Handling Fire Hazards by Fire Detection System Using IoT

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Abstract- ***Internet of things (IoT) based fire alarm and monitoring system best suited for industrial and home applications. Fire is the major cause of accidents claiming valuable lives and property. The chemical reaction between carbon-based materials in presence of oxygen generates flammable vapour causing a steady rise in temperature and results in a fire. The major characteristics of fire are it extends exponentially with time. Hence, timely detection of fire is critical for avoiding accident. In this project, fire alarm and monitoring system are integrated with IoT platform. It can sense smoke, the rise in temperature, flame etc. and send it to afar-away monitoring station through GSM to generate needful instructions for the actuators. In the design prototype, sensors are installed in three distinct locations to identify the exact location of fire hazards that has taken place.***

Indexed Terms- ***GSM networks, Fire alarm system, raspberry PI, Internet of thing (IOT), Energy-efficient, Home automation***

I. INTRODUCTION

IOT: The Internet of things refers to a type of network to connect anything with the Internet based on stipulated protocols through information sensing equipments to conduct information exchange and communications in order to achieve smart recognitions, positioning, tracing, monitoring, and administration. In this project we briefly discussed about what IOT is, how IOT enables different technologies, about its architecture, characteristics & applications, IOT functional view & what are the future challenges for IOT.

ENABLING TECHNOLOGIES FOR IOT: Internet of things (IoT) is a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies. With the Internet of Things the communication is extended via Internet to all the things that surrounds. The Internet of Things is much more than machine to machine communication, wireless sensor networks, sensor networks, 2G/3G/4G, GSM, GPRS, RFID, WI-FI, GPS, microcontroller, microprocessor etc. These are considered as being the enabling technologies that make "Internet of Things" applications possible. Enabling technologies for the Internet of Things are considered in and can be grouped into three categories:

- Technologies that enable "things" to acquire contextual information.
- Technologies that enable "things" to process contextual information and
- Technologies to improve security and privacy.

The first two categories can be jointly understood as functional building blocks required building "intelligence" into "things", which are indeed the features that differentiate the IoT from the usual Internet. The third category is not a functional but rather a de facto requirement, without which the penetration of the IoT would be severely reduced. The Internet of Things is not a single technology, but it is a mixture of different hardware & software technology. The Internet of Things provides solutions based on the integration of information technology, which refers to hardware and software used to store, retrieve, and process data and communications technology which includes electronic systems used for communication between individuals or groups

Fig1: Internet of Things

A fire is a chemical reaction of carbon based material that mixes with oxygen and is heated to a point where flammable vapours are produced. These vapors then come in contact with something that is hot enough to cause vapour ignition and results in a fire and its occurrence is random. Industry, home offices, hospitals etc are very much vulnerable to fire that has the potential to cause harm to its occupants and severe damage to property. On an average, in India, every year, about 25,000 persons die due to fires and related causes where female accounts for about 66%. As per the statistics of National Crime Records Bureau (NCRB), fire accounts for about 5.9% (23,281) of the total deaths reported due to natural and unnatural causes during the year 2012. The data on fire accidents in India reveals that close to 3 lakh people lost their lives in fire accidents between 2001 and 2014, averaging to 59 deaths per day. The estimate of property loss due to fire crosses about 1000 cores rupees every year.

The major characteristics of fire are it extends exponentially with time. Hence, timely detection of fire is critical for avoiding a major accident. Hence, the essence of having a sophisticated fire alarm and monitoring system is quite obvious. The early detection of fire can be made with the rise of temperature, the presence of smoke and flame. Hence appropriate sensors have to be installed at the vulnerable places to detect the mentioned physical quantities. The alarm information is generated by comparing them with predefined threshold values and send to a central processor that may be a microcontroller. The central processor decides the operation of actuators like LCD display, water sprinkler motors etc.

The major setback of traditional fire alarm system is the remote location of fire initiation points. It may be machinery inside the industry, unattended home appliances etc. Hence, the information generated by the sensors need to be conveyed a long distance, may be through transmission line followed by instrumental amplifiers. Some places, the deployment of such lines are not feasible. The low cost solution to such problem is to introduce wireless link. The present development of IoT platform would best suit for it. IoT is a complete embedded system where sensors and actuator are being monitored and controlled remotely across existing network infrastructure. It allows sophisticated computer-based control for more efficient and accurate operation. This project has proposed an internet of things (IoT) based fire alarm and monitoring system best suited for industrial and home applications. It can sense smoke, the rise in temperature, flame etc. and send it to a far-away monitoring station through GSM to generate needful instructions for the actuators.

