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AUTOMATIC FIRE EXTINGUISHER ROBOT

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Abstract:

The rise in human population and technological advancement has led to an increase in fire accidents and hazards. Adverse conditions and the physical limitations of human beings make fire extinguishing a challenging and risky task, often resulting in loss of life. Robotics emerges as a solution to protect both the environment and human lives. The automatic fire extinguisher robot, a hardware model, is designed to extinguish fires during accidents, thereby reducing errors and limitations encountered by humans in firefighting tasks. This paper presents a system comprising a NodeMCU, fire sensor, servo motor, motor driver, and water pump. The vehicle is equipped with a water tank and pump, enabling it to dispense water as required. The NodeMCU board controls the system, while the fire sensor detects the intensity of the fire, determining its location. Motor movements in various directions are controlled based on these sensor values. The paper discusses modern technologies for detecting and extinguishing fires remotely. A robotic vehicle is developed, controllable manually, via an Android phone connected through an IoT network, or using a Wi-Fi module. Additionally, it utilizes a water pump to spray water at the desired pressure.

Keywords: MCU, Fire Sensor, Servo Motor, Water Pump, Remote Control.

I. Introduction:

In contemporary times, fire accidents are prevalent, posing challenges for firefighters to save lives. Continuous human surveillance for accidental fires is impractical, necessitating the intervention of fire extinguisher robots. These robots detect fires remotely, particularly beneficial in industries with higher risks of accidental fires. The proposed vehicle detects and extinguishes fires automatically using smoke and humidity sensors. It integrates gear motors, a motor driver for movement control, and a relay circuit to regulate the pump. Upon detecting fire, the robot communicates with a microcontroller through a WiFi module. Equipped with a water jet spray, the robot can direct water towards the fire. It incorporates obstacle avoidance capability to navigate through obstacles towards the fire source. Communication between the mobile phone and robot occurs via Bluetooth, facilitated by a graphical user interface (GUI) for robot control. Upon WiFi connection, the mobile phone sets the module name and baud rate.

II. LITERATURE REVIEW

In the current era, fire extinguishing presents a significant challenge. Several authors have explored various techniques for fire extinguishment. Ratnesh Malik et al. have developed an approach towards a fire extinguisher robot. The robot is designed and constructed to autonomously extinguish fires. It

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integrates concepts such as environmental sensing, awareness, and proportional motor control. Utilizing ultraviolet, infrared, and visible light, the robot detects environmental components. It is capable of combating tunnel fires, industrial fires, and military applications. Ultraviolet sensors are employed for fire detection. Upon fire detection, the robot activates an alarm and releases sprinkles of water on the flame through an electronic valve. This robot automates fire detection and extinguishment using sensors and a microcontroller, making it suitable for high-risk areas where human lives are at stake. The project aims to design, build, and test a robot capable of extinguishing building and basement fires, replacing firefighters in highly dangerous situations. This robot enhances firefighter safety by enabling remote fire extinguishment and scouting of burning buildings before human intervention. While the robot design prioritizes robustness, the primary goal is to demonstrate proof of concept.

H.P. Singh et al. developed the control system for an autonomous industrial fire extinguishing mobile robot. The system consists of two optically isolated DC motors and utilizes infrared sensors for analog to digital conversion. Five infrared sensors are employed, two for robot motion control and three for flame detection. The extinguisher includes a DC water pump and water container, with infrared sensors detecting flames and the microcontroller controlling the extinguishing process.

Swati Deshmukh et al. developed a wireless fire extinguisher robot capable of detecting and extinguishing fires while maneuvering in multiple directions. Light-dependent resistors are utilized for fire detection, providing sensitivity to even small fires. The robot offers security for homes, buildings, factories, and laboratories, serving as an intelligent multisensory-based security system with integrated fire extinguishing capabilities.

III. SYSTEM DESCRIPTION

In this system, an advanced fire extinguisher robot is designed to independently detect and extinguish fires. With the world increasingly embracing technology and autonomous vehicles, firefighters face significant risks to their lives. Fires can spread rapidly and lead to explosions, especially in cases of gas leakage, posing serious threats to both property and human lives. To address these challenges and safeguard the lives of firefighters, our system offers a solution.

