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Comparison of Farm Alarm Detection System (FADS) Frameworks

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Abstract

Farms cover large areas of the total area in the Sultanate of Oman, and these farms need a high-quality security system against fires, which is the biggest threat to the lives of farmers. Farm Alarm Detection System (FADS) is a modern technology that protects individuals' and groups' property but is rarely used at present. The primary work of the FADS is to sense the smoke associated with the occurrence of fires and then warn the farm owner of the possibility of a fire in a short period after smelling the smoke. The device emits an audible alarm and sends an SMS to the farm owner about a fire possibility, according to the amount of smoke sensed through the sensors. This type of system's architecture requires four connected devices to accomplish the job. The results showed that when smoke and toxic gases are formed in a specific proportion, the device triggers an alarm and sends a text message indicating the possibility of a fire.

Keywords*:* Farm Alarm Detection System; Internet of Things IoT; temperature sensor DHT11; gas sensor MQ-2; Unified Modeling Language UML

1. Introduction

Internet of Things (IoT) is a modern field that has risen dramatically in the past few years to associate people and PCs, and ordinary articles with the Internet (Al-Bahri & Alkishri, 2021). IoT works can be accomplished by furnishing things with registering and correspondence capacities and mapping the physical world to the computerized one (Yousif J, 2011; AlKishri, & Al-Bahri, 2021; Alattar & Azeez, 2021). This vision has come from how individuals have restrictions on time and precision about information, social occasion, and age. However, if these procedures should be possible with no human impedance by having extraordinarily recognizable articles to report their status, area, addresses, and so on. The expenses and misfortunes could have diminished significantly (Kramp et al., 2013; Alblushi & Yousif, 2021).

Kevin Ashton (Ashton K, 2009) right put forward the idea of the Internet of things and introduced the Internet of things as unusually recognizable associated objects with recognizable radio-recurrence (RFID) innovation (Al-Shezawi et al.,2017). Be that as it may, the Internet of Things' precise definition is still in the shaping phase that depends on the perspectives taken. The Internet of things was commonly known as a "dynamic worldwide system foundation with self-arranging capacities dependent on measures and correspondence conventions" (Kramp et al., 2013).

Large numbers of fires were noticed on farms, and the owners were unaware of when the fire started. Environmental pollution and health are affected by damage to farms, and maybe fire gets to kill people and animals (Saini & Yousif, 2013; Alattar et al.,2019 ; Alattar & Yousif, 2019). In general, Farm Alarm Detection System (FADS) is a sensor used to detect fire on farms. Therefore, to control the fire problem and reduces the possibilities of fire occurrence in an area where smokes and gases are regular in the air (Yousif & Alattar, 2017). The alarm system FADS was designed to detect the fires on the farms and send notifications through (SMS) to the farm's owner based on the percentage of their presence in the air. In addition, FADS uses a buzzer to make an alarm sound to anyone around the farms. In short, the sensors work together to detect fires on the farm, then send a message to the farm's owner before the fire happens, and warn the owner before the fire gets out of control (Yousif & Abdalgader, 2022).

2. Background & Literature Survey

Lately, there has been an expanding pattern of vast quantities of individuals stirring towards urban living. As anticipated, by 2030, more than 60 % of the populace will live in an urban situation (Feng X, 2021).

A portion of the frameworks that can deliver provokes identified with an expanded populace will add to the improvement of the Smart City. A Smart City provides a creative approach to supervising parts such as transportation, well-being, vitality, homes and structures, and condition. The information generated in these parts is essentially from remote sensor systems. The Remote sensor systems have been sent in a wide variety of modern and customer applications, such as wellness screening, intelligent home applications, water monitoring, and condition control.

Sensor hubs related to various Smart City applications produce a lot of information that is essentially under-utilized (Scotneya et al., 2015). Utilizing the existing ICT framework, produced heterogeneous data can be brought together. Some of the latest developments in remote communications that can be misused to achieve this data conglomeration are 3 G, LTE, and WiFi. The Internet of Things (IoT) comprises PCs and other electronic devices to use embedded devices and existing network frameworks. The Smart City dream is subject to operating at a standard location on billions of internets of things gadgets.

Continued development of low-power remote system guidelines for sensors and actuators has empowered executives to remotely monitor and control broad scopes of sensor systems and actuators. The proposal is to convey the design on an aid stage. Different web applications can associate sensor applications through this stage and use them for a canny working condition (Gaur A, 2015).

Raspberry Pi and Arduino Uno: The projected fire alarm system is a real-time checking system that identifies the presence of smoke in the air due to fire and releases images when a fire occurs via a camera installed inside a room. Raspberry Pi and Arduino Uno are the embedded devices used to boost the fire alarm system. The system's key feature is the ability to send an alert remotely when a fire is detected. When detecting the presence of smoke, the system will display a status image on a webpage. Using Short Message Service (SMS), the device would require user approval to send the result to the Firefighter. The benefit of using this device is it would reduce the probability of real false warnings to the Firefighter. (Bahrudin M, 2013)

Automated Fault-Tolerant Fire Detection and Warning System this system comes in different types depending on the building. But all of them provide the same functionalities, such as detecting and sensing the fire through several sensors, sending an alarm signal through the IoT internet cloud and SMS along with the place of fire, and Activating fire or gas leakage alarm in the buildings. Different Types of Buildings include:

- Single-Story Buildings like Houses: The full system containing sensors will be installed on the ceiling of the buildings.

