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A Development of AI based Fire-Fighting Robots with Fire Department Alert System

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Abstract: *With the advancement of technology especially in Robotics it is very much possible to replace/support humans with robots for fighting the fire. This would improve the efficiency of fire fighters and would also prevent them from risking human lives. The Fire Fighting Robot based on Artificial Intelligence is going to be developed, which will automatically sense the fire and start the water pump. Sensors will sense the fire in the Building and then it will give order to Control system. Control System with Emergency Alarm will start playing siren with high voice to alert the people for fire and also give order to Fire department web portal. Then this Fire department Web portal will play the alert tune to give alert notification for fire department employee with location information which is previously stored in fire-department's web portal. This Web portal will give alert to fire-fighting robot. Robot will find out the fire place. Then the Robot will reach at the fire place and do their work to spray water. The Robot will do their basic work to blowing the fire until the fire department reaches to the place and this robot will also be used by fire fighters for the places in which the human can't reach, so the robot will go there and do fire fighting work. So, this paper contains real life implementation of AI based fire fighting robot with fire department alert.*

Keywords: *Flame Sensor, Fire detection, Fire, Fire Department, Fire-Fighting Robot, Artificial Intelligence, Fire-Fighting, Web Portal, Control System*

I. INTRODUCTION

This system is used to save and protect human hectic life from the fire. All people knew that fire will took big form from the small amount of form. This system will provide basic facility to protect people through fire. Using this system people save their and innocent animals life through the fire. This system contains three main modules like; 1) Control System, 2) Fire Department's Web portal and 3) Fire-Fighting Robot.

This system contains many hardware components like; Arduino, Flame Sensors, Node MCU, L298 Motor Driver, DC Motor, Buzzer, Hydraulic Pump, Jumper Cables, Wheels etc^[1]. Also contain software components like; Web-pages, Wi-Fi Connection, PHP Programming language, JSON, Embedded C Programming etc.

Flame sensors are mounted inside the room and set there at particular distance from each other. When fire will be occurred inside the room, this mounted flame sensors will sense that fire and will send the information to particular control system that was connected with that sensors.

Control system will get fire detection data from room's flame sensors. After that control system play the high voice siren to alert the people to leave that place immediately where fire was occurred. At the same time Control system send the fire related data to the fire department's web portal using registered control id that was stored in fire department's database. Control system must be connected with Wi-Fi to send and receive data from fire department's web portal and Flame sensors respectively.

Fire department's web portal will get fire data from Control System. Fire department's web portal will be developed using different programming language like; HTML, CSS, BOOTSTREP, PHP, JSON etc. That portal will give alert notification to the fire department's employee. Fire department's employee will be found that which control system detect the fire and will get information of that control system's user and its address/location. Using this information fire department reach at fire place and extinguish the fire. Fire department web portal also give alert data to the robot.

Fire-Fighting robot will get fire data from fire department's web portal and do their work to extinguish the fire. Fire-Fighting robot's some work is based on AI like; automatically find out the fire location, reach towards that fire location, spray the water etc. So, no need to give any external order to the robot. Fire-fighting robot will find out particular fire place and reach at that fire place using the rotating the wheels itself. If robot's flame sensors detect the high fire then spray the water on fire or try to extinguish the fire. Whenever the fire department can't reach the particular fire location at that time fire-fighting robot do their work to extinguish the fire. Fire fighting robot will be made using EPE^{[3][4]} water proof material so robot can be made safe from fire. EPE water proof

material cost is near about 5000 - 6000 per Square foot and role size is 100 m. Maximum Temperature of EPE water proof material is 70⁰ Celsius.

Overall using “AI based Fire-fighting Robot with Fire Department Alert” system people can save their life from fire. If people are not available at the time when fire was occurred then also this system will work completely. In this system the user needs to take care of the thing that the system must be connected with the Wi-Fi. So, this paper contain implementation of AI based fire fighting robot, control system and fire-department web portal.

