Automatic Fire Detection and Response System

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Abstract — Industries around the world have become complex and difficult from safety point of view. Given the structural characteristics of industries, easy and fast evacuation during fire or any disaster should be possible. An Industrial fire is a type of fire disaster occurs in an industrial setting. Industrial fires mostly occur together with explosions. They are most likely to occur in the environment where there is a lot of flammable material present. This paper suggests an Industrial based automatic fire detection and response system which can totally control and guide intelligently Using fuzzy logic and design of integrated control system using multiple sensor to address the problems with existing fire emergency response systems in times of fire disaster.

Index Terms —Internet of Things, Wireless sensor networks, Evacuation, Fire detection, Integrated Control System, fuzzy Logic

I. Introduction

Automatic fire detection and response system that can control security and safety of the industry intelligently within the minimum time and the design of a system using wireless sensor networks, fire alarm sensor, and human detecting sensor to address the problems with existing disaster emergency response systems in times of fire hazard. The system has decentralized control that can intelligently guide evacuees based on the detection of humans for removing them from industry to minimize the loss of human life and industrial assist.

The existing system was able to secure the industry but not within enough time as the system was designed using various sensors but not as a single unit to address the problems in times of fire or any other. Each sensor is connected to the system separately and function individually which makes the system slow.

The modified system can secure the industry intelligently within minimum time as the system is designed using different sensors as a single unit to address the problems in times of fire or any other.

II. Literature Survey

In this section latest fire accident detection technologies and intelligent prevention system are discussed. In [1] an efficient smart emergency response system for fire hazards using IoT is explained in detail which provide a quality public safety and security services to adopt leveraged data driven emergency response systems with urban IoT design standards. In [2] an intelligent fire detection and mitigation system safe from fire (sff) is being specified in detail with proper safety system. In [3] the design and Implementation of a fire detection and control system for automobiles using fuzzy logic is given with early detection and exact fire location detection using fuzzy logic. In [4] the efficiency increase for electrical fire detection and alarm systems through implementation of fuzzy expert systems is explained with high efficiency detection system. In [5] the fire detection system using fuzzy logic and data aggregation using fuzzy logic is elaborated in detail. In [6] the Fire Detection System with GSM Using Arduino is explained which gives the approximation location of the fire. In [7] internet of things in Industries-a Survey is given which tells about the latest IOT based technologies used by industries in today's date. In [8] IoT-based Intelligent for Fire Emergency Response Systems explains the system designed using IOT for fire emergency response system. In [9] a study on the fire IOT development strategy gives the analysis on the development and maintenance of firefighting facilities, etc. In [10] detection of fire using fuzzy logic gives the better accuracy of the detection system, as well as reduce the false alarm rate.

III. System Overview

Internet of Things has provided an opportunity to build strong and eligible industrial systems of wireless sensor networks with radio-frequency identification and sensor devices. The entire proposed system is divided into two assembly points: Assembly point 1 and Assembly point 2.These assembly points are used both for security and safety purposes.

A. Assembly Point 1

NodeMCU ESP8266 based security system using RFID – The system designed under assembly point 1 as shown in Fig. 1, is a security based system for industries. The system is fully automatic and does not require any manual operation. The system contains the following components:

1. NodeMCU ESP8266 Wifi Module

NodeMCU is an open source IoT platform. It includes firmware which runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module.

2. RFID Reader

RFID reader detects the RFID card and send a 12 digits alphanumeric unique code on the serial port.

3. RFID Card

RFID Card consists of RFID tags which emit radio signals usually embedded in things mostly used for entrance purposes.

4. Buzzer

Buzzer is a warning or an indication that an invalid attempt is made to gain access to the system.

5. LCD Display

A 2x16 LCD display is a display module can display 16 characters per line and there are 2 such lines.

