Design and Implementation of a Fire Fighter Robot in Fire Detection

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Abstract

In this paper, we have developed a robot that is able to detect the fire in the very initial stage and have the ability to move in front of the fire and spray water to put out the fire. We have also connected buzzer and LEDs (Light Emitting Diode) so that people will get to know about emergency. It will help us to bypass the big accidents that may occur due to fire. This device will be very helpful in various congested areas where human firefighters may not be able to reach, places as a server room, power control room, tunnels, etc. Especially in the disaster-prone area when the human firefighters take too much risk for their rescue mission, if they get this kind of device, they will be able to accomplish their mission smoothly, and quickly maybe they would have saved more lives. In the future, we are planning to set a level indicator in the tank so that it could automatically get to know the water level of the tank, and without our help, it will go back to the base to refill the water tank. It will be very effective.

Keywords: - *Fire Fighter, Robotics, IR Sensor, Arduino.*

INTRODUCTION

The firefighter Robot is defined as a mechanical design that is capable of performing human tasks or behaving in a human-like manner. Building a robot requires expertise and complex programming. It's about building systems and putting together motors, flame sensors, wires, among other important components. A firefighter robot has a small fire extinguisher in it. By attaching a small fire extinguisher to the robot, it automatically put out the fire, which will be controlled by a human. This paper concerns the design and construction of a robot capable of detecting and extinguishing the fire. Human firefighters face risky situations while extinguishing fires and saving victims; it is an inevitable part of being a firefighter. On the contrary, a robot can operate alone or be controlled remotely, which means that fire fighting and extinguishing activities could be carried out without endangering the human firefighters using robotic technology. In other words, the robot reduces the need for human firefighters to enter dangerous situations. This robot provides fire protection in the presence of a tunnel, or an industrial sector that use the automatic robot is controlled through the use of a microcontroller to reduce the loss of material damage as well as life [1-4].

Today firefighting is a very important issue in our life. Many of us are working on different techniques for firefighting and are being reported by several researchers. Henrik Carlsen et al. have developed different evolutionary paths, opportunities, threats and ethical aspects that are identified in the introduction of robotics in the home security sector using an iterative methodology of participatory seminars [5]. K. Schilling, F. Driewer has addressed specific aspects of the teleoperator to remotely control robots [6]. Steven A. Kahn, Clint Leonard, Young Gun Lee, Rick Boatwright, Jason Woods has shown Modern heat protection equipment that has reduced firefighter hazards from thermal and inhalation injuries but must be used correctly to be effective. [7]. Jennifer L. A. Keir, Umme S. Akhtar, David M. J. Matschke, Paul A. White, Jules M. Blais has done the measurement of exposure to polycyclic aromatic hydrocarbons (PAHs), antimony, cadmium, and lead using personal air samplers used by firefighters during emergency fires. [8]. Meredith McQuerry, Roger Barker, Emiel DenHartog have investigated design changes in structural firefighters suits for their ability to reduce heat stress during firefighting

