Wifi-Robot for Surveillance System

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Abstract— **This WiBot is a surveillance robot controlled using computer or laptop (equipped with Wi-Fi receiver) through wireless fidelity (Wi-Fi) connection. Wireless fidelity (Wi-Fi) works with no physical wired connection between sender and receiver by using radio frequency (RF) technology. WiBot also equipped with network camera (IP camera) to capture live feedback image and send it to user through Wi-Fi connection. The main objective of designing WiBot is to prove that Wi-Fi connection also can be use as a medium to control a robot and transmit back live feedback image captured by the IP camera to the user's computer or laptop. The main part of WiBot is a wireless router model Wrt54gl from Linksys attach with RS-232 serial port. Wireless router Wrt54gl acts as a receiver to the WiBot to receive instruction transmit from computer or laptop. Instruction receive by router will be send to microcontroller through a RS-232 serial port. RS-232 serial port consists of MAX 232 integrated circuit, several capacitors, DB9 male and female connector. PIC 16F628 functioned as a brain of WiBot. PIC 16F628 help to process instruction receive by router and send it to the motor controller circuit that consists of L293NE integrated circuit. A single L293NE integrated circuit can control two DC geared motor simultaneously. L293NE integrated circuit work based on logic input receive from the microcontroller to control the DC geared motor rotating either clockwise or counter clockwise. Almost every laptop this day was equipped with Wi-Fi receiver. Hence by controlling the WiBot using Wi-Fi connection, can cut cost and save time to design a receiver and transmitter for the WiBot. Wi-Fi connection also works better compare to infrared and Bluetooth connection that can only operate in short range and interrupt by obstacles.**

Keywords— **Wi-fi, WiBot, Radio Frequency, Bluetooth, router**

I. INTRODUCTION

Recently in Malaysia, there are many developers that have been investing seriously in Wi-Fi technology such as Maxis, Tmnet, P1 Wimax and Jaring. Wi-Fi used increasingly in the home, office, and public areas such as airports, coffee shops and university campuses. Wi-Fi technologies are supported by nearly every modern personal computer operating system, most advanced game consoles and laptops, and many printers and other peripherals [3]. Innovative ways to utilize Wi-Fi technology is helping people to work and communicate more efficiently and effectively. Increased mobility and with the absence of network cabling and other fixed infrastructure have proven to be beneficial for many users [1]. Wi-Fi technology expanded to next level because Wi-Fi connection not only use to surf internet but Wi-Fi connection can be use to control home appliances such as television, stereo, room lighting, alarm and many more appliances wirelessly [1]. Hence it is possible to control a robot using a Wi-Fi connection.

Fig. 1: EZL-80 PCMCIA-TTL interface with PCMCIA card

In designing the system, there are several projects that are use as reference to obtain good results. Some improvements need to be done to overcome the weakness of previous projects. Based on previous projects such as wireless mobile robots, Wi-Fi system robot's receiver is build using PCMCIA card (Fig. 1). PCMCIA stands for Personal Computer Memory Card International Association. A PCMCIA card is a credit card-size memory or I/O device that connects to a personal computer, usually a notebook or laptop [5]. PCMCIA card is divided into three main type depends on the function. Type 1 is for memory, type 2 is for LAN or modem and type 3 is for ATA hard drive. PCMCIA card for LAN is use for the wireless mobile robots [5] to make network between user's computer and mobile robot.

A big limitation of the above method is that the technology has obsolete and hard to find nowadays due to all modern laptop is already having built in Wi-Fi receiver and does not have PCMCIA card compartment or slot. An additional circuit such as EZL-80 PCMCIA-TTL circuit is required to connect the PCMCIA card onto the mobile robot. The EZL-80 circuit is complex and hard to find especially in Malaysia market.

