Design and Implementation of a Smartphone Based Robot

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Abstract— **Two of the marvels of modern age scientific and technological innovations are the sectors of robotics and smartphones. The field of robotics is a very diverse one with a large variety of robots being tasked to do numerous sorts of activities. And smartphones nowadays are packed with formidable computing power and are mostly used for communication and entertainment and is one of the technologies which has had one of the most massive outreach to the general mass in the history of Mankind. This paper aims to provide a design and implementation of a system that finds means to combine both the fields. The robot is designed to be a simple two-wheeled vehicle that can move forwards, backwards and can rotate. The smartphone is used to deploy a software application that can send commands to the robot to perform these simple movements through screen taps or voice commands.**

Keywords—Arduino,WindowsPhone,Robot,Bluetooth,Speech Recognition,Speech Synthesis

I. INTRODUCTION

Robots in all their forms and manifestations are one of the most advanced and exciting avenues for research and application. The developed Nations have placed an enormous investment therefore in the field of robotics. The robotics sector promises a more automated future in industry and households and a much easier lifestyle. The applications of robots are increasing day by day

Another immensely game changing and life changing product is the Smartphone. Based on Operating systems like Windows, Android, iOS etc. and advanced hardware, most of these gadgets compete with the Computing power of the average Personal Computers. With the advent of smartphones, there has been a revolution in the field of communication and entertainment.

The main aim of this work is to combine the platforms of robotics and smartphones. Generally robots are developed based on a central processor that's the brain of the robot. Besides the main chip there may be other electrical and mechanical components. This project aims to build a robot which will have the smartphone as controller of the robot, and the instructions to be actuated by an Arduino board, which in turn will bear the responsibility of driving the robot using the motor shield. There will be mainly two types of controls, voice control and remote control.

II. RELATED WORK

The idea of combining the Arduino platform with the modern day smartphone platforms such as Android, windows, iOS stemmed from the realization that the incredible processing power and sensors that the smartphones had could be combined with the simplicity and robustness of the Arduino platform to create amazing robots. This would relieve the need for the extra hardware, processors and sensors on-board the robot.

There are diverse and amazing application of these types of Android plus Arduino robots. A mobile robot tracking system [1] developed to track objects and following them is an implementation of the idea. The robot makes use of the camera on the android phone for this purpose, thus alleviating the need for an external camera mounted on the chassis of the robot.

A surveillance robot [2] built with Arduino, Android phone and an external chassis is another such example. This robot utilizes the on board camera of the Android smartphone to take pictures and record video, the GPS of the phone for geographical coordinates and the GSM of the phone for the radio messages.

An autonomous wall-painting robot [3], powered by the Arduino and controlled by an android Phone over Bluetooth provides an insight just how simple robot making can become with the harnessing of the combined powers of the two very different platforms.

Using Android as a control platform [4] for robotics due to its use of Java as a programming language for facilitating Software Engineering practices and its easy integration with Microcontroller platforms such as Lego or Arduino have been discussed by Students of Software Engineering group at Kassel University of Germany.

Commercial applications include Romo [5], a very interactive and multi-skilled robot built combining the Smartphone and the microcontroller platforms.

There are also a group of hobbyists who work on making many diverse implementations of the idea of transforming the

cell phones into actual robots. [6]. They have built many robots based on this idea, with different abilities and architecture. Most of them are Google employees.

Combining Android with proximity sensors [7] for obstacle detection and using a GUI to control a custom made robot was done by researchers at University of Ostrava. The control part was done in Bluetooth.

A group of researchers at Khulna University [9] have made a robotic arm which responds to basic voice commands.The platform for their experiment was the Windows Operating System on a Personal Computer.

Similar sort of experiment was made by some Malaysian researchers which was a basic voice command recognizing robotic car [10]. The Microsoft Speech SDK 5.1 was used in this regard to speak into the computer and a Bluetooth modem to convey the signal to the microcontroller on the robot.