Fire alarms are prime necessities in modern buildings and architectures, especially in banks, data centers and gas stations. They detects the fire in ambiance at very early stage by sensing smoke or/and heat and raise an alarm which warns people about the fire and furnish sufficient time to take preventive measures. It not only prevents a big losses caused by deadly fire but sometimes proves to be life savers. Here the building one simple fire alarm system, which will sense the fire and trigger the alarm.

The project is a fire alarm piloted by a simple Arduino UNO that activates a LED (connected by a relay), LCD display and a buzzer, whenever a flame is detected by the flame sensor module.

II. FIRE ALARM DETECTION SYSTEM

A fire alarm system has a number of devices working together to detect and warn people through visual and audio appliances when smoke, fire, carbon monoxide or other emergencies are present. These alarms may be activated automatically from smoke detectors, and heat detectors or may also be activated via manual fire alarm activation devices such as manual call points or pull stations. Alarms can be either motorized bells or wall mountable sounders or horns.

Fig.2 Fire Alarm Detection System

They can also be speaker strobes which sound an alarm, followed by a voice evacuation message which warns people inside the building not to use the elevators. Fire alarm sounders can be set to certain frequencies and different tones including low, medium and high, depending on the country and manufacturer of the device. Most fire alarm systems in Europe sound like a siren with alternating frequencies. Fire alarm electronic devices are known as horns in the United States and Canada, and can be either continuous or set to different codes such as Code 3. Fire alarm warning devices can also be set to different volume levels. Fire Alarm systems in the United Kingdom are tested at a weekly basis in compliance with the BS-fire 2013 regulations

III. PROBLEM STATEMENT

Most of the houses don't have a fire alarm system thus need to design a fire alarm system using digital logic system that all family members can use in single-family residences. It must be able to detect fires at all locations must be able to activate it from convenient locations themselves, and it must alert in all portions of the house .In most rooms, manual systems are used. A person forget to turn off the lights and fan when leaving the room so there is a wastage of power

Whenever the flame sensor sense the fire the flame sensor module will sends the temperature level to the arduino, the board is programmed in such a way that that, if the temperature is more than usual or harmful, then fire alarm system starts its duty. When this situation occurs LCD Display, Buzzer and LED lights will start doing their job as programmed

IV. OBJECTIVES

- Immediate identification and control of a developing fire
- Simple to use without human interference
- Enhanced life safety
- Immediate alert

Applications and Advantages of Fire Alerting System:

- Fire alerting system has a wide range of applications. IOT based fire alarm system using arduino can be used in Chemical Factories, Shopping Malls, local shops, Educational institutes, Parking Areas, Companies etc.
- IoT Based Fire alarm Notification System can be used as a pre-cautionary measure at all the places listed above, which can help in notifying the fire departments early. If appropriate and immediate action is taken as soon as the buzzer turns ON, it can help in avoiding an accident.

V. LITERATURE SURVEY

1 IOT based Fire Alarm and Monitoring System (2017):

The research in paper [1] elucidate a method of enhancing peak signal to noise ratio (PSNR) and minimizing mean square error (MSE) through spread spectrum image steganography. The Centre of focus is more onto security, for that three levels of security have been designed which are as follows: First level indicates security of hidden text inside cover media by RSA Encryption with DiffieHellman Key exchange algorithm, second level of security is maintained by compressing the data to be hidden using Run length Encoding (a lossless compression). Further the communication is kept more secured by spreading the message all over the pixels of cover media using pseudo random generator that generates random locations of pixels in an image and embedding message with Least Significant Bit algorithm to make it highly indiscernible. Thus, stego image is obtained. Attempt is made to obtain higher PSNR and lower MSE values for better imperceptibility and the image quality at the receiver end.

Advantages:

- As data is compressed before embedding, it increases the payload capacity.
- Combines steganography and cryptography.

Disadvantages:

- When used with Frequency Domain, the image quality may be degraded.

