HOME FIRE DETECTION NOTIFICATION SYSTEM USING IoT AND TELEGRAM BOT

Mohd Nizam Osman[1], Mushahadah Maghribi[2], Muhammad Syazmi Hafiz Shaharin[3]

[1,3]Universiti Teknologi Mara Perlis Branch, 02600 Arau, Malaysia
mohdnizam@uitm.edu.my[1], syazmi_hafiz97x@yahoo.com[3]
[2]Politeknik Tuanku Syed Sirajuddin, 02600 Arau, Malaysia
mushahadah@gmail.com[2]

Abstract: Fire outbreak has been known as the major tragedy that causes destruction, loss of life and property. Currently, many cases involving fire have happened in Malaysia because house owners were unable to detect the initial cause of the fire. To overcome the problem, we design and develop a low-cost home fire detection system using Raspberry Pi that detects the sense of fire, smoke or gas leakage and then, notify the house owner's and people nearby using a Telegram Bot through a mobile phone by sending the coordinate of fire location. The system utilizes the System Development Life Cycle (SDLC) by implementing the waterfall model as the methodology. Three experiments were conducted to evaluate the effectiveness of the system which is sensor detection range, response time and user acceptance testing. The findings indicated that the system has a positive impact and to be well accepted by users, efficient, effective, low-cost and easy to use.

Keywords: home fire detection system, telegram bot, raspberry pi, gas sensor, flame sensor.

1. Introduction

Fire outbreak has become a significant problem throughout the Malaysia. Compared to other hazards, fire outbreaks have become recurrent, destructive and the most influential disaster. Many cases involving fire have happened in Malaysia because home owners were unable to detect the initial cause of the fire. The number of deaths caused by fire in Malaysia in 2016 is 107 people with RM2.9 Billion losses compared to 2015, which is 153 people with RM4.4 billion of losses (Jabatan Bomba dan Penyelamat Malaysia, 2016). Although, the statistic showed 30% decrease in death cases and 34% decrease in loss of property, the figures still higher especially when it involves to the human life.

Nowadays, most of the home fire detection system in the market are expensive, very complex installation and some of the system come with cost of the separated system. Besides, some of the system also subject to the monthly subscriptions since they are monitored by the security service company. Therefore, the system become exclusively for those people, who are affordable and willing to pay extra costs in order to support home security fire related system. However, in reality, the house owner may face some difficulties to know the exact current situation of their house, either they leave for a short or long period of time, especially in the incident of fire. If the fire occurs without any notice, the owner might suffer a lot of losses, especially the destructive of property and human life. Hence, the presence of the fire detection system is necessary for avoiding fire hazard and helps in keeping our family save.

By the advancement of new technologies, controlling and monitoring services, especially in the hazards of home fire safety can be disclosed and addressed by the house owner. The Internet of Thing (IoT) can be utilized to increase the efficiency of the devices but also has economic benefits. IoT is a collection of sensors, actuators, software, electronics embedded with home appliances, physical devices and vehicles, which connect with each other to connect and exchange data over a network without requiring human-to-human or human-to-computer interaction. Recently, IoT has been applied to numerous applications (Abdel-Basset et al., 2019; Ansari et al., 2020; Osman et al., 2016) because it is low-cost and easy to develop. Therefore, the home fire detection system which utilized the benefits of IoT should be designed to discover the early fire detection which plays a significant role especially in protecting the safety of house owners. Besides, the property loss can be reduced because an appropriate control effort can be taken while the fire is still small.

In this paper, we have developed an IoT based for home fire detection notification system. This system has been initiated in order to prevent fire from spreading by alerting the owner and also to the people nearby when the fire is first detected by using Raspberry Pi as microcontroller. The microcontroller was equipped with wide variety sensors to detect the presence of any fire or smoke and a GPS module to identify the exact location of the origin of fire. The system will send time and location of the fire when it happens, using Telegram Bot, which is installed in mobile phone to the respective users. Besides, the Telegram Bot was used as a remote control to give commands in order to instantiate and activate the home fire detection notification system remotely. The rest of this paper is organized as follows. In section 2, the previous study is presented with the related works on fire detection system. Section 3 presents the methodology which covers the architecture of the proposed system and model used to develop the system. Section 4 discusses the result from the experiments conducted. We conclude the paper in section 5.