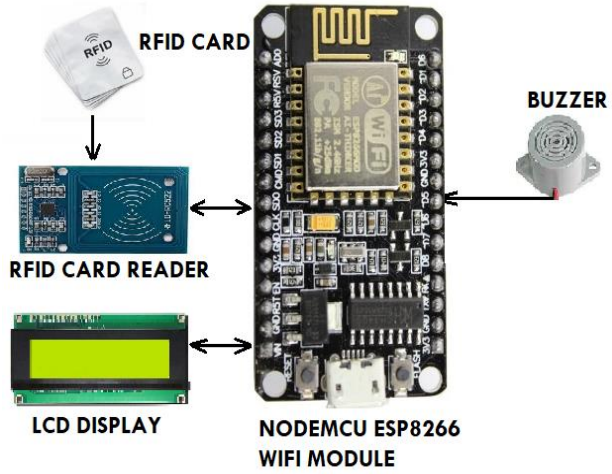

Figure 1. System architecture of assembly point 1.

B. Assembly Point 2

Fire Detection and Water Sprinkler system – This proposed system detects fire at early stage as shown in Fig. 2. This, in turn, helps in early reaction, solving lives and property of industries. It is totally designed for safety purposes. The proposed system can secure the industry intelligently within minimum time as the system is designed using different sensors as a single unit to address the problems in times of fire. Whenever the fire is detected by the sensor, it is indicated to the Arduino system. Then the Arduino takes the control action by switching on or off the water sprinkler with the help of relay coil and send a message or email to the industry in-charge and to fire brigade to provide their safety service as early as possible. It gives a fast process with decentralized control that can intelligently guide exit based on human detection. It reduces the time required for escape by guiding people. The system contains the following components:

1. Arduino UNO R3 Board

Arduino board is the main processing board or unit of the system which controls the entire system.

2. Buzzer/Alarm

It is warning or alert indication buzzer.

3. Power Supply

Transformers/Battery adapter/9V high watt battery.

4. SPDT Relay Coil

Single pull double through relay for the purpose of AC appliances (ON and OFF).

5. Water Sprinkler

Water Sprinkler system is used for the purpose of reducing the fire and making the disaster under control.

6. NodeMCU ESP8266 Wifi Module

NodeMCU ESP8266 wifi module can give access to your wifi network.

7. Sensors

A. Temperature Sensors (LM35)

Temperature Sensor Module is used to sense temperature and convert it into output signals.

B. Flame Sensors

Flame sensor can measure the heat of an object.

C. Smoke/Gas Sensors (MQ5)

Gas Sensor module is useful for detection of gas leakage.

D. PIR Sensors

PIR sensors allow you to sense motion, almost always used to detect whether a human has moved in or out of the sensors range.

8. GSM Module

GSM module is used to establish communication between a mobile and a GSM system.

C. System Flow

Fig. 3 shows the system working using system flow diagram. Whenever the fire disaster took place, the fire is initially detected by the temperature sensor which collects and check the data. If the data exceeds the threshold value, then the gas and flame sensors gets initialized which collects and measures the data. Further if the system finalize that the fire is actually occurred, the buzzer/alarm starts ringing after which the PIR sensor (Human detecting sensor) also gets initialized which counts the number of employees or persons passes through the exit point so that the system can identify the employees under danger and find those employees with the help of GPRS module. At last, the system automatically starts the water sprinkler and send a message or email to the industry in-charge and to fire-brigade to provide their safety service as early as possible.

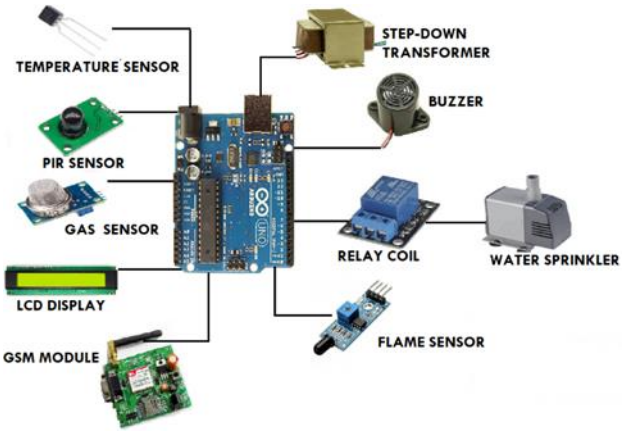

Figure 2. System architecture of assembly point 2

IV. Implementation Details

Industrial based intelligent emergency response system is basically divided into two assembly points where the first assembly is used for the entrance purpose and the second one is for the exit.

