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RESEARCH ARTICLE OPEN ACCESS

AUTONOMOUS FIRE FIGHTING ROBOT WITH MULTI SENSOR FIRE DETECTION USING ARDUINO

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ABSTRACT:

Recently, Multi-sensor Fire Detection System (MSFDS) is one of the important research issues. Here, a fire fighting robot is fabricated providing extinguishment platform. The base of the robot is made of the wood of "Rashed tree", locally known as "Kerosene wood". There is a water reserving capacity tank in the robot. An arduino based simple algorithm is used for detection of fire and measurement of distance from fire source while the robot is on its way to extinguish fire. When the fire is detected and the robot is at a distance near to fire, a centrifugal pump is used to throw water for extinguishment purpose. A water spreader is used for effective extinguishing. It is seen that velocity of water is greatly increased due to the use of water spreader. Two sensors: LM35 and Arduino Flame Sensors are used to detect the fire and distances on its way towards fire. Sensitivity of these sensors at different day times and distances is tested through analog reading of the serial monitor.

Keywords - Multisensor; Arduino; Rashed tree; Kerosene wood; Algorithm; Detection; Extinguishment

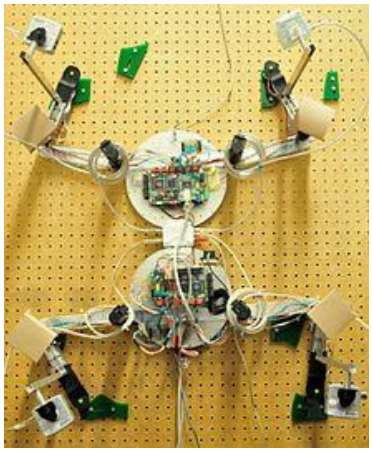
I.INTRODUCTION

Detection of fire alongside with extinguishment is a detrimental work that risks the health as well as the existence of a flame extinguisher person in the hazard but through utilizing a robot to execute fire detection and extinguishing in a fire-prone area, loss of lives and undesired incidents can be avoided in a considerable number. The day by day progress of advanced technology has made it feasible to develop different types of household and industrial robot and automation. The definition of the robot states that a system with the capability of executing human tasks or behaving in a human-like manner is regarded as robot. Continuous research and developments are going on for obtaining a reliable and effective method which can be enforced to develop a fire fighting robot to detect and extinguish the fire to lessen the risk of injury to victims.A Fire fighting robot is an independent ground vehicle which has two main functions - ability to detect fire and the ability to extinguish the fire. Small fire extinguisher systems along with various sensors are attached to a fire extinguisher robot for proper performance. The appropriate use of the robot will make sure that the fire combating as well as recovery exercises might be maintained without having place flame fighters life at danger through utilizing making use of automation technological innovation as an alternate choice of human. The design approach and implementation of a fire extinguisher robot is presented in this paper where three types of sensors of flame sensor, smoke sensor, and temperature sensor have been used for fire identification to make the detection process more reliable. Multiple control system has been implemented to make the robot more efficient to extinguish the fire. After that the robot will start extinguishing the fire using water from water tank utilizing a DC pump motor as well as a servo motor. The pipe of the water tank is flexible and attached to a servo motor which allows the robot to spray the water. The proposed model is divided into two major section; design and implementation as well as result analysis and discussion which have been discussed briefly.

II.ROBOTICS

Robotics is an interdisciplinary branch of engineering and science that includes mechanical engineering, electrical engineering, computer science, and others. Robotics deals with the design, construction, operation, and use of robots,

as well as computer systems for their control, sensory feedback, and information processing. These technologies are used to develop machines that can substitute for humans and replicate human actions. Robots can be used in any situation and for any purpose, but today many are used in dangerous environments, manufacturing processes, or where humans cannot survive. Robots can take on any form but some are made to resemble humans in appearance. This is said to help in the acceptance of a robot in certain replicative behaviors usually performed by people. Such robots attempt to replicate walking, lifting, speech, cognition, and basically anything a human can do.



