

Wi-Fi Based Communication and Localization Of An Autonomous Mobile Robot For Refinery Inspection

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Abstract - The industries such as Oil and gas refineries can be a dangerous environment for numerous reasons, they are heat, toxic gasses, and other unexpected failures. Among these failures Gas leakage can be catastrophic so to detect the gas leakage at an initial stage an autonomous mobile robotic platform is developed. This paper focuses on the use of Wi-Fi for both the communication and localization of the robot. By establishing access points robot can be connected to internet using the Wi-Fi module embedded in the robot. The location of gas leakage can also be sent to internet .For that purpose a GPS module is also provided with the robot. The autonomous operation of the robot is ensured by the three ultrasonic sensors.

Key Words: Oil and gas refineries, Gas leakage, Autonomous, Robot, WiFi communication, Gas detection

1. INTRODUCTION

As we all know safety is gainful and accident is painful. In an oil and gas industries gas leakage can happen at any time. In order to maintain safety in such industries gas leakage should be detected at a very early stage. So this project proposes the design of a robot [1] that can monitor the oil and pipe line industries autonomously and to detect the gas leakage at a very early stage. Robot [3] send this gas detected information along with the current location of gas leakage to the control room computer. The use of Wi-Fi communication compared to the use of radio waves ensures better range and less interference as well as noise signals.

1.1 ROBOT DESIGN OBJECTIVES

The main objective of robot design is the efficient communication with the control room. Robot must be able to communicate with the control room all the time when it is working. It is achieved by using IoT technology.

Another objective to be considered is the autonomous operation of the robot. Robot must not stop before an obstacle in its path. It should deviate its path when it meets an obstacle .This feature can be implemented by interfacing ultrasonic sensors within the robot.

For the communication of the robot a mobile hotspot is established to that robot is connected and thereby to internet. And finally robot status is accessible from internet.

A GPS Module is also interfaced with the robot get the location of gas leakage.

1.2 BLOCK DIAGRAM

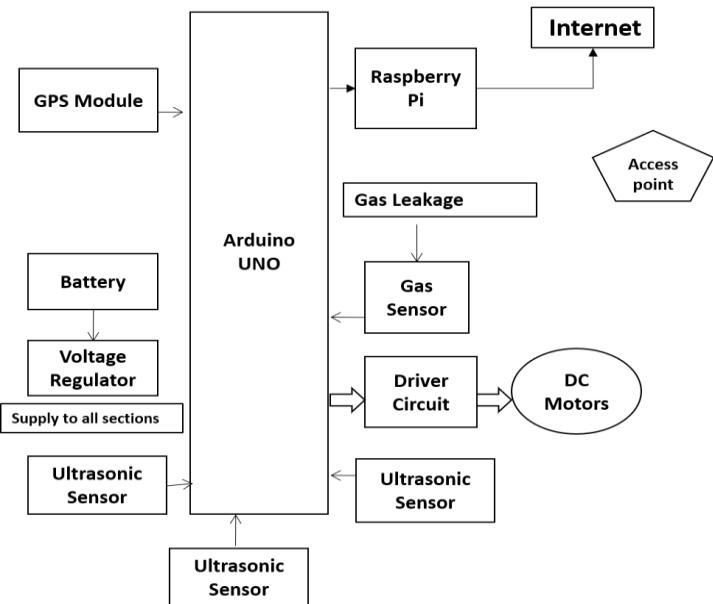


Fig -1: Block Diagram of the Robot

As we all know that using a Raspberry Pi computer in a robot to connect it to internet is as easy as pie. Here in the block diagram the three ultrasonic sensors which are inevitable for the autonomous operation of the robot is interfaced to the Arduino Uno. It is to detect the obstacles within 15cm from the robots current position in all three directions. A MQ6 gas sensor is also interfaced to the Arduino Uno to detect the gas. A L293D DC motor drive is used to interface the dc motors to the Arduino. In order to get the location of gas leakage a GPS module is also interfaced. The role of Raspberry Pi is to connect the robot to internet so that one can access the robots status in a webpage whether there is a gas leakage or not. Transmitter pin of Raspberry pi is connected to the Arduino. Whenever there is a gas leakage robot stops and the Arduino sends a high signal to Raspberry pi which then send the status to internet.

Raspberry Pi can be programmed using the Python language. One can access the Raspberry Pi computer from a remote system using the remote login option. For the remote login it is mandatory for knowing the I.P address of the Raspberry Pi. It then allows the user to run the program stored in the Raspberry .Also the I.P address of the Pi is entered in the webpage so that the robot status can be viewed.

