ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 11, November 2015

Autonomous Fire Dousing System with Manual Override

C.Arun Kumar[1], A.Adithya Bharadwaj[2], R.Balasubramanian[3], P.Gowtham[4]

UG Student, Dept. of ECE, SSN College of Engineering, Chennai, Tamilnadu, India[1]

UG Student, Dept. of ECE, SSN College of Engineering, Chennai, Tamilnadu, India[2]

UG Student, Dept. of ECE, SSN College of Engineering, Chennai, Tamilnadu, India[3]

UG Student, Dept. of ECE, SSN College of Engineering, Chennai, Tamilnadu, India[4]

ABSTRACT: In present days fire accidents have become a major problem in many cities. Fire accidents cause death and injuries for many fire fighters who endanger their own lives for others. Hence to reduce this risk faced by the fire fighters, the idea of an autonomous fire extinguishing robot is presented in this paper. The paper emphasises on the technique to extinguish fire automatically or by wirelessly controlling the mobile unit whilst consuming minimum power. Thermal sensors, coupled with thermal imaging camera are used to triangulate the location of the fire. Once the location of the fire is pinpointed, the robot can be controlled by the user and its movement coordinated towards the source of the fire. A fan arrangement fixed on the robot is used to put out the fire. The model proposed in this paper eclipses the currently existing solutions by adopting a novel traversal technique(inherent to the test case) and by providing a reliable manual override option.

KEYWORDS: Autonomous fire extinguishing, Thermal Sensors, Thermal Imaging Camera, Reliable, Manual Override

I.INTRODUCTION

Fire accidents have been on the rise in the past twenty five years. To effectively combat such instances of large scale fire disasters, it would be a welcome alternative to employ robots to put out fires, rather than risk manpower. One cannot question the skill and competitiveness of the fire fighting unit. However it would be more convenient to utilise a robot to focus on putting out the fire. Consequently, the manpower liberated from dousing the flames can be used to rescue trapped personnel and escort them to safety.

To reduce the number of casualties and loss of property as a result of major fire outbreaks serves to be the primary cause of motivation for this proposal. Protection of fire-fighters from potentially life endangering situations is the secondary motivation

II.LITERATURE SURVEY AND PRIOR ARTWORK

In the year 2012 there have been a total of 23281 cases of death due to fire accidents in India, which makes up 5.9% of the total deaths due to unnatural causes in that year. Of these cases 15.1% have been due to gas cylinder/stove burst, 6.3% due to short circuits, 1.6% due to fire crackers and the remaining 77% due to other fire accidents. Fire fighters, who selflessly put their lives at stake to save the victims of a fire accident, are most affected by these incidents. They suffer burns, heart attacks, asphyxia and many other complications during these rescue missions which might also prove to be fatal. A recent fire accident in Arizona, United States (on June 30, 2013), reportedly took away the lives of 19 fire-fighters and has been marked the deadliest day for fire-fighters since the 9/11 terrorist attacks. Another example of such fire accidents is the bush fires in Australia which cause a lot of damage to the human settlements and the wildlife present in the forests. To reduce these deaths and to effectively put out fires in all environments our wireless/automatic fire extinguishing robot will be extremely useful.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 11, November 2015

III.CONSTRUCTION

Construction of this system is as shown in Fig. 1.

