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Robotic Fire Fighting Car Powered by Arduino

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ABSTRACT

In an event of a fire breakout, numerous lives are at risk, and unfortunately, history indicates that fire accidents occur quite frequently frequently across a range of different industries – be it the chemical industry or electrical and clothing factories. Recent statistics indicate that approximately 10,000 fire incidents take place every year across the world, resulting in an average of 10,000 deaths each year. As we already know, especially in this era of advanced technologies, there are a number of technological innovations that can be used to minimize the chances of a fire breakout, but more specifically the likelihood of human casualties because of the fire. There are countries and factories all over the globe that have started utilizing a range of advanced technologies to aid in the continuation of a safe working environment, and as effectiveness would suggest, earlier forecasts which anticipated a drop-in fire-related casualties have shown the opposite. Essentially, technological advancements are indeed favouring the global fight against fire hazards. Keeping this in consideration, we planned and executed a project that focused on developing a fire extinguishing robot, which is a fire fighting vehicle and a robot without a driver. This vehicle is built on sensor and camera based technology, which is aimed to prevent wasting water on harmless areas of the building or a factory. The robot is practical and can perform the operation of locating a fire and extinguishing it autonomously, the robot can also drive itself during certain fire safety inspections.

Keywords: *Flame sensor, BO motor, Motor Driver (L298N), Servo motor, Arduino UNO, Water pump.*

Introduction

As we think of fire breaking out, it evokes some of the most frightening memories associated with great loss and obliteration, be it a building, an industry or nature on a broader level. People have been using fire extinguishing as an effective way of fire safety but, such methods raise not only safety concerns for the firefighters but are also bound due to human limitations. The firefighting industry has been evolving at a greater rate and with the engagement of AI, Revolutionary changes can be implemented to the approach without Saying robots are the future assets, Fire-fighting robots break the barriers, as they can traverse through extreme conditions, seek hot spots, and with slight engagement from humans completely eradicate fire posed threats. Such robots merely make use of simple machines that allow them not only to extinguish fires but respond accordingly as well, Such jobs when taken by AI would make life multiple folds simpler as, in the future, there is an infinite scope in the industry. This document will review in a systematic way the robot's perception-based vision frameworks for real-world fire suppression robots, the focal pursuit of key systems for robotics use in professional Fire fighting. It will look into the fire perception systems, on-board intelligence for navigation of the environment and the tools used to combat fire properly.

Literature Review

Fire fighting, fire extinguishing is the control and/or prevention of fires, especially: it just extinguishes the fire that is, pour waters on it. Oversees locations that are prone to natural disasters and bomb blasts. Robots measure temperature in the site where the said particular existing robot stands. In these industries, this robot will be useful, because the places of occurrence for the said natural calamities and bomb explosions. If sensors detect fire or if the water pump mechanism is activated manually, the water will be turned off using a relay circuit. The robot can move on its own when it detects fire. The motor driver circuit allows the Arduino to operate the motor. To rotate to whichever side they call right or left, for one motor the body part will be off while the other motor runs which makes the body rotate. If the flame is sensed through the arduino flame sensor then the robot will go towards the fire slowly. To make sure the robot moves slowly towards the fire, the algorithm is built in this way. In the case of fire alarm, robotic system has to come to a stand still at a safe distance from the source of the fire. should not run over the fire. The heat is sensed by the LM35 sensor used here. It stops and slightly steers backward by covering the region of extinguishing if thus, the sensor output is greater than threshold value. The project will be implemented in developing an Android application with pairing web server, material or a container of water is mounted on the robot's structure. Each time there will be fire in that region the robot will shoot water on it and extinguishes it. Finally, after what seems like an eternity, the robot pinpoints the precise location of the fire. and fires are extinguished as soon as possible once they are discovered. This study developed a two-part robot for fire inspections: The usual areas in a smart building include the following; smart lighting control, smart locks, smart elevators, smart security and safety such as ; smart security monitoring, smart parking, and smart system failure and faults such as; smart inspection, and smart fire fighting. The two main constituents considered in hardware development for an autonomous inspection system in this paper are the sensor unit and motion unit. A video surveillance system and a fighting fire system can be identified in the hardware concerning the built automatic fire fighting.