Many of today's robots are inspired by nature, contributing to the field of bio-inspired robotics. The concept of creating machines that can operate autonomously dates back to classical times, but research into the functionality and potential uses of robots did not grow substantially until the 20th century.

III.EMBEDDED TECHNOLOGY

A Dedicated computer system is called an embedded technology. They control a lot of common devices in today"s daily life. They have advantages such as low power consumption, low power unit cost, small size and several operating ranges. Nowadays embedded systems are often based on microcontrollers but ordinary microprocessors are also used.

Complexity varies from low to high, for example a single microcontroller chip which has low complexity or peripherals and networks in large enclosures which have extremely high complexity. The program instructions written for embedded systems are called firmware. These are stored in read only memory or flash memory chips and have the ability to run with limited computer hardware resources such as little memory, small or non-existent keyboard or screen. Embedded debugging can be done at numerous levels i.e., Interactive resident debugging, External debugging, In-circuit emulator (ICE), etc.

IV.ARDUINO

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog 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 a AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

Revision 2 of the Uno board has a resistor pulling the 8U2 HWB line to ground, making it easier to put into DFU mode.

Revision 3 of the board has the following new features: 1.0 pin out: added SDA and SCL pins that are near to the AREF pin and two other new pins placed near to the RESET pin, the IOREF that allow the shields to adapt to the voltage provided from the board. In future, shields will be compatible both with the board that uses the AVR, which operate with 5V and with the Arduino Due, that operate with 3.3V. The second one is a not connected pin that is reserved for future purposes.

V.EXISTING SYSTEM

According to National Crime Records Bureau (NCRB), it is estimated that more than 1.2 lacks deaths have been caused because of fire accidents in India from 2010-2014. Even though there are a lot of precautions taken for Fire accidents, these natural/man-made disasters do occur now and then. In the event of a fire breakout, to rescue people and to put out the fire we are forced to use human resources which are not safe. With the advancement of technology especially in Robotics it is very much possible to replace humans with robots for fighting the fire. This would

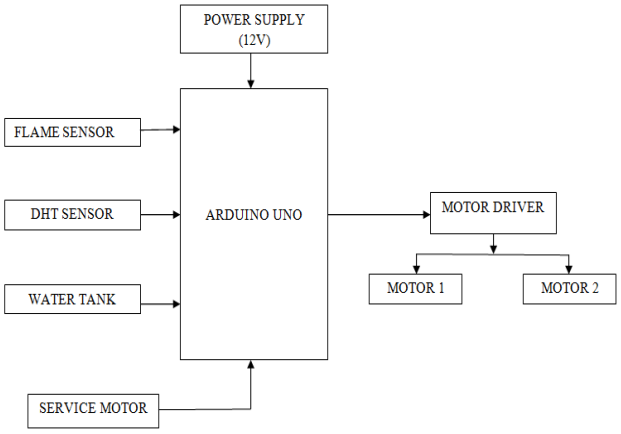
improve the efficiency of fire-fighters and would also prevent them from risking human lives. Today we are going to build a Fire Fighting Robot using Arduino, which will automatically sense the fire and start the water pump.

VI.PROPOSED SYSTEM

In this project, we have proposed how to build a simple robot using Arduino that could move towards the fire and pump out water around it to put down fire. It is a very simple robot that would teach us the underlying concept of robotics.

- The microcontroller used here is Arduino Uno controller which is better than the already existing PIR controller.
- The Arduino Uno controller is used for numerous applications and also for connecting many interfaces. It is also used for interfacing other sensors and motors.

The block diagram for the proposed system is given below which contains all the peripherals attached to it and connections for different peripherals are made accordingly with respect to the project.



VII.FABRICATION OF COMPONENTS

All the materials used in the fabrication of the robot were found locally. It is the purpose of the design to demonstrate a fabrication process of Fire Extinguisher Robot that can perform safely.

A. Making of the platform:

For the purpose of making the base light, “Kerosene wood” is used. This is famously known as the wood of “Rashed tree”. The density of this wood is about 370-400 kg/m3. So it can provide more 2016 5th International Conference on Informatics, Electronics and Vision (ICIEV) 909 surface area with light weight. Its thickness is 1 inch. It also has good strength and shock resistance capacity. It is also worth mentioning that this wood is also used to make the base of boat for its water resistance property. The dimension of the platform is 12×7×1.