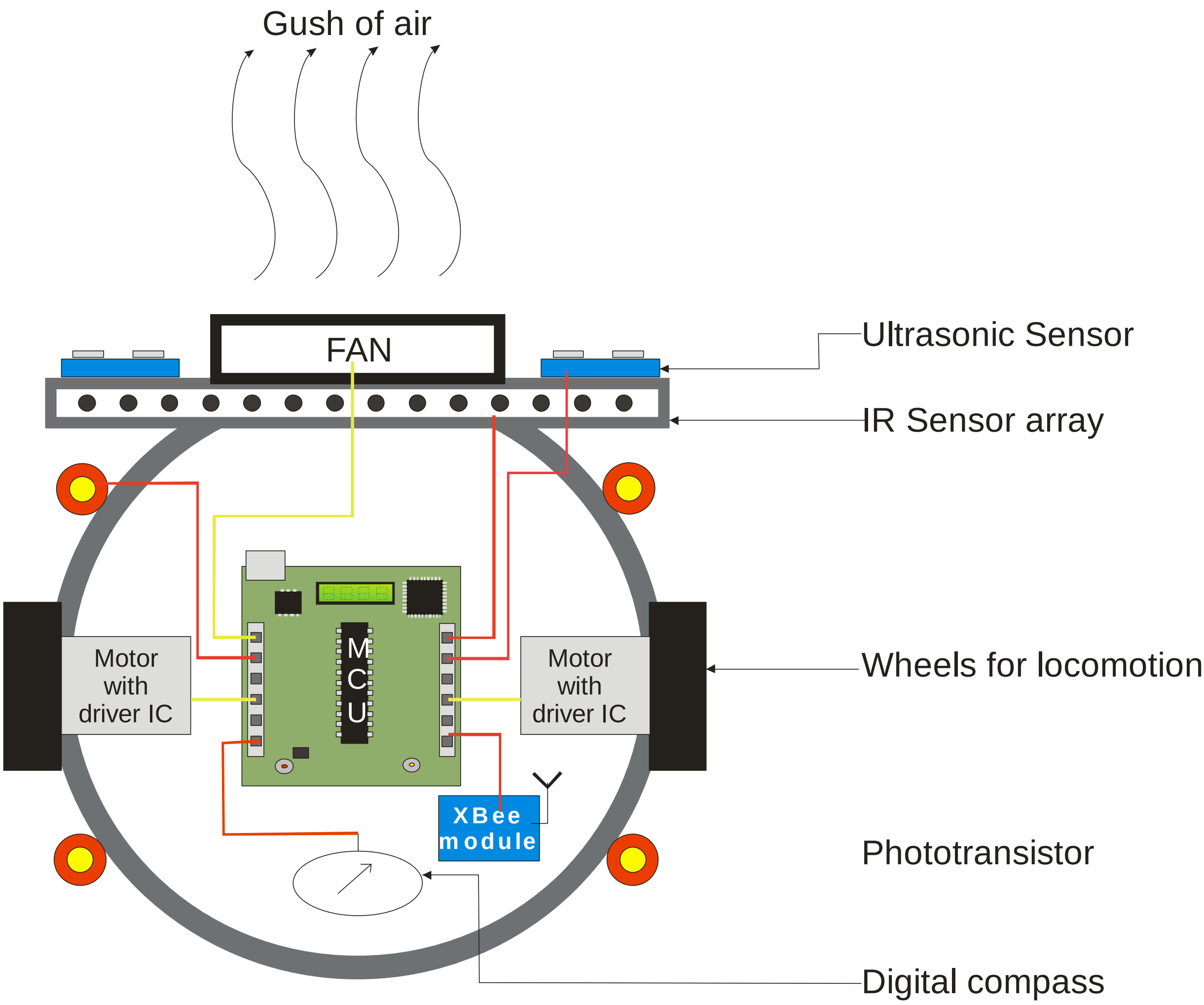

Fig. 1 Envisaged model of the fire extinguishing unit (top view)

The frontal portion has an array of infrared sensors to sense the entry into a particular room. Added to this, two ultrasonic sensors are placed at either end of the front face. These ultrasonic sensors, coupled with the infrared sensors, aid in the movement of the robot. A group of photo transistors are also strategically placed on the periphery of the robot to detect the presence of the fire. All the sensors are controlled by a central micro controller unit. For this purpose, a Texas Instruments microcontroller TI MSP430 G2553 is used. This has an operational voltage of 3V with 20 I/O ports. This is an ultra low power microcontroller and hence reduces the overall power consumption of the system making it more efficient. To the micro controller a fan arrangement is also interfaced. It is mounted on the head of the robot to facilitate the fire dousing action. Two 12 V DC motors are also interfaced with the microcontroller for the purpose of locomotion. In addition a thermal imaging camera is also integrated with the micro controller. In addition, a pre calibrated digital compass is used for course correction and thus provides for a more effective traversal.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 11, November 2015

During the manual override sequence, the feed from this camera is transmitted to the base station via an XBee module(zigbee protocol). Based on this data, the manual handler sends instructions by moving the joystick as shown in fig. 2.