The firefighting robotic system is powered by an Arduino Uno development board, incorporating various sensors and mechanisms for effective operation. Key components include:

1. **HC-SR04 Ultrasonic Sensor**: Mounted on a servo motor, this sensor is utilized for obstacle detection and navigation through free paths. It ensures the robot can maneuver safely through its environment.

2. **Fire Flame Sensor**: This sensor detects and approaches fires, allowing the robot to identify and target areas in need of extinguishment.

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3. **Water Tank and Spray Mechanism**: Equipped with a water tank and spray mechanism, the robot is capable of extinguishing fires effectively. The water spraying nozzle, mounted on a servo motor, ensures coverage of maximum area, while a water pump facilitates the pumping of water from the main tank to the nozzle.

IV. OPERATIONAL PROCEDURE

1. **Detection**: The fire extinguisher robot autonomously navigates its environment using the HC-SR04 ultrasonic sensor, detecting obstacles and identifying free paths for movement.
2. **Fire Detection**: Upon encountering a fire, the fire flame sensor detects its presence and signals the robot to approach the fire source.
3. **Extinguishment**: Once in proximity to the fire, the robot activates its water spray mechanism, directed by the servo-mounted nozzle. Water is pumped from the main tank to the nozzle, effectively extinguishing the flames.
4.

V. ADVANTAGES

- **Autonomy**: The robot operates independently, reducing the need for human intervention in hazardous firefighting situations.
- **Efficiency**: With sensors for obstacle detection and fire detection, the robot can navigate through environments and effectively target fire sources for extinguishment.
- **Safety**: By minimizing the exposure of firefighters to dangerous environments, the system enhances overall safety during firefighting operations.
- **Cost-Effectiveness**: The system offers a cost-effective solution compared to traditional firefighting methods, reducing risks and potential damages.
-

VI. FUTURE ENHANCEMENTS

- **Integration with Wireless Camera**: Incorporating a wireless camera would enable remote monitoring of firefighting operations, providing real-time visual feedback to operators.
- **Enhanced Sensing**: Further improvements in sensor technology can enhance the robot's ability to detect and respond to fires in diverse environments.
- **Advanced Navigation**: Implementing advanced navigation algorithms can optimize the robot's movement and response to dynamic firefighting scenarios.

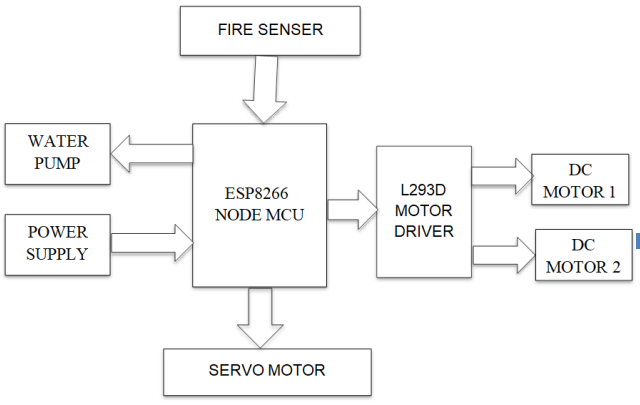

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Fig. 1. Block Diagram

III. METHODOLOGY

The methodology for developing the fire extinguisher robot involves detailing the block diagram, software, and hardware descriptions. This chapter provides insights into the functioning of the robot, its specifications, and the block diagram. Subsequent chapters will delve into the hardware components, followed by software development.

A. Working of Fire Extinguisher Robot

Fires can originate from various sources in remote areas or industrial settings, such as garments factories, cotton mills, or fuel storage facilities. These incidents can lead to significant damage, both financially and environmentally, posing a threat to lives and property. Robotics emerges as a solution to safeguard human lives, assets, and the environment. A fire extinguisher robot is designed with an embedded system to autonomously navigate through modeled floor plans while actively scanning for flames. In normal circumstances, the robot serves as a path guide, but in emergencies, it functions as a firefighting device. These robots are crucial for detecting fires before they escalate, potentially reducing risks and working alongside firefighters to mitigate damage and save lives.

