Fire disaster early detection system in residential areas

L. Kamelia*, N. Ismail and A.A. Firmansyah

Department of Electrical Engineering, UIN Sunan Gunung Djati Bandung, Jalan A.H. Nasution 105, Bandung - 40614, Indonesia

*lia.kamelia@uinsgd.ac.id

Abstract. The number of residential fires in urban areas is increasing every year. The use of automatic fire detection technology can prevent greater fire disaster losses. The fire detection system works by detecting increasing degrees of heat, ultraviolet radiation by flames, and gas leaks. The system will start automation if the LM35 Temperature sensor, MQ2 Gas sensor, and Light Dependent Resistor (LDR) detect the occurrence of fire according to the initial settings on Arduino Uno. After Arduino Uno processes input data from the sensor, there will be a notification marked with the Buzzer and a text will appear on the Liquid Crystal Display (LCD) that describes the condition of the sensor reading. Arduino Uno configures data via the GSM SIM900A Module. The last process is sending short messages (SMS) from the GSM SIM900A Module to the receiver to notify the initial warning of a fire. The delay time in testing the farthest distance (100 cm) is as follows: LM35 140 second Temperature Sensor, 130 second MQ2 Gas Sensor, and LDR 145 seconds.

1. Introduction
Rapid technological developments today cannot be detached from automated systems that are able to facilitate human occupation and improve human quality and safety. The increase in the number of people in the world is proportional to the increasing number of housing developments that integrate technology in everyday life. Residential areas that have a high level of security are housing demanded by consumers. One of the technologies that has been integrated into the construction of new residential houses is smart home technology. Smart home technology implements home lighting automation systems, home security systems from foreigners, home temperature control systems based on the number of occupants, online monitoring of CCTV cameras, centralized control of electronic devices and prevention of fire and gas leakage hazards [1].

Fire disasters can occur anywhere and anytime, whether at home, lecture buildings, offices, etc. The cause of the fire begins with a variety of factors, some are due to short circuit, some are due to minor negligence such as leaving the stove still on, a lit cigarette, a burning lantern, an overheated electrical appliance or LPG gas leak. To combat fires due to human negligence, an automation system is needed to detect the cause of the fire and can send information as early as possible if there are signs of fire. By using Fire Alarm Detector technology, fire disasters can be detected early.

Research on early detection of fire has been carried out with various methods such as the use of sensors, implementation of robots and automatic fire defeat control systems.

Fire prevention is an important part of smart home technology [2]. Several studies on smart home integrate lighting automation and home security by early detection of fire hazards using gas sensors and...
temperature sensors [3]. The system will start working to detect a fire from the active sensor. The system will then turn on the alarm as a warning that a fire has occurred in the area installed by the fire detector.

At present, the most widely used fire alarm system is based on the smoke detection method. Basically, two sensing techniques for early detection of commercially available fire alarm systems are photoelectric detectors (light detectors) and ionization detectors. The main hypothesis underlying the development of gas sensor detection is the emergence of a flame like in a fire disaster always beginning with the presence of gas and steam. The initial use of a gas detector is expected to be able to detect fire compared to the use of smoke sensors. More specifically in this research, the customized sensor platform was composed of an 8-MOX gas sensor, a PID sensor (PID-A1), a NDIR CO2 sensor (IRC-AT), a CO electrochemical sensor (CO-BF), and a temperature and humidity sensor (SHT75) [4].

The use of sensors is still the main method in preventing fire hazards. The sensor used in Khalil Azha's research is an ultrasonic sensor to move a fire extinguisher robot and a flame sensor to find a source of fire [5]. Fire prevention can also be done by automating exhaust fans and ventilation when there is smoke detection in a building. If the smoke condition is still too high, the fire alarm will give a warning to the parties concerned [6, 7].

Fire early detection systems in buildings can be carried out in 2 types, using wire cables and wireless systems. in large-scale buildings that have been installed with fixed wiring, a wired and wireless system can be integrated to facilitate installation and maintenance. For residential buildings, a wireless system can be used as a backbone system that supports the home security system [8].

The system for sending information from sensor measurements can be displayed wirelessly on LCDs such as Bluetooth technology and ZigBee Technology [9], then information is sent to users via an SMS, phone call or IoT-based system to social media, websites or smartphone applications [10]. In the research of Kumar et al. the system usually checks gas and or smoke in the surround environment as well as unexpected increase in the room temperature [11]. The values are continuously monitored against the threshold values which are calibrated in initial setup. Apparently, if the current measured values go above the threshold for any one of the situations, alarm will be announced via the speaker and together the GSM modem sends short message to the owner.

2. Prototype design of fire detection system

The system designed aims to detect the presence of fires using three sensors then processed by Arduino Uno R3 then informed to two recipients using the GSM SIM900A Module. The overall design of the system used in this study is in Figure 1.

![Figure 1. Block diagram of the system.](image)

The system will activate if the LM35 Temperature sensor, MQ2 Gas sensor, and Light sensor or LDR detect a fire according to the settings in Arduino Uno. Then Arduino Uno processes input data from the sensor and sends a notification marked with the sound of the Buzzer and displays text on the LCD that
describes the sensor measurement results. The application is extended with integrating GSM technology with three main subsystems; monitoring, detection and warning systems.

