THE DEVELOPMENT OF MOBILE ROBOT FOR AIR POLLUTION DATA CAPTURE (POPOBOT)

KHAIRUL AZLAN BIN A. RAHMAN

A thesis submitted in
fulfilment of the requirement for the award of the
Degree of Master's of Electrical Engineering

Faculty of Electrical and Electronic Engineering
Universiti Tun Hussein Onn Malaysia

MAY 2011

ABSTRACT

In the Modern era, the environmental issues have given significant impact to the human live. The air pollution indoor and outdoor environment sometimes dangerous to the human health and it needs to be justified. To fulfill this purpose, tele-measurement process and technique should be used. Therefore, in this research, the mobile robot with equipped by several air quality parameters sensors is developed. The robot is controlled using remote control and using wireless connection system. The air quality in target area will be monitored by using sensors which will capture data and send it to the Central Control (laptop) for analyzing. And then to be able monitor certain area investigation, the mobile robot is guided by using wireless camera. Result from this project can make user to monitor and navigate the target area by using mobile robot and this can make user know the situation on that area. PIC16F887A has been chosen in this project as the main device which is controlling all activities of the mobile robot. Data capture and robot movement has been done in wireless to make user easy to do the monitoring activities. From result, knowing that the error percentage of the data capture is small compare to the digital meter. So from that knowing this project is effective because it make user easy to do air pollution monitoring process also can prevent the gas poisoning cases from happen.

ABSTRAK

Dalam era kemodenan abad kini, masalah alam sekeliling dan pencemaran persekitaran sentiasa menjadi perbincangan dan telah memberi kesan yang sangat mendalam terhadap kehidupan manusia sejagat. Masalah pencemaran udara bukanlah satu masalah yang boleh diambil mudah. Ini kerana udara yang tercemar ini kini boleh membawa kematian kepada manusia dan oleh sebab itulah ia perlu diberi perhatian. Memantau kandungan udara adalah suatu usaha yang wajar diambil. Oleh sebab ni, projek robot mobil yang serba dilengkapi dengan alat pengesan kandungan gas di dalam udara telah dijalankan. Robot mobil ini adalah dikawal dengan menggunakan alat kawalan jauh atau lebih tepat lagi menggunakan komputer dengan kaedah komunikasi tanpa wayar. Kawasan yang telah dikenalpasti boleh dipantau kandungan udaranya dengan menggunakan alat-alat pengesan yang telah dilengkapi pada robot mobil ini dan segala data yang diperlukan untuk tujuan pemantauan ini telah dihantar terus ke computer secara komunikasi tanpa wayar untuk dianalisis dan seterusnya disimpan bagi tujuan rujukan. Untuk memudahkan robot mobil ini dikawal secara tanpa wayar, satu kamera mini tanpa wayar telah dipasang pada robot ini. Hasil dari projek ini, telah membolehkan pengguna memantau kawasan-kawasan yang dikhuatiri tercemar kandungan udaranya. Projek ini telah menggunakan PIC16F877A sebagai alat utama bagi mengawal segala operasi. Pengesan suhu, gas dan kelembapan adalah tiga alat pengesan yang digunakan dalam projek ini. Hasilnya didapati robot ini dapat bertindak seperti yang dikehendaki kerana hanya sedikit ralat sahaja yang terhasil. Ini menunjukkan projek ini berkesan dalam usaha untuk mengelakkan bahaya atau kematian manusia akibat dari udara yang tercemar.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

UART	Universal Asynchronous Receiver and Transmitter
GUI	Graphical User Interface
PC	Personal Computer
PPM	Part per Million
WWAN	Wireless Wide Area Network
WLAN	Wireless Local Area Network
WPAN	Wireless Personal Area Networks
CO	Carbon monoxide
Rx	Receive terminal
Tx	Transmit terminal
DC	Direct current
USB	Universal serial Bus
PIC	Programmable Integrated Circuit
RPM	Rotation per minute

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

Many things about mobile robot can do today than ever before, thanks to recent technical advances and cost reductions. These mobile robots are often used in situations where low dimensions (such us gas pipes or mines) as much as dangerous environments (radioactivity, toxicity, etc) forbid the human presence. The potential of robots to accomplish such tasks depends on how well they can locate and interact with objects in their environment. When a mobile robot moves in a low structured environment, it is necessary fit it up with perceptual capabilities. Machine vision and image processing are very broad areas of research, and there are an ever-growing number of creative and useful methods for retrieving information from images.

1.2 Problem statement

Nowadays, air pollution is very dangerous because of the pollution contains extremely poisonous gas which can kill. In some circumstances, working in polluted air cannot be avoided, because it is not easy to know the air quality in the environment or in the workplace is polluted or not. To overcome above problem, in this project is designed the mobile robot that equipped with air quality sensors. The

robot is controlled using remote control (laptop) and communication between robot and controller is using wireless communication system (Bluetooth). Besides that, it also equipped with wireless camera for guiding to come into target area. Data captures from sensors are sent to the Central Control with wirelessly. This can help human know the condition of target area before come into it.

1.3 Objective of Research

The main objective of this project is to control a mobile robot and capture data by using wireless connection such as Bluetooth System. The data capture by using sensor and transmitting wirelessly. Several projects objectives have been set out as the working focus point such as:

i) To implement wireless connection system on mobile robot.
ii) To transfer data captured (air quality index) from sensor to Central Control (laptop).
iii) To test the robot in order to analysis the performance.

1.4 Scope of Research

This project contains limited scopes which are:

i) The software uses in this project consist of Visual Basic 6, Proteus and MpLab.

ii) Mobile robot control and data transfer system done with wireless communication.

iii) The radius of wireless is about 30m.

iv) Wireless camera is used to monitoring and controlling the mobile robot movement to come into the target area.

v) Three types of sensors are installed in mobile robot. They are temperature sensor (LM35), gas sensor (TGS2600) and humidity sensor (HD10D).

1.5 Thesis Outline

Chapter 1 is introducing the introduction of the project title and project background. Also this chapter is to state the project objective and project scope.