2. Previous Studies

This section is an overview several of related works on fire detection system using various technologies, techniques and approaches conducted by the researchers.

2.1 Home Based Fire Alarm and Notification System

A group of researchers was designed a home fire alarm notification system using Arduino Uno and GSM module. The project is intended for the safety of the house, where the main objective is to prevent fire accidents for residents and properties within the house. It uses the board Arduino Uno together with the chip ATmega328 to control house fire alert that is subjected to the temperature sensor. This system will send an SMS notification to the users through the GSM module due to high rise temperature in the house. For communication purposes, it uses a GSM Sim card that is inserted into the module which provides information on the home fire detection (Mahzan et al., 2018). Meanwhile, other researchers were developed a fire alarm and detection system using Arduino Uno as a microcontroller to control the fire sensors, and then activates the GSM module to send an alert message to the home owner and the fire service personnel. Besides, the microcontroller also operates the alarm system and servo motor to tilt a fire bucket and downs the fire with flame-retardant materials (Izang et al., 2018).

A fire detection system with an ideal of gas sensor to detect a dangerous leakage of liquid petroleum gas (LPG) was developed by a group of researchers. This system can be used anywhere such as in a car, at the service pump stations, in storage tanks and homes. The system

is monitored by the Arduino Uno which identifies the LPG leakage if the signal becomes high. It will turn on an exhaust fan for removing gas out from the area. Besides, the system also sends an alert message to the mobile number that was registered (Sharma et al., 2017). Meanwhile, Paul et al. (2016) was developed a low-cost home and industrial automated security systems. The system utilized the Arduino Uno, temperature sensor and GSM module to detect any problem arise or temperature increase. This technology gave the advantages to the user because they do not need to bring any extra equipment to receive an alert message because most people had a mobile phone with them most of the time and indirectly develop a low-cost automated security system at home (Paul et al., 2016).

On the other hand, there are also previous studies that has been conducted by Zamal et al. (2017) about fire alarm with a security system. This project was designed to notify the user about fire at home when the owners were away and also notifying the fire station automatically. The system used GSM module to send an alert message to the users respectively. The system utilized the use of Arduino Uno, various types of sensors and automatic action module to give extra performance of the fire monitoring system (Zamal et al., 2017). Furthermore, other researchers used IoT and instant messaging application to notify and activate an alert alarm system remotely. The face recognition as smart home features was designed and built to be integrated in the home security system by utilizing Telegram instant messaging application as a remote control. This feature was used in real-time monitoring and can capture and transmits image data using Telegram application by sending commands that are available in the system (Made et al., 2018).

2.2 Intelligent Fire Detection and Alert System

According to the study conducted by Wang and Ren (2012) about the fire detection system, they proposed and developed an intelligent fire system using two different types of sensors, which are temperature sensor and smoke sensor. This project includes an information-processing module, control module, alarm module and single-chip microcomputer. When a fire takes place in the area, the temperature and smoke concentration will change. After a series of processing, this signal is sent to the single microcomputer. The system sends commands attention (AT) to the global mobile communication module by analysing the single chip microcomputer and processing it over the serial port if the defect occurs. Then, the information is sent in a short message to the user mobile phone (Wang & Ren, 2012).

Another project was about intelligent fire alert and escaping systems developed by a group of researchers. This system helps by providing navigation with the help of a camera built into a robot system to escape from the fire spot. Microcontrollers, cameras, robots, smoke detectors, flame sensor, and a GSM module were used in this type of system. Furthermore, this system will early detect the fire and monitors the situation using a wireless camera to find a safe way or place to escape (Joshi et al., 2017). On the other hand, other researchers proposed a real-time monitoring system to detect the presence of fire and capture images via camera and display on the screen using Arduino Uno, various types of sensors and GSM module. The advantage of this project is it is capable of obliterating fire early and is able to send an alert to the registered mobile number remotely (Singh et al., 2017).

