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Design and Implementation of Robocar in Various Modes Using IoT and Image Processing

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***Abstract*—** As we know the AI and IoT are one of the most emerging domains nowdays . IoT mainly focuses on to make human life more easier i.e. Every person having its own smart phone through which he can do many tasks from anytime anywhere. In today's world, Artificial Intelligence (AI) has begun to take center stage. One of the most important uses of AI in recent times has been its application in automated vehicle. The recent trend has been moving towards the creation of robotic devices which are capable of making spontaneous and effective decisions in demanding situations.In this paper we have created an Auto-following robo car. Here we have used Raspberry Pi3 Model B which is having many features with their inbuilt library functions like Wifi ,USB connector ,HDMI port, External SD card support. Hence its seems like mini computer. We are also using ultrasonic sensors, Bluetooth sensor, WIFI module, Camera ,gas leak sensor ,humidity sensor along with the Raspberry Pi. Here we are introducing image processing for live video streaming through web page. The main purpose is to provide the service for elderly peoples who lives alone at home when there is nobody at home. It is mainly focuses on image processing, obstacle detection and avoidance , image processing, live streming and through this concepts we can monitor and control the system from our device.

***Keywords*—** Image processing, Auto following ,WIFI, Ultrasonic sensors ,Raspberry Pi .

I. INTRODUCTION

The modern robotic system possessed with advance features like Digital Signal Processing, wireless connectivity, Bluetooth connectivity which gathers the information from surrounding and controlled via smart phones and systems.

In this modern robotics there are mainly three purpose of robots which can use for following purpose:

1. Industrial Service
2. Mobile Service
3. Personal Service

According to the Japan Robotic Association (JARA)

There will be over 100 million personal robots in use worldwide by year 2025.

Robots can perform various important tasks in humans' life.

i.e. taking care of old peoples, preventing them from dangerous environment, cleaning households etc.

John McCarthy was an American computer scientist who is the founder of AI. And he believe that a machine could be capable to perform all task that man can do. Machines are created to make human's life easier.

In this paper we have created robotic car by assembling open source hardware, Bluetooth module, advanced sensors. We have used various sensor to observe environment through a web page running on remote device connected to Raspberry Pi3 model B mounted over the car via Wifi module is used to access data.

The system consists two main modes:

1. Auto-following mode
2. Manual mode

The paper representing a simple architecture of robo-car with advanced features.

II. LITERATURE SURVEY

In this section we introduce a few of the related work of obstacle detection for auto-following robot car. Authors Hung-Chi Cu, Ming-Fu Chein, Tzu-Hsaun Lin, Zhi-Jun Zhang have used Arduino UNO development board, a wifi shield module[10], an ultrasonic sensors to detect obstacle then robot car will modify its original route to avoid obstacles .Users can use smart phones or computer to control robot car.

Here auto-following is achieved by positioning technology. A range free algorithm for energy efficient indoor localization with minimized radio communication and radios without RSSI.

Author Noel Sharkey proposed an idea of Doom(Cassandra) in 2008[2] . It is about an unmanned vehicles for warfare. Because of big budget and fastest technology it created only for military purpose.

Author Johansson , Keijo Haataja, Jarno Mielikainen , Pekka Toivanen[5] created the ZigBee and WLAN enabled robot car is driven by ZigBee based computer 1.3 MP real time video streaming from 802.11g and IP compatible camera is used.

These are few existing models of robot car. The result of this paper is to design and implement a robot car having following features

1. Auto-following Mode
2. Manual Mode
3. Live Streaming Camera
4. Fall detection
5. Obstacle detection and avoidance.

These are the main key features of our proposed system. It mainly focused on combining the different features together within the one system.
The rest of paper is organized as follows.
Section III contains system architecture.
Section IV contains System implementation in detail.
Section V conclude the paper.

III. SYSTEM ARCHITECTURE

There is one access point in available in indoor environment. The robot car is equipped with an Raspberry Pi3 Model B. A Wi-Fi module , Ultrasonic sensors, Gas leak sensors, Servo motors, camera sensor, Temperature and humidity sensors are equipped along with the raspberry pi.

