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The Design, Implementation and Performance Analysis of a Smart Fire Fighting Robot

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ABSTRACT

This research work Titled "Design and Implementation of a Smart Firefighting Robot" focused on developing a robotic system capable of moving to areas where firemen have to risk their lives to put off the fire. Fire disaster occur at any time and at any place without notice, which result in high losses. Due to the damage of buildings and explosive materials, it becomes a major task to save people and to put off the fire. The robot will reduce the risk of injury for firefighters and possible victims and minimize the monitory losses which increase considerably as fire duration increases. It consists of Ultrasonic sensor mounted on the servo motor for obstacle detection and equipped with flame sensors for detecting fire. It has a liquid-tank and spray mechanism for putting off the fire. The spring nozzle is mounted on the servo motor to cover a maximum area. The liquid is pumped from the tank with a 12v pump. The robotic system is programmed using Arduino Uno board which served as the brain of the robotic system.

Keywords: DC motor, Flame sensors, Firefighting, Pump, Robot.

1.0 INTRODUCTION

Nowadays, machinery and robotic design become important in helping human. The Fire Protection Robot help people in any destructive burnt situation where the robot can detect and extinguish burnt area immediately using autonomous system. In real life, destructive burnt area often happens without our realization. Therefore, this type of robot will require a high demands in the market because of its usefulness to the human as well as the environment transmit fire information to cell phone using GSM modern.

Firefighting is a very dangerous and high –risk job in saving human's life. A fire fighter has to be alert and well-prepared at any given time, so that they would be able to reach the scene within a shortest possible period of time and safely extinguish the fire. The quick action by the fire fighters can stop further damage and minimize casualties [11]. Fire fighters extinguish fires to protect lives and to avoid destruction of property and environment. Through extinguishing operation, many firefighters are killed and injured due to the absence of information about hazard building infrastructure. Sometimes, firefighters face serious challenges to get in the hazard building to extinguish fire, and locate the civilians, because in most cases, firefighters do not have a prior knowledge about the hazard building infrastructure. Firefighters face serious risks on the job, where they face flames, heat, high level of Carbon (II) Oxide and physical and mental stress. A large number of firefighters have been injured during practicing their duties, including extinguishing fire, and rescuing operations.

Therefore, there is an ideal target for robot technology to keep away firefighters from danger. Robotics is the branch of mechanical engineering, electrical engineering and computer science that deals with the design, construction, operation, and application of robots, as well as computer systems for their control, sensory feedback, and information processing. These technologies deal with automated machines that can take the place of humans in dangerous environments or manufacturing processes or resemble humans in appearance and behaviour.

A firefighter robot is the one which has small fire extinguisher attached to it. It is capable of detecting and extinguishing fires when designed and built. Once the flame is detected the robot sounds the alarm or blinks the light, it actuates the valve as per

command and releases sprinkles of water on the flame. The principles used in this design are such that it enables our robot to be a more robust system used to indoors.

2.0 STATEMENTS OF THE PROBLEM

Most of the firefighting robots are operated by humans and do not have independent planning and operation abilities. Human beings find it difficult to detect and locate small portion of the burnt area, so in places similar to this, a Smart fire-fighting robot with a water tank is really helpful. This Robot could also be used in a warehouse, luxurious hotels, and jewelry shops. Water or any other chemical substance may cause harm to the objects or things inside these structures. In order to avoid damage to the objects or things inside the buildings, warehouses, and luxurious places, firefighting Robot with a water tank could be used. The Robot could not just quench the fire immediately, it can help in solving the situation without deteriorations. Such robots really help during times of emergencies as it may prevent the spreading of fire at early stage. Any manual intervention would take longer to reach the place or simply put off the fire.

3.0 RELATED WORKS

Hasimi et al., (2010) developed a Fire Fighting robot, controlled by mobile which is used to detect a fire and extinguish it using a water pump. The Fire Fighting Robot has an extinguisher attached to it. A water pump attached to a water container is used to extinguish the fire. A mobile is used to control the Fire Fighting Robot.

