Rapid Application Development based Fire Alarm Device

Arvin Anthony S. Araneta
DMT, PCpE
College of Computer Studies
Eastern Samar State University
Salcedo, Eastern Samar, Philippines

Charito B. Lacasa
MIT
College of Computer Studies
Eastern Samar State University
Salcedo, Eastern Samar, Philippines

ABSTRACT
The use of different IoT devices for home automation has become very popular in recent years. Fire detection and avoidance of fire accidents is one of the necessary and important application of home automation using IoT. Traditional fire alarm system requires huge installation cost and labor. The proposed IOT based fire alarm system basically detects fire at an early stage, generates an automatic alarm and notify the remote user or fire control station about the fire outbreak. The goal of this study is to develop a monitoring tool for automated fire detection with an Arduino microcontroller and a smartphone. The Fire Alarm Device uses sensor data from two parameters: temperature and smoke and displays its reading in an application at the same time. The device includes an ESP32, which can send data via WiFi and Bluetooth. Testing results shows that the equipment was practical and useful since it met the specification. The device can be marketed to the public as a rapid-fire emergency notification system. More work is needed to expand the device's range, application structure, and functionality.

General Terms
Rapid Application Development, Fire Detection.

Keywords
Arduino device, fire detector, temperature sensor, gas sensor, fire prevention system.

1. INTRODUCTION
Fire safety has been a top priority as human civilization has progressed. Fire dangers may be lethal and demeaning to industrial and residential security, as well as hazardous to human life. Responding to an emergency as quickly as possible is the greatest strategy to reduce these losses. As a result, standalone autonomous fire detection systems are required. These systems provide the functions of fast detection, alarm notification, and, in certain cases, fire extinguishing. The systems, which are equipped with smoke, temperature, and pyro-electric sensors, may identify unfavorable unintentional conditions as they occur and, with the assistance of a processing unit, can notify immediately to take precautionary actions. Early detection and faster alert in these fatal situations will result in less property and life loss.

Among the catastrophes that have occurred in the resident area, fires have been identified as a deadly tragedy that may result in devastation, property, and life losses [1]. Fires have become the most common, damaging, and impactful disasters in numerous disasters when compared to other dangers. With the fast expansion of urban building, the likelihood of a major fire and other calamity increasing year by [2]. Early detection and warning of fires are two critical techniques to quickly extinguish the fire and minimize major casualties and material loss. As a result, the installation of intelligent fire alarm systems within buildings is critical, particularly in facilities that house many people or valuable items.

Chavez [3] reported that since January of this year, a total of 2,619 fire incidents have been documented across the country. According to the Bureau of Fire Protection, the statistic is higher than the previous year's total of 1,812 fire occurrences from January to March. According to research conducted by the agency's fire investigators, more people have recklessly utilized their electrical connections for lengthy periods of time, resulting in an increase in fire accidents.

Fire and smoke are two of the most common causes of unintentional accidents. Fire detection is critical because fires inflict significant damage to both human life and non-living goods. Most residences lack fire alarm systems, putting residents at danger of fires breaking out in their dwellings. Fires can even break out while residents are not there. Most fire alarm systems on the market are wired in connection. This sort of technology necessitates installation and expenditure, and it has its own set of constraints. It also does not fulfill the standards of the new automated smart home. As a result, an intelligent wireless fire alarm system that is low-maintenance, safer, and easier to use is required.

Electrical appliances, defective wiring, and other variables are frequently explored as causes of fires. If a fire breaks out when individuals are around, there is a good chance that it can be extinguished. It is because they can prevent the fire from spreading by using a fire extinguisher or calling the fire department immediately. The major issue of this endeavor is when no one is nearby or is unaware of the fire's existence. Having said that, the campus fire alert is specifically meant to notify the community if there is a potential for a fire tragedy on campus.

The design and development of a ESSU Salcedo fire warning system for this project is based on the Arduino board as the primary controller board, which interacts with a GSM module that operates in the communication section. The interaction is intended to inform the user about the present state in the campus. As the GSM module is accomplished by sending an SMS to the user, this system is entirely based on wireless network connection. The microprocessor within the Arduino board serves as the circuit's intellect, controlling circuit flows and executing all decisions.

