

INTELLIGENT FIRE ALARM SYSTEM ONBOARD SHIP

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ABSTRACT

Fires onboard ship is one of the most severe threats onboard ship, life-threatening, and cause property losses due to the presence of flammable material such as liquid fuel and electrical equipment that makes ships susceptible to fires. This paper proposed a design of an intelligent fire alarm system onboard ship and the system performance was analysed by measuring the delay time needed for the system to respond. The circuit mastermind, Arduino UNO, controls the fire detection using GSM technology subjected to the temperature and smoke sensors. MQ2 sensor detects combustible gas and smoke presence; meanwhile, LM35 detect heat changes. GSM works in the communication part, sending SMS to the users. This system controls and monitors each sensor's capability through microcontroller and system software. When the smoke or temperature input reaches a threshold value, the system detects a potential fire outbreak. It will immediately send an SMS alert to the users and simultaneously activate the buzzer upon the possible fire outbreak. This system helps protect lives and properties from fire consequences by immediately responding to prevent fire incidents onboard ships.

Keywords: *GSM; Arduino; temperature sensor; smoke sensor*

1. INTRODUCTION

Many researchers have conducted studies involving fire alarm systems in the last several years. To evaluate the living environment status, Po-Huan Chou used a multi-sensor circuit consisting of a temperature and a carbon monoxide (CO) concentration sensor [1]. Carbon monoxide (CO) sensor is high in cost and has a poor response to overheating and to a flaming fire. F Anwar used the fiber-optic connection to handle groups of building optimally and efficiently [2]. Fiber optic is expensive and has complex installation. Qin Wu used ZigBee transmission technology and E-charts for data visualization [3]. This system is high expenses and also has a complex installation. Saurabh Joshi used a flame sensor and RF wireless remote control, a robot with a fire alert system with a robot-inbuilt wireless camera [4].

The flame sensor is less sensitive and quite expensive. Besides, the video frame-based approach is not ideal for early-stage fire detection. It is because only minimal flame or very minimal smoke is present in the early stage of the burn. The device is also costly and has complex installation, particularly for the robot's deployment. Vijayalakshmi used digital image processing, embedded vision, and remote CCD cameras[5]. CCD cameras are costly. Moreover, this system risks interference because it integrates with radio signals. Asma Mahgoub used a Raspberry PI microcontroller incorporated with 4G module, MQTT (Message Queuing Telemetry Transport) [6]. Raspberry Pi is unable to do any complex multitasking. ESP8266 cannot be plugin into a breadboard without an adapter. It also does not have all input /output pins of ESP8266 chips. MQTT used to require more power and memory to operate. Yu Qiongfang used Fuzzy Neural Network and RS485 [7]. Fuzzy neural network-tuning parameters is a time-consuming task. RS485- limited communication speed, requires a special type of cables and ordinary cables cannot be used.

Moreover, it is expensive. Ping Lang used OpenCV in ARM, HIS model, temperature, humidity, smoke, adjustable resolution USB camera, central processing unit (ARM), Image and Data transmission bus, Supervisory computer[8]. Humidity sensor-may shift if used with water-soluble products. The existing fire alarm system triggers a water sprinkler attached to it in all areas, including non-affected areas, in the event of a fire. Therefore, water damage will occur in the non-affected area and affect the content of the surrounding structure. The conventional system also has difficulty in controlling and monitoring any fire incident onboard ship as there is no way of pinpointing the exact fire location using the system. The primary significance of the research is that fire outbreaks can be detected at an early stage because it enables us to pinpoint the exact fire location. Besides, to avoid delay, emergency responder using SMS alerts is also the concern of this system. Furthermore, through this system, essential onboard ship equipment can be protected, reducing property losses as water damage at the non-affected area can be avoided.

This project proposes a design of an Intelligent Fire Alarm System Onboard Ship. The development of a built-in fire alarm system is addressable, which each sensor has an address, allowing for easy identification of the same sensor that was activated. MQ2 smoke sensor and LM35 temperature sensor are used to develop a more responsive fire alarm system. This project also uses GSM technologies to resolve emergencies that work in the communication part. The circuit mastermind, Arduino UNO, is used to execute system decisions and to control circuit flow. The faster the fire is detect, the faster the emergency responder and it eventually will decrease the damage cost caused by the fire incident.