Hence, to solve this problem a wireless router model Wrt54gl from Linksys is use to replace the PCMCIA card. Wrt54gl wireless router has better Wi-Fi reception compare to PCMCIA card. The Wrt54gl wireless router is easy to find and use because of the graphical user interface use in Wrt54gl wireless router is user friendly. Wrt54gl wireless router can be attach with an IP camera or network camera through a LAN cable (Cat-5 cable). Hence, a monitoring device can be added onto the mobile robot without an additional circuit.
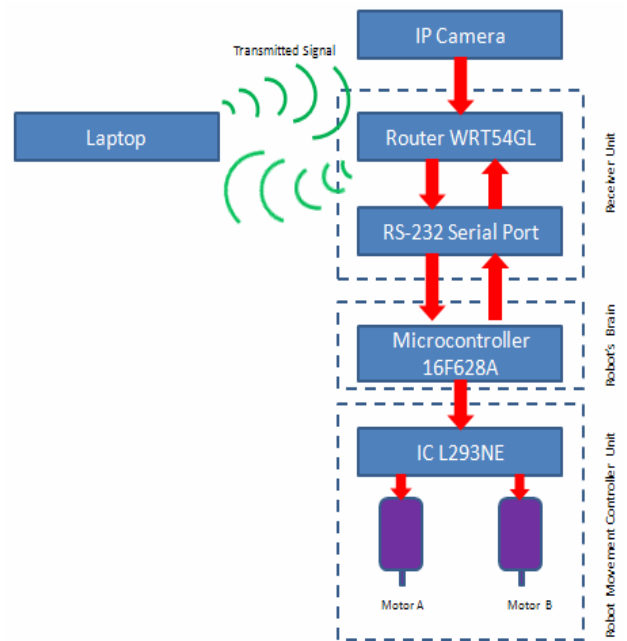
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II. SYSTEM OVERVIEW

Fig. 2: Functional block diagram of Wi-Fi robot (WiBot)

As illustrated in Fig. 2, the Wibot is control using a laptop or computer through Wi-Fi connection. Computer will detects a keystroke enter by user and transmit the instructions set according to the keystroke to the Wrt54gl wireless router. Wrt54gl router acts as receiver of the Wibot. A graphical user interface use to control Wibot is developed using Visual Basic 6.0 also known as VB6. Router Wrt54gl version 1.1 will be use as a receiver of the Wibot because it is easy to find in Malaysia market and there is many tutorials from internet teach how to install the third party firmware into the router. Third party firmware use in the Wrt54gl router is White Russian 0.9 from OpenWrt and Xwrt. The third party firmware need to be install into the router because in order RS-232 serial port to operate a driver must be install into the router using Secure Shell or SSH(Putty for Windows operating system). Wrt54gl router will received data and instruction from computer and send it to the 16F628A microcontroller through RS-232 serial port.

As for the controlling circuit, microcontroller 16F628A acts as a brain that control movement of the robot. Data received from the Wrt54gl wireless router will be processed by the 16F628A microcontroller and sent instruction to the motor controller integrated circuit, L293NE to move the motor. Output of the microcontroller will be input of the IC L293NE. The IC L293NE controls the rotation of the DC motor either to rotate clockwise or anticlockwise. Hence the robot will be move according to the instruction set by user from the computer.

The IP camera or network camera captured live feedback image and transmitted the image back to user laptop through Wrt54gl wireless router. The IP camera is connected to the router using LAN cable (Cat-5 cable). The IP camera is equipped with infrared LED. This feature makes WiBot able to capture live feedback image and navigate in the dark.

III.

IV. HARDWARE

A. Wrt54gl Wireless router

TheLinksys Wrt54gl wireless router (Fig. 3) is a Wi-Fi capable residential gateway from Linksys. The Wrt54gl router is use as a receiver for the Wibot. The router will receive instruction send from computer or laptop wirelessly and send the instruction to the programmable interface controller (PIC) through a serial port. The Wrt54g is notable for being the first consumer-level network device that had its firmware source code released to satisfy the obligations of the GNU General Public License (GPL) [8]. This allows programmers to modify the firmware to change or add functionality to the device. Router Wrt54gl version 1.1 will be use as a receiver of the Wibot because it is easy to find and there is many tutorials teach how to install the third party firmware into the router. Third party firmware use in the Wrt54gl router is White Russian 0.9 from OpenWrt and X-wrt. Compared to the preinstalled firmware on the Wrt54gl routers, third party firmware such as OpenWrt allows a reliable operation with a clearly larger functionality. In order for the router to work as a WiBot receiver, a software called 'carserver' need to be installed into the router.

