CSE360: Computer Interfacing

Lab Project Report

Project: DisasterGuard

Submitted by

Group 7

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Date of Submission: 05.08.23

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1. Introduction

In a world that constantly evolves and where safety is of the utmost priority, there has never been higher demand for reliable safety and multi-hazard detection devices. Traditional security methods frequently fall short when it comes to identifying and responding to various threats at the same time. As a result of the enormous dangers posed by thefts, fires, gas leaks, and other environmental hazards like earthquakes, a security strategy that is both smarter and all-encompassing is required. In response to these issues, an innovative system called the *DisasterGuard* - an all-in-one smart security system using Arduino has been developed as a solution. In this report, we look at how *DisasterGuard* uses cutting-edge tech to enable real-time monitoring and detection, making it a preventative and efficient way to keep both individuals and their property secure.

1.1 Motivation

The design and development of the *DisasterGuard* were driven by a profound dedication to ensuring the safety of the lives and assets of individuals, like home, office, and property spaces, as well as public spaces, in a society that is filled with continuous dangers and risks to our overall safety. Creating a secure environment in residences, workplaces, and public areas is the main driving force behind *DisasterGuard*, which aims to provide users with a sense of peace and assurance. The advanced functions of the system allow individuals to face the future with assurance, knowing that their safety and security are always prioritized and protected.

1.2 Objective

Our system provides 24/7 monitoring in the eventuality of natural disasters such as earthquakes, fire outbreaks, and toxic gas emissions. In addition to this, it also detects forceful entry and theft attempts. Through real-time notifications sent to the user's phone, it ensures the safety of their individual lives and also their home, workplaces, and so on, by guaranteeing immediate action and protection through alerts and buzzers.

2. Project Overview

2.1 Application Area

The *DisasterGuard* provides reliable safety and has the ability to detect multiple types of hazards in today's ever evolving world. This device can be installed in residential spaces, workplaces, and public areas. The existing traditional security methods often fall short in multiple categories, but our device aims to provide an all-in-one solution that is smarter and more convenient. The real time monitoring ability enables it to be used in multiple areas, ranging from industry usage to personal usage at home. It can also be used in hospitals, schools, colleges, and educational institutions to ensure the safety of students and potentially save lives. This device has huge potential and the ability to be used in a wide variety of places because of its simplicity and multi-hazard detection in an all-in-one form factor.

2.2 Technologies and Components

2.2.1 Hardware Components:

Our project revolves around the utilization of an Arduino board and some fundamental electronic components to create a simple yet effective home security system.

- **The Arduino board (Arduino Uno R3):** The fundamental control unit of our project, facilitates smooth communication between all components.

- **Breadboard (MB102 Breadboard)**: It serves as a prototype platform, facilitating the smooth connection and placement of numerous electrical components.

- **Jumper wires:** Jumper wires are necessary for creating electrical connections and ensuring effective communication between components on the breadboard.

- **Smoke and Gas Sensor (MQ135):** It detects the presence of hazardous gasses, alerting occupants in the case of a leak or accumulation and protecting against possible fire threats.

- **Accelerometer sensor (ADXL345):** It detects any rapid movement or manipulation and raises appropriate alerts, adding an extra degree of protection.

- **Microwave Motion Sensor Module (RCWL-0516):** It detects human movement, allowing for immediate response to potential intrusions.

- **GSM Module (SIM800L GSM Module)**: It allows SMS warnings to be delivered to users' mobile devices, facilitating distant communication and ensuring constant vigilance.

- **LED lights (RGB 2 Pin LED 5mm):** As visual indications, the LED lights indicate the condition of the system and give a rapid peek at any possible security concerns or breaches.

- **Buzzer Alarm (Piezo Buzzer):** The piezoelectric buzzer produces sound by vibrating a metal plate using pulse current and the piezoelectric action of piezoelectric ceramics.

- **Battery 3.7V lithium-ion:** Powering our entire home security system, the 3.7V lithium-ion battery ensures uninterrupted operation, providing a reliable and portable energy source.