2. RESEARCH METHODOLOGY

Figure 1 shows the flow chart of the Fire Alarm System (FAS). The FAS starts with smoke presence and temperature changes as input simultaneously. Whenever the sensor detects information more remarkable than the threshold value, the system will acknowledge the detector triggered. After that, the buzzer will turn on until the input value is below the threshold value. At the same time, an SMS alert is sent to the user via GSM, and the system ends. When the smoke sensor detects smoke greater than the threshold value, the system will acknowledge the unique address of the triggered sensor. If the smoke input is below the threshold value, the system will repeatedly detect smoke. Simultaneously temperature sensor detects heat. If the temperature sensor detects a temperature above a threshold value, the system will acknowledge the unique address of which the sensor has been triggered. If the temperature value is lower than the threshold value, then the system will repeatedly detect the surrounding temperature. Once the system has acknowledged the unique address of the sensor triggered, the buzzer will turn on till the input value of the sensor is lower than a threshold value. Once the system detects a fire outbreak, the system will send an SMS alert to the user for extended response through the GSM system (Global System for Mobile).

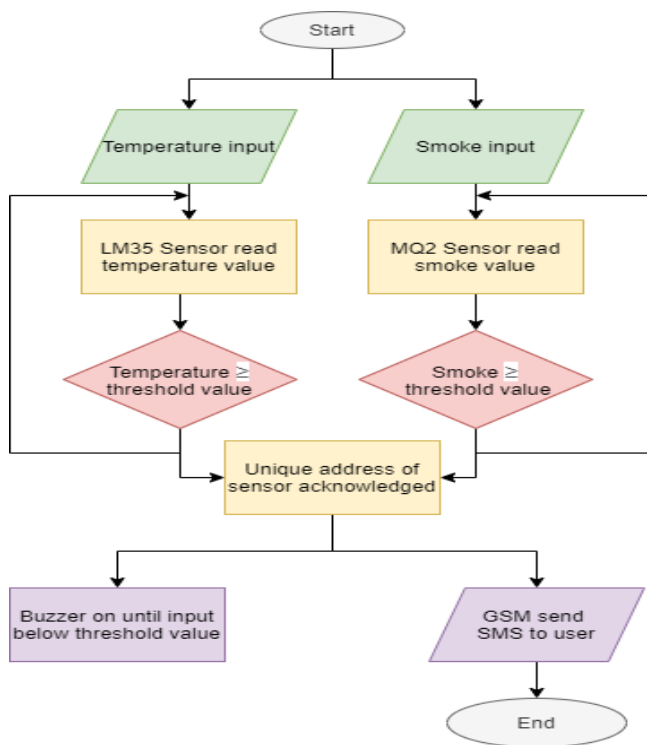


Figure 1: Flow chart of the Fire Alarm System

3. RESULTS AND DISCUSSION

The system performance analyses by applying heat and smoke to the sensor. Table 1 shows system performance under different statuses. The delay time for the system to respond to alerting users once a fire outbreak is detected is measured. The delay response time ranges from 5 to 8 seconds, which is a fast response. The threshold value set for the LM35 temperature sensor is 70 C, while the MQ2 smoke sensor is 200 ppm. Buzzer activates once either sensor is triggered, and so is the GSM.

Table 1: System performance under different status

Testing temperature (°C)	Testing smoke (Ppm)	LM35 value ≥ 70°C	MQ2 value ≥ 200ppm	Buzzer condition	SMS alert sent	Duration of SMS sent (secs)
51.32	116	X	X	OFF	NO	-
70.38	55	✓	X	ON	YES	7.25

43.00	208	X	✓	ON	YES	5.56
74.78	203	✓	✓	ON	YES	6.36

The developed prototype was triggered using a flame (candles) to test the system's functionality, and the serial monitor was observed. This is achieved by applying a flame (candle) near the sensor. The results obtained from the simulation are analyzed and display 'Smoke detected at Room 3' when the smoke sensor in Room 3 is triggered. At the same time, the buzzer is activated, and SMS is sent to the user. Multiple tests are held to test the functionality of acquiring sensor values and GSM in sending SMS. The delay time for the system to respond is measured from the moment the buzzer is activated until SMS is sent. From Table 1, it is observed that the system is under the normal condition when both temperature input and smoke input is below a threshold value. In coding, 70 Celsius is set as a threshold value for the LM35 temperature sensor, while for the MQ2 smoke sensor's threshold value is 200 ppm. When either one sensor is triggered, the buzzer is activated, and the system will send an SMS alert to the user regarding a potential fire outbreak. The system took a longer duration for SMS to be sent when both sensors were triggered than only one sensor. This is maybe because of the placement (distance) of the flame to the sensor is far. The farther the distance, the longer time it taken for the system to detect a potential fire outbreak. Another reason is maybe due to some signal congestion that happened during the test. From the line graph in Figure 2, it is analyzed that the duration of SMS sent is ranged from 5 to 8 seconds which is quite responsive.