2. CIRCUIT DIAGRAM

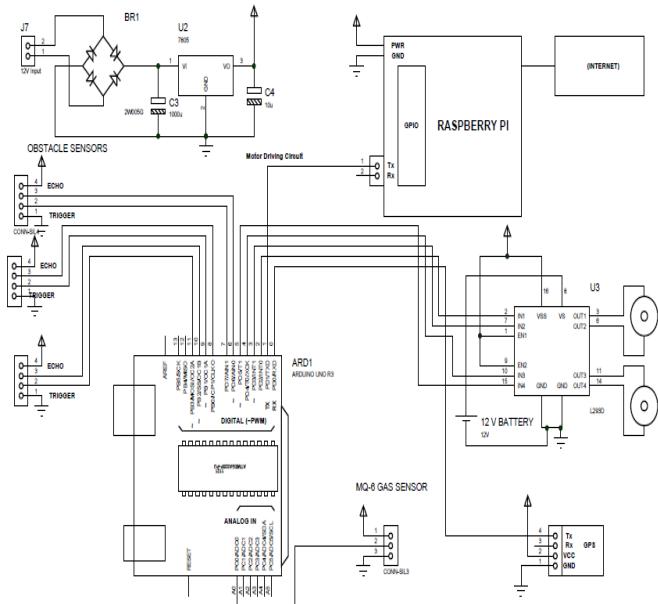


Fig -2:Circuit Diagram

The circuit diagram consist of an arduino microcontroller having 14 digital i/o pins and 6 analogue pins. There we are able to interface 3 obstacle sensors, Gas sensor ,GPS Module, motor driver module into it.

The obstacle sensor is an ultrasonic sensor. When a pulse of 10 microsecond is applied to the trigger pin, the ultrasonic transmitter sends 8 consecutive pulse of 40KHz frequency. As the eight pulse is sent the ECHO pin sensor becomes HIGH. Now the ultrasonic wave reflect from any source and are received by the receiver. Thus the ECHO pin become LOW. The time it takes to leave and return to the sensor is used to find the distance from the reflecting surface.

The motor driver we are using is L293D.This driver is a dual H-Bridge motor driver IC.Motor driver act as a current amplifier since they take a low-current control signal and provide a higher-current signal. This higher current is used to drive the two motor.

We use LM7805 voltage regulator for converting 12v DC to comparable voltage supplies to other IC.These regulator can deliver up to 1.5A of output current.

The Raspberry pi we have used is to connect the autonomous robot .Because this module is actually a credit - card sized computer. Also this have inbuilt Wi-Fi module. Therefore we can connect this module to internet via internet. The module is connected to the Arduino through transmitter pin. This pin will act as an interrupt which helps the motor to stop. Since this pin will get HIGH only when the Gas sensor detect any Gas leakage. The three ultrasonic sensor enables the autonomous operation of robot by

detecting the obstacles on three different paths around it. The Gas sensor detects the Gas leakage and output is given to the Raspberry pi after converting it digital. The GPS module provide the location of the robot. Detecting the Gas leakage the location of the robot send to the Raspberry pi. Raspberry pi is always connected to an Access point and thus to a webpage. The controller station retrieves this information from the robot and status is shown in a webpage along with the location and necessary actions are taken.

PCB DESIGN

After designing the circuit diagram the next task is to convert it into a PCB layout. So that it can be converted into actual hardware. PCB layout of the robot circuit diagram is developed using the Proteus software. Layout developed using the Proteus tool is printed so that it can be attached to a printed circuit board . Since a printed circuit board (PCB) mechanically supports and electrically connects electronic components using conductive tracks, pads and other features etched from copper sheets laminated onto a non-conductive substrate. A printed circuit board has pre-designed copper tracks on a conducting sheet. The pre-defined tracks reduce the wiring thereby reducing the faults arising due to lose connections. One needs to simply place the components on the PCB and solder them.

The making of PCB is a multi step process. They are Taking the printout of PCB layout, Cutting the copper plate according to the printout size, Making it smooth , Transfer the printed image from the photo paper to the board, Iron it, After ironing, place printed plate in Luke warm water for around 10 minutes. Paper will dissolve and, next is Etching and finally drill hole and solder all the component & PCB is ready. remove paper gently. Remove the Paper off at low angle & traces.

