtained with speech-to-text software, however manual methods are usually found more reliable [7, 8].

Touchscreen interaction for people who are blind is slightly different. One button press reads the label, while second press activates the button. For this interface, we have opted for a six cell design that matches the Braille alphabet.

D. Periodic User Checking

After the user has set out on their journey with the robot, they may wish to rest for a moment before proceeding. While this could be a rare occurrence in an indoor environment, it is important to be taken into consideration since some users need a break for stamina or a secondary task (eg. phone call). The robot wil ask the user every five minutes if they need anything. The user will also have the option to press the STOP/GO button to inform the robot of their choice. In the future, we are considering incorporating a pulse sensor to the robot's handle to infer fatigue from the user's pulse rate and interact accordingly.

E. Charge Awareness

The robot has the ability to check bettery charge level before undertaking a task. This will be needed to ensure the robot can safely complete the entire trip.

III. CONCLUSIONS

This effort has helped us gain insights into how minor features have the potential to greatly improve robot guidance for people who are blind or low vision. Such customization is even more important for people with disabilities due to the variety in interaction preferences and the effort when switching to a more useful and comfortable interface.

In this work, we have made an effort to enhance a user's experience while interacting with the robot. However, numerous features still remain to be improved or implemented. For example, it may be worth equipping the robot with an arm or tray to lift objects that a user may have dropped. This could be tele-operated by a remote human [9] and is especially useful if a soft floor silences the sound of the fall. Another feature we are considering is a camera for detecting approaching people. This would alert them that someone is approaching or is in the way. The same camera could be used to find and recognize the user when meeting the robot.

The quality of interaction that a robot can attain can clearly influence acceptance and use. Therefore, it is critical that deployed assistance robots have a user-friendly interactive system. This paper describes our initial steps towards this goal for shared mobile robots which assist building visitors who are blind or low vision.

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