ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

MANUALLY CONTROLLED ENHANCED WIRELESS INTELLIGENT FIRE FIGHTING ROBOT

Sandip Gupta Farogh Ahmad S. Sundar and Shanmugasundaram M.
School of Electronics Engineering, VIT University, Vellore, Tamil Nadu, India
E-Mail: yuvrajsandip9@gmail.com

ABSTRACT

Expanding human populace and innovative improvement has prompt increment in flame mishaps and dangers. Unavoidable conditions and physical constraints of person make fire extinguishing a testing and demanding assignment. Fire extinguishing is an exceptionally unsafe undertaking and it might likewise include death toll. Robotics is the rising answer to ensure the safety of the surroundings and human lives. Fire extinguishing robot is an equipment model which can be utilized for extinguishing the fire amid flame mischances. It can decrease the blunders and constraints confronted by the people during the extinguishing process. Our outlined robot can seek the zone, find the fire and extinguish it before it turns out to be out of control. It can explore the building while effectively checking for fire. It can be operated remotely by any individual from anyplace on the planet using mobile phone or a laptop. With the assistance of Internet of Things and machine talking application, it can alert and notify the client about the status of the situation at that particular location. The robot which we have proposed in this paper has discovered its application in flame dousing operations amid flame mishaps where the likelihood of the servicemen to enter the fire inclined region is less.

Keywords: fire fighting robot, VNC server, weaved, raspberry pi, remote desktop, telegram.

INTRODUCTION

With the increase in human population the incidents of fire accidents have been happening every now and again due to diversified causes which require strategies and techniques to be intervened. Fire accidents in places such as home, schools, offices, industries, factories etc. are very common and may prove to be lethal if proper safety precautions are not taken care of. The odds of achievement dealing with it are more prominent when the fire has recently broken out. The stifling environment may prove to be challenging for humans because of physical impediment and hence to deal with such situations fire fighting robots can be used. In this paper we have designed an enhanced wireless manually controlled smart fire-fighting robot which can be controlled by the user from any remote location using a smart device. The robot is equipped with various sensors which continuously monitors to detect flame, human casualties, temperature, humidity, distance between the obstruction and the robot and extinguishes the fire if present with the help of a DC fan. To have a proper and a broader view of the surrounding a webcam is mounted to continuously scan the surrounding so that the robot does not waste time searching for fire and deal with places where fire-fighting needs immediate attention first. The model developed does not totally depend upon sensors so that even if the sensors fails to work in such adverse environment or provide faulty readings, the robot could still extinguish the fire with the help of the webcam and vice versa. It is so programmed that it would never lead itself into fire.

LITERATURE REVIEW

The feasibility of fire-fighting robot to deal with such troublesome situations past the scope of human has been proposed in different papers [1]. In this paper we have dedicated our effort in designing a manually controlled fire extinguishing robot because autonomous fire-fighting robots proposed in earlier papers do not produce more efficient results than those which can be manually controlled by users [2]. Some of the robots that are proposed takes usually a longer time in processing and scanning the environment for presence of fire, their incapability to extinguish vulnerable affected areas first may lead the fire to spread wildly leading to loss of life and property causing mass destruction [3], [4]. In some cases the robots are operated in a given restricted environment and so there exhibit a constraint in their application in real time environment [5]. Totally depending upon the readings of the sensors in a fire hazard environment may prove to be inappropriate as faulty reading of sensors due to disruptive condition of the environment may cause the robot to be totally ineffective [6]. Moreover streaming videos over cloud may produce undesirable latency in real time application and hence is seldom used [7]. Hence our robot was designed keeping in mind all this factors to overcome such inefficiencies. The process of scanning the environment for the presence of fire usually takes a longer time and is overcome by giving the entire authority to the user to make the robot move in areas the user desires so that vulnerable areas are handled first, along with different sensors a webcam is also mounted on top of the robot so that even if the sensors provide faulty readings the user can still be sure of the situation and the surrounding the robot is under and vice versa. Robots which are controlled wirelessly using raspberry pi via Wi-Fi dongle from remote location solely depends upon distance of the robot and raspberry pi and with the increase in distance their operational delay seems to increase which may lead to havoc in fire-fighting scenario when being operated from remote location and so a Weaved IOT platform is chosen which only relies upon a good internet connection so that user can actively interact with the robot with least delay irrespective of the distance between robot and the user [8]. Weaved provides an IoT platform allowing the robot to be accessed by the user from remote location over different network by enabling Port Forwarding automatically which may otherwise prove to be a difficult task if done manually.

MATERIALS

Raspberry pi

The robot designed is been build up, executed and interfaced with all its several components using a mini-computer known as Raspberry Pi. Raspberry Pi 3 model B is the brain of our designed model. It has 40 General Purpose Input Output pins working in two modes, Broadcom mode and Board mode. The Board Mode refers to the number of the pins in the plug and in the Broadcom mode the pins are numbered using Broadcom SOC channel. The mode in which pi is programmed needs to be specified exclusively by the user. These pins allow us to connect various devices starting from sensors such as flame and temperature sensors to engine controllers. The tiny computer comes in a size of credit card running in 1.2 GHZ ARM Cortex processor supporting 4 USB drive, audio jack, Ethernet and HDMI ports to attach various devices such as Webcam, Keyboard, Speakers and projectors to it. The module moreover supports Wi-Fi and Bluetooth to it which gives pi the power to be controlled remotely from distant location. Python and Scratch are the principle programming language of Pi although it supports various different languages such as Java also. The Raspberry Pi 3 model B is shown in Figure-1.

