Smart Home Warning System for a Safe Environment

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Abstract

With the development of technology, further opportunities to protect vulnerable family members, who may need to be left alone for a while, are achievable. Furthermore, it is desirable to have a system that can detect gas leaks and control the temperature and humidity of a room, particularly in homes. This project provides a venue to build an Internet of Things (IoT) system that can detect gas leaks, high humidity levels, or other auxiliary factors that could cause a fire or undesirable consequences in a typical home. The project was developed using a microcontroller (Arduino-based) monitoring system with an appropriate smartphone application (Blynk) that can detect gas leaks and control the temperature and humidity of a house.

Index Terms
- Arduino
- Automation
- Gas Concentration Levels
- Humidity
- Temperature

Introduction

A. Problem Statement

Recent devices offer specific features for measuring environmental factors, such as temperature or humidity. These devices have continued to develop in quality and convenience, yet their one specific use limits them. Additionally, these devices are solely made for monitoring factors and do not cater to response, such as an alarm system, when environmental factors become hazardous. These restrictions further prohibit the comfort of easily monitoring important factors in an environment while the user understands that they will be notified of the event being controlled without the need for cooperation. This comfort is especially required in the case of vulnerable people, such as those who may not be able to monitor these elements and cannot react accordingly should a life-threatening incident arise.

B. Motivation

Protecting a vulnerable family member who might be left alone for a while is important. Additionally, it is desirable to have a system that can monitor temperature and humidity levels and detect any gas leakages in a room. Our project aims to provide a venue for participants to build an IoT system that offers these aspects with the prospect of preventing other dangerous events that could leave those living in a home at serious risk.

Background

In exploring similar projects, it was found that other works utilized a gas sensor and mobile application to monitor and alert the user when harmful gasses such as LPG, propane, butane, methane, and other natural gases in the area exceed a certain gas concentration level [1].

Automation has become increasingly prevalent daily, with wired and wireless systems almost becoming necessary. Furthermore, home automation continues to develop, taking advantage of IoT technology, as seen by converting ordinary homes into smart homes using digital assistants such as Amazon's Alexa, Google Home, Google Assistant, Apple's Siri, and Microsoft's Cortana [3]. Additionally, an Arduino-based system is a powerful and low-cost system that is easy to construct and is compatible with smartphone applications (Android) [2]. Combining the low-cost and powerful qualities of an Arduino-based system and the development of smart homes using IoT technology, several ventures into creating a device that monitors a room's temperature, humidity, and gas concentration levels have been published [4]. Contrastingly, these projects focus on the general monitoring of any facility and do not mention implementation into a smart city, which involves improving a citizen's quality of life using information and communication technologies. Like smart cities, smart home devices are connected and controlled through a smart device such as a smartphone, tablet, or laptop. Smart homes usually use home-based innovations such as smart thermometers, smart power outlets, and smart locks.

Methods

C. Components

Arduino is an open-source platform used in electronic prototyping and consists of several hardware types: circuit boards containing a microcontroller; and an integrated development environment, which is used to program the Arduino board. The Arduino components used in this project are looked at further below. Some applications will be taken as examples that can help make learning to program the Arduino board more interesting [5].

- **Arduino Uno R3**
  A type of Arduino board that utilizes the ATmega328P microcontroller. Of its many components, this project used 14 digital input/output pins, six analog inputs, a USB connection, a power jack, and a reset button to power and program the board to monitor a room's environmental factors.

Figure 1. Arduino Uno R3 Board

- **DHT11 Digital Temperature and Humidity Sensor**
  A basic, low-cost digital temperature and humidity sensor. Using a capacitive humidity sensor with a thermistor, the sensor measures the surrounding air and outputs an electrical signal according to the measurement.