The fire extinguisher robot is equipped with a water tank and pump mounted on its body, controlled by signals from a microcontroller. Operation is managed through proper signals from the transmitting end, with the entire process overseen by the microcontroller. A motor driver IC facilitates motor control by the microcontroller. Future enhancements could involve integrating a wireless camera to enable remote monitoring of the robot's operations on a display.

The primary objective of this project is to design a firefighting robot using RF (radio frequency) technology for remote operation. The robot is equipped with a water tanker and pump, controlled via wireless communication for water dispersal.

The speed of a DC motor can be regulated across a broad range by adjusting either the variable supply voltage or the pulse width modulation (PWM) signal. This versatility allows precise control over the robot's movements and actions, enhancing its firefighting capabilities.

IV. IMPLEMENTATION

A. HARDWARE DESCRIPTION

The implementation of the fire extinguisher robot involves the assembly of various hardware components, each serving a specific function within the system.

1. Power Supply:

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- A 7805 voltage regulation IC is utilized to provide a stable 5V direct current supply to the microcontroller. This ensures consistent and reliable power to the system.

2. Motor Driver IC:

   - The project employs the 293D dual H-bridge motor driver integrated circuit (IC). These ICs are crucial for controlling the four motors used in the project.
   - Two motor driver ICs are utilized, with each responsible for controlling either the front or rear motors of the robot. This configuration enables precise motor control and maneuverability.

3. Pump:

   - A 5V Brushless DC Pump serves as the actuator for maintaining a constant supply of water from the tank. This pump ensures efficient and controlled water dispersal during firefighting operations.

4. Motors:

   - The robot is equipped with 200 RPM DC Motors, which facilitate movement in forward, backward, left, and right directions. These motors are pivotal for the locomotion and navigation of the robot, enabling it to navigate through various terrains and obstacles effectively.

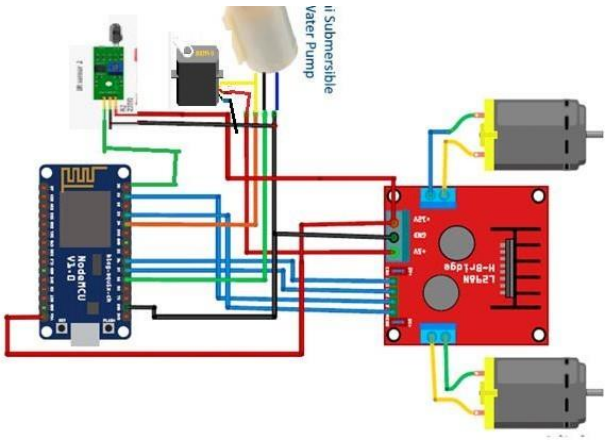

Fig. 2. Circuit Diagram

Overall, the hardware components work synergistically to enable the functionality of the fire extinguisher robot. Each component plays a crucial role in ensuring the robot's efficiency, reliability, and effectiveness in firefighting scenarios.

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1. **CIRCUIT DIAGRAM: B. HARDWARE DESCRIPTION**

2. Hardware Components :

- NODE MCU
- FIRE SENSOR
- SERVO MOTOR SG90
- WATER PUMP
- L298N Motor driver
- DC MOTOR 12V
- POWER SUPPLY

C. HARDWARE

Various components are employed for the operation of the robot, each facilitating different functions such as actuation, transmission, motion control, etc. To execute these functions, the following components are utilized, as explained below:

D. ESP8266 Node MCU The Node MCU is an open-source Lua-based firmware and development board specifically designed for IoT applications. It incorporates firmware that operates on the ESP8266 Wi-Fi SoC from Espressif Systems, along with hardware based on the ESP-12 module.