Chapter 2 is review on three major sections related to the research literature review. The first section describes the introduction of wireless. The second section explains the Bluetooth system concepts and the last section reviews the projects related to the wireless communication, Bluetooth system, mobile robot and also the air pollution.

Chapter 3 has explain about five major sections related to the research methodology. The first section describes the project overview. The second section explains the system requirements where some application had been defined. The third section describes the system architecture where the novel system architecture

has proposed. Hardware design had discussed in fourth section. The last section explains the software design where low and high level software had been discussed.

Chapter 4 is to discuss the result of the system development and testing on hardware and software. The testing is broadened into two parts: Interface testing and system testing. The interface testing discusses all hardware's unit that interfacing to the microcontroller. The system testing focuses the high level software operation.

Chapter 5 is the final chapter that provides conclusion of the system design and development. In addition, it discusses the possible direction of recommendation in future work based on the results presented in Chapter 4.

CHAPTER 2

LITERATURE REVIEW

2.1 Air Pollution

Air pollution is the introduction of chemicals, particulate matter, or biological materials that cause harm or discomfort to humans or other living organisms, or damages the natural environment into the atmosphere. The atmosphere is a complex dynamic natural gaseous system that is essential to support life on planet Earth. Stratospheric ozone depletion due to air pollution has long been recognized as a threat to human health as well as to the Earth's ecosystems. Indoor air pollution and urban air quality are listed as two of the world's worst pollution problems (Turner, 1994).

The following table lists the chemicals, when classified as hazardous wastes, meet the DTSC criteria for HWC as poisonous gases as adopted on July 1, 2003 in the California Code of Regulations, title 22, section 66261.111, with a July 10, 2003 effective date. The chemical names are excerpted from the U.S. DOT Hazardous Materials Table as revised October 1, 2002 (Bill, 2002).

Table 2.1: U.S. DOT Hazardous Materials

HAZARDOUS WASTES OF CONCERN LIST OF POISONOUS GASES EXCERPTED FROM THE U.S. DOT HAZARDOUS MATERIALS TABLE (as revised October 1, 2002)	
PROPER SHIPPING NAME	**HAZARD CLASS**
Ammonia solution, [relative density less than 0.880 at 15 degrees C in water, with more than 50 percent ammonia]	2.3
Ammonia, anhydrous	2.3
Arsine	2.3
Boron trichloride	2.3
Boron trifluoride, compressed	2.3
Bromine chloride	2.3
Carbon monoxide and hydrogen mixture, compressed	2.3
Carbon monoxide, compressed	2.3
Carbon monoxide, refrigerated liquid [(cryogenic liquid)]	2.3
Carbonyl fluoride, compressed	2.3
Carbonyl sulfide	2.3
Chlorine	2.3
Chlorine pentafluoride	2.3
Chlorine trifluoride	2.3
Chloropicrin and methyl bromide mixtures	2.3
Chloropicrin and methyl chloride mixtures	2.3
Coal gas, compressed	2.3
Compressed gas, toxic, corrosive, n.o.s. [Inhalation Hazard Zone A]	2.3
Compressed gas, toxic, corrosive, n.o.s. [Inhalation Hazard Zone B]	2.3
Compressed gas, toxic, corrosive, n.o.s. [Inhalation Hazard Zone C]	2.3
Compressed gas, toxic, corrosive, n.o.s. [Inhalation Hazard Zone D]	2.3
Compressed gas, toxic, flammable, corrosive, n.o.s. [Inhalation Hazard Zone A]	2.3

CO readily reacts with hemoglobin in the human blood and as a result the oxygen carrying capacity of the blood is reduced. In order to protect non-smoking, middle-aged, and elderly population groups with documented or latent coronary artery disease from acute ischemic heart attacks, and to protect fetuses of non-smoking pregnant mothers from untoward hypoxic effects, the World Health Organization (WHO) recommends that a carboxyl hemoglobin level of 2.5% should not be exceeded. WHO has adopted in 1996 four guidelines for the maximum CO concentrations (Burns William and Worthington Janet, 1998). Table 2.1 is about the WHO guidelines for the maximum Carbon monoxide, CO concentrations.

Table 2.2: Maximum Carbon monoxide, CO concentrations:

100 mg/m3 (90 ppm) for 15 minute
60 mg/m3 () for 30 minute
30 mg/m3 () for 1 hour
10 mg/m3 () for 8 hour

2.2 Wireless

Wireless networks serve as the transport mechanism between devices. Wireless networks can be categorized into three group based on their coverage range. They are Wireless Wide Area Network (WWAN), Wireless Local Area Network (WLAN) and Wireless Personal Area Networks (WPAN). WWAN includes wide coverage area technologies such as 2G cellular, Cellular Digital Packet Data (CDPD) and Global System for Mobile Communications (GSM). WLAN includes 802.11 and Hyper LAN.WPAN, representing wireless personal area network technologies such as Bluetooth and Infrared (IR). All of these technologies receive and transmit information using Electromagnetic (EM) waves (Mohammad Ilyas, 2002). Table 2.3 is about type of wireless.

Table 2.3: Type of wireless

Wireless Standard	Application Category	Usage Scenario
Bluetooth	Wireless Personal Area Networking (WPAN)	• I want to instantly connect my notebook computer to another Bluetooth enabled notebook to transfer a file. • I want to collaboratively work on a document where meeting participants use notebooks that are wirelessly connected via Bluetooth. • Using a Bluetooth enabled, wireless headset, I want to listen to a CD playing on my notebook computer while it is in my briefcase. • I often travel to a remote site and want to walk up to a shared printer, connect and print a document without having to physically connect using a standard printer cable. • I want to connect to the Internet via a cellular phone without having to take my telephone out of my briefcase
802.11b	Wireless Local Area Networking (WLAN)	• I want to always be connected to my corporate LAN while moving about in my office building or campus. • Usage demands that I have access to corporate network data at performance levels equivalent to a wire based LAN connection.
Cellular Technologies (GSM)	Wireless Wide Area Networking (WWAN)	• I want access to e-mail and web resources while traveling away from the home office.