- Multi-Storied Buildings: One central system will be committed to the building's fire alarms control board. The sensors will be distributed on each floor of the building. According to the owner's selection, they will be linked to the main system by wire or wirelessly.
- Institutional Buildings: There will be one main system attached to the automated fire alarms of the building, and the sensors will be distributed in the other buildings according to the range of used sensors. Still, more than one main system can be used according to the campus area. According to the owner's selection, the sensors will be linked to the main system wirily or wirelessly.

FreeRTOS Fire Alarm Project: these are time-dependent systems that must respond to external or internal replies within a given fraction of the time. RTOS must process the system input data and provide the desired output within a specified time. RTOS is divided into two groups of systems: hard real-time and soft real-time. In weak real-time systems, the deadline for each job is not always mandatory. However, the system cannot oversee the deadline for every task since system performance would be compromised. The method is strictly deterministic and time-limited in hard-time and real-time applications such as fire alarm systems, medical monitoring systems, and remote satellite imagery systems. If the deadline or response time is missed, the consequences may be irreversible, and the system's performance will fail. RTOS has been used in many embedded systems in the automation fields for years. Such systems have been developed to help embedded algorithms in military equipment, defense systems, and software used to monitor broad switching (Turci L, 2017). Developed an Intelligent Fire alarm system is to warn people to take time to evacuate the place before the fire spreads as quickly as possible. The fire alarm system has been used to detect addresses with the help of wireless connections between the regions. In addition, this system includes the control panel, notifications, hardware, and starting equipment for the fire alarm system where a wireless alarm system is used and opening units by initial and secondary battery (Elbehiery H, 2008).

Table 1: Comparison of Systems Advantages & Disadvantages

Systems Name	Advantages	Disadvantages
Raspberry Pi and Arduino Uno (Bahrudin and Abu Kassim, 2013)	- Low cost - Reliable instruments - Appropriate to develop	- False warning - Device error
Automated Fault Tolerant Fire Detection and Warning System (Khader et al., 2019)	- Automated fault tolerant fire detection. - Fast automated fire alert	- Cost more money. - Cannot work in open areas.

FreeRTOS Fire Alarm Project (Turci L, 2017)	- Respond to external or internal reactions in a particular fraction of time. - Real-time systems are developed to support systems, and software used to control large switching. - low cost	- Sensor do not detect the heat.
Developed Intelligent Fire alarm system (Elbehiery H, 2008).	- Accurate system and easy to install. - The main fire alarm control panel capable of transmit/receive more than one slave unit. - The system is adept of easy programming.	- It is tended to be configured and complicated -It cost more than the conventional equivalent from 50%_100%.

3. System Architecture

The system consists of four parts, where the main part is Arduino UNO, and the others are connected to it: the temperature sensor DHT11, gas sensor MQ-2, and buzzer. The hardware design components are shown in figure 1. The Arduino system provides a set of analog and digital pins connected to several other boards and circuits with entirely different design functions. It can be used to connect sensors that detect sound, light, or vibrations, turn on a light, change its color, start an engine, and many other things. SIM900A module is a selected GSM module due to its advantages: proven performance, standard industrial-grade interface, and TCP / IP protocol embedded, making it presentable and suitable for the electronics project. DHT11 Sensor is used to sense humidity and temperature and then communicate with the Arduino to analyze the data. MQ-2 Sensor is used to smell combustible gasses and smoke, then send data to Arduino. The buzzer is used to make a sound if the received data is high.

The lesson was well-balanced, with plenty of opportunities for engagement. The lecturer would ask simple questions to assess the students' prior understanding. Different visuals items, short questions, and verbal questions were used in the lecture. Only the lecturer needs to talk to the students that play with their mobiles. When there is smoke on the farm, the heat is sensed by DHT11. If a temperature reaches 40oC, then DHT11 will send a signal directly to the Arduino to inform it about the occurrence of high temperatures. On the other hand, MQ-2 might also send a signal about combustible gasses to the Arduino. This situation will cause the Arduino system to be aware of the owner via the GSM module, where an SMS will be sent to the owner to inform him about the possibility of having a fire on the farm. At the same time, the buzzer will make a sound to alarm anybody on or around the farm.

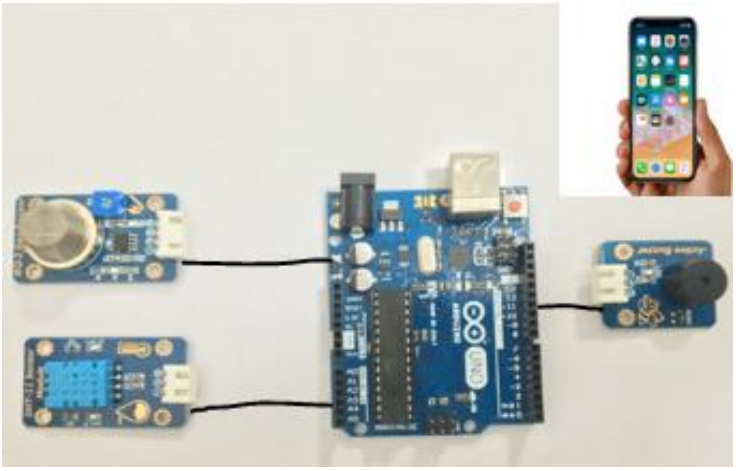

Figure 1: The proposed System Architecture.

