Internet of Robotic Things based Surveillance System with Motion detection and Email alert

¹ Vedulla Ramesh, ² Chavala Lakshmi Narayana M.Tech,

¹ PG Student, ² Assistant Professor,
Department of Electronics and Communication Engineering
Pragati Engineering College
Surampallem, AndhraPradesh, India

Abstract: The system is about remotely managed Robot for Surveillance through webpage or smart phone. The Surveillance system has become indispensable in daily life. The design and development of a Robot surveillance system based on Internet of Robotic Things (IoRT) and remotely monitoring technology, to confirm the accessibility has been implemented in this project. This project describes about the implementation and deployment of wireless control system and accessibility to environment for Surveillance. IOT based robot whose moment control through webpage and camera module are used for remotely view video stream of the Surveillance. The system uses controller interface system with Raspberry Pi which is low cost and consume smaller amount of power. The camera module interface to Raspberry Pi which is mounted on Robot send video stream via TCP/IP. The concerned authority can control the moment of Robot, view angle of camera and view video stream of Surveillance through webpage on browser or smart phone. The system provides concerned authority to use webpage on browser or smart phone to send command for Robot. The user can view the video stream on webpage designed by using html and Java Script. This system finds a wide application in areas where physical control system built using ARM1176JZF-S micro controller and tested for actual use in home environment.

Index Terms – **Internet of Robotic things, Robotic surveillance, Raspberry Pi, IoRT, TCP/IP protocol.**

I. INTRODUCTION

A mobile robot is a machine that is basically place or mounted on a movable platform and can be with the help of certain instructions. In today's world a lot of fields use mobile robots. Many of the complex robots that we now see have originated from the simpler mobile robots. This technology has increased many new applications in the industry. The combination of mobile devices and robots are leading to new ideas in lots of fields. The mobile devices are now being used in many of the industrial applications .Also, they have a data plan through a cell phone carrier which is convenient as we can interact with the mobile robot once the connection is established The mobile robots can be classified into different types. The track robot is the robot that uses tracks to move around. However, such robots are costly to build. Also, they are not as flexible as the wheeled robots. The wheeled robots are the robots which use wheels for moving. Such robots can move only on smooth flat surfaces. The third type is the legged robots which are based on human form. They have legs which helps them to move around. These robots are very difficult to design.

II. LITERATURE SURVEY

Surveillance cameras are video cameras used for the purpose of observing an area. They are often connected to a recording device or IP network, and may be watched by a security guard or law enforcement officer. Cameras and recording equipment used to be relatively expensive and required human personnel to monitor camera footage, but analysis of footage has been made easier by automated software that organizes digital video footage into a searchable database, and by video analysis software. The amount of footage is also drastically reduced by motion sensors which only record when motion is detected. With cheaper production techniques, surveillance cameras are simple and inexpensive enough to be used in home security systems, and for everyday surveillance. The surveillance system has become indispensable in daily life. In case of surveillance cameras, the cameras are fixed. So that we can watch in only one particular direction. Because of this reason, we were not using this technology in Defense field. Now a day's technology has been increasing day by day, every component or device or instrument is connected to internet and operating through internet from anywhere i.e., controlling an Air cooler from outside of the house. The Internet of Things (IOT) is the network of physical objects or "things" embedded with electronics, software, sensors, and connectivity to enable objects to exchange data using Internet. IOT is present up going and future technology, it is estimated that 25 billion things are interconnected by the end of 2020. So we are using Robotic surveillance system based on IoT (Internet of Things) and remotely monitoring technology. In Defence fields, where humans are not allowed we are using robot to observe each and every place and if any threat is there then it immediately captures the image and sends it as a mail alert to the concerned authority. Then the concerned authority observes the surrounding areas by controlling the angle of the camera which is mounted on the robot.