Priya et al., (2018) implemented a smart firefighting robot used to detect the fire and extinguish the fire immediately. The Fire Fighting Robot uses GUI (Graphical User Interface) and Bluetooth to connect the mobile to the robot for communication purposes. The Fire Fighting Robot uses the water sprinkling system to put off fire.

Vidkar et al., (2018) designed an autonomous Fire Fighting Robot which detects fire and moves towards the location of the fire and uses an extinguishing fan to put off the fire. The Robot moves towards the fire, stops at a certain distance and detects the fire. Then after extinguishing the fire, the Robot moves back to its original position.

Agrawal et al., (2018) developed an unmanned Fire Fighting Robot to detects fire and moves towards the fire and extinguishes the fire using a fan. This Fire Fighting Robot using Arduino and sensors detects the fire for further process.

Abdulkadir and Farooq (2016) developed a Fire Fighting Robot used to detects the fire and moves to the location of the fire. It uses the water tank to put off the fire. The temperature of the fire is monitored with the Fire Fighting Robot.

Kalaivani et al., (2019) designed and implemented a Fire Fighting Robot to extinguish the fire with the use of water. The movement of the Robot is fully controlled by a raspberry pi. A thermal camera and an infrared camera is mounted to the fire-fighting Robot. The thermal camera is used to sense heat while capturing footage of the fire scene. The infrared camera is used for capturing the fire scene at night.

Yang et al., (2016) developed an autonomous Fire Fighting Robot with vision camera and gas sensors. This Fire Fighting Robot uses a camera to detect the fire with the flame detector. The Fire Fighting Robot uses a water sprinkler to put off the fire.

Supriya et al., (2018) designed an Autonomous Fire Extinguishing Robot using sound waves. The direction of the sound waves plays a major role in the fire extinguishing process. The Fire Fighting Robot has a Wi-Fi enabled camera to the body of the robot which makes it easy to be control the robot from a remote place.

Prasad et al., (2018) developed a firefighting Robot. The firefighting Robot is controlled by a remote with a human from an area far away from the fire scene. This Robot is used for emergency situations to prevent loss of life and property damage.

Kristi et al., (2010) developed intelligent firefighting tank robot. Tank robot is made from acrylic, plastic, aluminum and iron. Robot components are two servo motors, two DC motors, ultrasonic sensor, compass sensors, flame detector, thermal array sensor, white detector (IR and photo transistor), sound activation circuit and micro switch sensor.

Rohini et al.,(2012) Has developed a wireless fire fighter robot. It comprises of machine which has ability to detect fire and extinguish it. The firefighting robot can move in both forward and reverse direction and can turned in left and right directions.

4.0 HARDWARE DESIGN

4.1 DC motor

A DC motor is a mechanical rotating device which converts electrical energy into mechanical energy. DC gear motor is a combination of DC motor plus a gearbox (motor reducer) in order to reduce the speed (RPM) of the motor, with a corresponding

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increase in torque. The planetary motor performance is stable and can be used in high torque environments. Outer diameter 30mm planetary gearbox is equipped with outer diameter 31mm DC motor, it can be customized with torque, material, shaft, gear ratios.

Fig. 1: DC Motor

4.2 Flame Sensor

A Flame Sensor is a device that can be used to detect presence of a fire source or any other bright light sources. There are several ways to implement a Flame Sensor but the module used in this project is an Infrared Radiation Sensitive Sensor.

4.3 GAS Sensor:

Fire Sensor is a device which detects the fire. Mainly it detects the temperature and some other features related to it. Categories in it are flame detection, gas detection and smoke detection. In this project we are using gas detection sensor. Mainly we use this sensor in household purposes. In houses LPG gas leak likewise many things may happen which are causes for the fire outbreak. In this project we use Gas sensor (MQ 2). This is used in detecting H2, LPG, Methane, CO, Alcohol, Smoke etc.