activities [9]. A. Naghsh, J. Saez-Pons, J. Penders, J. Gancet, R. Sebastia have demonstrated a real-world that involves two kinds of human-robot interaction, In-situ interaction between a team of robots and a firefighter, and the interaction between a remote operator and the whole system from a base station [10]. Khaled Sailan, Ing. Klaus-Dieter Kuhnert demonstrated that how can an obstacle be bypassed using a fuzzy controller for autonomous amphibious vehicles [11]. Shivan Agarwal, Nidhi Agarwal has developed a platform that is a combination of hardware and software for human-machine interaction. The design provides an accessible system for robots to communicate with the Android application via Bluetooth. [12]. Saravanam P., Soni Ishawarya has analyzed a method to control all the kinetics of fire fighting mobile robot using a blue-tooth module installed in the unit through a smartphone which operates on Android operating system [13]. S. Jakthi Priyanka, R. Sangeethahas developed a robotic vehicle capable of automatically detecting and extinguishing the presence of fire [14]. Jinzhu Zhang, Zhenlin Jin, HaibingFeng have proposed how to remove a series of protectable leg mechanisms (LMs) obstacle [15]. H. Saygin Sucuoglu, Ismail Bogrekci, Pinar Demircioglu has designed a mobile robot platform that is capable of early fire detection [16]. Jui-Sheng Chou, Min-Yuan Cheng, Yo-Min Hsieh, I-Tung Yang, Hsin-Ting Hsu has proposed an Intelligent integrated fire rescue system capable of providing real-time status updates, alarm reporting and evacuation guidance to firefighters through a combination of simultaneous automatic detection and communication systems [17]. Frauke Drawer, Markus Sauer, Klaus Schilling have proposed mobile robots can support human rescue workers to accomplish tasks in dangerous areas and locations of difficult access. The remotely operated rovers characterize the environment with their sensors [18]. L. Frund has shown the development of smartphones open new preservatives for low-cost mobile robot [19]. Angel Gonzalez Villan, and Joseph Jorba has proposed a new architecture for the remote control of Android mobile devices and analyzed the different alternatives, looking for the optimal solution in each case [20]. Jong Hoon Ahnn has the proposed schemes and the strategy adopted to establish two types of communication; one for wireless communication between a mobile robot and a remote base station, one for serial communication between a remote base station and a GUI application PC [21]. Shivam Agrawal, Nidhi Agrawal proposed to connect the robot with an Android app for back and forth communication [22]. Saravanan P., Soni Ishawarya analyzed a method to control all the kinetics of the mobile firefighting robot using a blue tooth module installed in the unit via a smartphone with an Android operating system [23]. Gignesh Patoliya, Haard Mehta has proposed a robot for the surveillance of human activities in the war field or border regions to reduce infiltrations from the enemy side[24]. Mohammed Faisal, Ramdane Hedjar, Mansour A. Sulaiman and Khalid A-Mutib have proposed an online navigation technique for a wheeled mobile robot (WMR) is studied in an unknown dynamic environment using fuzzy logic techniques. [25]. Mohamed Khaleel, R. Pranay Kumar, P. Manogna has proposed the architecture and accomplishing of firefighting is mainly based on the ascendancy of the semi-autonomous blaze angry adaptable robot[26]. Satya Veera Pavan Kumar Maddukuri, Uday Kishan Renduchintala, Aravinthan Visva Kumar has proposed an autonomous and semi-autonomous intelligent robot based on multiple sensors, which saves from fire accidents in everyday life [27]. V. Raudonis, R. Maskeliunas have proposed an algorithm and a control model of a real prototype, a rather promising experimental evaluation of autonomous inland navigation capabilities [28].

In this paper, we have proposed a cost-effective firefighter robot. It comprises of flame sensor which can detect fire. The fire-fighting robot can move in both forward and reverse direction, and in the left and right direction, the power factor can operate the robot at a very long distance, and there is no need for humans in that area. Fire light-dependent resistor is used for the detection of fire; this register is a highly sensitive device and is capable of detecting very small fire. When the robot is near a fire, water is sprayed to put out the fire. There is a small container used to carry water, a 5Volt pump is also placed in the container, and the whole container is placed on top of a servo motor to control the direction in which the water has to be sprayed.

MOTIVATION

The loss due to fire all over the world remains high, and firefighting is a dangerous task. To confront the challenges in firefighting, many research programs have been developed still there are significant losses due to fire every year. The entire direct and indirect cost of fire losses as a percentage of Gross Domestic Product (GDP) in the world is estimated up to 1% annually. The US fire departments responded to over 12,40,000 fires in 2013, which resulted in approximately 3,420

civilians fatalities, 15,925 injuries and property losses of about $12.4 billion 3 $. The human firefighters face risky situations while extinguishing the fire and rescuing victims. It is an inevitable part of being a firefighter. In India, the National Crime Records Bureau [NCRB] estimated that more than 1.2 lakhs of deaths occurred due to fire accidents from 2010 to 2014. During harsh conditions on the fire ground, such as smoke inhalation, fire bums, overexertion/stress, or even being trapped, it is considered to be the main attributions. More than 60% of the human firefighter dies, and over 20% injuries are seen. Even though there are a lot of precautions are taken to prevent fire accidents, few natural and man-made disasters do occur now and then. To put out the fire and rescue people, when there is a fire breakout, we are forced to use human resources that are not safe, and human firefighters risk their lives.

