Wireless Mobile Robot with Live-Feed Video using PIC16F628A Microcontroller

Jiwa Abdullah[1,*], Hairulazwan Hashim[2] and Mohd Rizal Khairi[3]
[1,2,3]Faculty of Electrical & Electronic Engineering,
Universiti Tun Hussein Onn Malaysia,
86400 Parit Raja, Batu Pahat, Johor.

*Corresponding email: jiwa@uthm.edu.my

Abstract

The unprecedented number and scales of natural and human induced disasters in the past decade has urged the emergency search and rescue community around the world to seek for newer, more effective equipment to enhance their efficiency. Search and rescue technology still rely on old technologies such as search dogs, camera mounted probes and technology that has been in service for decades. Hence, Wireless Mobile Robot with Live-Feed Video using PIC16F628A Microcontroller will create an alternative solution for rescue purposes which is recognized as a risky mission. In this project, a prototype mobile robot with simple locomotion mechanism and also network camera has been developed to support the rescue team. This prototype includes Wi-Fi router as a platform to communicate between mobile robot and computer and facilitate a network camera attached to the mobile robot. The mobile robot can be made to move around remotely by using GUI command on computer as well as live-feed video will be displayed on the computer. The control range of this mobile robot is up to 140m in a straight line of sight in open space.

Keywords: Wireless, mobile robot, PIC16F628 Microcontroller.

1 INTRODUCTION

Nowadays application of 802.11 protocol technology has become popular among the collaboration between short range communications such as computing, mobile phone and wireless mesh networks. A device must be able to interpret certain 802.11 profiles in order to use 802.11 protocols as a communication medium. Hence, a WRT54GL Wi-Fi router is used as a Wi-Fi transceiver between microcontroller unit and computer. User can use a graphical user interface (GUI) command on computer to send all instructions to move the mobile robot. Live-feed video data from DCS910 network camera attached to the mobile robot will be sending to the computer as a vision for the user. This mobile robot can do a risky mission by replace the rescue team to survey the victims at the disaster area replacing manual excavation. It can also be use in military such as a bomb observer. Other than that, this robot may be useful in danger areas which are polluted with chemical toxic or radioactive contaminants.

2 DESIGN METHODOLOGY

The block diagram of the overall system for this project is shown in Fig. 1. The mobile robot consists of one microcontroller unit (MCU) as the main controller of the system, WRT54GL Wi-Fi router and DCS910 network camera. The MCU has a serial communication with WRT54GL Wi-Fi router and PC will connected to the router wireless network [1]. User will control the mobile robot using this network link from computer using GUI. One of the outputs links used to control the motor via full-bridge motor driver [2]. The DCS910 network camera attached on mobile robot will send the live video data via the Wi-Fi router network to the PC [3]. A brief explanation for each component of the robot are described and summarized in Table 1.

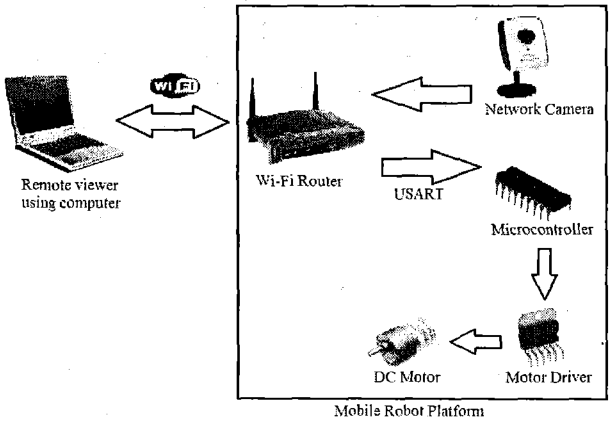

Fig. 1 Block Diagram of overall system

Table 1: Device specification

System Module	Device	Specification
MCU	PIC16F628A	4Mhz internal clock speed, PWM module, USART interface
Motor Driver	MD30B	2.5V to 46V dual full bridge driver, low saturation voltage, overheat protection
DC Geared Motor	SPG30	Rated voltage: 12VDC Speed: 220RPM Torque: 78.4 mN.m Output power: 1.1 Watt
Wi-Fi Router	WRT54GL	Wireless and wired connectivity, 4 port switch, Wi-Fi certified, omni-directional antenna
Network Camera	DCS910	VGA CMOS sensor, 4.57mm lens, minimum illumination
Power Supply	LM7805/ LM7812	Output voltage 5V/12V
Indicator	LED	3mm

2.1 Software Development

The flowchart of developing the Visual Basic GUI coding in controlling the mobile robot is shown in Fig. 2. The GUI coding has been compiled using Visual Basic 6 program as shown in Fig. 3 and installed to PC in order to communicate with Wi-Fi router and MCU. Then, the default IP address of Wi-Fi router is configured in the GUI.