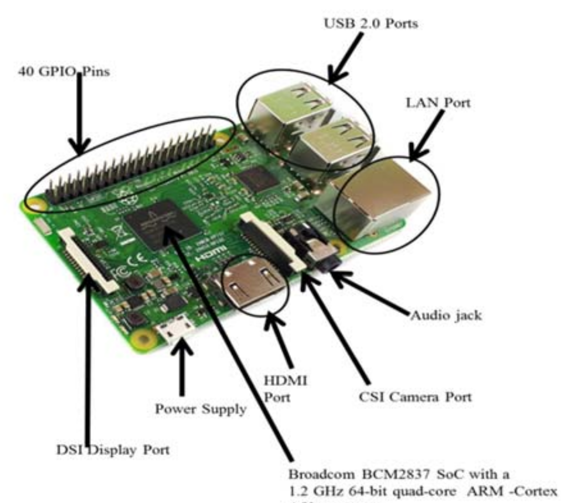

Figure-1. Raspberry Pi 3 Model B.

Webcam

A QHM495LM Quantum 25Mega-Pixel webcam is used in the proposed design to stream live videos, to make user aware of the surrounding the robot is in.

Sensors

Flame sensor is utilized for short range fire sensing. The accurate value of the flame sensor can be obtained up to 3 feet. It can sense flame or wavelength of light source in the range of 760-1100nm. The flame sensor is shown in Figure-2.

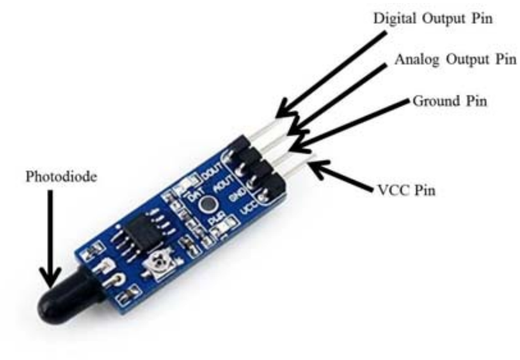

Figure-2. Flame sensor module.

DHT11 sensor utilizes a capacitive humidity sensor and a thermistor to gauge the encompassing air and releases a digital signal on the data pin of the sensor module. It requires a cautious timing to get information. Ultrasonic sensor is utilized to quantify the separation between the robot and hindrances before it. It gives exact, non-contact separate estimations inside 3m territory. Ultrasonic sensor creates high recurrence sound waves and assesses the reverberate which is reflected back by the sensor, measuring the time interval between sending the signal and receiving back the echo of the signal to decide the separation of an object. Ultrasonic sensor is installed on the servo motor with the goal that it can scan a large area to identify items or obstacles before the robot. A servo motor is an actuator that permits exact control of linear or angular motion. Webcam is utilized to record video which is interfaced with the USB port of the Pi. The DHT and ultrasonic sensor are shown in Figure-3 and Figure-4.

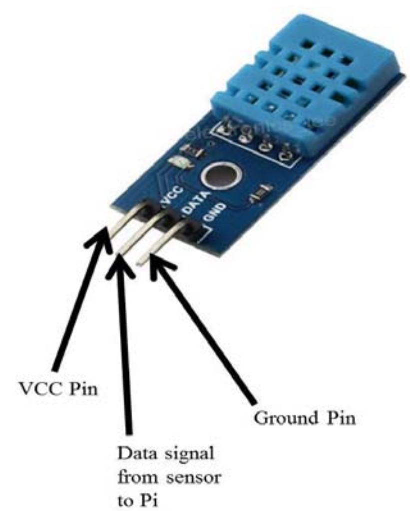

Figure-3. DHT11 Temperature and humidity sensor module.

VOL. 12, NO. 21, NOVEMBER 2017 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

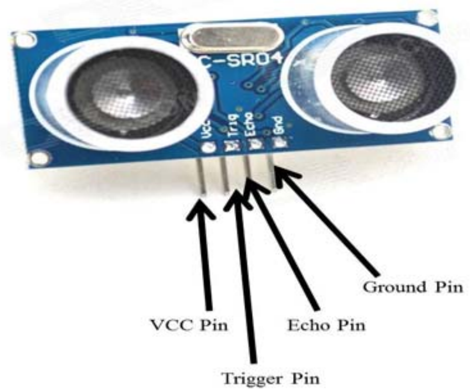

Figure-4. HC-SR04 Ultrasonic sensor module.

A passive infrared sensor (PIR sensor) is an electronic sensor that is used to detect motion of humans by measuring low infrared (IR) radiations transmitted from human body and are frequently utilized as a part of PIR-based movement detectors. The PIR sensor is shown in Figure-5.

Figure-5. HC-SR501 PIR sensor module.

DC fan

A DC fan is utilized as an extinguishing system and plays a vital role in fulfilling the purpose of the designed robot. The DC fan is controlled through L29110H dual channel motor driving module. The fan turns itself on as soon as the flame sensor senses fire and remains off rest of the time to support power consumption. Apart from depending upon the sensing capability of the fire sensor, the user can also manually turn the fan on and off after which the fan begins pivoting and douses the fire. The DC fan module is shown in Figure-6.

Figure-6. DC fan module.

DC motors

The two wheels of the robot are driven by a pair of DC motors which are interfaced with the Raspberry Pi through L-293 dual H-bridge module. L293 module can drive two dc motors which can be controlled in both clockwise and anticlockwise direction. It has yield current of 600mA and peak output current of 1.2A for every channel. The in-build diodes in the module guard the circuit from back EMF at the outputs. Supply voltage range is from 4.5V to 36V, settling on L293D an adaptable choice for motor drive. The structure of H-bridge is shown in Fgure-7.

