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METHODS

An internet of things enabled smart firefighting system

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A fire accident is a mishap that could be either man-made or natural. Fire accidents occur frequently and can be controlled but may, at times, result in severe loss of life and property. Many a time, firefighters struggle to sort out the exact source of the fire as it is continuously flammable and spreads all over the area. For this concern, we have designed an Internet of things based device which sorts out the exact source of fire through software and hardware devices, and also allows the complete detail of an area to be visualized by firefighters, which is pre-installed in the software itself. Because of our system's intelligence in decision-making during firefighting, the proposed system is claimed as a "smart firefighting system." The implementation of the smart firefighting system can make the firefighters analyze the current situation immediately and make the decision more quickly in an effective manner. Because of this system, fire losses in a building can be greatly reduced and many lives can be rescued immediately. Furthermore, fire spread can also be restricted.

Keywords: Internet of things (IoT), firefighting system, NodeMCU, ThinkSpeak, Pyrofighter

Introduction

The in the world is about >7 billion, and most of the people try to gather in the same place where wealth is constant. Also, people move from place to place due to modernization and urbanization. Many places in the world are clustered by shops, buildings, and large apartments. Hence, in such places, accidents that occur in the form of fire and in several other forms cause severe loss of human lives and materials. In India, a reputable newspaper, *The Indian Express*, conducted a study in malls, apartments, and all commercial buildings, and found that most malls and apartments lack proper fire safety systems and awareness. There are many advanced firefighting systems and techniques, but most of them are not utilized as the main reason behind it is that they require high initial investment. Implementation of an effective budgetary controlled smart firefighting system will overcome these difficulties. Most technology is automated and controlled through the Internet of things (IoT). To sort out these difficulties in firefighting and make a required solution, this smart firefighting system was introduced. This makes firefighting simpler and decision-making can be done in a short time.

Design and methodology

A firefighting system includes both hardware and software design. The hardware design contains the following components:

K-type thermocouple: A thermocouple is a sensor used to measure temperature. Thermocouples consist of two wire legs made from different metals. The wire legs are welded together at one end, creating a junction. This junction is where the temperature is measured. When the junction experiences a change in temperature, a voltage is created. The type K is the most common type of thermocouple. It's inexpensive, accurate, reliable, and has been optimized to detect a wide range of temperature fluctuations.

MQ2 gas sensor: It is a metal–oxide semiconductor (MOS) type gas sensor, also known as a chemiresistor, as the detection is based upon the change of resistance of the sensing material when a gas comes in contact with the material. Using a simple voltage divider network, concentrations of the gas can be detected. It can detect liquefied petroleum gas (LPG), smoke, alcohol, propane, hydrogen, methane, and carbon monoxide concentrations anywhere from 200to 10,000 ppm.

NodeMCU: NodeMCU means node microcontroller unit. The widely used ESP8266-12E Wi-Fi module serves as the foundation for the open source NodeMCU development board and software. It enables use of the Arduino IDE or the straightforward and potent LUA programming language to program the ESP8266 Wi-Fi module. It can be controlled by an Arduino program. Hardware is designed by Autodesk Eagle software. All the components are placed in the correct potion and all the connections are made by the software itself. Figure 1 shows the PCB layout of the proposed smart firefighting system.

Pyrofighter is the website that was created for this project. This website provides structural views and details of a building. The building model is created in software and inserted on this page. It gives a three-dimensional (3D) view of the building from all projections and a detailed building