Firstly, robot MCU must be switched ON followed by switch ON the Wi-Fi router. Then, PC must be connected to Wi-Fi router network by choosing the Wireless Network Connection on PC. After the Wi-Fi router and PC successfully connected, users have to connect GUI with network by pressing T on PC keyboard. Then, user can start control the mobile robot using Visual Basic 6 GUI. For the robot navigation, button W, S, A and D used while button H for horn. Then button ESC used to exit the GUI application.

In MPLab coding, the first command is to declare the initializing mode from UART. Before receiving the initializing mode command, the Red LED is turned ON. Then, after finished receiving the initializing mode command, the Green LED is turned ON. Then, the MCU will start to receive the instruction from UART.

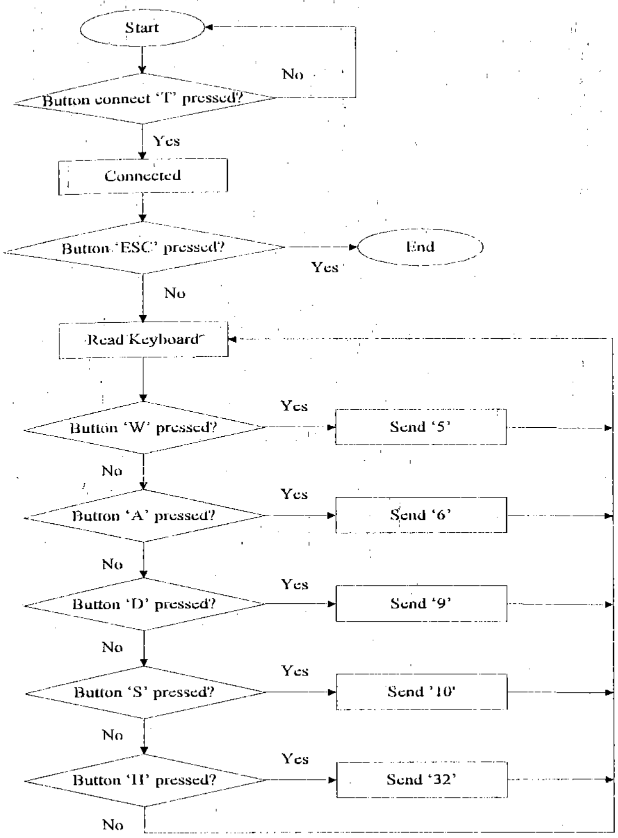

Fig. 2 Flowchart for Visual Basic 6 GUI

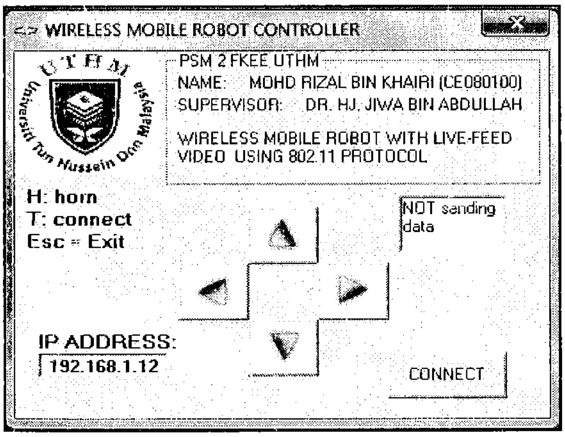

Fig. 3 GUI to control the mobile robot

3 RESULTS AND ANALYSIS

The robot MCU will read the instruction from Wi-Fi router via UART protocol. The UART setting is calculated in baud rate at 9600 bit per seconds, 8 data bits, no parity bit and 1 stop bit. The robot start to navigate after initializing process and the robot will start receiving the navigation command from PC by using Visual Basic GUI. The description of the commands and functions is summarized in Table 2 and the complete look of prototype mobile robot is shown in Fig. 4.

Table 2: Commands and functions

Command	Value in ASCII	Value in Binary	Function
Forward	5	00000101	Robot move forward
Left	6	00000110	Robot move left
Right	9	00001001	Robot move right
Reverse	10	00001010	Robot move reverse
Horn	32	00100000	Turn horn on

Fig. 4 Hardware prototype of mobile robot

3.1 UART interface between Wi-Fi router and MCU

The connection between Wi-Fi router and microcontroller unit is using UART protocol. Both transmit (Tx) and receive (Rx) pin are connected from Wi-Fi router to microcontroller unit. The comparison of the calculated baud rate value based on PIC16F628A microcontroller data sheet [5] and desired baud rate value are listed in Table 3. The formula used to calculate the desired baud rate (1) and the formula for calculating period is in equation (2). Equation (3) is the formula used to calculate the percentage error between calculated baud rate and desired baud rate.

