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A Multisensory Arduino-Based Fire Detection and Alarm System using GSM Communications and RF Module with an Android Application for Fire Monitoring

Mike C. Baba, JL-Joshua B. Grado, Dean Joshua L. Solis, Isagani M. Roma, Jeffrey T. Dellosa
Department of Electronics Engineering, Caraga State University,
Butuan City, Philippines

Abstract:- Presented in this paper is the design and development of a multisensory Arduino-based fire detection and alarm system using GSM communications and RF module with an Android application for fire monitoring. The device and its system were made to aid the response of the fire departments to reduce damages caused by fire. The device used four sensors to detect irregularities that may cause massive fire such as flame, smoke, butane, and temperature. Once one of the sensors was triggered, data is sent from the monitoring functions of an embedded Arduino Uno microcontroller to the users' mobile phone via SMS and the 'Voltech' mobile application. Data is also stored in an inventory of daily and monthly logs in the local host database through a JZ873 Radio Frequency transceiver. A mobile application was developed to ensure to users that they can easily update the status of the device and the room they are monitoring. The detection was calibrated into three levels: a) Level 0 – No detection, b) Level 1 – Warning. The device was tested and the results were remarkable as to how fast the information dissemination and accurate the reading was. This device was made to help fire response and it has performed well when tested.

Keywords:- *component; formatting; style; styling; insert.*

I. INTRODUCTION

Fire incidents have always been a great threat to property owners and every individual. Without an advanced fire detection and alarming system, fire can catch as rapidly as it should claiming innocent lives and robbing away someone's livelihood or property [1].

Fire is a very destructive agent that destroys things so easily by which in worst case scenarios leave nothing but ashes. Late detection and response cannot be blamed for this since there is no monitoring system available yet, and the most convenient way to alarm the Bureau of Fire Protection is by notifying them manually through their hotline [2].

Fire security is an essential requirement in establishing buildings. This is to ensure the safety of workers or other stakeholders that there is a fire plan in case of emergency. Fire detection systems are among the essential components in monitoring the environment of the establishments. It is more secure for the property owners if the monitoring system notifies them if there are fire related irregularities occurring within the vicinity [3]. Also, it is more convenient for the users if the system is linked to the Bureau of Fire Protection for them to also monitor and quickly respond if a fire incident is taking place.

Fire incidents are inevitable. Having household members capacitated on what to do to prevent or deal with fire incidents is not enough to ensure total fire safety. Fire incidents can still happen since it may come in several causes: fire attacks, natural cause, explosions, domestic wirings and etc. [4].

Most fire alarm and detection systems have already been implemented in some parts of the world. They can be seen being installed in large buildings. These buildings are sometimes referred to as 'intelligent buildings'. Engineers have developed these buildings by integrating the science of what is now called the 'Internet of Things'. They install sensors and hardware materials like sprinklers to combat fire when irregularities occur or variables are detected. Although these systems may kill fire as it starts, the protective measure it has on files and appliances that are easily destroyed with water is in question [5].

Engineers nowadays are paving technologies' ways to getting interconnected. These developed interconnected systems are called the 'Internet of Things'. IoT would represent the integration of software and hardware devices into one working force. It is defined as the use of intelligently connected devices and systems to leverage data gathered by embedded sensors and actuators in machines and other physical object [6]. IoT technologies through Arduino-based technologies are used in this project. The use of IoTs in artificial intelligence and renewable energy are becoming a norm with IoTs being applied in various applications including renewable energy systems, healthcare, and agriculture among others [7-21]. The intellectual property (IP) part of this research in IoT and renewable energy is also covered by the university's IP policy [22].

The 'Arduino-based Smart Fire Detection and Alarm System with Smoke, Butane, Flame, And Thermal Sensors Using GSM Communication and Radio Frequency Module for Fire Safety Monitoring' is devised in response to the need of a real-time monitoring of household and prevent massive fire incidents from happening.

The project uses four sensors: flame, smoke, butane, and thermal to ensure accuracy and avoid false alarms. These sensors housed in one device have their distinct monitoring functions in the embedded Arduino microprocessor. In the occurrence of fire, the four sensors detect irregularities in its respective parameters and sends data to its central core unit – Arduino. Once the microcontroller receives the data, an alert SMS through GSM communications will be delivered to the user. Also, through GSM communications, the user will be able to update the status of the vicinity through the 'Voltech' mobile application.

The monitoring system can be accessed in the local host through a radio frequency medium. Data is sent from the sensor node through radio frequency to a receiver node to allow messages in the local host. The local host will then tally and record the current status of the room wherein the device is installed.

