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Monitoring and Controlling of Fire Fighthing Robot using IOT

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ABSTRACT: There is a lot of likelihood of fire in any distant location or in an industry. For example, in products of clothing godowns, cotton factories, and fuel stockpiling tanks, electric short circuits may bring out monstrous fire and mischief. In the most noticeably terrible of cases and situations, fire causes overwhelming misfortunes both monetarily and by taking lives. Robotics technology is the most ideal approach to monitor human lives, protect wealth and preserve environmental health. A Fire-fighting robot is structured and worked with an embedded framework. It is equipped for exploring alone on a displayed place while effectively examining the blazes of fire and extinguishes it. The robot could be utilized as a way to manage as a crisis gadget. This robot is structured so that it look through a fire, and drenches it before the fire could spread out of range and control.

KEYWORDS: Fire-fighting Robot, Embedded System, Raspberry Pi, Flame Sensor, L298N Motor driver.

I. INTRODUCTION

According to National Crime Records Bureau (NCRB), it is estimated that more than 1.2 lakh deaths have been caused because of fire accidents in India from 2010-2014. Despite the fact that there are a great deal of safety measures taken for Fire mishaps, these common/man-caused disasters do happen once in a while. In case of a fire breakout, to protect individuals and to extinguish the fire we are compelled to utilize manpower which are undependable. Losses and property harm from fire keep on exist in fire catastrophes and new measures are consistently presented. Harmful gases and blazes keep on undermining calamity casualties and salvage labourers the same time.

A robot is an automated device which performs functions usually attributed to humans or machines tasked with repetitive or flexible set of actions. Numerous studies have shown that robot can be beneficial in medicine [1], rehabilitation [2], rescue operation [3] and industry. Over the years, robotics has been introduced in various industries. The industrial robots are multi-function manipulators designed for more specialized materials, divisions, gadgets or devices through various programmatic movements to perform various tasks [4].

With the progression of technological innovations particularly in Robotics, it is considerate that man power can be replaced with the robots for battling the fire. This would improve the proficiency of firemen and would likewise keep them from gambling their lives. While a scope of putting out fires robots have been created and placed in real life around the world, they have not yet contributed extraordinarily to the battle. Most robots help just in little manners, helping combat fires from a remote place or monitoring outside fire scenes. An indoor fire fighter robot is fit for performing salvage tasks without gambling human life, including fire extinguishers and helping individuals in case of danger.

In this paper, we have proposed a Fire Fighting Robot using Raspberry Pi 3B microcontroller board. The main function of this robot is to become an unmanned support vehicle, developed to search and extinguish fire. There are several existing types of vehicles for fire-fighting at home and extinguish forest fires [5].

Our proposed robot is designed to be able to work on its own or be controlled remotely. By using such robots, fire identification and rescue activities can be done with higher security without placing fire fighters at high risk and dangerous conditions. In other words, robots can reduce the need for fire fighters to get into dangerous situations. Additionally, having a compact size and automatic control also allows the robot to be used when fire occurs in small and narrow spaces with hazardous environments such as tunnels or nuclear power plants [6, 7].

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II. LITERATURE REVIEW

Fire-fighting robot may be used in industrial environment and even in household areas wherethere is more probability of occurring accidental fire [8-10]. Different sensors are used and fusion of their performances is ensured by an intelligent algorithm in Arduino computing platform or by soft computing techniques [11-12].

Su et al. [13] made an automatic fire detection system using Adaptive Fusion Algorithm (AFA). Multisensor Fire Detection System (MSFDS) along with Visual Basic to receive information was used and a general interface for supervised computer was designed in his study.

Viguria et al. [14] built an aerial/ground robot team applied to fire detection. They used a disturbed market based algorithm, called S+T and coordinated in between aerial and ground vehicles. Their simulations showed that if the number of services increased, communication and energy requirement would also increase.

Nam Khoonet.al [15] developed an Autonomous Fire Fighting Mobile Platform (AFFMP) that is equipped with the basic fighting equipment that can patrol through the hazardous site via a guiding track with the aim of early detection for fire. The tasks for the AFFMP once it navigates out of the patrolling route include the obstacle avoidance, locating for more precise location of fire source using front flame sensor and extinguish the fire flame. Their work was focused on outdoor fire fighting robot.

For early warning, a vision sensor based fire detection method is proposed by Ko et al. [16]. They developed an AVM classifier for fire pixel verification.

Kim et al. [17] made a portable fire evacuation guide robot system and demonstrated that robot system can be thrown into a fire to gather information, locate displaced people and evacuate them. They designed the robot with aluminum compound metal for thermal resistance with waterproofing and an impact distribution frame for impact resistance.