$$Desired\ baud\ rate = \frac{F_{osc}}{16(x+1)} \quad (1)$$

$$Calculated\ baud\ rate = \frac{F_{osc}}{16(x+1)} \quad (2)$$

$$Error = \frac{Calculated\ baud\ rate - Desired\ baud\ rate}{Desired\ baud\ rate} \quad (3)$$

Table 3: Comparison of the calculated baud rate and desired baud rate based on PIC16F628A data sheet

	Baud rate
Desired baud rate	9600
Calculated baud rate	$x = 16\left(\frac{F_{osc}}{Desired\,baud\,rate}\right) - 1$ $= 16\left(\frac{4\,MHz}{9600}\right) - 1$ $= 25.04$ ≈ 25 $Calculated\,baud\,rate = \frac{F_{osc}}{16(x+1)}$ $= \frac{4\,MHz}{16(25+1)}$ $= 9615$
Percentage error	$Error = \frac{(9615-9600)}{9600} \times 100\%$ $= 0.16\%$

3.2 Measurement of received signal strength from Wi-Fi router and theoretical calculation of signal strength received

The connection is established between Wi-Fi router and PC as a client. There are four factors can affect the signal received by the Wi-Fi router and client sides described as the antenna gain, power transmit, minimum sensitivity and distance. The measurement factors for both Wi-Fi router and client are described in Table 4.

The calculation of the distance signal lost (4) based on the noise to distance ratio base on free space air medium without any other object interference such as building, obstruction including cabinets or furniture and signal received by Wi-Fi router (5) are described.

Distance signal loss = 925 + (20 log f) + (20 log d) (4)

Signal Received by Wi-Fi router = Router Antenna Gain + Client Tx Power + Client Antenna Gain – Distance Signal Lost (5)

The measured signal for Wi-Fi router in blockage area and free space area has been done by using WildPackets OmniPeek network analyzer devices. The comparison for theoretical calculation of signal received for Wi-Fi router, measured signal in blockage area and measured signal in free space are described in Table 5 and Fig. 5.

Table 4: The measurement factors for Wi-Fi router and client

Factors	Wi-Fi router	Client (PC)
Tx Power	20dBm (for 100mWatt)	17dBm (for 50mWatt)
Minimum Sensitivity	-93dbi	-75dbi
Antenna gain	2.8dbi	2bdi

Table 5: Comparison for theoretical calculation, measured signal in blockage area and measured signal in free space for Wi-Fi router

Distance (m)	Theory calculation (dBm)	Measured signal in blockage area (dBm)	Measured signal in free space area (dBm)
0	-	-30	-28
5	-32	-48	-33
10	-39	-57	-41
15	-41	-67	-45
20	-44	-79	-51
25	-46	-85	-57
30	-58	-91	-62

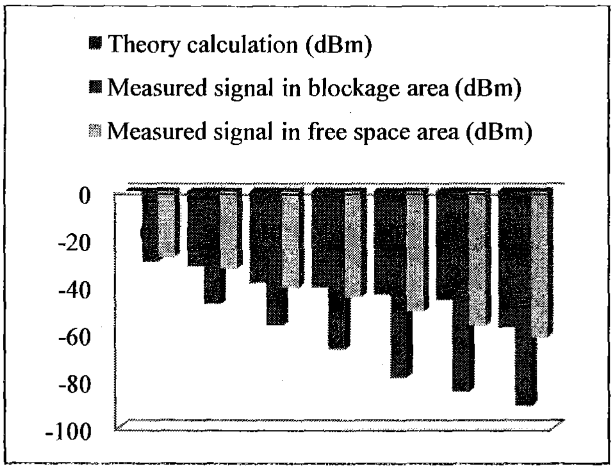

Fig. 5: Comparison graph for theoretical calculation, measured signal in blockage area and measured signal in free space for Wi-Fi router

3.3 Measurement of received signal strength Motor driver

The motor driver circuit is used to drive the motor. Dual full bridge driver MD30B is used as the motor driver for the robot. The measured voltage value at input and output of the motor driver are listed in Table 6. The measurement is obtained with digital multimeter. CW1, CCW1, CW2 and CCW2 are the input of the motor driver while MotorCW1, MotorCCW1, MotorCW2 and MotorCCW2 are the output of the motor driver. The results in Table VII shows that the motor driver MD30B has function properly, therefore the mobile robot will move accordingly to user commands. Then, Table 7 shows the speed of each motor in rotation per minute (RPM) by using tachometer.