4. Proposed System Requirements

4.1. FADS Devices

The Farm Alarm Detection System (FADS) consists of the following devices:

- Arduino UNO: It is an electronic development board consisting of an open-source electronic circuit with a computer-controlled microcontroller, and is design to facilitate the use of interactive electronics in interdisciplinary projects. (Khin, 2018)
- DHT-11 sensor: Sensor makes it really easy to add humidity and temperature data to our project electronics projects. It is perfect for remote weather stations, home environmental control systems, and farm or garden monitoring systems. (Srivastava, 2018)
- MO-2 gas sensor: Is useful for gas leakage detection (home and industry). It suitable for detecting H2, LPG, CH4, CO, alcohol, smoke or propane. Due to its high sensitivity and fast response time, measurement can be taken as soon as possible. The sensitivity of the sensor can be adjusted by potentiometer. (Santiputri, 2018)
- SIM900 shield: SIM900 GSM/GPRS shield is a GSM modem, which can be used in many numbers of IoT projects. this shield is used to complete almost anything a cell phone can perform; SMS text messaging, making or receiving phone calls, connecting to internet through GPRS. The shield generally supports quad-band GSM/GPRS network.

- Buzzer: A buzzer is an effective part for adding sound to fire alarm system. It is very compact 2-pin structure, which makes its use on breadboard easy, Perf Board and even PCBs, making it a frequently used feature for most electronic applications. (Active Passive Buzzer, 2017) reliable.

4.2. System Workflow

The system uses sensors such as MO-2 to sense gas/smoke and DHT-11 to sense temperature to detect a fire early. Both of these sensors are connected to the controller, which is Arduino. The controller is connected with another sensor, a buzzer, that makes a sound during the fire to alarm anyone around the area and send a message (SMS) to the farm owner. The following figure shows the use case diagram of the FADS system.

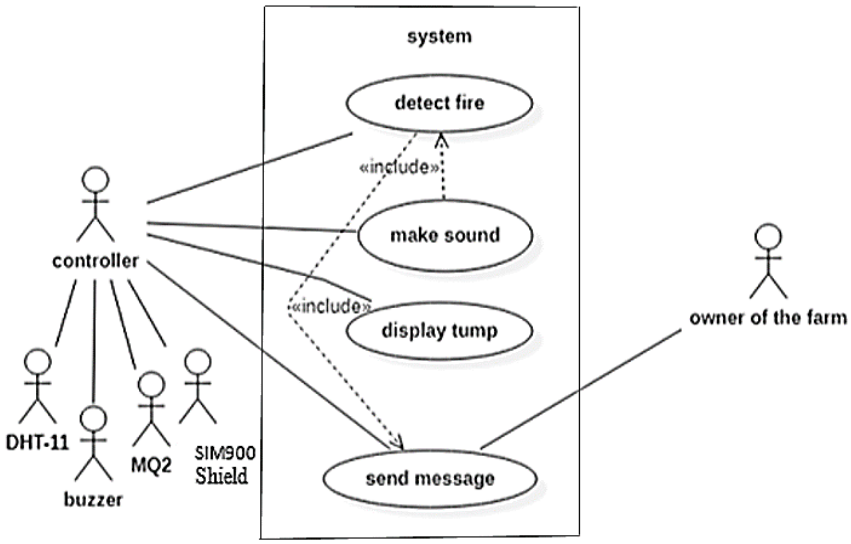

Figure 2: Use Case Diagram

The aim was to improve a multisensory system for fire detection to reduce fire risk and timely alert farmers, saving farms from fire. This is done by designing a multisensory approach that discovers fire and sends a signal to the receiver for a timely alarm. A UML class diagram for a fire alarm system in farms is shown in Figure 3. A sequence diagram is an interface diagram showing how the objects are with each other in a specific order. It is a message sequence map construct. Below is a sequence diagram for each sensor.

- DHT11 Sensor:

  DHT11 sensor communicates humidity and temperature data to Arduino. Arduino analyzes the data and checks humidity and temperature degrees; if it is high, Arduino will send the information to the owner's phone through a sim card (GSM) as shown in Figure 4.

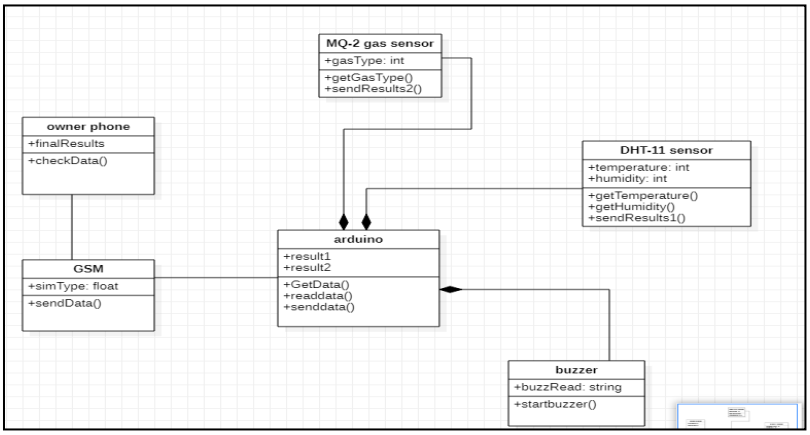

Figure 3: Class Diagram

- MQ-2 Sensor:

  The sensor (MQ-2) module senses combustible gasses and smoke. Can we use MQ-2 for gas leakage detection?

  IF the concentration of gas increases will send data to Arduino, Arduino will process and analyze data and then send information to the owner's phone through a sim card (GSM). The MQ-2 sensor is a sensor with an analog output (AOut) which signals the presence of smoke by increasing the output voltage shown in Figure 5. The more smoke, the higher the tension. It is possible to adjust the sensitivity of the module using the potentiometer located at the rear of the module. This allows you to modify an activation threshold for the digital signal (DOut), which changes when the threshold is reached.