White et al. [18] developed a vehicle mounted fire fighting system and included a series of flame and heat retardant coverings placed on all exposed parts of the system to prevent damage from exposure to extreme heat. Our effort is to develop an autonomous fire fighter robot which is constructed by locally available fire resistant and water-proof materials and performs on an arduino based fire detection and extinguishment algorithm. The robot is also fabricated so that it can save itself from fire by keeping safe distance from the source. At different distances from the fire and at different day time, the performance of the robot is evaluated by performing sensitivity tests on the sensors taking serial monitor readings in Arduino.

The vast majority of the work on fire fighting robots is focused on fire detection algorithms and less on the mobility of the robot inside the building such as climbing stairs and obstacles. Fighting fire within the building requires good thermal protection of the electronic components of the robots. This kind of protection has been considered in the proposed firefighting robot.

Taiser T [19], presented the design and assembly details of a robot developed to take part in an educational robotic competition. A control law based on Lyapunov theory was developed and implemented on a Programmable Logic Controller to control the robot.

Daniel J. et al. [20] conducted a design project to create an autonomous mobile robot that navigates through a maze searching for a fire (simulated by a burning candle), detects the candle's flame, extinguishes the flame, and returns to a designated starting location in the maze. The fire-fighting contest promotes interdisciplinary design and teamwork.

Kuo et al. [21] designed fire detection system using three flame sensors in the fire fighting robot. The adaptive fusion method was proposed for fire detection of fire fighting robot. He used computer simulation to improve the method to be adequate for fire detection. He incorporated the fire detection system in the fire fighting robot, and program the fire detection and fighting procedure using sensor based method.

Chee et al. [22] have conducted a good review paper about variety of technologies and state-of-the-art technology of fire fighting mobile robot. The paper also describes the first Malaysian designed and built fire fighting mobile robot, namely, MyBOT2000.

III. SYSTEM DESIGN

The electronic part is one of the vital parts in the development of fire fighting robot. It includes the several types of sensors, microcontroller, DC motor with wheel and Water pump. For the main structure of the robot, to get the preferred movement and speed, robot has two wheels at rear side and two wheels at front side. The wheels have the ability to stabilize the robot and make rotation until 360 degrees. The flame sensorson the sides and back of the robot were installed to detect the fire in all the directions. A water sprayer is positioned in the front to douse the fire at times when sensor senses any fire. In addition, mini camera was installed in front

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side of the robot to monitor the way and condition of the location and is linked to the smart phone.

