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№ 4676

# Design and Implementation of a Smart Mobile Robot with Living Organisms Detection for Fire Extinguishing in Closed Areas Based on GSM

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December 1, 2020

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## ABSTRACT

With the recent risen in the population growth and the construction of the urban, the fires occurring have become widely spread. Here the lives of firefighters are in continuing risk where they may be exposed to the flaming or inhaling of toxic gasses associated with the combustion process. So that it is necessary to discover smart and effective ways to overcome these risks. In this study, a mobile robot is with a DC motor speed control is proposed, designed, and implemented for fire extinguishing especially in closed areas. The proposed robot is based on the Arduino microcontroller, motion sensor, Bluetooth module, H-bridge module, and GSM module. In addition, a small water pump installed on a servo motor and placed on the robot front to spraying the water on the fire. Meanwhile, the fire is explored by the Wi-Fi camera after that the water pump is turned ON wirelessly via the Bluetooth module with the help of a special Android app that utilised to driving the robot (speed and direction control) and operates the water pump as well. Besides that, once the presence of a living organism inside the fire site the motion sensor will detect this presence and the GSM module will send a warning SMS to the robot driver.

## 1. Introduction

A robot is a machine especially one programmable by a computer capable of carrying out a complex series of actions automatically. Robots can be guided by an external control device or the control may be embedded within. Robots may be constructed on the lines of the human form, but most robots are machines designed to perform a task with no regard to their aesthetics. In other words, the robot can be defined as an instrumental mechanism used for the replacement of a human being in science or industry [1]. In general, the robot comprises from the following elements [2]:

1. **Robot Brain:** Is a module which prepares and process the input/output in the specific circumstance and directs the actuator to take the desired action.
2. **Robot Structure:** Represents the physical structure of the robot arrangement, such as the wheeled structure, arm structure, or other structures which made the robot dependent on the required task and able to associate with its surroundings, as illustrated in Figure 1.

**Figure** Error! No text of specified style in document.**:** Some of robot structures

3. **Actuators:** Generally, the actuators attribute to the tools or modules that made up the robot and make it able to move or carry out actions, such as hydraulic piston engines or servo motors.
4. **Sensors:** Generally, the sensors are utilised in the robot arrangement to make it can feel the neighbouring environment and produce useful work.
5. **Power Source:** The robot arrangement could have batteries, fuel tank, or power cord to provide the energy that required to maintain the brain, sensors, and actuators working.

The improvement in the field of robotics has contributed to less human interruption and the utilise of robots for safety purposes. Fire occurrences have become normal in our day-to-day lives, and can sometimes result in risks that cause saving human lives challenging for the firemen. In these situations, a robot for firefighting is utilised to protect against fire injuries human lives, property and the environment. This robot fire struggle project is innovative is investigated recently, the fire extinguishing robot merges the radio frequency technology for remote operation and further utilises microcontrollers. A fire extinguishing robot is capable to detect a fire inside the house or any other areas, by means of the fire extinguishing robot, human and resources can be protected from fire occurrences [3]. Figure 2 illustrates the fire extinguishing robot arrangement.

**Figure 2:** Fire extinguishing robot

## 2. Literature Survey

Many researchers have earlier investigated and produced the fire extinguishing robots utilising, some of these studies are exhibited in this section.

- In this work, the researchers utilised the Arduino UNO microcontroller as a robot brain and the flame sensor as a fire sensing device with a wheeled robot structure. The implemented robot is operated with a mobile phone using DTMF tones for robot movement and detection of the fire. The flame sensor was utilised to senses the presence of the fire and turning ON the water spray to extinguish the fire [4].
- In this paper, the researchers work to propose an automation system and the design of a self-governing fire extinguisher robot. Efforts were made to develop a mobile robot to expose fires (fire simulated, candle) that could happen in a closed area. The implemented robot capable to operate and motion by utilising the DC motor, obstacle avoidance by sensor MZ80, detect the flame by the flame sensor, and extinguish the fire by a small fan, and search for the fire. To control the robot a message should be sent from the mobile or tablet by using Bluetooth module, once the fire detected the extinguisher will be running. The implemented robot can move on the required path without caught in the obstructions and transfers a fire scan throughout it moves by utilising the Arduino microcontroller [5].
- In this paper, the design and development of a compact fire extinguisher robot, where a robot is located inside a house model and a small candle are utilised to simulate the flame of the fire which the implemented robot is able to detect and extinguish the fire quickly while travelling within the house and evading any barriers in the robot's route. The proposed model of the robot was motivated by the design of the car, where the implemented robot utilises two wheels. The Robot brain in this work is the AT89S52 microcontroller. The implemented robot consists of the Light Sensor, 2 DC motors, and the alarm module

are used in the robot configuration. The two series DC motors are utilised to control the rear wheels and the single front wheel is free. The programming code of the robot configuration is done via the microcontroller by using 8081 environments [6].