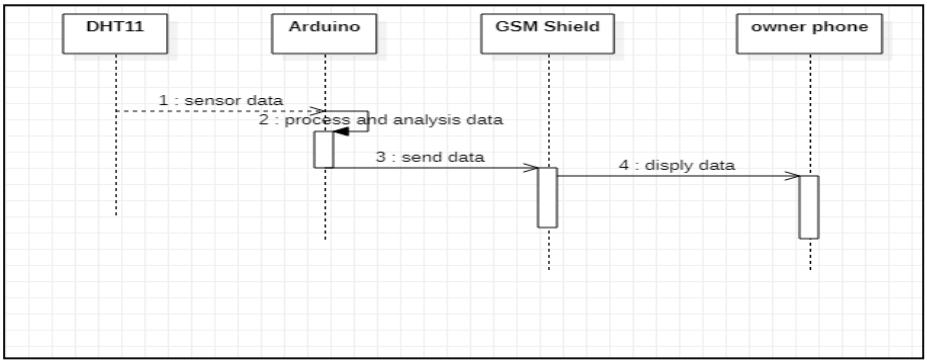

Figure 3: DHT11 Sensor Sequence Diagram

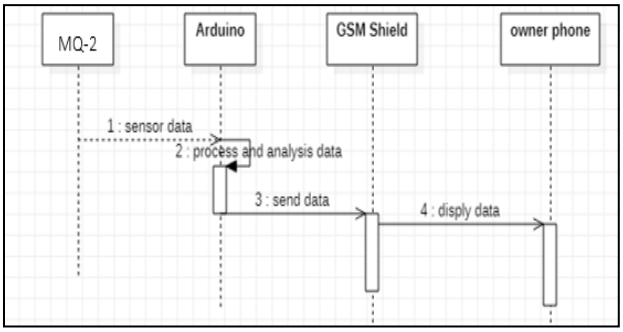

***Figure 4**: MQ-2 Sensor Sequence Diagram*

- Buzzer:

  To make a sound with a buzzer, we need to set which pin the buzzer is on, what frequency you want, and how long you want it to keep making the sound. If Arduino senses a fire, it will send voltage with different frequencies to produce sound shown in Figure 6.

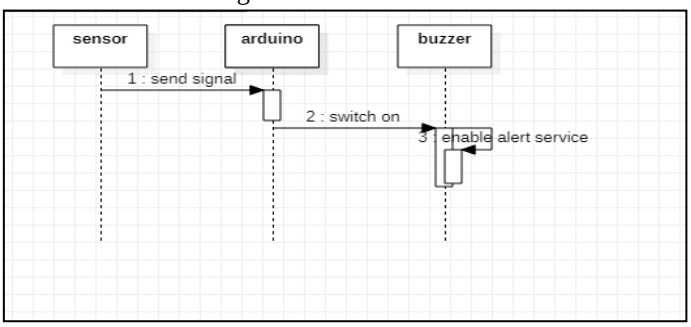

Figure 5: buzzer Sequence Diagram

5. Discussion & Results

A perfect fire recognition framework ought to promptly distinguish the fire when a fire starts, day or night, under any state of visibility with no bogus cautions. The plan of such a productive framework is presently exceptionally conceivable with new brilliant/keen sensors and by the utilization of a multi-sensor design enhanced for nonexclusive low force multi-sensor farms fire checking application. The general square chart for such nonexclusive low force multi-sensor farm's fire recognition framework is shown in Figure 7.

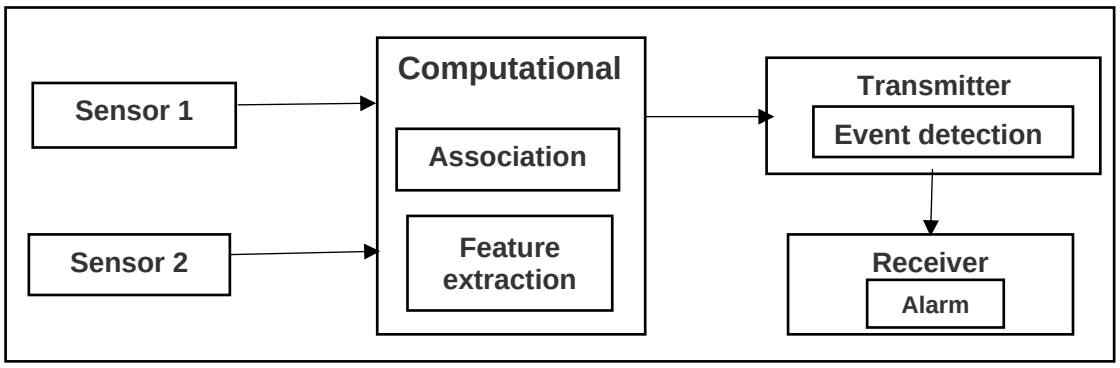

Figure 6: farms fire recognition framework

The plan for farms alarm using methods for GSM Module with Arduino-based Framework. The job is to protect farms where the core issue is to stay away from fire accidents. The ATmega328 chipboard used is similar to Arduino Uno. The central controller used is the ATmega328, which controls the fire alarm from farms exposed to the temperature sensor. To identify the warmth from the burn, a DHT-11 temperature sensor is also used to detect smoke and gas using the MQ-2 gas sensor. The GSM module is used, and an alarm message is sent to the client utilizing an SMS. When the system distinguishes the high temperature, it will send customers an SMS alarm at the high-temperature rise in the farms, and the buzzer will make a high sound for the additional alarm.