Fig. 2 Simplified block diagram for manual override

The micro controller is programmed using Code Composer Studio(CCS) and the XBee module using the XCTU software. The entire system can be concisely represented by the means of a block diagram as shown in fig. 3.

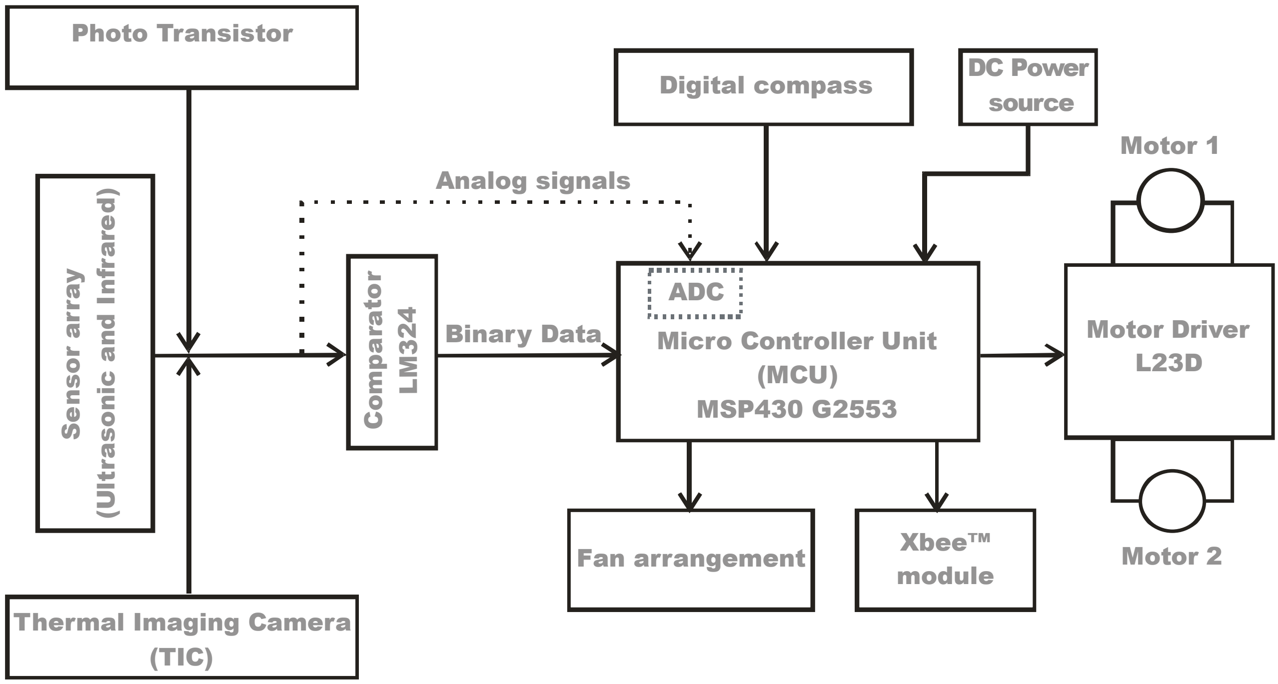

Fig. 3 Simplified block diagram

IV.IMPLEMENTATION

The Autonomous Fire Dousing Robot's implementation and working can be split into four modules as given below.

