Robot Face and Its Integration to the Mobile Robot for Wireless Signal Collection in the Fingerprinting-Based Indoor Positioning System

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Abstract. The wireless data collection for instance the Received Signal Strength (RSS) of the Wireless Fidelity (Wi-Fi) remained unfavourable in the Indoor Positioning System utilizing the signal fingerprinting approach. This is because the enormous sampling time and routines works making it tedious human labour. To alleviate this issue, we propose to use a robot for wireless data collection. The robot, named ‘ICSiBOT’ is a service robot with multiple purpose such as assisting human in daily lives, guest or hospitality robot and many others. This paper mainly describes the ICSiBOT robot face with speech recognition technology and the integration of the robot face to the motion controller. The experimental was conducted to see the correlation between the synthesized instructions from the speech in terms of distance need to be travelled i.e., the location for wireless signal collection and translate them into actual distance travelled. The results showed that the robot is able to travel to the specific distance as instructed to the robot face.

1. Introduction

Human–robot interaction (HRI) is a rising research field attracting many research works. Significant progress has been made towards building robots capable of interacting people on a social level in the late 1990s, one of the earliest social robots [1]. Despite significant advances in the subject of cognitive architectures, robots that could listen to human speech, comprehend it, interact with it accordingly to its transferred meaning and replies remain important scientific with sublimination technical difficulties. As a result, research into various techniques for developing the interaction-oriented control architectures capable of dealing with cognitive skills such as emotion and social elements of human-robot interaction is extremely beneficial [2].

In the coming years, the use of social service robots in social settings is projected to increase. The efforts are being made to enable them to perform normal duties, in locations including as homes, offices, hospitals, museums and even in governmental agencies. The presence of humans is a key feature
of these environments which robots need to deal with them socially, for example display emotional reactions during social conversation and smooth navigation in these environments with keeping social distance with human [3]. Today's robots' social capacities are still restricted. However, current social robot prototypes lack essential social features and exhibit only a narrow range of socially acceptable behaviours, preventing them from engaging in completely natural interactions with their user [4].

Social robots are autonomous robots that can interact and communicate with one another, and with people, and are programmed to follow social and cultural conventions. The foundation of human-robot interaction is intelligence [5]. In the tourist and services sector, social robots have grown commonplace. The need for an empirical understanding of the factors that influence visitors' inclinations to employ robots in such services has become critical for their long-term implementation [6]. The ability of a service robot to be sensitive to visitors' expectations, as well as its absorptive capacity, empathy, and information sharing, has a major influence on the desire to employ social robots in tourism, hospitality, and travel services. Only a few research have looked at the interactions between teenagers and robots. Social robots have been proven to be helpful in reducing loneliness and despair in sensitive groups such as children with autism and individuals who have experienced trauma [7]. Because many countries are now facing aging populations as well as a drop in the number of young workers, service robots are one of the most promising technologies for assisting the elderly. Humans are assisted by service robots who perform tedious tasks such as household chores. In some circumstances, service robots may be able to take the position of human caregivers in the care of the elderly [8].

Hence, our group intended to develop a service robot that capable of performing various indoor tasks, for instance in our case to assist in creating the signal fingerprint database of the wireless positioning system, able to interact in the social conversations with emotional face expressions, sharing useful information, and receiving speech commands from the user to control the mobile robot navigation. This paper presents the robot ICSIBot, in particular the robot face design concept, robot face integration with robot base, and the motion control based on user voice input. Finally, the conclusion of this work is drawn, and a concise action plan for future efforts is suggested.

2. Robot And Face Development

2.1. Mobile Robot Platform

The design and the analysis of the developed service robot is described in details in [9]. In order to minimize the budget and lead time, the design should examine the scope of application first, especially for academic and research purposes [10]. Most of the service robots available in the current market shared two characteristics: mobility and user interaction. Selecting the right components for a mobile platform is critical to ensure smooth mobility from one location to another. Choosing the type of wheel and its configuration is one of the steps in building the mobile platform. Differential drive is the most prevalent wheel configuration due to its simplicity, low cost, and ease of implementation. The user interactive system allows the robot to talk and engage with the user. The user interaction component of certain service robots is an LCD screen that displays valuable information as well as face expressions. figure 1 shows the design of ICSIBot while figure 2 illustrate the flow chart of the robot face development and its integration to the motion control.

2.2. Robot Face Design

The robot's head structure as depicted earlier in figure 1 is actually a 7” tablet running on Android Operating System. The tablet has a decent specification of which 2GB RAM and 32GB storage. All of the tasks of movement, listening, speech, and emotion management are implemented in a series of Android apps and communicate with external web services, as well as being able to operate the engines via web APIs. In terms of the robot's face and expressions, we have developed an Android-based application to display the robot's face as well as its expressions and emotions. An online Android
application developer i.e., MIT App Inventor is used to design the face with various expressions. The six basic emotions identified by our surveys with users are the happiness, fear, surprise, disgust, anger, and sadness face plus a neutral or relax face. The neutral face with blinking animation, similar to human blinking at about 15-20 times per minute, is shown in figure 3.

