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ENHANCING FIRE RESPONSE IOT-ENABLED MONITORING AND CONTROL OF FIREFIGHTING ROBOTS

#1RANGAM ANUSHA, Assistant Professor
#2BODDULA CHANDU
#3BOLLI MADHAN
Department of Electronics & Communication Engineering
SREE CHAITANYA INSTITUTE OF TECHNOLOGICAL SCIENCES, KARIMNAGAR, TS.

ABSTRACT: Any region or place far away is very likely to be damaged by fire. Electrical short circuits can ignite devastating fires and create additional damage in areas such as garment stores, cotton mills, and fuel storage tanks. Regardless of how bad things get, fires always kill people and cost a lot of money. Robotics technology is the most effective approach to monitor people's health, defend financial interests, and keep the environment clean. An embedded structure governs how a firefighting robot functions and is assembled. This gadget can look at fires, extinguish them, and investigate an area all by itself. The robot can be used to manage emergencies. Because of how it is designed, this robot can detect and extinguish fires before they spread.

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 The National Crime Records Bureau (NCRB) reports that more than 1.2 lakh persons died in fires in India between 2010 and 2014. Even though many safety precautions have been implemented to prevent fires, these common and predictable human-caused tragedies nonetheless occur on occasion. We must hire unstable workers to keep people safe and extinguish fires in the event of an emergency. Fires will always cause damage and loss of property, and new safety measures will be implemented on a regular basis. Fires and hazardous gases continue to endanger rescue workers and those injured by natural catastrophes.

Robots are machines that are programmed to perform tasks that would ordinarily require humans or other machines to move in a variety of ways or repeat the same action. A large body of research has demonstrated that robots can be valuable in business, health, rehabilitation, and rescue operations [3, 4]. Throughout history, robotics has been applied in a variety of fields worldwide. Industrial robots are versatile manipulators capable of performing a wide range of activities on specialized materials, departments, machines, and instruments [4].

Because technology is rapidly increasing, particularly in the field of robotics, it appears that robots may soon replace firefighters. This would not only keep firefighters safe, but it would also improve their performance. Many firefighting robots have been developed and deployed around the world, but they have had little impact on the ongoing conflict. The great majority of robots merely perform basic tasks to assist, such as looking for fires or battling them from a distance. There is a firefighter robot designed for houses that can assist those in need and extinguish flames without endangering people.

In this study, we advise developing a firefighting robot using the Raspberry Pi 3B microcontroller board. For the most part, this robot's job is to transform into an autonomous support vehicle capable of finding and extinguishing fires. Many types of vehicles can be employed to extinguish bush and home fires [5].

The robot we discussed can operate autonomously or with a remote control. These robots make it easier to identify fires and help people in need, while also protecting firefighters. To put it another way, if robots were present, firefighters might not

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have to face as many perilous situations. Because of its compact size and ability to manage itself, the robot can also be employed in hazardous environments such as tunnels or nuclear power plants, where flames might ignite in small spaces.

II. LITERATURE REVIEW

Robotic firefighting systems can be employed in both residential and commercial settings, where mishaps are more prone to cause fires [8-10]. Many sensors' performance is increased by integrating intelligent algorithms or soft computing technologies into the Arduino microcontroller platform [11-12].

Su et al. [13] employed AFA, or the Adaptive Fusion Algorithm, to develop an automated approach for detecting fires. In his research, he combined the Multisensor Fire Detection System (MSFDS) with Visual Basic to collect data and create a general interface for a computer that would be monitored.

Viguria et al. [14] organized an aerial/ground robot team to detect fires. S+T, a market-based algorithm that had been tampered with, was used to organize vehicles both on the ground and in the air. The simulations demonstrated that there is a clear relationship between the quantity of services and the amount of information and energy that individuals require.

Nam Khoonet et al. [15] developed the Autonomous Fire Battle Mobile Platform (AFFMP). It has a leading track and only the most basic combat equipment. Once the AFFMP leaves the preset patrol route, they must navigate around any barriers, extinguish the fire, and use a front flame sensor to accurately determine the source of the fire. They focused their efforts mostly on the outdoor firefighting robot.

Ko et al. [16] developed a vision sensor-based fire detection system to provide early notification. They created an AVM classifier to test fire pixels.

Kim et al. [17] developed and tested a portable fire evacuation guiding robot system that may be deployed during a fire to aid people exit the building. The robot was designed with an impact dispersion framework to increase its resistance to impacts. It was also constructed of an aluminum alloy metal to withstand heat and water.

To mitigate the damage that high temperatures could cause, White et al. [18] developed a vehicle-mounted firefighting system with various flame- and heat-resistant coatings on all of its exposed elements. Our goal is to create an autonomous firefighting robot that uses an Arduino-based application to extinguish and locate fires. It will be constructed using fire- and water-resistant materials readily available in the area. Furthermore, the robot is designed to keep itself safe by maintaining a proper distance from the fire source. To determine how well the robot performs, its sensors are subjected to stringent testing, and Arduino collects serial monitor values at varied firing distances and times of day.