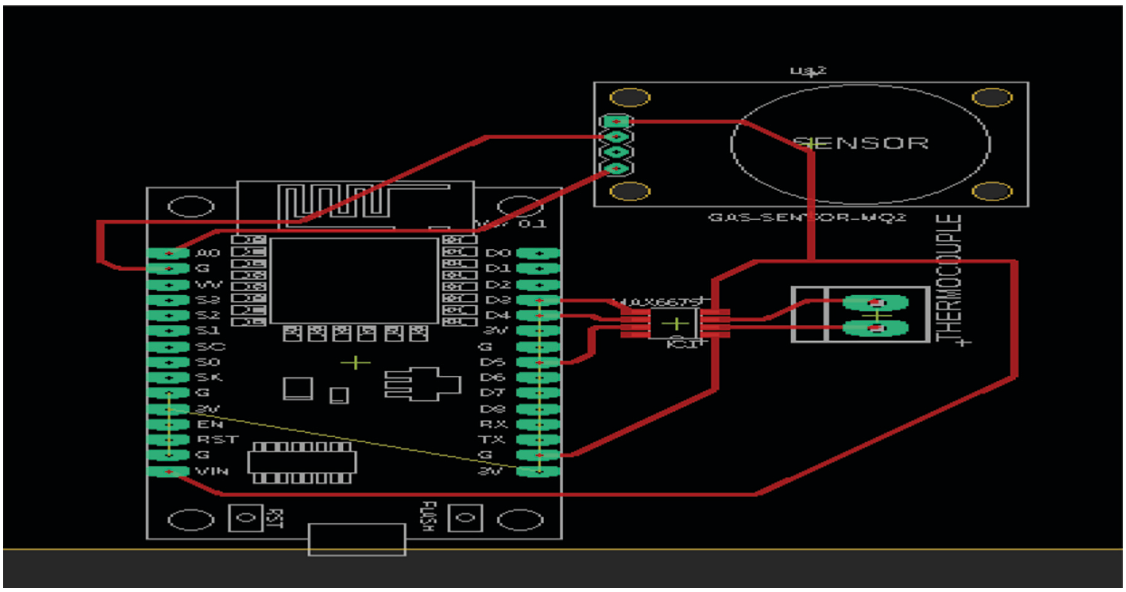

FIGURE 1 | PCB layout of smart firefighting system.

FIGURE 2 | Home page of the Pyrofighter website.

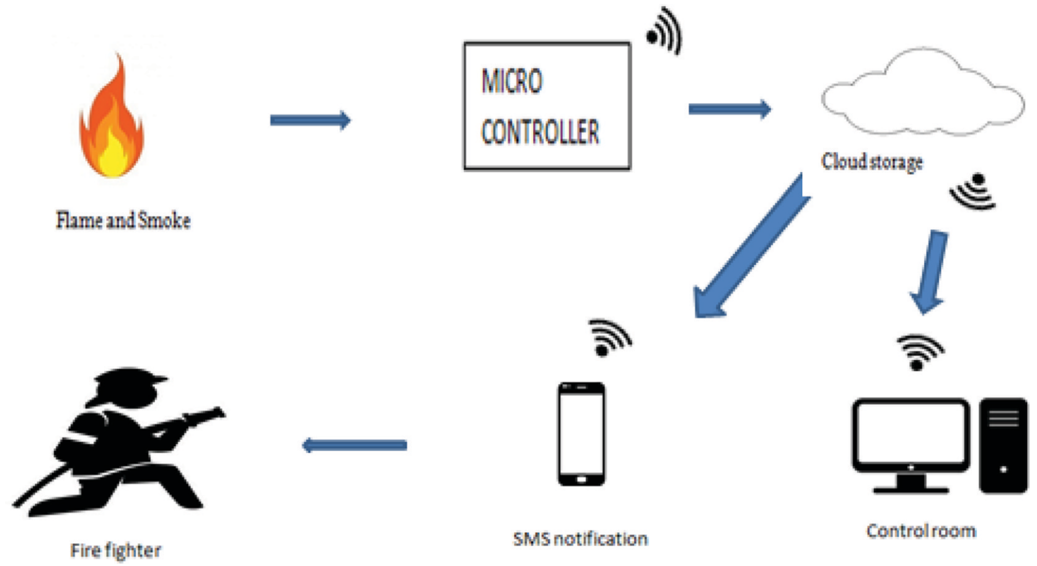

FIGURE 3 | Working of a smart firefighting system.

