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Automatic Fire Fighting Robot using Arduino

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ABSTRACT: Fire hazards demand rapid and innovative responses to ensure safety. This project outlines a fire-fighting robot controlled by an Arduino microcontroller, designed to autonomously detect and extinguish small-scale fires. The robot uses flame sensors or infrared (IR) sensors for fire detection, temperature sensors to measure heat intensity, and ultrasonic sensors for obstacle avoidance. A water pump and nozzle assembly act as the extinguishing system, effectively targeting flames in a controlled environment. The Arduino processes sensor inputs and directs the robot's movement using DC motors and a motor driver. This low-cost, accessible solution is ideal for educational and hobbyist purposes. Future developments could incorporate AI-based vision for remote operation, wireless connectivity for enhanced GPS for accurate navigation and sophisticated fire detection, increasing its application for home and business safety. This project demonstrates how Arduino may be used to develop workable, reasonably priced firefighting solutions for safer settings.

KEYWORDS: Fire-Fighting Robot, Sensors, Arduino Microcontroller, Fire Detection, Flame Sensor, Infrared (IR) Sensor, Water Pump Mechanism.

I. INTRODUCTION

One of the most frequent and hazardous risks encountered in both home and commercial settings is fire outbreaks. In order to minimize damage and save lives in fire crises, prompt action is essential. Human firefighters are frequently put at serious risk while using traditional firefighting techniques, particularly in situations involving hazardous chemicals, intense heat, or unstable structures. To address these challenges, robotics technology can be employed to create automated fire-fighting systems. A fire-fighting robot is a specially designed autonomous or semi-autonomous machine capable of detecting and extinguishing small fires. These robots serve as a first line of defence and can enter hazardous areas that may be unsafe for humans. They are particularly useful in environments like chemical factories, warehouses, and remote areas with limited human access. The creation of a small-scale, inexpensive firefighting robot is the main goal of this mini-project. The robot utilizes motorized wheels to move toward the danger zone and sensors to identify fire sources. When it reaches the fire, it triggers a suppression mechanism, usually a fan-based extinguisher or a tiny water pump. A microcontroller, such as an Arduino, powers the device. It operates as the robot's brain, processing sensor information and managing movement and extinguishing mechanisms. Other elements, such as ultrasonic sensors, aid in navigation and obstacle detection. This robot seeks to improve safety, can intervention, and show how simple electronics and programming can be used to solve practical issues by automating the detection and response to fire.

II.SYSTEM MODEL AND ASSUMPTIONS

An Arduino UNO microcontroller is used in the development of the automatic firefighter robot as the main component that controls and coordinates the complete system. It gets input data from a water level sensor that keeps track of the amount of water in the robot's tank and a fire sensor that detects the presence of fire. The Arduino interprets the input and turns on the water pump to put out the fire when the fire sensor detects flames. A servo motor is used to change the direction of the nozzle so that the water spray is precisely directed towards the fire source. The robot has four DC motors (M1, M2, M3, and M4) for mobility, enabling it to spin, move forward, and go backward as required. The L293D motor driver module provides the required current and control signals to these motors by acting as an interface between the Arduino and the motors. To guarantee uninterrupted operation of all electronic components, a dependable power source is supplied. The entire system is made to function independently, so once it is turned on, it can detect and put out flames without the need for human assistance. Real-time response to fire outbreaks is made possible by the

