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IoT Technology Based Fire-Fighter Robot

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ABSTRACT

Detecting and extinguishing fire is a hazardous job for a person who handles the fire using a fire extinguisher. The IoT firefighter robot is the solution for detecting and extinguishing fire efficiently. The robot is both autonomous and controlled. The controlling of robot is done by using a Remote Desktop application. The robot and the application (authority) are connected via Internet. In this paper we introduced how the concept of Internet of Things (IoT) is introduced in the robot. Authority helps the robot to identify the fire type to apply appropriate fire extinguishing methods. In future, the IoT firefighter robot can implemented as a drone for terrestrial areas.

Keywords : Internet of Things, Flame Sensor, Robotics, Firefighter, Artificial Intelligence, SSH, Wi-Fi

I. INTRODUCTION

Fire fighting is the activity of limiting the spreading of fire and extinguishes it. It is considered as a hazardous task for fire-fighting men who are working in risky situations. In addition, fire-fighters face difficulties while rescuing victims who stuck in fire. Instead of using a human fire-fighter, a fire-fighter robot can extinguish fire efficiently. A robot can be functioning itself or remotely controlled, which gives the idea for using robots instead of putting fire-fighter men in dangerous fire rescuing operations. Also the robot can be used as an assistant to fire-fighter men to know the safer path to fire if the robot has a monitoring system for viewing the environment. For a large building, the fire rescuing operation could be difficult, because the finding of victims will not be easy for a fire-fighter man. By using some object detection algorithm, a robot can easily find the people who stuck in a fire environment. Using the Artificial Intelligence technology, we can train a robot to apply suitable extinguishing methods. For all the cases, the usually using extinguishing methods may not be suitable. So, the robot must be trained for apply suitable extinguishing methods.

For example, Water pumping is not suitable method for all cases. When water is pumped to an electronic device, it will cause short circuit. That may result into a huge fire. The most appropriate method for extinguishing fire on an electrical device is to pump CO_2 gas. But the existing fire-fighter robot has many limitations such as it cannot switch from autonomous behavior to remote controlled or vice versa. Also it cannot monitor the environment to know the current situation of fire.

The IoT fire-fighter robot helps to extinguish fire efficiently. The robot is in the environment where the fire occurs and it is connected to the authority. Authority is some people who are monitoring the environment. All these are connected through Internet of Things (IoT). IoT is the interconnection of

objects via Internet and enabling them for communicate each other [1]. Here IoT enables better communication between robot and authority. Authority can view the environment through the robot and they can take appropriate action for extinguishing the fire.

II. METHODS AND MATERIAL

IoT fire-fighter robot comprises of two environments, authority environment and environment where fire occurred. Authority is for monitoring the fire through a web-cam which is plugged onto the robot. These two environments are interconnected via Internet.

The robot is consisting of Raspberry pi which helps in the motion of robot and other functions. The raspberry pi acts a server to enable the communication between robot and authority. Raspberry pi has inbuilt Wi-Fi facility to make the whole environment work in IoT. To establish the communication with the robot, enter the server IP address on the authority's remote desktop application. This application will provide the live streaming of the fire environment. The live streaming is done by the web-cam in the robot. When the robot detects fire using its sensor, it sends the data to the authority to alarm the fire. After getting the information of fire, the authority can monitor the environment or they can control the motion of robot using the application. The authority may not be available all the time. So, the robot has to work automatically [2] after the time-out notification on the application. The robot is programmed to extinguish the fire by the sensing the precise location of fire. The motion of the motors of the robot is pre-programmed and the path of the motion is determined by image processing and intensity of fire [3]. The extinguishing process can be performed by knowing the fire type by authority. Then the authority send instructions to the robot about which method should take for fire extinguishing.

2.1 System Design

Proposed system is a combination of software and hardware solution for the problem. The core components are Raspberry Pi, Web-Cam, Flame sensor, Ultra Sonic sensor, and Remote desktop application. The application acts as the user input-output interface. The Raspberry Pi processes the information collected from the environment where fire occurred via flame sensor and web-cam. The obtained live-streaming of the environment (captured video of the fire environment) undergoes some imaging processing techniques such as color detection, contour detection using OpenCV-python program. The movement and the extinguishing action of robot are done using the motors and pumps respectively. The system architecture is shown in Figure 1.