A. Assembly point 1

The first assembly contains the NodeMCU connected to rfid reader, LCD display, buzzer and three RGY LEDs. Initially, the NodeMCU connects to the wifi-connection where it blow the red LED while connecting or in case of any connection error as shown in Fig. 4.

Once the connection is built between the NodeMCU wifi-module and your wifi host system, the system switch off the red led and blows the yellow led as shown in Fig. 5.

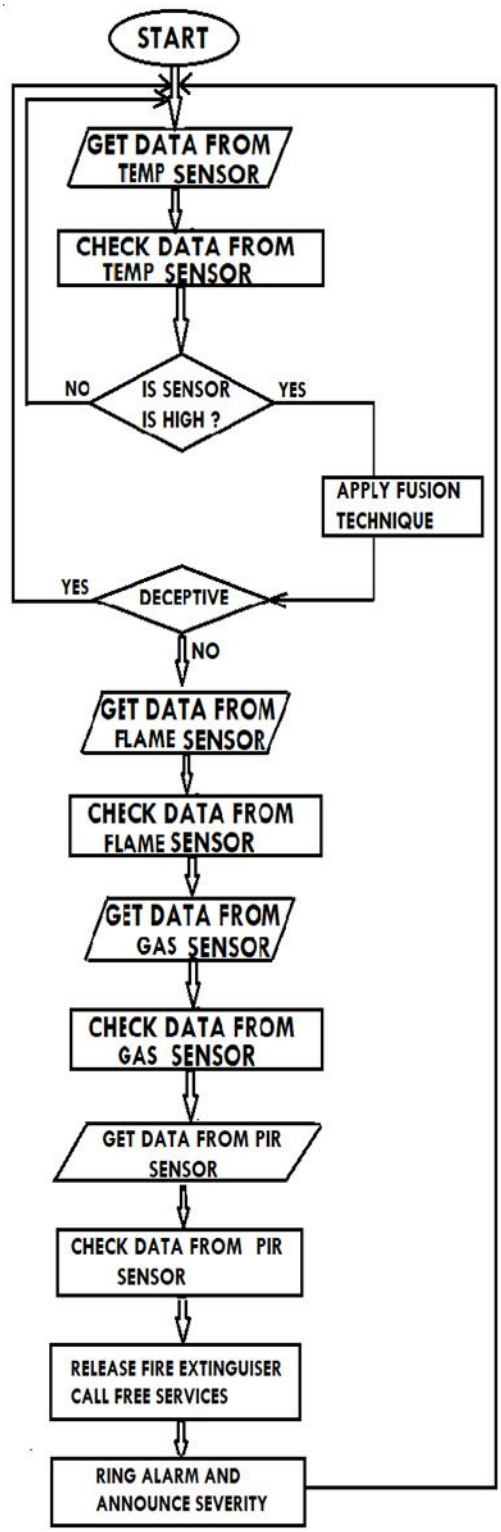

Figure 3. Flowchart of the system at Assembly point 2

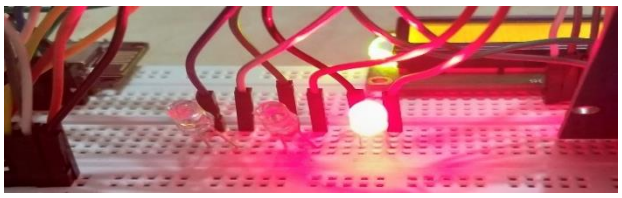

Figure 4. Connection in process or connection failure

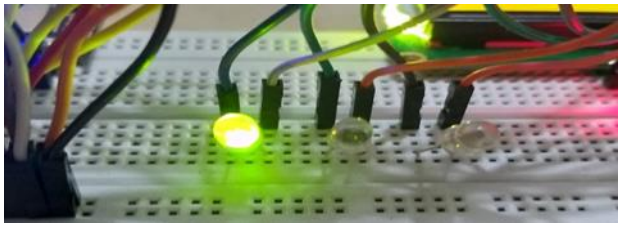

Figure 5. Connection established

Now once the connection is built and yellow led blows, the system is ready to use. The employees of the industries can now scan their rfid cards with rfid card reader to enter inside.

