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The kitchen fire prevention system using a global system for mobile

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ABSTRACT

Fire is one of the disasters that cause property loss and casualties. Based on statistical analysis, the cases related to Liquefied Petroleum Gas (LPG) fires caused by the stove, are repeated every year. There is no fire prevention system in the house, usually in the kitchen, applied as a safety and prevention measure to prevent fire. Therefore, this quantitative study aims to develop a prototype of the kitchen fire prevention system using the Global System for Mobile (GSM) modem to reduce the risk of fire in the living room caused by the kitchen appliances. The development of this project refers to the five steps in the Software Development Life Cycle (SDLC) method which is needs analysis, design, implementation, testing, and evaluation. The results show that the prototype combines two types of sensors namely MQ135, and LM35, where it works simultaneously in two conditions. Under "Reminder 1", when the MQ135 detects smoke above 100 while LM35 exceeds 40ºC, the Arduino Uno microcontroller directs the DC motor to turn off the kitchen valve automatically. Besides, GSM simultaneously sends the first warning message to the user. In the "Warning 2" state, when MQ135 detects smoke above 200 while LM35 is above 50ºC, GSM sends a second warning message. The findings of this study indicate that experts recommend improvements to use the 5V power supply from the AC / DC adapter. Overall, experts argue that the prototype design is clear and easy to understand and the prototype of the stove fire prevention system is suitable for development for safety and notification purposes.

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1. Introduction

Fire disasters cause loss of property and death. Statistics recorded by the Fire and Rescue Department of Malaysia in 2017 and 2016, cases of fires caused by hardware increased by 5.1% while fires caused by gas increased by 6.1% respectively [1]. Both of these cases are related to cooking activities in the kitchen where the kitchen appliances use Liquefied Petroleum Gas LPG gas as fuel. Based on a report from the Fire and Rescue Department of Malaysia, it was found that 17 cases of residential fires in the month of Ramadhan 2018 were due to negligence in the kitchen [2]. Based on a study report, consumers neglect safety in the kitchen especially while preparing food [3]. As the cooking activity progresses, the user performs other side tasks and

falls asleep for a moment. As a result, users forgot to turn off the cooking stove fire. This negligence will cause a fire.

Hasan & Razzak [4] explained that the failure of fire prevention systems is the cause of fire disasters. Based on statistical analysis, it was found that cases related to LPG fires caused in the kitchen are still recurring every year and there is no solution [1]. There is no fire prevention system in residential houses especially in the kitchen area which is applied as a safety and preventive measure to prevent fire. Although some homes have fire-fighting devices such as smoke detectors and heat detectors, such detectors only emit a buzzer sound. The sound of the buzzer cannot be heard when outside the house. Therefore, fire prevention systems need expansion and improvement over time to produce fast, accurate, and effective fire prevention measures [5]. According to Luis et al. [6], fire detectors should be able to detect early fires and have a quick, timely response and notify users directly. However, the existing fire prevention system does not have a notification system that acts directly to contact homeowners about the current condition of their homes when they are away from home. The smoke detectors and heat detectors used have no application that can prevent from burning LPG gas stove to stop burning.

A fire prevention system is a safety of the home used to prevent fire disasters. Fire detection systems should be equipped with three main techniques, smoke detectors, fire detectors, and temperature detectors [7]. Smoke detectors are used to detect the presence of smoke and warn of fire to users. Fire smoke contains small particles produced from a mixture of fuel and air. The diameter of the smoke particles ranges from 0.01 to 1μm. Theoretically, the volume of smoke during combustion has a certain mass (kg) and volume (2/3) [5]. Flame smoke consists of a combination of gases such as oxygen (O2), carbon monoxide (CO), carbon dioxide (CO2), water vapor (H2O), hydrogen cyanide (HCN), acetylene (C2H2), and nitric oxide (NO) [8]. These gases are toxic and cause air pollution if not controlled. Temperature sensors are used to measure thermal energy and detect current temperature changes. In the field of electronics, there are various types of temperature sensors such as LM35, thermometers, and resistance thermometers (RTDs). However, the most commonly applied temperature sensor in the development of fire alarm systems is the LM35. The LM35 device has an advantage over other temperature sensors because the LM35 output temperature unit can be set in Kelvin units and the LM35 detector output signal is also linear [9].