2.2.2 Software Components:

For this project, we used Arduino Uno, which supports a simpler version of the C/C++ programming language and is hence ideally suited for our project working with Arduino boards. The software communicates easily with the Arduino board, allowing for smooth control and synchronization of the numerous electronic components.

- **Arduino Integrated Development Environment (IDE):** The primary software interface used for writing code, compiling, and uploading programmes to the Arduino board

- **Programming Language:** The versatile C/C++ programming language employed to write the custom software programme that drives the home security system

- **SMS Notification System:** A software component integrated with a GSM module that allows the system to deliver real-time SMS alerts to designated phone numbers in case of security breaches or emergencies.

Our tool for writing code was the Arduino Integrated Development Environment (IDE), which came with a user-friendly code editor and gave us access to a variety of different libraries in order to configure and calibrate sensors and components. In addition, we used TinkerCAD to layout the circuit connections and ensure that all of the components fit appropriately in the basic blueprint of the project. Our project's effective conclusion was made possible by the use of TinkerCAD and Arduino together.

2.2.3 Technology Choices:

We chose the MQ135 sensor for smoke and gas detection in our home security system project because of its adaptability, sensitivity, cost-effectiveness, and availability. The MQ135 sensor detects a wide range of gasses, including dangerous ones like carbon monoxide (CO), methane (CH_4), and ammonia (NH_3), making it suited for a variety of applications. Its high sensitivity provides early identification of possible threats even at low gas concentrations, enhancing the safety of the system. Moreover, the MQ135 sensor's affordability makes it a budget-friendly choice, allowing us to implement a reliable smoke and gas detection system without significant cost constraints. Additionally, its widespread availability made the purchase procedure simple and straightforward, assuring seamless integration into our project.

Similarly, we picked the ADXL345 sensor for earthquake detection due to its high accuracy, broad sensing range, compactness, and digital output. The ADXL345 sensor measures acceleration and tilt with great accuracy, allowing for precise detection of seismic motions and vibrations. Its wide sensing range enables it to detect both little tremors and major seismic occurrences, allowing it to provide complete earthquake detection capacity. The sensor's tiny and lightweight form allowed for simple integration into our product, improving portability and ease of installation. These features collectively made the ADXL345 sensor the optimal choice for our earthquake detector, ensuring the home security system is equipped to respond effectively to seismic occurrences efficiently and safeguard the residents.

The Microwave RCWL-0516 sensor was chosen for intruder detection in our home security system owing to its efficiency in detecting human movement by emitting microwave signals and analyzing their reflections from nearby objects. It is a versatile microwave motion detector sensor module that is used for the purpose of motion detection. It also has the ability to detect motion from long range. It is energy efficient and conserves electricity, resulting in longer battery life in wireless applications. Its quick response time provides timely intrusion detection and response. Non-contact detection improves safety and decreases tampering risk, while filtering capabilities minimize false alerts. The Microwave sensor's high coverage range improves area protection with fewer sensors, boosting cost-effectiveness. Its simple integration with microcontrollers like Arduino simplifies development. Overall, the Microwave sensor provides a reliable and efficient means of securing homes from potential security threats.

2.3 System Functionalities

- **Real-time Multi-Hazard Detection**

  -detects earthquakes and toxic gas as well as smoke releases immediately by using the latest sensors

  -enables prompt action and response, which can help reduce the severity of potential loss

- **Earthquake Detection and Alert**

  -using ADXL345 an accelerator sensor the earthquake can be detected with real time monitoring

-emergency instant warning would be sent to the user to take precautions or immediate actions

- **Fire Outbreak Detection**

-integrate smoke and fire outbreaks

-buzzes alarm and alerts the user for the emergency actions

- **Toxic Gas Emission Monitoring**

-detects any harmful or hazardous emissions of toxic gasses like, CO, NH3 and smoke with MQ135