- In this paper, an intelligent fire extinguishing robot is presented since firefighters employed to perform an important position within populations, so many studies on the utilise of the robots to diminish the damages of firefighters as well as to improve the efficiency, safety and variety of the mission and its schemes are addressed. This robot's main function is to track, remove, and increase awareness of fire activity in the incident region. The origins of different kinds of flame. The implemented robot configuration is consisting of sensors, motor driver, DC motors, and servo motor, microcontroller, and water pump [7].
- Smart Home was applied in order to provide comfort, energy efficiency and better security. Smart Home System is still rarely utilised in Indonesia because of the cost and the difficulty of getting the device. The objective of this paper is to offer a Small Smart Home System designed and created by utilising a WLAN network based on Arduino microcontroller. The system is able to monitor and control lights, room temperature, alarms and other household appliances. The PIR sensor is used to detect the presence of motion. The sensor readings are utilised to turn off the lights if there is no activity and turn on the lights otherwise. In addition, this sensor is also used for security systems to detect suspicious movements [8].
- This paper presented a smart street lighting system which provides a safe nighttime environment for all road users and pedestrian. The main objectives are to build an automation system of street lighting using a low-cost microcontroller which is Arduino and to achieve energy-saving. Light Emitting Diode (LED) is represented as the light module. This system is controlled according to the specific model. These modes are controlled by two sensors which are Light Dependent Resistor (LDR) and Passive Infrared (PIR) sensor. This system can automatically turn on and off the lights according to traffic flow [9].

## 3. Problem Statement

Fire detection and extinguishing is a serious job for a firefighter, which regularly places a person's safety and life in the danger. The fire extinguishing robot intends to offer a technological solution for this problem. The fire extinguishing robot is a mechanical configuration capable of executing a complicated set of actions remotely. With the current rise in fires due to accidents, vandalism or natural disasters, the life and safety of firefighters are always at risk of being exposed to fire or suffocation due to inhaling the toxic gases, especially in closed areas and restrained areas. Consequently, it is necessary to find and produce solutions to diminish the risk of fire workers from burning or inhaling of the toxic gases from the combustion process. Fire extinguishing robot diminishes these hazards as the robot is commanded remotely to enter the scene of the fire and extinguish the fire by spraying water on the fire without the need for firefighters to enter the fire site. To minimise the dangers in the fire zone a passive infrared sensor is utilised in this work to detects the presence of the living organisms inside the fire zone and send an SMS to the robot driver for the warning purpose

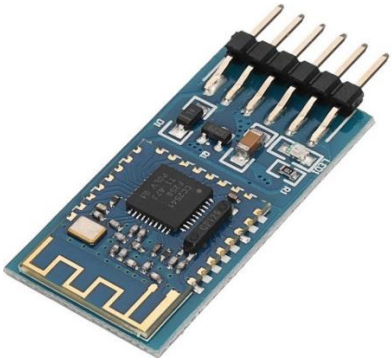
## 4. Study Objectives

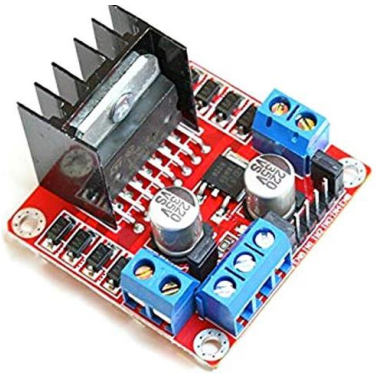
The major objectives for the proposed firefighting robot can be summarised as follows:

- Utilise the Arduino UNO microcontroller for the robot brain
- Utilise the WI-FI camera facilitate the proposed robot driving process
- Utilise the short-range wireless technology (e.g. Bluetooth technology) for the wirelessly driving for the proposed robot
- Utilise the L298N (H-bridge) module to control the speed and the direction of the robot motors
- Utilise the Passive Infrared (PIR) sensor to detect the presence of the living organism inside the fire zone
- Utilise the GSM module to send the warning SMS to the robot driver in the case of the presence of any living organism

## 5. The hardware of the Proposed Robot

This section presents the necessary apparatus that will be utilised to implement the proposed robot.

| | |
|---|---|
| HC-05 is a Bluetooth device used for wireless communication with Bluetooth enabled devices (like a smartphone). It communicates with microcontrollers using serial communication (USART). Default settings of the HC-05 Bluetooth module can be changed using certain AT commands [10]. |  |
| Arduino Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (six pins of them can be utilised to provides the PWM outputs), 6 analogue inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an 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 [11]. |  |