Global Mobile Systems (GSM) network technology is used as additional security that serves to increase security by providing notification information to users. Global System for Mobile (GSM) network technology is useful for security purposes by informing users about the current situation at home [10]. DC motors are used to turn off the valve when a gas leak is detected [11]. The motor circuit is connected to the H-bridge to allow the voltage at which the motor flows at opposite poles and allows the motor to rotate in two directions to open and close the kitchen valve [12]. Therefore, the Prototype of the Cooking Stove Fire Prevention System Using a Global System for Mobile (GSM) aims to reduce the risk of fire in the kitchen. Key features of the project include a fire detector, an automatic cooking stove valve, and a GSM network to send alert messages when a fire is detected. The Arduino Uno connected to the DC motor works to turn off the valve and the GSM modem automatically. The purpose of this project is to develop a prototype of a fire prevention and notification system in a cooking stove using an MQ 135 smoke detector, an LM35 temperature sensor, and a GSM modem. Both sensors work

simultaneously to sense the symptoms of fire in the kitchen especially when cooking and send notifications to the user when a fire occurs.

2. Method

This project was developed by referring to the Software Development Life Cycle (SDLC) method which is analysis, design, implementation, testing, and evaluation. Fig. 1 shows the steps of the SDLC method.

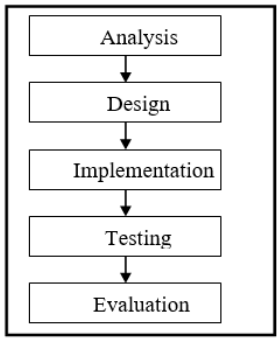

Fig. 1. SDLC method

At the beginning of developing this project, it is important to carry out a study on past research on the fire disaster and fire prevention system to justify the project scope. From the study, it has been concluded that this project is to develop a fire prevention system focusing on the cooking stove. The design of this project was divided into two parts that are the prototype and programming. The design of the prototype was included design drawings, selection of materials, hardware selection, and development of prototype concepts. The prototype design drawings were developed using the Sketch Up 2017 software. The programming of the project was developed using Arduino IDE software. Fig. 2 shows a flow chart of microcontroller software when detecting fire symptoms in the kitchen area.

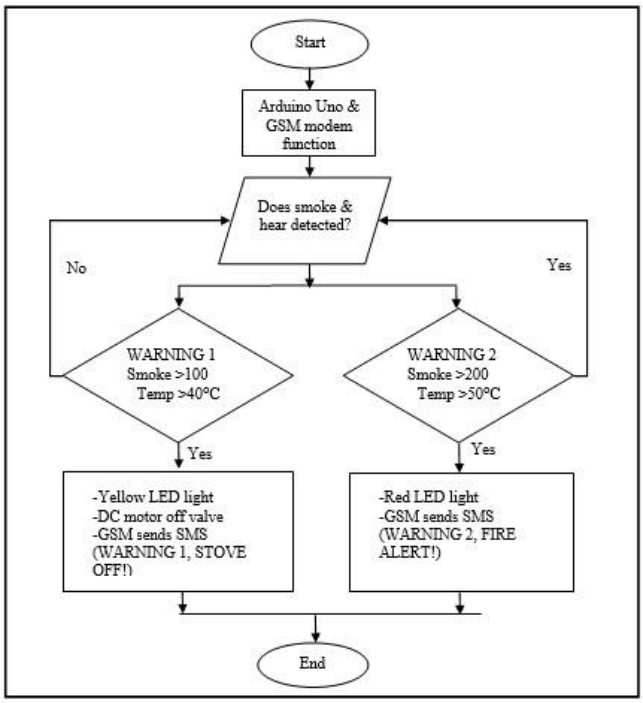

Fig. 2. Software flow chart of two fire conditions

The flow chart shows two programming fire conditions namely WARNING 1 and WARNING 2. WARNING 1 works when the smoke detector detects a value change above 100 while the detector detects a temperature above 40ºC. In the condition of WARNING 1, the yellow LED output lights up, the motor automatically closes the cooker valve, and SMS "WARNING 1, STOVE OFF!" is sent to the user. Also, if the smoke detector detects smoke at a value above 200 and the temperature above 50ºC, a red LED is emitted and the message 'WARNING 2, FIRE ALERT!" is accepted by the user. Both detectors work simultaneously. Fig. 3 shows the graph that changes the value of smoke and temperature in two conditions.