Fig.2: Gas Sensor

4.4 Relay

Relays are the switches which closes and open the circuits either by electromechanically or electronically. It's a tool that opens or closes the contacts to cause the operations of other electric control. It gives the commands to the breaker, when it detects the undesirable condition under an assigned area, it disconnects the affected area through ON and OFF.

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4.5 GSM

Fig. 3: Relay

GSM stands for Global System for Mobile Communication. It is used for transmitting mobile voice and data services which will operate at different frequency bands. It uses Time Division Multiple Access (TDMA) used for communicate the information. In this project we use SIM 800. It is a quad-band GSM/GPRS module that works on 850 MHz GSM, 900 MHz EGSM, 1800 MHz DCS and 1900 MHz PCS. It also features GPRS multi slot Class 12/Class10 (optional) and supports CS-1,CS-2,CS-3 and CS-4 GPRS coding schemes.

Fig. 4: GSM Module

4.6 Ardunio Uno

The Arduino Uno is a microcontroller board based on a removable, dual-inline-package (DIP) ATmega328 AVR microcontroller. It has 20 digital input/output pins (of which 6 can be used as PWM outputs and 6 can be used as analog inputs). Programs can be loaded on to it from the easy-to-use Arduino computer program. The Arduino has an extensive support community, which makes it a very easy way to get started working with embedded electronics.

The Arduino IDE is used for programming the arduino UNO. A program was written for the detection of fire, movement of Robots, and extinguishing the fire. If the fire is detected, the Robot starts to move towards the fire else, the Robot 'doesn't move. The movement of the Robot changes according to the direction of the fire. The IR sensors measure the direction of the fire, and the DC motors adjust the position of the wheel to reach the fire scene. The IR sensors detect the presence of the light using a transducer, which converts the light energy to mechanical energy. Therefore it powers the DC motors in coordination with the motor drivers. The DC motors function with Fleming's left hand rule as its main principle.

5.0 METHODOLOGY

A thermostat is a component of a control system which senses the temperature of a system so that the system's temperature is maintained near a desired-set-point. The thermostat does this by switching heating or cooling devices on or off, or regulating the flow of a heat transfer fluid as needed, to maintain the correct temperature. The name is derived from the Greek words thermos "hot" and status "a standing".

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When fire is detected, signal will be sent to the user in the form of a message which is performed by the use of GSM. In addition to it, there is a buzzer, for the detection of the fire. The second category of the project is to process the signal. There are total three motors in this robot. Two motors will be for the motion of the robot. Remaining one is used for splashing of the water over the fire. For this purpose, it is using the motor of car wind screen. Relays are to be used along with the motors. Totally there are 5 relays used in this research work. One relay is for the pump motor, remaining four relays are used for the motors which are used for motion purpose.

6.0 RESULTS AND DISCUSSION

The Robotic system developed has been tested through an environment with dimensions of 5×5 meters, where it moved randomly according to the environment conditions as shown in figure 6.

I. SIMULATION TEST

The program was written using Integrated Development Environment of Arduino and the HEX file was employed to Proteus software. The simulation design is shown in figure 5.