CONVENTIONAL AND PRPOSED WIRELESS ROBOTICS

In conventional robotics, the controlling and operation of robots is usually done by using RF [Radio Frequency] circuits. These circuits are widely used for control and working applications and are also reliable over a small range. The RF circuits consist of transmitter and receiver which are independent of each other. All the control signals and commands are sent via wireless medium in between transmitter and receiver There are a number of disadvantages of RF circuits over IOT based transmion such as Low cost, Ease of Construction & design, easy decoding, less maintenance cost etc. Besides these advantages, there are still many serious drawbacks of using a RF circuit in circuit.
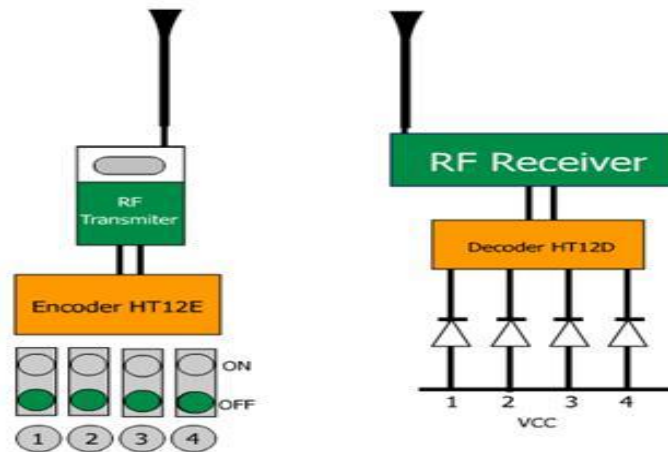

Figure 1: Transmitter & Receiver kit

- **Limited Frequency Range**

The frequency range used for typical RF communication is near about 3KHz-3GHz. The use of channel separator increases the reliability but decreases the actual usable working frequency range.

- **Limited Functions**

The limited number of channels causes less number of combinations and thus there are less numbers of available functions.

- **Limited Working Range**

The working range of RF circuits with transmitters and receiver is very small. It starts from a few meters to a few kilometers. The working varies from circuits to circuits, but mainly depends on the values of physical components used in the circuit. Mainly Wi-Fi and Wi-Max wireless services are used in RF transmitter and receiver circuits. The following table shows the actual working range of different wireless standards that can be used in wireless communication.

- **Reliability of Operation**

The RF circuits are very prone to errors due to external conditions such as EMI (Electro-Magnetic Interference), medium saturation, absorption due to repetitive reflections from surface. Hence the output recovered is not always what is expected. This might be a serious problem when working with scientific experimental components.

- **Security reasons**

This is the main disadvantage of using a RF circuit and the main reason why RF circuits are not preferred today. The RF frequency band is available for almost all the users for data communication. So there might be a scenario where more than one user is trying to accommodate channel for its own communication. In such case the frequency band may get interference from another user. Or worst case would be, some user intentionally trying to jam our communication network. The RF jammer circuits are very easy to design; hence the question of security arises when RF circuit is used in the circuit. This security loop hole can be very dangerous when the robot is being used for very confidential purposes. In areas of military these security threats can produce disastrous outcomes.

Mobile robots are robots which have the ability to move around and interact with their environment and not just hinged to a particular place. There are many labs and research groups from various universities and industries which are completely dedicated on researching mobile robots, because of their immense potential and varied application in industry, military, security, and entertainment. The robot is specially designed for surveillance purpose. The control mechanism is provided along with video transmission facility. The video transmission is practically achieved through high speed image transmission. Initially, the robot will be equipped with an Android smartphone which will capture the scenario in front of it & will transfer the images to the server on which the user will be controlling and watching the live feed. The Block Diagram given below explains the actual working of the robot. We can split it into three stages as follows