Fig. 3: Wrt54gl version 1.1 wireless router

B. IC MAX 232

The WRT54GL has a 10 pin connection slot on the board called JP1 (Fig. 4). This slot provides two TTL serial ports at 3.3V. Neither of the ports uses hardware flow control, so need to use software flow control instead. These two TTL serial ports on the WRT54GL router can be used as standard serial ports similar to the serial ports on a PC.
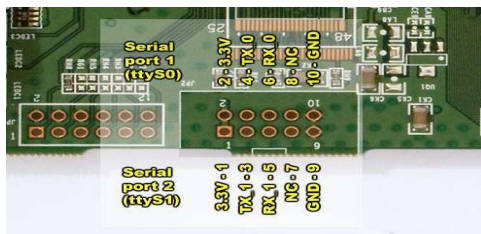
Fig. 4: Serial port pin connection (Wrt54gl router)

In order to do this through a line driver chip that can raise the signal levels to RS-232 levels is needed. This problem can solve by using IC MAX232. The serial port is use to send instruction or data receive by the wrt54gl router to the programmable interface controller (PIC) 16F628A.

C. IC L293NE

L293NE is a dual H-Bridge motor driver. L293NE function as a motor controller in WiBot, which receive input from PIC and control 2 dc geared motor. L293NE can interface two DC motors which can be controlled in both clockwise and counter clockwise direction. L293NE is designed to provide bidirectional drive currents of up to 1 ampere at voltages from 4.5 V to 36 V. Moreover for protection of circuit from back EMF, diodes are included within the IC. The output supply (VCC) has a wide range from 4.5V to 36V, which has made L293NE a best choice for DC motor driver. The motor direction is controlled by logic signals from the microcontroller. Two signals per motor are required to control the direction of dc motor..

D. PIC 16F628A

The PIC 16F84A is use to send input to the motor controller L293NE. The dc motor move clockwise or counter clockwise depends on the input receive by L293NE from PIC 16F628A. The PIC 16F628A has two ports, port A and port B. Each can be individually program as input or output. PIC 16F628A is specially choose for this project because of the UART function. Pin 7(RB1) is use for receiving data (Rx) and pin 8(RB2) is use for transmitting data (Tx) using UART. 4bits from port A is set as output (RA0, RA1, RA2 and RA3). This output pin will be connected to dc geared motor controller circuit. PIC 16F628A is easy to find and cheap.

E. DC Geared Motor (SPG30-20K)

A dc geared motor is a device that uses electricity to produce mechanical energy. The energy in an electric current causes the dc geared motor to spin. Any devices attached to the motor can then take advantage of this spinning motion to create another type of motion. In a gear motor, the magnetic current turns gears that are either in a gear reduction unit or in an integrated gear box. A second shaft is connected to these gears. The result is that the gears greatly increase the amount of torque the motor is capable of producing while simultaneously slowing down the motor's output speed. The motor will not need to draw as much current to function and will move more slowly, but will provide greater torque. Dc geared motor use in this project is MO-SPG-30-20K (from Cytron Technologies. This motor is power using 12V direct current. The speed of this motor depends on the voltage supply to the motor.

F. IP Camera (Prolink PIC 1002)

WiBot is use for wireless navigation. Hence an equipment for monitoring is important to let user know about obstacles need to b avoid and collecting data. IP camera is connected to WiBot's wrt54gl router through Cat-5 cable (LAN cable). IP cameras are Closed-circuit television (CCTV) cameras that use Internet Protocol to transmit image data and control signals over a Fast Ethernet link. IP cameras are also commonly referred to as network cameras. IP cameras are primarily used for surveillance in the same manner as CCTV. IP camera can be use to send feedback image from robot to the computer or laptop. There are several characteristic of IP camera need to be considered such as the camera cost and the picture quality. If the picture quality is

too high, time consumed to send picture back to the computer will be longer, the video receive at computer will be a bit late from the real time. Prolink IP Camera PIC1002 (Fig. 5) is the best solution for WiBot monitoring because the price is cheap compare to other type of IP camera, have built-in LCD screen(show IP address of camera), have built-in 6 IR-Led for night vision and have built-in USB port for additional webcam to serve as IP cam.

