Development of Mobile Robot Controlled by Android Phone via Bluetooth

Wan Nur 'Amirah Wan Idris Najaran
Faculty of Electrical Engineering
Universiti Teknologi MARA Malaysia
40450 Shah Alam, Selangor, Malaysia
E-mail: amirahidris1703@gmail.com

Abstract—**This robot is designed so that it can be controlled by an android phone instead of using the usual controller, which would be the PS2 controller. The android phone acts as a remote control to operate the movements of the robot. The robot is controlled wirelessly using the Bluetooth feature which is present in all android smart phones. A Bluetooth module is mounted on the robot to allow wireless communication between both the android phone and the robot. An open sourced application called Blue Control is downloaded into the android smart phone to enable the communication between both the android phone and the robot. This application acts as an interface between both devices. PIC microcontroller is used as a controlling device for this whole system. It is programmed to implement the movement algorithm of this robot.**

Keywords- Android smart phone, Bluetooth, Bluetooth module, wireless, PIC microcontroller.

I. INTRODUCTION

A robot is an automatic mechanical device often trying to duplicate the behavior of a human or animal. Modern robots are usually an electro-mechanical machine governed by a computer program or electronic circuitry. A robot can be autonomous or semi-autonomous [1]. It is a system that works together to perform a task by incorporating control systems, manipulators, power supplies and software[2]. A robot can be controlled by a human operator, sometimes from afar. Usually, a robot is controlled using a PS2 controller or any sort of other controller of such, be it wired or wireless. However, in this project, instead of using a controller as mentioned, an android phone is used to direct a robot.

What is android? Android is an operating system for mobile phones and tablets, in much the same way that PCs run Microsoft Windows as their operating system. Android comes in a few different versions and is maintained by Google[3]. Android is designed mainly for touch screen mobile devices such as smart phones and tablets. Android contains the vital functions to using mobile phones. However, user can buy or download applications for free to allow the smart phone to do more. For this project, an application (app) was downloaded for free from Play Store. The app is called Blue Control. It is a free application, available for users to program their own robot movements [4].

This project provides a clearer view of the transmitting and receiving signals from bluetooth module and how it is implemented and the range from where the signals can be read [5]. This project also introduces the use of android application to replace a PS2 controller. This technology is widely used in communication field but still new in robotic applications.

A. Research objective:

The key target of this project is to build a mobile robot that can be controlled from an android phone via Bluetooth. Here are some other key purposes of this project:

- To implement the use of embedded controller, specifically PIC microcontroller to process incoming information and perform specific control functions.
- To utilize the use of android phone as means to control the movement of the robot via Bluetooth.
- To link the free downloaded android application with PIC programming to act as a remote that sends commands to the microcontroller.
- To identify the range where the bluetooth module can receive signals strong enough to allow robot movement.

B. Scope and limitations of the study:

- This project is designed to analyze and build a mobile robot that has four wheels to allow stable and smooth movement of the robot.
- This robot will be controlled using an android phone via bluetooth transmission where a Bluetooth device will be mounted on the PIC microcontroller (microcontroller used for this robot) to allow communication between both devices; the microcontroller and the android phone.
- This project focuses on the range where the Bluetooth signals can be read and the speed of transmitting the Bluetooth signals.

C. Significance of study:

If this project is successful, more applications can be used by implementing Bluetooth transmission, rather than limiting the application to mobile robots only. The following potential applied research can be expanded into future research, amongst others and can be widespread. Users can revamp the command line to utilize the Bluetooth transmission into other applications such as household appliances like switching on or switching off the lights, opening or closing the electric gates, turning on the alarm system and many more, all programmed into the user's mobile phone, eliminating the use of many remote control devices [6]. This technology has not yet been explored widely in Malaysia. Hence, if it is delved into, it will be of considerable benefit to all.

II. METHODOLOGY

A. The development of this project can be divided into two sections which are software and hardware development. Both software and hardware development is carried out simultaneously to ensure that the project runs smoothly.

1) Software development

MPLAB IDE v 8.85 was used for this project to program the algorithms of the robot. This process involves learning and creating programs for the robot to communicate and move. This version of the software is compatible with PIC16F877A which is used in this project, with Hi-Tech PIC C-compiler v9.60 as the compiler. Microchip, as the manufacturer of PIC microcontrollers, has a practically bewilderingly large line of PIC microcontroller, and the architecture between lines changes. This can be a hassle if a user tries to transport codes from one architecture to another. Therefore, the correct version of the software with the suitable compiler needs to be used.