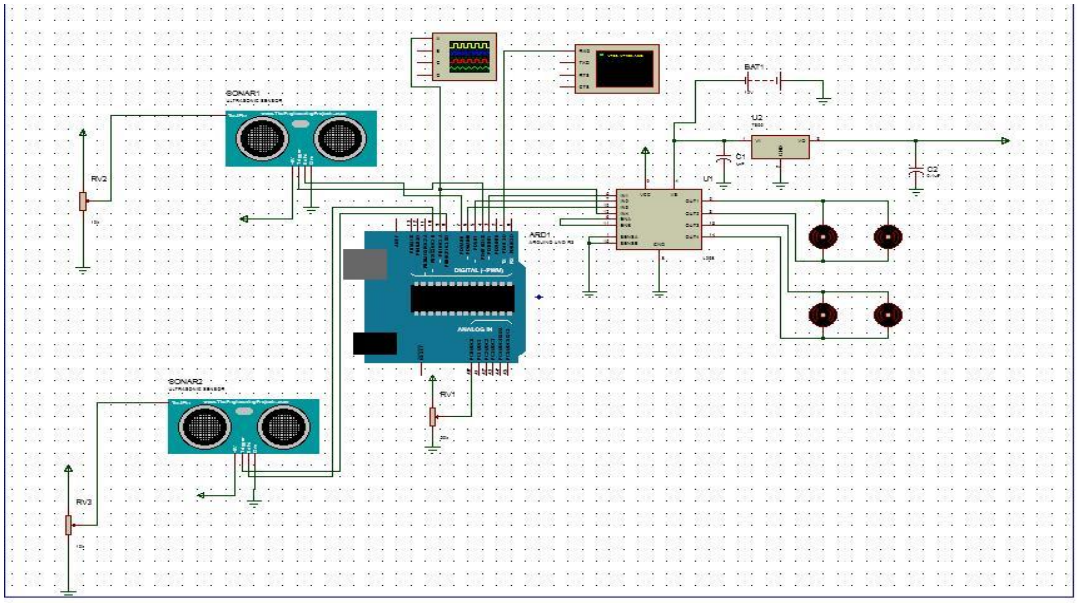

Fig. 5: Circuit Design

II. Experimental set up

The Firefighting robot designed and implemented is shown in figure 6

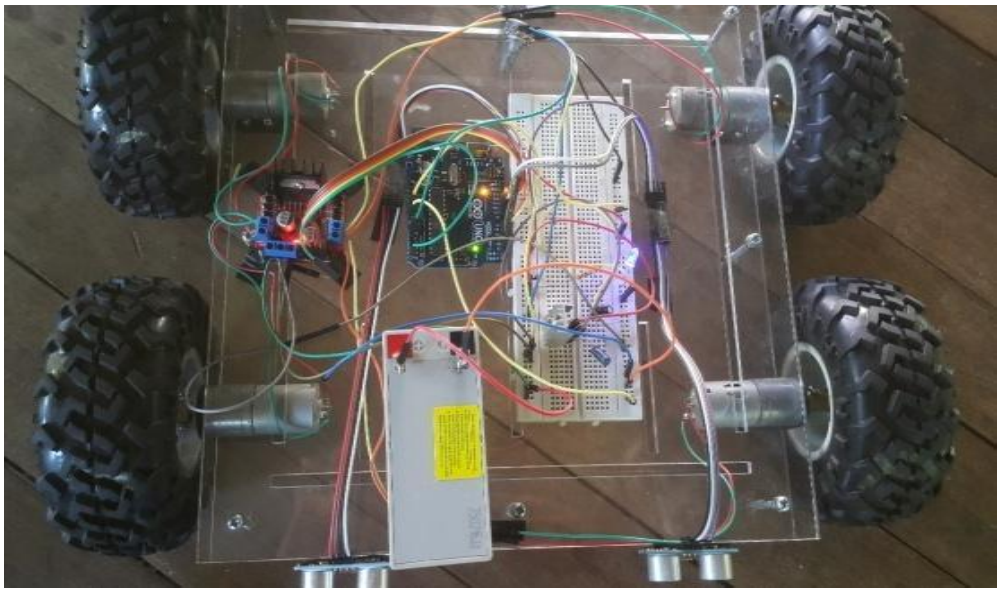

Fig. 6: Firefighting Robot

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Fire detection value can be expressed as shown in following table.

