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Development of a Fire Extinguishing Robot with SMS Alert Capabilities

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ABSTRACT
Fire incidents are disasters that can potentially lead to the loss of life and property. It can also leads to a temporal or permanent disability on the affected victim. The primary duty of fire fighters is to handle fire incidents, which often exposed them to high risks when carrying out the task of extinguishing fire, especially in hazardous area. This study presents the development of a fire extinguishing robot with SMS alert feature that can raise an alarm to notify occupants of the building, send an alert SMS message to a registered phone number, and also proceed to extinguish the fire unmanned. It is designed to be compact in size in order to ease movement into narrow spaces. The robot is equipped with an ultrasonic sensor to avoid collision with any obstacle and objects in the surrounding, while the flame sensor alongside a smoke sensor, were used to detect the fire. This developed autonomous system demonstrates capabilities of identifying fire locations automatically and extinguishes the fire using the stored mixture in the container placed on it.

Keywords: *fire alarm, flame sensor, robot, smoke sensor, ultrasonic sensor.*

INTRODUCTION
A robot is defined as a re-programmable multifunctional device which can be programmed to perform variety of tasks with little or no human supervision [1]. It is a machine designed to execute one or more tasks automatically with speed and precision [2]. Fire is the rapid oxidation of a material in the exothermic chemical process of combustion, releasing heat, light, and various reaction products [1].

Fire extinguishing has been a very challenging task for humans over the years due to physical limitation and adverse conditions in which they're exposed to during fire accidents [2]. Adverse conditions faced by fire-fighters includes long and irregular working hours, high environmental temperature, dust and low humidity and even life threatening situations like explosion and collapsed buildings [3]. Studies on the use of robots in firefighting are actively carried out to minimize firefighters' injuries and deaths as well as increase productivity, safety, efficiency and quality of the task given [3].

Robots can be classified into several groups such as Tele-robots, Tele-presence robots, Mobile robots, autonomous robots and androids robots [4]. Tele-presence robots are similar to tele-robots with the main difference of providing feedback through either video or sound [5]. Mobile robots are designed to navigate and carry out tasks with the intervention of human beings [6]. Meanwhile, autonomous robots can perform the task independently and receive the power from the environment, as opposed to android robots which are built to mimic humans [7].

A wireless remote-controlled fire-fighting robot was developed [3] in which the medium of interaction between the human and robot is through Console. The robot was implemented using two microcontrollers, Arduino Uno and Arduino Yun, flame sensor, temperature and humidity sensor, pair of servo motors, web cam, ultrasonic sensor, chassis, a pair of motors, H-bridge, water pump and nozzle. The flame sensor detects the presence of flames and temperature sensor would monitor the temperature. Ultrasonic sensor is mounted over one servo motor to scan the area for objects for obstacles. Webcam would capture the video and send it to Arduino Yun where it gets processed. The Arduino Yun is connected to the DHT 11 sensor and webcam. Temperature and humidity reading from the DHT 11 sensor is processed in the Arduino Yun before sending it to Google spreadsheet hosted on web server or cloud. H-bridge is used for the movement of robot in left, right, forward and backward direction. Nozzle is connected to the pump which is connected to small container containing water. The nozzle is mounted over servomotor so that it can spread water over large area of fire.

A remote-controlled fire-fighting robot was proposed by [3] which can be operated and controlled by remote user and has the ability to extinguish fire after locating the source of fire. It is equipped with a monitoring system and operates through a wireless communication system. The fire detection system is designed using the sensors mounted on the fire fighter robot. The robot is controlled autonomously using Android application

Reference [8] proposed a fire-fighting robot which is able to detect presence of fire by using gas sensor and temperature sensor and extinguish it automatically. It contains gear motors and motor driver to control the movement of robot. Relay circuit is used to control the pump and when fire is detected, communication with microcontroller (Arduino UNO R3) is done through Bluetooth module. The proposed robot has a water jet spray which is capable of sprinkling water. The sprinkler can be move towards the required direction. It provides a GUI for Arduino operation using android and detects obstacles using ultrasonic sensors up to a range of 80 m.

In this paper, a firefighting robot is proposed. The main function of this robot is to become an unmanned support vehicle, developed to detect and extinguish fire. By using such robots, fire identification and rescue activities can be done with higher security without placing fire fighters at high risk and dangerous conditions. In other words, robots can reduce the need for fire fighters to get into dangerous situations.