- **The implementation steps**

1. Programmed Arduino UNO using the available open-source Arduino software for writing methods such as pinMode ( ), digitalWrite(), and digitalRead().
2. Connection of the MQ-2 Sensor to Arduino UNO board.
    - In MQ2, connect the VCC pin to the Arduino 5V pin.
    - Link GND pin to Arduino ground pin in MQ2.
    - Link D0 output pin on the Arduino's MQ2 with Digitalpin#8.
    - Connect A5 output pin on Arduino's MQ2 to Analog pin#0.
    - **The Input:** The MQ-2 sensor connects to Arduino to sense any gas or smoke detected on farms. The sensor value is read by the analogRead() function analog input pin A5 in the loop function.
    - **The Process:** When the gas focus is high enough, the sensor usually outputs a value greater than 50C, and when the sensor value exceeds 50C, we will display a 'Smoke Detected!' message.
    - **The output:** Figure 8 shows MQ-2 results that detect smoke in the farm between almost 300-600 values rate. A small sample of the result is illustrated in Figure 9, where it shows the highest value detected is 590 and the lowest value detected is 302.
3. Connection of the DHT-11 Sensor to Arduino UNO Board
    - The DHT11 digital module delivers and receives a digital signal on a single serial input/output. Its two analog sensors are a resistance which determines the humidity rate, and an NTC (Negative Temperature Coefficient) type thermo-resistance to measure the temperature.
    - Connection:
    - In DHT11, connect the VCC pin to the Arduino 5V pin.

- In DHT11, attach the GND pin to the Arduino ground pin.
- Connect the Data output pin on Arduino's DHT11 to digital pin #8.
- **The Input:** DHT-11 connects to Arduino to sense any high temperature; this importin sensor in the system so it can know the temperature. In the programming, we use the read11() function, which reads the data from the sensor. We can read humidity and temperature values.
- **The Process:** The DHT object communicates temperature value in Celsius (°C), which will be converted into Fahrenheit (°F) using the formula number 1:

  $$T(°F) = T(°C) \times 9/5 + 32 \quad \ldots(1)$$

- When the temperature sensor value exceeds 50, we will display a 'Heat Detected!' message.
- **The output:** Figure 10 shows the DHT-11 result that detects the highest and lowest values of the temperature and the humidity percentage. A small sample of the result is illustrated in Figure 11, where it shows the values of both the temperature and the humidity stay stable with a minimum smoke rate.