2.3 Bluetooth

Bluetooth is a short range radio communication system designed for communication of devices like mobile phones, PDAs, notebooks, PCs, printers, headsets etc. It has low power consumption for easy implantation into mobile devices and should be cheap. First it should mainly replace cables, now this is forming complex system for communication which is able to create piconetworks (’radio LAN’) not only based on packet data transfer (ACL) but also for voice services (SCO) (Adam Pribyl, 2001). Layer structure of Bluetooth can see in Figure 2.1 below.

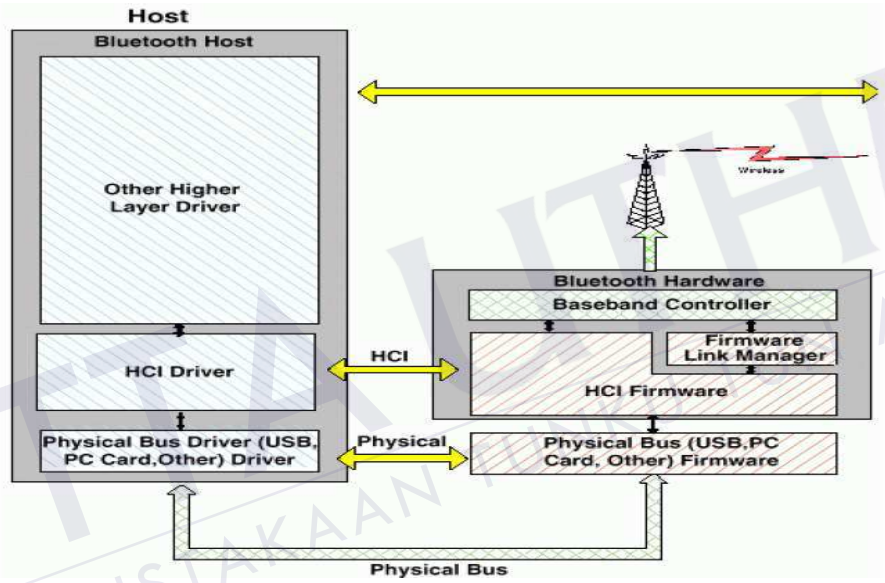

Figure 2.1: Layer structure of Bluetooth

2.3.1 Basic structure

There are three main parts which are Client, COM server and Bluetooth module software. Client and COM server are provided as software for windows. For demonstration there are in kit two applications - BT Test sample and BT Chat. Both aim to category of client applications and also sources are included. BT_COMserver which is COM server from picture is in application kit only in compiled form, but it serves as with all basic features needed. All these components are together called

Bluetooth PC reference stack. Main parts of COM server are RFCOMM which emulates COM port (RS-232, UART) for communication with Bluetooth device. SDP is Service Discovery Protocol and is basic stone of technology (Adam Pribyl, 2001).

The SDP provides a means for applications to discover which services are available and to determine the characteristics of those available services using an existing L2CAP connection. L2CAP is Logical Link Control and Adaptation Protocol for multiplexing capability, segmentation and reassemble operation. HCI is Host Control Interface (Adam Pribyl, 2001). The structure of routines is almost the same as Bluetooth layer structure can see at Figure 2.2 below.

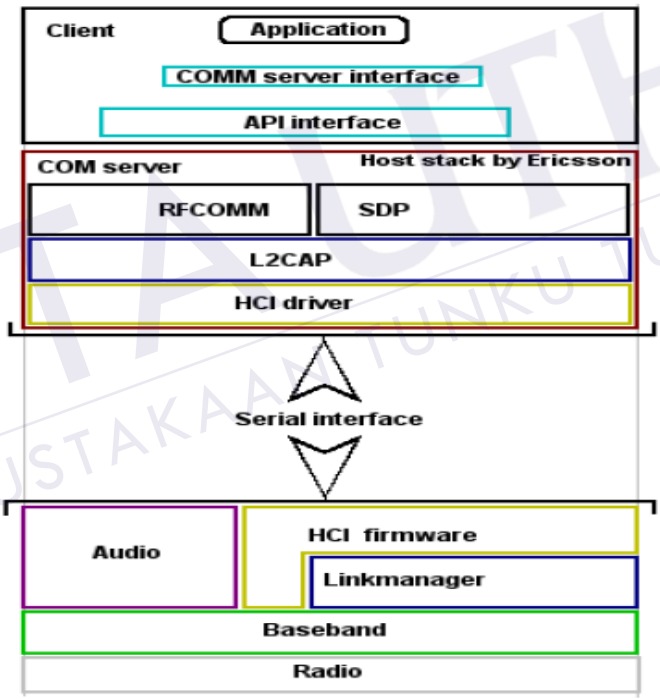

Figure 2.2: The detail of Bluetooth routines

2.3.2 Type of Bluetooth

Bluetooth comes into three classes. Every class has capability of transmitting (Bray and Sturman, 1999). The transmitting range cannot be explicitly stated for each devices class because every environment of the transmitting is slightly different and affects the signal in different way. The only way to compare each class is by comparing the outputs power. A higher output power means a longer range (Dijkstra and Mortena, 2001). Table 2.3 is represented the difference of each class of Bluetooth.

Table 2.3: Type of Bluetooth

TYPE	DESCRIPTION
Class 1	-long range -maximum output power of 100mW (20dBm) -Up to 100 meter range
Class 2	-Medium range (the most common) -maximum output power of 2.5mW (4dBm) -Up to 10 meter range
Class 3	-Short range(very rare) -maximum output power of 1mW (0dBm) -Up to 1 meter range

Bluetooth radio range is primarily defined by the maximum allowable path loss, which is defined as the delta between the max RF power output and the maximum sensitivity of the radio. The formula for path loss is given by equation (1.1)

$$L_{total} = 20 * \log_{10}(f) + N * \log_{10}(d) + L_f(n) - 28 \quad (1.1)$$

Where;

N = Distance Power Loss Coefficient

f = Frequency (MHz)

d = Distance (meters) between nodes ($d > 1$)

L_f = Floor Penetration Loss Factor (dB)

n = Number of Floors Penetrated ($n > 0$)

2.3.3 Bluetooth Operation

When Bluetooth enable devices come within range of one another, they automatically communicate with each other without needed to be prompted a command from the user. Bluetooth is able to determine whether they have data to share or data that's need to control. It's utilize a technique called 'spread spectrum frequency hopping' in which the Bluetooth enable device use 79 individual, randomly chosen frequencies within a designed range and change from one to another on a regular basis (Dijkstra and Mortena, 2001). Because of Bluetooth transmitters change frequencies 1600 times every second, more devices can make full use of a limitation slice of the radio spectrum without interfacing with each other (Visuri and Nilssan, 2000). Since the transmitter hopping so frequently, any interface from other Bluetooth devices would only last a fraction of a second. Bluetooth also uses the lowest transmit power of the wireless technologies, which further minimize interference from other device (Bo You et al, 2000).