A printed circuit board (PCB) was used for this robot where it was designed using a software called Proteus PCB Design. Creating printed circuit boards is a specialized task that requires solid knowledge in the area and also a set of tools to get the job done well and in good time. This software, through a well formulated interface, is most apt to design this type of circuit. Figure 1 shows the completed PCB circuit board.

A free, open sourced application was also downloaded from Play Store on the android smart phone. The application is called Blue Control. This application acts as a remote that sends commands to the microcontroller.

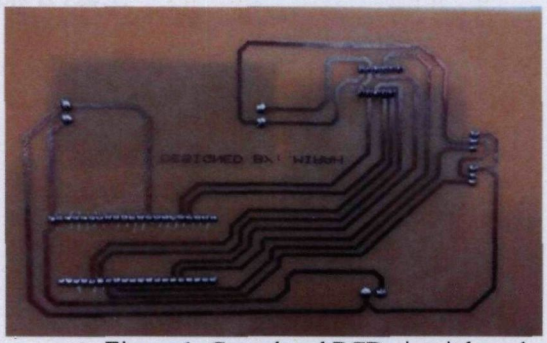

Figure 1: Completed PCB circuit board

2) Hardware development

A few considerations were done in designing the body of the robot. The size and the base of the robot, electrical characteristics, purpose, and rating of current, voltage and power, was all considered. The base of the robot was designed to fit the PCB board, DC motors and also the battery. The bluetooth module is mounted on the PCB board. The following are major components used in this project:

a) Bluetooth module HC-05

HC-05 module is an easy to use Bluetooth Serial Port Protocol (SPP) module, designed for transparent wireless serial connection setup. Serial port Bluetooth module is fully certified Bluetooth V2.0+EDR (Enhanced Data Rate) @Mbps Modulation with complete 2.4GHz radio transceiver and baseband. It uses CSR Bluecore 04-External single chip Bluetooth system with CMOS technology and with AFH (Adaptive Frequency Hopping Feature). It has the footprint as small as 12.7mm x 27mm [7]. After connecting this module, to pair devices, the default pairing code is '1234'. When paired, the blue LED will blink within one second intervals. When disconnected, it will blink within 500ms intervals.

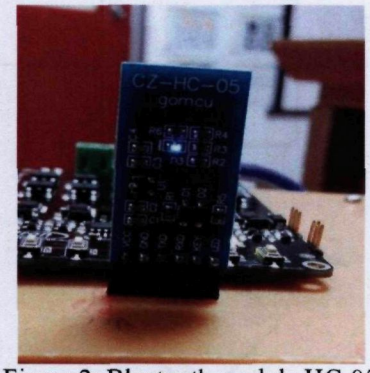

Figure 2: Bluetooth module HC-05

b) PIC16F877A

PIC microcontrollers are products of Microchip. PIC is originally known as Peripheral Interface Controller. In this project the PIC model that was used is PIC16F887A. This model of PIC is a low price microcontroller that has a wide range of application with high quality and easy availability. This type of PIC is an optimal solution in applications such as the control of different processes in industry, machine control devices, and measurement of different values. PIC16F877A has 256 bytes EEPROM memories that allow data to be written more than 1,000,000 times. Besides that it has 368 bytes of RAM memory and 3 independent timers and counters. It also has 8k ROM memory in FLASH technology that make the chip can be reprogrammed up to 100,000 times. All of these features make it ideal for more advanced level analog to digital applications in automotive, industrial, appliances and consumer applications.

c) Embedded Controller Board (SK40C)

Cytron's SK40C is a 40 pin PIC microcontroller starter kit that was designed to offer an easy to start board for PIC microcontroller (PIC MCU) user. SK40C is an enhanced version of SK40B [8]. Users are able to utilize the function of PIC by directly plugging the input and output components in whatever way that is convenient to them according to the project that they want or intend to do. With the UIC00B connector on board which is a simple and fast method to load program, user can start establishing projects, upload their code using UIC00A or UIC00B and have fun with this kit right away to do their project successfully. This kit comes without PIC microcontroller to provide the user some freedom to choose their own PIC model. But for this project, PIC16F887A was used as the PIC model. This board also comes with the basic elements for user to begin project development. It offers plug and also use features. One precaution step that the user must be aware of is do not try to use the onboard SK40C's 5V to power up DC motors as it may damage the regulator.