B. Mobility of the robot:

This is a high functioning mobile robot. For the mobility of the robot, two wheels made of Nylon and a caster ball is used. This is mainly a rear wheel drive type of vehicle. Two motors are mounted with the nylon wheel by two separate shafts. The wheels are of 3 inch diameter and 0.8 inch thickness. The motors" movement is controlled by a motor driver (L298) which responses to the signal from arduino. The motors have high torque and speed. These are locally made motor which do not give the same speed even when unloaded. The robot also seems not to have uniformly distributed weight. So, an algorithm is established which is programmed to control both motors separately. An extreme calibration is then done to match the speed of both motors so that they can go straight in a specific direction. The use of caster ball is made for simplicity and its low cost. The robots" movement is mainly controlled by rear wheels. Caster ball is used for front support providing a flexible mobility.

C. Water spreading Mechanism:

The water container has the capacity to contain at least 1L water. It is made of strong cardboard which has water resistant property. The pump is set with the container by screw and glue mechanism. The glue used here is water proof. A long aluminium pipe is fitted with the pump. The pipe is about 2 feet long because water should be thrown by keeping a safe distance from fire. A locally made water spreader is used at the front of the pipe to spread the water. The use of the spreader reduces the velocity of water from the pump greatly but spreads the water effectively for extinguishment purpose. So a safe distance from the source is maintained by making the pipe long.

VIII.CONTROL AND SENSOR UNIT

A. Control Unit:

The logic control unit of the robot is solely an Arduino Uno. Arduino Uno provides an Integrated Development Environment (IDE) which provides a base of programming for the C and C++ languages. The Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM

outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. The input/output pins are connected in different ways with the motor, pump and sensors through jumper wires and breadboard. In this way, it establishes control over each component of the robot and the robot does the job as per the programme induced in the Arduino Uno. The power supply control unit is solely a LiPo battery. To power the motor, pump and the whole circuit a Lithium polymer battery is used. It is a 2200 mAH and 12V battery. It is a rechargeable battery of lithium-ion technology in a pouch format. This type of batteries is lighter but also less rigid. To power the arduino, the voltage of the battery is stepped down to 8V by 7808IC. Because arduino operates best at this voltage. Motors and pump selected for the robot can be best powered at 12V. So choosing a 12V LiPo battery was efficient.

B. Sensor unit:

Multi-sensor Fire Detection System (MSFDS) is used for the detection and extinguishment purpose. This system includes the use of more than one sensor at a time and also makes the collaboration of the sensors. There are two highly sensitive sensors connected to the Arduino Uno: Arduino Flame Sensor and LM35.

`The Arduino flame sensor is very sensitive to IR wavelength at 760 nm ~ 1100 nm light. These types of sensors are used for short range fire detection. It has four pins.

A) VCC: Positive voltage input: 5V for analog 3.3V for Digital,

B) A0: Analog output,

C) D0: Digital output,

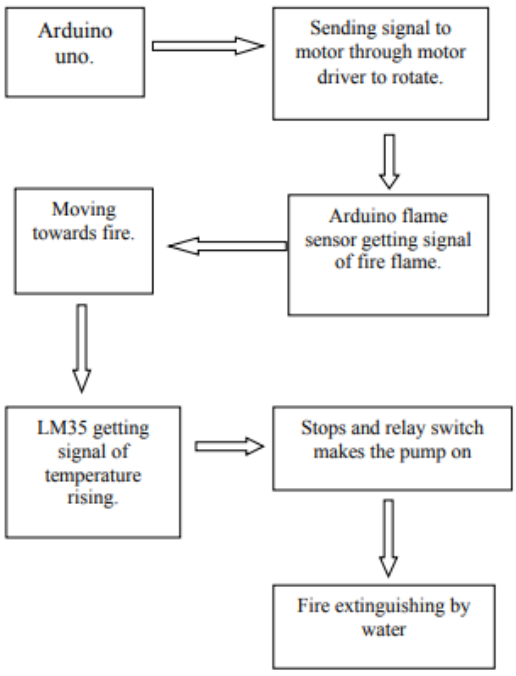
D) GND: Ground.