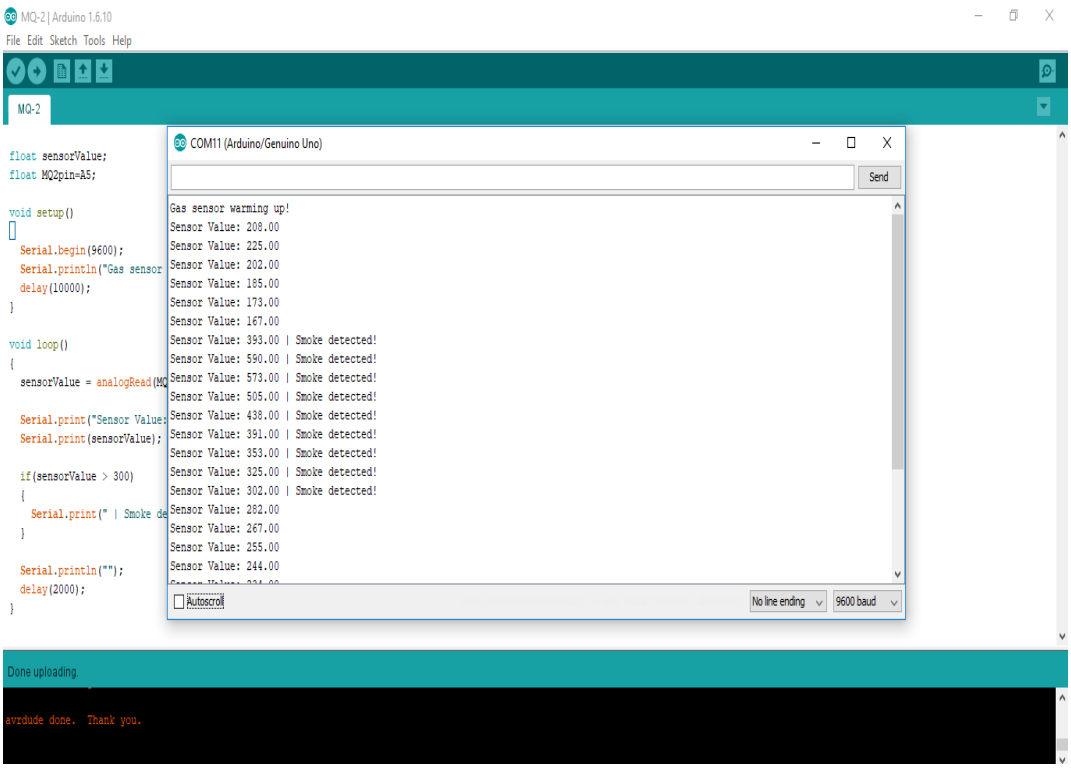

Figure 7: MQ-2 Result

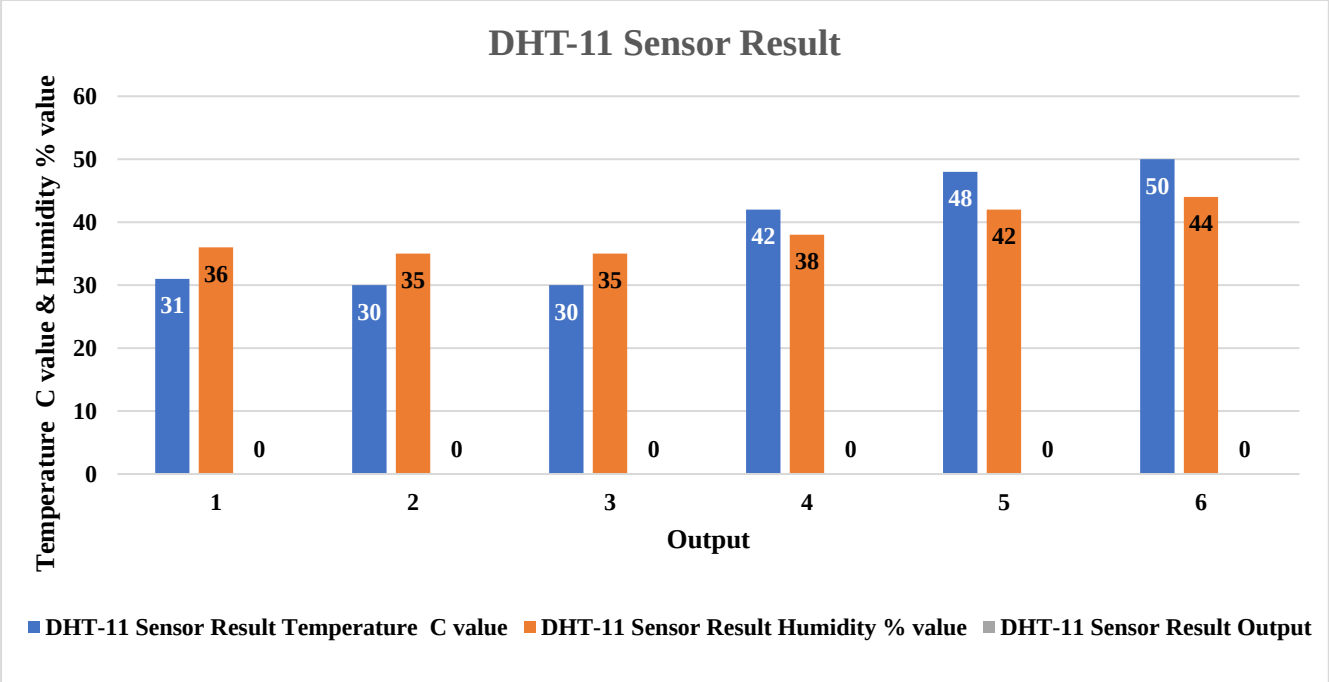

Figure 8: DHT-11 Sensor Result

4. Connect SIM900 Shield to Arduino UNO

Connect with any 2 G SIM, to any global GSM network. Send and receive SMS message. Also accepts Full-size SIM Card (Mahzan et al, 2019).

The Connections

- Link D7(Tx) and D8(Rx) shield pin to Arduino wireless pin#7 and #8.
- Connect GND pin in SIM900 Shield to the Ground pin on the Arduino.
- Attach the antenna and insert SIM card fully charged into the socket.
- The input: SIM900 must importin part in the fire system, it gets information from Arduino. Software use function known as update Serial) (waits for any serial monitor inputs and sends it through the D8 pin to the SIM900 shield.
- The Process: Arduino send an SMS to the owner phone number. First, we need to enter the phone number.
- The output: Figure 12 shows SIM900 Shield sensor output, where It's initialized and connected correctly.

Figure 9 SIM900 Shield sensor output

5. Connection of the buzzer to Arduino UNO board

A buzzer is a small component used to supplement sound features to our system. It is an alarming circuit, with the main purpose is to alarm the owner about the occurrence of fire.

The Connections

- Connect VCC pin in buzzer to the positive pin on the Arduino.
- Connect GND pin in buzzer to the ground pin on the Arduino.
- Connect Data-Out pin in buzzer to the digital pin 4 of the Arduino.
- The input: Get information (High or Low) from the MQ-2 sensor and the DHT-11 sensor throw Arduino.
- The Process: If the gas or temperature are high, that mean a fire in the farm so the buzzer will make a sound to alarm any on in or around the fire area.
- The output: High sound that alarm anyone in the farm throw fire.

6. Discussion & Results

6.1. Testing the system on small area.

We divided the process of testing the system in to sequences of steps, where each step indicates a start to the next step.

6.1.1 Step one

In this step we must make sure that all parts of the system are well connected to each other because each piece has its own place and changing their places or mixing them will introduce a failure to the work of system. Furthermore, the pieces are connected to each other using plugs, wires or specific places to be put inside it is also affecting the result of the system.

Therefore, the system will not work at all if one of the following cases are exist.

- The system is not well connected with each other.
- If there is a cut or damage in one of the pieces.
- If one of the pieces is not exists.

In short, the owner of the farm needs to make sure that the system is well connected by checking it manually.

6.1.2 Step Two

We put the Arduino alarm system device on the farm to test the system's response. We need to consider the place of putting the system as an importing step after connection. This is maybe cause damage to the system's part due to influencing factors such as water or heat. Such influencing factors will produce errors to the system output, which may have resulted in to false alarm. Overall, choosing a right place to put the system on without causing any failure.