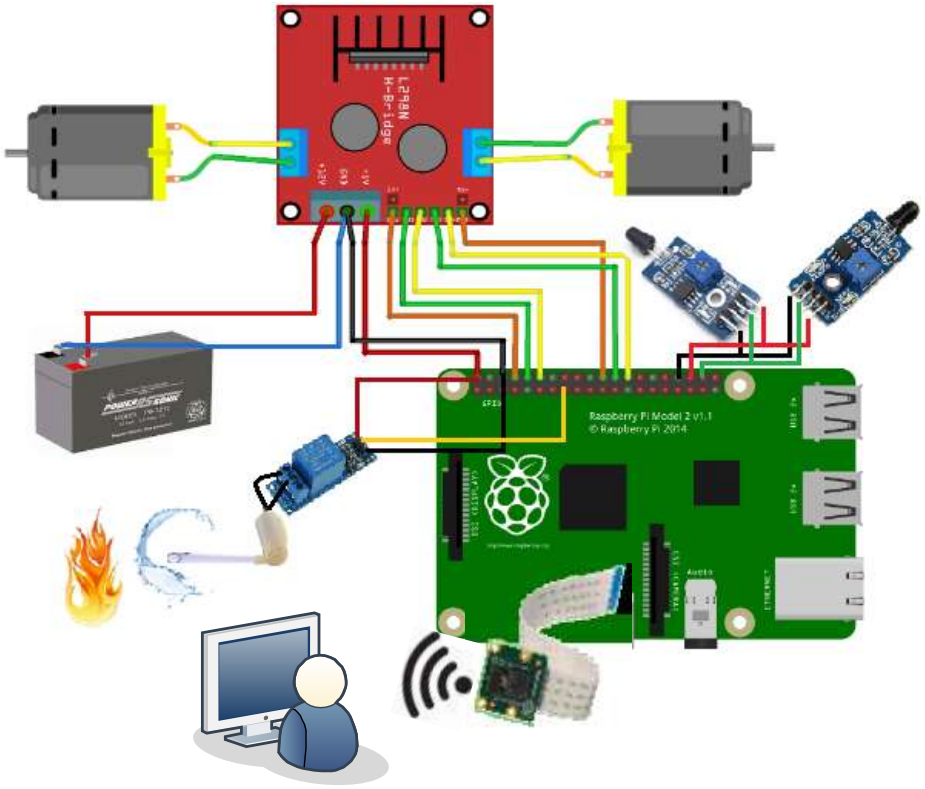

Fig. 1. System Architecture

Above fig. 1 shows the architecture diagram of the proposed robotstructure which consists of flame sensor as input of the system. Raspberry Pi 3B is used as a microcontroller that connected with other components. Motor Driver (L298N) is used to activate the moving of the servo motor. Flow of water and fire extinguisher were pump after being controlled by the operator. On the other hand, the operator can monitor the robot movements by using 5MP micro camera which connects to a smartphone through VLC player. Various components that we use in project are:

a. Flame sensor (YG1006):

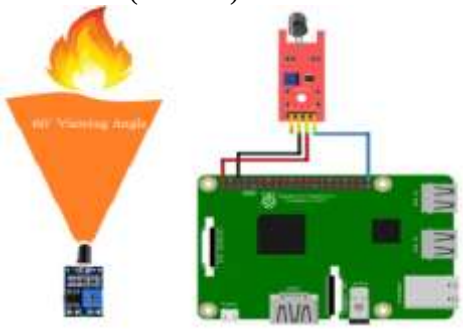

Fig. 2. Flame Sensor connection

In most fire-fighting robots, fire sensors perform an essential part in investigations, which are always used as robot eyes to discover sources of fire. It can be utilized to identify fire based on wavelength of the light at 760 nm to 1100 nm. The detection angle and distance are roughly 60 degrees and distance 20 cm (4.8V) to 100 cm (1V) respectively. Flame sensor has two signal pins that are Digital Output (DO) and Analog Output (AO). DO pins will give two kind of information that it's has flame or non-flame while AO pins will detect exact wavelength of different light.

b. DC motor with L298N Driver:

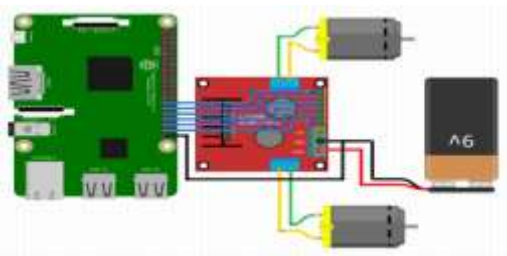

Fig. 3. DC Motor Driver Connection

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DC geared motor with rubber wheel are suitable material for this project. This DC motor are suitable to replace 2 WD and 4 WD car chassis. The working voltage for DC motor is around 5V to 10 V DC. While the ratio of the gear is 48:1. Suitable current for this motor is 73.2 mA. DC motor is used to move the robot to the fire location. L298N driver module is a motor driver for controlling two DC motors or one stepping motor.

c. Water pump:

Fig. 4. Water Pump

The water pump is important part in this robot as it will pump water or soap to extinguish the fire depending on the class of fire that occurs. Small-size and light-weight category of water pump has been selected for use in this project.

IV. SYSTEM PROGRAMMING

In this section some scripts are mentioned that were actually used in the system programming. Basic script to move wheels in directions is:

```
public void moveWheels(int leftPct, int rightPct)
  {
    //Left wheels
    int leftSpeed = getMotorSpeed(Math.abs(leftPct));
    if (leftPct > 0)
    {
      left.forward(leftSpeed);
    }
    else if (leftPct < 0)
    {
      left.backward(leftSpeed);
    }
    else
    {
      left.brake();
    }

    //Right wheels
    int rightSpeed = getMotorSpeed(Math.abs(rightPct));
    if (rightPct > 0)
    {
      right.forward(rightSpeed);
    }
    else if (rightPct < 0)
    {
      right.backward(rightSpeed);
    }
    else
    {
      right.brake();
    }
  }
```

b. Basic script to sense fire, move towards it and put on water pump is:

```
public void handleGpioPinDigitalStateChangeEvent(GpioPinDigitalStateChangeEvent event) {
System.out.println(" --> GPIO PIN STATE CHANGE: " + event.getPin() + " = " + event.getState());
          if(fs1.isHigh())
            myLed1.low();
          else if(fs1.isLow()){
            myLed1.high();
            for(int i=0;i<4;i++)
              mc.turnLeft(movement_speed);
             mc.brake();
            for(int i=0;i<4;i++)
              mc.forward(movement_speed,0);
            mc.brake();
            mypump.high();
            try{ Thread.sleep(3000);
}catch(Exception ex){}
            mypump.low();
          }
        }
    });
```