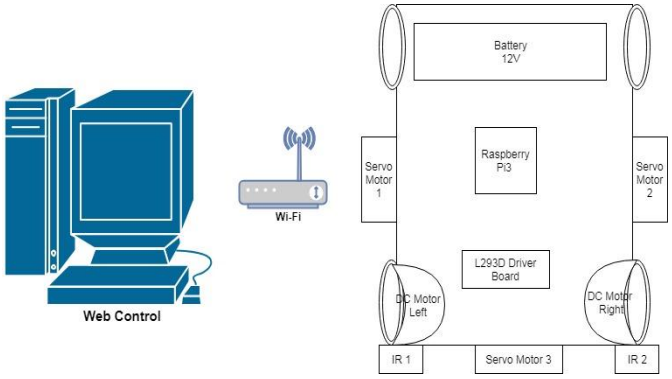


Fig. 1

Above diagram is architectural view of Auto-following robo car. As u can see there is one access point to control all the operations performed by this robo car.

Instead of IR sensor we have used 2 HCSR04(Ultrasonic sensors) for object detection.

Raspberry PI 5MP Camera Board Module is used for Image processing. There are total 4 DC motors are used . 12V battery is connected to the DC motor and Raspberry Pi for power supply. L293D driver board is used to drive the DC motors. We have designed PCB to divide voltage which will connected to the Raspberry Pi.

Following Fig.2 will show the block diagram of PCB which will flip over the raspberry pi3 for power supply as per given voltage of all sensors and motos.

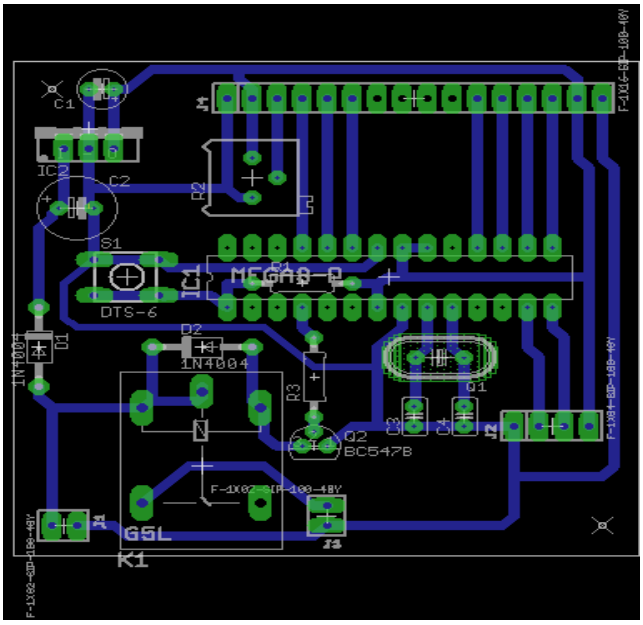


Fig. 2

System architecture is a conceptual model that defines the structural view of the system with its behavior.
The given diagram Fig.2 is block diagram of PCB which contains filter capacitor, voltage regulator and L293D motor driver. This PCB is connected by flipping over on Raspberry Pi3 using pins.
Whenever the system will get started is will be in manual mode by default. To get started with auto-following mode we need to restart the Raspberry Pi3.
As we know the system consist 2 modes

1. Manual Mode
2. Auto-following Mode

If user selects the manual mode then system controlled manually through following web page.