Fig. 5: Prolink IP Camera PIC1002

G. *Personal Computer (PC)*

Personal computer (equipped with Wi-Fi receiver) or laptop is used to communicate with WiBot using software called WiBot Controller Interface (WCI). WiBot Controller Interface is developed using Visual Basic 6 or also known as VB6 software. The data transmit to the WiBot depends on the keystroke enter by user through WCI. Personal computer or laptop also use for monitoring and recording live feedback image capture by IP camera.

V. SOFTWARE

A. *Software Overview*

In developing WiBot system there are also software part involved. The software part in WiBot system can be divided into three main parts. Part one consist of Wrt54gl wireless router programming using third party firmware. Part two consist of microcontroller programming using MPLAB IDE v8.46 and PICkit 2 v2.60. Part three consist of WiBot Control Interface (WCI) programming using Visual Basic 6.0.

B. *Third Party Firmware (Wrt54gl Wireless Router)*

The original firmware from Linksys does not have as many features compare to the third party firmware. The third party use for the Wrt54gl wireless router is White Russian 0.9 and X-Wrt. In order for the RS-232 serial level converter circuit to work properly, a third party firmware need to be installed into the Wrt54gl router. The third party firmware will enabled user to SSH into the router and enabled the function of the RS-232 serial port. Secure Shell or SSH is a network protocol that allows data to be exchanged using a secure channel between two networked devices. SSH can be access from Windows operating system through a software call Putty, as shown in Fig. 6.
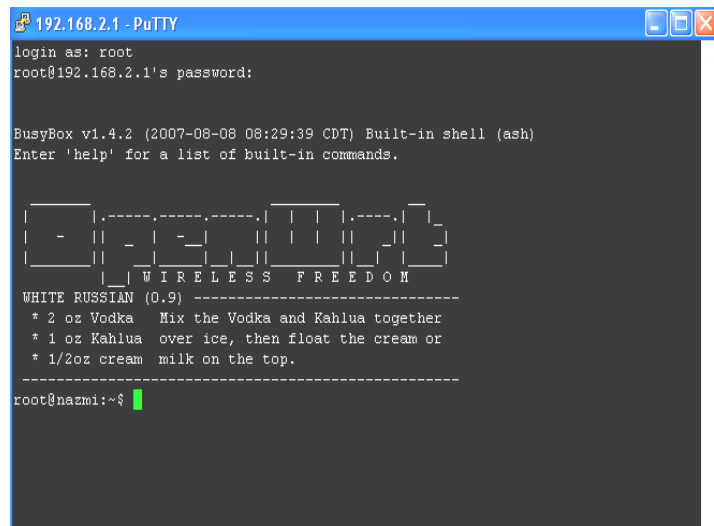

Fig. 6: Putty software

After installing White Russian 0.9 and X-Wrt, some software packages that is use in WiBot system such setserial and carserver need to be installed into the Wrt54gl wireless router [9]. The setserial software package is use for serial ports enabling and configuration. The carserver software use to send data receive by the Wrt54gl router from computer to the serial ports. Both of this software is very important in WiBot's system. Fig. 7 shows that the setserial and carserver software packages were installed into the Wrt54gl wireless router.

Fig. 7: Setserial and Carserver packages

C. *Microcontroller Programming*

The main component of WiBot's system is the microcontroller. Microcontroller functioned like a brain for WiBot. The microcontroller use in WiBot's system is 16F628A. PIC 16F628A is specially choose for this project because of the UART function. Pin 7(RB1) is use for receiving data (Rx) and pin 8(RB2) is use for transmitting data (Tx) using UART. 4bits from port A is set as output (RA0, RA1, RA2 and RA3). This output pin will be connected to dc geared motor controller circuit. The 16F628A microcontroller is program using MPLAB IDE v8.46 and PICkit 2 v2.60. MPLAB IDE v8.46 is use to create a .hex file format for the WiBot's program. Then the .hex file format will be write into the 16F628A microcontroller using PICkit 2 v2.60 software. PICkit 2 v2.60 comes with hardware to