1. Robot   2. Remote Computer   3. Communication link between the above two, which is a Web server.

III. SYSTEM ARCHITECTURE

IOT based robotic surveillance system consists of two components, Robotic Embedded System (RES) is part of surveillance where monitoring system implemented and Remote Control Unit (RCU) is a framework implemented on Users Personal computer or laptop or smart phone.
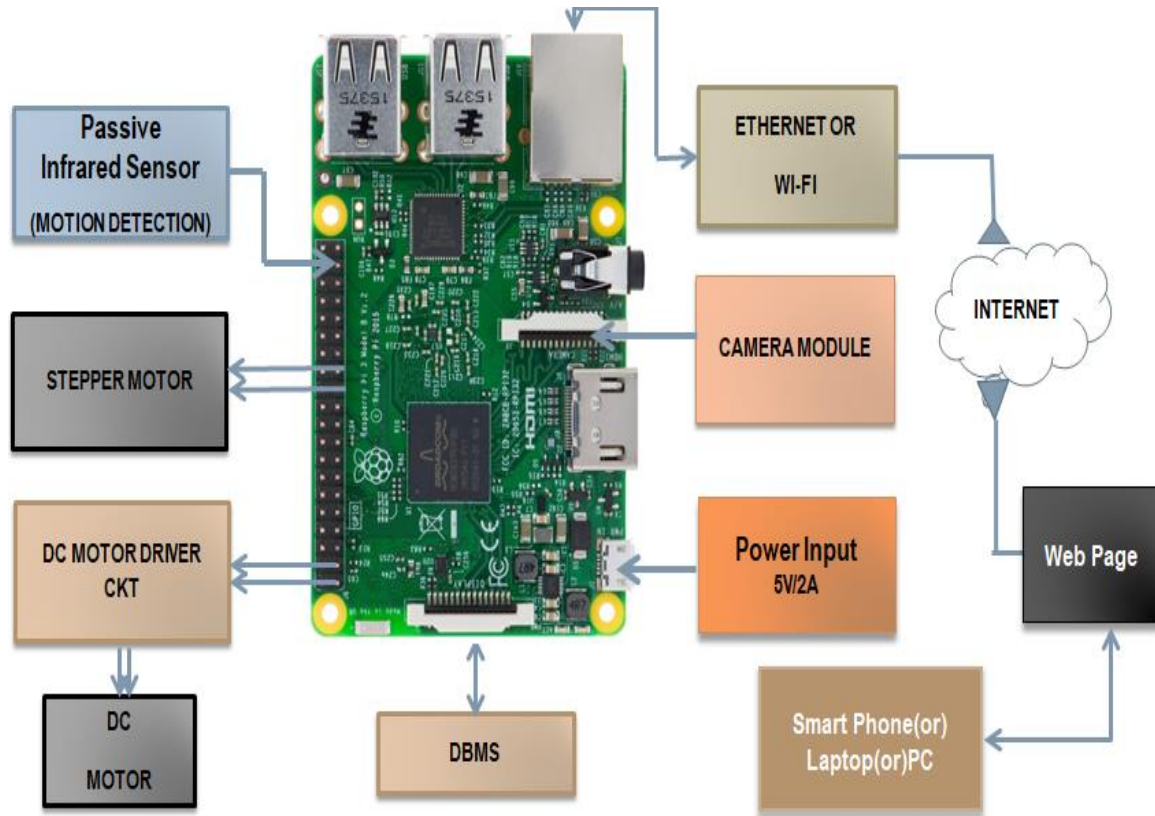
IV. BLOCK DIAGRAM

Figure: 2 Block diagram

V. ROBOTIC EMBEDDED SYSTEM (RES)

RES is efficient, low power consumption, low cost robotic system for surveillance monitoring and allows the user to remote monitoring and controlling. RES have a Raspberry Pi setup with Raspbian Jessi operating system installed on SD card. PIR sensors are interfaced with Raspberry pi to detect the motion of the person, Raspberry pi camera for image capturing, live video streaming and alerting the presence of human in the surveillance area. RES also consists of SERVO SG90S for pan and tilt movements of Raspberry pi camera to rotate 180 degree.

- **Raspberry pi3**

  The Raspberry Pi is a single computer board — developed to encourage and aid the teaching of programming and computing. It is also a fantastic starting point for the development of the Internet of Things (IOT) projects. Pi is the perfect experimental tool, whether you want to use it as a desktop computer, media center, server or monitoring/security device within your home. It has no limits. Linux-based operating systems run on the Pi with plenty of access to free software and download. The new Pi 3 brings more processing power and on-board connectivity, saving you time with the development of your application.
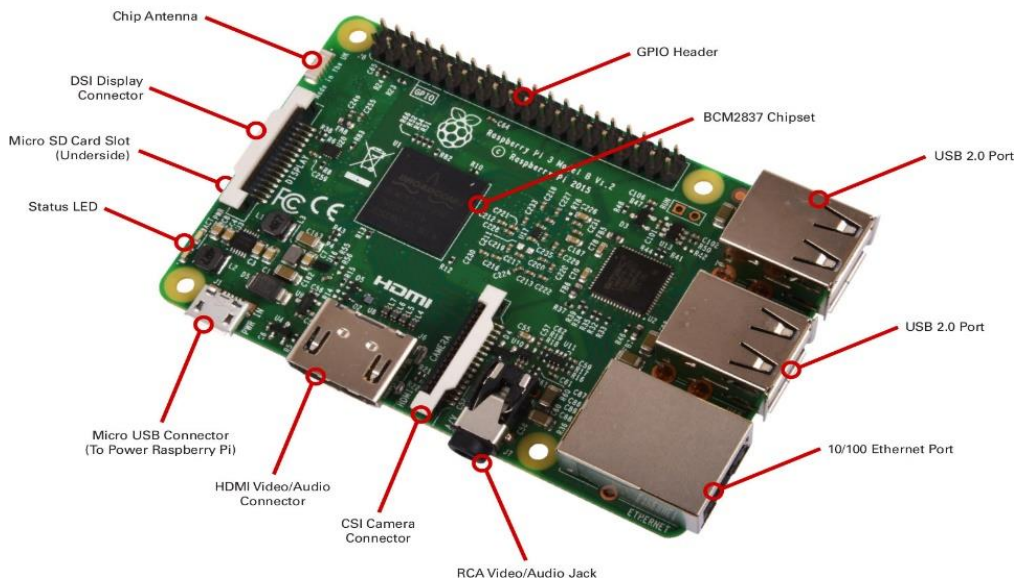