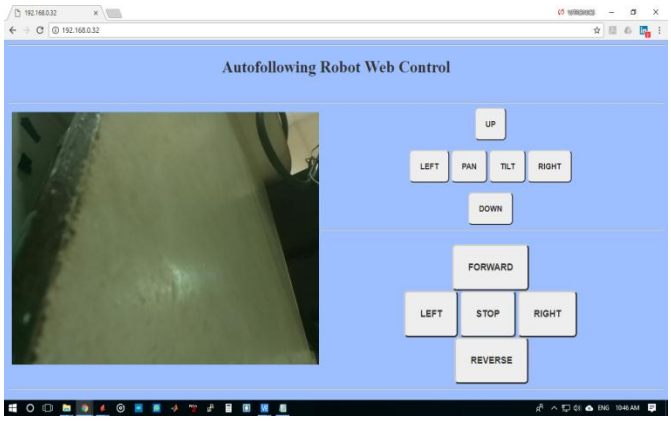


Fig. 3

It performs only the following operations given on the web page.
If user selects Auto-following mode the car will follow the person by its body movements.

IV. SYSTEM IMPLEMENTATION

In this section, we are implementing the next phase of Auto-following robot car . The design and implementation of an auto-following robot-car robot-car is based on an Raspberry Pi3 Model B and equipped with a Wi-Fi module ,ultrasonic sensors, servo motors, camera sensor , temperature sensor and gas leak sensors . All this sensors are combined together within a single device.

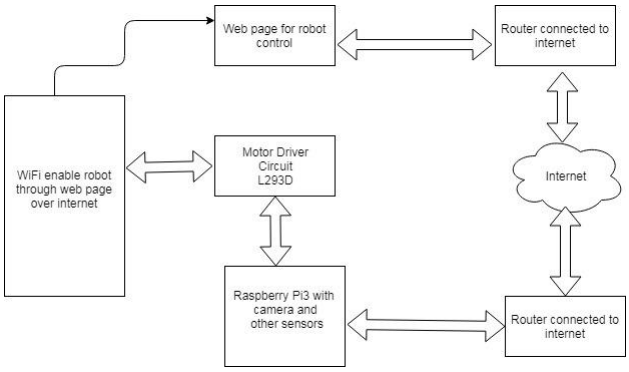


Fig. 4

This is the functional block diagram of WiFi control robot.
If user selects Auto-following mode Raspberry Pi restarts.
After restart it will be in auto-following mode.
Before implementation we need to know which software and hardware are used to make the Robo-car.
Hence there are some hardware and software description is given as follows.

3.1 Hardware Description

3.1.1. Raspberry Pi3 Model B

The **Raspberry Pi** are small single-board computers that come in the form of series developed in the UK by the Foundation of Raspberry Pi in order to promote and popularize the education of basics of computer science in educational institutes and countries that are developing.
The Raspberry Pi 3 Model B is the third generation Raspberry Pi. This powerful and tiny Raspberry Pi can be used for many applications and proves to be superseding the older versions like Raspberry Pi Model B+ and Raspberry Pi 2 Model B.

It consists of 1GB RAM in order to run large and powerful applications. It has full HAT compatibility. It consists of extended GPIO of about 40 pins to enhance "real time" projects. It also can connect a Raspberry Pi camera and screen display with touch screen. It allow streaming of HD video output with 1080p. Loading your operating systems and storage can be done by using the MicroSD card slot. In order to connect the Raspberry Pi to the Internet 10/100 BTE socket, an Ethernet socket is used to do it quickly.

Why Raspberry?

An Arduino is a microcontroller motherboard. It can be said as a simple computer that can run one program at a time, over and over again. It is very easy to use.

A Raspberry Pi is a general-purpose computer, with linux as operating system, and has ability to run multiple programs at a time.

Another benefit os Raspberry Pi has good technical specification as compare to the Arduino.

3.1.2. HC-SR04 (Ultrasonic Sensor)

The sound frequencies that are audible by humans are from 20Hz to 20 kHz and Ultrasonic is not one of them. The Ultrasonic sensors were designed to sense proximity of objects and sometimes range using ultrasound reflection, considering the working of radar which is similar, to calculate the time it takes to reflect ultrasound waves between the sensor and a solid object. Ultrasound is mainly used because of its inaudibility to the humans and relatively shows accuracy in small distances.
This sensor output signal, i.e., ECHO on the HC-SR04 is rated at 5V. However, the input pin on the Raspberry Pi GPIO is rated at 3.3V. Sending a 5V signal into that unprotected 3.3V input port could damage your GPIO pins. Hence we have used PCB to divide and control the voltage passing through it.