2 An SMS based Fire alarm and Detection System(2018):

The paper [2] depicts that in the present scenario the use of images increased extremely, so that we can easily transfer data in a secured way. Here the process combines both steganography and cryptography, along with hashing so that attacker doesn't know about the message hidden in it. The textual data entered by the user is encrypted using AES (Advanced Encryption Standard) algorithm which involves different transformations like byte substitution, Shift rows, Mix columns, and Add round key transformations. After encryption, data is divided into blocks and stored in one array list and another array list will contain the pixel locations where these blocks have to be stored, obtained using a hash algorithm. Then the first element of the first array list and second array list is read and compared, and bytes are placed accordingly, which repeats till the end to get an image containing embedded textual data. The decryption structure is similar to the encryption transformations in reverse way.

Advantages:

- Hiding of large textual data is possible.
- Quality of the image does not get disturbed.
- Images of almost all formats can be used for hiding data.

Disadvantages:

- It has to be extended to embed the data in audio as well as video for multimedia transmission.

3 Need for Wireless Fire Detection System using IOT(2017):

The paper [3] takes an input message which is a computer file of any type and hides in selected cover or carrier file which is a computer file of certain type. The cover file could be a pdf, jpeg or png file. A special block of bytes called Identification(ID) block of 64 bytes is needed which contains a hash value, extension of file and a key index to point to start of message sequence in stego file. Advanced Encryption Standard (AES) with Rijndael Algorithm is used for encrypting the message with key length of 256 bits and message block size of 128 bits. The process for hiding file is as follows: The content of message and chosen carrier file are read as binary into array of bytes. A randomly generated 128 bit salt along with user given passphrase is used to generate 256 bit secret key. The message is put into block of 128 bit using PKCS7 padding. The first block of message is XORed with a randomly generated initialization vector (IV) and encrypted using the algorithm. The remaining blocks are XORed with previous cipher text before encrypting. The 64 byte ID block is appended to encrypted message and the whole block is appended to cover byte array and written to stego file. The file recovery is the reverse process of file hiding.

Advantages:

- Append insertion steganography method is flexible and allows the user to choose any kind of file to hide.
- No limitation on the message size.

Disadvantages:

- Need increase in robustness to detect various attacks by making the cover and the message seem inseparable.

4 IOT based Fire Emergency Response System (2016):

In the paper [4] the author proposes improved steganography approach for hiding text messages in lossless RGB images. The aim here is to increase the security level by randomly distributing text message over entire image and improve storage capacity by compression techniques. The keyless steganography method used here, is applicable for lossless image formats like BMP, PNG or TIF. The message to be hidden is first compressed and stored in the cover file using MSB bit of RGB channels as pixel indicator. The randomization is based on hashing with respect to MSB of channels to skip R number of bytes, where R is the value generated from Random Number Algorithm. The above step is repeated till entire message is encoded. The message retrieving process is a similar reverse process where the message in stego image is obtained by skipping R bytes every time using indicator values. The obtained output is uncompressed to get original text message.

Advantages:
- Varying indicator helps in random distribution of message and enhances security.
- Improved storage capacity due to initial compression of source text message.
- Degradation of image quality is minimum.

Disadvantages
- The approach is applicable only to text messages.
- Improvements needed in robustness of algorithm.

5 Fire Detection and Prevention Monitoring System using Wireless Sensor Network enabled Android Application (2016):

The paper [5] presents a novel data hiding and image encryption scheme using random diffusion and two dimension Arnold cat mapping transform. The secret message bits are placed in least significant bit positions of cover image. The shared key is used to generate 8 bit random integer stream and is added to stego image in random diffusion step. Arnold cat transformation is done to scramble the pixels. Two step random diffusion and Arnold transform mapping are done alternatively several times to completely encrypt the image content. Pseudo random generator is setup with shared key. The odd/even asymmetry is decided by Pseudo random generator. A random unsigned 8 bit integer sequence is added to the pixels modulo 256.

Advantages:
- The embedding capacity of one bit per pixel is achieved.
- Security analysis shows that the encryption is highly secured.
- The number of collision is low thus preventing brute force attacks.
- The original cover image is recoverable with minimal losses.

Disadvantages:
- Embedding capacity is less.
- LSB causes little distortion in image.