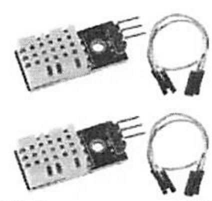

Figure 2. DHT11 Temperature and Humidity Sensor

- **MQ-5 Gas Sensor**
  Using a sensitive filament of tin dioxide, the sensor measures gas concentration levels and electrical conductivity depending on how clean the environment's air is. Specifically, in cleaner air, the filament has a lower conductivity. When the conductivity of the filament rises, the change in the filament's resistance indicates the equivalent gas concentration.

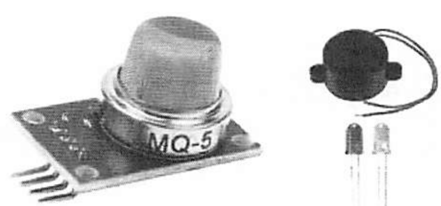

Figure 3. MQ-5 Gas Sensor

- **Arduino LCD**
  Used in conjunction with the Liquid Crystal library in the Arduino IDE, this component shows information programmed on a 16x2 display.

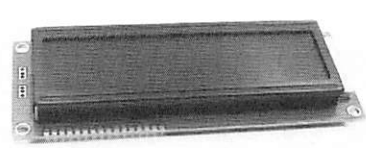

Figure 4. LCD Display

- **Bit Fenix Specter**
  A simpler component used in the project, this fan is powered using wires typically used by aspiring electrical engineers and provides low-noise air cooling.

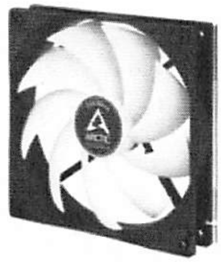

Figure 5. Bit Fenix Specter 140 mm Fans

- **Arduino IDE**
  The Arduino's Integrated Development Environment (IDE) was used to send instructions to the Arduino Uno board. The software allowed the programming of the Arduino to monitor and display a room's environmental factors on the LCD using data from the connected sensors.

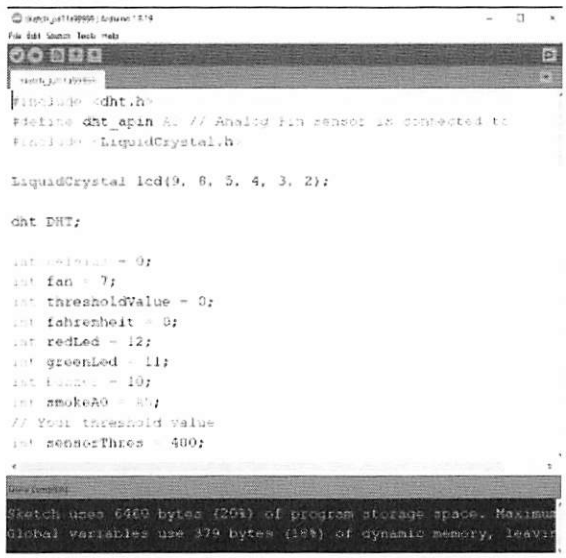

Figure 6. Arduino IDE

D. Technical Approach

To construct the monitoring/detecting circuit, a general idea of how the circuit should be constructed was conjured and displayed visually in the block diagram below.

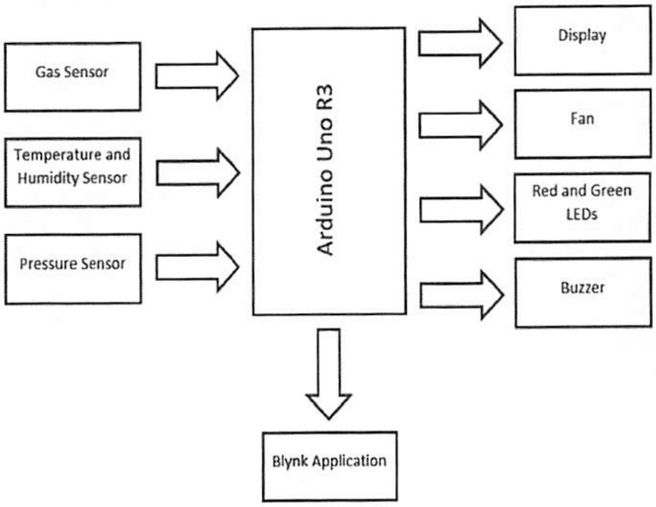

Figure 7: Block diagram of the project.