3.1.3. L293D

L293D is a Motor driver or Motor Driver IC which allows DC motor to drive in different directions. It is a 16-pin IC that has the ability to control two DC motors in order to move in any direction and this is done simultaneously. A single L293D can control two DC motors simultaneously.

3.1.4. MQ-6 GAS Sensor

As the name suggests they are used in detection of gas leakage equipments that are domestically and commercially used, also are suitable to detect LPG, iso-butane, propane, LNG. It is also capable of examining alcohol and fumes created while cooking and smoke created from cigarettes.

Features of MQ-6

- Sensitivity is maximum to LPG, iso-butane, propane
- Sensitivity is minimum to alcohol, smoke.
- Response time is quite fast.
- Long life and durable.
- Circuit is simple.

3.1.5. DS18B20 Temperature Sensor

These sensors come in a tiny package of 3-pins similar to a transistor and are accurate. Raspberry Pi does not have ADC, it cannot use an Analog temperature sensor like that is used in the TMP36, and that results in using DS18B20 as a good choice for sensing the temperature. DS18B20 just looks like a regular transistor, but the working inside is much more. It consists of the special 1-wire serial interface as well as control logic sensor and the temperature sensing sensor . Digital messages are sent by the output pin and it also involves an interface to get and read those messages. .SSH and command line can be platforms in which this device can be experimented.

Features of DS18B20:

- Power supply range is 3.0V to 5.5V
- Measures temperatures from -55°C to +125°C. Fahrenheit equivalent is -67°F to +257°F
- ±0.5°C accuracy from -10°C to +85°C
- Can be powered from data line.

3.1.5. 5MP Raspberry Pi Camera Module

Fig.5

Features of Camera:

- 5 megapixel native resolution.
- Sensor capable of 2592 x 1944 images that are pixel static.
- Supports 1080p30, 720p60 and 640x480p60/90.
- In the latest version of Raspberry Pi, Camera is supported.
- Preferred OS is Raspberry Pi.

3.1.6. Other Hardware used:

1. Castor Wheel
2. Wires
3. Breadboard
4. Small PCB
5. Male headers
6. Female headers

3.2. Software Description

3.2.1. VNC Viewer

We have used VNC Viewer[14] in this project to connect raspberry pi with our computer or mobile.

To create and connect to a virtual desktop:

- Raspberry Pi is connected using VNC Viewer, once we enter IP address and Name, it will ask for the username and password.
- After that, successful connection is created allowing access to the Raspberry pi.

3.2.2. Advanced IP Scanner

To connect to Raspberry Pi from a web browser, or remotely using a Terminal, we need to find our Pi's IP Address. Its IP address is like a postal address, and allows us to find your Pi on your local network.
Free utility Advanced IP Scanner is used to check IP of any device that is on the network, only scan the network to get your Raspberry Pi IP.

Raspberry Pi have different IP addresses depends on it is connected to WiFi or Ethernet. So using IP Scanner we can find the IP address of the Raspberry Pi which will allow us to create connection.

These are software and hardware used to build auto-following Robo-car. Python is used in this project for programming. With its easy-to-read syntax, the introduction is gentle and the overall experience much better for a newbie.

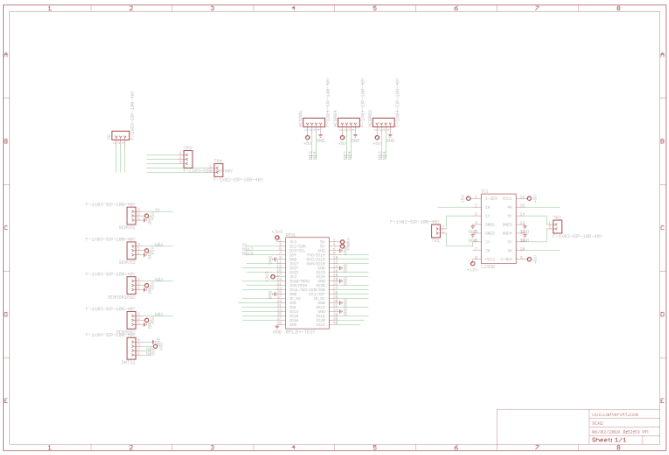


Fig.6

Fig.2 shows the schematic diagram of Raspberry pi with its PCB and all sensors.

