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Smart Fire Fighting Robot

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Abstract

Ever since the Industrial revolution, more and more factories and industries are being set up around the world. Be it manufacturing or iron-steel industry. There are many places in factories, industries, manufacturing plants, oil fields, etc. where there is a risk of fire but they are unmanned. There may be fires in remote places like, in small gaps or in narrow pipes where humans can't reach. The solution to these problems is our smart firefighting robot which can be controlled via mobile, and can even detect nearby fires and extinguish them. We aim to create a small smart firefighting robot that can be remotely controlled as well as act on its own by detecting nearby fire and extinguish it using on board water supply. The robot will use Arduino as well as NodeMCU so that it can be connected to Wi-Fi and controlled. The robot will also sound the buzzer whenever it detects fire, so that even if the fire can't be extinguished, people nearby can be alerted.

Keywords: Fire Safety; Internet of Things; Robotics; NodeMCU; Arduino UNO

1. Introduction

Fires are hazardous to both – human life and property. Annually, fires kill thousands of people around the world and these deaths aren't only limited to developing countries. This is a worldwide problem. India is statistically one of the deadliest places in terms of fire – related deaths, averaging about 35 every day! However, when we think about fire accidents, we tend to forget that firefighters also lose their lives in attempts to save others. Fires don't just always erupt out of nowhere as most of the times they start out small and, in some time, reach extreme intensity. Fires in factories, warehouses or workshops may have places that are prone to a fire accident, but are in tight places and difficult to reach while also being costly to assign a person to look out for it. We need to come up with something that can reach tight places in order to detect and extinguish fires either autonomously or remote controlled, and also lowers the risk of injury and death in firefighters. Our 'Smart fire-fighting robot' could possibly be a solution, as it is can do all the things mentioned above. It is a basic prototype and could easily act as foundation to future bigger and more efficient firefighter robots.

2. Literature review

- In this paper they propose the Mission Critical "bot" concept as an entity capable of gathering environmental/situational information and triggering certain automated actions without the need of human intervention. They prove that in certain circumstances these bots can help quickly resolve emergency situations and complement traditional centralized coordination from Dispatch Control Rooms. They explain how such "bots" relate and expand the 3GPP Mission Critical Communications architecture framework, considering different architectural approaches and complexity levels. [1]