d) Dual Channel Motor Driver (MDD10A)

Cytron's dual channel motor driver, MDD10A is devised to drive two brushed DC motor with high current of up to 10A, continuously. However, for this robot, this motor driver is used to drive four DC motors, where the wiring of the motors to the driver is slightly altered. MDD10A supports locked-antiphase and sign-magnitude PWM signal. It is using full solid state components that result in faster response time and eliminate the wear and tear of the mechanical relay.

e) DC Geared Motor

Geared DC motors can be defined as an extension of DC motor. A geared DC motor has a gear assembly secured to the motor. The speed of motor is counted in terms of rotations of the shaft per minute and is termed as RPM. The gear assembly helps in increasing the torque and reducing the speed. Its speed can be reduced to any desirable figure by using the correct combination of gears in a gear motor. This concept where gears reduce the speed of the vehicle but increases its torque is known as gear reduction. For this robot, four DC geared motors are used. The motors have a rated speed of 26 RPM and rated torque of 588mN.m with rated current of 410mA each. Hence, the motor driver used; MDD10A is suitable for these four motors, since the maximum current for MDD10A is 10A continuously. The gear ratio for these motors is 120:1.

B. Flow chart of project

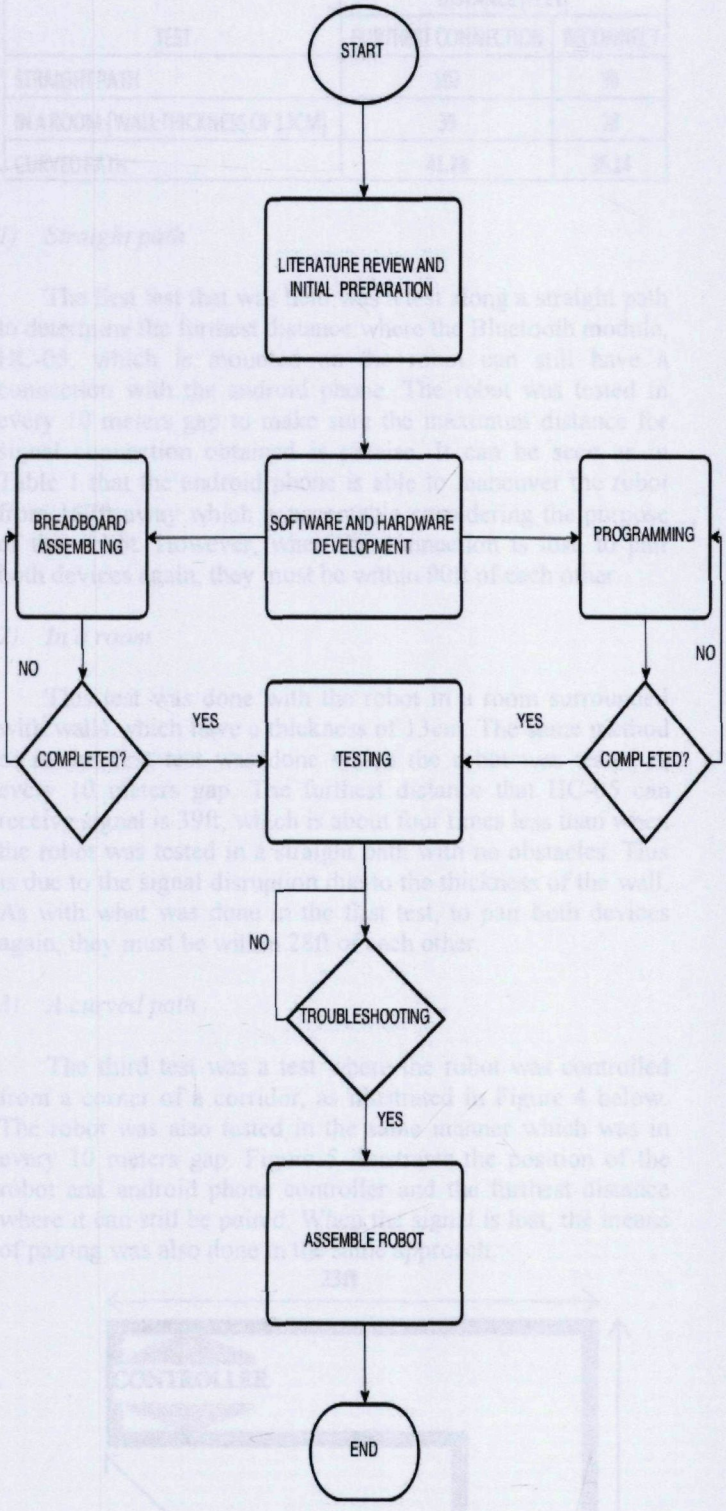

Figure 3: Flow chart of project

C. Schematic diagram of project

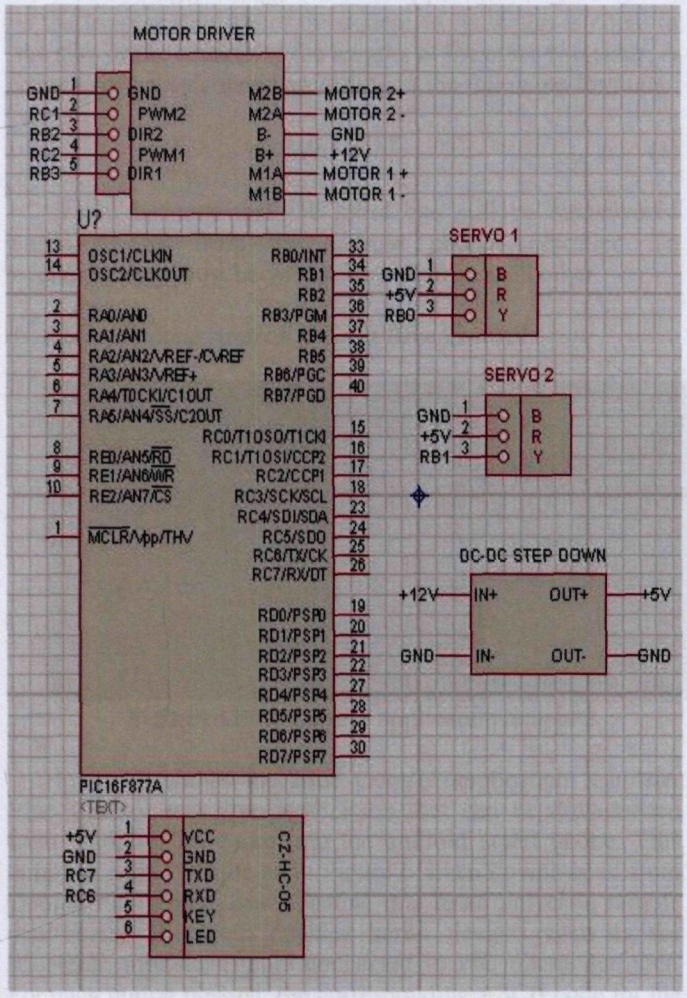

Figure 4: Schematic diagram of the hardware

Figure 4 shows the schematic diagram of the whole project which was done using Proteus PCB Design software.

III. RESULTS AND DISCUSSION

A. Tests to determine the range of Bluetooth signal

Table 1 shows the result of three types of test which was held to identify the range where the Bluetooth module can receive signals strong enough to allow robot movement. Each test was held under different conditions as per stated in the table. The results were taken to an approximate of two feet. Furthest connection means that the Bluetooth signal from HC-05 is still connected with the android phone up until this distance and the signal is lost beyond it. When the Bluetooth signal is lost, the user needs to pair again both the HC-05 and the android phone. The distance where both devices can be paired again is stated in the column named reconnect in Table 1. When HC-05 Bluetooth module is no longer paired with the android phone, the blue LED on HC-05 will blink once continuously with 500ms intervals. If both devices are paired, the blue LED will blink twice continuously with intervals of one second. Further explanations on the tests held are explained below.

