National Conference on Innovative Trends in Science and Engineering (NC-ITSE'16) ISSN: 2321-8169
Volume: 4 Issue: 7 220 - 223

Wi-Fi Controlled Smart Robot with ARM Cortex-M4 Processor

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***Abstract*—** In this paper we are presenting a design of a smart robot embedded with some useful sensors that can be operated either through the use of Wi-Fi or mobile application to complete the given set of tasks. We have mounted temperature and humidity sensor DHT11 and CO_2 sensors on our robot. Graphical analysis of sensors input taken for 24 hours has been discussed in the second half part of this paper. We ensure that our smart robot with equipped sensors plays a vital role in the field of advanced robotics.

Keywords*- Smart robot, Wi-Fi, Sensors.*

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I. INTRODUCTION

In the emerging world of Internet of things thousands of objects can sense, communicate and share information with each other through networks. In this new era of Internet of Things the interconnection networks are growing rapidly with smart devices because of its major applications in various fields such as agriculture, medical, home automation and industry automation etc.

Robotics is much demanding and fastest developing field of inventions. Robots are required where human interventions are nearly impossible. Due to this, a concept of designing sensors embedded robot, which can be controlled through Wi-Fi or through a mobile application was emerge in our mind. Designing of the system requires the knowledge of ARM cortex processor, sensors, programming in open source operating system such as Linux, embedded system and decision algorithm. Following figure shows the general block diagram of Wi-Fi based robot controlling. Fig.(1).

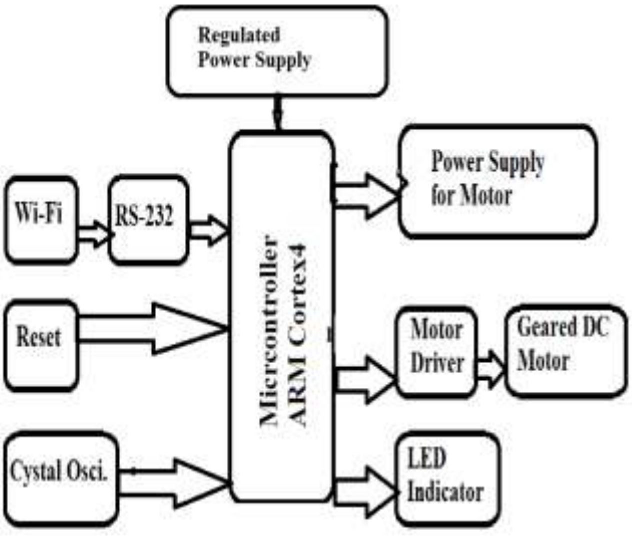

fig.1: Wi-Fi based Robot Controlling

II. SYSTEM COMPONENTS

A. Wireless Technologies

Now a day due to high proportion of research in communication engineering, more wireless technologies have been evolved, which includes Bluetooth, Wi-Fi, Zig-Bee, X-Bee etc. It is important to compare these technologies on the basis of their bandwidth, frequency, data rate to transfer data among the devices for better development of mobile robot controller. Following table shows the comparison of three various popular wireless technologies. Fig. (2).[1]

Types of Wireless Technology	Range	Frequency Band(s)	Data Rate
Bluetooth	33 feet	2.4Ghz	1.5Mbps
Wi-Fi IEEE802.11b IEEE802.11g	100-150 feet	2.4Ghz	11Mbps 54Mbps
3G CDMA	Global	800 MHz – 1900 MHz	2Mbps

fig.2: Comparison of Wireless technologies

B. Wi-Fi or Wireless LAN

Wi-Fi or WLAN (Wireless Local Area Networks) is a wireless network based on a series of specifications from the Institute of Electrical and Electronics Engineers (IEEE) called 802.11. Wi-Fi uses unlicensed radio frequency, mostly in the 2.4GHz band. It enables a person with a wireless-enabled computer or PDA to connect to the Internet via a wireless access point. The geographical region covered by one or several access points is called a hot spot. Wi-Fi was intended to be used for mobile devices and local area Networks, but it is now often used for Internet access outdoors. There are several types of Wi-Fi:

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a) 802.11a (offering transmission speeds of 24mbps to 54mbps)
b) 802.11b (6mbps to 11mbps) and 802.11g (24mbps to 54 mbps)
c) 802.11n (50mbps to 100mbps) is a proposed specification that will become a Wi-Fi standard once it's finalized by the IEEE, and the Wi-Fi Alliance completes its interoperability testing.