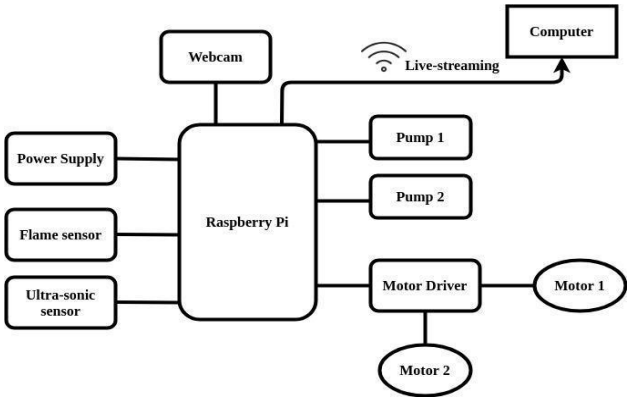

Figure 1. System Architecture

2.2 System Components

2.2.1 Raspberry Pi 3 B+

It is a small computer board with CPU, USB ports Input/output pins, Wi-Fi module, Bluetooth module, and they together functions like an actual computer. The technical specifications of this model are CPU with 64 bit and 1GB RAM, Broadcom BCM2837B0 chipset, 40 pin header, four USB ports, Micro SD socket, MicroUSB Power Source Connector, HDMI,

and inbuilt Wi-Fi and Bluetooth modules. Figure 2 shows the Raspberry Pi 3 B+ Model.

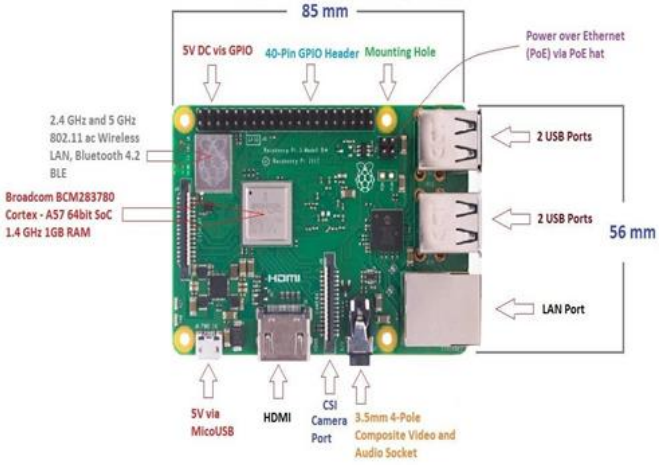

Figure 2. Raspberry Pi 3 B+ Model

Here the raspberry pi can act as a server in order to perform the live-streaming of the environment. The Wi-Fi [4] module in the raspberry pi creates an IP address which can be used for the authority to monitor the fire environment.

Raspberry Pi 3 B+ Pin out Diagram is shown in Figure 3.

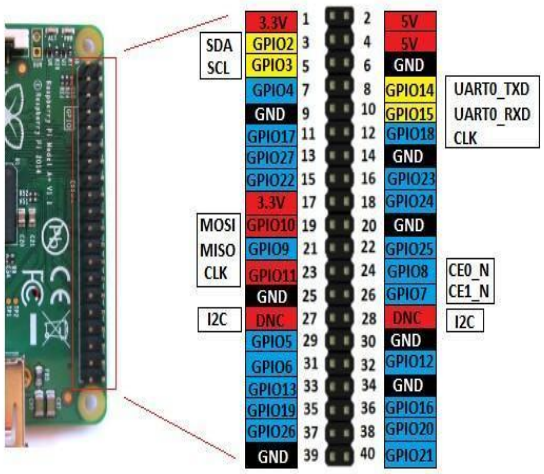

Figure 3. Raspberry Pi 3 B+ Pin out Diagram

From Fig 3, out of 40 pins, 26 are used as a digital I/O pins and 9 of the remaining 14 pins are termed as dedicated I/O pins which indicate they don't come with alternative function.

2.2.2 SMPS

A SMPS (switched-mode power supply) is an electronic circuit which converts power using switching devices that are turned on and off at high frequencies, and storage components to supply power when the switching device is in its non-conduction state. Here, 5V 5A SMPS - 25W - DC Metal Power Supply is used.

2.2.3 Flame Sensor

A sensor which is highly sensitive to the light of the flame is known as a flame sensor. So it is used in flame alarms. This sensor detects flame for the wavelength within the range of 760 nm- 1100 nm from the light source. The output of the sensor can be an analog signal or digital signal. These sensors are used as a flame alarm in fire fighting robots.