METHODS OF APPROACH

In our proposed model, the main brain is Arduino UNO. The sensors we have used here have an IR Receiver that is used to detect the fire. A small amount of Infrared light is emitted when the fire burns; this light will be received by the IR receiver on the sensor module. An Op-Amp is used to check for a change in voltage across the IR Receiver so that if a fire is detected, the output pin (DO) will give 0Volt (LOW), and if there is no fire, then the output pin will be 5Volt (HIGH). Three sensors are placed in three different directions of the robot to sense in which direction the fire is burning.

As the sensor detects the direction of the fire, the motors start to move the robot near the fire by driving our motors through the motor driver module. When the robot is near a fire, it starts to spray water. There is a small container that is used to carry water, a 5Volt pump is also placed in the container, and the whole container is placed on top of a servo motor to control the direction in which the water has to be sprayed. Table 1 shows the detailed pin configuration of the Arduino UNO.

Table 1: Pin configuration of Arduino UNO

Element	Range
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6 - 20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 Ma
DC Current for 3.3V Pin	50 Ma
Flash Memory	32 KB (ATmega328) of which 0.5 KB used by the boot loader
SRAM	2 KB (ATmega328)
EEPROM	1 KB (ATmega328)
Clock Speed	16 Hz

a. Flame Sensor

A flame detector is a sensor that is designed to detect the presence of a flame or fire. It responses to a detected flame depending on the installation; it may also include the sound of an alarm, the deactivation of a power line (such as a propane or natural gas line) and the activation of a fire suppression system. When there is fire, a small amount of infrared light is emitted; this light will be received by the photodiode (IR receiver) in the sensor module. So we use an operational amplifier to control the voltage variation in the IR receiver, so if a fire is detected, the output pin (DO) will provide 0 Volt (LOW), and if no fire is detected, the output pin will be 5 Volt (HIGH). An IR based flame sensor is used. It is a highly sensitive and high-speed NPN silicon phototransistor. It is capable of detecting infrared light with a wavelength between 700 nm and 1000 nm, and the detection angle is approximately 60°. A flame sensor module consists of a photodiode (IR receiver), resistance, capacitor, potentiometer and comparator in an integrated circuit. Sensitivity can be adjusted by varying the onboard potentiometer. The working voltage is between 3.3 Volt and 5 Volt DC, with a digital output. The high logic in the output will indicate that there is a presence of flame or fire. Low logic at the output will indicate that there is an absence of flame or fire.

b. Communication System

Arduino Uno has a series of services for communicating with a computer, another Arduino or other microcontrollers. ATmega328 provides UART TTL (5V) serial communication, available on digital pins 0 (RX) and 1 (TX). An ATmega16U2 on the board transmits this serial communication via USB and appears as a virtual port for the software on the computer. The firmware 16U2 uses standard USB COM drivers, and an external drive is not required. However, on Windows, a .inf file is required. The Arduino software includes a serial monitor that allows the sending of simple text data to and from the Arduino board. The RX and TX LEDs on the board will flash when the data is transmitted via the USB chip to the serial port and the USB connection to the computer (serial communication on pins 0 and 1 cannot be done). A serial software library allows serial communication on any Uno digital pin. The ATmega328 supports I2C (TWI) and SPI (Serial Peripheral Interface)

communication. Arduino software includes a Wire library to simplify the use of I2Cbus; See the documentation for more details. For SPI communication, use the SPI library. Figure 1 shows the detailed block diagram of the proposed fire-fighter robot. Figure 2 shows that the detailed working flow chart of the proposed fire-fighter robot.