Table 1: Range of Bluetooth signal

TEST	DISTANCE (FEET)	
	FURTHEST CONNECTION	RECONNECT
STRAIGHT PATH	167	90
IN A ROOM (WALL THICKNESS OF 13CM)	39	28
CURVED PATH	41.88	36.14

1) Straight path

The first test that was held was a test along a straight path to determine the furthest distance where the Bluetooth module, HC-05, which is mounted on the robot can still have a connection with the android phone. The robot was tested in every 10 meters gap to make sure the maximum distance for signal connection obtained is precise. It can be seen as in Table 1 that the android phone is able to maneuver the robot from 167ft away which is acceptable considering the purpose of this robot. However, when the connection is lost, to pair both devices again, they must be within 90ft of each other.

2) In a room

This test was done with the robot in a room surrounded with walls which have a thickness of 13cm. The same method as in the first test was done which the robot was tested in every 10 meters gap. The furthest distance that HC-05 can receive signal is 39ft, which is about four times less than when the robot was tested in a straight path with no obstacles. This is due to the signal disruption due to the thickness of the wall. As with what was done in the first test, to pair both devices again, they must be within 28ft of each other.

3) A curved path

The third test was a test where the robot was controlled from a corner of a corridor, as illustrated in Figure 4 below. The robot was also tested in the same manner which was in every 10 meters gap. Figure 5 illustrates the position of the robot and android phone controller and the furthest distance where it can still be paired. When the signal is lost, the means of pairing was also done in the same approach.

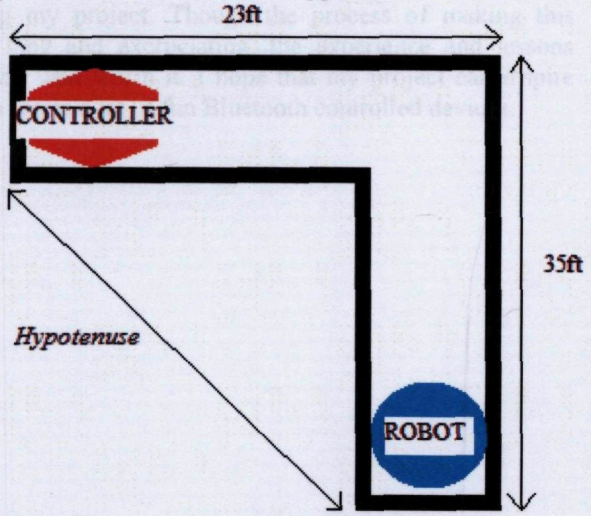

Figure 5: Placement of robot and android phone controller in third test for furthest connection

The tabulated result is the hypotenuse. A hypotenuse is the side of a right triangle which is opposite the right angle. It is the longest side where the square of its length is equal to the sum of the squares of the lengths of the other two sides. A hypotenuse is calculated according to the following formula:

$$c = \sqrt{a^2 + b^2} \quad (1)$$

It can be seen that the robot can still be maneuvered within 41.88ft from the android phone controller. To reconnect, they must be within 36.14ft from each other.

B. Android phone controller using Blue Control

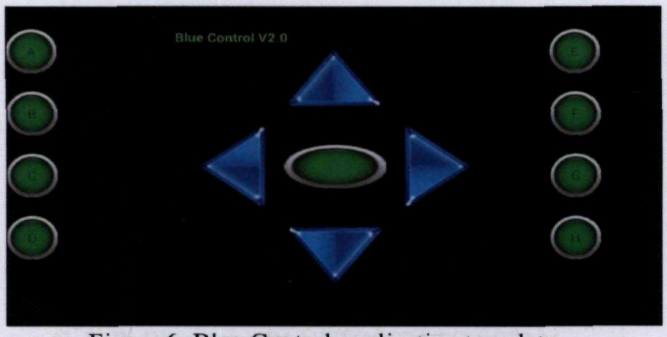

Figure 6: Blue Control application template

Figure 6 shows the Blue Control application template. Blue Control is a free application that can be downloaded from Google Play Store into the android smart phone. This template appears to be as in Figure 6 when downloaded from Google Play Store. Blue Control is a basic universal remote control for Bluetooth enabled serial devices such as the Bluetooth module, HC-05 connected to PIC microcontroller. For each button pressed, the corresponding ASCII code for the label will be sent. For example, when the user presses the up button to move the robot forward, character 'U' will be sent and when the user presses the down button to move the robot backwards, the character 'D' will be sent. To link this application to the robot, a program is written using MPLAB software. The program implements the UART function since HC-05 Bluetooth module requires transmitting and receiving signals. Before using this application, the user must first turn ON the Bluetooth feature on the android smart phone.