This avenue of combining smartphones with microcontroller platforms is relatively new and few areas have been explored in this regard. So building such a robot which is controlled by both voice and remote terminal along with live video feed will be a very interesting and innovative matter.

III. SYSTEM DESIGN

Our system basically works in two ways, by navigation control and by voice. The Mobile application has interfaces for both voice control and remote control. The Robot is a combination of the Arduino Uno, HC-05 Bluetooth module and the L-298 Motor Shield. All these hardware are mounted on a Chassis which has two DC motors and two wheels. All the communication between the Mobile application and the robot is via Bluetooth. To be precise, it is a serial port communication between the two devices at an agreed baud rate of 9600 Hertz.

A. *Speech and Remote Control System*

After initiating the application and pairing with the Bluetooth module, the application starts listening for commands. Each successful recognition results in an action and each unsuccessful command is requested to be re given with speech synthesis.

The remote control system is a simpler one which sends commands to the robot with the Graphical User Interface (GUI) on the Mobile Aplication
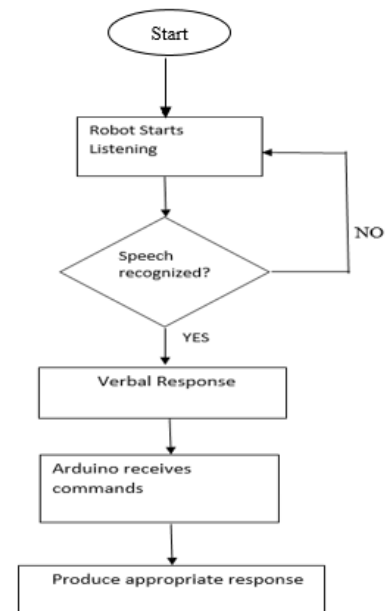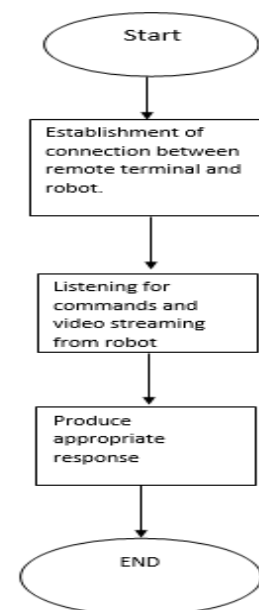

Fig 1. Voice Command System

Fig 2. Remote Control System

B. *Preliminaries*

- Arduino Uno , which is based on a 32-bit AVR microcontroller with complementary components that facilitate programming and incorporation into other circuits.

- HC-05 module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. It uses 3Mbps Modulation with complete 2.4GHz radio transceiver and baseband. It also uses single chip Bluetooth system with CMOS technology. Its default Baud rate is 38400, but is also supports 9600.

- L298, which is a dual full-bridge driver designed to drive inductive loads such as relays, solenoids, DC and stepping motors. An H-Bridge is a circuit that can drive a current in either polarity and be controlled by Pulse Width Modulation (PWM).

- The speech recognition in Windows can be done in various ways, but The Speech Recognition Grammar Specification (SRGS) Version 1.0 is the industry-standard markup language for creating XML format grammars for speech recognition and provides the best results. The grammar is defined along with phrases and weights assigned to ascertain the accuracy in a separate XML file when an application is developed.

- The speech synthesis in Windows is done using the TTS(Text To Speech) functionality. The text which is provided by an application or user is read aloud using TTS. There are multiple languages and a male voice and a female voice for speech synthesis in Windows Phones.

- The Bluetooth programming mainly uses the PeerFinder and StreamSocket Windows Phone Runtime APIs. The PeerFinder first searches for all paired devices and returns a list. Then a socket connection is established.