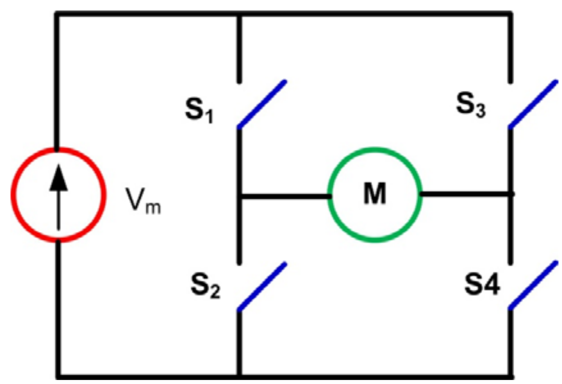

Figure-7. H-bridge.

H-bridge is an electronic circuit that allows voltage to be applied over a motor in both directions. The Table-1 shows the operation of the H-bridge, with S1-S4 relating to the Figure-7.

Table-1. Operation of the H-bridge.

S1	S2	S3	S4	Operation
1	0	0	1	Motor moves in clockwise direction
0	1	1	0	Motor moves in anti-clockwise direction
0	0	0	0	Motor stops
0	1	0	1	Motor breaks
1	0	1	0	Motor breaks
1	1	0	0	Short circuit occurs
0	0	1	1	Short circuit occurs
1	1	1	1	Short circuit occurs

ARPN Journal of Engineering and Applied Sciences

Servomotors

A servomotor is a rotating actuator or linear actuator that takes into consideration exact control of angular or linear position, velocity and acceleration. It comprises of a motor coupled to a sensor for position feedback. We have mounted our webcam and ultrasonic sensor on top of the servomotors in our design to scan a wider range of area through webcam and to find out the actual distance of the object webcam is pointing by mounting an ultrasonic sensor on top of the robot. A servomotor is shown in Figure-8.

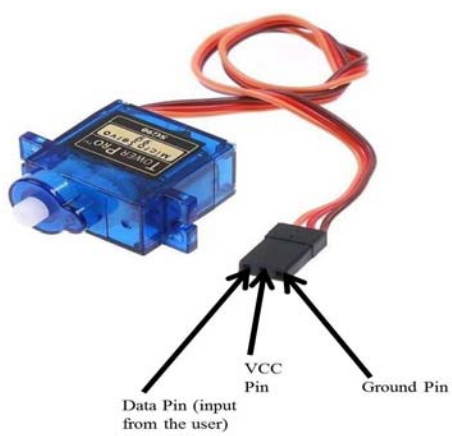

Figure-8. Servomotor.

Putty

Putty is an open source terminal emulator serial console and network file exchange application. A few networking protocols which are SCP, SSH, Telnet and so forth are supported by putty. Putty programming is utilized by the PC to initially configure the Pi for activating the secure shell protocol so that remote login is enabled. A putty terminal is shown in Figure-9.

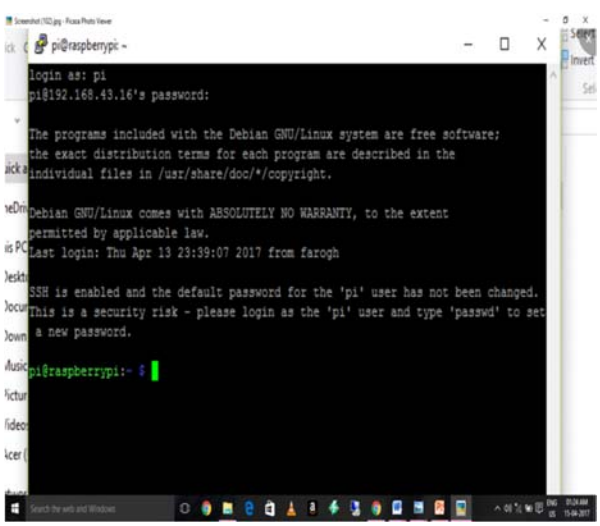

Figure-9. Putty terminal to control Pi.

TightVNC

TightVNC is a cross-stage free and open-source remote desktop software application. It is produced utilizing and broadening the RFB convention of Virtual Network Computing (VNC) to permit end-clients to control another PC's screen remotely from any corner of the world. The VNC protocol is a basic protocol for remote access to graphical UIs. It depends on the idea of a remote framebuffer or RFB. The protocol essentially permits a server to refresh the framebuffer showed on a viewer. Since it works at the framebuffer level it can be used in all other operating systems, windowing systems and applications. This incorporates X/Unix, Windows 3.1/95/NT and Mac, however may likewise incorporate PDAs, and for sure any device with some type of communication link. The protocol will work over any dependent transport, for example, TCP/IP.

Weaved

Accessing pi over different network to monitor the surroundings and controlling the entire robot was only possible by using an Internet of Things platform [9]. The Weaved IoT pack gives Software Defined Networking (SDN) to any networked device. The installer for Raspberry Pi presets for capacity to design Weaved for any TCP based administration you need to make accessible remotely. Software Defined Networking (SDN) is a way to deal with PC organizing that permits arrange overseers to automatically introduce, control, change, and oversee organize conduct powerfully by means of open interfaces and reflection of lower-level functionality.

Telegram

Telegram is a social networking messenger application which is used in our proposed design to control the designed robot via smartphone. Telegram is used in our modelled robot as it not only allows human but also machines to talk back. The user sends various commands to perform different task as mentioned in Table-2 and after receiving those commands from user it performs the required task, updating back the user with Temperature, Humidity and presence of human casualties.