2.4 Previous Project

The several previous project and cases which are related to this study have been assembled in order to achieve the objective of this project. Most of it is based on Bluetooth robot and toxic gas. There are six project including cases found and related to this project.

2.4.1 Bluetooth Transceivers for Full Duplex Communications in Mobile Robots

This work explores the implementation of Bluetooth technology in mobile robots. The mobile robot has the capability to move around autonomously using complicated and powerful algorithm. The algorithms are stored in the master as the server. All sensor readings from the mobile robot is transmitted to the master and processed. Then, command or instruction for further action is transmitted from the server to the mobile robot in a bi-directional full duplex communication mode. Hence, the main "brain" is in the server instead of the mobile robot. This project is focusing in the interfacing between Bluetooth transceiver and Handy Board MC68HC11 micro-controller of mobile robot. For a common case, a receiver and transmitter are needed for each device (robot and control unit), but by using the Bluetooth technology, only two Bluetooth transceivers are needed to achieve full duplex connection. The mobile robot can be controlled wirelessly via Bluetooth transceiver (Shamshudin, 2008).

2.4.2 Automobile Functions Control System via Bluetooth Utility

This paper presents a design of an Intelligent - Low Cost Car Control System using Bluetooth Technology. The end user of this design are enables to control different functions, so that it can be controlled quickly and accurately by using his own cellular phone as he/she connects it with the hand free Bluetooth device. The functions can be freely selected and each can get its own mechanism based on a

microcontroller program. Up to nine separated functions can be controlled each with two switching keys, these functions include starting the engine, windows controlling in both directions, center lock, lights and alarm system, stereo system, and any other functions. The proposed system is reliable, robust and adjustable through all its designed parts to insure the maximum comfort ability of the user. Proteus and C language are used here to make the required simulation (Abu Ein et al, 2000).

2.4.3 Design and Implementation of a Multi-Functional Mobile Robot

In this paper, an intelligent multi-functional mobile robot is presented. The hardware involves the ultrasonic sensor, Bluetooth device, wireless camera, DC servo motor, and mechanical gripper. To complete the object localization, one single ultrasound sensor is programmed in order to seek the object. A human-machine interface is developed to remotely control the mobile robot. The exploration of a tiny and harsh environment can be carried out by using the wireless communication and camera. Hardware description language is used in the controller design and the peripheral I/O circuit. Human-machine interface is completed by C language (Ying, 2002).

2.4.4 Six Children Killed By Poisonous Gas in Cave

This case was reported in Kunming; cave in Zhenjiang Country, southwest China's Yunnan. Six children have died and another injured after they inhaled toxic gas while playing in a deserted mining cave. According to the country government chief, that place had been deserted for dozens of years and because of that, it is full of poisonous gas. After the casa had happen, the country government has ordered all deserted mining caves to seal off due to the tragedy (Chinadaily, 2010).

2.4.5 15 Killed By Poisonous Gas in China Mine: State Media

Another case that reported due to toxic gas was happen at Yuanlutang in Hunan. In this situation, fifteen miners died after inhaling toxic gases in a graphite mine in central China. The report said no further details were immediately available on the accident, which it said was under investigation. China's poorly regulated mining industry is among the world's deadliest, with thousands of miners killed every year in underground explosions, cave-ins, mine floods and gas leaks (Terradaily, 2009).

2.4.6 Poisonous Gases Portion of the List of Hazardous Wastes of Concern

Senate Bill 489 (2002) defined hazardous wastes of concern (HWC) as having the potential to be intentionally and effectively used to harm the public in a terrorist or other criminal act. Transporters and facilities handling HWC must immediately report missing wastes and submit disclosure statements and fingerprints to the Department of Toxic Substances Control (DTSC). The HWC Emergency Regulations, fact sheet, and related documents can be found at www.dtsc.ca.gov under Law, Regulations, and Policies, Emergency Regulations (Bill, 2002).

2.4.7 Asian Air Pollution

Air pollution has long been a problem in the industrial nations of the West. It has now become an increasing source of environmental degradation in the developing nations of east Asia. China in particular, because of its rapid push to industrialize which is experiencing dramatic levels of aerosol pollution over a large portion of the country (David, 2009).

2.4.8 Health Effects of Air Pollution

This paper provides background reading for the Population-Environment Research network's online seminar. The purpose of this seminar is to foster a discussion that will lead to identification of key issues, knowledge gaps, and methodological shortcomings in understanding health impacts of air pollution, both indoor and outdoor (Vinod, 2003).

2.4.9 Data Capture and Data Mining Of Urban Air Pollution: The Building-Based Approach

The method and accuracy of data capture dominate the spatial distribution of urban air pollution. Due to limited budget, installation space, and labor resource, permanent or temporary air pollution monitoring sites are very scattered. Air quality assessment of a city based on scattered monitoring sites may be incorrect because non-homogeneous distribution of air quality is neglected. Therefore, a number of model systems have been developed to estimate urban air quality at unsampled sites. The results show that the building-based approach may open an innovated methodology in data mining of urban spatial data for environmental assessment.

CHAPTER 3

MEETHODOLOGY

3.1 Introduction

The project's target is to be able to measured data in dangerous area and also to transmitting and receiving data via wireless connection which is Bluetooth System. The project system overview is shown in Figure 3.1 and the overall of project activities in Figure 3.2.