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- They aim to design a robot capable of detecting and suppressing fires. By designing and implementing an autonomous robot capable of detecting and extinguishing flames, disasters can be avoided with minimal risk to human life. In this research, we illustrate an autonomous robot capable of detecting flames indoors and manoeuvring towards the flame to extinguish it with the help of carbon dioxide. [2]
- This case study deals with the issue of fire safety in historic buildings that undergo functional change, restoration, replacement of construction, facade or installation renovation. It analyses the current technical state in relation to microclimate and fire safety in historic buildings in Slovakia. It pays attention to the legislative framework for building conservation in the Slovak Republic considering its impact on the reconstruction and restoration of historic buildings. This paper makes one understand how dangerous is fire and that we need to find new ways to combat it, and prevent it. Getting help on time can mean everything in the situation. [3]
- The construction industry in India is the country's second largest industrial sector. The construction industry makes a remarkable contribution to the Indian economy and provides employment to a large number of people of India. We know, fire is a chemical reaction of a combustible substances with oxygen, involving heat and is usually accompanied by a visual flame or incandescence. Ensuring fire safety has always been a challenge to the stakeholders, i.e., building owners, construction companies, contractors and sub-contractors, and government employees due to the multiplicity of the factors involved and their complexity. There are various legal standards and requirements for ensuring fire safety on construction sites. However, there isn't always proper implementation of these standards, and conflagrations literally destroy buildings. Thus, we need newer ways to avoid and fight fires. [4]
- The main purpose of this paper is to design a Fire-Fighting Robot to protect Human-Life from all the unpredictable fire. The robot built has 3 flame sensors to quickly detect the presence of flames and 3 ultrasonic sensors for path-tracing and avoiding the robot from dashing over the obstacles in its path. This paper mainly focuses on the fact that during a fire accident at homes, schools, offices and buildings, the top most priority is to ensure safety of all humans present at that location. [5]
- The main aim of this paper is to resolve the issues related to the deaths caused to the fire-fighters in process of saving other people's life from burning in fire. The firefighting robot mentioned in this paper, is designed in such a manner that it can quickly detect the fire using the fire sensor (IR) and even smoke using the smoke sensor which is attached to the Robot along with the water tank and a pump which is required to extinguish the fire from that location. [6]
- The purpose of this paper is to design a fire-fighting robot in such a way that it can distinguish fire in the debacle prone territory immediately and easily. The Fire Fighting Robot consisted of a flame sensor, Arduino UNO circuit, Arduino software and various other sensors which made it a highly automated and successful Robot. This firefighting robot is able to be controlled using microcontroller Arduino UNO and be easily operated by humans successfully. [7]
- The purpose of this paper is to design a robot which can perform the functions and tasks required to compete in the Fire Fighting Robot Competition held in the year 2010. They used C language for the programming part to determine the robot action gain from the sensor's input. The robot is made in such a way so that it can move around in the maze using the wall-follower method and rescue the victim by stopping the fire from that place. [8]
- The purpose of this paper is to design and built an Arduino based Fire Fighting Robot. They used Arduino Software for the backend purpose and some hardware and sensors to prepare the robot. A RF remote controller with a range of 17 feet was prepared to control the robot by humans if necessary. [9]
- The main aim of this paper is to design and construct a robot for the contest aim at simulating the real-world scenario. The paper discussed the design of a fully autonomous firefighting robot which is able to navigate and perform the task based according to the rules laid by the National Engineering Robotics Competition (NERC), 2005, and be able to compete in the competition. [10]

3. Components

3.1. NodeMCU-ESP8266

NodeMCU is an open-source Lua (HL programming language) based firmware and development board that is best suited and made for IoT-based Applications. It's anything but's a high taking care of force with in-manufactured Wi-Fi and Bluetooth limits and Deep Sleep Operating features make it ideal for IoT projects. It is effectively programmable with the Arduino IDE and is not difficult to use with not very many equipment necessities.

3.2. Arduino UNO

The Arduino Uno 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 an AC-to-DC adapter or battery to get started.

3.3. LM35 Temperature Sensor

The LM35 sensor is a precision integrated-circuit temperature sensor. The output voltage is linearly proportional to the temperature (o C). Linear temperature sensors which are calibrated in ° Kelvin have a disadvantage against LM35 sensors as it is not required to subtract a large constant voltage from the output to obtain appropriate Centigrade scaling. Typical accuracies of ±1/4 °C at room temperature and ±3/4 °C over a full −55 to +150 °C temperature range can be provided by LM35 sensors without any external calibration. The cheap cost is guaranteed by trimming and calibration at the water level. The LM35's characteristics such as low output impedance, linear output, and precise inherent calibration make communicating to readout or control circuitry very easy. LM35 sensors can be used with both, single power supplies and plus, minus supplies as well. The sensor draws only 60 microamperes from its supply and as a result it has very low self-heating (< 0.1 °C in still air). The LM35 sensor is rated to operate over a range of −55 to +150 °C.

3.4. Fire Sensor

Fire sensor is highly sensitive to ordinary light which is why its reaction is generally used as fire alarm causes. The sensor can detect wavelength of the light source in the range of 760 nm to 1100 nm. Small plate output interface and single-chip can be directly linked with the input output port of micro-computer. There should be a certain distance between the flames and the sensor to avoid damage to it. The shortest test distance can be 80 cm but in case if the flame is significantly large, the distance has to be increased and tested accordingly. The detection angle is of 60 degrees. The output of fire/flame sensor can be analog or digital signal as well.