II. METHODOLOGY

This section defines information related to different implementation methods for fire-fighting Robots. It also includes different methodologies to implement this “AI based Fire-fighting Robot with Fire Department Alert” system is Mechanical schematics, followed by hardware description and the finally on the programming design. All parts were assembled together and experiments were then performed to determine the optimal distance of fire fighting robot to extinguish the fire.

A. Mechanical Design Structure

Google SketchUp software and AutoCad^[12] is used to produce 3D and 2D schematic diagram. In this system robot and control system structure is designed by hand using simple fundamental logics. For the main structure of the robot, to get the preferred movement and speed, Fire fighting Robot have two wheels at rear side and one small wheels at centred. The body of Robot is made up using ply board. The body of fire fighting Robot contains holes that make it easier to mounting of various type of sensors and other mechanical components. The three flame sensors were installed at front of the robot to detect the fire. The structure of fire distinguisher robot is as shown in Fig.1. Fire fighting robot contains in the autonomous robot implementation category^[11].



Fig.1 Fire fighting Robot Model

B. Hardware Implementation

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 wheels and Water pump. Fig. 3 shows the block diagram of the Fire fighting Robot operation which consists of flame sensor as input of the system. Arduino Uno is used as a microcontroller that connected with other components. Motor Driver (L298N) is used to activate the moving of the gear motor. Fire fighting robot was operated using Wi-Fi and also use Node MCU to give Wi-Fi connectivity to Fire fighting Robot.

- 1) **Arduino UNO:** The Arduino UNO^[5] is a microcontroller board based on the ATmega328. It has 20 digital input/output pins (of which 6 can be used as PWM outputs and 6 can be used as analog inputs), a 16 MHz resonator, a USB connection, a power jack, an in-circuit system programming (ICSP) header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. Arduino used in robot and control system for gave Input or take data as a output.

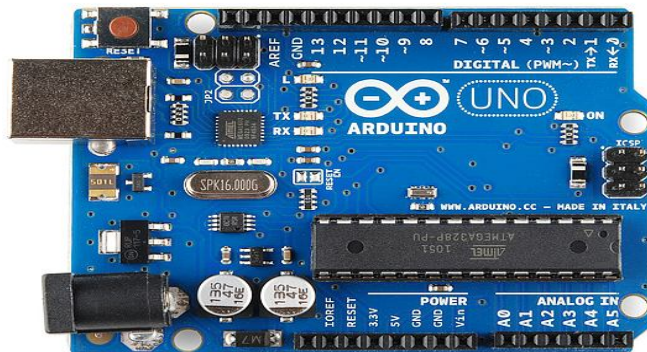


Fig.2 Arduino UNO^[13]

- 2) **Node MCU:** Node MCU is an open-source firmware and development kit that helps you to prototype or build IoT product. It includes firmware which runs on the ESP8266 Wi-Fi SoC (System-on-a-Chip) from Espressif Systems, and hardware which is based on the ESP-12 module. The firmware uses the Lua scripting language. The node MCU board supports directly flashing from USB port. It combines features of WIFI access point and station + microcontroller. These features make the Node MCU extremely powerful tool for Wi-Fi networking. It can be used as access point and/or station, host a webserver or connect to internet to fetch or upload data. Node MCU used in Robot and control system to provide Wi-Fi connectivity.



Fig.3 Node MCU^[14]

- 3) **L298 Motor Driver:** The L298 is an integrated monolithic circuit in a 15- lead Multiwatt and PowerSO20 packages. It is a high voltage, high current dual full-bridge driver designed to accept standard TTL logic levels and drive inductive loads such as relays, solenoids, DC and stepping motors. Two enable inputs are provided to enable or disable the device independently of the input signals. The emitters of the lower transistors of each bridge are connected together and the corresponding external terminal can be used for the connection of an external sensing resistor. An additional supply input is provided so that the logic works at a lower voltage. Two DC Motors controlling using one L298. Controlling two DC Motors using L298 enable pins.