It takes the input from the environmental data and gives an analog output. If there is a significant change of IR wavelength, it detects as a flame and increases the analog output. Then the robot is programmed in such a way that it stars to move in the direction where the flame is detected. The LM35 is a precision integrated-circuit temperature devices with an output voltage linearly-proportional to the Centigrade temperature. This sensor gives a proportional value of the temperature as an output. When the robot moves in the direction of the flame, LM35 identifies significant temperature rise near the source of the flame and changes the output. The robot is programmed to stop when this output changes significantly. Since LM35 has to come very near to the source for heat detection, two measures of safety has been taken. One, LM35 sensor is connected with the control unit through a long jumper wire inside a pipe of about 10 inch long. So, the sensor maintains a considerable distance from the main body. Two, when it detects temperature rising, the motor stops and within a fraction of second, it gets back to a safe and accommodated distance to throw water.

IX.WORKING PRINCIPLE

The working principle is very simple. At the beginning of operation, the robot rotates on its own axis. Arduino will control the motor through the motor driver. To rotate, one motor will remain off and other one will move, thus resulting in rotation of the body. The robot does this rotation to search fire at different corners of the room. Eventually Arduino flame sensor will detect the fire if there is any. Then the robot will move forward to the fire slowly. Here, algorithm is needed to make a slow approach of the robot towards fire. Because the robot needs to stop at a certain limit and it definitely does not want to mess up with the fire. The LM35 sensor senses the heat. If it finds a remarkable increase in the temperature, it stops and moves back slightly to accommodate extinguishing. Then a centrifugal pump throws water at fire to put it out. A unique mechanism is used to enable spreading of water.

The flowchart of the whole operation is given below:



X.STUDY OF PERFORMANCE

A. Problem Specification:

Arduino Flame Sensor and LM35 are voltage sensitive sensors. They can take the input of 0-5V. These voltages are changed into an analog reading (0-1023) in Arduino serial monitor reading. This conversion gives us a better range and a good variation in the output. So, the robot can be programmed at different circumstances. When the flame sensor identifies the flame, a change in the analog output is obtained. This sensor has different sensitivity at different daytimes. So, the performance of the robot is varies with time. LM35 also responds to the temperature change and changes the analog output when the robot is near the source. Here, Sensitivity is the output reading obtained from the serial monitor. The main aim of our study is to check the sensitivity of flame sensor at different daytimes and at different distances with or without fire source and to observe the response of LM35 sensor. In this way, our study shows the best and worst possible situation of the day, the fabricated model of fire fighter robot has to handle.

B. Test Procedure:

The test is done to check the sensitivity of arduino flame sensors and LM35 at different day times and at different distances from the fire source. Different test is done placing a candle at different distances from the arduino flame sensor. The best stable reading obtained at the serial monitor analog output is at 3feet away from the fire source. From that distance, readings are taken with or without the fire source at different daytime with half hour interval. When the flame sensor detects the fire, the robot starts to move towards the direction of fire. At 3 inch distance intervals, the readings are noted. When the robot comes near the source, temperature rises and the output of LM35 changes which is also recorded. The experiment was done on 22nd December, 2015. The average temperature of the day was 26 degree Celsius.

XI.RESULTS AND DISCUSSION

A. Sensitivity of flame sensor at day and night:

Sensitivity of Arduino Flame Sensor is tested at day and night without any fire and from 3 feet distance away from the fire source and the results is demonstrated in Figure 4 and 5 respectively. It is seen from Figure 4 that at 7 o″clock, the sensor gives higher output with or without fire source. But as the time goes on, the reading keeps falling. This is because of the presence of infrared rays in the sunlight. Nearly at 12-13 o″clock, the intensity of sunlight increases to the highest of the day and thus increases the availability of infrared rays to which the flame sensor responds. So, the output reading is the lowest at this time of the day with or without fire source. But after 15 o″clock, the sun″s intensity starts to fade away and as a result the output reading starts to increase. It reaches the maximum value at the end of the day when the Sun sets off. It is also observed that throughout the day, the serial reading profiles almost maintained constant offset and almost parallel patterns were found.