3.5. MQ2 Gas Sensor

MQ2 Gas sensor is another important part of a robot since its only function is to sense the concentration of gases in the air like LPG, hydrogen, smoke, methane and carbon-dioxide. This is the most important component of a Fire-Fighting Robot since it has to do the work of sensing the gases and smoke in the air. This sensor is also called as "chemiresistor" since it consists of a sensing material whose resistor changes when it comes in contact with the gas. This change in the resistor acts as a signal which is required to detect the gases. This sensor can detect the gases in the concentration of range 200 ppm – 10000 ppm.

3.6. Buzzer

A buzzer is an electric device which is built for generating sound. Buzzers are powered by DC voltage and are of two types i.e., Piezo Buzzer and Magnetic Buzzer. These two buzzers not only differ in design and usage but can also generate different sounds. In Piezo Buzzer, the main core and differentiating component is the piezoelectric element. This piezoelectric element is made up of piezoelectric ceramic and a metal plate which is joined by using adhesive. As the name suggests, the Magnetic Buzzer is composed of mainly magnet, coil and a vibrating disk which is a ferromagnetic disk. This Magnetic Buzzer acts as an indicator which also consists of a transistor.

3.7. BO Motor

It's a BO DC Motor Plastic Gear Motor. The BO series straight motor gives decent torque and rpm at lower operating voltages, which is the biggest precedence of these motors. A small shaft with matching bus gives an optimized design for your operation or robot. Mounting holes on the body & featherlight makes it suitable for in- circuit placement. This motor can be used with 69 mm Periphery Wheel for Plastic Gear Motors and 87 mm Diameter Multipurpose Wheel for Plastic Gear Motors. Low- cost geared DC Motor. It's a volition to our essence gear DC motors. It comes with an operating voltage of 3-12V and is perfect for erecting small and medium robots. Available with 60 and 150 RPM. The motor is ideal for DIY suckers. This motor set is affordable, small, easy to install, and immaculately suited for use in a mobile robot auto. They're generally used in our 2WD platforms.

3.8. L298N Motor Driver

This L298N Motor Driver Module is trusted to be a high-power motor driver perfect for driving DC Motors and Stepper Motors. It uses the popular L298 motor driver IC and has the onboard 5V controller which it can supply to an external circuit. It has the ability to control up to 4 DC motors, or just 2 DC motors with control over speed and direction. This motor driver is exemplary for robotics and mechatronics systems and excellent for controlling motors from microcontrollers, switches, relays, etc. Also perfect for driving DC and Stepper motors for micro mouse, line- following robots, robot arms, etc.

4. Methodology

- The overall working of this system of Fire Fighter is based on the concept of IOT. NodeMCU ESP 8266 and Arduino UNO are the main components in the system.
- In this system the NodeMCU ESP 8266 acts as the main device for movement control of the system, as all the motors which are controlled via the applications are connected at the digital pins to the NodeMCU ESP 8266.
- The Arduino UNO on the other hand which is connected to all detectors attached serves as the brain of the entire system.
- It helps in detection of all the concerned threats and raising an alert as per the threshold, as the Fire Sensor, Temperature Sensor, Smoke Sensor, Gas Sensor and other detectors are connected to it via Digital as well as Analog Pins.
- As the movement of the entire system is based on the NodeMCU, the BO motors are connected to it at the digital pins via the L298N motor driver which helps in the functioning of the motors.
- The 4 motors used for driving the system are configured so as to be able to move in all possible
- This NodeMcu is interfaced with an application named Blynk which gets connected through the IP address and provides commands to the Robotic System to be able to move and accepts the input from the sensors with respect to the surrounding conditions.
- The Sensors are connected to the Arduino via the Digital and Analog Pins and detect the concerned information in the vicinity of the system. They work together to detect Fire, Smoke, LPG, CO2 and other such factors that can be a potential hazard before or at the time of a fire.
- These sensors have a threshold set up via the Arduino UNO. As soon as the threshold is crossed by values of any of the sensor the Arduino does the needful actions.
- If the threshold of fire-sensor is crossed and the fire get detected the motor will be turned on and will proceed with the Fire Extinguishing process.
- If the threshold for any other sensor is overstepped then the system will alert the user and then the user can take control of the system and can take necessary measures to prevent the outbreak of any fire hazard.