a) Module for locomotion: This module consists of the locomotion control of the robot where the robot moves through the building using a pre-defined algorithm, which is formulated based on the dimensional specification of the requisite floor plan. This model uses an array of infrared sensors (10 in number) for obstacle avoidance. They have an appropriate sensing range of 5cm. Ultrasonic sensors were also used for obstacle sensing and navigation by wall sensing. There are demarcations made(as black lines) at the entrances of each room for indication purpose. The IR sensors placed at the frontal periphery of the robot senses this mark and sends a corresponding signal to the central control unit. Upon reception of this signal, the robot begins its pursuit of searching for fire in that particular room.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 11, November 2015

For optimal traversal of the area under study, the technique of wall following is incorporated. This technique makes use of ultrasonic sensors mounted left-hand side surface of the robot. A per this technique, the robot checks its left hand side for the presence of the wall at every step by calculating the distance between itself and the wall. When this distance exceeds the width of the corridor, it implies that there is a break in the wall. Consequently the robot executes the command to turn left. Change in direction and speed operations are done by using PWM technique.

For obstacle detection, the robot uses mid-range ultrasonic sensors. These are placed at either end of the front side of the robot. The readings of this sensor help the robot take a decision on which side to move in order to successfully evade that obstacle. Once the robot dodges the object, it gets back on track with the help of the data from the digital compass. This compass is pre-calibrated and hence aids in successive course corrections. Once the robot enters the room, it thoroughly scans for the presence of fire and extinguishes it. Subsequently the robot moves on to the next room until it covers the entire area under study. The path followed by the robot for a test case is as shown in fig. 4.

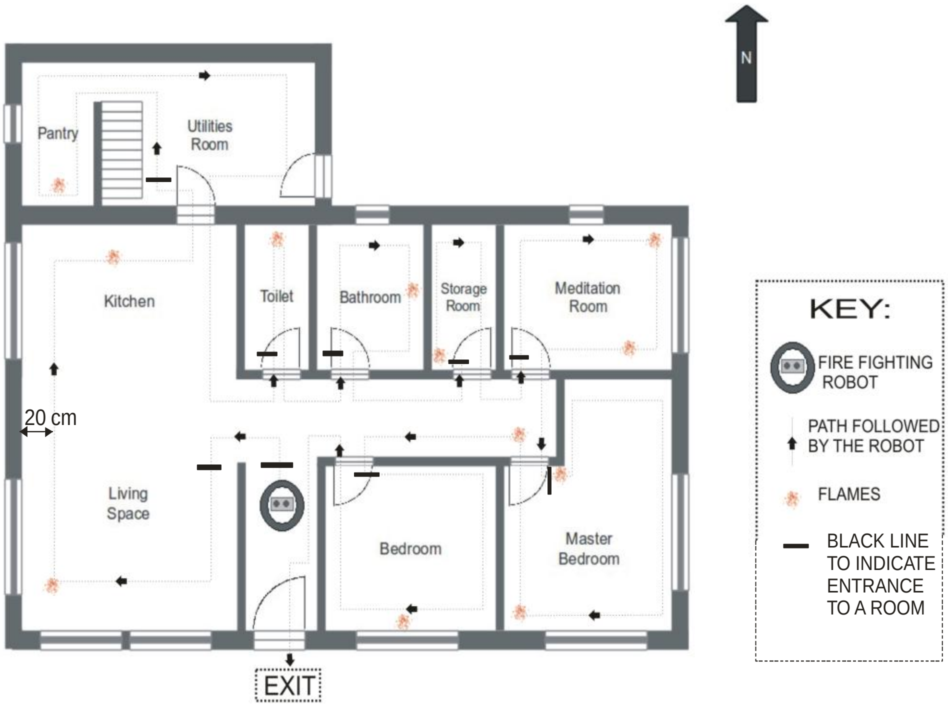

Fig. 4 Top view of the working of the fire dousing robot in a normal household (schematic)