The diagram is associated with the flow of data and what elements are used sequentially. An implantation diagram involving images of the sensors used was also created to provide an in-depth visual representation of the overall circuit.

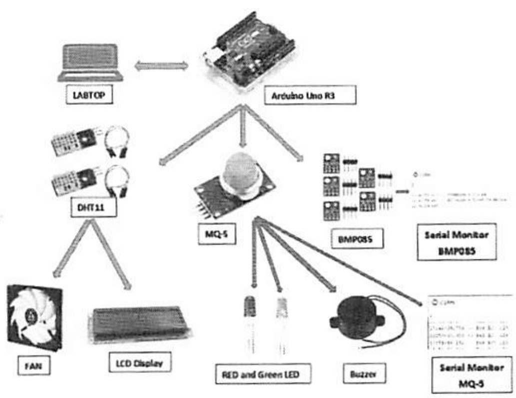

Figure 8. The implementation diagram simplifies the connections made for our circuit.

System analysis

E. Implementation

An individual understanding of each sensor was needed to design a circuit that implements the connections and behaviors seen in the previous diagrams. This was done by constructing separate circuits, each with its respective sensor to measure a particular environmental factor. Coinciding with each circuit, the Arduino Uno was programmed to further implement a certain behavior, determined by the data from each sensor. Although the code used to program the Arduino was provided, it was also studied to understand each function and how it can be implemented in the overall circuit.

The following figures indicate each subcircuit, highlighting the sensors and external components utilized.

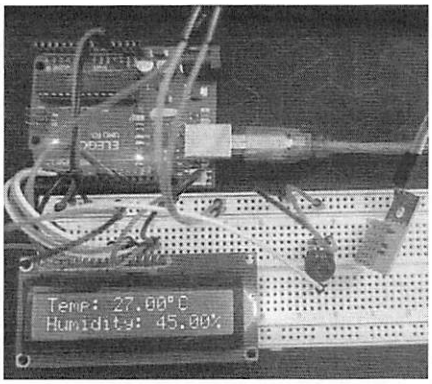

Figure 9. The temperature and humidity circuit, with the DHT11 sensors' data displayed on the LCD. Although not shown in this figure, it is worth mentioning that the fan works in compliance with this circuit, turning on should the temperature exceed 15°C.

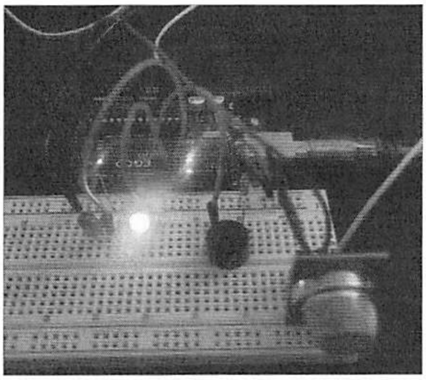

Figure 10. Gas concentration circuit, with the data from the MQ-5 sensor determining which LED TO power on; in this case, since the concentration level is below the threshold value, the green LED is on. Should this value be exceeded, the red LED would turn on along with noise from the buzzer.

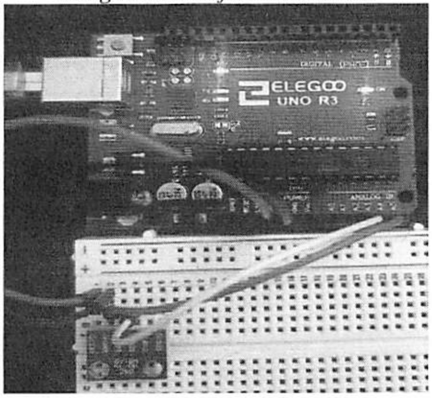

Figure 11. Pressure and altitude circuit, utilizing the BMP085 digital barometer.