II. MATERIALS AND METHOD
Smoke Detector Unit
The smoke detector (Figure 1) used in this design is the MQ5 gas sensor, they are used in detecting leakage of gas such as LPG, natural gas, town gas, cooking fumes and cigarette in homes and industries.

Figure 1: Smoke Sensor

Infrared (IR) flame sensor

IR sensors like all other photo-sensor works on the principle that a photon of sufficient energy can knock out electrons leading to a change in the resistance of the circuit. The flame sensor, shown in Figure 2, can be used to detect fire source or other light sources of the wavelength in the range of 760 nm - 1100 nm.

Figure 2: IR Flame Sensor

Ultrasonic Sensor

An ultrasonic sensor (Figure 3) is a device that measure the distance to an object by using sound waves. It measures distance by sending out a sound wave at a specific frequency and listening for that sound wave to bounce back. By recording the elapsed time between the sound wave being generated and the sound wave bouncing back, it is possible to calculate the distance between the sonar sensor and the object.

Figure 3: Ultrasonic Sensor

SG-90 Servo Motor

A servo motor (Figure 4) is an electrical device which can push or rotate an object with great precision. If we want to rotate an object at some specific angles or distance, then we use servo motor. It is made up of simple motor which run through servo mechanism. The position of a servo motor is decided by electrical pulse and its circuitry is placed beside the motor.

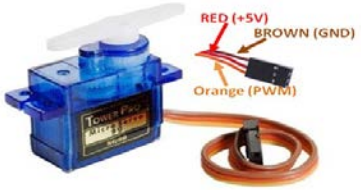

Figure 4: SG-90 Servo Motor

Arduino Mega

The microcontroller used in this work is the Arduino mega. It is the brain of the system which interfaces the sensing and actuating devices to perform the required functions, and also controls all the activities of the system. To power the Arduino mega microcontroller board, a 9v battery is used, to ensure easy portability of the project. Figure 5 shows the Arduino mega board.

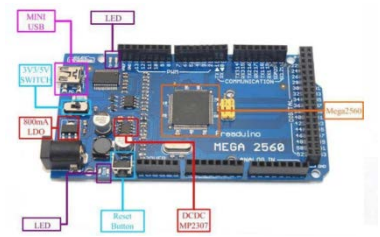

Figure 5: Arduino Mega

L298D Motor Driver IC

At the heart of the module is the big, black chip with chunky heat sink is an L298N. The L298N is a dual-channel h-bridge motor driver capable of driving a pair of dc motors. That means it can individually drive up to two motors making it ideal for building two-wheel robot platforms. The L298N motor driver is shown in Figure 6.

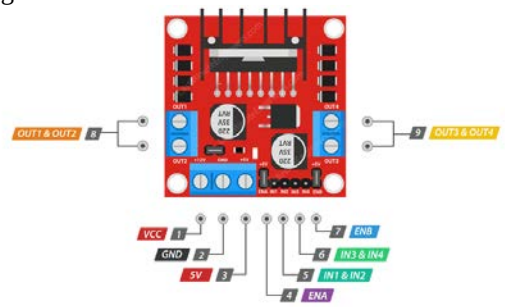

Figure 6: L2983D Motor Driver IC

Dc Motors

A direct current (DC) motor (Figure 7) is a rotating electrical device that converts direct current, of electrical energy, into mechanical energy.

Figure 7: DC Motor

GSM Module

SIM800 is a quad-band GSM/GPRS module that works on frequencies 850 MHZ, 900 MHZ, 1800 MHZ and 1900 MHZ. This module (Figure 8) is responsible for sending the SMS alert to a predefined mobile number.

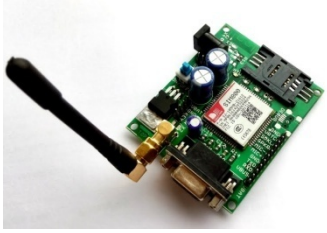

Figure 8: SIM800 GSM Module

Light Emitting Diodes

A light emitting diode (LED) as it is more commonly called, is basically a specialized type of p-n junction diode, made from a very thin layer of fairly heavily doped semiconductor material.