Figure 3: Raspberry Pi3

- **PIR motion Sensor:**

The PIR (Passive Infra-Red) Sensor is a Pyroelectric device that detects human body motion by measuring changes in the infrared levels emitted by surrounding objects. This motion can be detected by checking for a high signal on a single I/O pin. Incorporating a Fresnel lens and motion detection circuit. High sensitivity and low noise. Output is a standard 5V active low output signal. Compact and complete, easy to use Pyroelectric Infrared (PIR) Sensor Module for human body detection. Module provides an optimized circuit that will detect motion up to 6 meters away and can be used in burglar alarms and access control systems. Inexpensive and easy to use, it's ideal for alarm systems, motion-activated lighting, holiday props, and robotics applications. The Output can be connected to microcontroller pin (GPIO pins of Raspberry Pi) directly to monitor signal or a connected to transistor to drive DC loads like a bell, buzzer, siren, relay, opto-coupler (e.g. PC817, MOC3021), etc.

- **Raspberry pi Camera module:**

The Raspberry Pi Camera Module is a custom designed add-on for Raspberry Pi. It attaches to Raspberry Pi by way of one of the two small sockets on the board upper surface. This interface uses the dedicated CSI interface, which was designed especially for interfacing to cameras. The CSI bus is capable of extremely high data rates, and it exclusively carries pixel data. The board itself is tiny, at around 25mm x 20mm x 9mm. It also weighs just over 3g, making it perfect for mobile or other applications where size and weight are important. The camera is connected to the BCM2835 processor on the Pi via the CSI bus, a higher bandwidth link which carries pixel data from the camera back to the processor. This bus travels along the ribbon cable that attaches the camera board to the Pi. The sensor itself has a native resolution of 5 megapixels, and has a fixed focus lens on-board. In terms of still images, the camera is capable of 2592 x 1944 pixel static images, and also supports 1080p30, 720p60 and 640x480p60/90 video. The camera is supported in the latest version of Raspbian, Raspberry Pi's preferred operating system

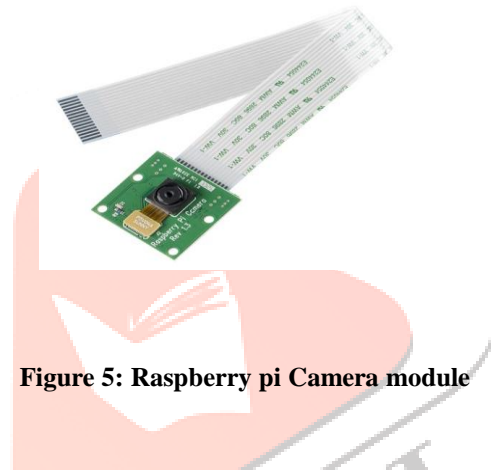

Figure 4: circuit diagram of PIR sensor   **Figure 5: Raspberry pi Camera module**

- **SERVO SG90S:**

This servo motor finds many applications in areas which require a 180 motion of light weight objects. Highly used in many robotic projects that require Pan-Tilt mechanisms for Cameras, Ultrasonic Sensors etc. This motor has 3 pins- middle wire (red) connects to Vcc, brown wire connects to GND, and yellow wire is signal which is to be connected to the digital pin of the raspberry pi board. It is usually a good idea to power the motors from an external power source and not directly from the raspberry pi board. When powering the motor from the external source, it is important to remember to create a common ground, by connecting the GND of the source with the GND pin of the Raspberry Pi board.