The majority of the research on firefighting robots focuses on building algorithms for detecting flames. The robots' ability to move around inside structures, particularly when climbing up and over barriers, is not given as much consideration. To prevent building fires from starting, the electrical components of robocops must be properly shielded. This level of safety was considered when the proposed firefighting robot was being constructed.

Taiser T [19] discussed the design and assembly guidelines for a robot developed to compete in an educational robotics tournament. To move the automaton, a control rule based on Lyapunov theory was developed and implemented using a programmable logic controller.

Daniel J. et al. [20] developed a mobile robot that can move on its own. This robot navigates a maze by detecting and extinguishing a bright flame that appears to be a fire. After that, it returns to its initial place in the maze. The firefighting competition encourages design teams to collaborate and incorporate ideas from other sectors.

Kuo et al. [21] developed the fire detection equipment by integrating three flame sensors to the firefighting robot. The adaptive fusion method was developed for firefighting robots to locate

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fires. Computer simulations were performed to make the method for finding fires more likely to work. A sensor-based method was employed to program the fire detection and fighting procedure, which was then added to the firefighting robot.

Chee et al. [22] done an excellent job of putting together a summary of all the new and varied technologies that are employed in mobile firefighting robots. The report also talks about the MyBOT2000, which is the first mobile fireman robot created and constructed in Malaysia.

III. SYSTEM DESIGN

In the process of constructing firefighting robots, the electrical aspect is highly crucial. Parts include a water pump, multiple kinds of sensors, a computer, and a DC motor with a wheel. Two wheels on the back and two wheels on the front make up the robot's main structure, which gives it the movement and speed it needs. Stabilizing the robot can be done with wheels that can turn in any direction. There are flame monitors on the robot's sides and back so that it may locate fire from all sides. A water sprinkler is set up ahead of time to put out any fire that a sensor picks up. On the front of the automaton, a small camera was mounted so that its position and condition could be tracked.

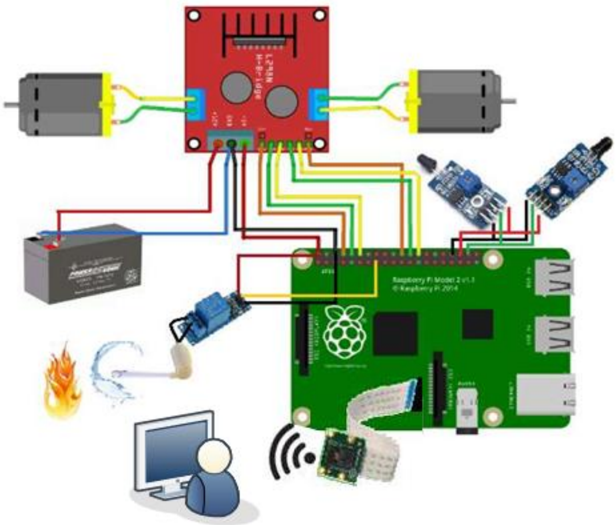

Fig. 1. System Architecture

The suggested robot structure contains a design diagram in Figure 1 that depicts how a flame sensor would be attached to the system. The Raspberry Pi 3B processor makes it easy for other elements to talk to each other. The servo motor obtains its power from a motor driver (L298N). The guy running the fire and water apparatus regulated the flow of water and flames. On the other hand, the user can view what the robot does by connecting a smartphone to a 5MP tiny camera with VLC player. Among the various pieces that make up the project are the following:

Flame sensor (YG1006):

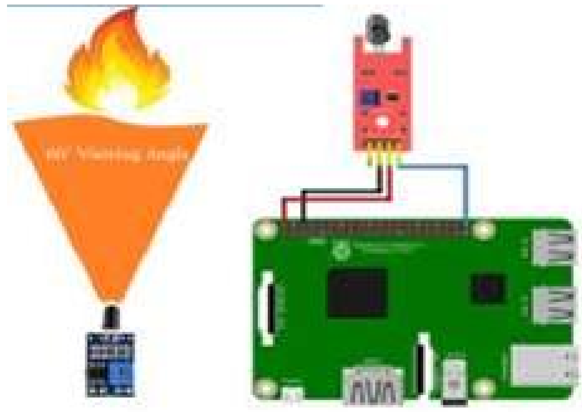

Fig. 2. Flame Sensor connection

Most firefighting robots employ fire monitors, which operate like eyes, to identify fire sources. The frequency of the light, which runs from 760 to 1100 nanometers, is utilized to find fires. A detection angle of roughly 60 degrees is utilized to find the distance between 20 cm (4.8V) and 100 cm (1V). The flame monitor includes two signal ports, one for analog output (AO) and one for digital output (DO). DO pins send two different types of information. First, they notify you if the thing is burning. AO pins tell you the exact wavelength of different light sources.