6.1.3 Step Three

We burned a test fire to measure the response of the sensors in the system with taking all the caution in order to save ourselves and the rest of the farm. In this step we used a little dry grass to be burned and mud in order to put down the fire. What we notice is while the grass starts to burn, a lot of smoke came out of it, which what we really need to reach in this point because smoke is what we need to make the system work perfectly. In all, smoke came out of the burned dry grass as wanted in this stage.

6.1.4 Step Four

After the grass has been burned, the smoke came out of it. Now we can test the sensors, are they sensing any smoke or not and/or are they working at a perfect time before the fire starts up or they need lots of times which will cause damage then they will work. What really happened is that the DHT-11 temperature sensor and the MQ-2 smoke sensor sense the smoke immediately and produce a result, which is what we waited for. The results of them is high sound alert as a reflection of sensing a smoke. In short, the DHT-11 temperature sensor and the MQ-2 smoke sensor are working fine as the buzzer sound alert was activated.

6.1.5 Step Five

We cannot reach to this stage unless we first placed the system in its right place, burned a dry grass in order to make a smoke and checking both of the gas sensors in order to produce a sound. Where then SIM900 Shield starts to work after receiving a signal form both DHT-11 temperature

sensor and MQ-2 gas sensors. This is resulted in SIM900 Shield sent a message (SMS) to us as the farm owner in this test, through the SIM associated with the SIM900 that is responsible for sending the (SMS) alarm to warning the farm owner about high temperature and the fire on the farm. Now we can go and check the smoke in the farm. If there is a fire even if it's very little, we should call civil defense before taking any action. But if the smoke is just to start, then we or the owner can handle it alone. The overall steps of testing are summarized in Figure 13.

```
Initializing…
AT
OK
AT+CSQ
+CSQ: 24,0
OK
AT+CCID
889166994280892961 81
OK
AT+CREG?
+CREG: 0,1
OK
```

Figure 10: SIM900 Shield sensor output

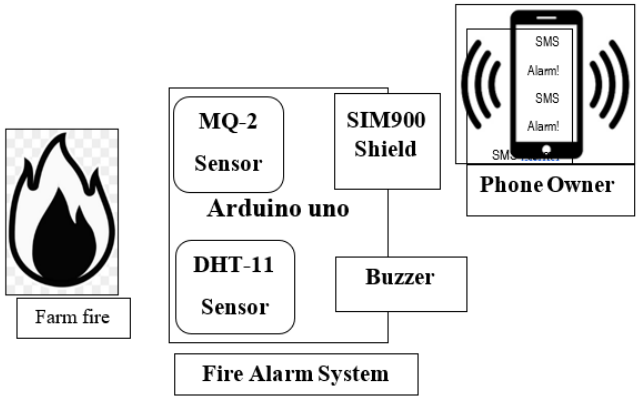

Figure 11: Testing Steps Summarization

6.2. Results

The sensors detect the increase of gas/smoke and temperature in the air and send warning. Result of testing are showing in Figures 14, 15, 16.

```
#include <dht.h> // Temp sensor lib

#include <SoftwareSerial.h> // lib to access Serial for send

 //for Temp sensor
#define dht_apin A0 // Analog Pin sensor is connected to DH

//Create software serial object to communicate with SIM900
SoftwareSerial mySerial(7, 8); //SIM900 Tx & Rx is connected

//for buzzer
const int buzzer = 9; //buzzer to arduino pin 9

dht DHT;

bool tempHazard;
bool gasHazard;

bool isSMSsended;

//for Gas sensor
float sensorValue;
float MQ2pin=A5;

void setup(){
```

COM11 (Arduino Uno)

Send

```
High temperature detected!
30.00 gas: 473.00
High temperature detected!
30.00 Smoke detected!
556.00
High temperature detected!
30.00 Smoke detected!
542.00
High temperature detected!
30.00 Smoke detected!
555.00
High temperature detected!
30.00 gas: 432.00
```