Figure 6: Pan-Tilt   **Figure 7: SERVO SG90S**

Technical Specifications:

- ❖ Plastic Gears
- ❖ Operating Voltage: 4.8V
- ❖ Stall Torque: 1.8 kg*cm (4.8V)
- ❖ Rotational Range: 180°

- ❖ Analog Modulation
- ❖ Operational Speed: 0.1sec/60°(4.8V)
- ❖ Pulse Width: 500-2400μs
- ❖ Dimensions (lxwxh): 23*12.2*29mm

- ❖ Temperature Range: 0°C-55°C
- ❖ Weight: 9.0g
- ❖ Rotation: Bushing

- **L293D Driver Board:**

The L293 and L293D are quadruple high-current half-H drivers. The L293 is designed to provide bidirectional drive currents. The L293D is designed to provide bidirectional drive currents of up to 600-mA at voltages from 4.5 V to 36 V. Both devices are designed to drive inductive loads such as relays, solenoids, dc and bipolar stepping motors, as well as other high-current/high-voltage loads in positive-supply applications. All inputs are TTL compatible. Each output is a complete totem-pole drive circuit, with a Darlington transistor sink and a pseudo- Darlington source. Drivers are enabled in pairs, with drivers 1 and 2 enabled by 1,2EN and drivers 3 and 4 enabled by 3,4EN. When an enable input is high, the associated drivers are enabled, and their outputs are active and in phase with their inputs. When the enable input is low, those drivers are disabled, and their outputs are off and in the high-impedance state. With the proper data inputs, each pair of drivers forms a full-H (or bridge) reversible drive suitable for solenoid or motor applications.
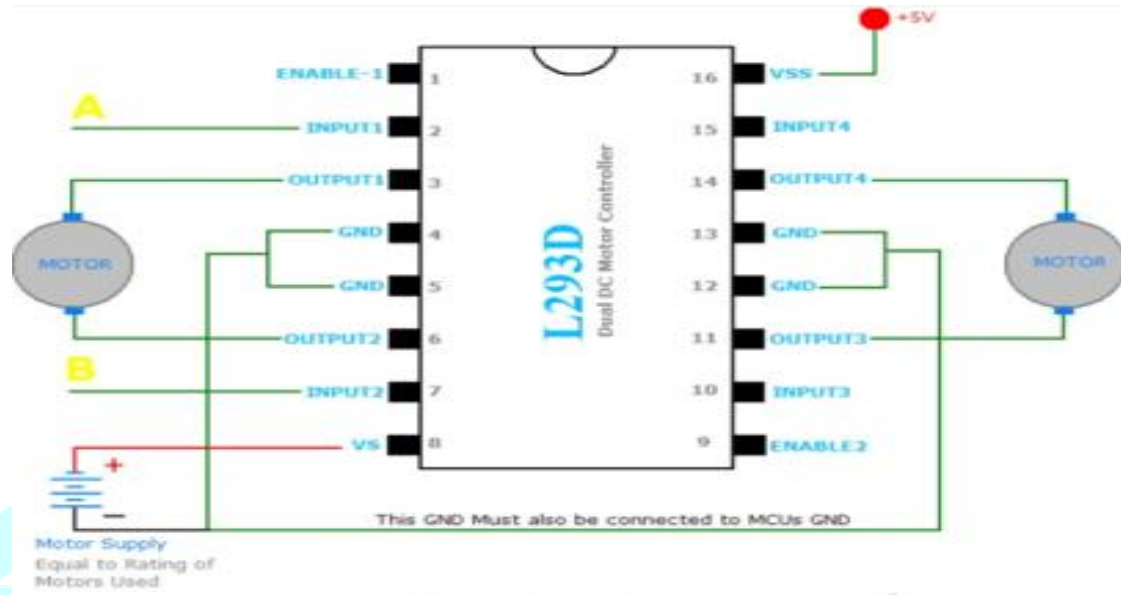
Figure 8: Pin diagram of L293D

VI. OPERATING PRINCIPLES

For the purpose of connecting an object to the IOT, We can control the robot (or anything), using low level commands written with shell scripts commanded straight from a HTML page. Not using higher level languages as Python for example, makes the robot very responsive and quick to act.The RPi will be set as a WebServer and will receive commands from an HTML page. Those commands will change the GPIOs status, making the RPi control motors (direction and speed) and turn ON/OFF LEDs

Figure 9: Flowcharts for Design Procedure

VII. REMOTE CONTROL UNIT (RCU)

RCU is a software tool implemented on Users Smart Phone. Provide GUI (Graphical User Interface) to send predefined Linux Terminal Commands via SSH to IMS... SSH are a secure protocol and the most commonly used to administrate and communicate with Linux servers. RCU is implemented on android platform using python Script on PDK (Python Development Kit) and Eclipse IDE An efficient and accurate embedded access control system based on vibration, temperature, humidity and lightning detection is wide range of commercial and security application .Many countries are doing research for adopting the civil industrial Parameters Monitoring.