II. METHODOLOGY

A. System Process

The device system process basically starts from detection of the basic sensors used by the researchers in development. Sensors includes: flame sensor, which detects the presence of flame in a room and is calibrated for effective detection; smoke sensor, which is designated for smoke detection; butane sensor, detects explosive and flammable gases and is used in this device to specifically detect the presence of butane gas in a certain reach of its range; thermal sensor, which also another way of detecting the presence of fire that is a sudden increase of temperature above the normal threshold.

All sensors give a real-time status of detection that will then be fed to the base station. Before it gets to the base station, the microcontroller, Arduino Uno R3 is responsible for the control of data displayed via serial communication. The data displayed is transferred through the use of RF data transceiver, this module carries the data in a radio frequency up to 433MHz range. The base station that contains a microcontroller and a RF data receiver receives the data and displayed to the local host.

Another way of retrieving data from the device detection is through the use of the android mobile application. Its great advantage is that monitoring the device activity can be made easy despite of distance. This feature uses a GSM module added to the device function to address distance issue and internet incapability of the user. A single press of the button in the mobile application will give feedback from the device which is displayed in the application interface.The alarm system process involves two levels of detection:

0 – No Detection
1 – Warning

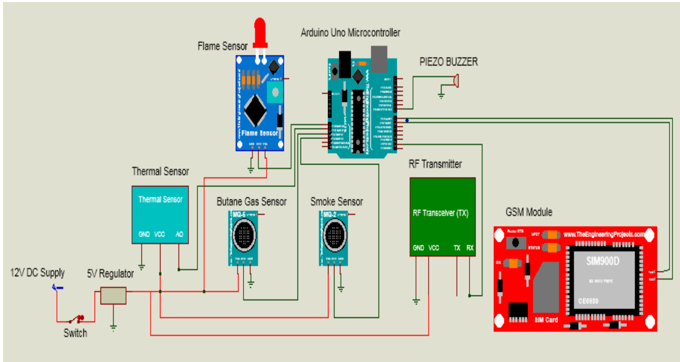

Fig. 1: Schematic diagram of sensor node.

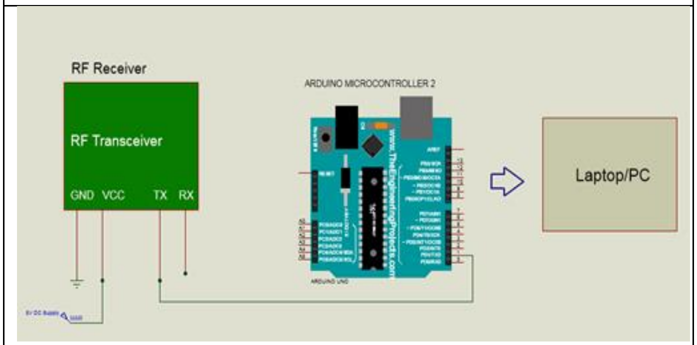

Fig. 2: Schematic diagram of base station.

On the first level, no alarm will be triggered in both SMS and buzzer. In the second level of detection, an SMS alarm will be sent to the user and at the same time the buzzer will be triggered. When two sensors are simultaneously triggered, an SMS warning alarm will be sent to the user.

When three sensors are simultaneously triggered, an SMS warning alarm will be sent to the user and also to the BFP hotline.

B. Design and Development of Mobile Application

There are two ways to create mobile application which is to go through an online app inventor or is by installing an executable file for offline use. The researchers used a common app inventor, an open-source web application through online and accessing the site, http://ai2.appinventor.mit.edu.

Fig. 3: Mobile application design

C. Design and Development of Mobile Application

The device provides and ensures a real-time fire monitoring through the use of RF data transceiver. RF data transceiver transmits real time data to another transceiver in the base station where the receiving process also displays time correspondingly to the localhost.

Fig. 4: Local host data logs

III. TEST RESULTS AND DISCUSSIONS

A. Flame Sensor Testing

Fig. 5 is the graphical representation of the Flame Sensor's detection given a distance in meters with a corresponding threshold values. The testing uses a trash of paper to create flame and placed in a line-of-sight basis. The flame sensor was able to detect the radiated light emitted from the flame source, creating an advantage of detection up to six (6) meters range of distance. Flame sensor has a maximum analog threshold value of 250, noting that it is the shortest distance of testing and a threshold value of 65 as what the farthest distance can detect.