It should be mentioned that the readings from the BMP085 were initially displayed on the LCD. However, the sensor failed to perform individually and was not later incorporated into the overall circuit.

Once the performance of each sensor was confirmed, the circuit containing all sensors and external components (except the BMP085) was designed and can be seen in the schematic below. A schematic was and is shown below.

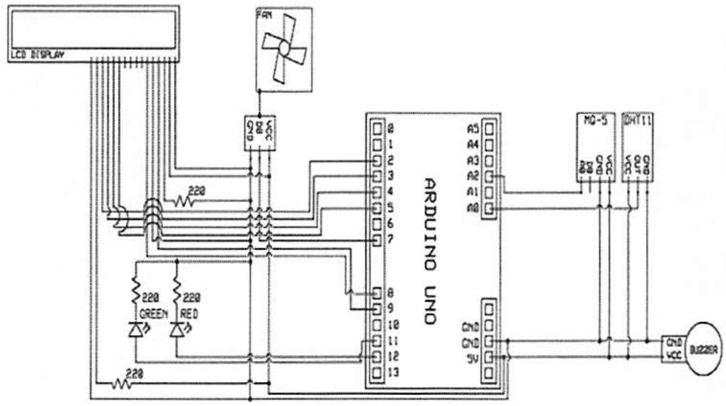

Figure 12. Schematic of the overall circuit designed by the connections of the subcircuits in figures 9, 10, and 11.

It is worth mentioning that not all pins of the Arduino Uno are shown, but rather those that were pertinent to the project. Additionally, the connection made to the computer to power and program the Arduino was not shown; this is solely due to the circuit not relying on the computer to function and can utilize any power source within the Arduino's limits once it has been programmed. Once again, due to the BMP085 digital barometer not performing correctly, it was not incorporated into the overall circuit.

After completing the schematic of the overall circuit, the code was rewritten to have all functioning sensors and external components work congruently. To do so, the code used to program the circuits seen in figures XX, XX, and XX was combined and can be found with a general explanation of each significant area below.

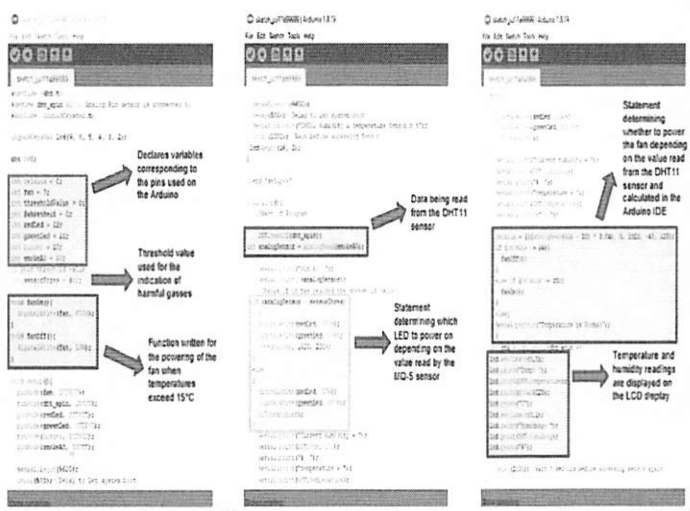

Figure 13. Code that programs all sensors and external components to work simultaneously.

After the circuit's design and code were completed, it was then constructed, and its performance was verified. The constructed circuit can be seen in the following figures.