WORKING OF THE ROBOT

The design of the Robot is shown in the below mentioned figures- Figure-10, Figure-11 and Figure-12 which depicts the front view, side view and the top view of the designed robot.

VOL. 12, NO. 21, NOVEMBER 2017 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

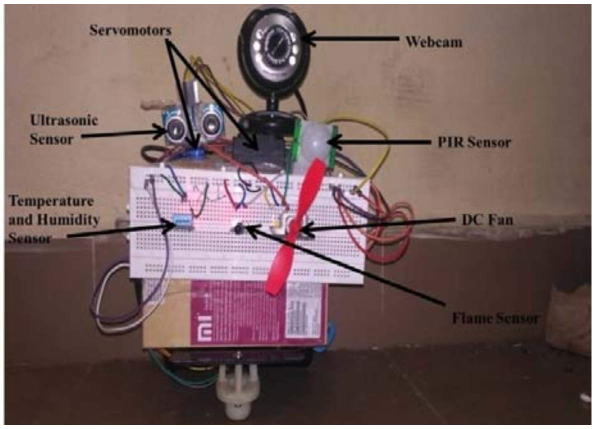

Figure-10. Front view of the designed robot.

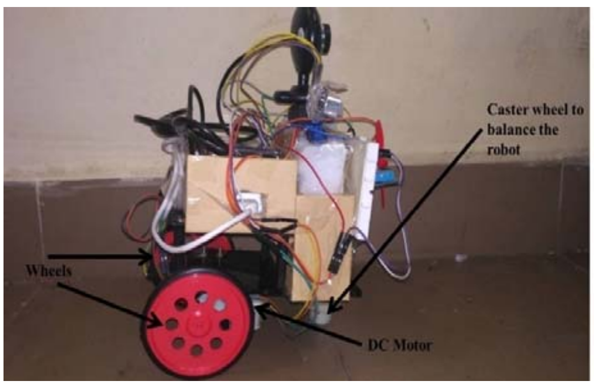

Figure-11. Side view of the designed robot.

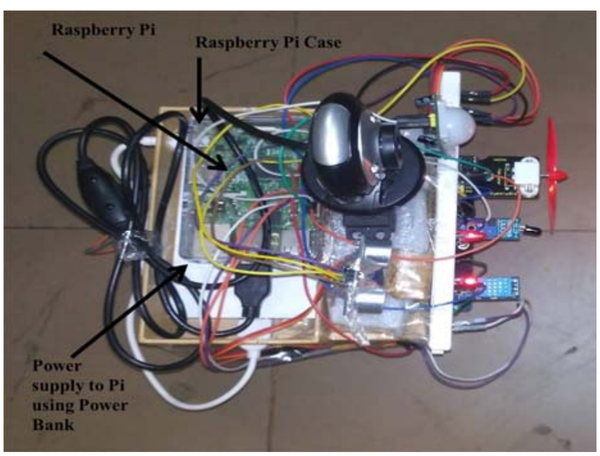

Figure-12. Top view of the designed robot.

The proposed robot works in two different modes which are the PC control mode and smartphone control mode as per block diagrams shown in Figure-13 and Figure-14.

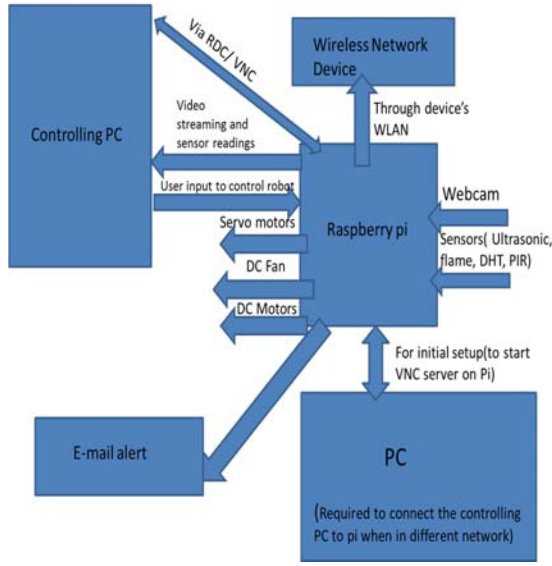

Figure-13. Block diagram controlling robot via PC.

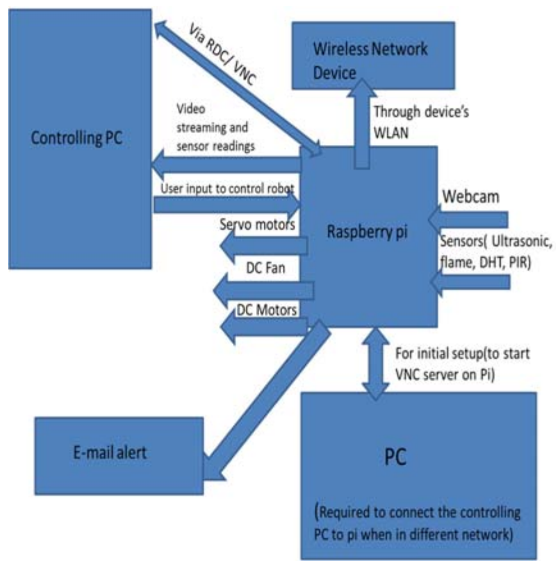

Figure-14. Block diagram controlling robot via smartphone.

Figure-15 shows the flowchart of the designed robot which explains how the robot is being controlled by the user by observing the circumstances around his surroundings.