- **Cloud Server**

A cloud server is a logical server that is built, hosted and delivered through a cloud computing platform over the Internet. Cloud servers possess and exhibit similar capabilities and functionality to a typical server but are accessed remotely from a cloud service provider.

- **PC/Laptop/Smart Phone**

It acts as a graphical user interface (GUI).Which can be used to visualize the output.

VIII. SOFTWARE IMPLEMENTATION FOR RCU

The System was implemented on a Raspberry pi development board in Linux environment, which supports SMTP (Simple Mail Transfer Protocol), TCP/IP, HTTP. The web server Flash File System supports dynamically generated files that can include output data from hardware resources. This type of file is called an embedded server page (ESP).

- **Installing OS and configuring Raspberry Pi**

First we need to install Raspbian on your micro SD card that will be used in Raspberry Pi. We can download the latest image of Raspbian OS from Raspberry Pi website.

http://www.raspberrypi.org/downloads/
http://www.raspberrypi.org/documentation/installat...
After successfully installing Raspbian OS on Raspberry Pi, we need to update software. To do this we need to run following Linux commands:

         $ sudo apt-get update $ sudo apt-get upgrade

- **Raspberry Pi Camera Configuring**

After successfully installing Raspbian OS on Raspberry Pi, we need install Pi camera Library files. To do this we need to run following Linux commands

         $ sudo apt-get install motion
         $ sudo apt-get install python-picamera
         $ sudo apt-get install python3-picamera

After installing Picamera Library files, we need to enable camera by running command :

         $ sudoraspi-config

- **Installing software for sending email alert**

Now after setting up the Pi Camera, we will install software for sending the Email. Here we are using *SMTP,* which is an easy and good solution for sending Email using command line or using Python Script. We need to install two Libraries for sending mails using SMTP:

IX. PYTHON PROGRAM FOR RCU

The Python Program of this project plays a very important role to perform all the operations. First of all, we include required libraries for email, initialize variables and define pins for PIR, LED and other components. For sending simple email, SMTP Library is enough but if we want to send mail in cleaner way with subject line, attachment etc. then we needs to use MIME (Multipurpose Internet Mail Extensions). The following library module files are imported on python script.

- **Controlling motors with raspberry pi**

WiringPi is a GPIO access library written in C for the Raspberry Pi. It is very easy to use and simplify a lot any project involving RPi and electronics. The WiringPi library includes a command-line utility "gpio that can be used to program and setup the GPIO pins. You can use this to read and write the pins and even use it to control them from shell scripts. It can be used in scripts to manipulate the GPIO pins – set outputs and read inputs. It's even possible to write entire programs just using the gpio command in a shell-script.
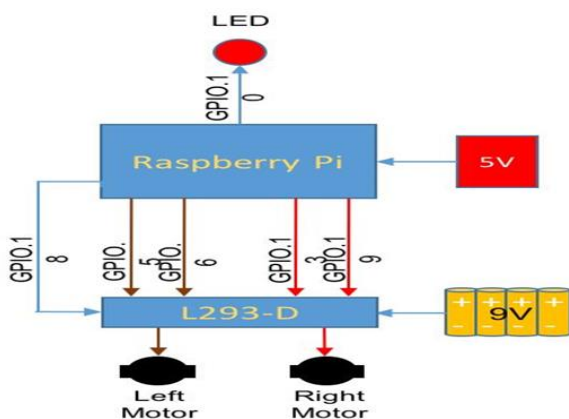

Figure 10: Pin Connections of Raspberry Pi to L293-D

	LEFT MOTOR		RIGHT MOTOR	
Stop	L	L	L	L
Right	H	L	L	H
Left	L	H	H	L
Reverse	L	H	L	H
Forward	H	L	H	L
GPIO.	5	6	13	19

Figure 11: GPIOs for H-Bridges Inputs

Both "motors enables" input will be connected together and will be controlled by GPIO.18. This pin will be responsible for the speed control. If you do not want control the speed, leave those pins in HIGH, for example. We will discuss this further in this step. Let's make a convention that if we want the motor LEFT to run forward, we must setup motor+ as HIGH and motor- as LOW. To run on a reverse direction, we must do the opposite: motor- as HIGH and motor+ as LOW.