Existing System:

Residential Fire Safety: Alerts residents of fire hazards and attempts to extinguish small fires autonomously.
Industrial Fire Prevention: Monitors and suppresses fires in factories or hazardous areas with gas leaks.
Public Spaces: Utilized in malls, schools, or hospitals to detect and respond to fire outbreaks
Disadvantages::

- **Limited Range of Detection**:
  Flame, temperature, and gas sensors have a limited detection range, which might delay fire detection in larger areas.
- **Dependence on Power Supply**:
  The system relies on rechargeable batteries, which may run out of charge during critical operations.
- **Sensor False Positives/Negatives**:
  Sensors can trigger false alarms due to environmental factors like sunlight, steam, or cooking smoke.
- **Terrain Restrictions**:
  The locomotion system may struggle on uneven or highly obstructed terrains, limiting deployment in certain environments.
- **Limited Fire Extinguishing Capacity**:
  The water tank or CO2 supply may deplete quickly, making it unsuitable for larger fires.

- **Connectivity Issues**:
  GSM or Wi-Fi modules may face connectivity issues in remote or signal-restricted areas, delaying alerts.
- **Cost of Components**:
  High-quality sensors, microcontrollers, and communication modules can make the system expensive.
- **Environmental Restrictions**:
  The system may not operate effectively in extreme weather conditions, such as heavy rain or high winds.

Proposed System:

- Develop a fully autonomous fire-fighting robot capable of detecting extinguishing fires in indoor and outdoor environments, reducing the risks faced by human firefighters.
- I am used very advanced components
- Detects fire by sensing infrared light from flames.
- Microcontroller(e.g., Arduino, Raspberry Pi) Processes data from sensors and controls the robot's actions.
- Locomotion System Motors & Wheels: For movement across different terrains. Motor Driver as **a** Controls motor speed and direction.
- Fire Extinguishing Mechanism as a Water Tank and Pump: For spraying water.
- **Buzzer:** Emits a loud sound to alert nearby people.
- **Messaging System:** GSM Module (e.g., SIM900): Sends SMS alerts. Wi-Fi/Bluetooth Module (e.g., ESP8266): Sends notifications via an app.
- Rechargeable Battery: Powers all components.

Components

1)Arduino UNO

Among the many varieties of microcontrollers, Arduino UNO stands out. Its core architecture is the ATmega328P. A microcontroller known as an Arduino UNO has fourteen input/output pins. There are a total of twelve pins: six for analogue input, and six for pulse width modulation. It also has a power connection that can accept a five-volt power supply and a USB port that may be used to upload programs. Each part—sensors, relays, motor drivers, servo motors, etc.—is connected to the Arduino in order to send and receive data. The components may be powered by a 5-volt source and connected to a ground via the Arduino. As a result, the robot's movements are controlled by Arduino, which also ensures proper synchronization with all other parts.

2) Motor Drivers

The H-bridge design is what allows robots to use L298n motor drivers. The two or four motors (two pins for one motor) may be controlled (clockwise or anti-clockwise) by means of the four

pins on the L298n driver. in addition to two enable pins that let us modify the motor speed or change the motor speeds to suit our requirements. A 12-volt power supply was provided to the Arduino UNO so that it could run the motor driver.

3)Pump:

Mechanical devices are what a pump is. This is an activated 9-volt DC motor. To extinguish the fire, we made use of a water pump. This fire extinguisher is an easy-to-understand DC motor pump.

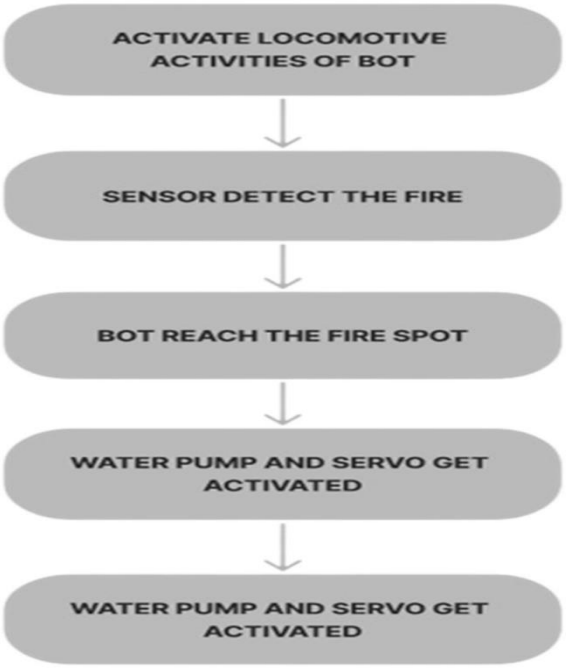
4) Flame Sensor:

Aflame sensor is a device used to detect the presence of a flame or fire in a system, typically for safety and control purposes. It is commonly found in gas furnaces, boilers, and other heating systems to ensure that fuel combustion is occurring as expected. If a flame is not detected, the sensor signals the system to shut off the fuel supply, preventing gas leaks or dangerous conditions.