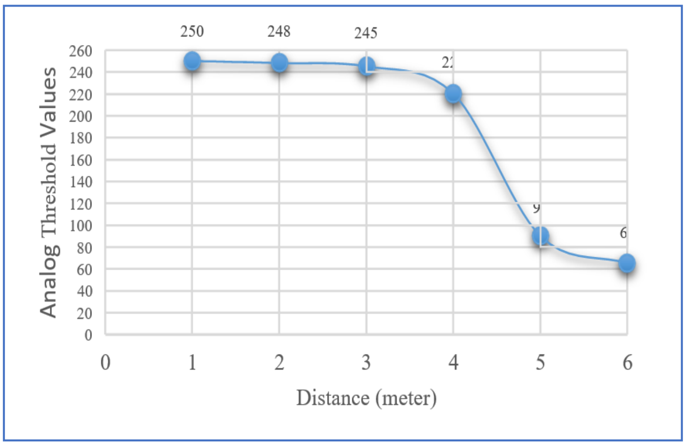

Fig. 5: Flame Sensor Testing

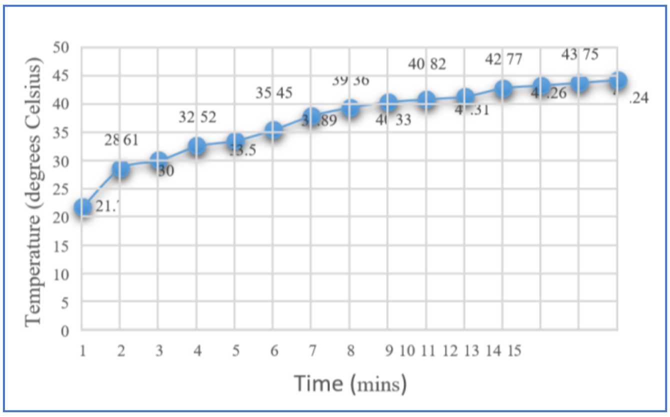

Fig. 6: Thermal Sensor Testing

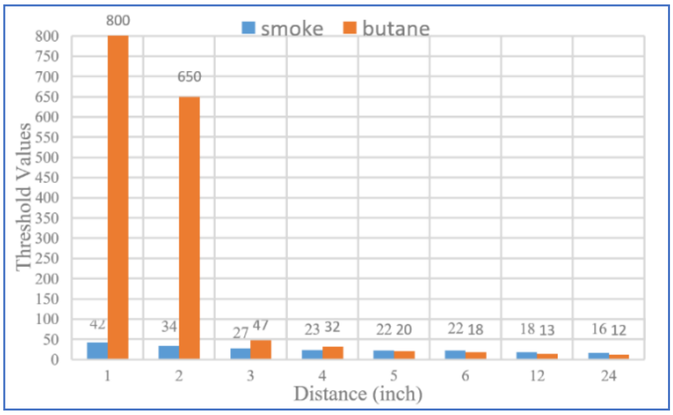

Fig.7: Butane Sensor Test Results

As a result, within one (1) minute of exposure, the thermalsensor detects 21.78 degrees of temperature from its environment and after the fifteen (15) minutes test, the thermal sensor detects 44.24 degrees of temperature.

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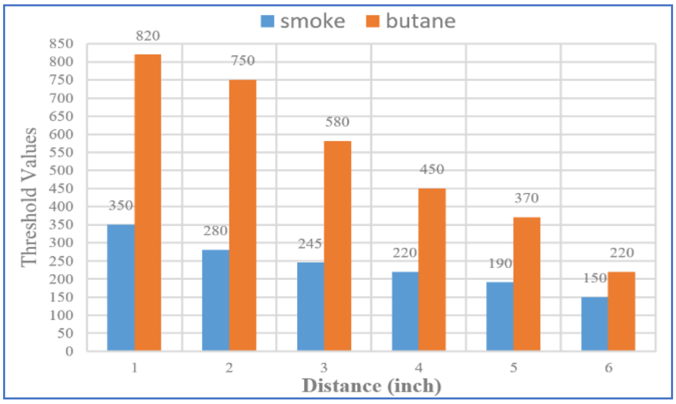
B. MQ-5 Butane Sensor Testing

MQ-5 sensor is a type of gas sensor that is able to detect both smoke and butane during the experiment. Since MQ-5 is specifically used in this study for butane detection, measuring the threshold values helps to initialize the coding process of the controller section. Measuring the parameters involve distance of concentration and the threshold values. The researchers use a disposable cigarette lighter as a source of butane gas since it's the cheapest way to provide and has less risk of accident compared to large scale butane gas sources.Shown in Fig. 7, butane has the highest detection compared to smoke as to the nearest distance it got. With the maximum threshold values of 800, MQ-5 makes it ideal more for butane gas detection.