Mobile robot moved according to the commands sent through the wireless channel by a desktop computer or laptop. Characteristic Wi-Fi systems used in this development are wideband is around 100MHz, with a center frequency of 2.45GHz, for the IEEE802.11b and IEEE802.11.This WLAN responsible for transmitting operators' commands, the position information of the robot .Through using a high gain antenna and an amplifier communication distance of WLAN can extend to over 30km.[1] Fig. 3 shows the WLAN of Bridge Connection Pattern used in our project.

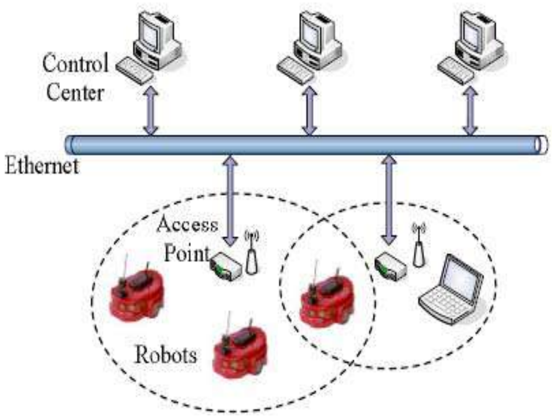

fig.3: WLAN of Bridge connection pattern

C. *Marvell 88MW302 (ARM CORTEX 4)*

Heart of our design is the ARM Cortex-M4 processor, which is built on a high-performance processor core, with a 3-stage pipeline Harvard architecture, making it ideal for demanding embedded applications, providing high-end processing hardware including optional IEEE754-compliant single-precision floating-point computation, a range of single-cycle and SIMD multiplication and multiply-with-accumulate capabilities, saturating arithmetic and dedicated hardware division.

Marvell EZ-Connect MW302 is a IoT Starter Kit which include a mini USB to USB cable, and Marvell 88MW302 development board with the following (preliminary) specifications:

1. SoC – Marvell EZ-Connect MW302 ARM Cortex-M4 WiSoC with 512KB SRAM
2. Connectivity – 2.4Ghz b/g/n Wi-Fi (built-in MW302 MCU
3. USB – 1x micro USB OTG,
4. Debugging – 1x mini USB for UART console and JTAG, 1x 10-pin JTAG connector
5. Expansion headers – 2x 32-pin header with access to SPI, I2C, UART, I2S, PWM, ADC, DAC, as well as power signals and GND.
6. Miscellaneous – Reset key, four buttons, various jumpers, two LEDs
7. Power Supply – 5V DC via power jack.

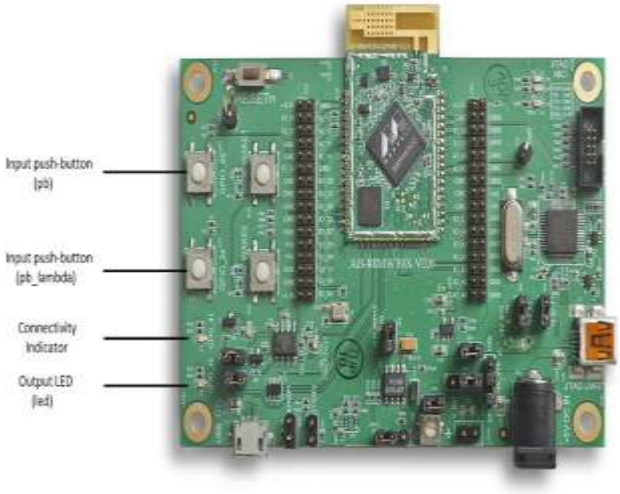

fig.4: ARM CORTEX 4 based Marvell 88MW302 kit

D. *MOTOR CONTROLLER*

L293D IC is used to drive 2 geared motors. L293D is a dual H- bridge motor driver integrated circuit (IC).[4] It contains two inbuilt H- bridge driver circuits. Here in this robot we are using it in common mode where two DC motors can be driven simultaneously, both in forward and reverse direction. The motor operations of two motors will be controlled by a webpage or mobile app or by using a Wi-Fi When forward button is pressed logic 01 will be send to driver circuit through microcontroller and for reverse 10 will be send [5]. Similarly when stop button is pressed logic 00 or 11 will be send for corresponding motors.