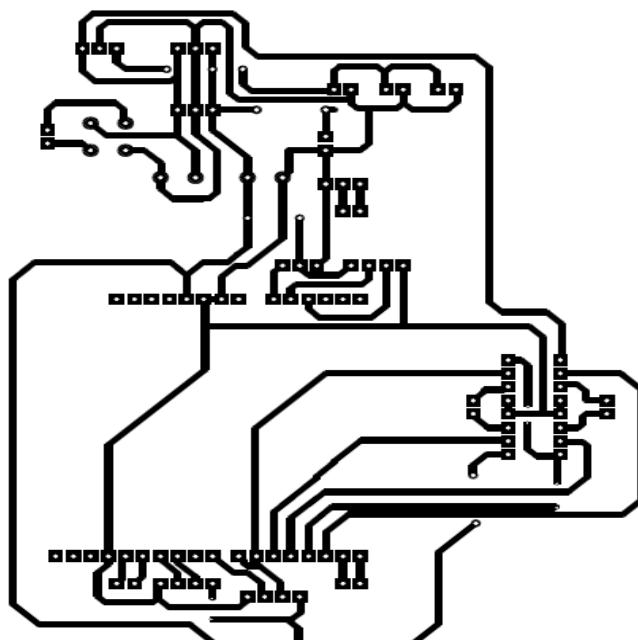


Fig -3: PCB Layout of the Robot

3. ACCESSING ROBOT FROM CONTROL ROOM

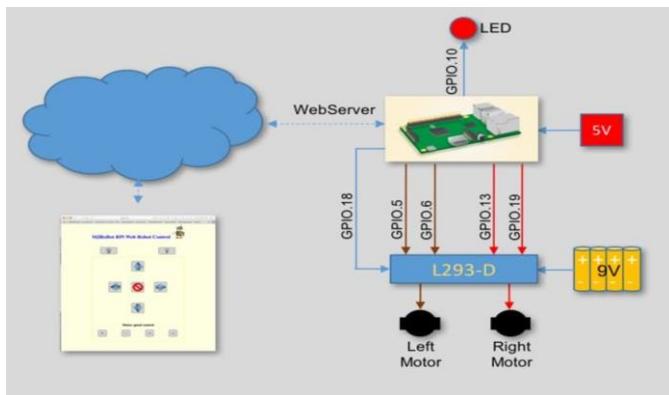


Fig -4: Accessing the robot status from internet

In order to access the robots status that is whether there is a gas leakage or not .First step is to find the I.P address of the Raspberry Pi used in the robot. Communication to any computer begins with its I.P address .After getting the I.P address of the Raspberry Pi. Remote Desktop option in the Control station computer is enabled. It take the I.P address of the Raspberry Pi to connect the control room computer to the robot .For successful remote login it is mandatory to enter the user name and password of the Raspberry Pi in the control room computer. By default Raspberry Pi user name and password are Pi and Raspberry respectively.

After the successful remote login control room computer is connected to the computer within the robot that is raspberry Pi itself. Then open the required folders in the Raspberry Pi from computer through the control room computer and run the program stored in the Raspberry Pi. Then Open a web browser in the control room computer and enter the IP address of the Raspberry Pi. Then the status of the robot starts to display on The webpage. At normal conditions it will be displayed as safe environment .Whenever the Robot detects the gas in the refinery status on the webpage in the control room computer changes to Gas detected also the location of gas leakage is also displayed.

2. PROTOTYPE DEVELOPED

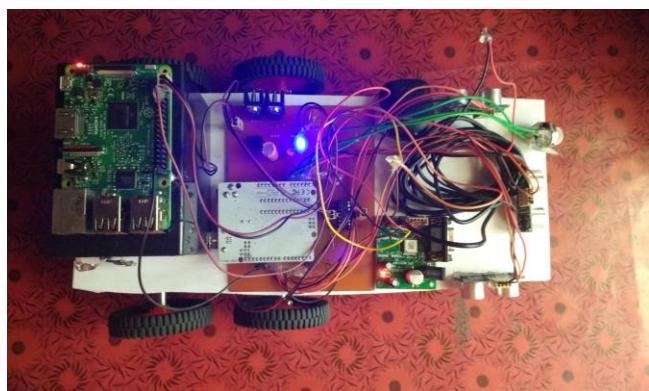


Fig -5: Prototype of Wi-Fi controlled autonomous mobile robot for refinery inspection

Once the PCB design is over Raspberry Pi computer is programmed using the python language .Compile the program and after debugging it is saved into the Raspberry Pi. Arduino Uno is programmed using the C language and is loaded into the microcontroller. After the programming phase They are suitable connected in the appropriate holes in the PCB and ends are soldered. Sensors, DC motors ,GPS are also interfaced with the Arduino Uno.A 12V 5A power supply is also provided for the entire system. Finally Robot chassis is developed and the PCB along with the attached components are mounted on the chassis. Now the Robot is ready to inspect. A simple html code is also inserted in the Raspberry Pi for the Webpage Creation which necessary for accessing the robots status.

3. CONCLUSION

As we all know that it is difficult to inspect some areas of industries like pipe lines in oil refineries and other unmanned areas. To check whether there is a gas leakage on those areas a robot is the perfect choice. And for a robotic system to autonomously navigate in an oil and gas refinery, it must be able to communicate with the control room and also localize itself. In this project we define the kinds of communication required to deploy an autonomous robot. And we found that it is affordable and efficient to use Raspberry Pi interfaced robot for refinery inspections.

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