program the microcontroller called UIC00A programmer from Cytron Technologies. Fig. 8 shows a flowchart of PIC 16F628A program.
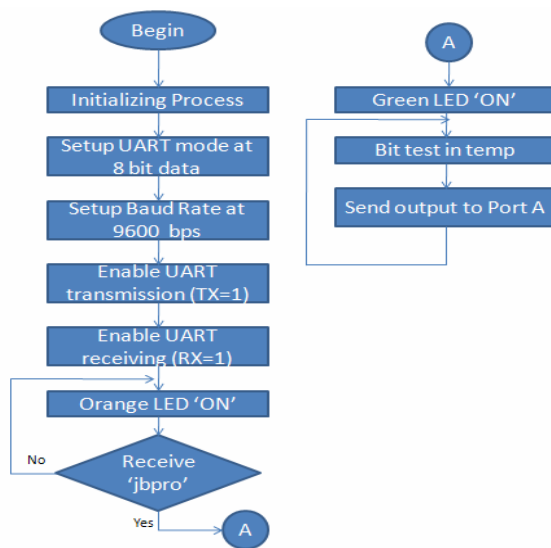

Fig. 8: Flowchart of PIC 16F628A program

During initializing state, the PIC 16F628A will set all bit in port A as output and enable the UART pin in port B. Pin 7 for UART receiving function and pin 8 for UART transmitting function. The program will set the comparator off because comparator function does not necessary in this project. The programs start at address 0x00h. The program is set to operate at 9600 bps baud rate speed for the UART function. The baud rate speed is set using Baud Rate Generator Register (SPBRG). SPBRG is a special function register (SFR) located in bank1 and address 0x99h. The program set the transmission into asynchronous transmission and set the BRGH high by setting the TXSTA to b'00100100'. Bit 2 in TXSTA is to set the BRGH function and bit 5 in TXSTA is to set the TXEN (transmission) function. The UART receiving function is set using RCSTA register. The RCSTA is set to b'10010000' to enable the asynchronous reception function. The orange LED indicates the program is still in initializing state and the system is not ready to function properly. After initializing process is complete and the Wrt54gl wireless router is in idle state, the green LED will turn on. The green LED indicates the WiBot's system is ready. Data receive from the WiBot Controller Interface (Visual Basic 6) will be stored in temp. The output send to port A is based on the data stored in temp. The program will continue looping to scan every input send to the PIC 16F628A from WiBot Controller Interface. Fig 8 shows a flowchart of PIC 16F628A program.

D. *WiBot Controller Interface (WCI)*

WiBot Controller Interface is a graphical user interface (GUI) use to control WiBot from computer or laptop (Fig 9). A PC-Based system was chosen because it allows much more flexibility in programming, allows for easy internet control, has an enhanced processing capability necessary for vision systems, provides a reduced need for specialist hardware, and wireless communications have already been well established. The WCI is developed using Visual Basic 6.0 software. The wireless communications are handled by TCP/IP through the powerful Winsock control. WiBot is connected to the WCI using Winsock control function. User must enter the router IP address into the IP address box and click start button to enable wireless connection between WiBot and computer. WiBot movement is controlled through this interface. WiBot will move forward when user press up keystroke or click on the up arrow using mouse. WiBot will move backward when user press down keystroke or click on the down arrow using mouse. WiBot will turn left when user press the left keystroke or click on the left arrow using mouse. WiBot will turn right when user press the right keystroke or click on the right arrow using mouse.
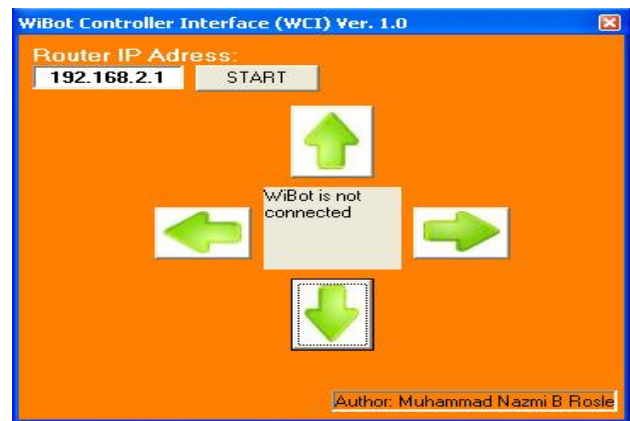