X. WEB PROGRAMMING

There are several server side scripting languages which process the data on the server and send the data to the browser. PHP was primarily chosen because it is open source and for the easiness of embedding the scripts in the HTML page itself. HTML or Hypertext Mark-up Language is used to create web pages and it gives a clear understanding of the primary objectives. The HTML language is designed to achieve an efficient way of achieving transfer of data, and to evolve as new media formats were created, whilst remaining predictable to use. HTML is a set of codes that a website author inserts into a plain text file to format the content. Here we will be using HTML to design our web page to get a look of the video data transmitted from the camera on the bot. We will be having a login system to provide access to details transferred from bot to only required person.HTML is the basis for our video data transmission process. The Android device will be the creator of the video via the camera and responsible for transmitting the video over the internet to the server. It also maintains communication with the server through a custom protocol to ensure proper identification and video streaming. Since many image processing algorithms require high complexity cost, running these algorithms on a mobile client with responsive interactions is often infeasible. One remedy to this problem is to offload the work to a high-performance server over the network. Video streaming from the Android device entails a combination of many elements. The custom RTSP server built to interact with the Android devices, their video streams and applications (ex. VLC) capable of playing live video is the largest contribution of the project (over 2000 lines of code). The user will first capture an input image using an Android client and send the image to a server via HTTP. A PHP script on the server then invokes the server-side application to compute SIFT on the image. This project develops an open source solution capable of transferring the live video with little overhead on the phone and/or server. Users will have the ability to broadcast news and events live using only an Android-enabled mobile devices and an internet connection via the cellular network or Wi-Fi.

- **Video Streaming code**

```
<iframesrc="http://192.168.43.59:9000/javascript_simple.html" frameborder="0" align="middle"
width="500" height="280" align="middle" scrolling="no"></iframe>
```


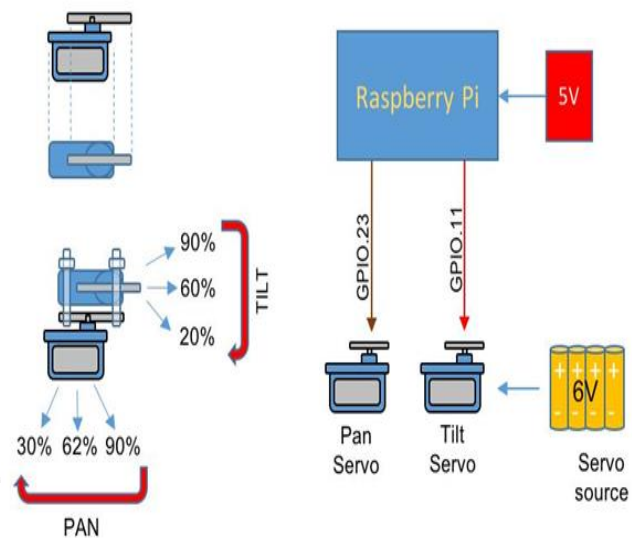**Figure 12: HTML Web Page for Remote Control**   **Figure 13: PAN/TILT Angles**

XI. PAN/TILT MECHANISM

Connect the +V of both servos on a separate power supplier than the RPi (of course, both GND must be connected). Once we will install the Pan/Tilt mechanism to the robot, you can use the same battery (5V) that was used with DC motors. In this case, a 6V Voltage regulator will be necessary.

```
GPIO.setmode(GPIO.BCM)
GPIO.setup(21, GPIO.OUT)
pwm=GPIO.PWM(21,50)
pwm.start(5)
pwm.ChangeDutyCycle(4.5)
time.sleep(1)
GPIO.cleanup()
```

XII. RESULT ANALYSIS

The below image is the IoT-controlling a Raspberry Pi Robot in which the Pi Camera interfaces with Raspberry Pi which is mounted on the Robot sends video stream via TCP/IP. The concerned authority can control the moment of robot, view angle of camera and view video stream of surveillance through using smart phone or laptop or personal computer The smart robot deals whenever anyone or intruder comes in range of PIR sensor, PIR Sensor triggers the Pi Camera through Raspberry Pi. Raspberry pi sends commands to Pi camera to click the picture and save it. After it, Raspberry Pi creates a mail and sends it to the defined mail address with picture. The mail contains a message and picture of intruder as attachment. Here we have used the message "Find Image Attachment", you can change it accordingly in the Code given at the end. This is the overall Block diagram of the project