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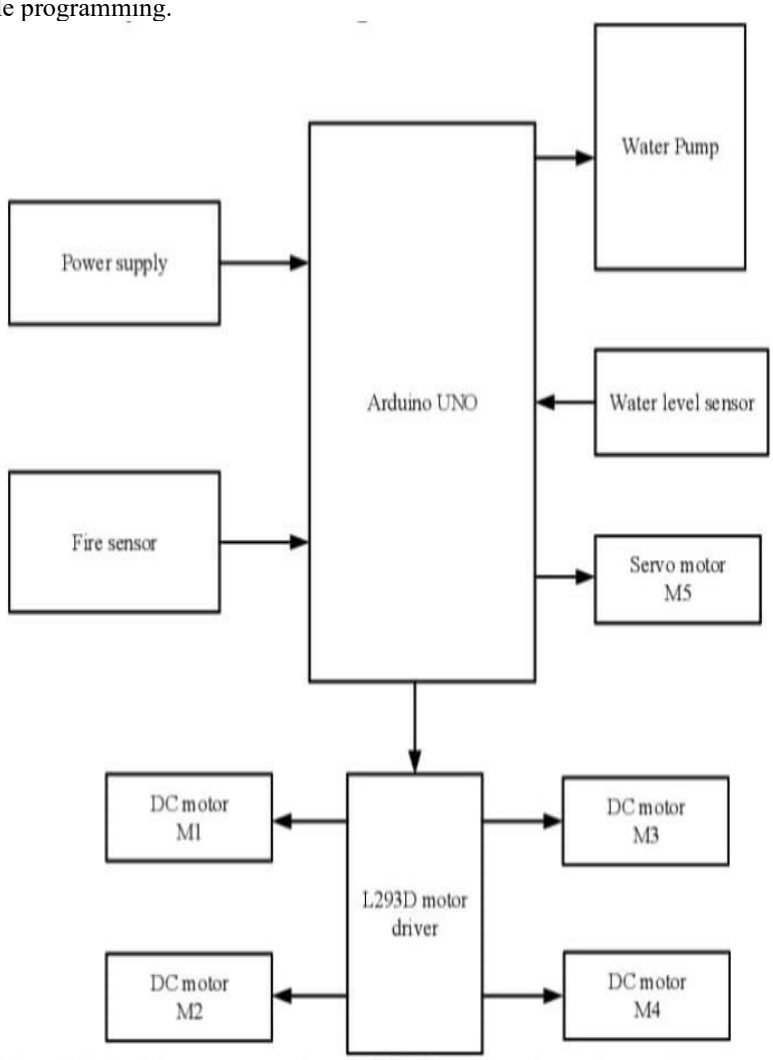
nearly instantaneous communication between the sensors, Arduino, motor driver, and output devices. In an emergency, this clever coordination enables the robot to respond swiftly and efficiently. The system is made to be small, energy-efficient, and adaptable to different types of fires. The robot's modular design also makes maintenance and upgrades simple. Furthermore, the Arduino UNO makes it simple to integrate with other sensors or connectivity modules in the future and permits flexible programming.



This system's performance boundaries are defined by a number of crucial assumptions that are necessary for its successful operation. In order to ensure that the robot can react before the fire spreads much, it is expected that the fire sensor has a dependable detection range that allows it to detect flames within a few meters. It is assumed that the power source is steady and adequate to sustain the Arduino, sensors, motors, and water pump operating all at once. In order to avoid mobility issues and preserve balance, it is also required that the robot works on a comparatively level, obstacle-free surface. Since the robot lacks a system for automatically refilling the water tank while in use, it must be filled before deployment. The robot's entire weight, including the water tank and its electronics, should be supported by the DC motors' sufficient torque and speed. For the Arduino to make the right judgments, it is believed that the fire sensor and the water level sensor would provide accurate and timely signals. To guarantee real-time reaction, there should be very little communication delay between the components. The robot is made especially for semi-controlled outdoor areas or inside settings where environmental elements like wind and heavy rain won't have a big impact. It is considered that the components and materials utilized can withstand a brief period of moderate heat exposure without experiencing any problems. Lastly, the system makes the assumption that there aren't any unforeseen outside disruptions that could impair the robot's ability to operate in an emergency, including big moving objects or abrupt changes in the landscape.

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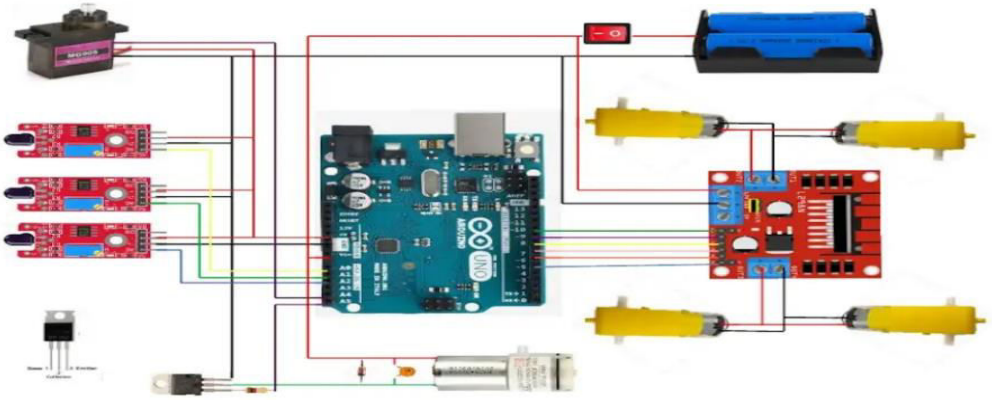
III. CIRCUIT DIAGRAM



IV.COMPONENTS AND WORKING

Arduino UNO:

The Arduino Uno is a popular microcontroller board based on the ATmega328P microprocessor. It is essential in many robotics and automation projects due to its simplicity, low cost, and versatility. The board operates at 5V and has a clock speed of 16 MHz. It has 14 digital input/output pins (six of which provide PWM output), 6 analog input pins, and a USB interface for programming via the Arduino IDE. In a fire-fighting robot, the Arduino Uno serves as the core control unit, handling all components and allowing the robot to detect and kill fires.