MIT App Inventor is the suitable platform to develop the robot face since it is an online platform used to create concepts of machine thinking through the construction of mobile applications and has been proved to be the best platform for designing and developing the robot face and building the robot database. There are two primary editors: the editor of designs and the editor of blocks, which are used to program application activities by dragging and dropping components into a design editor and utilizing blocks to program application actions. The template editor shown in figure 4 provides a drag-and-drop interface for outlining the application's user interface elements (UI), while figure 5 shows the graphical interface to build up the app logic using color-coded blocks that snap together as jigsaw pieces to form the software in the block’s editor.

![Figure 1. ICSiBOT design](image1)

![Figure 2. Flow chart of robot face development](image2)

![Figure 3. The design of ICSiBOT face](image3)
Figure 4. MIT App Inventor’s design editor.  Figure 5. MIT App Inventor’s blocks editor.

We used the speech recognition in our robot to allow users to communicate with it and interact with it by using voice commands to control the robot's movements and conduct other tasks. All Android smartphones include speech recognition. This may be used to translate speech to text, which can then be delivered to the robot through Bluetooth, in which case the messages are transferred to the Arduino for robot control. This functionality is simple to use in the MIT app creator.

3. Robot to Face Integration

3.1. Mobile Robot Base
In order to emphasize the works on integrating the robot face to the robot body, the focus on the mobile robot base can be considered as significant tasks. There are five main components in our robot control hardware: power supply, Bluetooth, microcontroller, smart series motor drivers, and actuator. For the robot, the rechargeable 12V lead acid battery with a 7.2Ah capacity is the power supply. Compared to other cell types with the same power, this battery is selected for its relatively low price. The voltage from the power supply will be controlled by a set of regulators. The overall process that occurs on the robot systems is managed by the Arduino to control the motor driver (MDDS30) in order to move the motors, reading data from the sensors. The DC motor is the actuator used to power the robot. Bluetooth Serial Transceiver HC-05 is the tool used for connectivity and serial data exchange. The hardware connection of mobile robot is shown in figure 6. We chose differential drive with one castor system for the mobile platform since it is low-cost and simple to execute. The robot's mobile platform specification has been evaluated in terms of wheel size selection and motor rated power as presented in [9].

Figure 6. The hardware connection of mobile robot
3.2. Integration of Robot Face with Robot Base

The integration between the robot face and the mobile robot, which is the underlying subject in this paper, is presented in figure 7. The Bluetooth module is used and established a connection between the robot base and the Android App on the tablet. The Android App sends ASCII commands to the robot, which will be verified by the Arduino for motor control to move the robot in the desired direction. Bluetooth Serial Transceiver HC-05 is the Bluetooth modem that will be utilized in this project. This device connects to any Bluetooth device and can be connected to any serial data exchange microcontroller. It has an 18-meter range and can deliver data at a rate of 2400 bits per second to 115200 bits per second.

Figure 7. Block diagram for hardware connection and control system

3.3. Mobile Robot Motion Control

For the mobile robot navigation, two fundamental methods to control the mobile robot movements which are speech commands via voice recognition, and manual control by using arrow keys which appear on the screen upon command or touch. For manual control, several virtual buttons i.e. up, down, left, right, and stop are used for motion control. On the other hand, the speech commands delivered by a Bluetooth app to Arduino which is programmed to transforms voice messages into text and sends them to the MDDS30 driver, which moves the motors in the desired direction.

1. The command “FORWARD” moves the motors forward.
2. The command “BACKWARD” moves the motors backward.
3. The command “TURN RIGHT” moves the motors to right.
4. The command “TURN LEFT” for the motors to left.
5. The command “STOP” the motors stop.

To evaluate the accuracy of the robot DC motors to travel specific distance, several experiments were conducted in order to find the suitable delay for the DC motors to rotate with limited PWM signal to reach the required distance. The data collected from these experiments have been analyzed by linear regression using Excel software in order to get the suitable question to perform this function. The experiments for forward motion and backward are also set with respect to the difference in the DC motors speed among the motion forward and backward.

Forward equation:

\[ y = 25.826x + 302.34 \]  

(1)

Backward equation:

\[ y = 42.599x - 5.9643 \]  

(2)
Based on these equations, we developed an Arduino code to perform the calculations of the required time need to move the robot motors to the desired distance by speech commands, for instance when we ask the robot to move forward 10 meters it will move exactly 10 meters, also for reverse movements. The analyzed data from the experiments shows the linear regression slope in the graph for the forward distance-delay analysis shown in figure 8 and backward distance-delay analysis shown in figure 9. This is particularly useful especially for wireless data collection where the robot is required to travel a specific location at some distance by instructing the robot via speech commands.

4. Conclusion

In this paper we have presented our experience with ICSiBot, a service robot able to perform human-robot interaction HRI. Service robots are a promising platform with various opportunities of applications, research, and enhancement prospects. In this paper, we have presented the works on design and development of robot face for ICSiBOT using Android-based application, and the integration of the robot face to the robot base for motion control. Equations for forward-delay and backward-delay were formulated which will correlate speech command and the required distance to be travelled by the robot. It is very useful for commanding the robot to move to a specific location, for instance the location for wireless data collection. In addition, more experiments are under planning, for example to observe the wireless signal trustworthiness as collected by the robot, comparing with the data collected by human.

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