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Design and Development of Four Directional Fire Protection System

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Abstract-

The creation of an autonomous Four Directional fire protection robot is long overdue. Thanks to the creation of such a device, people and property can be rescued at a much higher rate with only minimal fire damage. It hwas our responsibility as engineers to develop and evaluate a prototype fire detection and suppression system. For this project, we created a solar-powered feature for uninterruptible power supply. mobile robot with wireless control. The robot can move around a model building, find a fire, and then use a water spray to extinguish it. the demand Long overdue is the development of an autonomous fire extinguisher robot. People and property can be saved at a considerably greater rate with only little fire damage thanks to the development of such a device. As engineers, it was our job to create and test a prototype fire detection and suppression system. For uninterruptible power supply, we designed a solar-powered feature for this project. Wirelessly operated mobile robot. The robot is the one that can go through a model building, locate a fire, and then put it out with the aid of a water spray.

Keywords: Arduino uno Controller, LCD display, BT Module, Automatic Fire detection, 360° fire protection, Buzzer etc.

I. INTRODUCTION

Robotics is one of the engineering fields that is currently growing the fastest. Robots are designed to carry out hazardous or labor-intensive jobs without the assistance of people and in hostile situations. Robot usage is more common than ever today and is no longer just found in heavy industrial companies. the need The creation of an autonomous fire extinguisher robot is long overdue. Thanks to the creation of such a device, people and property can be rescued at a much higher rate with only minimal fire damage. It was our responsibility as engineers to develop and evaluate a prototype fire detection and suppression system. also reduces air pollution. In this project, we build a robot that is wirelessly controlled. The only thing that can navigate a model building, locate a fire, and then put it out with the aid of a water jet.

The goal of the project is to create a remote-Firefighting robot controlled by Bluetooth (BT) technology. A wirelessly controlled water-throwing pump and a water tanker are also part of the robotic vehicle's setup. The controller for the Arduino Uno is used for the specified operation. Push buttons are used to transfer commands from the transmitting end to the receiving end, instructing it to drive the robot forward, backward, left, right, and in other directions. At the other end, a microcontroller is attached to three motors, two of which are used to propel the vehicle and one of which is used to operate the robot arm.

Before transmitting the signal to a different microcontroller to drive DC motors via motor driver IC for the required duty, the receiver decodes the signal. The BT transmitter then functions as a BT remote control with the advantage of a suitable range (up to 30 metres with the right antenna). The microcontroller output via the appropriate signal from the transmitting end regulates the operation of a water tank and water pump installed on the robot body. The entire operation is controlled by an Arduino Uno board. The controller drives the motors through the microcontroller, which connects to the microprocessor and motor driver IC.

The concept can be further enhanced by attaching a wireless camera to it so that the person in charge can observe the robot's performance from a distance.

II. PROBLEM IDENTIFICATION

- A fire disaster is one of the risky situations that can cause substantial harm monetarily and in terms of lives lost. Because of the explosive chemicals, smoke, and high temperatures, it might be difficult for firefighters to reach the scene of a fire.
- Hazardous conditions can endanger the lives of fire crews. In these circumstances, robotic firefighting devices may be helpful. This firefighting robot uses Internet of Things technologies.
- Our objective in Fire Extinguishing Robot is to develop a system that can extinguish a small flame by locating it and moving towards it. When fire fighters are late, it has a variety of repercussions.
- The robot that extinguishes fires constantly monitors its environment and extinguishes fires without leaving a trace.

III. NEED OF THE PROJECT

The duty of safeguarding and preserving an institution's structures, collections, operations, and occupants falls to cultural property management. To reduce the negative effects of climate, pollution, theft, vandalism, insects, mould, and fire,

constant attention is necessary. Fire poses one of the more dangerous threats due to the speed and breadth of its destructive forces. Structures that have been vandalised or ecologically damaged can be repaired, and stolen goods can be found. But, items that are destroyed by fire are lost permanently. Uncontrolled fires have the power to burn out an entire structure in a few hours or destroy an entire room's contents in a matter of minutes. So, it has become imperative to manage and put out the fire in order to safeguard lives and more expensive items.