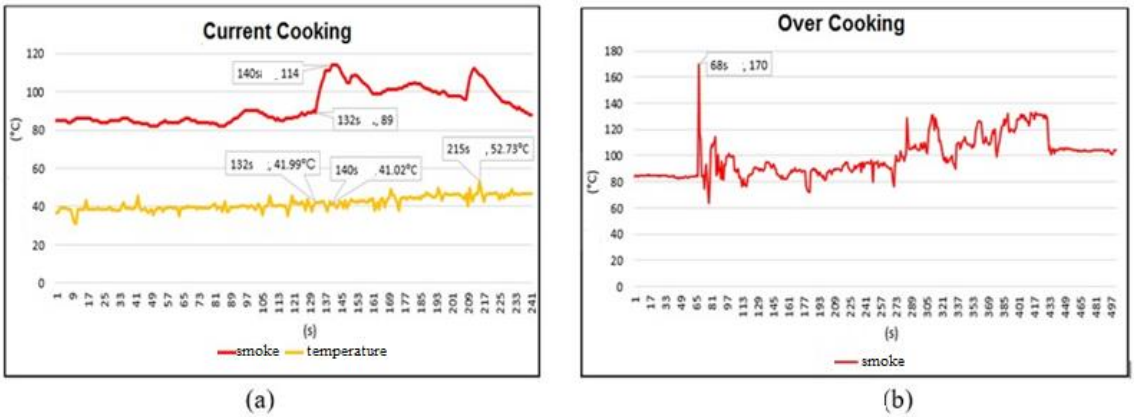

Fig. 3. Smoke and temperature value in (a) current cooking and (b) overcooking

When the sensors detect the first condition as Warning 1 the DC motor automatically functions to shut off the stove valve and GSM sends an alert message as “WARNING 1, STOVE OFF!”. When sensors detect warning 2, the GSM sends “WARNING 2, FIRE ALERT!”. Fig. 4 shows the system logic instruction code.

```
if ((analogSensor >= Thres2)&&(tempC >= hot2))
else if ((analogSensor >= Thres)&&(tempC >= hot))
else
```

Fig. 4. System logic instruction code

Logic functions should be used in instruction code when using more than two detectors in a system or circuit. To turn on the output component function, the logic function of the microcontroller needs to be applied to the Arduino microcontroller. The logical instruction codes used in this fire prevention system are if, else if, and else. Fig. 5 shows the AT command of GSM programming. For the GSM to function, the attention command (AT command) was instructed to the programming.

```
Serial.begin(9600);
 while(!gprsTest.init()) { //gprs init
    delay(1000);
    Serial.print("init error\r\n");
 }
 Serial.println("gprs init success");
 //Serial.println("start to call ...");
```

Fig. 5. AT command of GSM

To ensure that the entire GSM system works, the AT command code on the GSM is written in programming i.e. while (! GprsTest.init ()). This code ensures that GSM is connected to the telecommunication network.

As the product was completely developed, the prototype was tested and evaluated. The testing is the overall functionality of the product including the functionality of MQ135 and LM35 to work simultaneously, the functionality of the DC motor, and the functionality of GSM to send an alert message. The last step is evaluation. The product was evaluated by three experts which expertise in Electrical and Electronic engineering. Fig. 6 shows an overall block diagram of the prototype. The prototype is equipped with a smoke sensor and temperature sensor. When the sensors detect fire symptoms the Arduino Uno sends a signal to DC to automatically of stove valve and at the same time GSM modem sends an alert message to a user.