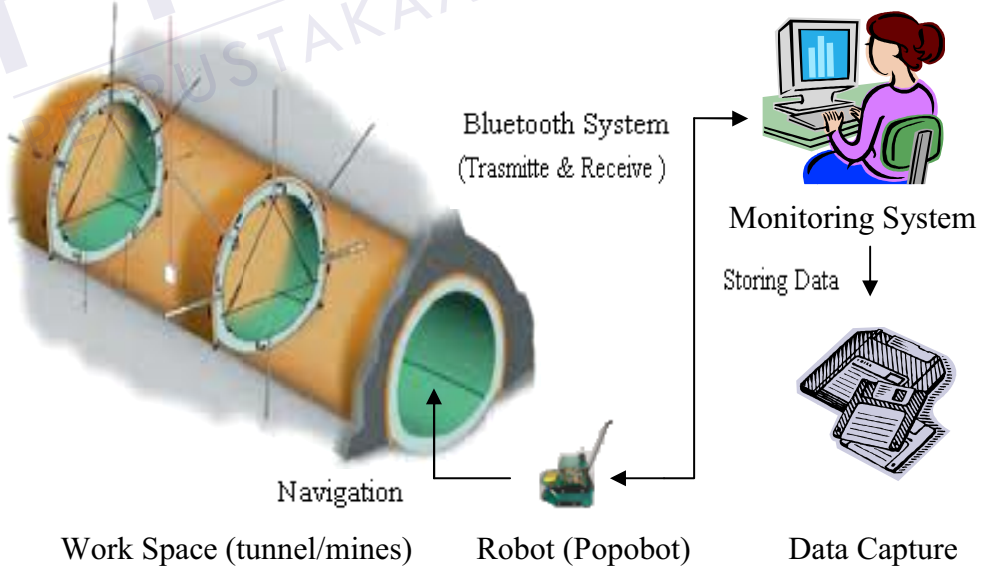

Figure 3.1: Project System Overview

In the development process needs clearly status of system requirement. This system requirement is defined based on problem statement, literature review and the capability of related hardware and software Figure 3.2 has give detail about the project acivities..

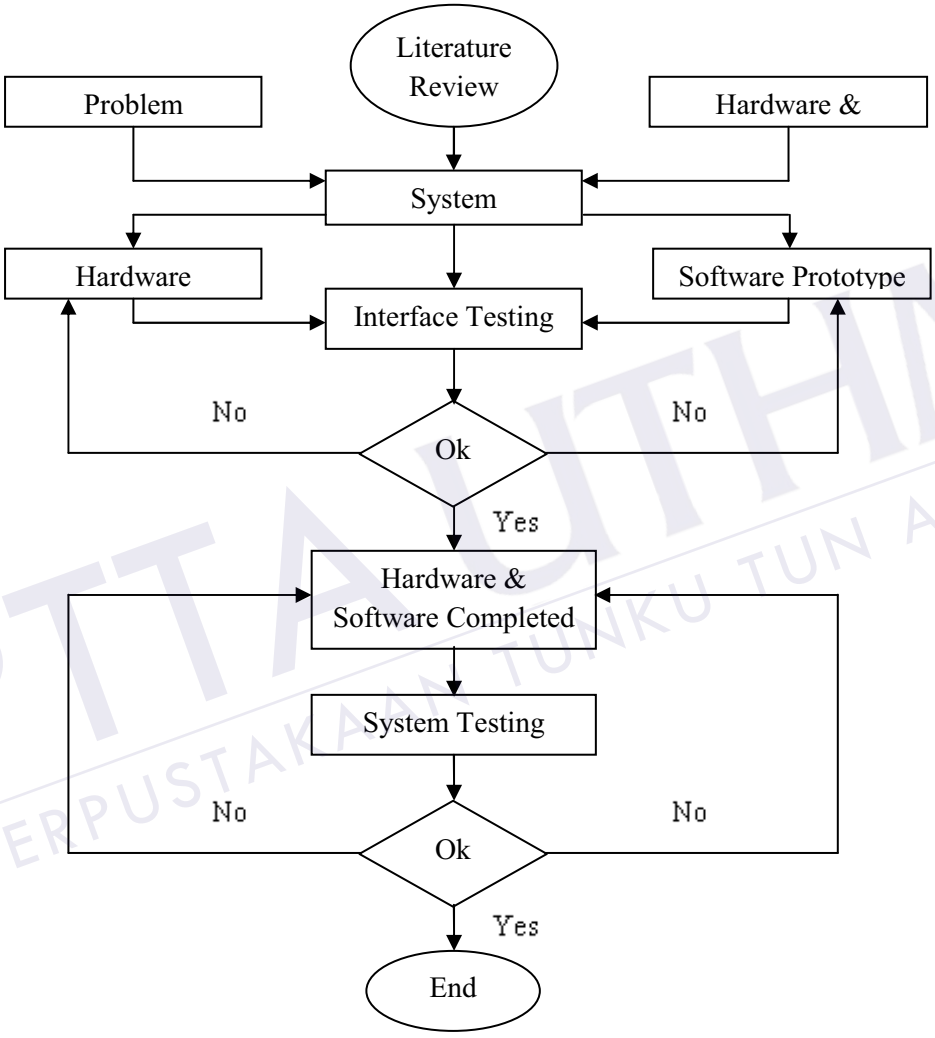

Figure 3.2: Project Activities

3.2 System Requirement

The system requirement is based on outputs of the system features. Figure 3.3 below describes the system features that are divided into three main categories. There are, robot movement, display and capture function.