Table 1: Infrared Based Fire Detection

Experiment	Distance from the fire (cm)	Measured voltage (v)
1	10	3.80
2	20	3.00
3	30	2.50
4	40	1.90
5	50	1.10
6	60	0.65
7	70	0.11

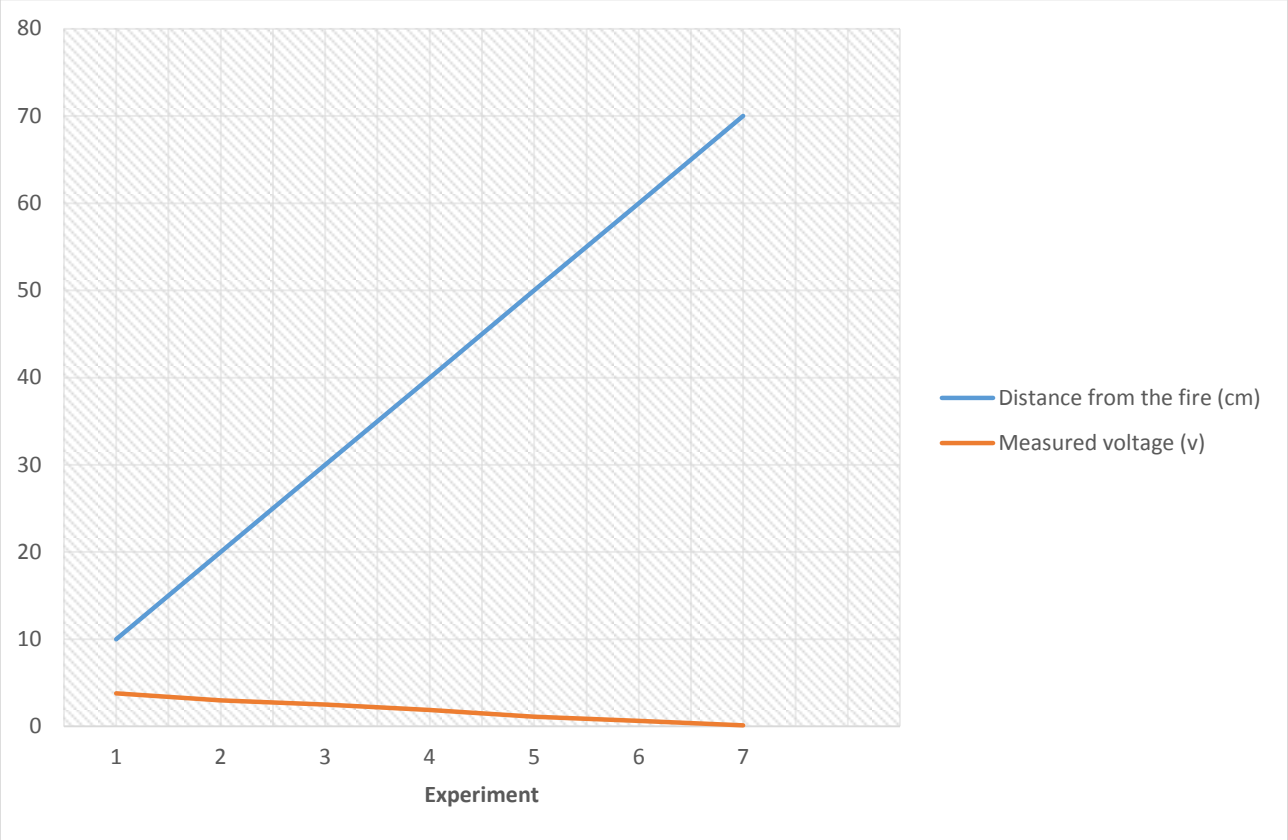

Figure 7: Graph showing results for the flame sensor

Table 2: Ultrasonic based obstacle detection

Experiment	Actual value (cm)	Measured value (cm)
1	5	5.00
2	10	9.95
3	15	14.80
4	20	19.40
5	25	24.25
6	30	29.10

Table 2 shows the result between the actual and measured value for ultrasonic sensor range in centimeter. For the range that is near to the transmitter, the amount of error difference is virtually the same with the actual value obtained. The higher the distance for the obstacle detection, the higher the error.