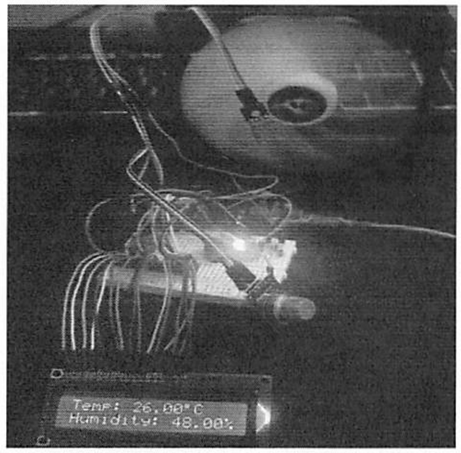

Figure 14. The constructed overall circuit displays the room's temperature and humidity, which then power the fan, indicating the environment is free of harmful gasses (as indicated by the green LED).

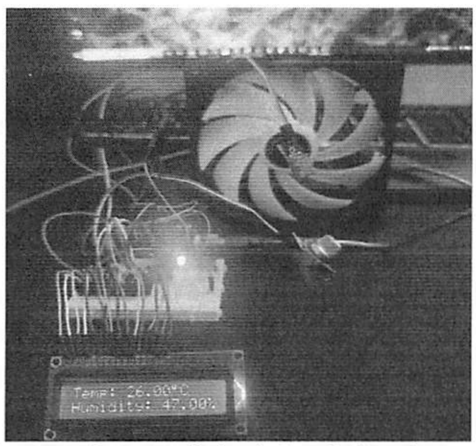

Figure 15. Constructed an overall circuit that displays the previous figure's functions but with the fan powered off for a clearer figure.

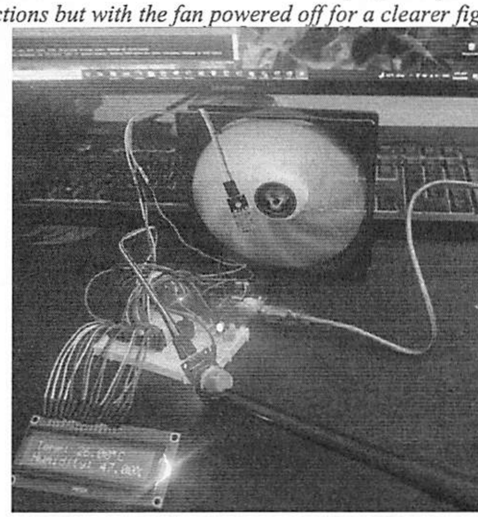

Figure 16. Circuit indicating harmful gas concentration levels (as indicated by the red LED and the sound of the buzzer) due to applying gas from the lighter.

F. Challenges

Unfortunately, the Arduino Uno R3 cannot incorporate notifications sent to the user's phone through the Blynk application. When compiling the code, the USB connection did not allow the information to be properly sent to the Blynk database and, therefore, could not connect with smartphones.

Certain components, such as Arduino shields, were not provided, which would have allowed the information to be sent via wi-fi or Bluetooth. In trying to manipulate the code, the main issue lay in not knowing which library/function was to be used for this behavior. The project was able to control the Arduino board from a smartphone. However, the regarding overall code circuit was unable to compile.

Results

To analyze the data recorded from the circuit, a consistent measuring process was maintained for one week to analyze its performance. This process entailed powering the circuit, programming the Arduino Uno to display the measurements of each sensor (either through the connected LCD or the serial monitor from the Arduino IDE), and recording the data into an excel sheet hourly. Although the data would have more merit if documented over a longer period, the project's limited time allowed for only one week of recording measurements. It was important to ensure that the circuit measured the factors of one specific environment to not affect the results and, subsequently, the overall conclusion. In the case of this circuit, it was exclusively used in a bedroom and therefore was not affected by other elements.

The recorded data can be found in the table below.

Table 1. Hourly data was recorded for this week using the DHT11 and MQ-5 sensors. The pressure and altitude data are not included because of the inability of the BMP085 to perform correctly.