6 Automated Fire Detection and Controlling System(2015):

The paper [6] proposes a safe and secure way to hide messages in LSB techniques. Least Significant Bit (LSB) is a very popular method in the spatial domain of stenographic images. The XOR operation is performed to encrypt the message before embedding on LSB. The MSB bits are used as keys in the XOR operation. In this technique, the first XOR operation is performed on bit 6 and bit 7, the result is XORed with bit 8, then the result is XORed with message bits and the value is stored in the message bit. This value is converted to uint8 whose result is the value of stego image pixel value. The proposed work is tested using six grayscale images and cover image, and binary image as the message, all having the same pixel size. Then one pixel of message image is embedded on one cover image pixel.

Advantages:
- High peak signal to noise ratio of more than 50dB and mean squared error not more than 0.3
- The use of an integrated key in the cover image maintains the same size for stego- file, hence no key delivery is required for the receiver.
- Speeds up the messaging process as the file size is maintained.

Disadvantages:
- Based on histogram analysis there is a distinct pattern difference between the cover image and stego image

VI. REQUIREMENT ANALYSIS

Here requirements elicitation and the analysis activities are documented according to the analysis of the required tools to this application. This tells us about the software and hardware tools used while building this application. This chapter completely describes the system in terms of functional and non-functional requirements and serves as a contractual basis between the customer and the developer. Functional requirements describe the high-level functionality of the system. Non-functional requirements describe user-level requirements that are not directly related to functionality. This includes usability, reliability, performance, supportability, and implementation, and interface, operational and legal requirement.

1 Hardware requirements

The hardware requirements in this project

No	Component	Descriptions
1	Arduino UNO	Microcontroller board based on ATmega 328P
2	Flame sensor module	It senses fire
3	Buzzer	5v Active alarm
4	Lcd display	16 pin interface
5	Resistor	221 ohm

Table 1- Hardware requirements

2 Arduino UNO

Arduino Uno is a microcontroller board based on the ATmega328P (datasheet). 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. 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.. You can tinker with your UNO without worring too much about doing something wrong, worst case scenario you can replace the chip for a few dollars and start over again.

Fig 3: Arduino UNO

3 Flame Sensor Module

A flame sensor module that consists of a flame sensor (IR receiver), resistor, capacitor, potentiometer, and comparator LM393 in an integrated circuit. It can detect infrared light with a wavelength ranging from 700nm to 1000nm.The far-infrared flame probe converts the light detected in the form of infrared light into current changes. Sensitivity is adjusted through the onboard variable resistor with a detection angle of 60 degrees. Working voltage is between 3.3v and 5.2v DC, with a digital output to indicate the presence of a signal. Sensing is conditioned by an LM393 comparator.

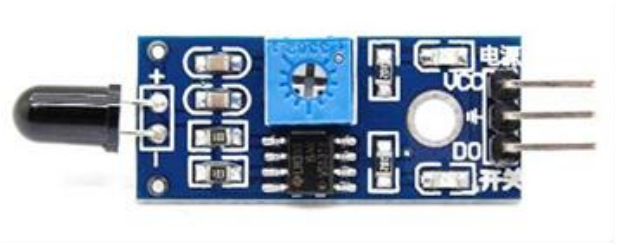

Fig 4 Flame Sensor Module

4 Buzzer

A 5V Active Alarm Buzzer Module for Arduino is an audio signalling device, which may be mechanical, electromechanical, or piezoelectric. Just like what you are viewing now, it is 5V DC Electronic Part Active Buzzer Module. Using top quality material, it is durable in use.

What is more, an active buzzer rings out as long as it is electrified. Compared with a passive buzzer, it is a bit expensive but easier to control. Typical uses of buzzers include alarm devices, timers, and confirmation of user input such as a mouse click or keystroke. A good choice for you all.

Fig 5 Buzzer

5 LCD Display (16 X 2)

The Liquid Crystal library allows you to control LCD displays that are compatible with the Hitachi HD44780 driver. There are many of them out there, and you can usually tell them by the 16-pin interface. The LCDs have a parallel interface, meaning that the

microcontroller has to manipulate several interface pins at once to control the display. The interface consists of the following pins.