DC motor with L298N Driver:

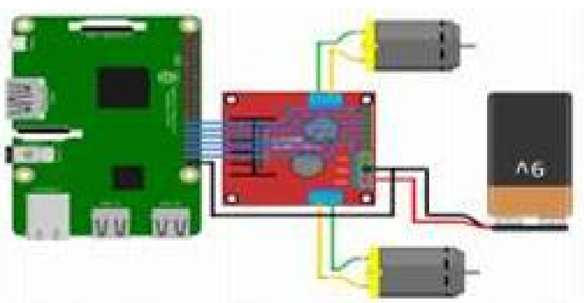

Fig. 3. DC Motor Driver Connection

The optimum parts for this project are a DC geared motor and rubber wheels. This DC engine can be used instead of a chassis for an automobile

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with two or four axles. The direct current in a DC motor is between 5 and 10 volts, and the gear ratio is 48:1. The best current for this motor is 73.2 mA. An electric motor (DC motor) propels the robot toward the fire. Two DC motors or one stepped motor can be controlled by the L298N driver module.

Water pump:

Fig. 4. Water Pump

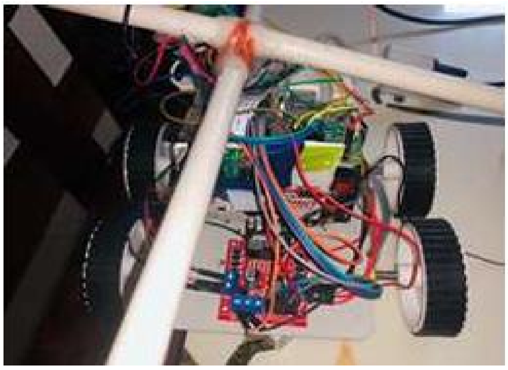
The water pump on this robot is incredibly crucial because it will either pump water or soap to put out a certain sort of fire. One compact and light water pump worked nicely for this project.

IV. RESULTS

Flame-fighting robots that can find and put out fires have started to be constructed. This robot is equipped with a flame scanner that can find the cause of a fire. Right now, the three flame monitors are trying to find the fire. Each of the three sensors was connected to the Raspberry Pi, which controlled how the DC motor moved.In the event of a fire alarm, water will be released from a front water pump outlet. In Table 1, you can see the path that the robot took based on the sensor data for each movement.

Table 1: The robot action using sensor input

Here are a few photographs that show the robot model completely put together



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

Fig. 5. Robot Hardware (Top View)

In Figures 5 and 6, the model is displayed from both the front and the top. It is evident that the L298N driver, the Raspberry Pi, and the DC motors are all connected. The wire for the flame sensor was buried inside the pipes. In addition, the front view shows a small camera.

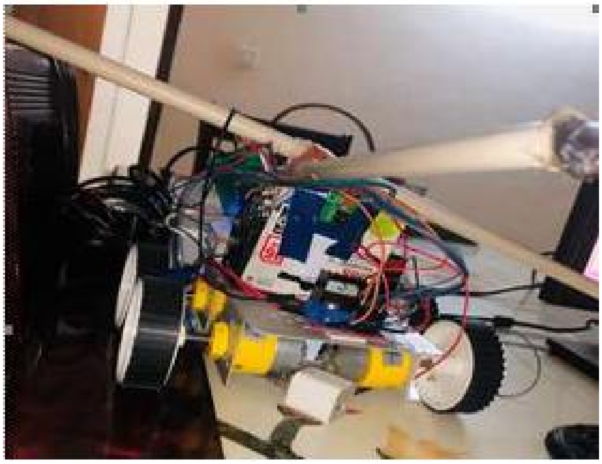


Fig. 6. Robot Hardware (Front View)

Figure 7 displays the numerous code classes that were built for the robot's distinct tasks.

It is apparent that there is class link. Java codes were designed so that individuals could program, and BlueJ software is the IDE. The operating system that runs on the Raspberry Pi is Linux, and it is VGA hooked to the screen.

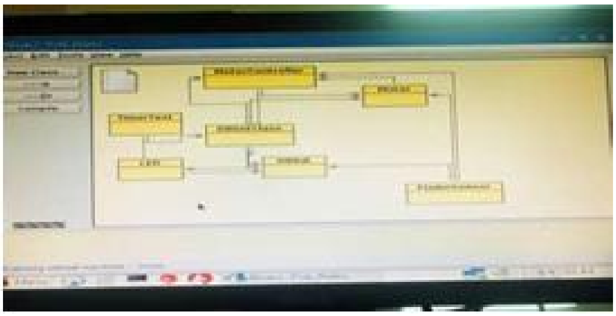


Fig. 7. System Class Design

V. CONCLUSION

Locally sourced materials are used to make the firefighting robot, and its performance is evaluated in a variety of environmental settings. A number of studies have been done on the Raspberry Pi3-based microcontroller type. The results suggest that the embedded system makes work more efficient. The main purpose of this project was to construct an integrated model that could identify and put out flames in real time.

At this time, it can only fight by releasing energy near up and not throughout the whole region. It may be transformed into a true fire extinguisher by setting the microcontroller to put out all the flames in the room and connecting a fan to the carbon dioxide cylinder. Because of this, duties that used to be done by people can now be handed to automata.

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