Table 6: Voltage (V) measurement at each motor

Mo vem ent	CW 1	CC W1	CW 2	CC W2	MC W1	MC CW 1	MC W2	MC CW 2
For war d	4.76	0	4.78	0	7.98	0	7.97	0
Rev erse	0	4.67	0	4.69	0	7.95	0	7.96
Rig ht	4.77	0	0	4.78	7.87	0	0	7.89
Left	0	4.77	4.76	0	0	7.91	7.93	0
Stop	0	0	0	0	0	0	0	0

Table 7: Speed of each motor in rotation per minute (RPM)

Movement	MCW1	MCCW1	MCW2	MCCW2
Forward	169	0	167	0
Reverse	0	158	0	157
Right	164	0	0	162
Left	0	165	168	0
Stop	0	0	0	0

3.4 Circuit simulation for MCU

The circuit simulation for microcontroller unit (MCU) is done by using Proteus software. A connection between each component including PIC16F628A, MAX232 and serial connector DB9 are as shown in Fig. 6. The complete coding for MCU are converted to HEX file then loaded in the simulation file to check the functionality of the circuit.

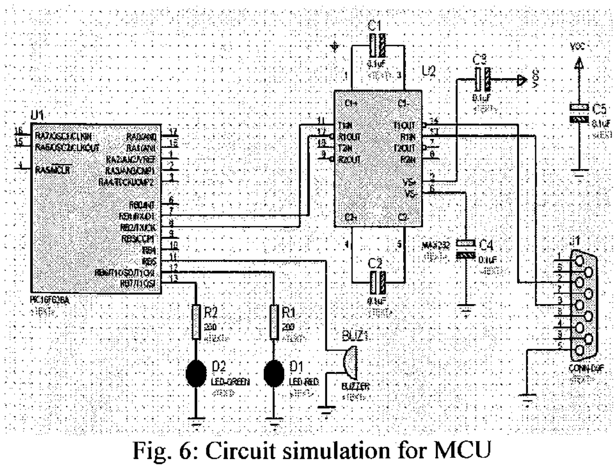

Fig. 6: Circuit simulation for MCU

3.5 Network Camera

The network camera used is connected to the Wi-Fi router by using Ethernet cable. Network camera model DCS-910 is using static IP address [2]. This network camera can capture a video up to 15 frame rate per second at 640x480 resolutions. By using the bundled software, the live video can be displayed on the PC in a full screen mode and the live video can be recorded. The bandwidth of the video is more or less depending on how much light was in the image. If there was lots of light, it would use more bandwidth. The video displayed in PC is as shown in Fig. 7.

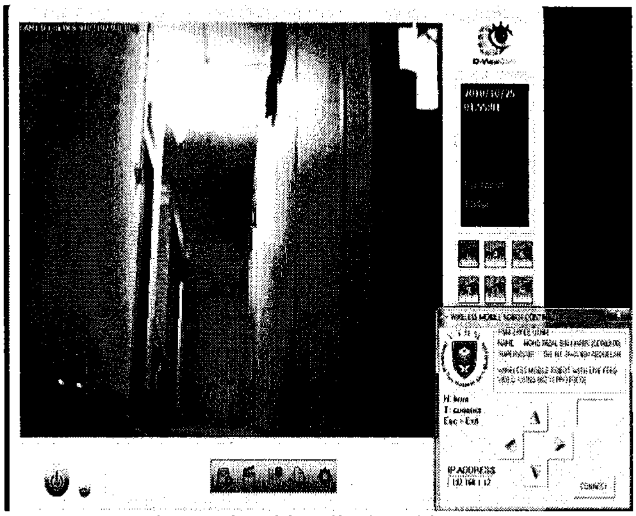

Fig. 7: The video displayed in PC

4 CONCLUSION

The main purpose of this project is to develop a wireless mobile robot and control by using IEEE 802.11 protocol using Wi-Fi router from computer. The locomotion system was implemented by using PIC16F628A microcontroller family while the control system medium is via wireless or IEEE 802.11 protocol. Meanwhile, the connection between MCU and Wi-Fi router are established using the serial communication or UART interface. The mobile robot controller is using Visual Basic 6 GUI as the interface between robot and user. A user can control the movement of the mobile robot while the vision of the robot can be seen on the PC by user.

Therefore as mention earlier the IEEE 802.11 protocol can be use to perform various applications. The prototype of this project had been successfully completed, including the task where the robot can be controlled remotely with a live video according to the instruction given by user. The idea of implementing IEEE 802.11 protocol with microcontroller is because of the wide range of the data transfer. The mobile robot can do a risky mission by replace the rescue team to survey the victims at the disaster area replacing manual excavation. The application of the robot is not limited for rescue application but it also can be used in security where the mobile robot will navigate and guard the building replacing human.

In additional, the robot can be upgraded if required to apply in complex situation. Some of the appropriate suggestions are listed as below. These suggestions can be continued in future research to build a better design. User can add more function such as a microphone and a spotlight which there are a few available ports in MCU. Then, wheels with high grips and efficiency are recommended for the mobile robot. Besides that, implementing the robot with microphone so the user can hear sounds around the mobile robot while navigating will improve the performance of the robot.

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