ARPN Journal of Engineering and Applied Sciences

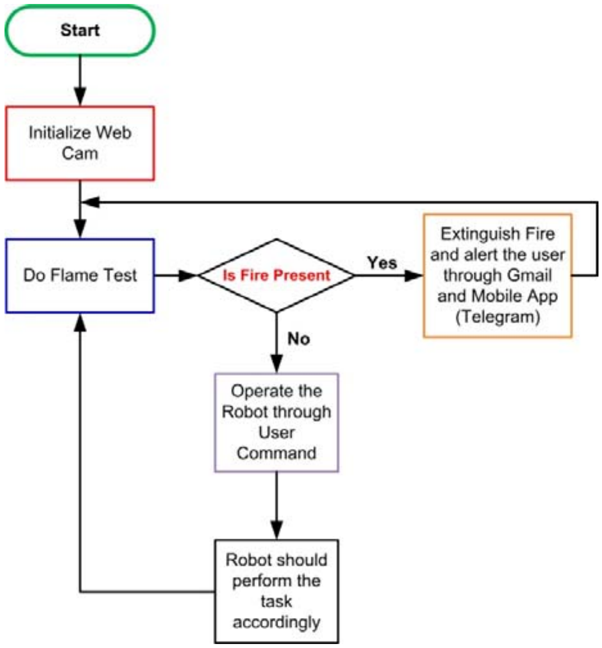

Figure-15. Flowchart of the robotic model designed.

Controlling the robot using PC

Once the Raspberry Pi is powered up, it is connected to the users Wi-Fi. A PC is also connected to the same Wi-Fi network. This PC is required to set the Raspberry Pi to get connected with other PC which is on different network. This is done by activating the Tight VNC server and by signing into the Weaved account already created by user using the credentials pre-assigned by the user during the initial installation process in the Pi. The Weaved uses Internet of Things platform to connect the Pi to the VNC server over different network by automatically enabling Port forwarding itself.

Once the connection to VNC server is established, the controlling PC is now needed to enter the client address provided by Weaved into its Remote Host connection tab. Once entered the Tight VNC viewer can now access the graphical user interface of the Pi remotely through different network as shown in Figure-16 and Figure-17, Figure-18 and Figure-19.

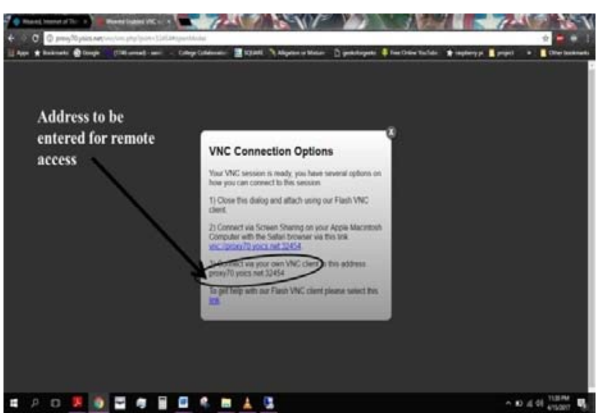

Figure-16. Address assigned for remote access.

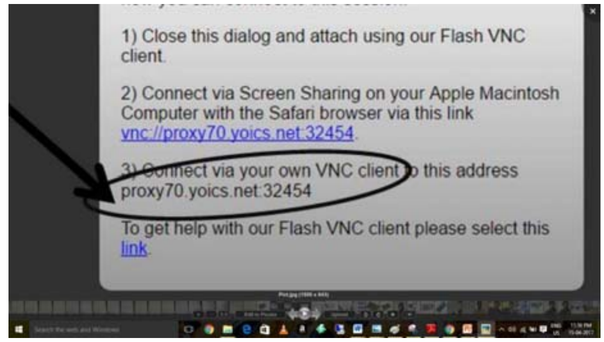

Figure-17. Magnified image of Figure-16.

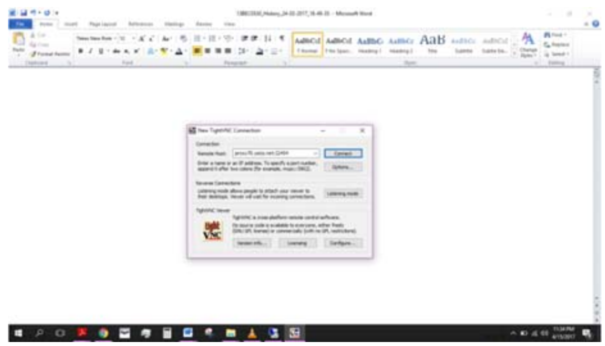

Figure-18. Address required connecting to TightVNC viewer.

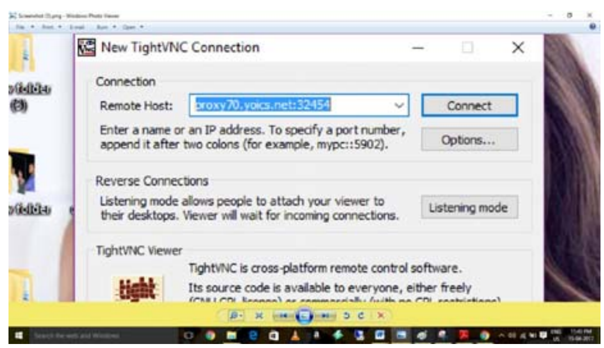

Figure-19. Magnified image of Figure-18.

Once the controlling PC is connected to the Pi, the user can control the Pi through the controlling PC as per his requirements. The graphical interface of Pi through VNC is shown in Figure-20 and Figure-21.

ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

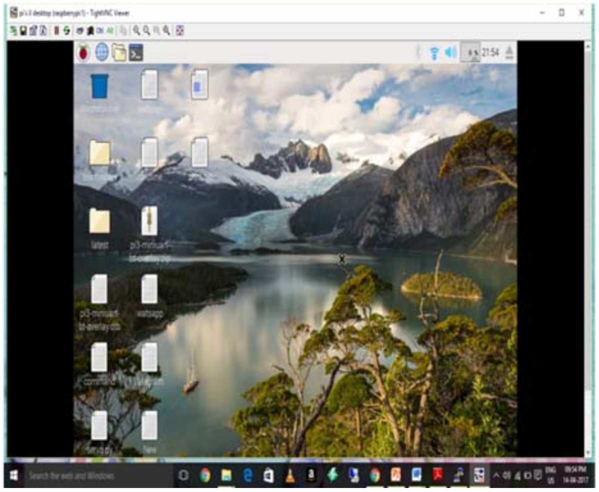

Figure-20. Graphical interface of Pi via tight VNC viewer

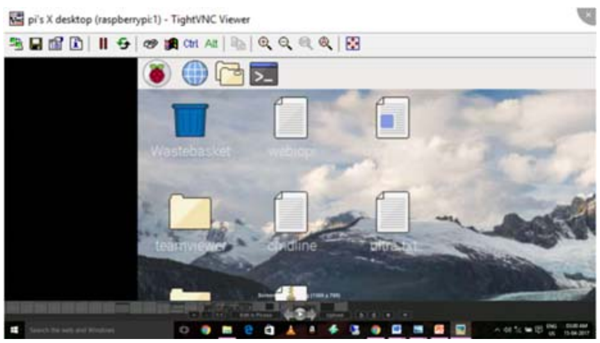

Figure-21. Magnified image of Figure-20.

If the controlling PC is on the same network as that of the Pi then there is no need to connect to VNC server. The PC can access the graphical interface of the Pi using the Remote Desktop Connection (RDC) by entering the Pi's IP address and credentials to sign into the Pi. RDC to access Pi remotely is shown in Figure-22 and Figure-23.

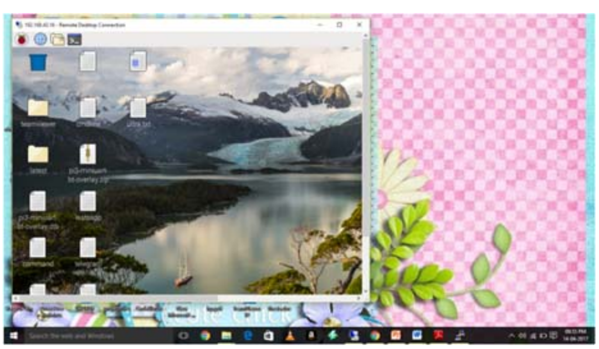

Figure-22. Graphical interface of Pi via RDC.

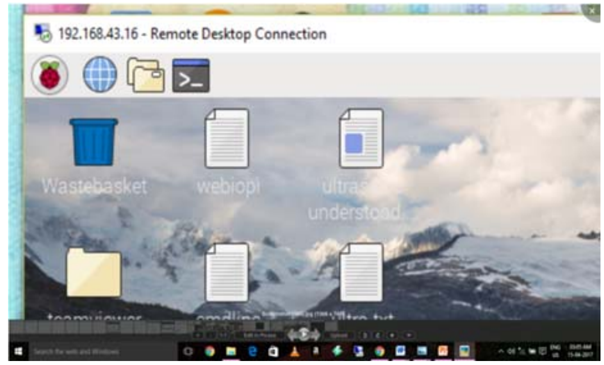

Figure-23. Magnified image of Figure-22.

Since the controlling PC can now control the Raspberry Pi, so now the user only needs to run the python scripts which are required to control the robot. On running the script, the user can see the live streaming of the surroundings and also observe the readings of flame, PIR, ultrasonic and the temperature, humidity sensor and make robot move accordingly.

The webcam and the ultrasonic sensor are mounted on the servomotors which are continuously rotating to scan a wide range of area, so that the user can get the live streaming in all direction of the surroundings and ultrasonic sensor can give the distance of the object in front of the robot. The servomotor rotates at an angle of 45 degrees per 5 seconds so that the user can have a clear view of the surrounding. The user can control the robot using the commands as shown in the Table-2.

Table-2. Commands to control the robot.

Input	Controls
q	To test flame
m	To rotate camera and ultrasonic sensor
n	To fix camera and ultrasonic position
w	To move forward
s	To move backward
i	To move forward slightly
k	To move back slightly
a	To turn left
d	To turn right
j	To turn slight left
l	To turn slight right
z	To stop
f	To start fan
h	To stop fan

The user can now watch the live streaming of the surrounding through the webcam and also at the same time get notified about the environment through the flame sensor, the distance of the obstacle in front of the robot,

VOL. 12, NO. 21, NOVEMBER 2017 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

presence of any human casualties, temperature and humidity of the surrounding through ultrasonic, PIR and DHT11 sensor respectively. If the robot senses fire an automatic Gmail and Telegram alert is send to different users such as the fire department or our neighbours as programmed by the user who may help in handling the fire scenario. By observing the video streaming and also the sensors reading, the user may command the robot to move towards that location and after reaching closer to that location the user commands the robot to start the DC fan which extinguishes the flame. When the extinguishing task is performed, the user commands the robot to stop the fan and scanning other locations in search of fire is performed.