We intended to create the fire-fighting robot for that purpose. Robots that have autonomy are machines that can act without a controller. The fundamental concept is to program the robot to react a specific way to external inputs. The really basic bump-and-go robot serves as a decent example of how this operates. A bumper sensor is used by this type of robot to identify impediments. The robot moves straight ahead when you turn it on. Finally, the impact of the impediment pushes in its bumper sensor. Every bump causes the robot, according to its programming, to reverse direction, pivot to the right, and then advance once more. This allows the robot to adjust its course if it encounters a barrier. This similar concept is used in more sophisticated ways by advanced robots. To make robots more intelligent and perceptive, roboticists develop new software and sensor technologies. Robots are capable of navigating a variety of surroundings nowadays.

IV. BLOCK DIAGRAM

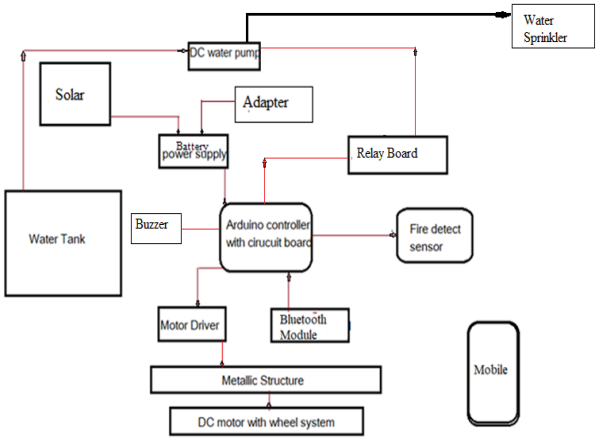


Fig.1.Block Diagram

V. WORKING

The main goal of this project is to build a firefighting robot that runs on solar power and remote control. The robot is powered by solar energy. This robot has a water tanker and a remotely controlled water-spraying pump. The intended action is carried out via a controller for an Arduino uno.

To move the robotic arm in one of four directions—forward, backward, right, or left—commands are delivered to the receiving end through Bluetooth using smartphone keys at the transmitter end.

The remote control has an appropriate range of up to 20 metres with the right antenna, and the decoder decodes data before transferring it to a different microcontroller to drive DC motors through a motor driver.

A water tank and water pump are attached to the robot's body. The water tank and pump are automatically activated in response to a fire sensor's detection, and the appropriate signal from the microcontroller regulates how they operate. Every operation may be seen on the LCD monitor.

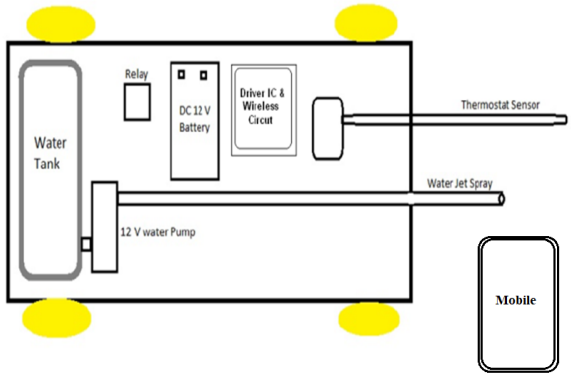


Fig.2.System Architecture

VI. COMPONENTS

- Adapter
- Battery
- Bluetooth module
- Arduino Uno
- Relay Board
- Solar Panel
- Motor Driver
- DC Motor
- High pressure Dc water pump
- Wheels
- Frame
- LCD display
- Wireless Camera
- Nozzle
- Others

Components Specification:

- ***Arduino Uno* (12v)**

The Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be

interfaced to various expansion boards (shields) and other circuits.

- ***LCD Display (5v)***

A liquid crystal display (LCD) is a thin, flat panel used for electronically displaying information such as text, images, and moving pictures.
LCD stands for Liquid Crystal Display. LCD is finding wide spread use replacing LEDs (seven segment LEDs or other multi segment LEDs).

- ***Relay Board (12v)***

A relay is usually an electromechanical device that is actuated by an electrical current. The current flowing in one circuit causes the opening or closing of another circuit. Relays are like remote control switches and are used in many applications because of their relative simplicity, long life, and proven high reliability.

- ***DC Water Pump***

Operates on 12V supply. The Speed Control circuit technology is able to stabilize the voltage changes and load changes, water flow is very stable.
In particular, it is suitable for users who have the demand for a steady flow.