2.2.4 Ultrasonic Sensor

Ultrasonic distance sensors are the sensors used to measure distance between the source and target using ultrasonic waves. This sensor is used to avoid touching of obstacles by the robot. The safer distance between obstacle and the robot is measured by using this sensor.

2.3 Work Flow Diagram and Algorithm

The work flow diagram for the basic working of robot is shown in Figure 4.

Algorithm:

Step 1: The robot reads flame data.
Step 2: The sensor in the robot confirms whether there fire occurred or not. If yes go to step 3, else step 1.
Step 3: Send the information of fire to the application in the authority environment.
Step 4: Check whether the authority is available to control the robot or not. If yes go to step 5 to 6, otherwise go to step 7.

Step 5: Monitor the environment via the camera which is fitted in the robot

Step 6: Authority controls the robot through the application [5].

Step 7: Robot find its path [6] with the help of ultrasonic sensor and extinguishes fire itself by identifying the fire.

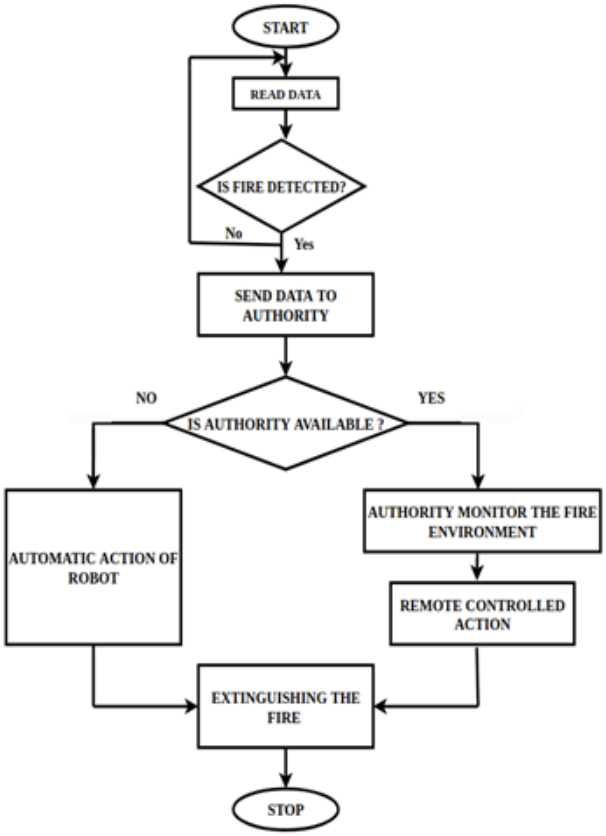

Figure 4. Work Flow Diagram

2.4. Working Principle of the System

When the flame sensor detects fire, it alarms the fire via application on the authority's system. The authority's computer will always stay connected to the robot. Then it starts to live-streaming the environment. If the authority is available before the time-out, the robot can be controlled by some keyboard commands. Otherwise the robot will be on automatic action.

2.4.1 Automatic action of Robot

The automatic action of robot is done by using Image processing. Here, Contour detection is used to find the fire. Contour detection is a process of finding curve joining all the continuous points (along with the boundary), having same color or intensity. The contours are a powerful tool for shape analysis and object detection and recognition [7]. Figure 5 shows the Automatic action of robot.

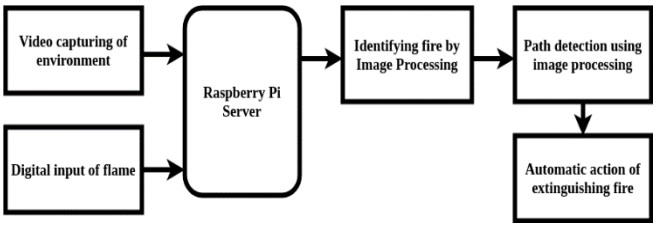

Figure 5: Automatic action of Robot

Once the robot recognizes the color of the fire, the robot will move towards the fire in a safer distance. The safer distance is measured by using Ultra-sonic sensor. Ultrasonic distance sensors are designed to measure distance between the source and target using ultrasonic waves [8]. The motion of motors in the robot is controlled by setting GPIO pin values in the raspberry pi. The motion towards different directions can be also done by setting the GPIO pin values.

