



Faculty of Electrical Engineering
Universiti Teknikal Malaysia Melaka

**INTERNET-BASED ROBOTIC CONTROL SYSTEM VIA ANDROID
PLATFORM**

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Bachelor of Mechatronics Engineering with Honours

2017

“I hereby declare that I have read through this report entitled “*Internet-based Robotic Control System via Android Platform*” and found that it has comply with the partial fulfilment for awarding the degree of Bachelor of Mechatronics Engineering with Honours.”

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LOR SHENG QIN

**A report submitted in partial fulfilment of the requirements for the degree of
Bachelor of Mechatronics Engineering with Honours**

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2017

I declare that this report entitled “*Internet-based Robotic Control System via Android Platform*” is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name :

Date :

To my beloved father and mother

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ABSTRACT

As Internet of Things (IoT) emerges to become popular and rapidly growing in this era, it allows people to connect all sensors that interact in our daily life for various purpose. Aside from real time data monitoring, data collection and exchanging, this concept aimed to transfer data without human interaction with machine. Nowadays, with the combination of low-cost components that can be easily obtain from electronic stores, IoT can be made possible by self learning and hands-on projects. There are problems of accessing places or areas that are unfit for human such as collapse building, radioactive factory, explosive device area or even disaster area. Human are prone to life-threatening diseases and injuries while mobile robot does not, the parts can be replaced whenever damaged while human cannot. Hence, this project proposed a Arduino powered Omni-wheel mobile robot that can be control with Android device through internet wirelessly. Objectives involved are design and develop a mobile robot that can be controlled by Android platform device wirelessly, develop an Android application for mobile robot control and analyse the distance and obstacle detection using sensor. This system involves two interrelated components which are Android platform application and mobile robot, as objectives both will communicate and interact with each others through cloud server. Obstacle detection system is added to the mobile robot, where it can detects obstacle ahead using multiple sensors. Reliability study of the mobile robots which includes the translational motion, rotational motion, data transmission test and obstacle detection test had been carried out. Each experiment on the mobile robot will be repeated 10 times to increase accuracy as well as consistency, results are tabulated with average value. Expected results would be successful control of mobile robot using Android application and obstacle detection system is successfully deployed. These analysis will make way for future researcher in making IoT mobile robot more successful.

ABSTRAK

Objek Rangkaian Internet (IOT) muncul untuk menjadi popular dan berkembang pesat dalam era ini, ia membolehkan orang ramai menyambung semua sensor yang berinteraksi dalam kehidupan seharian kita untuk pelbagai tujuan. Selain daripada memantau data dan mengumpul data, konsep ini bertujuan untuk permindahan data yang tanpa interaksi manusia dengan mesin ataupun komputer. Pada masa kini, dengan gabungan komponen kos rendah yang mudah didperolehi daripada kedai-kedai elektronik, projek IOT boleh dibuat oleh seseorang dengan pembelajaran sendiri dan praktikal. Projek ini boleh membantu untuk menyelesaikan masalah mengakses ke tempat atau kawasan-kawasan yang tidak sesuai untuk manusia seperti bangunan runtuh, kilang radioaktif, kawasan letupan atau kawasan bencana. Manusia terdedah kepada penyakit dan kecederaan manakala robot tidak, bahagian-bahagian yang rosak boleh diganti bila-bila masa manakala manusia tidak boleh. Oleh itu, projek ini bercadang satu robot mudah alih Arduino yang boleh dikawal oleh peranti Android secara wayarless melalui internet. Objektif yang terlibat adalah mereka bentuk dan membina sebuah robot mudah alih yang boleh dikawal oleh peranti Android secara wayarless, membina sebuah aplikasi Android untuk mengawal robot mudah alih dan menganalisis pengesanan jarak dan halangan yang menggunakan sensor. Sistem ini melibatkan aplikasi platform Android dan robot mudah alih, sebagai objektif kedua-duanya akan berkomunikasi dan berinteraksi antara satu sama lain melalui pelayan awan. Ciri pengesanan halangan objek ditambah kepada robot mudah alih, di mana ia boleh mengesan halangan pada depan menggunakan sensor yang ada. Kajian kebolehppercayaan robot mudah alih yang termasuk gerakan translasi, gerakan putaran, ujian penghantaran data dan ujian mengesan halangan telah dijalankan. Keputusan yang dijangka daripada projek ini adalah kejayaan mengawal robot melalui aplikasi Android dan sistem mengesan halangan berjaya dilaksanakan. Analisis ini akan memberi laluan kepada penyelidik masa depan dalam membuat IOT robot mudah alih yang lebih berjaya.