Flame sensor:

The flame sensor serves as an essential element in a fire-fighting robot, tasked with identifying both the existence and direction of fire. It functions as the robot's 'eyes,' enabling it to detect flames from a distance and respond accordingly. Typically, a flame sensor is composed of a photodiode or phototransistor that is responsive to infrared (IR) light emitted by flames, particularly within the wavelength range of 760 nm to 1100 nm. While some flame sensors utilize specialized IR receivers or UV sensors, the most prevalent type found in basic fire-fighting robots is the IR flame sensor. These sensors can identify a flame from a distance of approximately 80 cm to 1 meter, contingent on the fire's size and the sensor's sensitivity. In fire-fighting robots, the flame sensor is generally positioned at the front or mounted on a rotating base to facilitate a broad scanning range. When a flame is detected within the sensor's field of view, it generates an analog or digital signal indicating the presence of IR light associated with fire.

BO gear motor:

The BO gear motor wheel plays a crucial role in enabling movement for a fire-fighting robot. It integrates a compact DC gear motor with a lightweight wheel, facilitating smooth motion on flat terrains. Within the robot, two or four BO motors are affixed to the chassis and managed by a motor driver module linked to an Arduino. Upon detecting a fire, the Arduino transmits commands to the motors, allowing the robot to advance, retreat, or pivot towards the flame. The gear reduction mechanism within the motor ensures sufficient torque for precise and stable maneuvering during firefighting operations.

Mini Water Pump 5V:

The 5V Mini Water Pump is utilized in a fire-fighting robot to extinguish minor fires. It functions on a 5V DC power supply and is managed by the robot's Arduino via a relay module. Upon detection of fire by the flame or temperature sensor, the Arduino triggers the relay, activating the water pump. The pump retrieves water from an onboard reservoir and disperses it through a nozzle aimed at the fire. This mechanism enables the robot to effectively extinguish flames

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autonomously. The pump is lightweight, energy-efficient, and well-suited for portable robots designed for indoor or small-scale fire emergencies.

Servo motor:

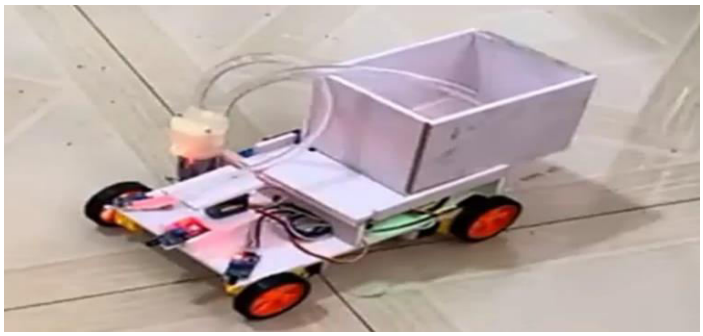
A servo motor utilized in a fire-fighting robot facilitates accurate movement and controlled positioning. Unlike standard motors, a servo motor rotates to a designated angle as instructed by the Arduino or microcontroller. In the context of a fire-fighting robot, the servo motor is typically connected to the nozzle or water-spraying apparatus. Upon detecting a fire, the servo motor modifies the nozzle's orientation, enabling the robot to precisely aim and direct water at the flames. This capability to regulate the angle and position of the extinguisher significantly enhances the robot's efficiency, particularly when addressing fires situated at varying heights or angles. Additionally, the servo motor is energy-efficient and maintains its position securely once adjusted, which is crucial during firefighting tasks. In summary, the servo motor contributes flexibility, accuracy, and dependability to the robot, ensuring that fires are effectively targeted and extinguished without unnecessary water or energy consumption.Battery: In a fire-fighting robot, the battery serves as the primary power source for all its components. Generally, a lithium-ion battery is preferred due to its lightweight nature, reusability, and ability to deliver consistent voltage and current. This battery powers the Arduino microcontroller, flame sensors, temperature sensors, motor drivers, DC motors, water pump, and servo motors, enabling the robot to function wirelessly without reliance on an external power source. Upon activation, the battery channels electricity through voltage regulators and circuits, ensuring that each component receives the appropriate power levels. Throughout its operation, it facilitates the motors in propelling the robot, energizes the sensors for fire detection, and operates the water pump or fan for extinguishing fires. A fully charged battery equips the robot with sufficient energy to search for, detect, and combat fires for a specified period.