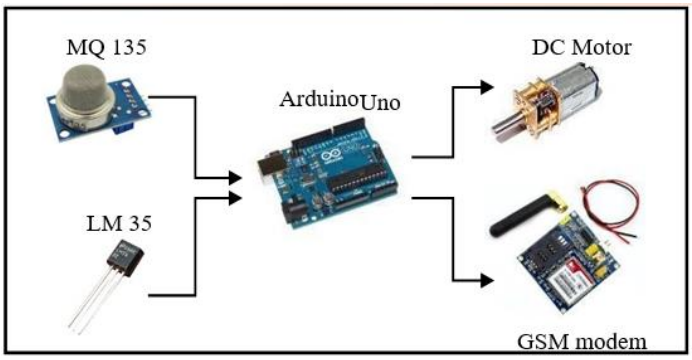

Fig.6. Block diagram

3. Results and Discussion

This quantitative study aims to develop a prototype of the kitchen fire prevention system using the Global System for Mobile (GSM) modem to reduce the risk of fire in the living room caused by the kitchen appliances. The development of this project refers to the five steps in the Software Development Life Cycle (SDLC) method which is needs analysis, design, implementation, testing, and evaluation.

3.1 Analysis

In identifying the problems encountered, the scope of the study analysis was narrowed by identifying the cause of the fire in the kitchen. Based on the report recorded in the current news, a fire in the kitchen occurred when the user forgot to turn off the fire in the stove. Consumer negligence is the cause of fires that result in the destruction

3.2 Design

The kitchen fire prevention system consists of three parts, namely input (input), process (process), and output (output). When the smoke detector and heat detector detect the presence of smoke and heat, the Arduino Uno microcontroller processes the smoke detector value and the temperature detected from the fire symptoms in the stove, and the LED output (green, yellow and red) will light up based on the reference value (threshold value) smoke and heat detector. While the motor will close the stove valve and the GSM modem will send an SMS to the user. Fig. 7 shows the project block diagram.

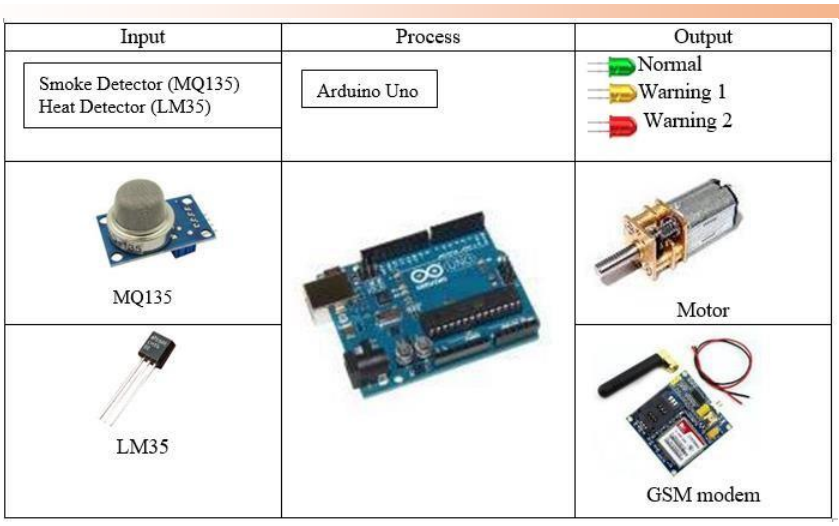

Fig.7. Project block diagram

3.3 Implementation

At the implementation phase, work planning, hardware, and software design are implemented and developed as planned. The development phase of this project is divided into two parts, namely hardware development, and software development. In the hardware development phase, the selection of materials and components and the estimated project cost are aspects that are emphasized in hardware development. In the software development phase, the system programming instruction code is edited through Arduino IDE Version 1.8.9 software. Researchers found that the Arduino IDE 1.8.9 software is the latest to be launched which has a more advanced serial monitor display facility which is the timestamp command. The timestamp command function makes it easy for the user to monitor changes during the sensor value. Therefore, this software was chosen by the researcher. Table 1 shows the project development cost.