2.4.2 Manual Controlled action of Robot

When the authority responds before the time-out of the fire alarm through live-streaming, the robot will be under manual control. The motion of robot and extinguishing of fire can be done using keyboard by monitoring the live-streaming of environment. Manual controlled action of robot is shown in Figure 6.

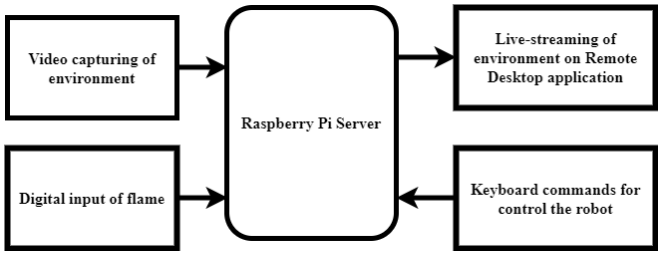

Figure 6: Manual Controlled action of Robot

The arrow buttons on the keyboard is used for the motion of robot. Some specific keys are used for extinguishing purposes too. By the authority's monitoring, one can apply appropriate fire extinguishing methods which is shown in the application.

2.4.3. Circuit Diagram

The circuit diagram of the robot consists of mainly Raspberry pi 3 B+ model. It needs 5V power supply. For getting constant and steady output, a 7805 voltage regulator is used. The GPIO digital pins in the raspberry pi connected to the motor driver (L298 Motor driver module) in order to move the four motors for motion of the robot. Raspberry pi sends signals to the motors through motor driver according to the openCV-Python program [9]. The relay module in raspberry pi turns on or off the pump to extinguish the fire. According to the use, much number of pumps can be added. And these are controlled via raspberry pi using openCV-Python program. The webcam (Logitech C170 Webcam) is connected to the pi module for monitoring the environment. The flame sensor (LM393 comparator chip) is connected to the pi module for detecting fire. When the flame sensor detects the fire, the connected pi module sends an alert to the remote desktop application. Circuit diagram of the robot is shown in Figure 7.

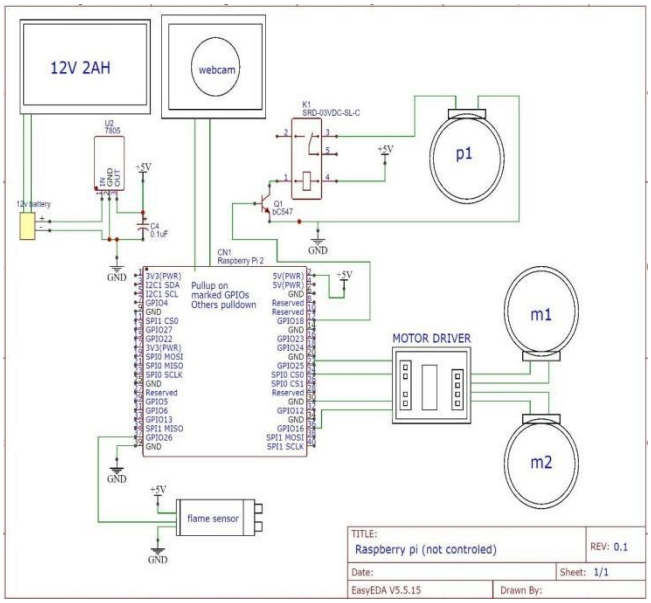

Figure 7. Circuit Diagram of the Robot

2.4.4 Wireless Control over the Robot

To control the robot, the computer and the robot is connected wirelessly using Wi-Fi. Using remote desktop application, one can control the robot using its local IP address. For that we need to enable SSH [10] to allow remote connection. SSH (Secure Shell or Secure Socket Shell), is a network protocol which gives users a way to access a computer over an unsecured network. After enabling SSH, using 'ifconfig' command, we can find the local IP address of the raspberry pi which resides in the robot.

III. RESULTS AND DISCUSSION

In this paper, we have developed an IoT fire-fighter robot which is both autonomous and controlled. Figure 8 shows the robot model that we've developed.