All the sensors are connected to the PCB including battery and PCB is connected to the Raspberry Pi.

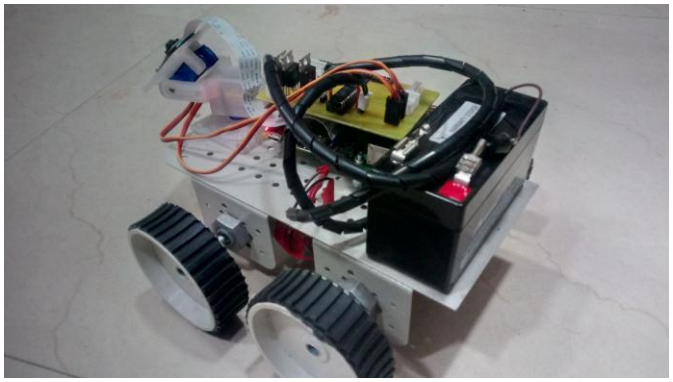


Fig.7. Robot car

Fig.7 Shows the actual implementation of robo-car and functioning of the car is as follows:

V. IMPLEMENTATION

The real-time implementation we intend to follow the elder person in the house to prevent them from accidents.

The robot is divided into three sections: camera in use (input), the motors that control the movement of the robot (output), and the hardware Raspberry Pi, DS18B20, MQ-3 , Ultrasonic sensors, camera sensor to take the decisions based on the input from the camera and it will send the control signal to the motor. Raspberry Pi Camera Module is an official product from the Raspberry Pi Foundation. The original 5-megapixel model where visible light and infrared versions are there. camera that provides a serial interface for transmitting the images pixel-by-pixel.

The camera is positioned at the bumper level, so that it captures the area immediately in front of the robot car and provide a clear and wide view of the path which will make easy to detect obstacles .

It is necessary know the the person's identity to follow him/her hence here we are referring Haar cascade to detect human body. The data or captured image will be stored in Raspberry Pi's memory .

Here we are using OpenCV in Python to detect full human body. Using libraries of OpenCV it is enabled to detect human budy structure. We can load the cascade using CascadeClassifier::CascadeClassifier()cthen use CascadeClassifier::detectMultiScale() to obtain the regions within the given image where the object (body) was detected. adjust the parameters which are given to detect using detectMultiScale() to speed up and increase accuracy of detection. We can detect a person's motion and identify and body parts moving.

Here we achieved the Image Processing concept for human body detection using OpenCV and referred algorithm is Haar cascade for human body detection.

The main feature of Auto following car is if any accident happens i.e. gas leakage, change in temperature it will immediately inform to the following system and we can see Live video streaming of the situation.

VI.RESULT

The manual control web interface have been created using html. The Up, Left, Pan, Tilt, Right and Down are the operations for the movement of the camera. The Forward, Left, Stop, Right and Reverse operations are performed for the movement of the car. Live Streaming is performed using 5MP camera.

In auto-follow mode, the robocar performs image processing and detects the human body. Accoding to the movement of the human, the movement of the car has been defined. OpenCV and Harr Cascade libararies.

The VNC Viewer and Advanced IP Scanner are used to find IP of Raspberry Pi and to connect it. Then the camera access commands are given in console to connect the camera. Program is executed to perform the manual and auto-follow mode on Python 2.

The RGB to Grey Scale Image processing is done to detect background and foreground frames which allow us to detect the motion of the person. The robocar is programmed in such a way that it will follow the person and the auto follow feature will implemented.