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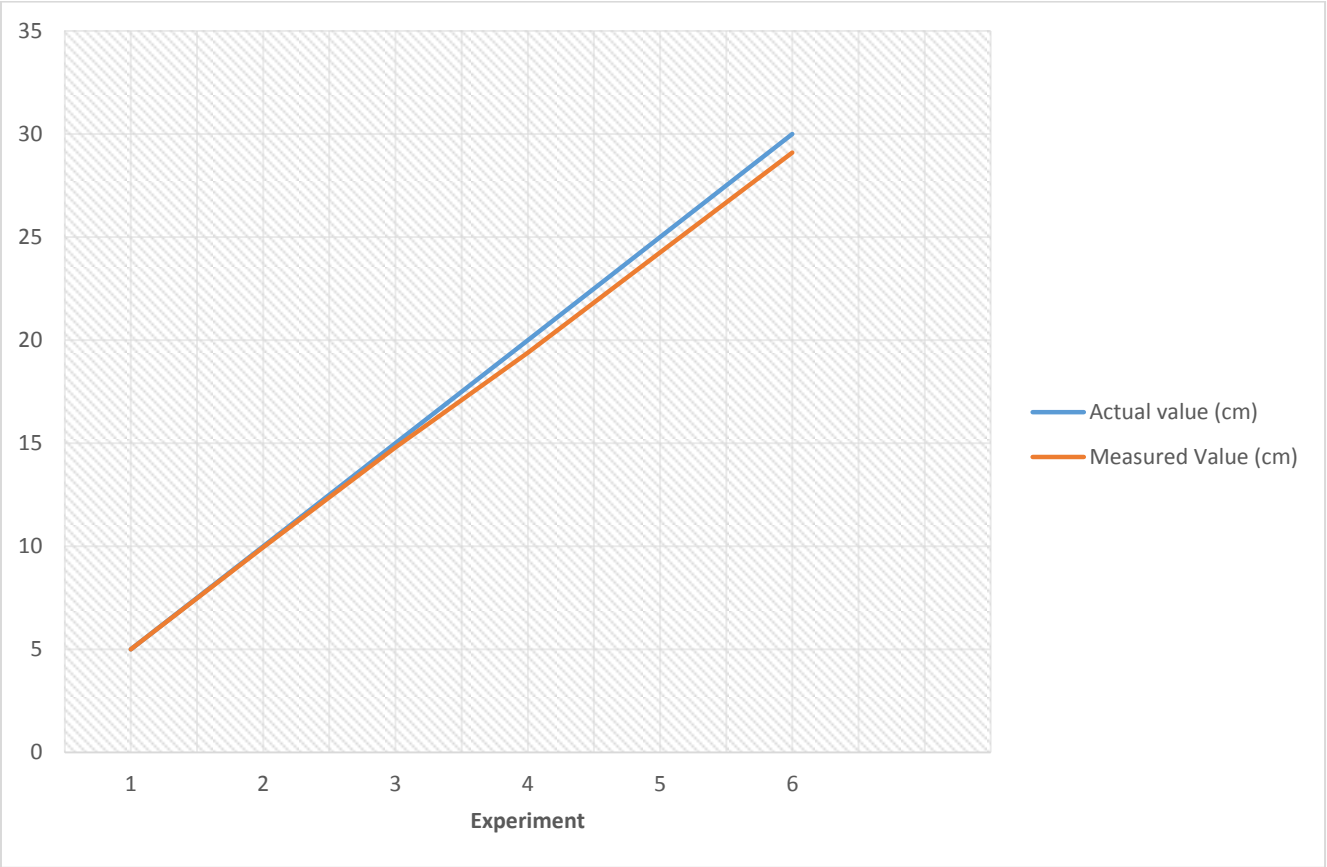

Figure 8: Graph showing results for the ultrasonic sensor

III. CONCLUSIONS

The results show that the measured distance are satisfied for use in the firefighting system being developed. It used sensors to detect and identify the intensity and direction of fire with its location. Firefighting is the act of extinguishing fires, it sprinkles water on to the fire. If fire is detected with the help of sensors or manually, operates the water pump mechanism through relay circuit. It can be concluded that the robot can be used in place of humans, thereby reducing the risk of life of Firefighters. It can also be used in Homes, Labs,Offices etc.

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