Controlling the robot using Smartphone

To control the robot using the smartphone, we have used Telegram, a social networking messenger application available in Google Play Store which needs to be installed in the smartphone, which features Bot API by which the robot can communicate with user. A personal Bot account needs to be setup by a special bot named 'BotFather'. This bot is specially designed for obtaining a bot account. The BotFather assigns the user certain unique token while signing in which needs to be used while installing telepot libraries in Raspberry Pi.

The python script created for commanding robot to perform different task needs to be powered with unique token obtained while setting up bot account using only which we can communicate with our robot and command it to perform different task mentioned, giving the user total access to the robot.

Using a smart device to view the surrounding by installing Tight Virtual Network Computing and using the smartphone which has access to the bot, the user can view the surrounding using webcam and give commands mentioned above in Table-2 to control the fire fighting robot. The user timely gets notified about the situation, temperature and humidity of the environment, distance of the objects in front of the robot and also the presence of any human casualties in the surroundings every time the robot relocates. These notifications are communicated by the robot by sensing different sensors attached to it back to the user. Once the user is notified about the surroundings, he can control the robot through Telegram with the help of the smart device in which he views the surrounding as per his own requirement.

RESULTS AND DISCUSSIONS

The proposed design of the robot was successfully designed in real life and was also taken to a series of tests giving positive results most of the time. The following Figures from Figure-24 to Figure-29 show the results observed by the designed robot.

Figure-24. Video streaming and sensor readings obtained on controlling PC.

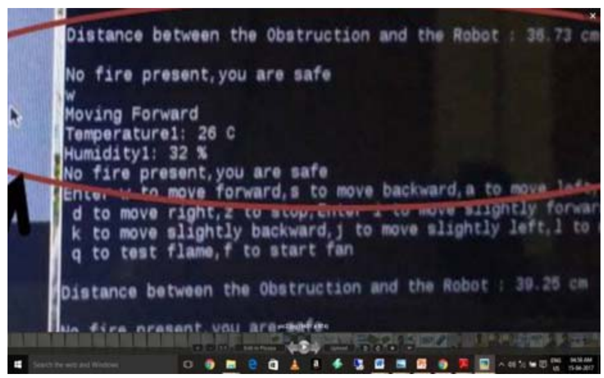

Figure-25. Magnified image of Figure-24.

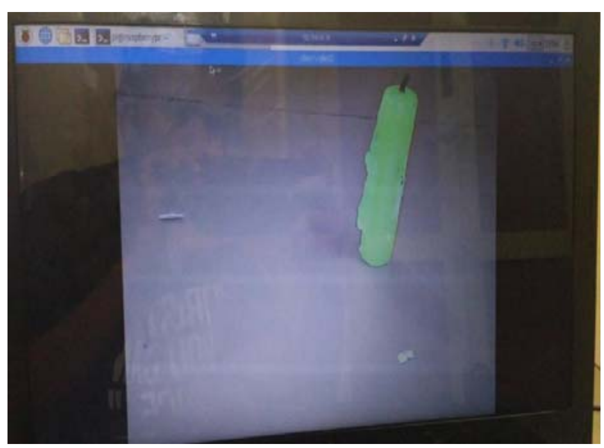

Figure-26. Video streaming when controlling the robot via smartphone.

ARPN Journal of Engineering and Applied Sciences

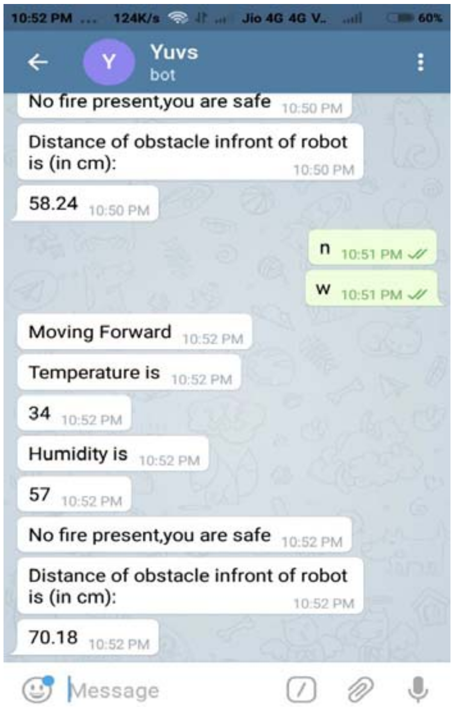

Figure-27. User being notified on smartphone.

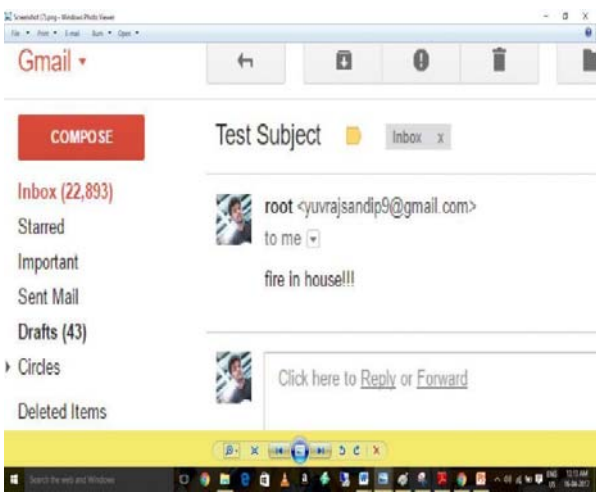

Figure-28. User being notified on g-mail.