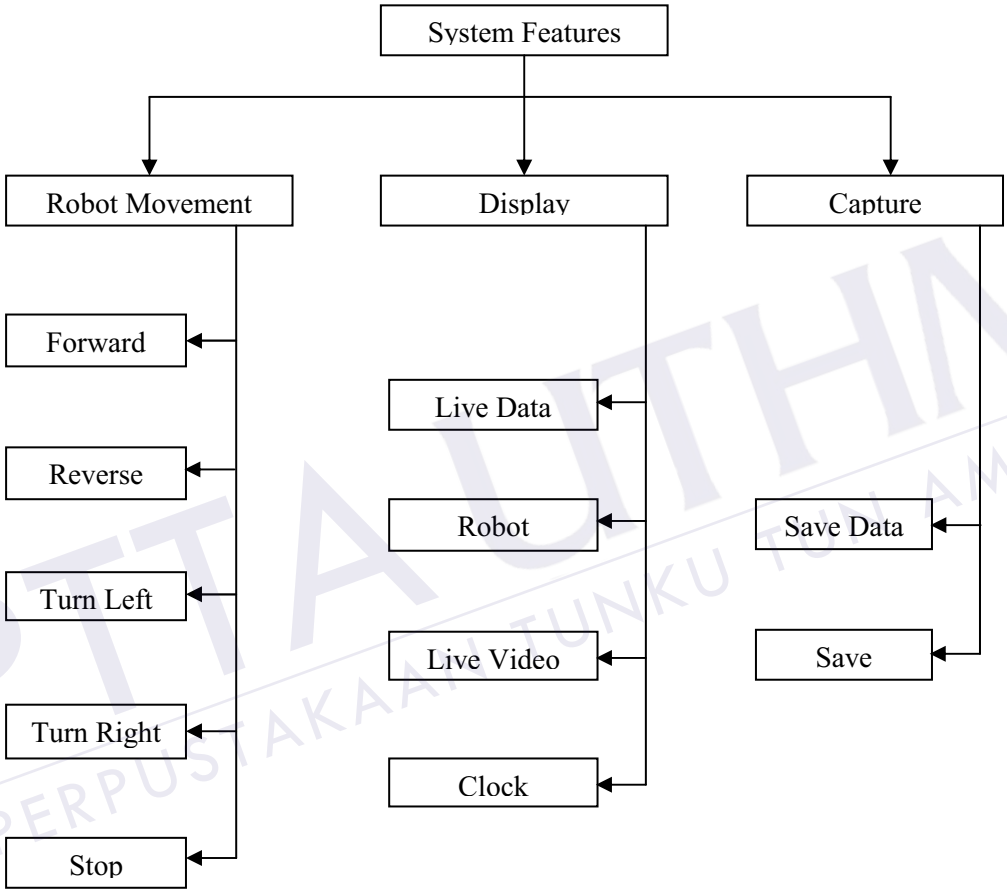

Figure 3.3: System Features

There are five main movements of robot which are forward, reverse, turn left, turn right and stop. There also have four other movements that robot can do: turn left reverse, turn right reverse, anti clock wise and lastly clock wise. The basic concept of all movements is either one of the motor will off or all motor will on at the same time. For moving forward, all motor must on at the same time in same direction. For turning left, the left motor is turn off and only the right motor is turn on.

In the display function, there are four task have been display on LCD and monitor. LCD display only for the live data and robot movement while the laptop monitor displays all the tasks above: live data taken by temperature sensor, gas sensor and humidity sensor, live video taken by wireless camera, robot movement controlled by user and lastly the clock taken same as laptop clock.

The last function is data capture. The data that display on the monitor can be captured and saved in user's laptop. The data captured represent the target area condition and can be used to analyze the pollution level. Besides that, user cans take the image at target area using wireless camera that has been install in robot. The data captured has been saved in text file extension while the image captured was n jpeg file extension.

3.3 System Architecture

The above system requirements give basic idea of designing the system architecture. The system needs four input hardware units of data collection (temperature sensor, gas sensor, humidity sensor and wireless camera), one output hardware display of process data (LCD), one user interface output (GUI by using Visual basic 6), one data capture program (VB6) and one system of wireless communication (Bluetooth module) unit. All of these units are controlled by a microcontroller. The main power supply for this system is by using the rechargeable batteries (7.2V for microcontroller, 4.8V for DC motor and 9V for wireless camera). The overall architecture of this system is show in Figure 3.4.

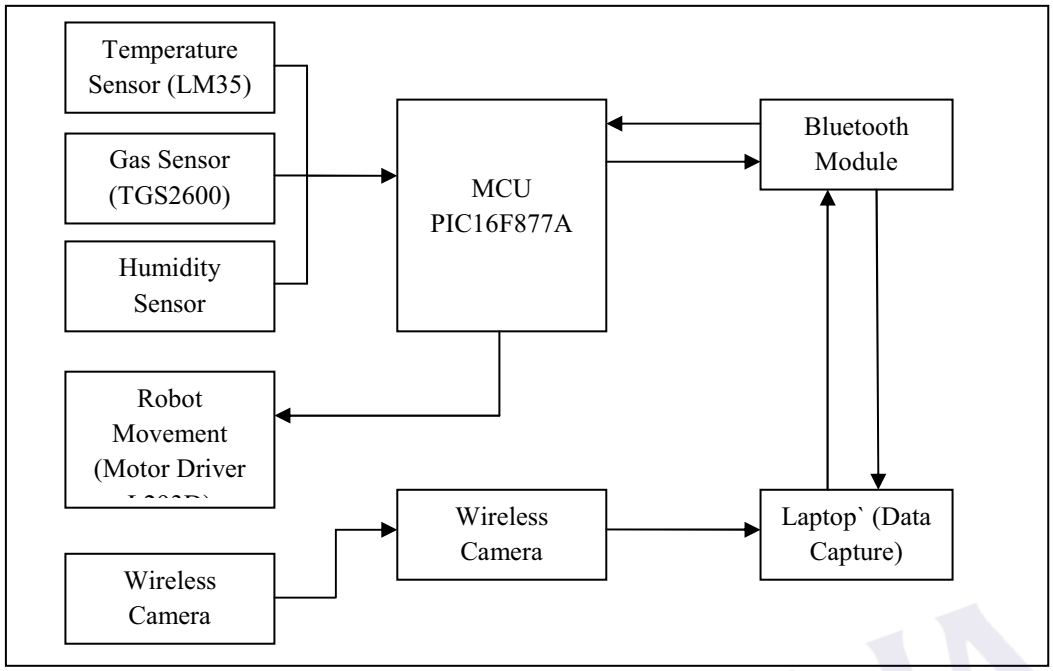

Figure 3.4: Overall Operation of Project

3.4 Operation System

Air pollution can happens due to of gas and temperature level was high from normal thus resulting the danger situation to work force. In order to avoid the pollution from happen, one system that can measure the level of temperature and gases should be developed. In this project, that system has developed using both hardware and software so that it is a user friendly system and becomes more practical. The system functions when the sensors detect the level of temperature and gases contain in the air and then the liquid crystal display (LCD) and laptop monitor will display the reading. The wireless camera was used as the eyes of the robot to show the view of the work space.