The GSM Module oversees the communication component of the circuit. It receives instructions from the Arduino on where and what information to deliver. It communicates with a GSM SIM card. It is essentially simply a modem that communicates with the Arduino through serial communication and requires

Hayes compliant AT instructions. The user provides the alert message and the recipient's phone number via the project codes. As soon as a fire is detected (the temperature reaches a particular limit), an SMS will be sent to the recipient's phone number from the SIM card connected inside the module to tell the user of the fire detection in the residence.

2. OBJECTIVES

The following objectives were set for this study:

1. To design an Arduino-based fire alarm device with SMS notification.
2. To develop the Arduino-based fire alarm device, which will monitor the presence of fire using two sensors in one device.
3. To test the Arduino-based fire alarm device in terms of its functionality and general usability.

3. METHODOLOGY

The design and development of this project are divided into two main parts: hardware architecture and software details. In the hardware architecture, the creation of the circuit was constructed, and the prototype of the project was built. While in the software development, the whole complete prototype was operated via programming codes.

3.1 Hardware Architecture

Because Arduino is the primary board, the microcontroller on it, ATmega328, is employed as the main controller to govern the circuit. It is a well-known open-source microcontroller-based kit for developing digital gadgets and interactive tools that can interact with LEDs, LCD displays, switches, buttons, motors, speakers, and a variety of other components. The Arduino system provides a set of analog and digital pins that may be combined into a variety of other boards and circuits with a variety of functionalities in a design. For loading programming from a computer, the Arduino board has a USB serial connection port. Arduino has created its own software called the integrated development environment (IDE), which fully supports the C and C++ programming languages. Figure 1 shows the Arduino UNO board that is used throughout the project.

Fig 1. The Arduino UNO board which uses microcontroller ATmega328 onboard.

The GSM SIM900A type is chosen for the GSM module to carry out the work in the communication section. It has a dual-band frequency range of 900-1800 MHz and is only intended for use outside of Europe and the United States. It features a proven performance, an industrial grade interface standard, and an inbuilt TCP/IP protocol, making it attractive and suited for an electronics project. It is stated to be able to interface with any low power consumption microcontroller since it uses less power during operation. It may be interfaced by a variety of interfaces, including I2C, SPI interface, PWM, antenna pad, two serial interfaces, and so on. Figure 2 depicts the GSM SIM900A device prior to its connection to the Arduino board.

Fig 2. The GSM SIM900A module to communicate with Arduino board.

The LM35 temperature sensor was chosen because it is an analog and linear temperature sensor with a linear connection between output voltage and temperature changes (oC). Furthermore, the LM35 does not require external calibration to provide an accuracy of (1/4)oC at ambient temperature or (8/4)oC at temperatures ranging from -55oC to +150oC . The

LM35's low input impedance, linear output, and precise intrinsic calibration make sensor reading and control circuitry interface simple. Typically, the gadget is utilized with a single power supply or with plus or minus supplies. It can accept input voltages ranging from -2V to 35V and output voltages ranging from -1V to 6V. Figure 3 depicts the LM35.

Fig 3. LM35 sensor by Texas Instrument

.

MQ2 is a semiconductor sensor that detects smoke, LPG, methane, butane, propane, and other hydrocarbon flammable gases. Tin dioxide is the sensitive ingredient in this sensor (SnO2). When the sensor comes into touch with the gas to be monitored, its electrical resistance drops, allowing the microcontroller to respond to the situation. The analog voltage from the sensor is applied to the comparator IC LT1013's input, while the reference input voltage is provided via a variable resistor to modify the sensing intensity. The comparator output has been linked to the MCU via a single data line. When smoke or gas is detected, the output increases and the indication LED illuminates.