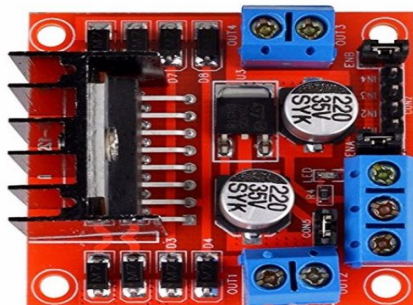


Fig.4 L298 Motor Driver^[15]

- 4) *Flame Sensor*: In most firefighting robots, fire sensors perform an essential part in investigations, which are always used as robot eyes to discover sources of fire^[1]. 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. In this project one flame sensor^[7] used for different purposes 1) Room's Flame Sensors- which was built in room and 2) Robot's Flame Sensors- which was built in robot head. Room's flame sensor connected with the Control system Arduino and Robot's flame sensor connected with the robot's Arduino.

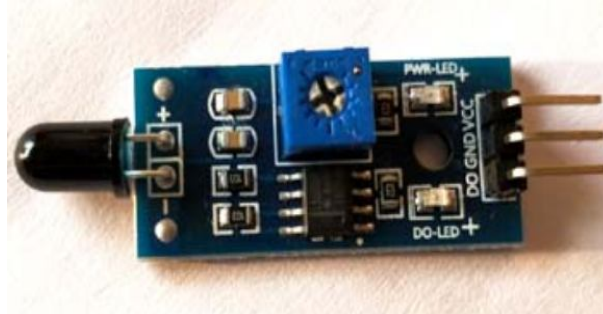


Fig.5 Flame Sensor^[16]

- 5) *DC motor and wheels with L298 Motor Driver*: DC motor driver^[6] with rubber wheels are suitable material for this project. The working voltage for DC motor is around 5V to 10 V DC. DC motor is used to move the robot to the fire location. DC Motors operated using L298 motor control driver.

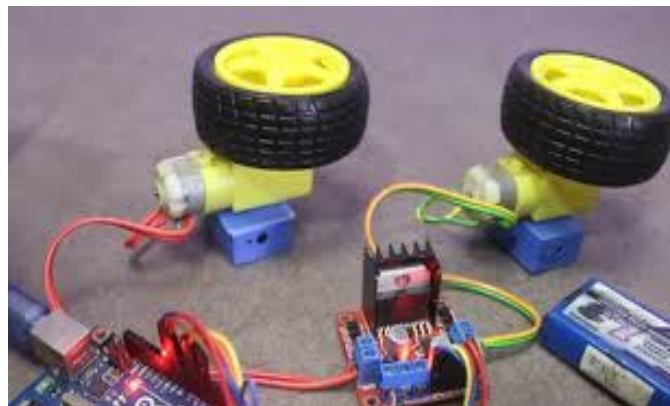


Fig.6 DC Motor Controlling using L298 Motor Driver

- 6) *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. Moreover, it has low noise, high effectiveness and minimal power consumption. In this project we used hydraulic water pump to spray the water. Working voltage for this water pump is around 12V with the working current 0.8A. Hydraulic water pump put inside the water tank and using pipe robot spray the water.

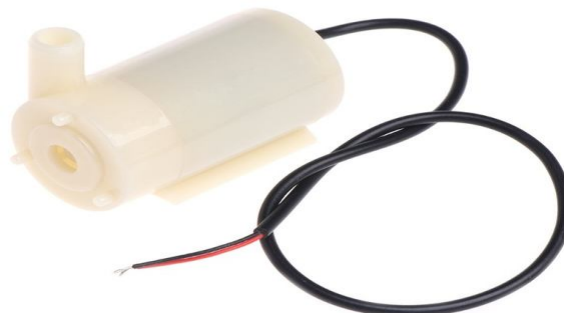


Fig.7 Hydraulic Water Pump^[17]

III. FLOW OF CONTROL

Fig.8 shows the flowchart of Fire Fighting Robot using ultrasonic sensor and flame sensor. These codes will be used to program the movement of fire fighting robot to find the fire location.