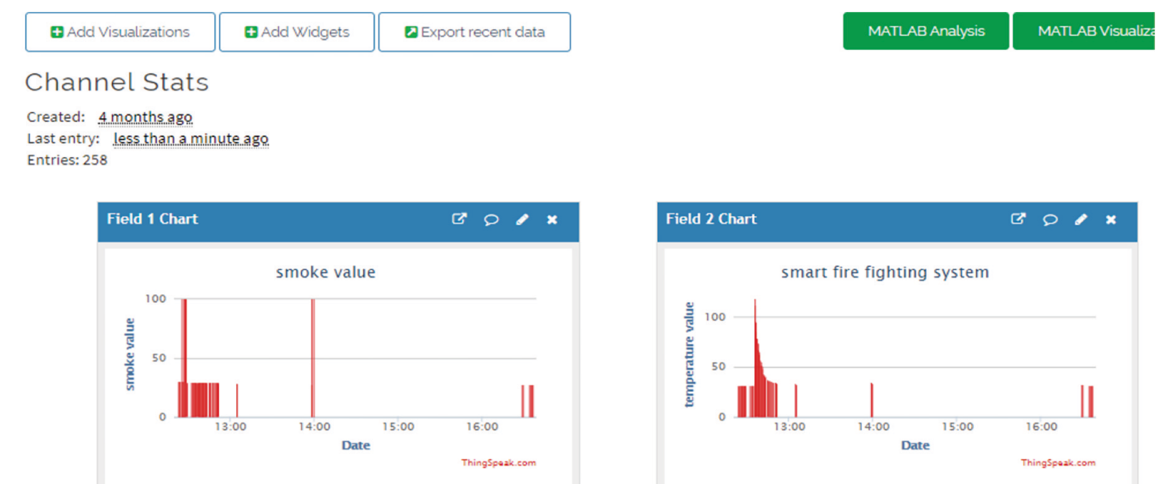

FIGURE 4 | ThingSpeak channel showing values of fire.

plan. Every floor has a detailed plan and a description of each room. And it also provides internal images of each room and the things that are presented in that room, as well as description of the things and their quantity. This website can be accessed from the website link: http://Pyro_fighter%202%20(1)/Pyro_fighter/PyroHome.html. **Figure 2** shows the home page design of the Pyrofighter website.

Using the hypertext transfer protocol (HTTP) and message queuing telemetry transport (MQTT) protocols over the Internet or over a local area network, ThingSpeak is an open-source IoT application and API that stores and retrieves data from objects. Application development for location tracking, sensor logging, and a social network of things with status updates is all made possible by ThingSpeak. It is an IoT analytics platform that enables cloud-based data aggregation, visualization, and analysis of real-time data streams. ThingSpeak provides instant visualizations of data posted by user's devices to ThingSpeak. With the ability to execute MATLAB code in ThingSpeak, users can perform online analysis and processing of the data as it comes in.

Pushbullet is one of the fastest and easiest ways to get links, notes, lists, files, and addresses both from a user's desktop computer to their mobile device and vice versa.

The ThinkSpeak and the Pushbullet websites, which are part of this project, are also linked with this website itself. The data required for this website is collected and uploaded here from the building while implementing this firefighting system in that building.

Implementation and working

The program for the firefighting system is uploaded to the NodeMCU and the whole firefighting kit is placed in all the