b) <u>Fire detection module</u>: Once the robot enters a room, this module is executed. As the robot follows the wall, it simultaneously senses for the presence of fire using the photo transistors. Using this technique, the robot can successfully locate fire on the walls. Furthermore, the robot also has photo transistors on all its sides. Hence the presence of fire at all parts of the room can be detected. For instance, as the robot moves along its path following the wall and it detects fire to its right hand side, then it moves along that direction until it reaches a permissible distance from the fire(10 cm in this case). It then executes the routine o extinguish the fire. Once the fire is doused, it goes back to the point in its original path, the point from which it initially digressed, and continues its journey as intended. In situations where the location of the fire cannot be triangulated properly, the system can be manually overridden and the control shifted to its manual handler. The manual handler uses the data received from the thermal imaging device to accurately pin point the location of the fire. This is done for the sake of achieving accuracy and to distinguish the flame from other light sources. Upon detection of the presence of fire, the fire extinguishing routine is carried out.

c) <u>Fire extinguishing module</u>: Once the location of the fire is pin pointed it is put out using the fan arrangement. Whilst using the thermal imaging camera, the fan is targeted at the centre of the flame in order to achieve a more efficient

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 11, November 2015

extinguishing action. The fan is switched on and concentrated on the area of flame. The gush of air from the fan extinguishes the flame.

iv) Wireless control module: Even though this robot is programmed to automatically detect and extinguish fire, it can never match the presence of a human. Since human instinct is far superior to the in-built program of a robot, a manual override option has been included. Also the data from the photo transistors can occasionally be abstruse. Therefore, in extraneous situations, the robot can be switched to manual control where the robot can be wirelessly controlled by a trained personnel, using a joystick interfaced with an XBee module (zigbee protocol), from a safe distance. The signals generated from the operation of the joystick are communicated to the central control unit via the XBee modules. Based on this data the movement of the robot and the fan action is controlled and thus the fire is put out. A sample image of a flame as recorded by a thermal imaging camera is as shown in fig. 5.

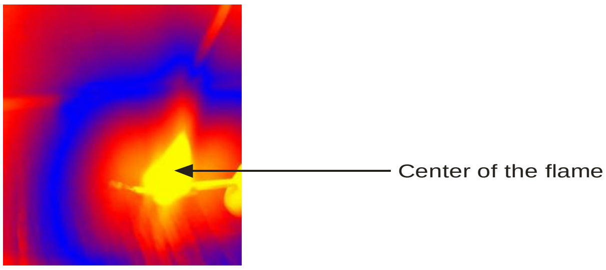

Fig. 5 Image of a flaming object as captured by a thermal imaging camera

The sequential working of the robot can be diagrammatically expressed using a flow chart as shown in fig. 6.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 11, November 2015