Three LEDS are visible in the design as indicators, the blue led indicates the presence of smoke and blinks steadily, the red led indicators the presence of fire as detected by the flame sensor and the white LED indicates a standby mode in which no fire is detected.

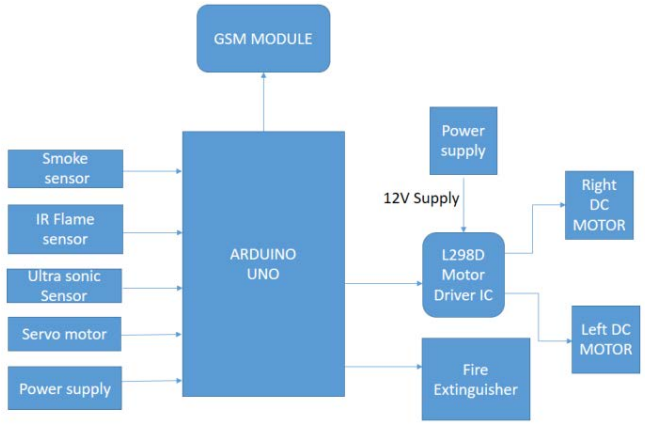

Figure 9: Block Diagram of the System

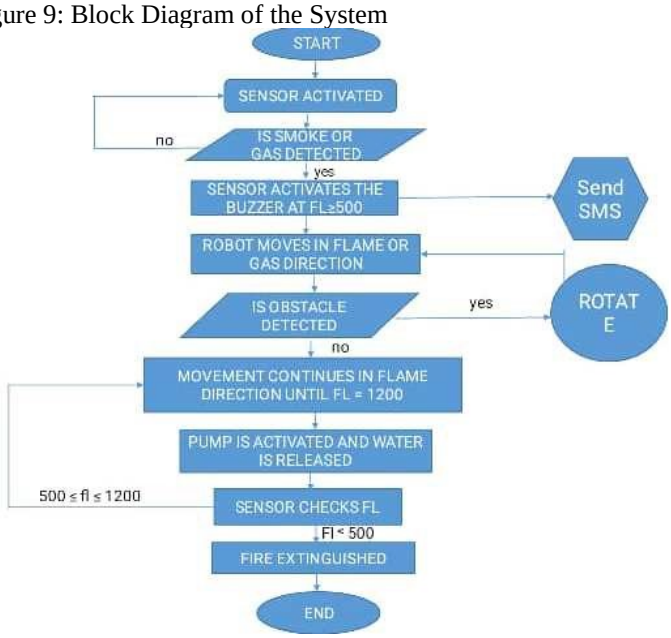

Figure 10: System Flow Chart

Figure 11: Circuit Diagram of the System

III RESULTS

The robot was switched on using a switch which kept the system in hibernation as long as there was no presence of fire in its environment having to put on a white LED to show that the robot is on. As soon as smoke and flame was detected, the red and blue LEDs came on and were blinking continuously while the buzzer was sounding an alarm. An SMS was received on the registered number to alert there was a fire and the robot was advancing to extinguish it.

Fire was ignited on firewood as a simulation of fire outbreak and obstacles were set on the path of the robot towards the fire. The firewood generated enough smoke and flame triggered the activation of the robot and thee robot advanced autonomously. The robot kept on moving forward and avoided the obstacles on its path by turning to the left of right and still advancing forward to keep the fire source in view.

On successful maneuver around the obstacles, the robot proceeded towards the fire and stopped at a distance of 30 cm from the fire source and activated its pump. A pipe was extended from the tank on the top of the robot and the content of the tank was sprayed onto the fire source.

As soon as the fire was quenched, an SMS was sent to the registered number to notify the user of the current situation and the buzzer was deactivated while the red and blue LEDs were deactivated while the white LED comes on.

IV CONCLUSION

The development of an autonomous firefighting system with SMS alert feature has been developed and implemented. This study has therefore provided a solution to problem of a sudden fire outbreak by developing an extinguishing robot for fire outbreak. The sensors used in this design can sense both gas leakages and fire with a high sensitivity. In the case of fire outbreak, the system is designed to work for three hours provided the lithium ion battery is fully charged. The major drawback of the system from test is the dependence on the GSM module, in places with no network coverage the GSM module won't be able to send a SMS notification.

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