3. Methodology

3.1. Architecture of the Proposed System

Figure 1 shows the system architecture depicts the flow of the control. Basically, the system architecture mainly consists of three components, which are Raspberry Pi Zero W, Telegram Bot and the sensor devices which are the main detectors. The sensors act as input devices that give input data to the Raspberry Pi which then process the information and deduce through the unique algorithm, whether there is a fire or not. The system is fully controlled by the Raspberry Pi Zero Was a microcontroller, and this microcontroller will continuously monitor to check the input coming from the sensor devices and send a message through the Telegram Bot in the case of fire detection. The microcontroller is connected with different type of devices like flame sensor, gas sensor and GPS module. Each sensor plays a vital role in detecting a fire if it occurs and then sends the alert message to the users. Moreover, Raspberry Pi be able to attach to the all sensor and module and it comes up with built-in Wi-Fi and Bluetooth Low Energy (BLE) onboard. The main function of the GPS module will dynamically pinpoint the source of the fire, and it will relay the coordinates of the fire to Telegram Bot with longitude and latitude. Meanwhile, flame sensor was used to detect flames and will respond whenever there is a presence of fire and gas sensor detects gas leak or other emission, which can be used to deduce what is happening or going to happen and is very useful, particularly in fire safety.

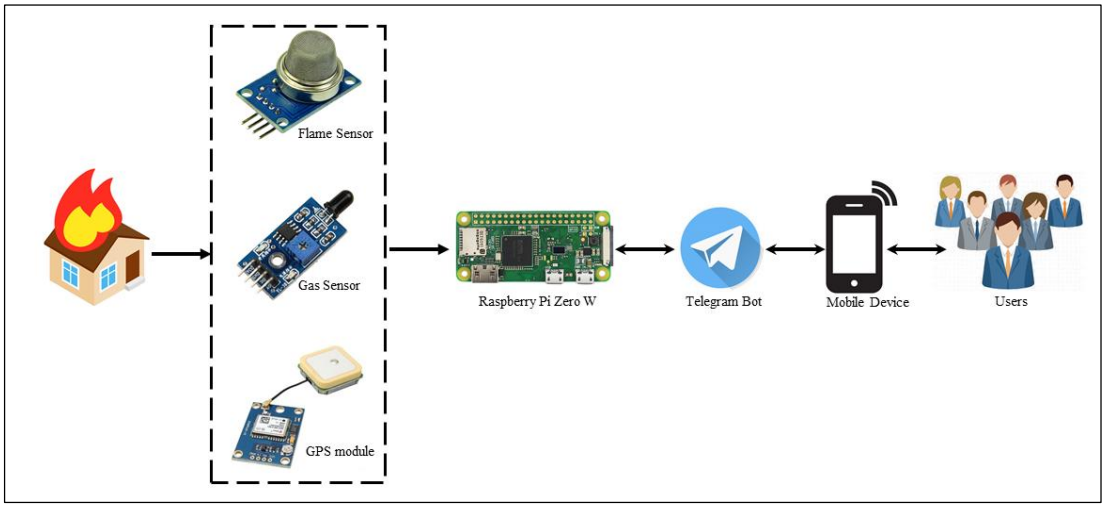

Figure 1. System architecture

Microcontroller and mobile devices are connected to the Internet by using an access point. This is important to ensure that the microcontroller can send a notification to the user when a fire occurs so that the user can take immediate action to prevent fire from spreading. The notification received through Telegram Bot instant messaging installed in the smart phone. Besides, the Telegram Bot also will be used to give a real-time command to the system in order to activate the system, remotely. When the fire broke out at the house, the microcontroller and sensor devices play a major rule by sending an alert message to the house owner and group members. They will receive a notification through his/her mobile phone via Telegram Bot if the flame sensor exceeds its threshold value or when gas is detected. Besides, the GPS module sends the coordinate of the location where the fire occurred. Thus, the owner can take immediate action on whether to use a fire extinguisher or call the fire department immediately to prevent the fire from spreading and thus saving his house from burn down.

3.2. Model Used for the Development of the Proposed System

The System Development Life Cycle (SDLC) based on the waterfall model (Bassil, 2012) was used to develop the home fire detection notification system. It consists of five phases such as analysis, design, implementation, testing and maintenance.

3.2.1 Analysis

In this phase, all information, data and problems of the project were gathered by reading articles, journal and thesis from previous research. Besides, the specific websites were referred in order to examine the use of the current technology in home fire detection and notification technique. From the information gathered, all the requirements and opportunities were recognized. Besides, the activities included were the identification of the hardware and software requirement in the development system, scope of project, schedule of activities such as gantt chart and the total budget.