- ***12 v Battery***

12 V , 2 Amp Battery is high power battery easily handle all the function.
Main things are to collect electrical energy from solar panel and provide to various components For running specific function.

- ***Bluetooth module (HC-05)***

The **HC-05** is a very cool module which can add two-way (full-duplex) wireless functionality to your projects. You can use this module to communicate between two microcontrollers like Arduino or communicate with any device with Bluetooth functionality like a Phone or Laptop.

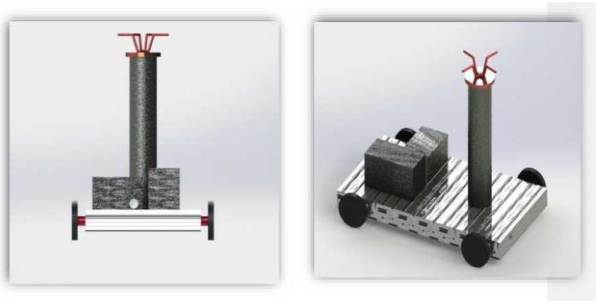
- ***DC motor***

DC motor is an electrical machine that utilizes electric power resulting in mechanical power output. Normally the motor output is a rotational motion of the shaft. The input may be direct current supply or alternating supply. But in case of DC motor direct current is used.

- ***Motor Driver IC (L293D)***

L293D is a dual H-bridge motor driver integrated circuit (IC). Motor drivers act as current amplifiers since they take a low-current control signal and provide a higher-current signal.
This higher current signal is used to drive the motors. L293D contains two inbuilt H-bridge driver circuits.

VII. DESIGN OF SYSTEM



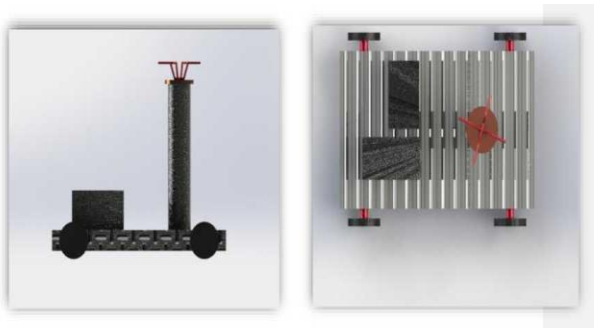


Fig.3. CAD Design of system

VIII. CALCULATION

The main purpose of the robotic vehicles is to make the firefighter's job easier. Fire brigade robots can move forward, backward, left and right using Zigbee communication technology when an operator presses a button. By moving the boom left, right, up and down, you can also direct the water to the fire source and extinguish the fire. Its movement is also connected via a remote control.

Supports that give the robot system stability and resist back pressure. Use the calculations below to determine back pressure, actual water jet height, and displacement. The reaction force that causes water hammer is ,

$R = (1.57 \times P \times d2)/10$ Eq^{n} (1)

Where P is the pressure in bar at the nozzle and d is the diameter of the nozzle in mm

The theoretical height of jet is find out by,

$H=V2/2g$ Eq^{n} (2)

Where , H is Height in meters; V is velocity in m/s and g is the acceleration due to gravity

The effective height of jet of water is given by,

$He=2/3(H-0.113H2/d)$ Eq^{n} (3)

Where He is the effective jet in meter, d is diameter of nozzle in mm, and H is the theoretical height of water jet

The discharge rate is found out by,

$Q=2/3 \times d2 \times (p)1/2$ Eq^{n} (4)

Q is the discharge rate in litres per minute, d is the nozzle's diameter in millimetres, and p is the pressure in bars. The robotic firefighting arm has a 5mm nozzle with a 2 bar pressure.

By changing equation (1) to reflect the reaction force caused by the water hammer,

$R=(1.57 \times 2 \times 52)=7.85$ newton

The theoretical height of water jet is found by equation (2)

$H= 19.82/(2 \times 9.81)=20$ m

The effective height of water jet is found by equation (3)

$He=2/3(20-0.113 \times 202/5)=7.3$ m

The rate of discharge is found out by equation (4) as

$Q=2/3 \times 52 \times (2)1/2=23.57$ litre/minute.