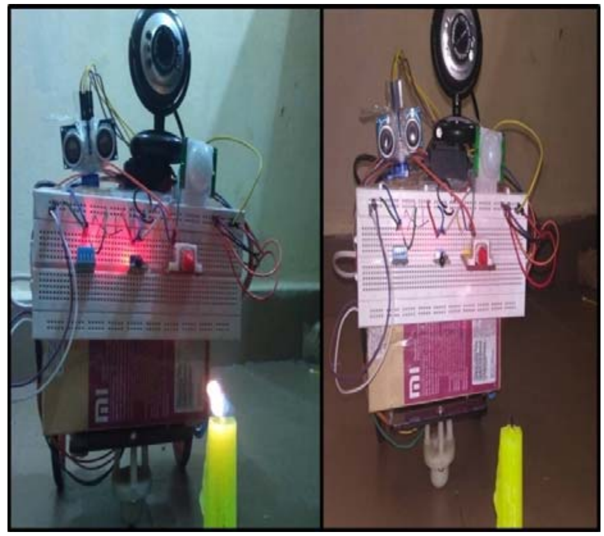

Figure-29. Robot performing the extinguishing task.

This paper represents a fire extinguishing robot which serves the purpose to reduce fatality and injuries caused due to fire accidents. A fire-fighting robot is designed using Raspberry Pi 3 Model B equipped with equipment such as PIR, Ultrasonic, Flame, Temperature and Humidity sensors which senses the fire, human casualties, monitoring temperature and humidity of the surrounding and distance between the robot and the obstruction in front of it so that user could properly operate the robot under extreme circumstances. The increased intensity of fire may disrupt the sensor and so additional measures are taken care by using webcam which would provide a clearer view of the environment in which it is been operated by rotating it by 45 degrees with the help of servo motor in every 5 seconds. Ultrasonic sensor is also synchronized to rotate with the camera with the help of servo motor so that both point to the same object giving exact distance between the robot and the object which the camera is viewing. To extinguish the fire a 5V DC Fan is used which starts functioning as soon as the flame sensor senses for fire. To control the robot from remote location Tight Virtual Network Computing server is used which uses Remote Frame Buffer protocol to send screen pixel data of Pi's desktop. To access the robot over different network an IOT based platform called Weaved is used which automatically does port forwarding and provides an encrypted connection on port 80(http). The robot can be controlled by a smart device such as smartphone or a laptop which have an access to internet. To make the robot more flexible it is programmed in such a way that it can also be remotely operated using an application called Telegram using Telegram Bot which enables machines to talk allowing the Raspberry Pi to receive command from user to move and reply back with temperature, humidity, human casualties and if fire is present by reading the sensors attached to the robot.

CONCLUSIONS

We have successfully designed and interfaced our fire-fighting robot with different sensors. The manually wireless controlled robot model design has an advantage over other existing models as it can be controlled from any remote location from any smart device with the help of Weaved and Tight Virtual Network Computing Server. Further to add more flexibility, a smart phone application known as Telegram is used to send and receive command from the robot. The model developed, on sensing fire starts it's extinguishing process and also additionally alerts the user by mailing them about the situation on their g-mail id. Since the video of the environment live streamed by the camera to the user produces a delay of around 20milliseconds, the robot can be used to handle real time fire threat. Since usage of DC fan for different types of fire with different intensities is not appreciated and can be fatal so in future usage of fire extinguisher is proposed. If the environment is badly affected then due to high humidity webcam may not produce clearer video of the surrounding and relying only on sensors is not appreciated so thermal imaging can be used which by reading the heat signature of the objects finds out the regions in fire. Obscurants such as fog haze and smoke can also be penetrated using thermal imaging. Hence usage of thermal imaging and instalment of Fire Extinguisher may further bring advancement in the existing model developed.

REFERENCES

[1] Rangan M K, Rakesh S M, Sandeep G S P, C Sharmila Suttur. 2013. A Computer Vision based approach for Detection of Fire and Direction Control for Enhanced Operation of Fire Fighting Robot. IEEE. pp. 8-13.

[2] K. Altaf, A. Akbar, B. Ijaz. 2007. Design and Construction of an Autonomous Fire Fighting Robot. The IEEE International Conference on Information and Emerging Technologies, ICIET.

[3] B. Swetha Sampath. 2011. Automatic fire extinguisher robot. IEEE. pp. 215-218.

[4] Mukul Joshi, Rajashri Madri, Madhuri Joshi. 2013. Real Time Motion Tracking Algorithm for Search and Rescue Robots. IEEE. pp. 9-13.

[5] Kristi Kosasis, E.Merry Sartika, M. Jimmy Hasugian, Dan Muliady. 2010. The Intellegent Fire Fighting Tank Robot. Electrical Engineering Journal. 1(1): 73-80.

[6] Tawfiqur Rakib, M. A. Rashid Sarkar. 2016. Design and Fabrication of an Autonomous Fire Fighting Robot with Multisensor Fire Detection Using PID Controller. IEEE, 2016, pp. 909-914.

[7] Akib Islam, Navneet Kaur, Farogh Ahmad, P. Sathya. 2016. Intelligent Wireless Fire Extinguishing Robot. International Journal of Current Engineering and Technology. 6(1): 321-327.

[8] M. Vanitha, M. Selvalakshmi, R. Selvarasu. 2016. Monitoring and Controlling of Mobile Robot Via Internet Through Raspberry PI Board. IEEE. pp. 462-466.

[9] Mohannad Ibrahim, Abdelghafor Elgamri, Sharief Babiker, Ahmed Mohamed. 2015. Internet of Things based Smart Environmental Monitoring using the Raspberry-Pi Computer. IEEE. pp. 159-164.