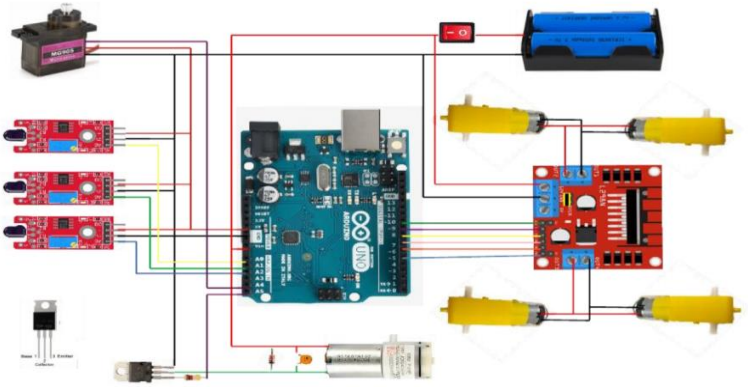
5) Servo motor:

Servo motor is a rotary or linear actuator designed for precise control of position, speed, and acceleration. It operates using a control signal to adjust its movement to a desired position, making it ideal for applications requiring accuracy and repeatability.

Flow Chart:



Circuit Diagram:



The Arduino UNO, as shown in the circuit diagram, is the central component of the robot and

will be responsible for controlling all other components. We use three flame sensors to detect the flames. Each of them is placed on a different side, so together they cover 180 degrees. Since flame sensors need a 5-volt DC supply, we may connect VCC to the 5-volt pin on the Arduino UNO, GND to ground, and DO to the I/O pins. The flame sensor's three pins are ground, VCC, and DO. Four BO motors have been used to control the bot's mobility. Both the BO motors and the motor driver are now linked. All BO motors are controlled by the motor, which also regulates the direction, speed, and ON/OFF status. The motor driver has complete control over the BO motor, including the ability to turn it on and off, as well as the speed and direction (left, right, and forward). The motor driver needs a 12-volt DC source, therefore we gave it a 12-volt battery. To control the speed in both directions, we utilized all six of the motor driver's pins that are attached to the I/O pins of the Arduino UNO. One pin controls the forward direction and one pin controls the reverse direction. We connect the 5 volt output pin of the motor driver to the 5 volt pin of the Arduino UNO since we are utilizing a 5-volt DC source. We connected one end to the 9-volt DC source and the other to the relay since the fire-putting DC water pump requires a voltage supply of 5 to 12 volts. In this particular instance, we typically activated the pump using relays. The last battery terminal is where you'll find the relay. There are three pins on the relay that the Arduino UNO is linked to: VCC, ground, and l/O. We utilized a single servo motor to cover a large area with water. A servo motor is linked to an Arduino.

Algorithm:

A **fire-fighting robot car** is designed to detect and extinguish fire automatically. Below is an algorithm for its operation:

Algorithm for Fire-Fighting Robot Car

Step 1**:** Activate all sensors and actuators.Ensure the water reservoir is filled, and the pump is operational.

Step 2:Fire Detection as aContinuously monitor inputs from multiple flame sensors positioned to cover different directions (left, right, forward).Determine the direction of the fire based on sensor inputs.

Step 3:Navigation as aIf a fire is detected, move the robot towards the fire by controlling the motors accordingly.If no fire is detected, the robot can either remain stationary or continue patrolling the area.

Step 4: Extinguishing the Fire asUpon reaching the vicinity of the fire, stop the robot.Activate the water pump to spray water towards the fire.Utilize a servo motor to adjust the direction of the water spray, ensuring comprehensive coverage.

Step 5: Verification is aAfter a predefined duration of spraying, reassess the flame sensor readings to confirm the fire is extinguished.If the fire persists, repeat the extinguishing process.

Step 6: Completion is a Once the fire is confirmed to be extinguished, resume patrolling or return to a standby mode.

This algorithm is implemented using components such as an Arduino microcontroller, flame sensors, motor drivers, a water pump, and a servo motor.The robot's movement and actions are controlled based on sensor inputs, enabling autonomous fire detection and suppression.