IX. RESULTS & DISCUSSION

Locally obtainable components were used to construct the firefighting robot, and tests were conducted to evaluate its effectiveness in various scenarios. This performance test will assist us in creating a better model because a firefighter robot must be able to survive in a variety of circumstances. The following inferences can be formed based on the design and experimentation of the respective robot:

- Water cannot escape in this way since the water tank is made of fireproof aluminium alloy and the pipelines are made of waterproof white cardboard. The water velocity in the pump is greatly reduced by a water sprinkler at the end of the pipe, which also spreads the extinguishing water efficiently. They make extinguishing easier by delivering water to a precise and secure distance. The LM35 sensor, which transmits heat detection technology to the measured distance, is likewise carried by the other tube.
- Analogue output measurements are at their lowest during the day. The output reading difference between readings with and without the fire source, which is typically between 300 and 350, is provided by this, though. Thus, even in these circumstances and with the worst possible result reading, an effective algorithm can be created.
- When there is no source of light, readings are lowest at night and greatest during the day. Its detecting range is effective.
- The time period between 23:00 and 03:00 is excellent for identifying the fire's origin. This presents the best opportunity for device customization ever.
- The robot detects the fire and begins to move in its direction. The power of the LM35 fluctuates with temperature.
- The LM35's output change is not linear. Readings are acquired at various distances because the robot is calibrated to stop at a safe distance from the source.

Analysis

A. Sensitivity of flame sensor at day and night:

The results of testing the Arduino flame sensor's sensitivity during the day and at night, in the absence of a fire, and at a distance of three metres from the fire source are shown

in Figures 4 and 5. Figure 4 demonstrates that the sensor output is larger at 7 o'clock with or without a fire source, but the reading falls over time. This is because sunlight contains infrared photons. Around 12 or 1 o'clock in the afternoon, when the sun is at its strongest for the day, a flame detector can pick up more infrared photons. Consequently, this is the time of day when the output reading is lowest, whether or not there is a fire source. However, after 3 o'clock the sun's intensity starts to wane, and as a result the initial reading starts to rise. When it sets at the end of the day, the sun is at its highest. Additionally, it was discovered that throughout the day, nearly identical patterns were seen and that the deviation of serial number profiles was fairly constant.

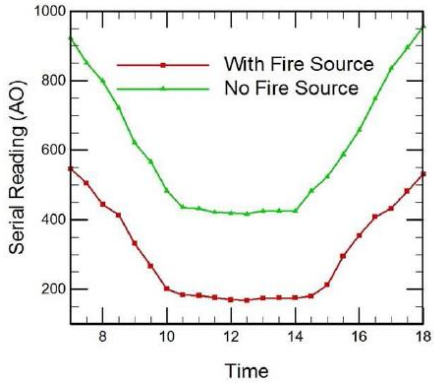


Figure 4: Effect of sensitivity of flame sensor at day

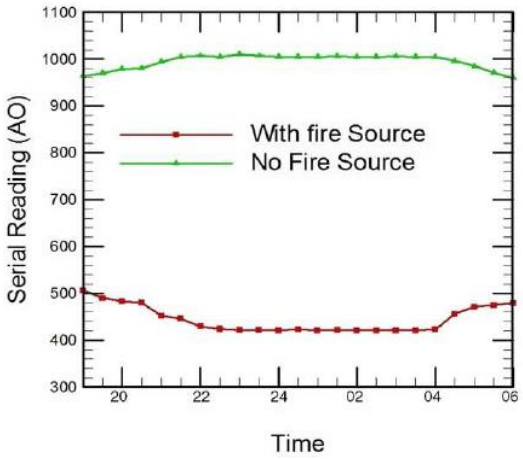


Figure 5: Effect of sensitivity of flame sensor at night

Figure 5 illustrates that the nighttime readings with and without the fire source are nearly equivalent. The initial reading is highest without the fire source and lowest with it at 23:03, when the sun's impact begins to wane. The discrepancy between the two readings is therefore highest at this hour of the night. The biggest distinction between a fire source and a typical circumstance can be made at this time. Therefore, at night, the flame detector will undoubtedly detect a fire.