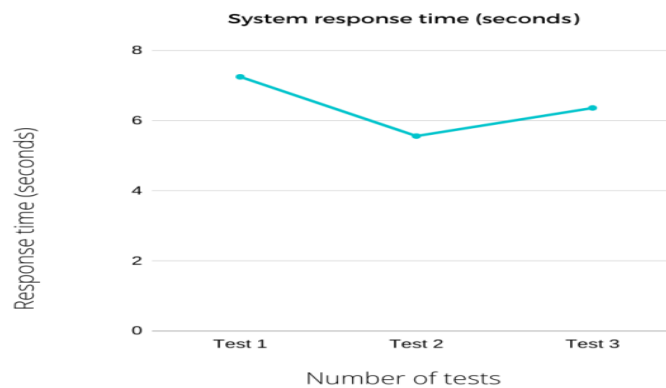


Figure 2 System response (time taken)

4. CONCLUSION

This project presents a system with optimum performance and reliability at a low cost, which is a special enhancement from the existing system for onboard ship security. This system undoes the need for a person to monitor the area continuously. This system helps protect lives and properties from fire consequences by immediately responding to prevent fire incidents onboard ships. Both smoke sensors and temperature sensors help the system with the monitoring. Authorities are alerted with the help of a buzzer and message alert. For future recommendations, the system can be improved by adding the act of fire extinguishing via a water sprinkler. Another suggestion is to make it accessible through an internet network.

REFERENCES

- [1] P. H. Chou *et al.*, "Development of a smart home system based on multi-sensor data fusion technology," *Proc. 2017 IEEE Int. Conf. Appl. Syst. Innov. Appl. Syst. Innov. Mod. Technol. ICASI 2017*, pp. 690–693, 2017, doi: 10.1109/ICASI.2017.7988519.
- [2] F. Anwar, R. I. Bobby, M. M. Rashid, M. M. Alam, and Z. Shaikh, "Network-Based Real-time Integrated Fire Detection and Alarm (FDA) System with Building Automation," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 260, no. 1, 2017, doi: 10.1088/1757-899X/260/1/012025.
- [3] Q. Wu *et al.*, "Intelligent Smoke Alarm System with Wireless Sensor Network Using ZigBee," *Wirel. Commun. Mob. Comput.*, vol. 2018, no. 2, 2018, doi: 10.1155/2018/8235127.
- [4] I. Journal and T. Special, "Intelligent Fire Alert and Escaping System 1," vol. 8, no. 1, pp. 108–110, 2017.
- [5] S. R. Vijayalakshmi and S. Muruganand, "Fire alarm based on spatial temporal analysis of fire in video," *Proc. 2nd Int. Conf. Inven. Syst. Control. ICISC 2018*, no. Icisc, pp. 104–109, 2018, doi: 10.1109/ICISC.2018.8399002.
- [6] Q. Yu, D. Zheng, Y. Fu, and A. Dong, "Intelligent fire alarm system based on fuzzy neural network," *2009 Int. Work. Intell. Syst. Appl. ISA 2009*, no. 0624460012, pp. 38–41, 2009, doi: 10.1109/IWISA.2009.5072924.
- [7] P. Lang, M. Y. Gao, and Z. W. He, "ARM-based new ship fire alarm-control and data transmission system," *2011 Int. Conf. Electron. Commun. Control. ICECC 2011 - Proc.*, pp. 4192–4195, 2011, doi: 10.1109/ICECC.2011.6066346.
- [8] R. Dvhg and L. U. H. Odup, ",R7 %Dvhg)Luh \$Odup 6\Vwhp," pp. 162–166, 2019.
- [9] Q. Yu, D. Zheng, Y. Fu, and A. Dong, "Intelligent fire alarm system based on fuzzy neural network," *2009 Int. Work. Intell. Syst. Appl. ISA 2009*, no. 0624460012, pp. 38–41, 2009, doi: 10.1109/IWISA.2009.5072924.
- [10] P. Lang, M. Y. Gao, and Z. W. He, "ARM-based new ship fire alarm-control and data transmission system," *2011 Int. Conf. Electron. Commun. Control. ICECC 2011 - Proc.*, pp. 4192–4195, 2011, doi: 10.1109/ICECC.2011.6066346.