3.2.2 Design

In this phase, the researcher designed the requirement needed in the system development. It implicates the plan for a solution which included the system components, system architecture, schematic diagram, flow diagram and flow chart.

3.2.3 Implementation

The process of converting the whole requirements and blueprints into system was done where all components of the hardware are assembled together. The flame sensor, gas sensor and GPS module were connected to the Raspberry Pi Zero W board as a microcontroller. The microcontroller was programmed in the Python language. The Python code script was written to program the entire hardware sensor functionalities with microcontroller. Besides, the microcontroller was programmed to send the specific information such as fire or gas detection to the users. Telegram application was prepared for receiving notification from microcontroller by using Telegram Bot. In addition, Telegram Bot also used to give commands to the microcontroller to activate the sensor devices remotely.

3.2.4 Testing

Debugging and testing of the program for fixing bugs or errors of the design were done in this phase. Then, the system was evaluated to determine the system performance and to ensure all requirements accomplished. Three different tests were conducted toward the proposed system, which were sensor detection range testing, response time testing and user acceptance testing based on Technology Acceptance Model [TAM] (Venkatesh & Bala, 2008).

3.2.5 Maintenance

After testing phase, minor refinement was done to integrate corrections of bugs and the user's feedback which was focused mainly on fine-tuning of system, configuring, installing and usability issues.

4. Results and Discussion

To evaluate the performance of the proposed system, three experiments were conducted. The first experiment was setup to detect the range of the flame sensor to the fire source. Meanwhile, second experiment was to evaluate the time taken for the GPS module to send the information to the Telegram Bot. Finally, the third experiment to perform a user acceptance test to the selected respondents.

4.1 Flame Sensor Detection Range Testing

The accuracy of the flame sensor was recorded in the different distances of the sensor to the fire source. This test case was performed to identify the best sensor detection range of distances. Table 1 shows the results of flame sensor detection range.

Table 1. Results of flame sensor detection range

Distance of fire source from flame sensor (cm)	Detection
0	Yes
5	Yes
10	Yes
15	Yes
20	Yes
25	Yes
30	Yes
35	No

From the experiment, the sensor detects fire at distance from 0 cm to 30 cm and sends an alert notification to the user via Telegram Bot. However, if the flame source is more than 30cm from the sensor, the sensor will not detect the presence of the fire. The fire cannot be detected because the fire source is not within the detection range of the sensor.

4.2 Response Time Testing

Two experiments were conducted to evaluate the response time for the GPS module to send location of the house to the Telegram Bot and Telegram Bot receive the data from the Raspberry Pi when the sensor detects the fire. Table 2 shows the response time for the GPS module to send location of the house to the Telegram Bot when the device detects the fire.

Table 2. Response time for GPS Module to send location to Telegram Bot

Number of test (time)	Response Time (Seconds)
1	8.06
2	6.43
3	7.89
4	8.56
5	7.45
Average	7.68

The response times were recorded in between 7.5 to 8 second to send the notification to the Telegram Bot and the average response time was calculated about 8 seconds. Therefore, the result is acceptable because the delay recorded is reasonable in time. Besides, the house owner and the people nearby will get the notification in a reasonable time. However, the result also depends on the Internet speed of both sides, which is Raspberry Pi and Telegram application installed in the user's smart phone.

Meanwhile, Table 3 shows the response time for the Telegram Bot receives the data from the Raspberry Pi, when the sensor detects the fire.

Table 3. Response time Telegram Bot receive alert notification

Number of tests (time)	Response time to send alert notification to Telegram(seconds)
1	1.32
2	1.28
3	1.35
4	1.13
5	1.10
Average	1.23

The average response time taken is about 1 second and the outcome, therefore is good because the delay is extremely short.

4.3 User Acceptance Testing

To evaluate the user acceptance test for Home Fire Detection Notification system, the study was tested to thirty (30) respondents. The targeted respondents were the house owner, which is randomly selected in Arau area. The experiment was conducted by given a demonstration on how the system works to the respondent. Then, they were required to answer a set of questionnaires, which consist of thirteen (13) questions and divided into several categories. The study has successfully done to evaluate the effectiveness of the system and categorized into four (4) components, which includes perceived ease of use, perceive usefulness, attitude and intention to use. The data were analyzed using arithmetic mean technique based on the ranking score value. The respondents required to rate the answer with the scale of 1 to 5 as shown in Table 1.