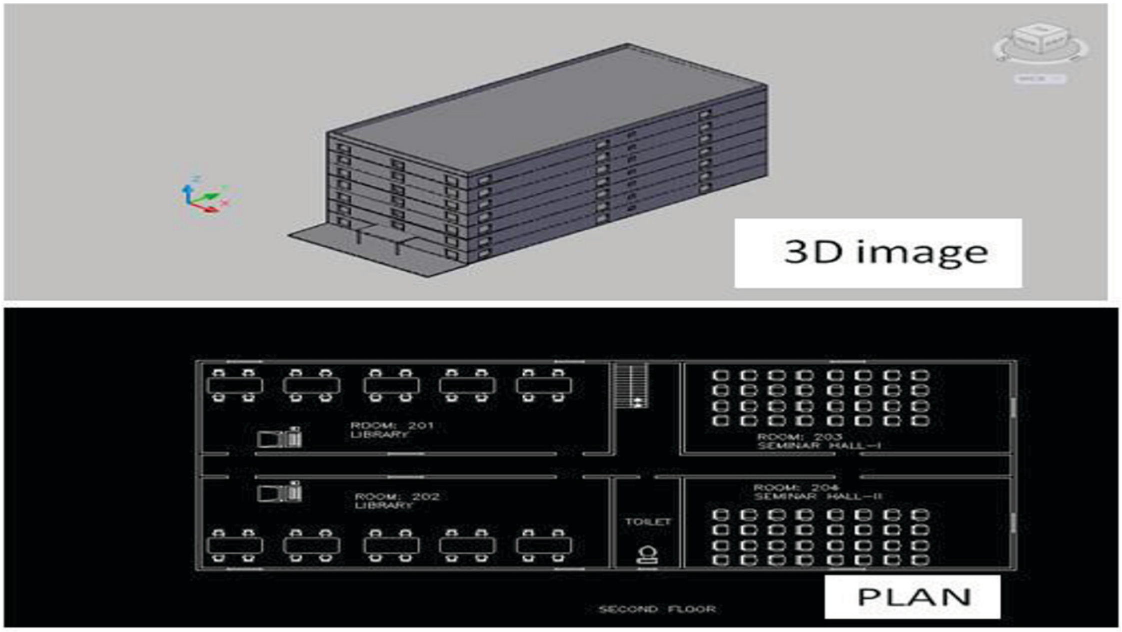

FIGURE 5 | Three-dimensional image and plan of the building on the Pyrofighter website.

rooms of the building. That program contains connectivity details for Wi-Fi and ThingSpeak channels. Each and every detail of the building is collected and uploaded with images to the Pyrofighter website.

Figure 3 shows the workings of a smart firefighting system. When the building gets a fire, it will produce smoke and fire. The smoke from a fire is detected by the MQ2 gas sensor, and its analog values are converted into digital values and analyzed by the NodeMCU. When the concentration of the smoke is above 100 ppm, then this microcontroller system will send a signal to the buzzer alarm. The alarm will function until the smoke concentration is reduced. When the smoke sensor is triggered by the smoke, it will force the Pushbullet channel to send a fire alert notification to the building owner's phone and building security's phone via the Internet. Figure 4 shows the ThinkSpeak channel values of fire.

The thermocouple always measures the temperature of the room, converts the data into digital data, and sends all the data to cloud storage via the Internet. The sensor data is updated on the cloud every 20 s. The data from the cloud storage is analyzed by the ThingSpeak channel. The ThingSpeak channel plots the graph using the data stored in the cloud. This graphical representation helps the firefighter understand the exact situation inside the room. Likewise, all the sensors from each room will give the current temperature to the ThingSpeak channel. This data will help the firefighters understand the situation and condition of the fire. The Pushbullet service is also connected to cloud storage.

Moreover, the firefighters can also visualize the building using the 3D images and plans of the building from the Pyrofighter website. When the firefighter is approaching the fire accident site, he will get two types of data, namely, data about the fire and the density of the fire and data about the building. The data about the fire is viewed by the ThinkSpeak channel. It shows the density of fire in graphical form with quick updates. The information about the building was obtained from Pyrofighter, which provided a 3D image of the building, a detailed floor plan of the building, a description of each room, and items inside each room with their description and quantity. Both of these pieces of information assist the firefighter in determining the exact condition and location of the fire.

This implementation can make the firefighters immediately analyze the current situation and make the decision in an effective manner. With the implementation of this system, fire losses in a building can be greatly reduced and many lives can be rescued immediately. Furthermore, fire spread can also be restricted.

Results

The firefighting system is executed as per the procedures and the results are as followed. The system was tested to its maximum frequency, and it withstands a temperature of about 500°C. Also, it shows the entire data completely with minimum errors. So, hopefully it can work up to a temperature of about 1,200°C.

The response time of the system is as expected as it has not delayed at any time during the process. The response time of the whole system is about 20 to 30 s.

Conclusion

With the implementation of the smart firefighting system, the firefighters can analyze the situation immediately and make the decision quickly and effectively. And also, by this system, fire losses in a building can be greatly reduced and many lives can be rescued immediately, and moreover, fire spread can also be restricted to other areas. So, it can be concluded that the smart firefighting system is effective both in cost and in processing.

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