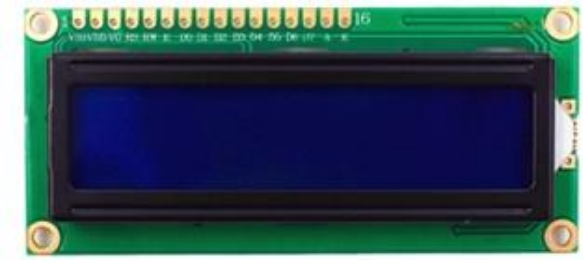

Fig 6: LCD display

Fig 7: Hardware architecture of the home fire alert

6 Software requirements

Sl no	Software requirements	Specifications
1	Arduino IDE	1.8.9 version
2	C	Programming code

Table 2 Software requirements

7 Arduino

The Arduino integrated development environment (IDE) is a cross-platform application (for Windows, mac OS, Linux) that is written in the programming language Java. It is used to write and upload programs to Arduino compatible boards, but also, with the help of 3rd party cores, other vendor development boards.

The source code for the IDE is released under the GNU General Public License, version 2.The Arduino IDE supports the languages C and C++ using special rules of code structuring. [4] The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub main() into an executable cyclic executive program with the GNU tool chain, also included with the IDE distribution. The Arduino IDE employs the program avrdude to convert the executable code into a text file in hexadecimal encoding that is loaded into the Arduino board by a loader program in the board's firmware.

8 C language

C is an imperative procedural language. It was designed to be compiled using a relatively straightforward compiler, to provide low-level access to memory, to provide language constructs that map efficiently to machine instructions, and to require minimal runtime support. Despite its low-level capabilities, the language was designed to encourage cross-platform programming. A standards-compliant C program that is written with portability in mind can be compiled for a wide variety of computer platforms and operating systems with few changes to its source code; the language has become available on various platforms, from embedded microcontrollers to supercomputers.

9 Functional requirements

- SIM registration & updating: User has to register himself with the SIM.
- Test SMS for fire detection unit: SMS is sent for testing fire detection system.
- Normal environment: No fire is detected yet.
- Abnormal environment: SMS is sent to the registered SIM when fire is detected.

10 Non-functional requirements

- Install ability: Ease with which a software system can be installed or uninstalled or reinstalled into a target environment.
- Efficiency: By using less space more data processing is done.
- Performance: Execution of the tasks like registering SIM, updating and SMS sending are done successfully.

VII. SYSTEM DESIGN AND IMPLEMENTATION

4.1 System design

The conventional fire alarm and monitoring system comprises of three major subsystems:

- central processor which is basically a microcontroller system that is responsible for all decision making process along with that
- sensor subsystem that has sensors sense the physical quantities to identify fire followed by comparator and
- Actuators driven by relays. The functional block diagram of conventional fire alarm and monitoring system.

The central processor is basically a microcontroller system that takes sensor output as input. The sensor outputs voltages are analog in nature and are compared with a pre-determined threshold by the comparator. The comparator outputs are either '1' or '0' that is being given input to the processor. After receiving and analyzing the information, it provides necessary instruction to the actuators. The actuators of the system are LCD display, water sprinkler motors, buzzer alarm and main power disconnection switch. Other than LCD display, all actuators need more current to drive. Hence relay circuits are being used.