When an employee having the access to enter the industry scan their cards, the serial monitor shows that UID tag and the message of authorized access whereas an employee card is blocked or denied, the serial monitor displays the UID tag with the message of access denied as shown in Fig. 6.

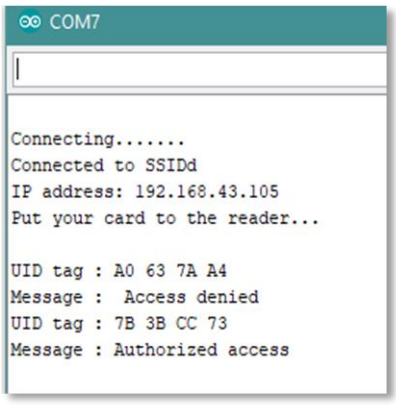

Figure 6. Employee authentication access or denied

Whenever a card is scanned through card reader, it blows the green led as shown in Fig. 7. This green light shows that the data of rfid card is entered into the database along with its log id and log date as shown in Fig. 8.

Figure 7. Rfid card scanned through the card reader

RFID LOGS

Log Id	Card Id	Log Date
17	1712840	April 26, 2019, 6:06 pm
18	1310550	April 26, 2019, 6:06 pm

Figure 8. Rfid data enter into the database

B. Assembly point 2

Initially, the temperature sensor LM35 detects the temperature of the industry and displays it on 2x16 LCD display in terms of degree celsius as shown in Fig. 9.

Figure 9. Temperature displays on the LCD display

When temperature increases and exceeds the threshold value, the system activates the flame sensor and gas sensor MQ5. The flame sensor detects the flame if occurred and the buzzer activates whereas the gas sensor detects the flammable gas released through fire and as the smoke level exceeds its threshold value, it displays an alert message as shown in Fig. 10.

Figure 10. Smoke sensor displays alert message

When the smoke level exceeds threshold value and displays an alert message, then the system makes a call using GSM module to fire brigade and HR manager of industry as shown in Fig. 11.

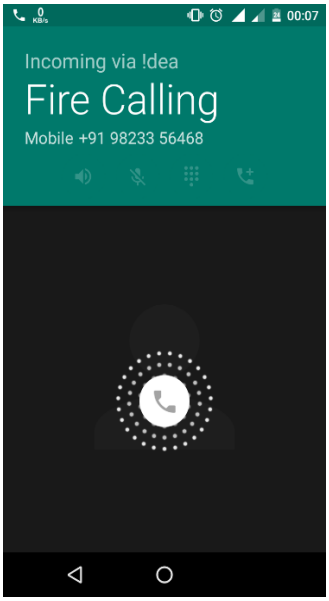

Figure 11. Incoming call of the system to fire brigade on fire detection

As the fire and gas sensor displays the alert message, system activates the human detecting sensor (HDR) which detects the number of employees available inside the industry by counting the number of people passes through it and displays it on the screen.

The same information is further passed to the fire brigade and HR of the industry for safety purpose. Fig. 12 and Fig. 13 shows the two cases of employee present inside the industry and employee absent when disaster took place.

Figure 12. HDR detects and displays nobody is present inside the industry

Figure 13. HDR detects the number of people inside the industry

Conclusion

Industrial based automatic fire detection and response system can reduce the casualties of the disaster in industries to prevent the employees, industrial machines and infrastructure by responding and alerting the system in minimum amount of time. The developed system can also help disaster fighting with the help of water sprinklers as it allows for a quick process of the disaster with decentralized control that can intelligently guide evacuees based on the detection of humans.

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