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FIRE EXTINGUISHING ROBOT

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Abstract:

This paper presents the design and implementation of a firefighting robot leveraging Arduino microcontroller technology. The robot is equipped with various sensors and actuators to detect and extinguish fires autonomously. The core functionalities include fire detection using temperature and flame sensors, obstacle avoidance through ultrasonic sensors, and fire suppression using a water pump mechanism. The Arduino microcontroller coordinates the robot's movements, sensor data acquisition, and decision-making algorithms. The system's effectiveness and reliability are demonstrated through experimental tests, showcasing its potential for assisting in firefighting operations in hazardous environments.

As technology advances at a swift pace, there is a noticeable shift towards automation in various fields. However, the profession of firefighting remains perilous, with individuals frequently facing life-threatening situations. A significant number of fatalities in this line of work can be attributed to the presence of hazardous gases encountered during firefighting operations.

Index Terms – Arduino Uno, Flame sensor, Servo motor, DC Motor.

I. INTRODUCTION

Robotics stands out as one of the most rapidly advancing branches of engineering in contemporary times as well as the intension to eliminate the influence of human involvement. These machines are employed to alleviate labor- intensive tasks and mitigate risks associated with hazardous work environments, as well as to operate in areas that are difficult to access.

From the past few years, we can see there are almost 62 deaths per day due to fire accidents, according to the National Crime Record Bureau. This is why the fire extinguisher robot that can detect and extinguish fire on its own is more in need, with the development of this device significantly enhances the ability to protect the ability to protect human lives and property, achieving a higher success rate while minimizing fire related damage. As engineers, our objective was to create a system capable of autonomously detecting and extinguishing fires as well as providing the option for manual intervention through a remote control equipped with a live streaming camera.

II. PROBLEM STATEMENT

The aim of the fire extinguishing robot project is to design, develop, and implement an autonomous robotic system capable of accurately detecting, navigating to, and efficiently extinguishing fires in hazardous and inaccessible environments. This practice has increased significantly in contemporary times, within the heavy production sectors.

Over the past few years, data form the National Crime record Bureau indicates that fire accidents result in nearly 62 fatalities each day. This alarming statistic underscores the urgent need for a fire extinguisher robot capable of autonomously detecting and extinguishing fires. The development of such a device has the potential to significantly enhance the protection of human lives and property while minimizing the damage caused by fires. As engineers, our objective was to create a system that not only autonomously identifies and extinguishes fires but also allows for manual operation via remote control, complete with live streaming capabilities. Additionally, our design focuses on reducing air pollution by ensuring that fires are extinguished more swiftly.

III. OBJECTIVES

The objective is to identify fire using flame sensors. Upon detection of fire, the system will impulsively actively extinguishing measures.