STEP 1:

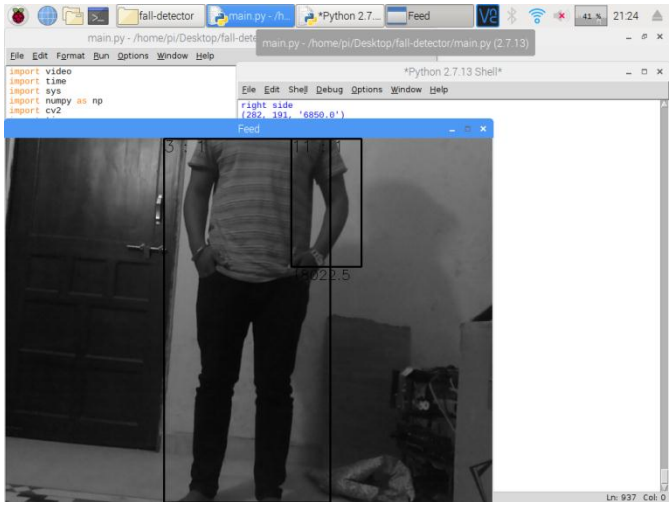


Fig.8

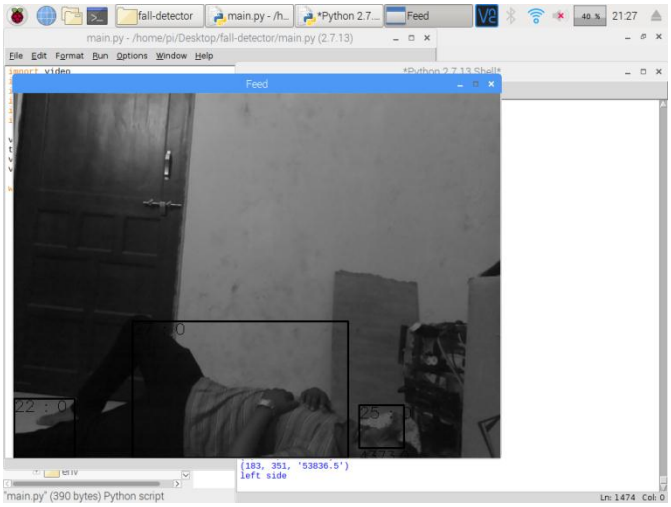


Fig.9

In the Fig.9, we can see that the fall has been detected by sudden change in x-y direction, this will send the mail to the proper authority and fall has been detected will be notified. In such way the robocar wil help the old people to detect the fall.

STEP 2:

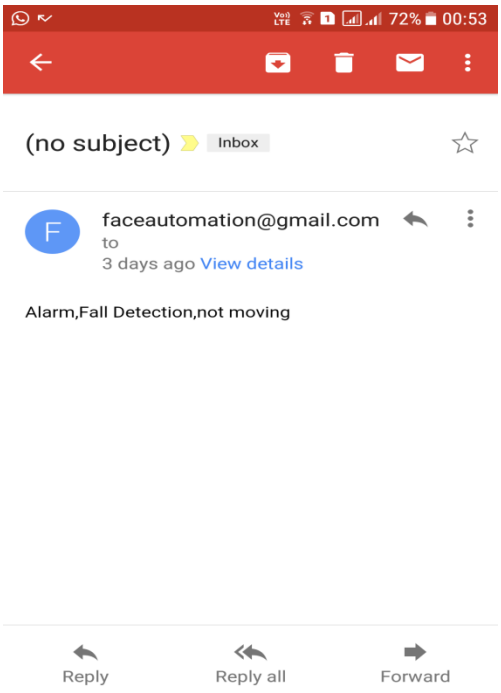


Fig.10

After the fall detection the message which is shown in Fig.10 will be immediately send on particular e-mail address which is stored in the Raspberry Pi's database.