Figure 3.5 below shows the control system diagram of the air pollution monitoring system that has been designed in this project. The robot (Popobot) is controlled by wireless system. The figure below also describes the procedure in how the robot operated to monitor and navigate the air pollution at the target area.

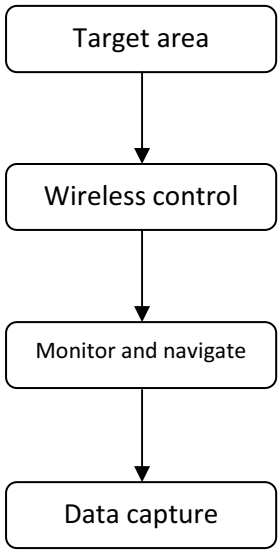

Figure 3.5: Step State Figure

Firstly, user should determine the area that user want to monitor and navigate the condition and the air quality of that place. Usually the tunnel and mines have high risk for the poisonous gas cases to happen. This is to protect human being from involve into poisonous air pollution accident because this accident can kill the human being.

Then for second step, user can control the robot (Popobot) wirelessly to monitor the area. The Popobot has sent the reading for temperature, ambient gas and humidity from that area direct to the user laptop wirelessly. User can control the Popobot wirelessly because this Popobot is using Bluetooth as the communication system and the wireless camera as its eyes to make user easy to control it.

User also can monitor and navigate the area by looking to the GUI/control panel in laptop. This is for the third step. From the GUI, user can control the Popobot and also can get the reading of the sensor. This has made the monitoring and navigation operations become easy and not become dangerous to human being.

The last step is the storing all the data. User can capture/save the reading of the sensors just by click one button on the GUI/control panel in laptop. The system has saved all the reading automatically every ten seconds until user clicks the stop

button. User also can capture the image of the area by using the wireless camera. All the data capture/save can be printed. This saved data is useful to do the analysis for the air quality at the target area.

3.5 Hardware Design

3.5.1 Microcontroller

Figure 3.6 is the illustration of the PIC16F887A which is used in this project. The figure below also describes the details about its pins functions.

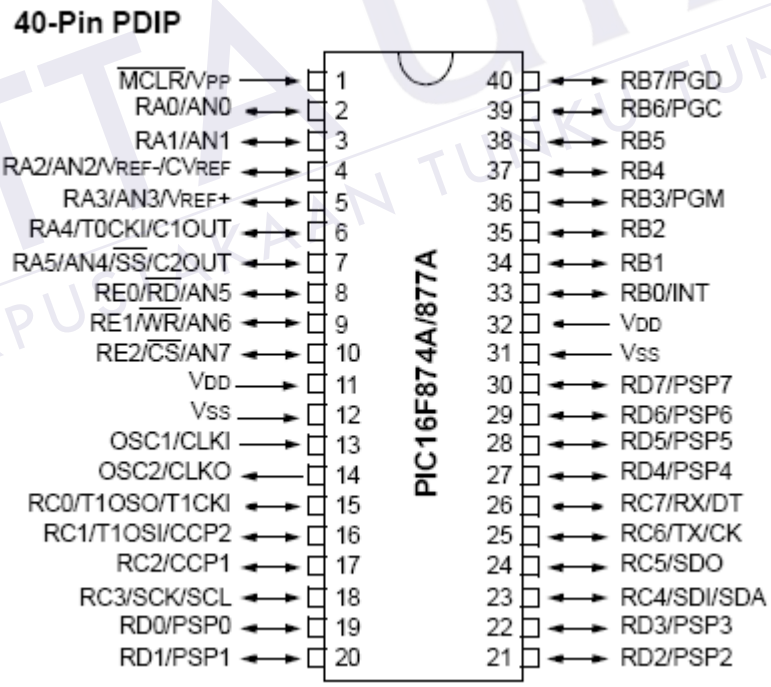

Figure 3.6: PIC16F877A

This microcontroller is the main device of this project and will act as the transceiver host for the Bluetooth system. The main advantages of using the microcontroller are low external part count, a wide range of chip sizes available, nice choice of compilers (assembly, C, BASIC, etc.) good wealth of example/tutorial source code and easy programming. The microcontroller need to be programmed using C language and its hex file would be used to usable in a circuit software like Proteus later.

The PIC has capability to become host for Bluetooth transceiver. There are many types in PIC16F family such as PIC16F877A and PIC16F876. The main concept of interface Bluetooth module and this PIC is the serial communication (TX/RX connection). The receiving pin of PIC is connected to the transmission pin of Bluetooth module, while the transmission pin of PIC is connected to the receiving pin of Bluetooth module. Figure 3.3 below shows the connection between PIC and Bluetooth module.