IV. PROPOSEDARCHITECTURE

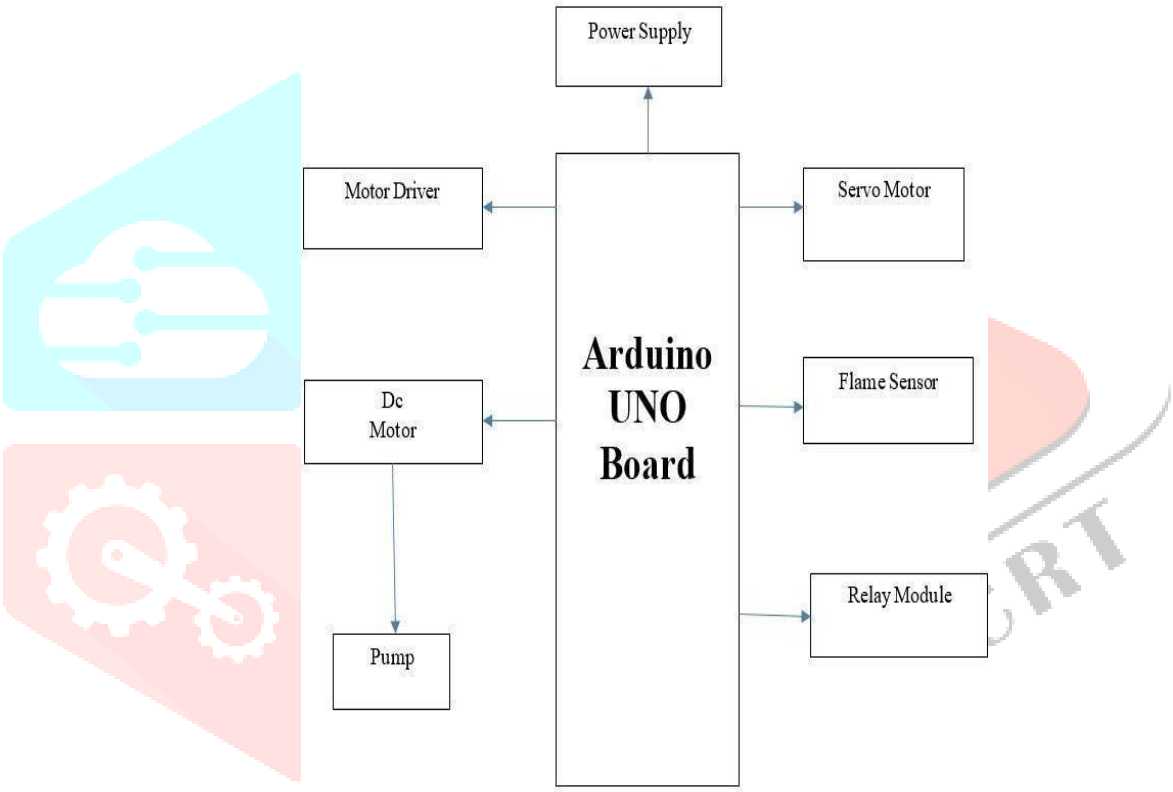

Fig.1 Proposed Architecture

- **Flame Sensor**

  A flame sensor detects the presence of a flame using infrared or ultraviolet light. It provides a digital or analog signal based on the presence of a flame and typically operates at 5V or 12V. Commonly used in fire detection systems, industrial monitoring, and home automation, it offers quick response times to enhance safety and trigger alarms or safety measures.

  when the sensor detects heat or light from the flame, it generates a tiny electric current. If the sensor doesn't sense a flame (meaning no current is detected), it assumes something is wrong and cuts off the fuel supply. This safety feature ensures that fuel is only provided when there's a proper flame to burn it.

Fig. 2 Flame Sensor

- **Arduino Uno**

  The Arduino UNO is a versatile and beginner- friendly microcontroller board based on the ATmega328P chip. It operates at 5V and includes 14 digital I/O pins, of which 6 are capable of delivering PWM output. With32 KB of flash memory, 2 KB of SRAM, and1 KB of EEPROM, it has ample resources for a wide range of projects. The board is programmed via a USB connection and is compatible with numerous shields and sensors. Its robust support community and extensive resources make it an ideal choice for both novice and experienced makers looking to develop electronic prototypes and learn about programming.

  Easy to Program: You write code on a computer, then upload it to the Arduino. This code tells the board what actions to perform.

  Flexible: It has a range of pins that let you connect various devices like LEDs, sensors, and motors, so you can create projects ranging from simple light displays to more complex robots.

  Community and Resources: Arduino Uno has a huge online community, with tons of tutorials and projects available to learn from, making it ideal for beginners and hobbyists.

Fig. 3 Arduino Uno R3

- **Relay Module**

  A relay module is an essential component that enables low-power microcontrollers, like those in Arduino projects, to control high-power devices safely. It consists of one or more relays mounted on a circuit board, often featuring additional elements such as diodes for protection and opto couplers for electrical isolation.

Fig. 4 Relay Module

- **Motor Driver**

  The motors and the control circuits are interfaced with by motor drivers. While the controller circuit operates on low current signals. A large quantity of current. Thus, vehicle drivers' job is to adept low-current regulates signal before converting into a higher-current signal It is able to power a motor. LN293D is the motor driver that is employed in this scenario. Motor drivers act as an interface between the microcontroller (like an Arduino or Raspberry Pi) and the motor, as microcontrollers

  generally cannot provide the power that motors need. The driver takes the low- power control signal from the microcontroller and amplifies it to drive the motor.

Fig.5 Motor Driver module

- **Servo Motor**

  An electrical device designed to accurately rotate an a object. If you need to rotate an object to a specific angle or move it certain distance. It consists just of basic motor that through the servo system. An ultrasonic sensor is positioned such that the ultrasonic sensor can see over the servo motor left and right to detect any barriers.

  Components: A typical servo mechanism includes a motor, a sensor (like an encoder), a control circuit, and a feedback system.

  Control System: The control system receives instructions (usually in the form of pulses) about the desired position or movement and adjusts the motor's behavior accordingly.

  Feedback Loop: The feedback loop is the defining feature of servos. It continuously monitors the

  position (or speed) and compares it with the desired value, adjusting the motor's action to reduce error.

Fig. 6 Servo Motor

- **DC Geared Motor (12V, 60 rpm)**

  A gear assembly is attached to the motor of geared DC motor. These are mostly employed to increase torque by slowing down a sequence of gears. This notion in which a vehicle's speed is decreased via gear s, but Its torque increase is referred to as gear reduction. These motors are employed in the construction of wheels. A DC gear motor is a motor powered by direct current (DC) with an attached gearbox. The gearbox reduces the speed of the motor while increasing its torque (turning force). This setup allows the motor to move heavy loads more slowly but with more power.