V. SNAPSHOTS

Firefighting robot has been developed to find the location of fire and extinguish it. This robot has an ability to find the location of fire by using flame sensor. The 3 flame sensor is functioning to sense the location of fire. All 3 sensors are connected to Raspberry Pi, which controlled the movement of DC motor.In the front, a water pump outlet is fixed to spray water in case of fire detection. Table 1 show the robot action depending on the sensors input for any movement.

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Table 1: The robot action using sensor input

Sensor Input							Robot Action
A_0	A_2	A_3	A_4	A_5	A_6	A_7	
0	0	0	0	x	x	x	stop
0	0	0	1	x	x	x	Turn Left
0	0	1	1	x	x	x	Turn Right
0	1	1	1	x	x	x	Right U-turn
1	1	1	1	x	x	x	Straight

Below are few of the pictures of the robot model that is developed.

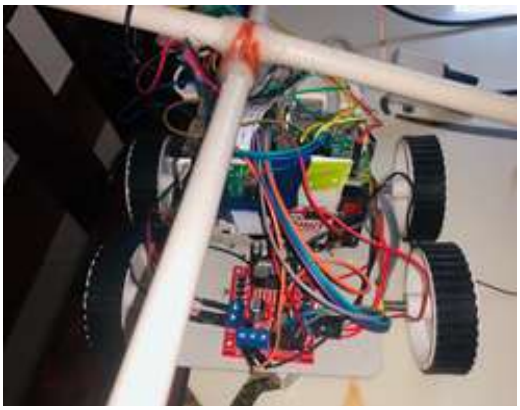

Fig. 5. Robot Hardware (Top View)

Fig. 5 and Fig 6 shows the model from top and front view. The connections are clear between the L298N driver, RPi and the DC Motors. The pipes were used to hold wiring of flame sensors. A micro camera is also visible from the front view.

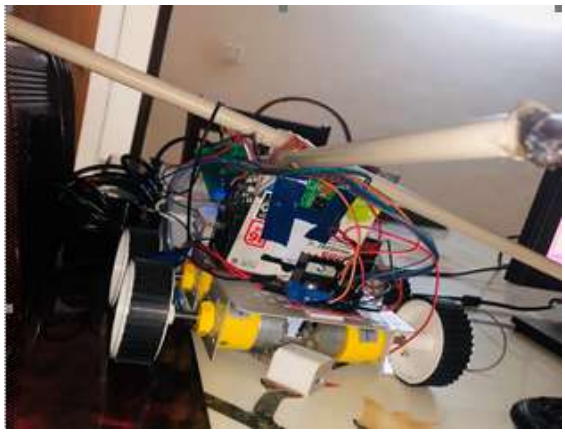

Fig. 6. Robot Hardware (Front View)

Below Fig. 7 shows the coding classes that were developed for various actions of robot. The connectivity of classes can be seen there. The programming IDE is BlueJ software and Java codes were developed as a programming tool. The OS running in RPi is a variant of Linux and monitor connection is through VGA wire.

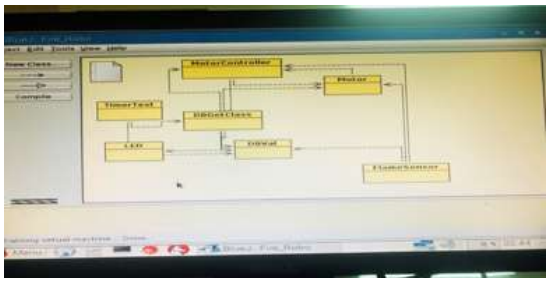

Fig. 7. System Class Design

VI. CONCLUSION

The Fire Fighting Robot is fabricated with locally available materials and some tests are done to observe its effectiveness at different situation. Experimental work has been carried out carefully on the Raspberry Pi3 based micro controller model. The result shows that higher efficiency is indeed achieved using the embedded system. This work has been inspired by the zeal to develop an embedded based model that can sense fire and douse them in real time.

In the current condition it can combat fire just in the proximity and not in all the rooms. It tends to be stretched out to a genuine fire extinguisher by integrating a fan by the carbon dioxide cylinder and by making it to douse flames of all the room utilizing micro-controller programming. This gives us the chance to give to robots undertakings that generally people needed to do.

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