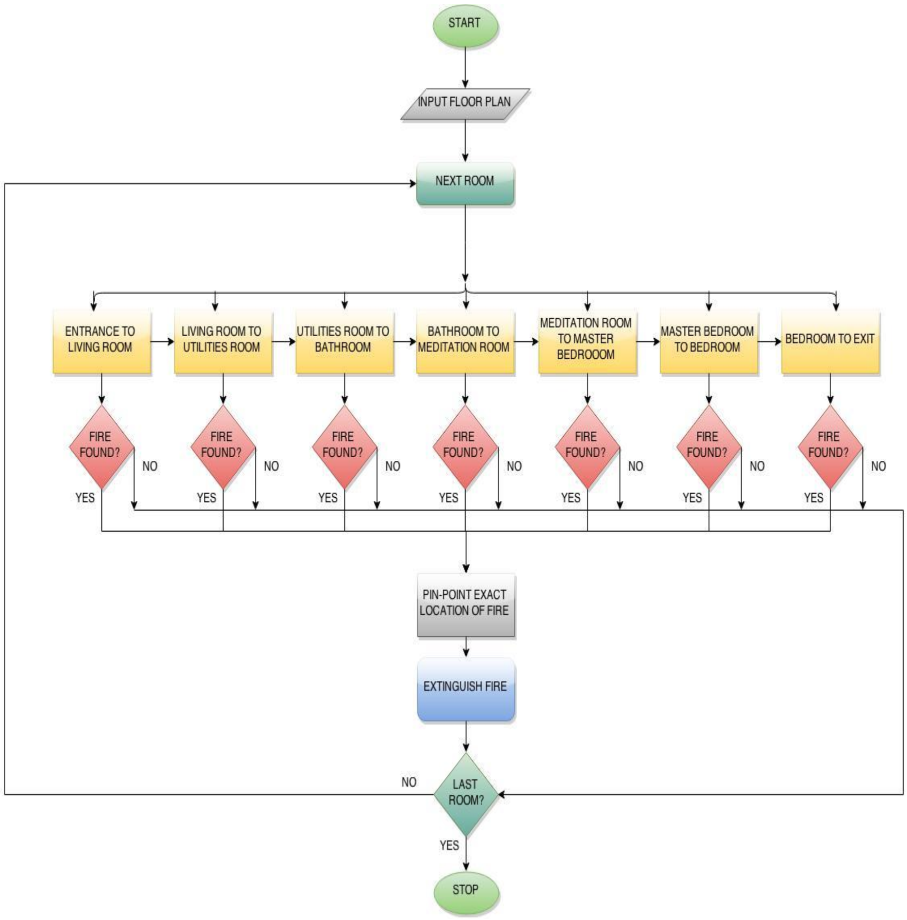

Fig. 6 Flow chart showing the sequential working of the robot

V. RESULT AND DISCUSSION

The results of the experiment are tabulated as shown below. The table below shows the distance as measured by the ultrasonic sensor. A SEN136B5B is used for this purpose. The pulses transmitted by the ultrasonic sensor are recovered by the micro controller and the distance is calculated as follows.

Table 1 Distance measured as a function of time

Input Pulse Duration(μs)	Distance(cm)
3074	53
2320	40
1276	22
580	10
232	4

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 11, November 2015

We know that the speed of sound is 340 m/s, which roughly translates to 29 µs/cm. The pulse from the ultrasonic sensor travels out to the object and back to the source. We can thus calculate the distance from the total time taken as: Distance(cm) = (Time taken(µs) / 29(µs/cm))/2. This is illustrated in Table 1.

Fig. 7 shows the readings of the phototransistor observed by varying the distance from the flame. The signals from the phototransistor were passed through an ADC and the resultant readings were recorded.