C. Implementation.

The Arduino chip along with the Bluetooth module and Motor shield are mounted on a chassis. The power supply of the Arduino and Bluetooth is from a 9V battery while the Motor Shield and the DC Motors are driven by 4 batteries, each of 1.5V amounting to a total of 6V.
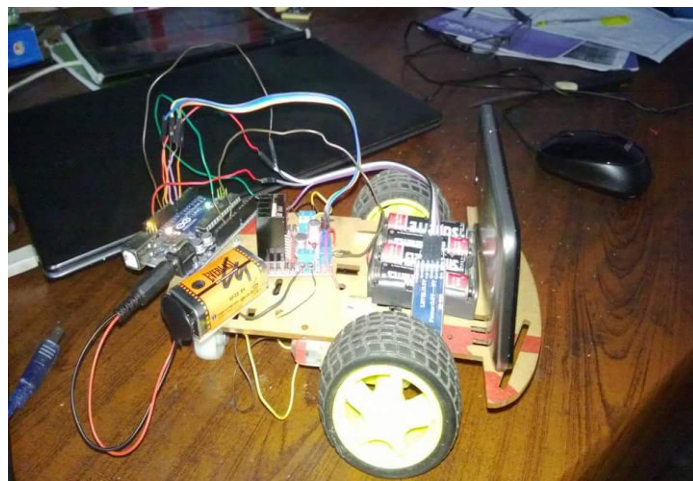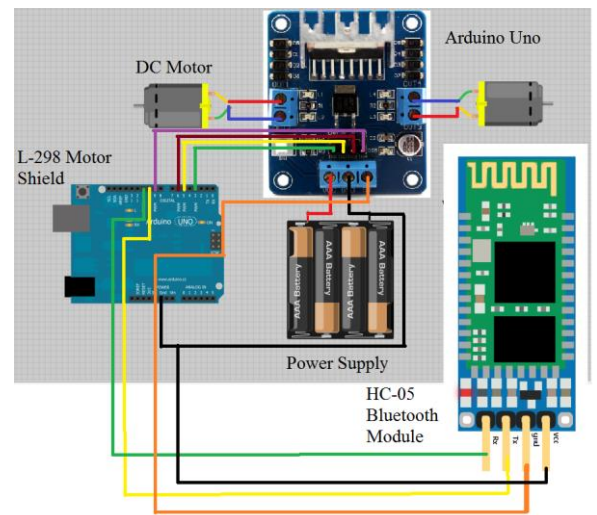

Fig 3. The Robot

Fig 4. Circuit Diagram

As it is evident in the circuit, the positive and negative ends of both the motors are fed into the the two ends, A and B of the DC motor channels. The 5V, GND and VCC are coupled with the original lines of the power supply. The pins of the motor logic control are connected to their respective Digital Pins on the Arduino as provided in the code.

On the Mobile Application end, At the first when application starts, the avatar greets the user and starts listening for commands. The voice commands can be turned on and off by tapping on the microphone logo at the bottom of the screen. The buttons for wireless control are also provided on the same interface.
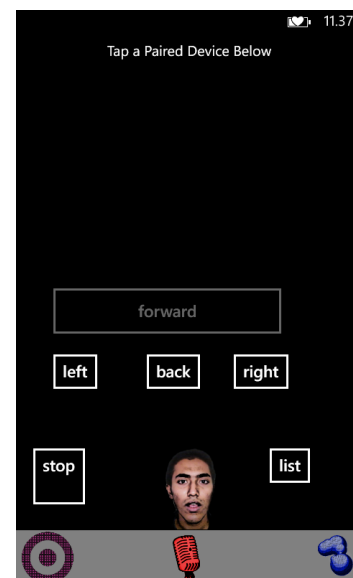