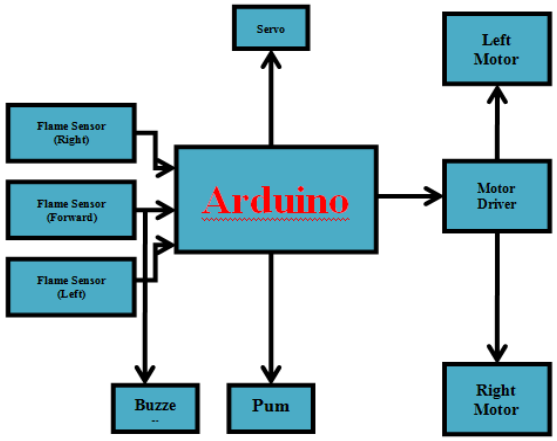

Figure 1: Flow chart of the proposed fire-fighter robot

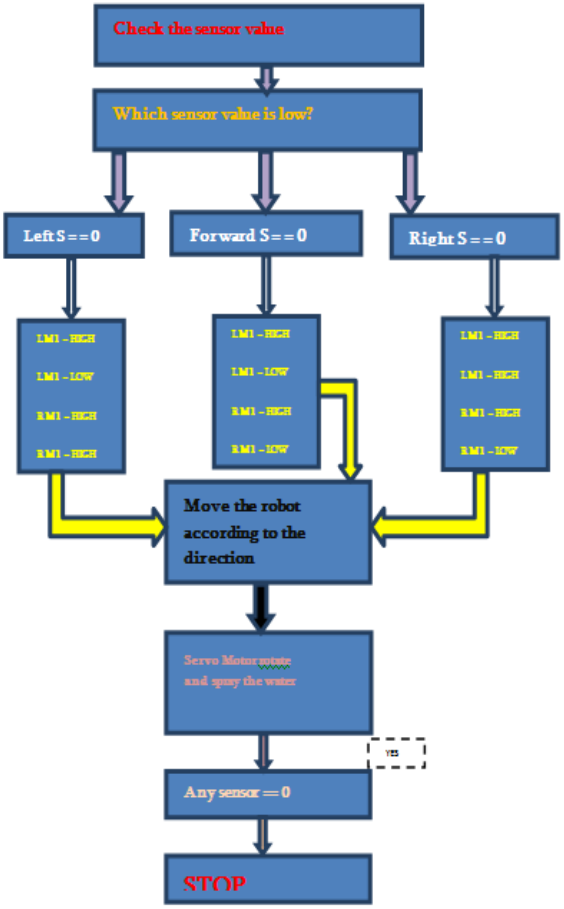

Figure 2: Block Diagram of the proposed fire-fighter robot

RESULT AND DISCUSSION

We have decided to use rechargeable batteries to supply power to the robot for convenience as well as to reduce expenses (replacing disposable batteries is an unreasonable option). We have used two packs of the batteries in order to prevent the situation (if we have only one pack) where we will have to stop our test on the robot and recharge the battery. After we did some rough analysis on how much total power will be needed. We have found that the maximum current our robot will draw at any given time will be approximately 5 amps. So, we have decided that we will use a 6.5 Volts battery. They are also economical compared to other similar products. A linear 12 V regulator is used to supply power to the Arduino. Table 2 shows the output result of the flame sensor which is used in this proposed fire-fighter robot.

Table 2: Output Result of Flame Sensor

Element	Variable	Value
Flame Detector	Wavelength	760nm – 1100nm
Resistor	Resistance	Decreased (since T∞1/R)
Comparator Op-Amp	Voltage gain (Av)	>1 (increased)
Transistor	Base Current (Ib)	Generated
(Relay) Coil Terminal	Voltage signal	Generated

CONCLUSION AND FUTURE PLAN

This paper has presented a unique vision of the concepts which are used in this particular field. Our aim is to promote technology innovation to achieve a reliable and efficient outcome from various instruments. Experimental work has been carried out carefully. The result shows that higher efficiency is achievable using the embedded system. In a common digitalized platform, these instruments will increase flexibility in operation, control, and expansion allowed for embedded intelligence, essentially foster the resilience of the instruments and eventually, it benefits the customers with improved services, reliability and increased convenience. In this paper, the major features and functions of the various concepts that could be used in this field are discussed in details through various categories. Since in this initial work everything cannot be addressed within the proposed framework and vision, more research and development efforts are needed to fully implement the proposed framework through a joint effort of various entities. This modest invention is built to create connections between disabled persons and wheelchair to help them become independent. Since it is operating in three different modes of control, which makes it user friendly.

Moreover, users can control their home appliances. This Robot will be economical and affordable to common people.

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