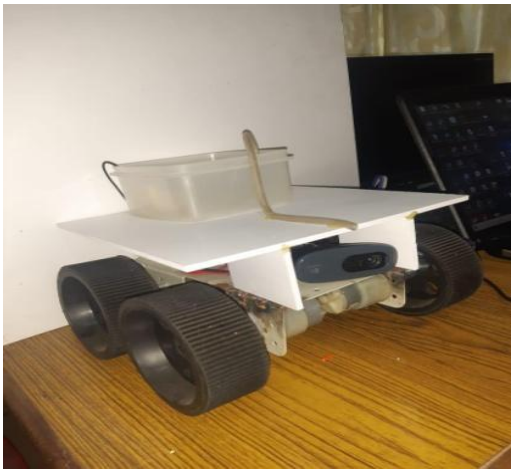

Figure 8. IoT fire-fighter Robot

When the robot detects fire using flame sensor, it waits for manual control for certain time. If there is no one came to control the robot, it will turn into automatic extinguishing action. The fire alert is send to the remote desktop application. There will be a monitoring window for the fire environment. The remote desktop application should always be connected to raspberry pi via Wi-Fi.

Figure 9 shows the monitoring system of fire environment. This is where the manual action can be carried out. Both the automatic and manual actions on robot are carried out by the OpenCV-Python program.

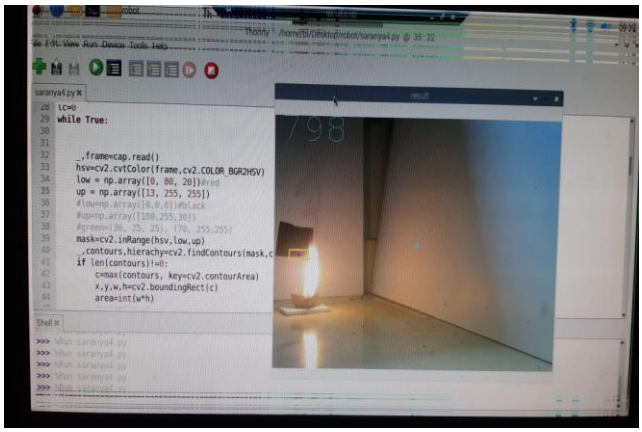

Figure 9: Monitoring System for Fire Environment

When the robot detects fire, it starts moving towards the fire. Figure10 shows the extinguishing action of robot. Here, robot sprays water on the burning paper. The burning paper is a 'class A' type fire, which should be extinguished with water or foam.

Figure 10. Extinguishing action of the Robot

For using other type of extinguishing methods, the robot can carry appropriate materials and it is placed on the robot with pumps. It is showed in Figure 11. To add more than one extinguishing materials, the pumps used in material's tank should connect with the relay module of raspberry pi.

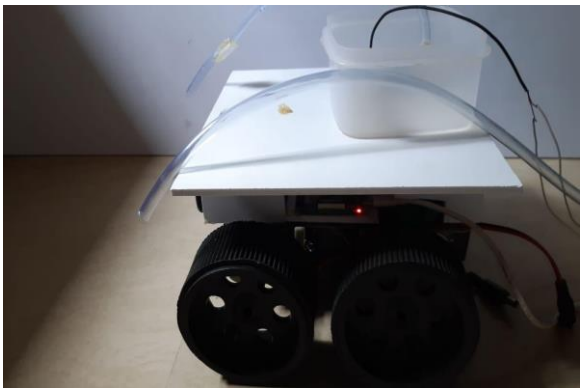

Figure 11: Robot with multiple extinguishing materials

Moreover, this robot is helpful for firefighter men in order to assist them. The developed model is correction to the existing firefighting robot models. In the advanced model, the robot can even carry people who stuck in fire environment. Using the application of artificial intelligence [11], it could be trained to apply appropriate extinguishing methods for different situations.

IV. CONCLUSION

Nowadays, the concept of fire-fighter robot is very common. But this IoT fire-fighter robot solves some issues in the existing fire-fighter robots. They are both autonomous and controlled. It has a monitoring system to know the fire and people who stuck in the environment. Also the monitoring system can be implemented as an Android application [12]. The robot helps other fire-fighter men by giving them a safer path to fire. Because lots of fire-fighter men have lost their life while saving other's life. Using the robotic arm in the robot, it can pick up the people who stuck in there for help. This IoT fire-fighter robot can be implemented as in the form of drone. Using the application of artificial intelligence, the robot can be trained to find fire type and to choose appropriate extinguishing methods. For some large fires like forest fire, the extended version of this robot helps to extinguish the fire in a large amount. So, nowadays the relevance of this robot is increasing.

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