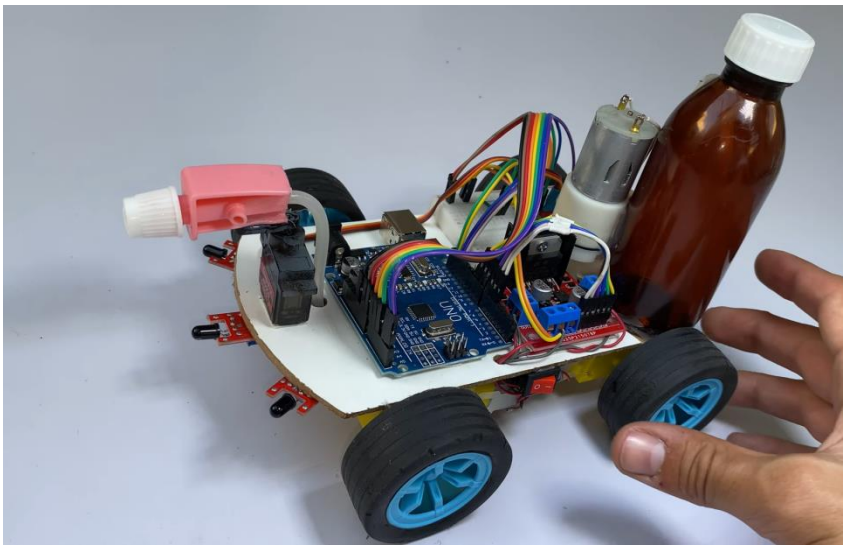
Comparative Study:

When comparing a fire-fighting robot car with an older version using an Arduino Uno for control, several factors come into play. Here's a breakdown of the key differences you might encounter in terms of hardware, functionality, and overall performance.

Old Project	New Project
Older fire-fighting robots may use basic flame sensors and rely more on simple switches or basic heat sensors	The new fire-fighting robot typically uses more advanced sensors for detecting fire and obstacles, such as: • Flame sensors(infrared or ultraviolet sensors to detect flames)
Older robots may rely on manual pumps or simpler mechanisms to extinguish fires. They might not have as much precision in aiming or water spraying.	Modern designs might feature **servo motors* for precise control of fire-extinguishing equipment • A water pump controlled by a relay or motor driver
The movement might be basic, relying on simpler DC motors or stepper motors.Navigation may be limited to remote control or basic pre-programmed movement.	Differential steering using motor drivers like L298N for smoother control • Better wheel motors*(e.g., geared DC motors) for greater torque and stability
Older versions may use NiMH or NiCd batteries, which have a lower energy density and shorter runtime. Power regulation may not be as optimized.	More efficient batteries(like Li-ion or Li-polymer batteries) Better power regulation circuits to optimize battery life and ensure stable voltage levels..
The cost of older robots might be lower, but their functionality may be less advanced due to outdated sensors and limited capabilities.	Newer models might use advanced sensors and motors, which could increase the cost of the robot. However,open-source hardware and affordable components have made building these robots more accessible.

Results and Discussions

The real mode of the project is presented on the Figure . The robot is operated by four BO-DC motors, whose speed is 160 RPM Model .The dimensions of some of these drafting tables are as follows: length of about 17 cm, breadth of about 10 cm, and measurements of about 1.5 KG. All of the components are inserted into the board as shown in the accompanying diagram. The robot can glide on flat surfaces thanks to the connection we made between the water pump pipe and the servo motor. it may surface, sprinkle water along the x-axis, and cover a full 360 degrees. Three flame sensors are used by us coordinates" have a 180-degrees field of detection.



Saves human firefighters from being injured. Can reach areas that constitute danger by involving human with complicated labor. Operates singly or nearly independently using very little or inverted reliance on human input. The initial cost they attract might relatively be high due to the components and technology involved. Maintenance and reliability issues in even more harsher conditions would have to be investigated further as well as. More testing with firefighters in general to better understand use in industrial chemical facilities and warehouses. Firefighting in city environments especially in narrow alleyways and high risk areas. Combining forest fire management with the ability to scale.

Conclusion

Proposed as a Fire Fighting Robot Car is an effective and quite practical tool to deal with fire risks in dangerous or hard to reach areas. The robot, equipped with powerful sensors, can work under remote operation and evacuate personnel safety, and with a very effective extinguishing system, detect and fight fires independently. It not only enhances security but also shortens response time when necessary. This model brought to evidence that disarray mitigated by robotics and automation in emergency response systems can be controlled. The future possible improvements can be navigation system improvement and adding artificial intelligence for decision-making purposes and expand the ability of the fire-fighting robot in dealing with different situations. This success indicates why innovation through the use of technology in creating tools that threaten to put human life at risk is so important.

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