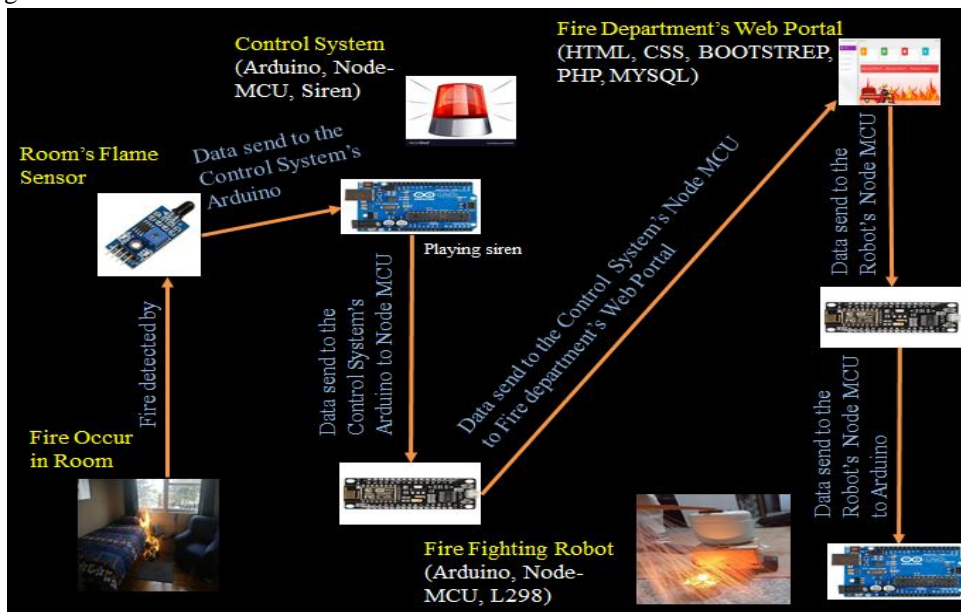


Fig.8 Flowchart of Fire fighting Robot

Control system receives the data from the room's flame sensor or plays the buzzer on the room to alert the people and at the same time also send data of fire to the web portal of fire department.

Fire department web portal contains the information of buyers of control system with their address. It also contains the fire department employee information with username and password field. When the fire department's employee opens the web portal, the employee login page is viewed with username and password field. When the fire department web portal get alert from the control system at that time it also plays the alert tune to alert the fire department employee. It also highlights the field of the control system user and display the location information as shown in fig.9. Also send the fire data to the particular control system which is connected with particular fire-fighting robot.

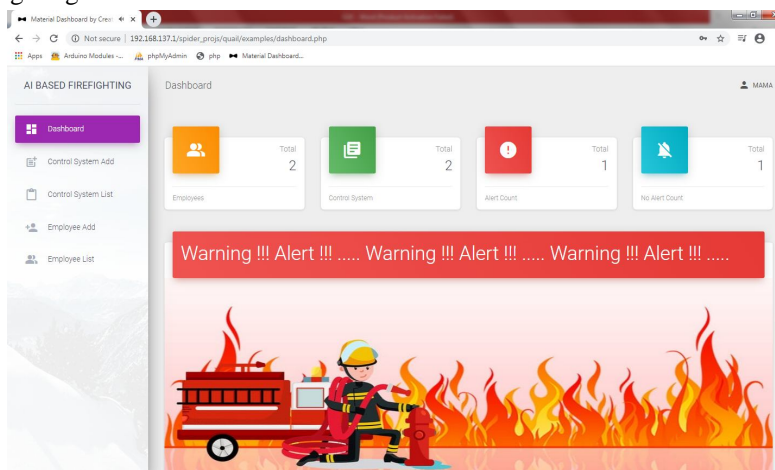


Fig.9 Fire department's Web portal Dashboard

Fire-fighting robot has been developed to find the location of fire and extinguish it. Fire-fighting robot has an ability to find the location by using flame sensors. The flame sensor is functioning to sense the location of the fire. Flame sensors are connected to Arduino Uno, which controlled the movement of DC motor.