Table 1. Ranking score value

Category	Value
Strongly Disagree	1
Disagree	2
Neutral	3
Agree	4
Strongly Agree	5

Then, overall mean was calculated and classified into three categories, which is negative, neutral and positive based on the range of mean value in between zeros to five as shown in Table 2. This table will be used to identify the level of user's acceptance toward the proposed system.

Table 2. Range of mean value

Category	Range of Mean
Negative	0.00 – 1.66
Neutral	1.67 – 3.33
Positive	3.34 – 5.00

Meanwhile, Figure 2 summarizes the results for the identified criteria and total mean for each category respectively. The results showed that the target respondents were satisfied and positively accepted all functionalities and features provided by the home fire detection notification system. This can be indicated by the total mean result for the perceived ease of use (PEU) received 4.20 and perceived usefulness (PU) received 4.02 respectively. On the other side, most of the respondents wanted to use the home fire detection notification system because the system is able to prevent or reduce fire outbreak that could cause destruction and loss of life based on total mean results obtained 4.00 for attitude (AT) and 4.20 for intention to use (ITU). Besides, the overall total mean for the user acceptance test was 4.09. Therefore, this indicates that the respondents were positively accepted the home fire detection notification system as a tool for home security purposes.

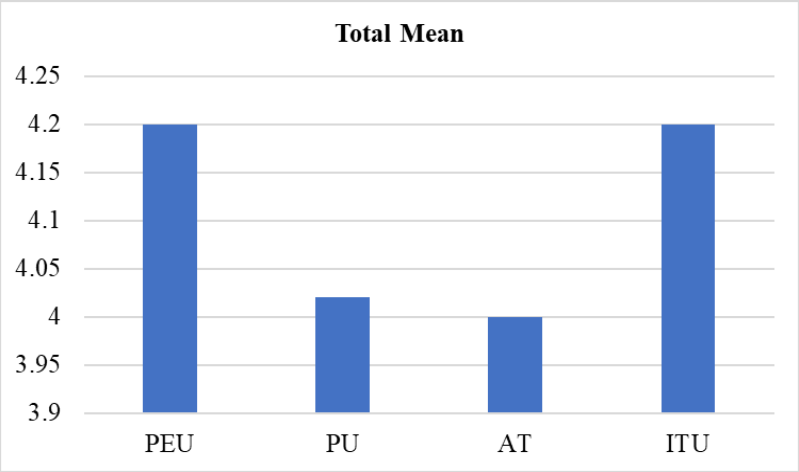

Figure 2. Total mean for each category respectively

5. Conclusion

This paper presents an efficient solution and low-cost home for fire safety. Internet of things (IoT) was the main concept used to develop the home fire detection notification system with simple hardware and minimum cost. The outcome from this system is useful to be implemented at home to help reduce the probability of injury or deaths, furthermore to minimize the loses that the victim must bear due to fire hazard. Therefore, this system become a special enhancement from the existing system for home security purposes which most of the house owner are affordable to install and use this system.

The system was developed and work properly to detect and send the alert notification to the smartphone house owner and a group of users using Telegram Bot instant messaging. The system utilized the IoT technology such as Raspberry Pi as microcontroller, flame sensor, gas sensor and GPS module. The exact location of coordinate of the fire source, will dynamically

send to the user respectively to take an appropriate action when the fire happened. Besides a real-time command can be used to activate the system remotely using Telegram Bot. Therefore, the system would help to prevent and reduce the number of house fire cases.

The system was measured using a user acceptance test based on the technology acceptance model to evaluate the acceptance of users towards the system. The questionnaire was divided into four (4) categories. The test was participated by thirty (30) respondents. Most of the respondents were satisfied with the functionalities provided by the system and found that it was a great idea to develop a system that focused on the home fire detection notification system. This is indicated by the average means for each category was above 4.0. Besides, another two tests conducted to evaluate the performance of the system by monitoring the response time and distance range test. The results showed the system can detect the presence of the fire and send the notification in a reasonable time. Hence, it appeared that the system was suitable to be used by the house owner.