where we are using webpage through Internet to control the movement of the robot and to change the angle or position of the camera (Pan/Tilt) using servo motors. The Raspberry Pi will be set as a Webserver and will receive commands from the HTML page. Those commands will control the GPIOs, making the RPi position the Pi Cam via the servomotors (direction and speed).
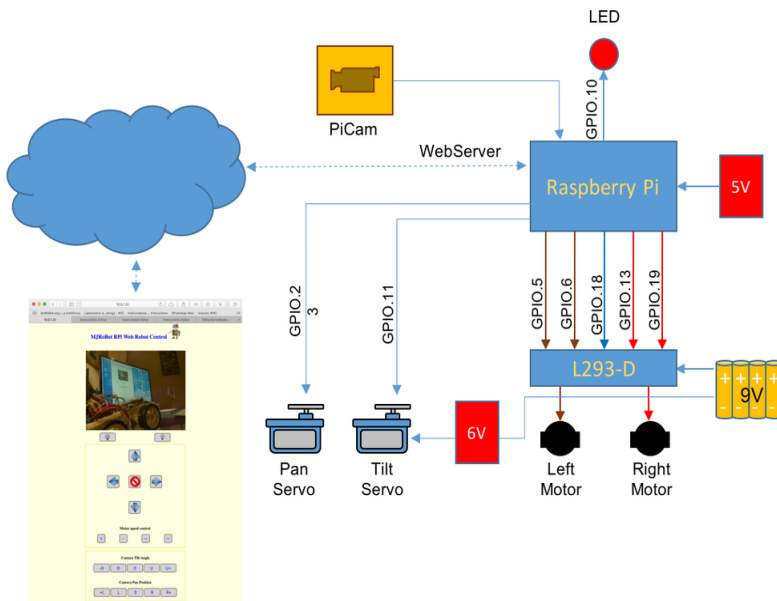

Figure 14: Working Experimental setup

Figure 15: Working Experimental setup Photo

XIII. CONCLUSION

In the designing of our projects, we have kept in mind the user. The controlling of robot is easy as the various buttons are available on the web page specifying the various actions. The Android device used here makes possible the fast and good quality of image transmission. The programming used gives very good control on the movements of the robot. The Controlled Wireless communication can be achieved using Wi-Fi network or internet. The future implications of the project are very great. The robot is very robust. The proposed robot has scope of widespread industrial, defense and home applications. It can be used to analyze the environment of a coal mine without any human intervention. It can also be employed in a hostage situation to pin point the exact location of terrorists with the help of ultrasonic and PIR sensor, saving many lives during rescue mission. Another application is home security system to sense movement of intruder through PIR sensor. Various advantages of this system are its range of operation up to 100m, secure data transfer can be done with the help of Bluetooth Module and Android Application. Entire project will help in Military and Defense operations such as human detection, distance measurement, obstacle detection and also due to their bug like wheels it can travel in all terrains.

XIV. FUTURE SCOPE

There are lots of improvements that can be made on the current design and technology and lots of additional features can be added. The current autonomous navigation is a blind method where the robot doesn't keep track of the direction and position of where it is heading. So in the future we would like to add an electronic compass for the robot to keep track of the direction. And a better method of cell based navigation can be done with the help of encoders for which a provision is provided. The architecture can also be modified by providing a more powerful embedded computer which could handle HTTP requests within the robot itself. The modified architecture is shown in the figure below.

REFERENCES

1. Shaik Anwar , D. Kishore "IOT BASED SMART HOME SECURITY SYSTEM WITH ALERT AND DOOR ACCESS CONTROL USING SMART PHONE " 2016 International Journal of Engineering Research and Technology (IJERT).
2. PheySiaKwek, Zhan Wei Siew, Chen How Wong, BihLii Chua and Kenneth Tze Kin Teo "DEVELOPMENT OF A WIRELESS DEVICE CONTROL BASED MOBILE ROBOT NAVIGATION SYSTEM" 2012 IEEE Global High Tech Congress on Electronics.
3. SaliyahKahar, RizaSulaiman, Anton SatriaPrabuwono,_MohdFahmiMohamadAmran, SuziyantiMarjudi "Data Transferring Techniqu e for Mobile Robot Controller via Mobile Technology" 2011 International Conference on Pattern Analysis and Intelligent Robotics 28 -29 June 2011.
4. Xichun Li, AbudullaGani, RosliSalleh, Omar Zakaria. 2009. The Future of Mobile Wireless Communication Networks. 2009 International Conference on Communication Software and Networks.
5. Michael Ransburg, Mario Jonke, and Hermann Hellwagner; An Evaluation of Mobile End Devices in Multimedia Streaming Scenarios.