First of all the fire fighting robot move left and right side to find out the fire when left, right and center flame sensor found the fire, then the robot move forward towards that fire and the DC motor (fire fighting robot) will stop at 50 cm from the fire. The operator will be extinguishing the fire using spray water from the particular distance.

A. *Playing Buzzer In Control System Depends On Data Of Flame Sensor*

Control system get alert or fire data from the room's flame sensor. Room's flame sensor data input to the arduino and the output of that data is playing the buzzer to give alert to the people to leave that fire place.

B. *Time to Extinguish the Fire Depends on Distance of Firefighting robot with Fire Source*

Time of extinguish is depended on the distance of stopping the robot and also depended on the intensity of the fire. If the intensity of fire is high then firefighting robot will be stopped far to that fire location. In this paper contain the robot stop at particular distance far from the 50cm of the fire place and also retrieve the intensity value is < 70 . If fire-fighting robot satisfies these two conditions then only fire will be extinguished.

C. *Alert Fire Department Employee Using Control System*

Alert the fire department employee through the fire department's web portal. Control system in arduino get fire data from the room's flame sensor and pass output that data node MCU through fire department's web portal using control system ID. Control system ID is primary key so that the fire department employee can easily identify the control system's location address and its users' information. Also, the fire department's web portal contains the high voice tune to alert the fire department employee.

IV. ADVANTAGES OF THE SYSTEM

- A. We all know that fire take big form from the small spark also, so we have to take action to extinguish the small form of fire. So, this system provides basic first-aid facility to protect when the fire is in a small form and easily extinguish the small form of the fire.
- B. Using control system (buzzer) people get alert to leave the place when the fire will be occurred.
- C. Fire-fighting robot is based on AI so no need to give any external order to the fire-fighting robot.
- D. Fire-fighting robot contains some amount of AI so, the firefighting robot does not harm any human.
- E. Fire department web portal contains all the details of control system users. These details were stored at cloud, so fire department employee can access all users' details from any place at any time.
- F. Fire department web portal contain the alert tune to alert the fire department employee to get notification of fire with its location address.
- G. Fire department web portal is secured by using the username and password fields, so no other people will miss use the web portal.
- H. Using this system people can control the fire without help of any person, when fire is in small form. So the fire cannot take big form and harm any human.

V. DISADVANTAGES OF THAT SYSTEM

- A. This system may not work without Wi-Fi or internet connectivity.
- B. Firefighting robot is not containing that much intelligence to identify the fire occurrence is from the electrical short-circuit or any other sources.
- C. Maintenance of the Flame sensors, Control system and firefighting robot must needed in periodic manner.
- D. If this system will be used at big place then the sensor must be designed according to the requirements of that place.

VI. FUTURE ENHANCEMENT

- A. We can use smoke detector sensors^[9] or temperature detector sensors^[8] which replaces room's flame sensors or Robot's flame sensors.
- B. Room's sensors and robot's sensors may be different. It can be used according to requirement.
- C. Using IR sensors or Ultrasonic sensors, the object or obstacles can be detected.
- D. The system can be made wireless using Bluetooth or Wi-Fi.
- E. The wireless cameras can be mounted on surface of the robot to scan surroundings. Many sensors mounted surrounding to detect flame, human casualties and fire extinguishing if the Wateriest turbine connects with the robot^[10].

VII. CONCLUSION

This paper contains design and working of “AI based Fire-fighting Robot with Fire Department Alert” system. Also describe all the components used to make robot and also show which programming languages were used to make fire-department web portal. This paper also contains the flow diagram to move robot towards the fire based on AI. This paper contains the advantages and disadvantages of that system. Future enhancement of that system also discuss in this paper. Workflow of “AI based Fire-fighting Robot with Fire Department Alert” system also shows in this paper.

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