Fig.8: Smoke Sensor Test Results

C. MQ-2Smoke Sensor Testing

MQ-2 sensor is able to detect both gases involve in the study. It is used specifically in smoke sensing. The sensor was tested in both gases: butane and smoke and the result are depicted in Fig. 8. Though butane gas has a larger threshold value of detection but this condition will be addressed through the coding of the microcontroller. Smoke sensor was tested in a wide room where the smoke is spread instantly.



D. Radio Frequency Data Transceiver Testing

The RF data transceiver used in the device is a JZ873 model. The researchers test the actual distance of data transmission inside the Caraga State University campus in line-of-sight transmission 5 feet above the ground. The efficient transmission without distortion reaches up to 804 meters which is from main gate to the concrete road of Carabao center of the university.

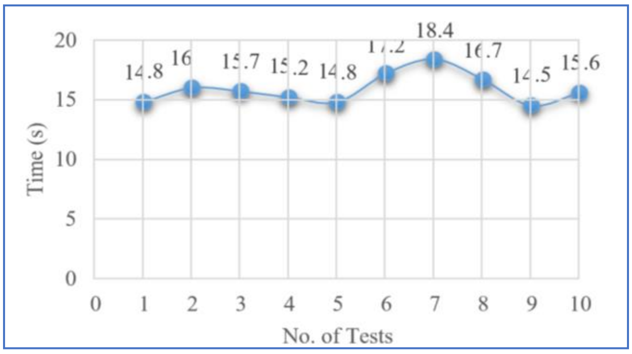


Fig. 9: RF Data Transceiver Testing

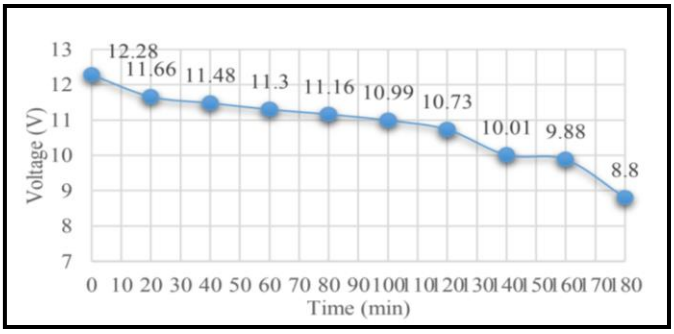


Fig. 10: Mobile Update Testing

E. Mobile Update Testing

Figure 9 a graphical representation of tests results done in mobile texting update. The test is measured in seconds from the tapping the update button from the android mobile application until it receives the feedback update from the device. The lowest feedback update time is 14.8 seconds and the highest or longest feedback time received is 18.4 seconds. The average mean value of time is about 15.89 seconds. Response time may vary due to the strength of signal that is available in the area and the ability of device to receive the signal. The testing was done inside a 34x34 feet laboratory room.

F. Device Power Test

The actual device has a current consumption of 1.340A. Sustaining the life of the device without the external power source only last up to 2 hours and 28 minutes. With an 8.8v power from the backup batteries, it is not sufficient to supply the whole device which automatically turns off the whole system.

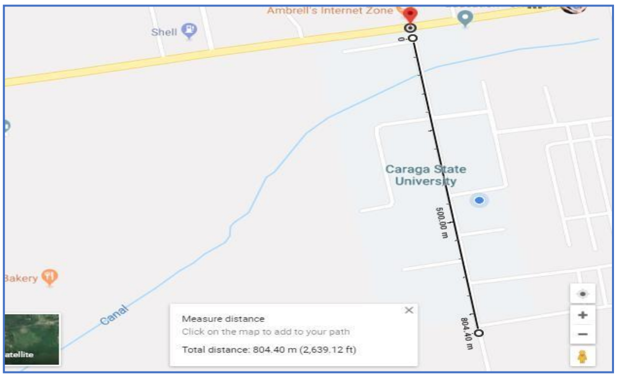


Fig. 11: Device power test results

IV. CONCLUSION

Designing and developing a Smart Fire Detection and Alarm System has a lot of factors to consider. Through testing, the researchers were able to calibrate the sensors in order for them to operate effectively. The device was able to send data wirelessly via RF yet it is only capable to transmit undistorted data within the approximated range of up to 804 meters, considering line-of-sight wireless data transmission. With regards to GSM Communications, the device successfully received and sent SMS data utilizing the Arduino compatible GSM Module. Certain delays on the GSM communications may vary depending on the strength of the signal, hence considering the location of the device. The integration of the components illustrated in the previous chapters were maximized and used effectively throughout the study.

The creation of the Android Mobile Application gives an additional feature to the study. The tests done in the application makes the researchers full conclusion that its truly effective in fetching the data from the device through the GSM Communications services.

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