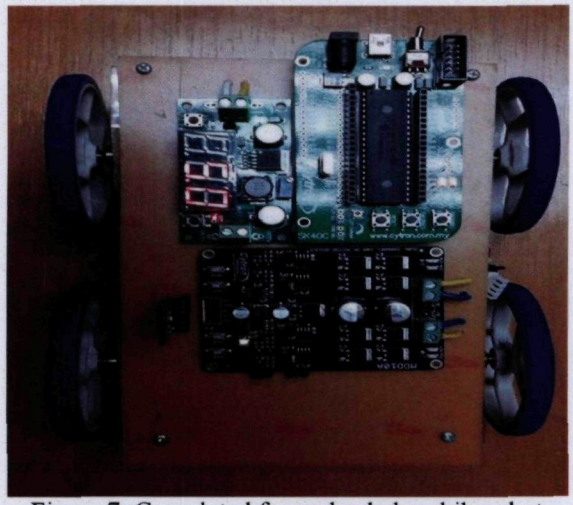

Figure 7: Completed four wheeled mobile robot

IV. CONCLUSION

As a conclusion, the objectives of this research have been met. This project demonstrates the use of Bluetooth interface to maneuver and control the robot. An android mobile phone was used as a remote to control the movements of the robot where the linkage between the phone and the robot was programmed using MPLAB software into the PIC16F877A chip. This project uses the PIC microcontroller rather than the Arduino microcontroller. PIC microcontrollers are relatively cheaper than Arduino microcontrollers. Even if the Arduino has a wider available source regarding Bluetooth transmission, however using PIC is simpler in terms of the programming language and protocol. The language is closer to C language compared to Arduino's language. The development of this project enhances the knowledge of software and hardware skills that can be executed during working later on. The distance accepted for Bluetooth signal is also fair, for all conditions tested.

ACKNOWLEDGMENT

This project utilized huge amount of work, research and dedication. It would not be completed if it wasn't for the support of many individuals. Therefore, I would like to express my earnest gratitude towards those who lent a hand in making sure this project is completed in time. First and foremost, I would like to praise Allah the Almighty for giving me the patience to endure the development and perfecting this project. I am also greatly thankful to my project supervisor, Dr. Rosidah Sam for having faith in me. I would like to express my sense of obligation to Dr. Rosidah for her guidance and tolerance in over viewing my project for two semesters. I would also like to express my sincere thanks towards the IRC club members for giving me valuable lessons on building a robot from scratch. I've learnt most of the tricks and tips of a robot from them and from being in the robotics laboratory. I am also greatly indebted to the club since I used many of the machines and tools available in the laboratory. Nevertheless, I would also like to express my heartfelt appreciativeness to my families and friends for their ideas and support, and for constantly encouraging me to keep on perfecting my project. Though the process of making this robot is long and excruciating, the experience and lessons gained was well worth it. I hope that my project can inspire people to create a lot of fun Bluetooth controlled devices.

REFERENCES

[1] "Robot - Wikipedia, the free encyclopedia." .

[2] P. C. Hills, "Introduction to robots," *Automatica*, vol. 22, no. 5. p. 614, 1986.

[3] "What is Android_ A beginner's guide _ TechRadar." .

[4] E. Data and G. S. M. Evolution, "Smart phone Android Operated Robot," pp. 2–5.

[5] Y. L. Y. Lim, J. K. J. Kim, S. L. M. S. L. Min, and J. S. M. J. S. Ma, "Performance evaluation of the Bluetooth-based public Internet access point," *Proc. 15th Int. Conf. Inf. Netw.*, pp. 643–648, 2001.

[6] "IEEE-Xplore-Abstract-Android-based-home-door-locks-application-via-Bluetooth-for-disabled-people." .

[7] B. Spp, S. P. Protocol, E. D. Rate, M. Modulation, and C. S. R. Bluecore, "BLUETOOTH TO SERIAL PORT MODULE."

[8] "Cytron-Technologies-Enhanced-40-pins-PIC-Start-Up-Kit." .