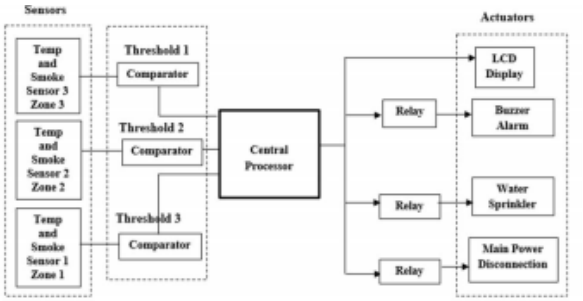

Fig 8 Block Diagram of Conventional Fire Alarm &Monitoring System

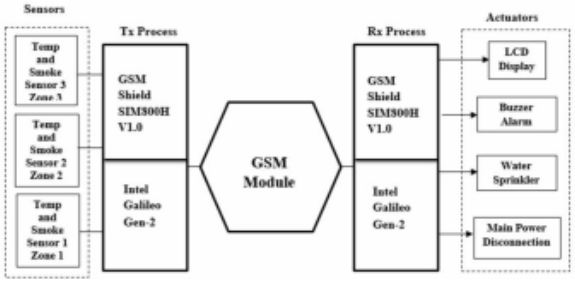

Fig 9 Block Diagram of Proposed Fire Alarm &Monitoring System

4.2 Implementation

The software of the project is based on the flow chart in fig 10 when the system begins, LM35 will always sense the surrounding temperature. Whenever a fire is broken out, even a small little fire, a temperature rise is occurred. When that happens, LM35 can detect the temperature value instantly. At the time when the temperature reaches 40oC or above, microcontroller on the Arduino UNO board will notify GSM module to send an alert message to the user. Value of temperature limit that can be triggered by LM35 can be changed in the code upon request by the user. The limit is not constrained to any value since the LM35 sensitively senses any surrounding heat with regards to the temperature range it can count (55oC to +150oC). During hot weather in Malaysia, the temperature can reach up to almost 38oC. Thus, the limit temperature to be detected; 40oC is definitely agreeable in accordance to the Malaysia's weather. Figures illustrate the flow chart of the home fire alert and the pseudo codes it represents for the project respectively. By referring to both figures, the complete program can be constructed later in Arduino IDE software.

Fig 10 Architecture of proposed Fire Alarm and Monitoring System

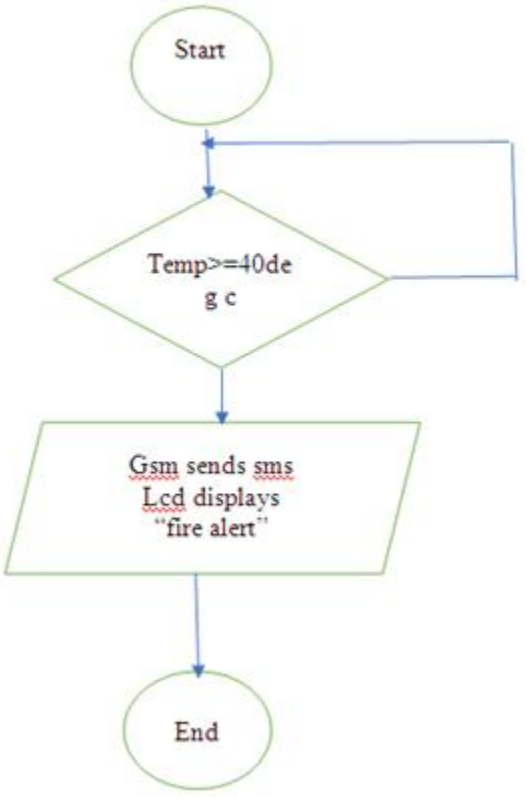

Fig 11 Flowchart of the home fire alert system

VIII. SCHEMATIC DIAGRAM

The overall project schematic diagram is shown in figure 11. While figure 4.6 illustrates the connection schematic diagram between Arduino UNO board with LM35 and GSM module. Since the Proteus© software does not have the GSM module component, it is replaced with the input connector available which the connector pins will be attached directly to the Arduino UNO board. For the particular part of detecting fire from LM35, the code is written and portrayed in figure 10. In the code, measured temperature from surrounding is basically identified in voltage. It is because LM35 is an analog sensor which values voltage unit. The voltage unit received will then be converted into knowable standard SI unit; degree Celcius in the subroutine called 'CheckTemp()'.

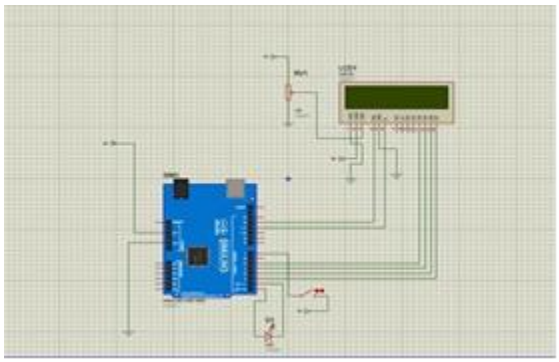

Fig 12 Project schematic diagram.