***B. Change of output of flame sensor when the robot moves towards** fire:*

Figure 6 depicts the difference in flame sensor power at 10 a.m. and 10 p.m. when the robot detects fire and begins to move towards the source. The analogue output reduces as you go closer to the source since the source's intensity has increased. Additionally, when you are farthest from the source, readings at 10 p.m. are higher than at 10 a.m. Because the analogue reading of the sensor is distorted by the sun's infrared radiation around 10:00 AM, the value decreases more dramatically at 10:00 PM than it does at 10:00 AM. However, if they are at a safe distance from the fire during the day, it can also be found because the readings are essentially the same at night and during the day. because as the source's intensity increases, more infrared photons are produced. Due to this, the output reading at 10 PM and 10 AM, respectively, both show a quick attenuation and a slight attenuation.

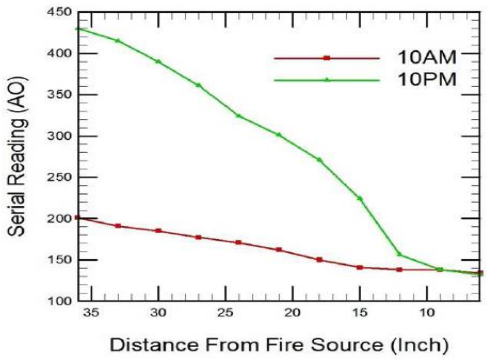


Figure 5: Change of output of flame sensor when the robot starts moving towards fire Source.

C. Change of output of LM35:

When the temperature begins to rise, the robot begins to move in the direction of the fire. A relatively small area can have heat detected by the LM35 sensor. It is frequently necessary to touch the source of fire in order to detect it, even with minor sources of fire. The LM35 sensor can detect heat at least 6 inches away from the source because of the intricate construction of the robot. Because it is mounted through a tube on the robot's front, the sensor is placed even closer to the source of the heat. The robot is able to keep a sufficient gap between itself and other people. As a result, when it notices a spike in temperature, the LM35 modifies the power. When the change reaches a certain threshold, the robot is trained to put out the fire predetermined threshold.

Table 1. Change of output readings of LM35

Temperature (°C)	Serial Reading(AO)
26	55
40	88
55	123

The fire robot's power allows it to extinguish minor flames. In regions with poor lighting, it is especially combustible. It was created to prevent bots. because it can put out fires before they spread and can identify them early. This multi-sensory robot can offer protection from all types of fire risks. Given enough funding and scope, this robot's design has more reserve power to put out larger fires, and its upgraded sensor can spot fire early in any situation.

X. SCOPE OF THE STUDY

- The goal of the project is to create a remote-operated firefighting robot that utilises Bluetooth technology.
- The robotic vehicles is equipped with a water truck and a wirelessly operated pump that shoots water.
- To control movement, orders are transferred to the receiver end Bluetooth module from the transmitter's mobile side using a keypad.
- The robot uses a pump motor attached to a water tank installed on its body to put out fires when it encounters one.
- Watering is done automatically and using two-way Bluetooth technology.
- With a sufficient range, the BT transmitter functions as a remote control.

XI. ADVANTAGES

- The robot will be used in places that would be dangerous for humans to enter.
- It has the ability to move around the room unattended and automatically.
- It is a device for supplying solar energy continuously.
- The autonomous water sprinkler will start to run anywhere a fire is detected.
- The robot is fire resistant, thus it can be used in environments where the temperature is 120 degrees Celsius.
- It can be managed externally using an Android phone.

XII. Conclusion

This embedded systems project demonstrates a firefighting robot that interacts through Bluetooth and was built using an Arduino controller (MCU). The experimental work was done with extreme care. The result shows that using the embedded system does, in fact, lead to higher efficiency. The suggested approach has been proven to be effective for both commercial and security needs. Only water moving quickly can currently be thrown by the robot. In the future, the robot will be able to use cameras to recognize objects and launch water with robotic arms under control. In order to fulfil all the features, it can be utilized as an additional project extension.

In this project, a all directional fire-fighting robot with RF communication is shown. The Arduino controller (MCU) was used in the embedded system domain to develop and implement the robot. The experimental work has been meticulously done. The outcome demonstrates that employing the embedded system does really result in greater efficiency. The effectiveness of the suggested method for both industrial and security purposes has been confirmed. The robot can currently only throw water at a high flow rate. The robot will eventually be able to recognize objects using cameras on it and fling water with controlled robotic arms. It can be used as an additional project extension to complete all the functionality.

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