Table 1. Project development cost

No	Material	Quantity	Cost/Unit	Total (RM)
1	Smoke detector MQ135	1	RM 16.00	RM 16.00
2	Heat detector LM35	1	RM 7.50	RM 7.50
3	Arduino Uno	1	RM 30.00	RM 30.00
4	GSM Modem SIM900A	1	RM 60.00	RM 60.00
5	6V Micro Metal DC Gear Motor	1	RM 40.00	RM 40.00
6	Transmitter diode	3	RM 1.00	RM 3.00
7	Relay module	1	RM 6.00	RM 6.00
8	Jumper wire	1 set	RM 5.00	RM 5.00
9	Terminal block	1	RM 1.00	RM 1.00
10	9V battery holder	1	RM 2.50	RM 2.50
11	Valve button	1	RM 2.90	RM 2.90
12	Valve stove	1	RM 18.80	RM 18.80
	Total			RM 193.70

3.4 Testing

This kitchen fire prevention system used Arduino Uno as a microcontroller to control the function of the sensor, DC motor, and GSM network. The two sensors work simultaneously detects fire symptoms. The results in Fig.8, show the output condition when the fire symptoms were detected.

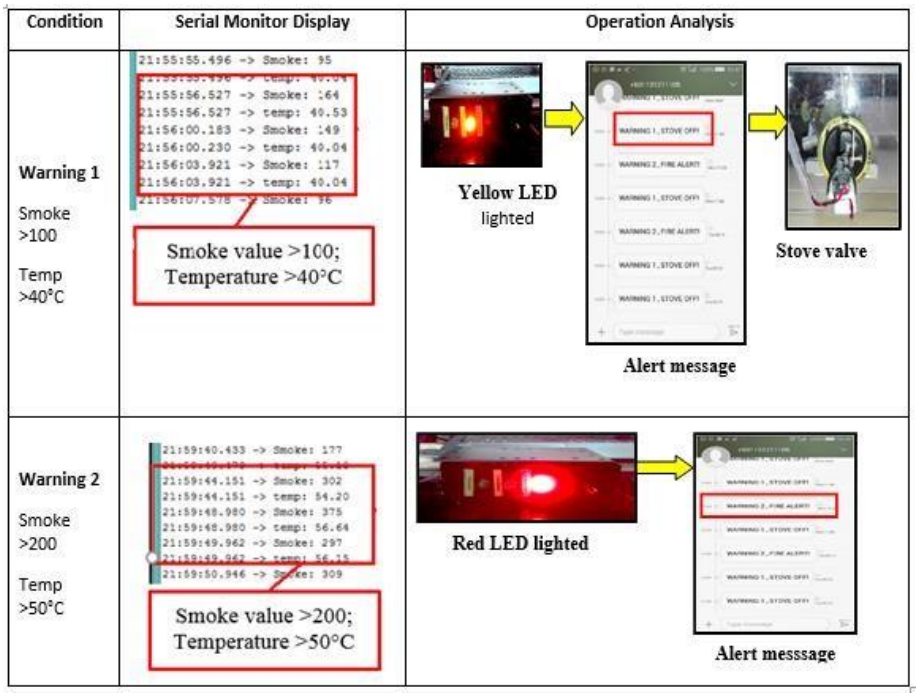

Fig.8. Output result of system

3.5 Evaluation

The kitchen fire prevention system was evaluated by three lecturers of Faculty Technical and Vocational Education, Universiti Tun Hussein Onn Malaysia (UTHM) which has expertise in Electrical and Electronic engineering. The evaluation was carried out to identify the objective of the project achievement based on the objectives which are design, development, and functionality. Fig. 9 shows the result of the evaluation. The results indicated that all three projects objective have been successfully achieved. Fig. 10 shows the final product of the prototype Cooking Stove Fire Prevention System Using Global System for Mobile (GSM).