This paper has highlighted the use of IoT technology and takes advantage of Telegram Bot instant messenger capabilities in order to enhance the home fire detection system and achieve its proposed goal effectively. The contribution lies in cost saving, provide reliable services and alert the house owner and group of users, thereby reducing loss of live and property.

References

Izang, A., Ajayi, S. W., Onyenwenu, C. B., Adeniyi, F., & Adepoju, A. (2018). An SMS Based Fire Alarm and Detection System. *International Journal of Computer Trends and Technology*, *58*(1), 58–61. https://doi.org/10.14445/22312803/IJCTT-V58P109

Abdel-Basset, M., Manogaran, G., Mohamed, M., & Rushdy, E. (2019). Internet of Things in Smart Education Environment: Supportive Framework in the Decision-Making Process. *Concurrency and Computation: Practice and Experience*, *31*(10), e4515. https://doi.org/10.1002/cpe.4515

Ansari, S., Aslam, T., Poncela, J., Otero, P., & Ansari, A. (2020). Internet of Things-Based Healthcare Applications. In *IoT Architectures, Models, and Platforms for Smart City Applications* (pp. 1–28). IGI Global. https://doi.org/10.4018/978-1-7998-1253-1.ch001

Bassil, Y. (2012). A Simulation Model for the Waterfall Software Development Life Cycle. *International Journal of Engineering and Technology*, *2*(5), 1–3.

Jabatan Bomba dan Penyelamat Malaysia. (2016). *Laporan Tahunan 2016 Jabatan Bomba dan Peyelamat Malaysia* (pp. 1–226). Jabatan Bomba dan Penyelamat Malaysia.

http://www.bomba.gov.my/bomba/resources/user_1/UploadFile/Penerbitan/BOMBA%202016.pdf

Joshi, S., Sharma, D., Sammal, Y., & Das, S. (2017). Intelligent Fire Alert and Escaping System. *International Journal on Emerging Technologies*, *8*(1), 108–110.

Made, N., Piarsa, N., & Sasmita, A. (2018). Telegram Bot Integration with Face Recognition as Smart Home Features. *International Journal of Computer Applications*, *182*(13), 42–47. https://doi.org/10.5120/ijca2018917778

Mahzan, N. N., Enzai, N. I. M., Zin, N. M., & Noh, K. S. S. K. M. (2018). Design of an Arduino-based Home Fire Alarm System with GSM module. *Journal of Physics: Conference Series, 1019*, 1-9. https://doi.org/10.1088/1742-6596/1019/1/012079

Osman, M., Maghribi, M., & Zulrahim, M. (2016). RaspyAir: Self-Monitoring System for Wireless Intrusion Detection using Raspberry Pi. *Journal of Computing Research and Innovation (JCRINN)*, *1*(No 1), 36–46.

Paul, D., Ghosh, A., Banerjee, S. J., & Jana, D. (2016). *GSM Based Fire Sensor Alarm Using Arduino*. *International Journal of Scientific & Engineering Research, 7*(4), 256-262.

Sharma, S., Singh, D., Rathore, S. S., & Bansal, P. (2017). *Fire Detection System with GSM Using Arduino*. *Imperial Journal of Interdisciplinary Research (IJIR), 3*(4), 2245-2243.

Singh, D., Sharma, N., Gupta, M., & Sharma, S. (2017). *Development of System for Early Fire Detection using Arduino UNO*. *International Journal of Engineering Science and Computing* 7(5), 10857-10860.

Venkatesh, V., & Bala, H. (2008). Technology Acceptance Model 3 and a Research Agenda on Interventions. *Decision Sciences*, *39*(2), 273–315. https://doi.org/10.1111/j.1540-5915.2008.00192.x

Wang, Y., Ren, X., Zhao, M & Sha, J (2012). An Intelligent Fire Alarm System Based on GSM Network. *Communications and Information Processing. 282*, 232-240. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-31968-6_28

Zamal, Md. F. B., Sayed, S., Bhuiyan, T., & Rahman, M. (2017). An Efficient Multi-sensing and GSM Equipped Fire Monitoring System. *MATEC Web of Conferences*, *140*, 1-6. https://doi.org/10.1051/matecconf/201714001003