Relay module:

A channel relay module is essential for managing high-power devices such as water pumps and exhaust fans. Initially, the robot's sensors detect the presence of fire and transmit signals to the microcontroller. The microcontroller, which operates at a low voltage, activates the relay module. The relay functions as an electronic switch, enabling high voltage to be safely directed to the firefighting equipment, thereby protecting the microcontroller from potential high current damage. By utilizing multi-channel relays, the robot can simultaneously control various devices, including a water sprayer and a cooling fan. Additionally, relay modules provide electrical isolation, enhancing the safety and reliability of the system. Their compact design, affordability, and ease of programming render them particularly suitable for robotic applications. Once the fire is extinguished, the microcontroller deactivates the relay, thereby disconnecting the power supply. In summary, the channel relay module is crucial for the effectiveness and safety of the firefighting robot.

Motor driver:The motor driver is essential to a firefighter robot's ability to move and be controlled. It serves as a conduit between the robot's motors and the microcontroller, like an Arduino or Raspberry Pi. The motor driver boosts the signals to a level appropriate for powering DC or servo motors because microcontrollers can only supply low-power signals. By varying the voltage and employing pulse width modulation (PWM), the motor driver can regulate the rotation and speed of each motor, enabling the robot to move in various directions. The motor driver of a firefighter robot can also control other parts, such as a motorized water-spraying system, in addition to controlling the wheels for navigation. The driver makes sure the robot can effectively reach the fire and carry out its firefighting duties with accuracy by controlling several motors at once.

V. RESULT AND DISCUSSION



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Under controlled circumstances, the automatic firefighter robot was successfully created, put together, and tested. Small fires started with candle flames were successfully identified by the fire sensor during testing, and the robot promptly moved in the direction of the source. The fire was effectively put out when the servo motor precisely directed the nozzle and the water pump turned on to spray water. On level terrain, the robot moved smoothly thanks to the DC motors' sufficient speed and steadiness. The pump was kept from running dry by the precise monitoring of the tank's water level by the water level sensor. Without any discernible lag, the Arduino UNO controlled the actuators and analyzed sensor data effectively. Overall, the system successfully accomplished the main goal of autonomous fire detection and suppression by exhibiting good coordination between sensing, decision-making, and action. During early trials, minor tweaks were needed to fine-tune the servo motor angles for accurate water aiming.The project's outcomes demonstrate how an Arduino UNO combined with basic sensors and actuators may provide an affordable and efficient firefighting robot for indoor or semi-controlled settings. Nevertheless, throughout testing, some restrictions were noted. The fire sensor struggled to identify distant or tiny fires and had a limited detection range, indicating that adding a thermal camera or more sensors could increase dependability. The robot's mobility was adequate on level floors but less efficient on crowded or uneven surfaces, suggesting that stronger obstacle avoidance or suspension technologies are required. The operational duration was also restricted by the water capacity, underscoring the significance of pre-deployment monitoring and replenishing. Additionally, while the robot's heat resistance proved adequate for little fires, extended exposure to larger fires may harm delicate electronics. Notwithstanding these drawbacks, the system operated effectively within the parameters of its design, demonstrating the potential of Arduino-based autonomous robots for early-stage fire detection and suppression in small-business and residential settings.

VI.CONCLUSION

To sum up, the Arduino UNO-based automatic firefighter robot effectively proved its capacity to recognize and put out tiny fires on its own in controlled settings. The robot's ability to react swiftly and efficiently to fire outbreaks was made possible by the combination of motorized movement, a servo-controlled water pump, and fire and water level sensors. For indoor applications, the system proved to be dependable, economical, and effective, requiring little human involvement. The total performance satisfies the main goal of early fire suppression, despite certain restrictions in terms of detecting range, terrain adaptability, and water capacity. A solid basis for future advancements and improvements in autonomous firefighting systems is established by this study.By adding cutting-edge sensors like infrared cameras or flame detection modules, the robot's capabilities might be greatly expanded in the future, increasing its precision and range. The addition of navigation and obstacle detection methods, including AI-based vision systems or ultrasonic sensors, may also allow the robot to function in more challenging surroundings. The robot would be more resilient to bigger fires if its water storage capacity was increased and its component heat resistance was improved. With these upcoming improvements, the automatic firefighter robot can transform from a basic prototype into a dependable safety tool for a range of commercial, industrial, and residential uses, significantly advancing early fire prevention initiatives.

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