STEP 3:

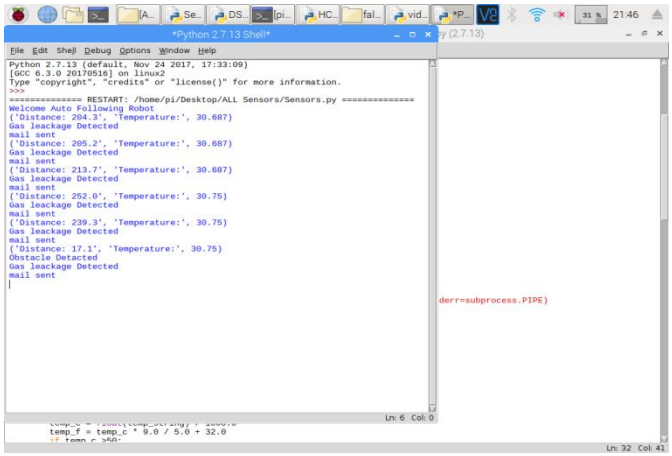


Fig.11

In Fig.11, we can see the gas has been detected. We've set the limit if it sense the gas leakage it will immediately send the mail as we have seen in fall detection as follows :

STEP 4:

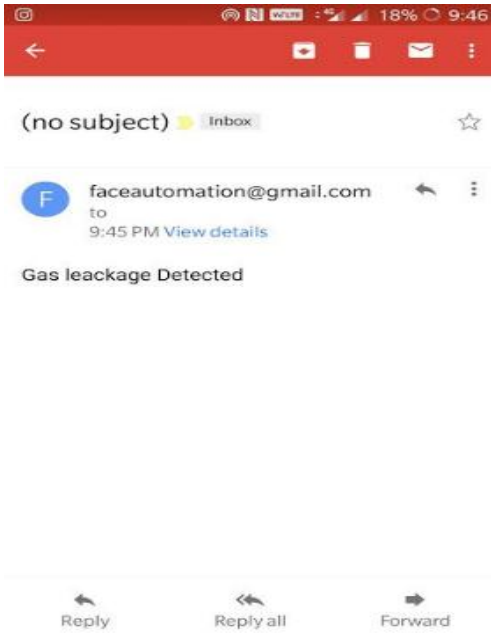
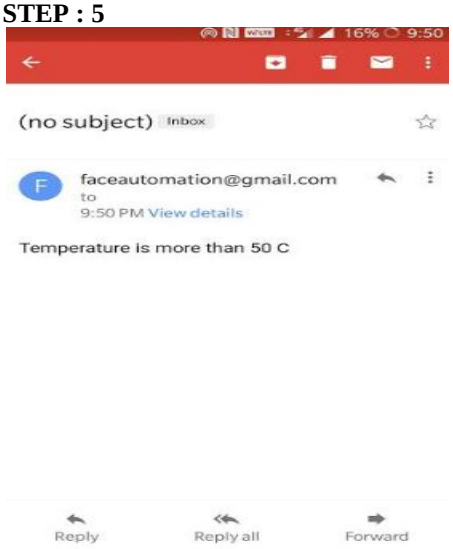


Fig.12

After the gas leakage the mail has been sent.

One another remaining feature is temperature. We have set the temperature limit which is 50° C. If the temperature is more than 50° C then mail will be send immediately. The following is screenshot after the temperature is increased the following message will be send on the e-mail as follows :

STEP : 5



VII. CONCLUSION

In this paper, a robocar is implemented having manual and auto following features, accessible throught web based and mobile based application wirelessly. Different sensors are used to provide the information about the environment to protect the user from any casuality. For the auto following feature, image proceesing is used using OpenCV libraries based on Harr Cascade Algorithm. Surveillance is provided using the feature of Live Video Streaming. Also the mail of fall detection ,temperature, gas leakage will send on particular mail address which will be stored on Raspberry Pi's data. So we can immediately take action for this kind of accidents.

VIII. FUTURE SCOPE

- We can use it in office environment and hospitals also to monitor the employees working properly or not.
- We can implement Artificial Neural Networks in this to make robot more user friendly and to take decisions by its own.
- i.e. If the patient is taking medicine it will automatically zoom the camera and click the pictures and send the message to prevent the patient from overdose of medicines.

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