Abbreviations and acronyms

- NodeMcu: Node Micro Controller Unit
- IOT: Internet of Things

Limitations

- As of now the control of the system has to be taken by the user in any case to exhaust fire as the depending on the intensity of fire, we have to take certain decisions.
- The system can be controlled over long distances but as soon as the user would lose the sight of Device there is no way through which the device activities will be visible to the user.
- The system has to find way to reach heights and depths if needed this would be a reason for restricting its reachability.
- The water pump is installed on the system considering its weight and other factors, but simple water has very limited application when we think of extinguishing fire, this way finding a more sustainable exhaust will serve as an upgrade for this system.

Future scope

Even though our Smart Fire Fighting Robot is capable enough to extinguish small fires, it is still a prototype for a better and efficient version of Fire Fighting robots. The robot can detect fires, can pump water and extinguish fire automatically. It can also measure the water level in the tank. But this isn't it.

The robot can be upgraded and modified as well to make it more useful in future. Some features that can be added on are:

- Installation of a camera: A camera mounted on the top of our robot will make it much easier for the user to operate it. Moreover, it will also help the user to analyse the intensity of the fire while maintaining a safe distance and thus make proper decisions.
- Add Propellers: The robot with propellers added to it will resemble to the vehicle in the image below. The robot can also be modified into a VTOL (Vertical Take-off and Land) vehicle so that it can even fly to different altitudes, along with travelling on the ground with wheels, to detect and put out fires. The future scope is unlimited as long as there are enough funds and time to implement them. (Fig 1.0)

Figure 1 Smart Drone

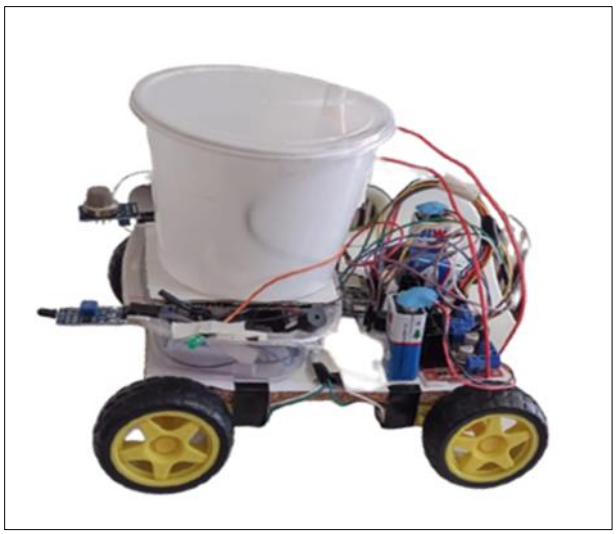

Figure 2 Smart Fire Fighting Robot (proposed model)

This will not only help the robot move on ground but also levitate to a certain height. This will increase the range of area which the robot covers. Factors such as weight of the robot, stability of components attached etc. have to be taken care of while adding this feature.

- Installation of Standard Fire Extinguisher: The water tank can be replaced by a standard fire extinguisher as a fire extinguisher is much more suitable for fighting fires involving solid combustibles such as wood, paper and textiles. It is also safe to use a fire extinguisher than water to extinguish fires caused due to electrical equipment or electric short circuits.

The current model could be called a prototype for perhaps, a bigger and even more efficient robot. The possibilities are endless in this domain of unmanned fire safety. The robot can have an on-board camera as well which makes accessing remote and tight places even easier as visual feedback is added. The robot could be made bigger to be able to carry more water or even, replace water with a fire extinguisher.

5. Conclusion

This Fire Fighting Robot is capable of using its various sensors smoothly and instantly and even extinguish the fire completely form the area with minimal delay. This robot can move in all the four directions with smooth turning movements. The robot can operate in the environment which is out of human, can reach there in very short time, so the delay employed is very minimal. The robot accurately and efficiently finds the fire and within minimum time after the fire is detected, it is extinguished.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors whose names are listed certify that they have NO affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript. All the above information is true and correct

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