V. IMPLEMENTATION AND WORKING

- **Fire Detection**
  Flame Sensor: Flame sensors are capable of detecting light in the IR spectrum (usually between 760 nm and 1100 nm), typical of fire and flames. When a fire is detected, the sensor sends a signal to the Arduino

- **Movement and Navigation**
- **Motor Driver Module**: The Arduino cannot directly drive motors due to limited current. Instead, it sends signals to a motor driver (like the L298N), which powers the motors based on these signals.
- **DC Motors and Wheels**: The robot's wheels are powered by DC motors, allowing it to move toward the fire once it is detected. Using multiple flame sensors can help the robot orient itself in the direction of the strongest flame source by comparing sensor readings.

- **Fire Extinguishing**

- **Servo Motor and Water Pump**: The Arduino triggers the servo motor to position the water pump in the direction of the detected flame. The water pump is subsequently engaged to release water, with the objective of putting out the fire.

- **Relay Module**: A relay module might be used to regulate the operation of the water pump, as it generally operates at a higher voltage than the Arduino can provide directly. Once close to the fire, the Arduino activates the water pump and servo motor to spray water on the fire. The robot continues this process until no flame is detected. A fire extinguishing robot is a specialized autonomous or remotely controlled machine designed to detect, approach, and extinguish fires, particularly in hazardous or hard-to-reach areas. These robots are equipped with sensors, cameras, and extinguishing mechanisms, such as water, foam, or gas dispensers, to fight fires while keeping human firefighters out of danger.
  Sensors: Firefighting robots have infrared and thermal imaging cameras to detect heat and flames. Some models also include gas sensors to detect smoke or hazardous chemicals.
  Navigation: Robots are equipped with wheels, tracks, or legs for movement, and they use GPS, LIDAR, or sonar to navigate around obstacles. These allow the robot to move toward the fire without human intervention.
  Autonomy vs. Remote Operation: Some robots operate autonomously using AI and pre-set programming, while others are remotely operated by a human controller for real-time decision-making.
  Water or Foam: Many fire extinguishing robots have onboard water or foam tanks and a nozzle system to spray water or foam directly onto flames.
  Remote Communication: Robots typically include communication system that enable them to transmit temperature data and provide status updates.
  Feedback Loops: Robots often have feedback mechanisms to adjust their actions based on real-time fire behavior. If the fire intensity changes, they can alter the extinguishing pattern, pressure, or move closer or farther.
  Industrial Facilities: In oil refineries, factories, and warehouses, where fires can be hazardous and challenging for humans to handle.
  Urban and Structural Fires: They can enter burning buildings and navigate through narrow corridors, fighting fires within apartments or office spaces.

VI. CONCLUSIONS

Fire can result in significant destruction and loss of life and property. In certain situations, it may be challenging for firefighting personnel to reach the fire site due to the presence of explosive materials, smoke and extreme temperatures. This leads to the conclusion that robots can be deployed in scenarios where human safety is compromised. These robots are capable of functioning in environments that are inaccessible to humans, allowing for rapid response times. In such conditions, fire extinguishing robots

can play a crucial role in combating fires. These robots should be operated by remote personnel situates at a safe distance from the fire scene, utilizing remote communication systems. The robots are designed to locate and address the fire efficiently and effectively, minimizing the time taken after detection.

VII. RESULT

The development of a fire-extinguishing robot typically involves testing its effectiveness in navigating environments, detecting fires, and deploying extinguishing mechanisms. Here's an outline of the factors that are commonly evaluated and potential results: A successful robot should be able to navigate complex environments (e.g., stairs, uneven ground) autonomously or semi-autonomously. Performance can vary based on terrain type, with challenges often seen in cluttered spaces. Ensure the robot reliably detects fire and high temperatures. Accurate and prompt detection of heat and flames is critical. Results show that combining infrared and thermal imaging sensors typically provides better detection accuracy, with reduced false positives.

Fig. 7: Model of Fire Extinguisher Robot

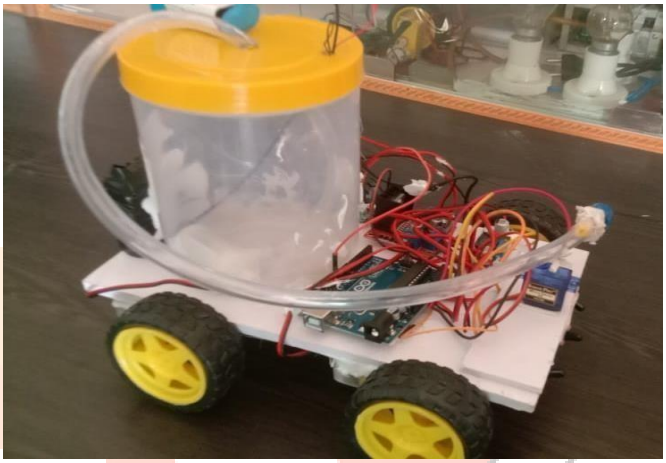

Fig. 8: Model of Fire Extinguisher Robot

Fig. 9: Image during the water sprinkling on fire

Fig. 10: Image during the water sprinkling on fire

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