Environmental measurements

Temperature (°C)

Days/Time	9	10	11	12	13	14	15	16	17	18	19	20	21
Monday	24.35	25.12	25.96	25.82	25.23	26.58	26.22	26.44	27.33	27.53	27.52	27.12	27.35
Tuesday	25.30	25.31	25.35	25.45	26.11	27.52	27.37	27.45	27.93	28.13	28.12	27.17	26.90
Wednesday	24.53	25.16	25.4	25.80	26.36	26.45	26.58	26.86	27.23	27.53	27.34	27.42	27.05
Thursday	24.22	24.25	25.5	24.72	25.48	25.5	26.22	27.23	27.34	26.98	27.53	27.36	27.96
Friday	24.23	24.33	25.45	24.4	25.96	25.53	25.45	25.55	24.93	24.4	24.5	24.4	24.56
Saturday	24.5	24.35	24.45	24.35	24.45	25.44	25.33	26.44	26.33	26.44	24.4	24.12	25.45
Sunday	24.45	24.35	24.90	24.59	24.55	24.37	24.93	26.33	26.34	26.45	24.57	24.13	25.96

Humidity (%)

Days/Time	9	10	11	12	13	14	15	16	17	18	19	20	21
Monday	49	47	48	48	47	46	49	51	52	53	53	53	54
Tuesday		48	49	49	53	54	53	53	53	50	48	48	52
Wednesday	49	47	48	48	47	46	49	51	52	53	53	53	54
Thursday	50	51	52	51	47	47	46	51	52	53	53	53	56
Friday	50	51	53	50	52	50	54	57	49	49	51	49	51
Saturday	49	50	52	52	51	52	52	53	54	54	53	49	49
Sunday	52	51	51	51	50	50	49	49	51	52	48	48	51

Gas Concentration

Days/Time	9	10	11	12	13	14	15	16	17	18	19	20	21
Monday	180	144	163	148	164	131	133	144	137	133	108	137	139
Tuesday		139	133	123	120	130	120	123	119	122	120	126	121
Wednesday	132	130	136	135	125	125	128	136	127	126	126	126	126
Thursday	120	125	123	124	122	151	100	104	104	100	90	130	90
Friday	180	144	165	148	164	131	133	144	137	133	108	137	139
Saturday	174	176	123	175	177	178	181	179	176	175	178	168	167
Sunday	178	173	173	172	172	175	174	176	177	175	173	174	174

The data were then visually represented by a line graph to indicate the stability of the circuit's performance throughout the recording period.

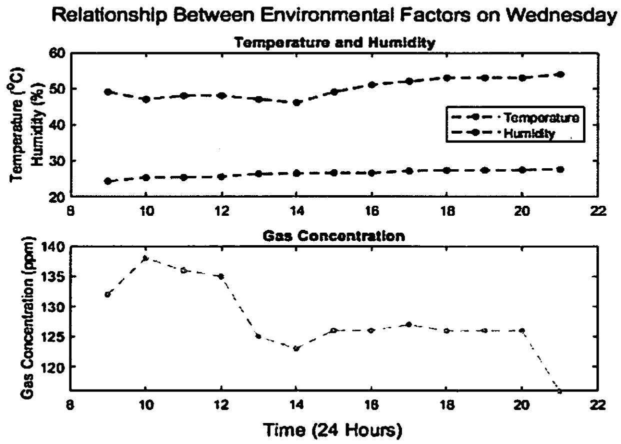

Figure 17. Temperature, humidity, and gas concentration levels were collected on Wednesday using the data from the excel sheets seen in Table 1.

Conclusions

Acknowledging the challenges that were not overcome during the project, the overall circuit was still successfully constructed and programmed to do the following: display measurements from sensors on an LCD and Arduino IDE's serial monitor, notify users of a high gas concentration level with a red LED and a buzzer, automatically turn on a fan when a certain temperature has been exceeded. By creating a program that involved all sensors working simultaneously and implementing this program on the Arduino-based system, the recorded hourly data was used to analyze the sensor's results and verify the circuit's performance.

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