After Arduino Uno processes data from the sensor reading, Arduino Uno will configure data through the GSM SIM900A Module. The final process of the overall system is sending Short Message Sending from the GSM SIM900A Module to the receiver. Short messages received by the receiver in the form of text that describes the indicator of fire. The message receiver consists of two cell phone numbers. These two cell phone numbers are analogous to the building owner's contact number and fire department. So that prevention of fires can be resolved early, even though the building is empty.

Figure 2. System design.

Figure 2 is the configuration between the LM35 Temperature Sensor, MQ2 Gas Sensor, Light Sensor or LDR, Arduino Uno R3, Power Supply, Buzzer, Liquid Crystal Display (LCD), GSM SIM900A Module, and the receiver.

The ports configuration used on the Arduino Uno R3:

- Port A0, analog port connected with Vout LM35 Temperature sensor.
- Port A1, the analog port is connected to the Vout Gas sensor.
- Port A2, the analog port is connected to the Vout Light sensor.
- Port 0 or RX, the digital port is connected to TX as USB data.
- Port 1 or TX, the digital port is connected to RX as USB data.
- Port 2, the digital port is connected to the foot 14 LCD.
- Port 3, the digital port is connected to the foot 13 LCD.
- Port 4, a digital port connected with 12 feet LCD.
- Port 5, the digital port is connected to the foot 11 LCD.
- Port 6, the digital port is connected to the GSM SIM900A TX Module.
- Port 7, the digital port is connected to the GSM SIM900A RX Module.
- Port 11, the digital port is connected with 6 feet LCD.
- Port 12, the digital port is connected by foot 4 LCD.
- Port 13, connected to the Buzzer

The program used to send messages resulting from sensor readings is AT-Command. This program is installed on the GSM SIM900A Module. The AT-Command program regulates sending messages to recipients. Both telephone numbers as recipients of short messages are regulated by the AT-Command program. Each telephone number registered in the AT-Command program will receive a short message according to the standard set on Arduino Uno.
3. System implementation
First implementation by connecting the temperature sensor on the port on the Arduino Uno. Then connect Arduino Uno with the GSM Module using a jumper cable. After all is installed, the Arduino Uno is connected to an AC power source using an adapter with a capacity of 5 V so that the entire device will turn on.

![Figure 3. The temperature sensor reading process.](image)

After all devices are installed, the system is ready to be tested by providing input to the LM35 Temperature sensor. Then the flame is brought close to the LM35 temperature sensor. The system will start running marked with the Buzzer sound then the text display on the LCD changes to "Heat Temperature Detected".

![Figure 4. The connection of sensor and the buzzer.](image)

The last process is sending short messages (SMS) from the GSM SIM900A Module to the receiver to notify the initial warning of a fire. the delay time in testing the farthest distance (100 cm) is as follows: LM35 140 second Temperature Sensor, 130 second MQ2 Gas Sensor and LDR 145 seconds.

The overall system testing is carried out to determine the working principle of the tool and its connectivity between inputs in the form of sensors, processing with Arduino, and output in the form of short messages using the GSM SIM900A Module. Tests carried out with several stages including (Table 1):

- Periodically testing every 5 minutes for each sensor.
- The testing phase with more than one sensor as input and 2 telephone numbers as recipients.
Table 1. The system testing process.

| No. | Sensor Type | Receiver |
|-----|-------------|----------|
|     | Temperature | Gas      | Light    | Phone 1 | Phone 2 |
| 1.  | √           | x        | X        | Sent    | No      |
| 2.  | x           | x        | X        | Sent    | No      |
| 3.  | x           | x        | √        | Sent    | No      |
| 4.  | √           | √        | X        | No      | Sent    |
| 5.  | x           | √        | √        | No      | Sent    |
| 6.  | √           | x        | √        | No      | Sent    |
| 7.  | √           | √        | √        | Sent    | Sent    |

If only one sensor detects symptoms of fire, a short message will be sent to recipient 1 which is analogous to building manager or homeowner. Whereas if there are 2 types of sensors at the same time that detect symptoms of fire, a short message will be sent to recipient 2 which is likened to a fire department. And if all three sensors simultaneously detect symptoms of fire, then a short message will be sent at once to the two recipients.

The system created will be implemented in the smart home area system. LCD will be placed at the security guard post so that the building manager can monitor and find out whether or not the building has a fire sign, other than via short message. In this study there are also 2 mobile phones as recipients of short message information analogous to the telephone number of building managers or homeowners and firefighters.

The system can be integrated with other automaton system for fire disaster system, for example the automation of exhaust fan and ventilation system [7]. The other warning system if the system detect the fire is the warning system for the householder to immediately out from the fired house, it can have implemented in the application of alarm / buzzer as the output / actuator of the system [12].

4. Conclusion
Designing a fire warning system using Arduino Uno based on SMS Gateway in the residential area it functions optimally at a distance of less than one meter between the fire source and the LM35 temperature sensor, the MQ2 gas sensor, and the Light sensor or LDR. this system is a research part of smart home systems that are increasingly in demand by consumers. this system helps reduce the potential for fires in residential areas as well as in high-rise buildings.

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