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CHAPTER 1

INTRODUCTION

1.1 Overview

This section includes a few topics such as motivation, problem statement, objectives and scopes of study. It outlines the motivation regarding this proposed project with existing problem in real life. Besides that, objectives of this project set aim to solve the problem existed in our life. Furthermore, the scope of study includes the area study of experiments, limitation and target of the project.

1.2 Problem Statement

Internet of Things (IoT) application in real life works on wireless interconnectivity of devices and cloud wirelessly, where the type of wireless communication method is important for data exchange and transfer, without it data are not able to go from one end to another. Nowadays, there are wide range of wireless communication to control mobile robot without physically present at a location. In order to effectively transfer and exchange data with cloud, a reliable and effective type of wireless communication is required, so that the limitation of range is able to overcome without affecting the performance of the system.

Next, the controllability of mobile robot have to be flexible rather than can be control using laptop with user interface due to its weight and size that directly affects its mobility. With the rise of smartphone era, task no longer restrain to be perform only by laptop, mobile applications is created by developers to diversify the functionality of smartphone and to overcome restrain. An application should be develop to substitute the task performed by laptop and for the control of mobile robot. Application of the device platform should be programmable, have wirelessly connectivity, mobility and user-friendly.

A mobile robot that situated a place that user hard to reach or estimate surrounding area can be said as blindfolded and hence is one of the challenge. This is because obstacle ahead or around the mobile robot have the possibility to deal damages on it as mobile robot is unable to avoid on itself and lack of self-awareness on surrounding hazard. Camera on-board might be one of the effort to solve this issue and it requires machine vision technique but the camera is unable to rotate and monitor the surrounding of mobile robot at a time. Thus, obstacle detection feature must be implement to any of the mobile robot system.

1.3 Motivation

Remote controlled mobile robot nowadays are everywhere using Bluetooth and WiFi technology as a communication channel between the user and mobile robot. Using method above are common in the research area because both proves to provide effectiveness in controlling the mobile robot. This project was inspired by the advancement of internet connectivity with every WiFi-enabled devices, sensors or machines and introduction of Internet of Things (IoT).

As internet has become part of human life, it revolutionised human way of living and now with a simple touch anyone could access the world. Internet does make impossible things to possible in every way such as getting in touch with people around the world, gathering information without camping in the library, and knowing news from every corner of the globe. With introduction of WiFi, the rate of American went online has increased drastically according to Pew Study from 29% to 71% since 2000 until as of today's date [2].

Internet of Things (IoT) are making a buzz these days, it is built based on the network of sensors and cloud computing with application. Data are collected into the cloud in real time and work around the clock in order to provide flexibility and accessibility, it is like a medium of exchanging data between sensors and user with further features like analysing, leveraging or interpreting [3]. A research conducted by Juniper predicted that there will be 38.5 billions of devices connected to each other and also the internet. It is all about making everything around us smart, easier and efficient [4].

Next, Android is an open source platform aims to introduce more innovative and successful product that could improve users' experience on mobile. It provide all developers the freedom to customize to ones need, however every legitimate developers or users are required to join in the Android Compatibility Program that would require developers to achieve the status of "Android Compatibility" as one of the effort to maintain a common ecosystem [5]. Android provides unlimited resources that one needs to create an application, its flexibility and customizability are much easy to fuse in any projects with existing library and back-end

support. Using Android platform in this projects also due to large numbers of user with similar device platform, increasing chances of application being notice and hence increase feedback on the development of application based on their needs.