Autoscroll | No line ending | 9600 baud

Figure 14: Testing Results measurements

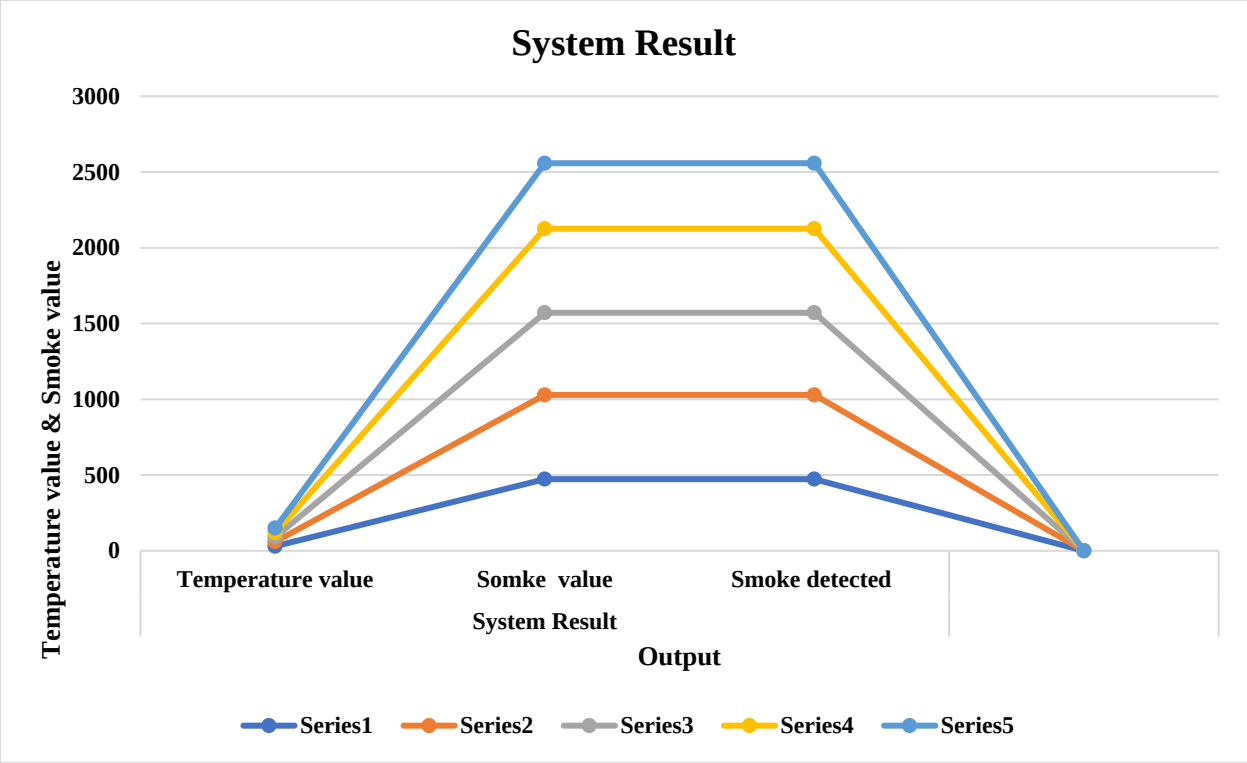

Figure 15: System Results

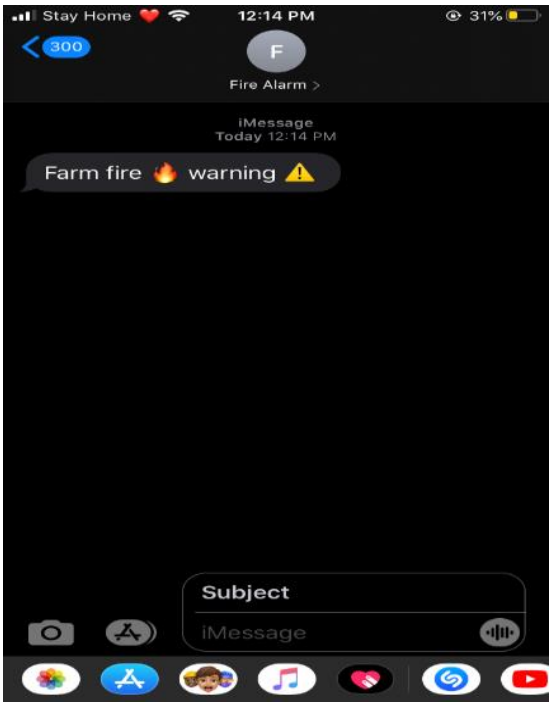

Figure 16: Testing Results on mobile framework

6.3.Testing the system on a large area

As most of us know that the farm is measured using square feet, kilometers or yards. The right measurement is selected according to how large is the farm. Therefore, the area of the farm can be considering as a factor that affected the work of the system.

In our project, all the sensors and pieces of the system are used to test small area of a farm. Such sensors actually are used for a study or research. So, they are not used for abuilding a complete consisting system in business demand.

If such business demand project is required, then all the sensors must be updated or changed in to industrial standards sensors in order to give better result or to sense better detection. Since, our system is not designed to work in a large area of the farm, therefore, we did not test it on such kind of area because we already know that it isn’t right due to the type of equipment that we used to build the system.

6.4 Testing the system during bad weather

Weather condition is considered as a key factor that affect any outside system. It causes different and various inputs reading of the air. For example, gas result in a raining weather is completely different from a result in a windy day. This kind of study required updating the system's sensors with other type of sensors that are designed to work in such climate. It's also required to do the study in a long period of time might be years. Besides, such sensors are expensive to be bought, since we are students. So, our system has not designed to work on different weather conditions, therefore, it's not tested on variety of changed climate.

7. Conclusion

Farm fires do significant harm to society, the economy, and the environment. Farm fires cause social well-being to be lost, livelihoods to be lost, and environmental quality to be reduced. Agriculture, recreation, and wildlife are among the economic sectors most adversely affected by fires. Nonetheless, due to the limited data and studies on the fire impacts, we consider the fire impacts. A fire alarm network, a mixture of remote sensing, is a significant array of industrial and private premises safety devices. This complements a fire extinguisher-a special piece of equipment used to put out any fire in a building that might break out. A fire alarm system is a substantial collection of safety procedures

and devices for both industrial and private premises. Our fire alarm system is for any farm. A fire alarm system consists of a few devices that work together to detect fire and alert people in the event of a fire outbreak via audio or visual signals and through sending messages to the owner of the farm. The current system describes the structure of a farm alarm using GSM Module methods with an Arduino-based system. The purpose of it is to avoid the fire accidents that have happened on farms and in properties within farms. It uses an ATmega328 chipboard similar to the Arduino Uno. The central controller used is the ATmega328, which controls the alert of a farm fire exposed to the sensor of temperature and the sensor of gas/smoke. In the GSM module, an alarm message will be sent to the client via short message administration.

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