Fig 5. Home Screen of the Application

The list of paired Bluetooth devices can be obtained and displayed with a tap on the LIST button. It is to be noted that the Bluetooth module HC-05 must be manually paired with the phone before trying to operate the robot through the phone.
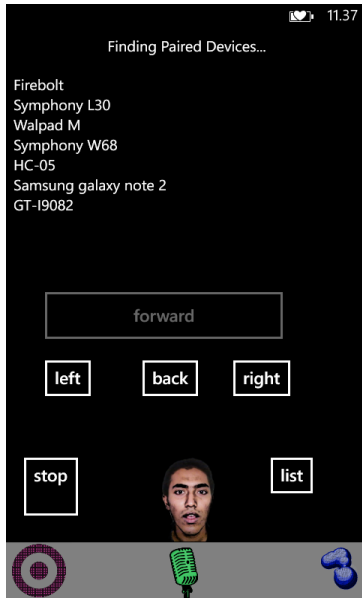
Fig 6 Showing Paired Device List

D. The Robot Manipulation

An Arduino when connected to a HC-05 Bluetooth module in an appropriate circuit, can receive data over an established connection. It is a serial port data stream.

The data sent by the Mobile application after processing the voice command or button press command is received by the Arduino and is basically just one character for each action to be carried out. As we demonstrated in the previous sections, after recognizing a particular phrase or word, the application on the Windows Phone transmits a single character over a serial COM port via Bluetooth, and each character on being received by the Bluetooth module paired with the Arduino board, is sent as a command for a specific movement to the motor shield. The Table below illustrates this.

TABLE 1. Function of Each Character in Controlling the Robot

Character	Function
1	Forward
2	Backward
3	Right
4	Left
0	Stop

IV. RESULTS

There are basically five English and Bangla commands to drive our robot, four for directions and one for stopping.The same command was repeated ten times and tested for accuracy. However,it must be said that the pronounciation in English must be perfect in order for the robot to recognize it. The external noise is also desired to be as low as possible.

A. English Speech Recognition Accuracy

There are basically five commands to drive our robot, four for directions and one for stopping. The same command was repeated ten times and tested for accuracy. However, it must be said that the pronunciations in English must be perfect in order for the robot to recognize it. The external noise is also desired to be as low as possible.

TABLE 2. Accuracy Analysis for English Commands

Input Speech	Forward	Right	Left	Back	Stop
Number of Tests	10	10	10	10	10
Number of Successful Recognition	9	10	7	10	9
Accuracy	90%	100%	70%	100%	90%

B. Bangla Speech Recognition Accuracy

The same process is repeated for testing the accuracy in Bangla Language.

TABLE 3. Accuracy Analysis for Bangla Commands

Input Speech	সামনে	ডানে	বামে	পিছনে	থামো
Number of Tests	10	10	10	10	10
Number of Successful Recognition	9	10	10	7	5
Accuracy	90%	100%	100%	70%	50%

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C. Comparison with Similar Works

Our system is compared below with some of the related works which drive robots via voice commands. The voice is processed in various ways,some on the Personal Computer

using Microsoft Speech SDK and the others using Microsoft's speech API on Windows Phone. Either way this shows the trend of using Microsoft based speech tools for it's robust and flexible use and behavior. The robots are also of various types ranging among Bi-pedal, Arm or a Car like our system. The accuracy is presented where information about it is received.

TABLE 4. Comparison among similar works

Name	Platform	Language	Type	Input	Average Accuracy	Vocabulary
Al Ahassan et al.,2011 [10]	PC	English	Robotic Arm	One Word Speech	-	6 words
Prabuwono et al.,2013[11]	PC	English	Robotic Car	One Word Speech	80.60%	10 Words
Ghosh et al., CUET,2014	Windows Phone	English and Bangla	Bi-pedal	One Word Speech	-	-
Proposed System	Windows Phone	English and Bangla	Robotic Car	Sentence Speech	86%	50 words

V. CONCLUSION

The integration of Microcontroller platforms with smartphone platforms presents us with a huge opportunity to experiment and develop versatile robots. Among the commercial microcontrollers, Arduino is one of the most popular ones. And Windows Phone is also the third most popular Smartphone platform. So as our robot is built with these two platforms combined, it eases up the creation, manipulation and addition of various features.

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