This project will implement a system that able to control the mobile robot wirelessly and remotely. A mobile robot with holonomic movement are used as conventional wheeled robot could not move in any direction instantaneously without performing sort of motion to change the robot heading. Then, an application are needed to control the movement and interaction of mobile robot where it is able to communicate with the controller on mobile robot itself wirelessly, so that every command sent would be receive and execute by the controller. Thirdly, user that control the mobile robot may not able to estimate the distance between obstacle and robot, therefore an obstacle detection ability is aim to provide a safe perimeter around the robot so that it will not collide with any object that may damage itself.

With the completion of this project, it will take a leap into the advancement of mobile robot control system that integrate with IoT that may apply into the various fields such as warehouse logistics and conventional use.

1.4 Objectives

The objectives set for this project are:-

1. To design and develop a mobile robot that can be controlled by Android platform device wirelessly.
2. To develop an Android User Interface application for mobile robot.
3. To analyse the distance and obstacle detection using ultrasonic sensor.

1.5 Scope of Study

The scopes of this projects are:-

- (a) Experiments of mobile robot are conducted on flat and even surface such as brick, ceramic, concrete, limestone, mosaic and etc.
- (b) The activity of mobile robot is limited to control by Android platform device that only installed with self-developed application.
- (c) The activity area of mobile robot is limited to Wireless Local Area Network (Wireless LAN) environment.
- (d) Wireless communication module and device which comes with specifications that user should not operate beyond the limit.
- (e) Android application to control and monitor the activity of mobile robot is designed and developed using Android Studio.

1.6 Summary

Problem statements were outlined in this section with the rise of motivation towards those problem and objectives of study were clearly listed out above. The scopes of this projects are set accordingly to fulfil the objectives of study. The following chapter would be literature review on this project.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, literature review are done based-on trusted resources such as articles, conference proceedings and journals prior to the relativity with this project. Reviews on related works, wireless technology and controller platform are studied with comparison within each others. The evaluation on each components, methods and comparison are listed below. This section is to review a few research or project that have some similarity and has been carried out by other researchers. These projects utilized different approach of communication method within robot and controller, different robot platform or microcontroller and controller to robot interacting method.

2.2 Related Works

G. Ersahin and H. Sedef has studied and developed a tablet computer controlled mobile robot that communicate using Wi-Fi. The mobile robot is equipped with on-board web camera that is used to obtain real-time video feed and send to controller wirelessly. The mobile robot itself is controlled with Raspberry Pi that used ARM processor and programmable by using Linux operating system. The Raspberry Pi consists of general purpose input/output (GPIO) ports with PWM enabled are responsible to control the wheel movement through L293D motor driver that supported with 12V DC power supply. Besides that, Raspberry Pi is used to process video feed from the camera, communicate and transmit data to the controller wirelessly through Wi-Fi device.

Surveillance Robot is proposed and studied using communication of Android platform smartphone and remote user over the internet. The Android smartphone on the mobile robot served for two purposes, one acts as a communicating bridge between Arduino UNO microcontroller and the controller, where it receives command from the remote host and relay them to the microcontroller using USB On-the-go cable. The second is it used for live video feed transmission to the remote host over the Internet using internet sockets [6]. The MATLAB Graphical User Interfaces is designed and created using GUIDE toolset to control the mobile robot remotely, however the Android application is coded using Android Software Development Kit (SDK) in Java language [7].

Development of smartphone remote control robot conducted in reference [8] are based on Android operating device that coded in Java Language. The communication between robot host with 802.11N compatible wireless network card and smartphone with Wi-Fi functions are using Wi-Fi network. There two schemes of indoor Internet sharing, point-to-point network and Wireless Hub. For this system, it used the Ad-Hoc mode which belongs to the first scheme that does not require through a wireless router. TCP protocol is used due to its reliability, order and sequence of data transmission.

2.3 Wireless Technology

Nowadays, there are various wireless technology that can be choose to implement in Internet of Things (IoT) and Machine-to-Machine (M2M) projects communication method [9]. IoT-based robotic system requires a medium for interchanging data and information whether its within an area or remote from far. In this project, wireless communication is required in order to communicate, control and interface with the mobile robot through Arduino. Reviews under Wireless Technology includes Wi-Fi, Bluetooth/BLE and WiMAX.