Controller program is designed so as to enable the microcontroller to control robot using Wi-Fi technology. Webpage with different controls are designed for operation of the robot. Interfacing of Wi- fi module and Microcontroller has been done. When the designated Web address is entered into the web browser of the computing device, the web page for stipulated controls of the Robot is actuated and now visible on the computing device. When we click on the respective direction controls for the Robot on the webpage, the subsequent packets are generated. These packets at the transmitter end via Internet gets into the Router at the Receiver end and eventually gets dumped into the receiver module. L293D H-Bridge motor driver is as shown below. Fig (5)

fig.5: L293D H-Bridge Motor Driver

E. Mobile Application

Robot is moved Forward, Reverse, and Left, Right with the appropriate controls dictated by the mobile app. Buttons are designed to perform certain action on press. Buttons are forward, reverse, left, right, stop, ON and OFF. Each button functions as the name suggest. When button is pressed corresponding signal will pass through Wi- Fi and will be received by robot through Wi-Fi module. Wi- fi module forwards it to microcontroller and microcontroller will perform corresponding operation.

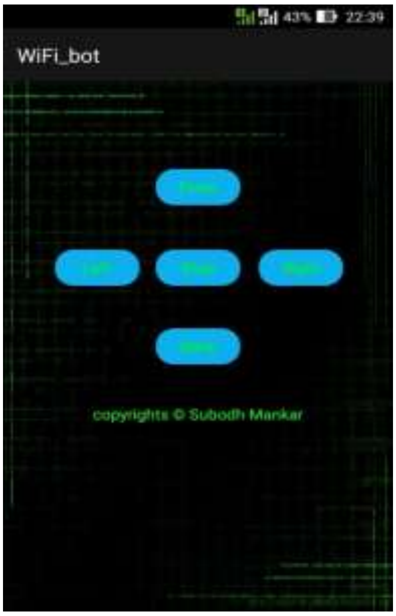

fig.6: Mobile App. For Robot Direction Control

III. SMART SENSORS

A smart sensor is a device that takes input from the physical environment and uses built-in compute resources to perform predefined functions upon detection of specific input and then process data before passing it on. Smart sensors enable more accurate and automated collection of environmental data with less erroneous noise amongst the accurately recorded information. These devices are used for monitoring and control mechanisms in a wide variety of environments including smart grids, battlefield reconnaissance, exploration and a great number of science applications

A. Temperature and Humidity Sensor

DHT11 Temperature & Humidity Sensor features a temperature and humidity sensor complex with a calibrated digital signal output. DHT11 measures temperatures between 0°C and +90°C (with an error of ±2 °C) as well as humidity from 20% to 90% with + 5 % RH. The temperature and humidity sensor with signal conditioning, ADC, calibration and communication interface all built inside it greatly simplifies the design and reduces the overall cost. It uses the exclusive digital-signal-acquisition technique for temperature & humidity sensing technology. This sensor includes a resistive-type humidity measurement component and an NTC temperature measurement component, and connects to an 8-bit microcontroller.

The calibration coefficients are stored as programmed in the OTP memory, which are used by the sensor's internal signal detecting process. The single-wire serial interface makes system integration quick and easy. It has low power consumption and can transmit signal up to 20 meters. The component is 4-pin single row pin package.

DHT11's power supply is 3-5.5V DC.

The communication type used in DHT11 is a single-bus data format for communication and synchronization between MCU and DHT11 sensor. The single communication method process is about 4ms.

Data format: 8bit integral RH data + 8bit decimal RH data + 8bit integral T data + 8bit decimal T data + 8bit check sum. The check- sum should be the last 8bits of : 8bit integral RH data + 8bit decimal RH data + 8bit integral T data + 8bit decimal T data.

When MCU sends a start signal, DHT11 changes from low-power-consumption mode to the running-mode, waiting for the MCU comparing the start signal. Once it is completed, DHT11 sends 40-bit data that include the relative humidity and temperature information to MCU. Once data is collected, DHT11 will not give the response signal to MCU. Once data is collected, DHT11 will change to the low-power-consumption mode until it receive start signal from MCU again.following figure shows temperature/humidity sensor along with graph showing the result for 24 hours input data.