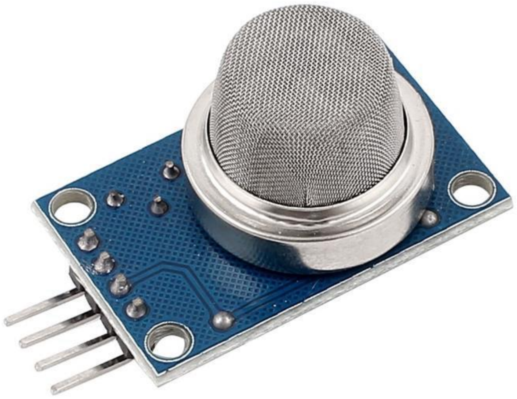

Fig 4. MQ2 Semiconductor Sensor.

3.2 Software Design

The entire system will be controlled by firmware written in embedded C and produced using the mikroC compiler. The software is then transferred to the 8-bit Atmega8L microcontroller. The Program Flowchart is depicted in Figure 5. It entails creating the system's algorithm, assigning memory blocks based on functionality, writing distinct routines for various interfacing devices, and lastly testing them on the built hardware.

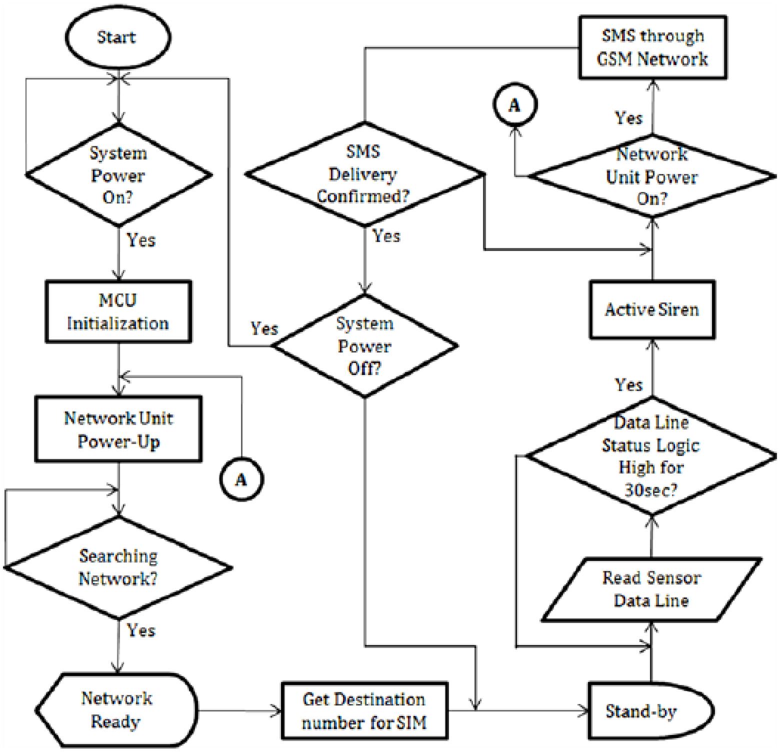

Fig 5. Flow code of the System Program.

4. RESULTS AND DISCUSSION

The device was subjected to several testing methodologies to assess its quality following the development process. The goal of testing was to determine whether the device meets the user requirements and whether it is suitable for delivery (Software Testing Fundamentals, 2022). The researcher employed the ISO 9126 quality characteristics to assess the device general acceptability.

Table 1 presents the summary result of functionality, reliability, usability, efficiency, and portability quality attribute during the acceptance test of the RAD Based Fire Alarm Device. In the criterion of "Functionality", "Usability", and Portability" obtained a mean value of 5.0 and was interpreted as Excellent. It was noted during the acceptance test that the device provided the agreed result. The device enables the user to learn its application and can easily adapt in different environment. In terms of "Reliability", the system obtained a mean value of 4.9 and was interpreted as Very Good. The criterion of "Efficiency", and "Maintainability", obtained the value of 4.5 and was interpreted as Very Good . Results shows that the designed system is now functional, dependable, useable, efficient, and portable, and it is ready for implementation. This also implies that the parameters have already been calibrated to its requirements and will reflect the right result.