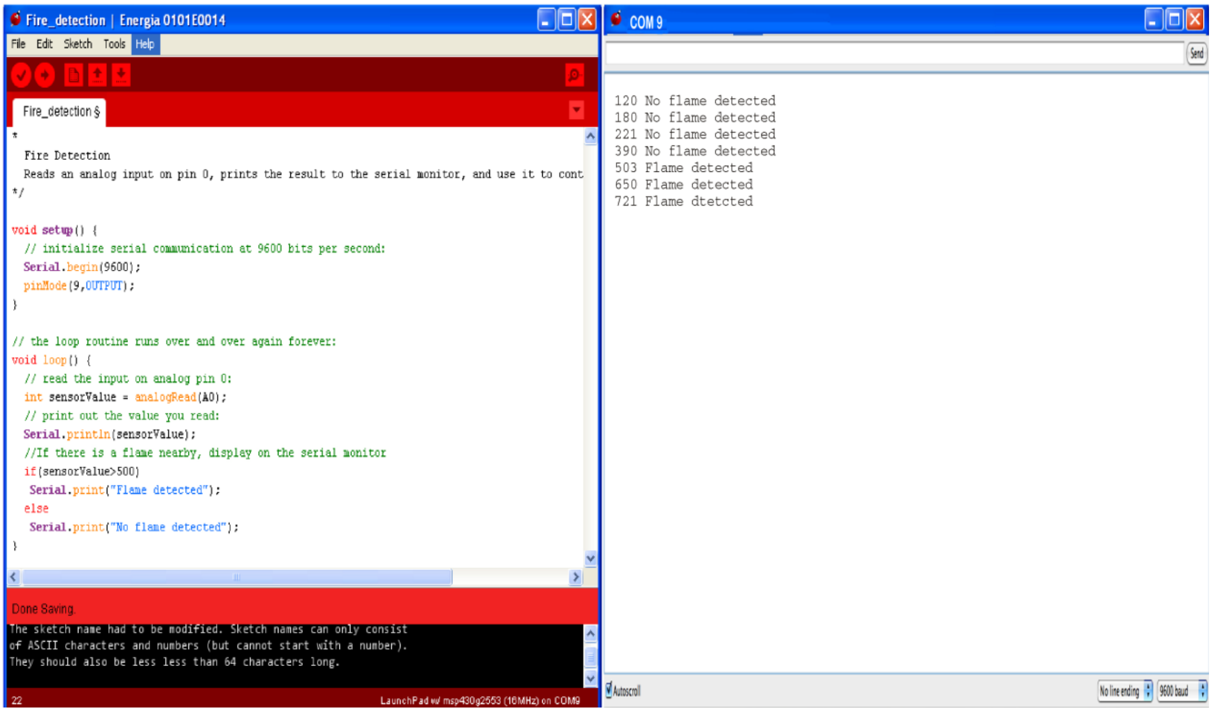

Fig. 7 Flame detection simulation

VI.FEASIBILITY

The fire dousing robot proposed deals with the detection of a fire and its subsequent extinguishing. This module would be particularly useful in residential places or warehouses which are not inhabited. The breaking out of an accidental fire can be effectively detected and doused. It can be operated automatically when any fire occurs. Since it is small in size, less in weight, it requires less space. The thermal sensors and the thermal imaging camera enable it to detect the object on fire even when line of sight detection is not possible. The ultrasonic sensors which are interfaced with the robot, aid in its movement past obstacles, which are identified from the floor plan of the building in question. By focusing on the fires, it redirects manual help to trapped personnel and ultimately, aids in saving more people.

VII.CONCLUSION

From the idea presented in this paper, a successful working model of a fire extinguishing robot can be constructed. With the use of an ultra low-power microcontroller, a novel traversal method and strategically placed sensors, a very efficient system can be built to serve the purpose of extinguishing fires. Furthermore, the presence of manual override adds to the reliability factor of the system. Thus by the technique presented in this paper, fire can be sensed and put out efficiently and many lives can be saved in the process.

REFERENCES

[1] A. Hassanein, M. Elhawary, N. Jaber, M. El-Abd, "An autonomous firefighting robot," in Proc. IEEE Advanced Robotics (ICAR) 2015, pp. 530-535, Jul.27-31, 2015.

[2] S. Dearie, K. Fisher, B. Rajala, S. Wasson, "Design and construction of a fully autonomous fire fighting robot," in Proc. Electrical Insulation Conference and Electrical Manufacturing, Coil Winding Conference 2001, pp. 303-310,Oct.16-18, 2001.

[3] T.L. Chien, H. Guo, K.L. Su, S.V. Shiau, "Develop a Multiple Interface Based Fire Fighting Robot," in Proc. IEEE Mechatronics, ICM2007, pp. 1-6, May 8-10, 2007.

[4] Jing Wang, Haifeng Zhao, Stephan Winter, "Integrating sensing, routing and timing for indoor evacuation," Fire Safety Journal, vol. 78,pp. 111–121, Nov. 2015.

[5] T. AlHaza, A. Alsadoon, Z. Alhusinan, M. Jarwali, K. Alsaif, "New Concept for Indoor Fire Fighting Robot," Procedia - Social and Behavioral Sciences, vol. 195, pp. 2343-2352, Jul. 2015.