Node MCU ESP8266 Specifications Features:

- Microcontroller: Tensilica 32-bit RISC CPU Xtensa LX106.
- Operating Voltage: 3.3V.
- Input Voltage: 7-12V.
- Digital I/O Pins (DIO): 16.
- Analog Input Pins (ADC): 1.
- UARTs: 1.
- SPIs: 1.
- I2Cs: 1.
- Flash Memory: 4 MB.

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- SRAM: 64 KB.
- Clock Speed: 80 MHz.
- USB-TTL based on CP2102 is included onboard, enabling Plug n Play.
- PCB Antenna.
- Small-sized module to fit smartly inside IoT projects.

E. ESP32 The Dual-Core Processor The ESP32, the predecessor of ESP8266, features a built-in processor. However, due to the multitasking involved in updating the WiFi stack, most applications utilize a separate microcontroller for data processing and interfacing with sensors and digital input/output.

F. Programming NodeMCU ESP8266 with Arduino IDE Programming the Node MCU Development Board with Arduino IDE is straightforward and can be accomplished in 5-10 minutes. After installing the Arduino IDE on the computer, connect the Node MCU board using a USB cable and select the correct board and port within the IDE. With the appropriate settings configured, load the desired code and upload it to the board.

G. MOTOR DRIVER IC (L293D) The L293D is a dual H-bridge motor driver integrated circuit, serving as a current amplifier by taking a low-current control signal and providing a higher current signal to drive the motors. It contains two built-in H-bridge drivers.

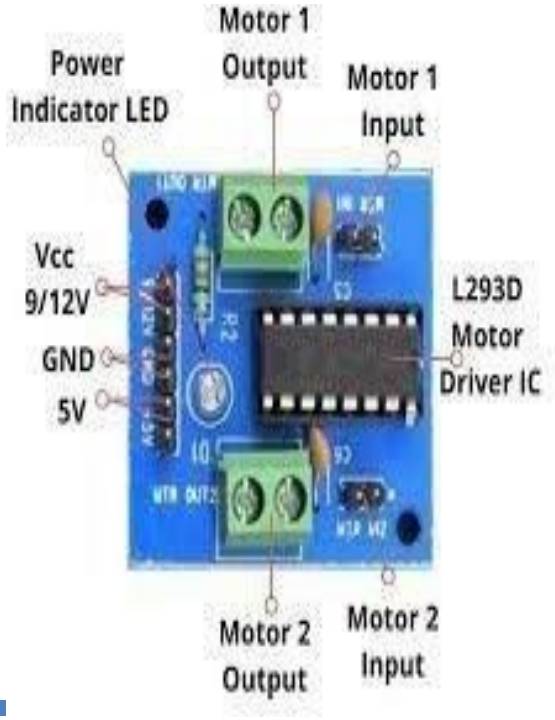

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Fig. 3. Motor driver

In the conclusion and future scope sections, you highlighted the successful development of a fire extinguishing robot and discussed its potential applications and future improvements. You also mentioned the advantages, disadvantages, and various applications of the robot. Here's a summary of the key points:

Conclusion:

- The fire extinguishing robot has been successfully developed, offering automation in firefighting and aiding in situations where human intervention is difficult or dangerous.
- The robot's modular design strategy facilitates its implementation and operation, enabling movements in multiple directions and obstacle avoidance.
- It reduces human efforts, protects property, and shares the burden of firefighters in firefighting tasks.
- The prototype efficiently integrates basic hardware components for fire detection, navigation, and extinguishing.
- Future enhancements may include keypad programming for directional control, integration with long-distance sensors for improved performance, and applications in various industries beyond firefighting.

Future Scope:

- The fire extinguishing robot has potential applications in industries for pick-and-place operations, military patrols, civil defense, search and rescue missions, domestic services, security and surveillance, and exploration.
- Further advancements could involve enhancements in navigation, sensing, and extinguishing capabilities, making the robot more versatile and effective in various scenarios.
- The robot could be deployed by organizations, private agencies, and governments for firefighting and other relevant tasks.

Overall, the development of the fire extinguishing robot represents a significant advancement in robotics technology, with promising prospects for addressing firefighting challenges and enhancing safety and efficiency in various applications.

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