Fig. 9: WiBot Controller Interface

VI. RESULT AND ANALYSIS

During initializing state, the orange LED will turned on to indicates that the system is not ready. In this state, user cannot connect to the WiBot because the program is still running and the wrt54gl wireless router is not detected. Fig 10 shows WiBot is in initializing state.
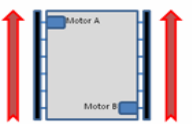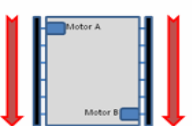

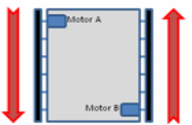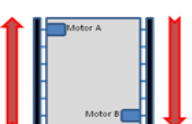Fig. 10: WiBot's orange LED is on

When WiBot's system is ready to be use, the green LED will turn on. The green LED shows that WiBot is in idle state. The green LED will turn on when the program in PIC 16F628A receive 'jbpro' string from Wrt54gl ireless router. The 'jbpro' string is send by carserver software packages installed in the Wrt54gl wireless router. Fig 11 shows that WiBot is in idle state.

Fig. 11: WiBot's green LED is on

WiBot's movement is depends on the input send by the WCI. WCI supplying input by sending a binary bit to the PIC 16F628A according to the keystroke or button click by user. When user press up keystroke on the keyboard or click on the up arrow using mouse; WCI software will send binary '0000 0110' to the PIC 16F628A. The input will be send to the motor controller circuit (L293NE circuit) to move the motor. WiBot will move forward. Others input for others direction are show in table 1.

TABLE I
PIC 16F628A inputs

WCI (VB6) Button	16F628A Input (binary)	RA 0	RA 1	RA 2	RA 3	Direction
Up	0000 0110	0	1	1	0	Forward
Down	0000 1001	1	0	0	1	Backward
Left	0000 0101	1	0	1	0	Turn Left
Right	0000 1010	0	1	0	1	Turn Right

The output from PIC 16F628A will send to the motor controller circuit (L293NE circuit) to control the direction of both dc geared motor. Direction of dc geared motor will influence the movement of WiBot. Motor A is controlled

through input receive from RA0 (pin 17) and RA1 (pin 18) of PIC 16F628A. Motor B is controlled through input receive form RA2 (pin 1) and RA3 (pin 2) of PIC 16F628A. When RA0 is low and RA1 is high, motor A will move in counter clockwise direction. Motor B will move in clockwise direction when RA2 is high and RA3 is low. The combination of this two dc geared motor movement will force WiBot to move in forward direction. Other dc geared motor direction combination that control movement of WiBot is show in Table 2.

TABLE II
Dc geared motor direction

WiBot Direction	Motor Direction		Logic Input (L293NE)			
	Left	Right	Motor A		Motor B	
	Motor A	Motor B	IN 1	IN 2	IN 3	IN 4
Forward	Counter Clockwise	Clockwise	0	1	1	0
Backward	Clockwise	Counter Clockwise	1	0	0	1
Turn Right	Counter Clockwise	Counter Clockwise	0	1	0	1
Turn Left	Clockwise	Clockwise	1	0	1	0

Table 3 shows the chassis specification of WiBot. Aluminum is the basic material for WiBot's chassis because aluminum is easy to shape, cut, and light. Fig. 13 show a complete design of WiBot including aluminum chassis.