Wi-Fi or known as Wireless Fidelity is one of the technology that connecting two or more device with similar radio waves wirelessly without the connection of cables. It can be said as the most notable technology as it have achieved an enormous growth in these few years [10]. This type of wireless network that operate based on the 802.11 standards [11] that developed by the Institute of Electrical and Electronics Engineers (IEEE) which available at 2.4GHz UHF and 5GHz SHF ISM bands [12].

Bluetooth or Bluetooth Low Energy (BLE) are technologies that used to transmit data over a limited distance which mostly used at hand-held or mobile devices such as smartphone and tablet. It is a UHF radio waves that used to be standardized under IEEE 802.15.1. [12]. Todays Bluetooth connections basically are supported by most of the mobile devices which give it a benefit of convenience over others device. However, the disadvantage of using Bluetooth are high and jittering on latency with instability issues [13].

Table 2.1 below shows the table of comparison of frequency, nominal range, signal rate, typical current absorbed and output power between Bluetooth and Wi-Fi technology [14]. Next, World Interoperability for Microwave Access stands for WiMAX in short that

Table 2.1: Comparison of Bluetooth and Wi-Fi specifications.

Specification	Bluetooth	Wi-Fi
Frequency	2.4 GHz	2.4 & 5 GHz
Nominal range	10 m	100 m
Signal rate	1 Mbps	54 Mbps
Typical current absorbed	1-35 mA	100-350 mA
Typical output power	1-10 mW	30-100 mW

runs at IEEE 802.16 standards is able to deliver low cost yet high speed wireless broadband with larger coverage compared to WiFi. Although WiFi and WiMAX serve the same purpose of interchanging data but both are designed to suit two complete different needs. Table 2.2 shows the corresponding spectrum, theoretical data rates and typical data rates of WiMAX fixed and mobile standards [15]. Wi-Fi proved itself to be a better choice over

Table 2.2: Comparison of data rates for fixed and mobile standards.

Standards	Spectrum	Data Rates	Typical Data Rates
Fixed	20 MHz	75 Mbps	20-30 Mbps
Mobile	10 MHz	30 Mbps	3-5 Mbps

the rest where it is able to provides faster rate of data transmission, more secure network (properly configured) and greater signal range compared to Bluetooth technology [16]. As to control the robot remotely at two different location and in the case as Wireless network are presence, Wi-Fi technology is chosen over WiMAX for implementation in this project due to the multiple reason. Broadcasting range of WiMAX requires more energy and high cost infrastructure to sustain whereby Wi-Fi can be installed easily at low cost providing access point to users. Most of the smart device or electronic gadgets with WiFi enabled nowadays mostly are compliant to Wi-Fi 802.11 standards rather than WiMAX 802.16 standards [15].

2.4 Controller Platform

In order to receive, transmit and execute command from the remote host, this project requires a controller to communicate with the remote host using Wi-Fi module in order to control the movement of mobile robot. The controller also requires to process data or information that obtain through the sensors that attach to it and send to the remote host for monitoring and controlling purpose, thereby it is important to choose a controller with specifications within the allocated budget that are suitable with the purpose and operation of the system, such as the complexity of whole system, number of task, repetitive of task and complicated decision making.

Arduino Mega 2560 as shown in Figure 2.1 is a board-based open source microcontroller using ATmega2560 chip that designed and manufactured by Atmel Corporation consists a total of 70 General Purpose Input/Output (GPIO) that includes 54 Digital I/O and 16 Analog I/O, clock speed of 16 MHz, 256 kb of flash memory, a reset button, ICSP header, power jack and 4 UARTs. With the price of \$35, this microcontroller operates at 5V DC with the maximum input voltage of 20V and can be connected to computer using USB cable for programming or power up. It is also compatible to most of the modules or shields that are designed for the former version of Arduino. Arduino microcontroller can be coded with C or C++ language using Arduino integrated development environment (IDE). It is well-known and widely use by beginners, professionals, researchers, hobbyists and engineers for completing various research and projects due to its low cost, open-source, cross-platform microcontroller and easy-to-use programming environment [17].