Table 1. Summary Result of Acceptance Testing

Criteria	Mean	Interpretation
1. Functionality	5.0	Excellent
2. Reliability	4.9	Very Good
3. Usability	5.0	Excellent
4. Efficiency	4.5	Very Good
5. Maintainability	4.5	Very Good
6. Portability	5.0	Excellent
Overall Mean	**4.8**	**Very Good**

4.1 Usability Testing

After the experimental testing, the usability test followed to guarantee that the developed device meets the requirements and is ready for implementation. The respondent used the System Usability Scale (SUS) by the (Digital Equipment Corporation, 1986), which measures how well a product allows users to accomplish their goals. The SUS Scale is generally used after the respondents had an opportunity to use the system being evaluated before any debriefing or discussions take place.

To calculate the SUS score, first sum the score contributions from each item. Each item's score contributions will range from 0 to 4. For items 1,3,5,7 and 9, the score contribution is the scale position minus 1. For items 2,4,6,8 and 10, the score contribution is the scale position minus 5. Multiply the sum of the scores by 2.5 to obtain the overall value of the SUS. A SUS score of 68 is considered above average, and anything below it is below average.

The evaluators of the system usability tests were three five officers from Bureau of Fire Protection - Salcedo.

Table 2 displays the summary for system usability on the quality of the RAD Based Fire Alarm Device that was done on the second week of September 2022. It represents the overall score of the 10 item statements. It obtained an overall SUS score of 92.50. It implies that the developed device is usable and now ready for implementation.

Table 2. System Usability Results on the Quality Attributes of the RAD Based Fire Alarm Device

Criteria	Mean	SUS Score
1. I think that I would like to use the device frequently	3.50	2.50
2. I found the device unnecessarily complex	0.50	4.50
3. I thought the device was easy to use	3.75	2.75
4. I think that I would need the support of a technical person to be able to use the device	4.00	4.50
5. I found that the various functions in this device were all integrated	4.00	3.00
6. I thought there was too much inconsistency in this device	0.00	5.00
7. I would imagine that most people would learn to use this device very quickly	3.75	2.75
8. I found the device very cumbersome to use	0.50	4.50
9. I felt very confident using the device	3.75	2.75
10. I needed to learn many things before I could get going with this device	0.25	4.75
SUS Score		**37**
Overall SUS Score (SUS Score x 2.5)		**92.50**

5. CONCLUSION

Based on the study's findings and evaluation, the researcher determined that the device is appropriate not just for ESSU Salcedo but for the whole community. The researchers created an application that was simple to use and comprehend.

6. RECOMMENDATION

Based on the study's findings, the researchers issued the following recommendations. The gadget can be sold to the community as a rapid-fire emergency notification. Further development is required to increase the device's range, application structure, and functionality.

7. ACKNOWLEDGMENTS

Our thanks to the experts who have contributed towards development of the template.

8. REFERENCES

[1] Lian, C.-yuan. (2011). *Design of intelligent fire alarm system based on GSM Network*. IEEE Xplore. Retrieved August 25, 2022, from https://ieeexplore.ieee.org/document/6013128

[2] Elbehiery, H. (2012). *Developed intelligent fire alarm system.* . PDF Free Download. Retrieved August 25, 2022, from https://docplayer.net/15393656-Developed-intelligent-fire-alarm-system-hussam-elbehiery.html.

[3] Chavez, C. (2022, March 1). *Fire incidents rise in first 2 months of 2022*. Manila Bulletin. Retrieved August 25, 2022, from https://mb.com.ph/2022/03/01/fire-incidents-rise-in-first-2-months-of-2022/#:~:text=A%20total%20of%202%2C619%20fire,January%20to%20March%20last%20year.

[4] Mahzan, Najwa & Md Enzai, Nur & Zin, N & Noh, K. (2018). Design of an Arduino-based home fire alarm system with GSM module. Journal of Physics: Conference Series. 1019. 012079. 10.1088/1742-6596/1019/1/012079.