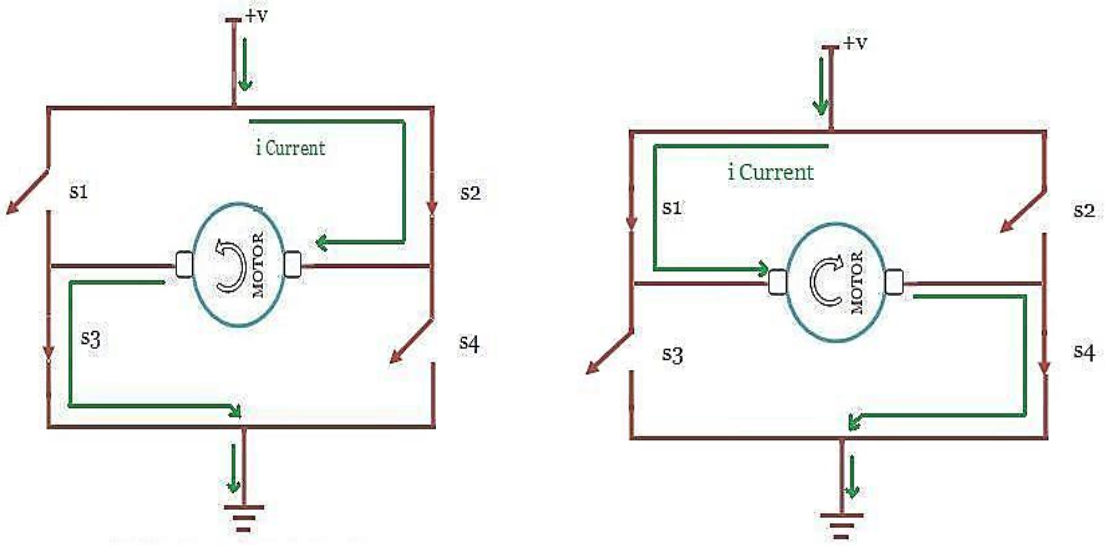
| | |
|---|---|
| This Shield is based on SIM900 and is compatible with Arduino and its clones. The GPRS Shield provides a way to communicate using the GSM cell phone network. The shield allows you to achieve SMS, MMS, GPRS and Audio via UART. The shield also has the 12 GPIOs, 2 PWMs and an ADC of the SIM900 module (They are all 2V8 logic) present on board [12]. |  |
| This L298N Motor Driver Module is a high power motor driver module for driving DC and Stepper Motors. This module consists of an L298 motor driver IC and a 78M05 5V regulator. L298N Module can control up to 4 DC motors, or 2 DC motors with directional and speed control [13]. |  |
| A passive infrared sensor (PIR sensor) is an electronic sensor that measures infrared (IR) light radiating from objects in its field of view. They are most often used in PIR-based motion detectors. PIR sensors are commonly used in security alarms and automatic lighting applications [14]. |  |
| A servo motor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors [15]. |  |

## 6. Working Principle for the Proposed Robot

In this section, the necessary steps for the implementing of the proposed robot will be present. Also, the working principle of the proposed robot for firefighting will be discussed and explained.

### 6.1. Proposed System Design

In this work, the s-wheeled robot structure is utilised to build up the proposed fire extinguishing robot based on the Arduino Uno microcontroller. The speed and direction of the proposed robot is controlling by the H-bridge module that connected with the motors of the robot. In order to control the direction of rotation of the robot motors, only the current direction through the motor should be reversed and this done by the H-bridge, as shown in Figure 3.




(a) C.W. (b) C.C.W

**Figure 3:** Working principle of the H-bridge motor driver

A PIR sensor is utilised in this work also for the purpose of detecting the presence of any living organism inside the fire zone and sends a warning message to the robot driver through the GSM module. In addition, a small water pump also has been installed on the servo motor and controlled by utilising a transistor as a switch principle, where the pump is fed externally from a source of 7.2 Volts battery and the Arduino microcontroller is limited to giving a control pulse of voltages to the Base of the transistor to turn the water pump ON or OFF. A Wi-Fi camera with voice and video will be installed on the front of the robot, that utilised to facilitate the driven process, as illustrated in the block diagram of Figure 4.