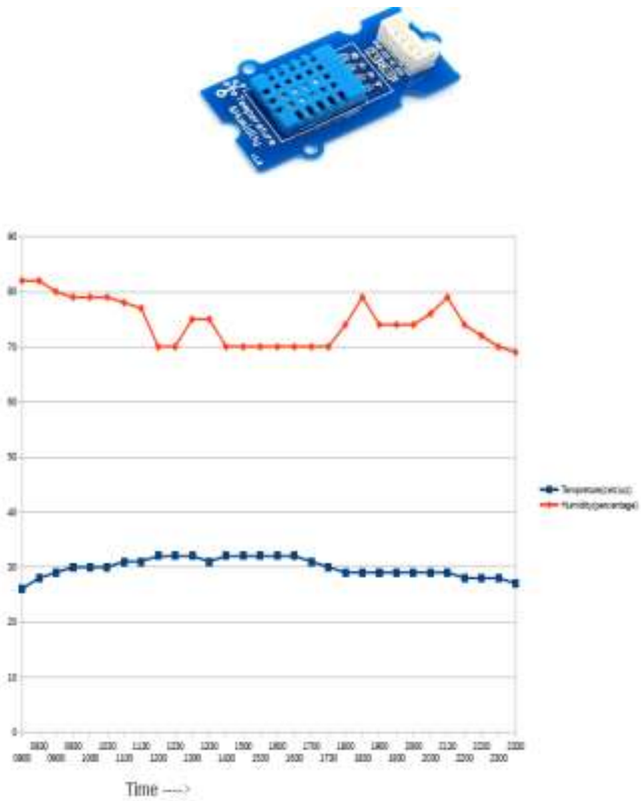

fig.7: Temperature/Humidity sensor and its signal analysis graph

B. CO_2 Sensor

CO_2 Sensor equipped with our robot has been selected with the resolution of 1 PPM 0-2000 parts per million (PPM). Its accuracy is supposed to be of 200 PPM. It's warm - up time is of 3 minutes. Its calculated response time is less than 90s.It can designed to work with the operating temperature 0 to 50℃ and that of Humidity 0% ~ 90% RH. Its storage temperature is - 20-60℃. Operating Voltage is ranges between 4.5 V to 6 V DC.

The Current maximum Current of less than 100 mA, the average Current of less than 50 mA. If the resolutions of CO_2 sensor becomes 350~1000ppm, then the air is fresh for smooth breathing. For resolutions more than 1000 but less than 2000ppm, the air was stagnant and feels asleep. Resolution between 2000~5000ppm may results in headache, asleep, dull, unable To Focus, heart beat rock and even mild nausea Greater than 5000ppm causes severe depletion of oxygen, permanent brain damage and even death

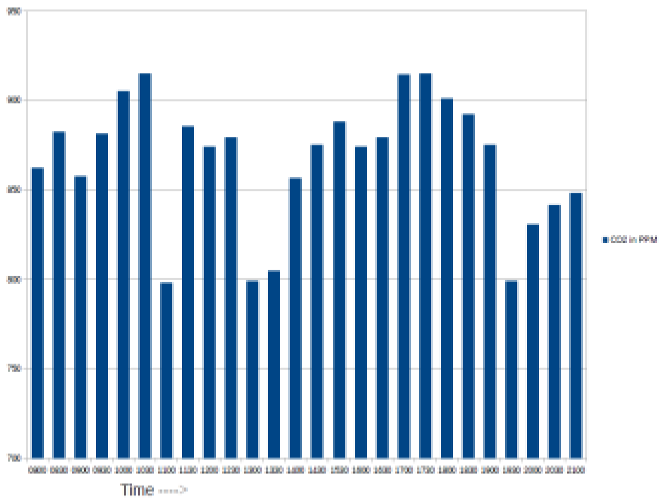

fig.8:Graphical Analysis of CO_2 sensor results

IV. CONCLUSION

A robot developed in this paper is controlled through the Wi-Fi or through the mobile application designed for this purpose. This robot can be used to enter to confined spaces when it is needed. In future work the improvements for this robot would be the implementation of a camera to be introduced to places where human beings could not get also more number of sensors can be place over it so that it will works like an autonomous robot.

V. ACKNOWLEGMENT

We are thankful to Vadactro Pvt.Ltd.Pune for sponsorship and their assistance for the completion of this project.We also express our gratitude to Dr.C.M.Jadhao, Principal of Mauli College of Engineering, Shegaon for his encouragement and time by time support

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