It is evident that the readings are almost similar throughout the night with and without the fire source. As the effect of Sun ceases to exist around 23-03 o″clock, the output reading without the fire source is the highest and it becomes the lowest with the fire source. So the gap between these two readings is highest in this portion of the night. This range of time gives the most adequate difference for the proper distinguishment between fire source and normal condition. So it is fact that flame sensor detects fire irrefutably without any inconvenience at night.

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

It shows us the effect in output of the flame sensor at 10AM and 10PM when the robot detects a fire and starts moving towards the source. When it starts moving towards the source, the analog output will decrease because of the increase in the intensity of the source. It is also observed that the readings at 10PM are higher than that at 10AM at the highest distance away from the source. The fall of the reading is steeper at 10PM than at 10AM. Because at 10AM, the infrared rays from the Sun disturbs the analog reading of the sensor. But it is also found that near the safe possible distance to fire source, the readings at both day and night are almost same. Because the effect of the fire source becomes dominant. It is also observed that at near distance to the fire source, the curve becomes equally steeper for both the cases. Because there are increased infrared rays with the increase of the intensity of the source. So, there is a rapid attenuation for the output reading in case of 10PM and in the case of 10AM, the attenuation is slight.

C. Change of output of LM35:

When the robot starts to move towards the fire source, temperature starts to rise. LM35 is a sensor which can detect heat at a very near distance. Even sometimes for small source of fire, it has to come in contact of the fire source to detect the existence of fire. The tricky design of the robot allows the LM35 sensor to detect heat at least at a distance 6 inch away from the source. Because the sensor remains even at more close to the heat source as it is placed at the front side of the robot through a pipe. It also allows

the robot to keep itself at a safe distance. So, LM35 detects temperature rise and changes the output. When the change crosses an irrefutable range, the robot is programmed to stop and on the process, it makes the necessary extinguishment.

XII.CONCLUSION

The Fire Fighting Robot is fabricated with locally available materials and some tests are done to observe its effectiveness at different situation. As the Fire Fighter Robot has to endure different situation, this effectiveness test will help us to make a better model. Addressing to the pertinent design of the robot and the tests, following closing remarks can be drawn.

- The platform of the robot is made of locally available wood of „Rashed Tree". It has enough strength and the capacity of resistance to fire and water. Its low density also helps to make a less weighted structure with a firm support.

- The water container is made of white cardboard which is waterproof. This provides resistance to water leakage.

- The pipes are made of aluminum alloy which is fire resistant. These carry water at a safe and calibrated distance to accommodate extinguishing and another pipe is also used to carry LM35 sensor to detect heat at a measured distance.

- The water spreader at the front of the pipe reduces the velocity of the water thrown by the pump greatly but spreads the water for effective extinguishment.

- In presence of daylight, the analog output readings are the least. But it provides us a nearly constant difference of 300-350 between the readings of the output with or without the fire source. So, an efficient algorithm can be made at this circumstance even with the worst possible output reading.

- In day, sunlight is absolutely a dominant factor to control the values of the output reading.

- At night, the readings have quite large value without fire source and the least value is obtained without the presence of fire. This provides a good range of detection.

- The best possible range for detection of fire source is from 23-03 o"clock. This provides the best platform to program the device during any time of the day.

- After detection of fire, the robot starts to move towards the source. With the change of temperature, the output of LM35 is changed.

- This change of output of LM35 is non-linear. So, at different distance, the readings are taken and the robot is calibrated to stop at safe distance from the source.

The Fire Fighting Robot is effective enough to fight against fire on a small scale. It can sense fire flame better at darker places. It is made as a preventer robot. Because it can detect fire instantly and can extinguish it before spreading. This multisensory based robot may be a solution to all fire hazards. With enough funding and scope, this design of robot can also fight against large fire with larger reserving capacity and an improved sensing unit can provide even an earlier detection of fire at all circumstances.

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