TABLE III
Chassis specification

Design Aspects	Specification
Weight	Total : 3.8kg (include batteries)
Size	42.5cm x 30.5cm x 17.5cm (with IP camera)
	42.5cm x 30.5cm x 13.0cm (without IP camera)
Material	Platform : Aluminum plate
	Frame : Aluminum bar
	(Hollow : 0.55inch x 0.55inch)

Fig. 13: Complete design of WiBot

Live feedback image for monitoring system is capture using IP camera PIC-1002 from Linksys. The IP camera is connected to the Wrt54gl wireless router through LAN cable (Cat-5). The IP camera can capture image even in low light environment or even in the dark because the IP camera is equipped with infrared LED. As example in Fig. 12, shows an image capture by the IP camera in low light environment. The IP camera PIC-1002 can be access through a web interface supplied by the provider, Prolink. User can access the IP camera using the IP address of the camera.
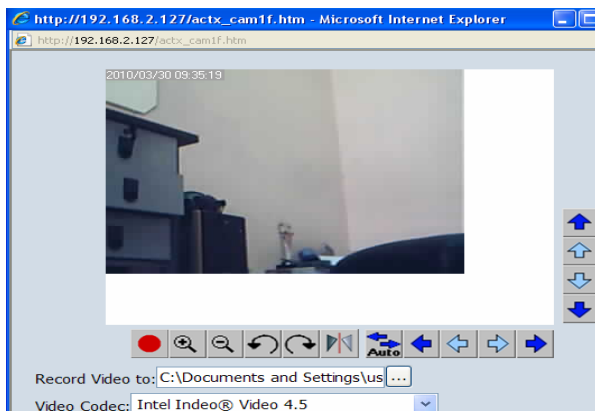

Fig. 12: Image capture by the IP camera

VII. CONCLUSION

This project presents the initial and testing of Wi-Fi robot system, WiBot. The main objective of this project is to design a mobile robot that can be control by computer or laptop through Wi-Fi connection. The secondary objective of this project is to interfacing the mobile robot with an IP camera for capturing live feedback image and sends it to the computer or laptop. Both of these objectives are successfully implement in mobile robot system. Hence, WiBot could be used for many real world applications such as military reconnaissance, extreme condition (environment), or in artificial intelligence robotics. Another application could be in schools, colleges, and universities interested in experimentation and development of robots.

However, there is still some modification needed to overcome all infirmities in WiBot's System. For future developments, WiBot's system can be upgrade into a rough terrain mobile robot by changing the dc geared motor used into a more powerful dc motor such as power window motor. WiBot's range of effectiveness can be increase by changing the 5 dBi antenna of Wrt54gl wireless router to a 12 dBi antenna or Wi-Fi outdoor antenna. WiBot is design for a long range operation; hence WiBot chassis need to be design for waterproof purpose to avoid WiBot from damage and short circuit. WiBot can be upgrade to operate longer by changing the Sealed Lead Acid (SLA) battery used to a more efficient battery such as LiPo battery. WiBot also can be equipped with solar system.

REFERENCES

[1] Raymond J. Smith (2003). "WiFi Home Networking". New York,NY.McGraw-Hill.

[2] Mike Outmesguine (2004). "Wi-Fi Toys 15 Cool Wireless Projects for Home, Office, and Entertainment".Indianapolis, IN,Wiley Publishing,Inc.

[3] Houda Laboid, Hossam Afifi, Costantino De Santis (2007). "Wi-Fi^{TM}, Bluetooth^{TM}, ZigBee^{TM} and WiMax^{TM}". London,Springer.

[4] Dennis Clark, Micheal Owings (2003). "Building Robot Drive Trains". New York,NY. McGraw-Hill.

[5] Dr. Richard S. Wolff (2006). "Wireless Mobile Robots: A Tool for Undergraduate Electrical Engineering Instruction". Montana State University.

[6] Diane Zak (1999)."Programming with Microsoft Visual Basic 6.0". New York,NY.Course Technology.

[7] Gordon Mccomb (2000), "The Robot Builder's Bonanza". New York,NY.McGraw-Hill

[8] Paul Asadoorian, Larry Pesce, Raúl Siles (2007). "Linksys® WRT54G Ultimate Hacking". Burlington, MA.Syngress.

[9] *Jonathan Bennett* (2008, August). Wifi Robot. Retrieved January 12, 2010, from website: http://www.jbprojects.net/projects/wifirobot/