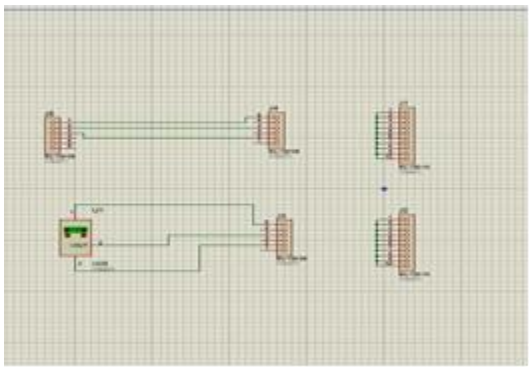

Fig 13 Schematic diagram for connection between Arduino UNO board with GSM module and LM35.

IX. SOFTWARE TESTING

Testing is an important phase in the development life cycle of the product. During the testing, the program to be tested was executed with a set of test cases and

the output of the program for the test cases was valuated to determine whether the program is performing as expected. Errors were found and corrected by using the following testing steps and correction was recorded for future references.

1) Testing Process

Testing is part of verification and validation. Testing performs a very critical role for quality assurance and ensuring the reliability of software.

Testing can be performed in various levels:

- Unit testing: Unit testing tests the individual components to ensure that they operate correctly. Each component is tested independently without other system components.
- Integration testing: Integration testing is another aspect of testing that is generally done in order to uncover errors associated with the flow of data across interfaces.
- System testing: System testing tests a completely integrated system to verify that it meets its requirements.
- Test cases: A test case is a software testing document which consists of events, action, input, output, expected result and actual result.

2) Testing Criteria

Individual modules expected output are tested and written in form of test cases

Test case 1: SIM registration
Objective: To register the number
Expected results: Messages should be displayed
Results: Message is displayed

Test case 2: Normal environment
Objective: To detect the fire
Expected results: No fire should be detected
Results: No fire is detected

Test case 3: Abnormal environment
Objective: To detect the fire
Expected results: Fire should be detected
Results: Fire is detected and triggers the alarm

X. RESULTS AND ANALYSIS

The proposed application is useful for safety of human beings via SMS alert sent to the mobile. The system includes SIM, Arduino, Flame sensor, GSM module, Buzzer, LCD display. These are the working snapshots of the system.

Snapshots

1 Fire alarm and monitoring system

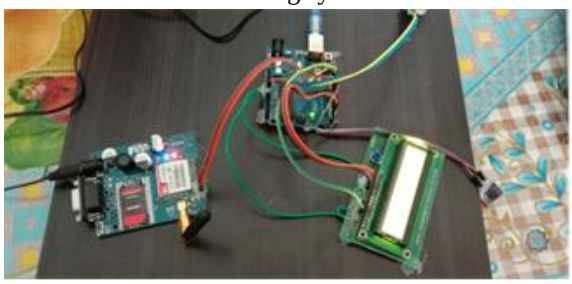

Fig 14 Fire alarm and monitoring system

The above fig14 shows Fire alarm monitoring system. In this system you have a fire monitoring panel installed and connected to your fire alarm system. When the fire alarm system goes off the fire monitoring panel will immediately send a signal to the signal receiving stations.

2 Normal environment

Fig 15: Normal environment

The above fig 15 shows normal environment when no fire has occurred. There will be no changes in the environment factors such as soil, water, climate, landforms and natural vegetation.

3 Abnormal environment

Fig 16: Abnormal environment

The above fig 16 shows abnormal environment when fire is caused. The factors the macro environment includes economic, socio-cultural, political, legal, technical. Generally, it will affect a large area an affect the ecology of that area. These affects are focused in the location where the fire occurred or relatively short distance away.

An SMS alert

Fig17: An SMS alert

The above fig 17 shows an SMS alert. These are the SMS alerting messages the user receive. So that, the user can visits the fire location.

XI. CONCLUSION AND FUTURE SCOPE

1 Conclusion

The work deals with how to handle Fire hazards using Fire Alarm systems. People think that not a single project is ever considered as complete forever because over mind always think new and our necessities also are growing day by day.

People always want something more than that what they have. This application also, if you see at the first glance that you find. It has to be completed but want to make it still mature and fully automatic.

2 Future scope

The project has been motivated by the desire to design a system that can detect fire and take appropriate action, without human intervention. This provides an opportunity to pass on to robot's tasks that traditionally humans had to do but were inherently threatening. Fire-fighting is an obvious candidate for such automation.

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