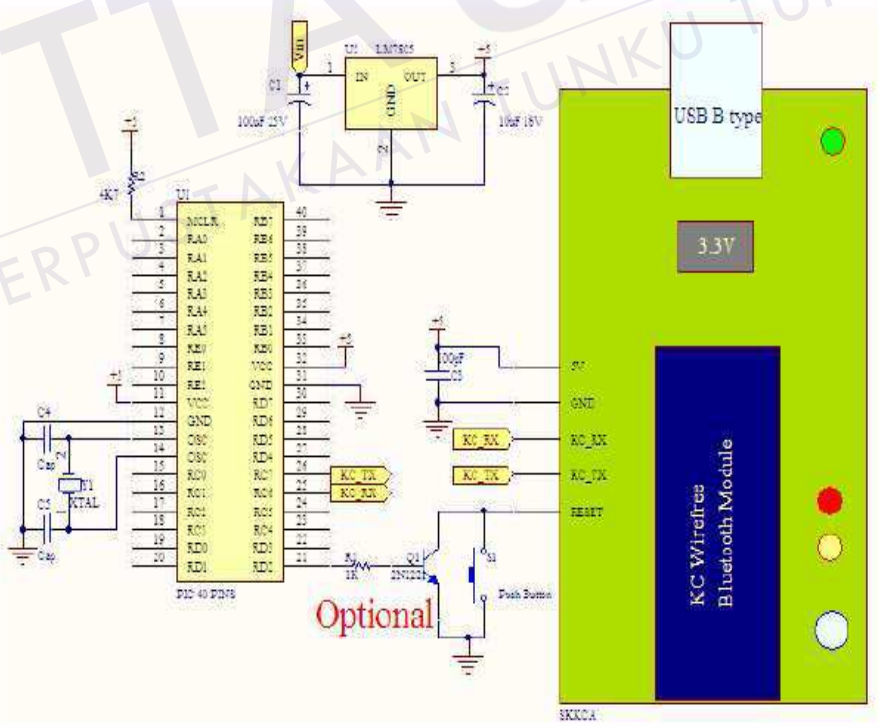

Figure 3.7: Connections between PIC and Bluetooth Module

This project is used PIC16F877A with several reasons as following:

i) Up to 8K x 14 words of FLASH Program Memory.
ii) Only 35 single word instructions to be learnt with Assembly
iii) Have interrupt capabilities, which might be used later.
iv) Low cost.

There have many types of PIC in 16F family. Each type has advantages and disadvantages by using it. Table 3.1 below has made the comparison of several types PIC in 16F family.

Table 3.1: Comparison PIC in 16F family

Key Features	PIC16F873A	PIC16F874A	PIC16F876A	PIC16F877A
Operating Frequency	DC – 20 MHz	DC – 20 MHz	DC – 20 MHz	DC – 20 MHz
Resets (and Delays)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)
Flash Program Memory (14-bit words)	4K	4K	8K	8K
Data Memory (bytes)	192	192	368	368
EEPROM Data Memory (bytes)	128	128	256	256
Interrupts	14	15	14	15
I/O Ports	Ports A, B, C	Ports A, B, C, D, E	Ports A, B, C	Ports A, B, C, D, E
Timers	3	3	3	3
Capture/Compare/PWM modules	2	2	2	2
Serial Communications	MSSP, USART	MSSP, USART	MSSP, USART	MSSP, USART
Parallel Communications	—	PSP	—	PSP
10-bit Analog-to-Digital Module	5 input channels	8 input channels	5 input channels	8 input channels
Analog Comparators	2	2	2	2
Instruction Set	35 Instructions	35 Instructions	35 Instructions	35 Instructions
Packages	28-pin PDIP 28-pin SOIC 28-pin SSOP 28-pin QFN	40-pin PDIP 44-pin PLCC 44-pin TQFP 44-pin QFN	28-pin PDIP 28-pin SOIC 28-pin SSOP 28-pin QFN	40-pin PDIP 44-pin PLCC 44-pin TQFP 44-pin QFN

3.5.2 Microcontroller Unit

For PIC 16F887A, it has 40 pins and not all pins are used. There are not necessary to use all pins, just only used the pin needed because each pins has its own function. Table 3.2 below has assigned which pins are used in this project.

References

Abu-Ein, Suleiman Abu-Ein, Sayel M. Fayyad & Ghazi Al-Marahlehand Waleed Al-Momani. (2000). Automobile Functions Control System via Bluetooth Utility Qusai

Adam Pribyl (2001). Bluetooth. Retrieved December 20, 2010, from http//:www.sandbox.cz/~covex/bluetooth/Bluetooth

Bo You, Dongjie Li, Jiazhang yu & Deli Jia. (2000). The Designed of O-Line Mobile Robot Over Bluetooth. College of Automation, Harbin University of Science. Thesis

Bray,J.Sturman CF. (Ed) (1999). Bluetooth Connect without Cable. Prentica Hall PRT. pp.115-126,

Burns Wiliam C & Worthington Janet. (1998). Practical Robotics. Pretice Hall

David L. Alles. (2009). Asian Air Pollution. Western Washington University,

Dijkstra & M. Mortena. A. R. (2001). Controlled Robot Car Using Ericsson Bluetooth Starter Kit. University of Korlskorna/Ranneby, Thesis.

McComb Gordan. (2001). The Robot Builder's Bonanza. McGraw Hill

Mohammad Ilyas. (Ed) (2002). The Handbook of Ad hoc Wireless Networks. CRC Press. pp. 624.

Motorola Technical Brief Bluetooth Radio Performance. (2011). Class 1 vs. Class 2 Bluetooth - Adaptive Frequency Hopping (AFH).

Senate Bill. (2002). Poisonous Gases Portion of the List of Hazardous Wastes of Concern.

Shamshudin Amin. (2008). Bluetooth Transceivers for Full Duplex Communications in Mobile Robots. Seminar paper.

Turner, D.B. (1994). An Introduction to Dispersion Modeling. 2nd ed. Workbook of Atmospheric Dispersion Estimates

U. W. Tang. (2008). Data Capture And Data Mining Of Urban Air Pollution: The Building-Based Approach. Macau (PR China): Department Of Civil And Environmental Engineering, University Of Macau.

Vinod Mishra. (2003). Health Effects of Air Pollution. Honolulu: East-West Center

Visuri & P. Nilssan. (2000). Developing a Bluetooth Test System. Land University. Thesis.

Ying J. Huang, Yuan Z. Chen, Tzu C. Kuo & Hong S. Yu. (2002). Design and Implementation of a Multi-Functional Mobile Robot

Yousef Moh Abueejela Mosbah, (2010). Fuzzy Logic Controller Design for Wall Follower of Autonomous Robot. Universiti Tun Hussein Onn: Master's Thesis

(2010). Poisonous Accident Kill Human Being. Retrieved December 20, 2010, from http://www.chinadaily.com

(2009), "Air Pollution. Retrieved January 15, 2011, from http://www.terradaily.com