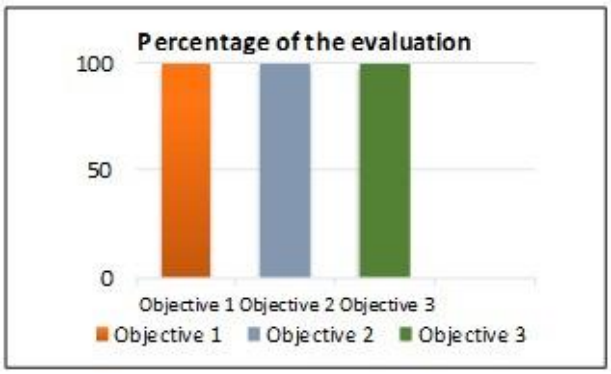

Fig. 9. The result of the evaluation

Fig. 10. Final product

The development of this project refers to the five steps of the Software Development Life Cycle (SDLC) model. This project is a combination of two developments namely hardware and software programming. The hardware part is a cooking stove prototype, automatic shut-off valve, and electronic circuit while the software is a programming command on an Arduino Uno microcontroller. Sensor programming uses logical commands on the microcontroller i.e. 'if', 'else if', and 'else' commands. A logical command is a basic instruction set to perform two or more sensors in an electronic circuit. The design of this system combines two types of detectors namely smoke detectors and heat detectors. Based on the study of Kumar et al. [13], the operational functionality of a microcontroller fire system combining several types of detectors can be determined by giving logical instructions to the microcontroller. Next, the prototype design of this project is also included with the notification system using GSM technology.

In designing this software AT command programming is an abbreviation of attention command used as stated by Nasution et al. [14]. The kitchen stove prototype was developed similar to the commercial LPG cooking stove feature with a DC motor application to turn off the kitchen valve automatically. In addition, fire detectors can detect cooking stove fires and notify users by sending a warning message via the GSM network. DC and GSM motor network functions are tested. DC motor works. It rotates and turns off the kitchen valve automatically when the fire detector sensor detects fire. When the detector detects a fire, at the same time GSM sends a warning message "REMINDER 1, OFF!" under Warning 1 and "WARNING 2, FIRE ATTENTION!" at warning conditions 2. These findings and results are being evaluated and overall, the experts agree the project objectives were successfully achieved.

The results of the expert evaluation feedback in this study have supported the previous study that was conducted by Soundarya & Anchitaalagammai [11] who found that motors are used to close knobs when detectors detect gas leaks. Moreover, the findings of SMS analysis from GSM in this study also strengthen the study by Shinde et.al [7] who showed that this kitchen fire prevention system successfully meets the concept of development of current fire surveillance (real-time surveillance). The findings of this study are also in line with the findings of Muthuvinayagam et al. [15] namely that GSM technology is a wireless communication system used as an alarm and security unit. The motor capability of closing the stove valve has been thoroughly tested along with fire detectors and GSM. As a result, the motor works to close the cooker valve after detecting fire symptoms. Besides, the findings of this study support the study

of Luis et al. [6] who found that a good fire prevention system should have high reliability and accuracy.

4. Conclusion

Fires are disasters that can cause loss of property and casualties. The goal of this study was to develop a prototype of a kitchen fire prevention system using GSM. The purpose of this study is to produce a product that can prevent fire and provide safety notifications to consumers. The system uses an Arduino Uno microcontroller and a GSM modem. These fire extinguishers use two types of detectors, namely smoke detectors, and heat detectors as tools to detect the early symptoms of a kitchen fire. When the detector detects the symptoms of fire in the cooking stove, the motor will work automatically to close the cooking stove valve at the same time an SMS is sent to the user as a safety notification. In conclusion, the project objectives were successfully achieved. Cooking Fire Prevention System Using Global System for Mobile (GSM) can be implemented as real-time monitoring to prevent fires especially fires caused by cooking stoves. For an added safety measure, a DC motor is built to turn off the stove valve automatically. Furthermore, the combination of smoke and temperature sensors is an ideal and reliable technique for detecting fire symptoms. For further research, this suggests making some improvements on user-friendly motor design and expanding the Internet of Things (IoT) using GSM networks.

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