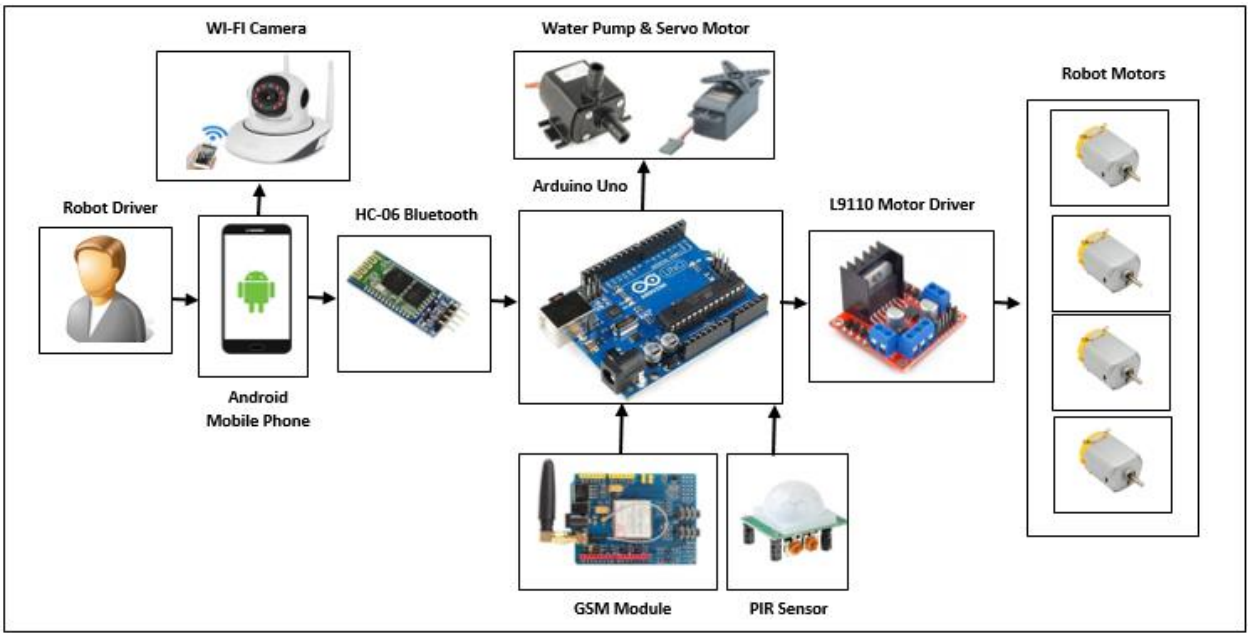



**Figure 4:** Block diagram of the implemented robot

The robot is fully wireless driven by Bluetooth technology utilising an Android-compatible app that is shown in Figure 5.

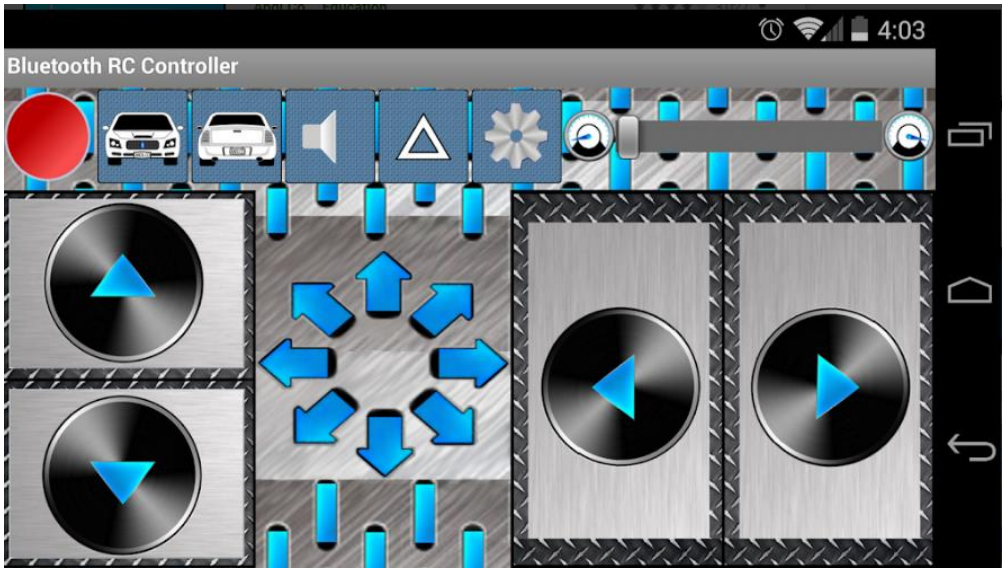



**Figure 5:** The graphical user interface of the Android app

## 7. Conclusion

In this work, a novel of the mobile firefighting robot has been presented in this study. The proposed robot is based on the Arduino Uno microcontroller, H-bridge module, motion sensor, Wi-Fi camera, Bluetooth module, and GSM module. The main contribution of this work is to develop a simple firefighting robot with high abilities to utilised specially to extinguish indoor fires that are difficult to reach easily. The proposed robot is fully wireless control via the Bluetooth technology with a speed and direction control.

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