-helps to balance a moderate quality of the air for the particular space with the immediate instant sms warning

- **Forceful Entry and Theft Detection**

-using Microwave motion sensor the area (home/workplace/property space) for any signs of intrusion or theft is monitored

-notifies users of any unauthorized access, protecting them from negative consequences

- **Emergency Notifications and Alerts**

-gives users instant alerts during emergencies like earthquake or toxic gas emission

-conveys out a warning to people so they can leave the area or take other safety precautions

- **Backup Power and Redundancy**

-no need of continuous power supply

-incorporates redundancy to ensure continued operation under hazardous circumstances

3. Project Working Mechanism and Circuit Diagram

3.1 Working Mechanism of the system and sensors

The functioning of our system is based on the combination of sensors and ICs. Earthquake detectors, along with gas and smoke detectors are all linked to dedicated ICs that can accurately evaluate the signals they generate. The three sensors will continuously send their readings to the Arduino Uno, which will process them in real time. These ICs are the first stops in the data chain because they perform critical signal conditioning and early processing on the raw sensor data. During this stage, the signal is amplified, the noise is filtered out, and the analogue signal is converted to a digital signal.

The system is made to be installed against walls or next to doors, ensuring optimal coverage. A crucial point is that sensor inputs go through a calibration phase that consumes 30 seconds. Then, by calculating the average of the raw inputs, this step aims to reduce distortion and unstable signals.

The Microwave-RCWL-0516 sensor operates by emitting microwave signals, receiving the reflected rays, and analyzes the waves. When an object within range moves closer or further, the frequency of the reflected waves changes due to a phenomenon in physics known as the Doppler effect. Following this mechanism, this sensor is able to detect motion in its environment. The module's internal circuitry processes this frequency change and triggers a digital output signal, indicating motion detection. Microwave sensors, the first of which detects motion and temperature changes, provide the basis for the system's operation. To visually show when the microwave has detected motion, an LED lights up in our system. As an added safety measure, the circuit's integrated GSM (SIM800L) module, which uses a Nano SIM for its functionalities, immediately sends a notification to the designated phone. This module offers instant notifications in the event of recognized risks or security breaches for motion detection or fire breakout by detecting the presence of toxic gas or smoke after crossing a certain threshold implemented with the circuit programming, facilitating users to take corrective action in time to prevent them. This adds an extra layer of security, enabling rapid response and effective management of potential risks when using the GSM (SIM800L) module as a feature in the system. The MQ135 sensor reads analogue data for hazardous gas and smoke detection. After being digitized, it functions in the same way as the Microwave sensor, lighting up a different colored LED and sending alerts through text message as well as ringing up an active buzzer alarm for warning. It has a porous tin dioxide (SnO_2) sensor device that is heated by an internal heater. The surface of the SnO_2 sensing element goes through chemical changes that change its electrical conductivity when exposed to various toxic gasses. CO_2, alcohol, benzene, and NO_x tweak SnO_2 material resistance, which is evaluated to assess pollutant levels by which it will detect the threshold of pollutants according to the certain threshold set in the programming code and will light up the LED and buzzer will turn on. The ADXL345, which was developed to detect earthquakes, follows a similar methodology like MQ135 including a different color LED light up and buzzer alarm. It is a microelectromechanical system (MEMS)-based digital accelerometer which is made up of micro capacitive components that move in reaction to acceleration, influencing capacitance. Thus, with the help of the internal analog-to-digital converter, these modifications are transformed into digital signals that may be used to quantify acceleration along three dimensions with accuracy when someone crosses in front of the sensor. When it picks up on seismic activity, it uses a standard algorithm to evaluate the situation with a certain threshold of checking.

Hence, positioning sensor calibration and system integration all collaborate to enable reliable threat identification. Instant alerts, visual indicators, and different colored LEDs make it easier to decipher the results of various sensor detections ensuring an efficient safety system.

3.2 Circuit Diagram and data flow

3.2.1 Circuit Diagram

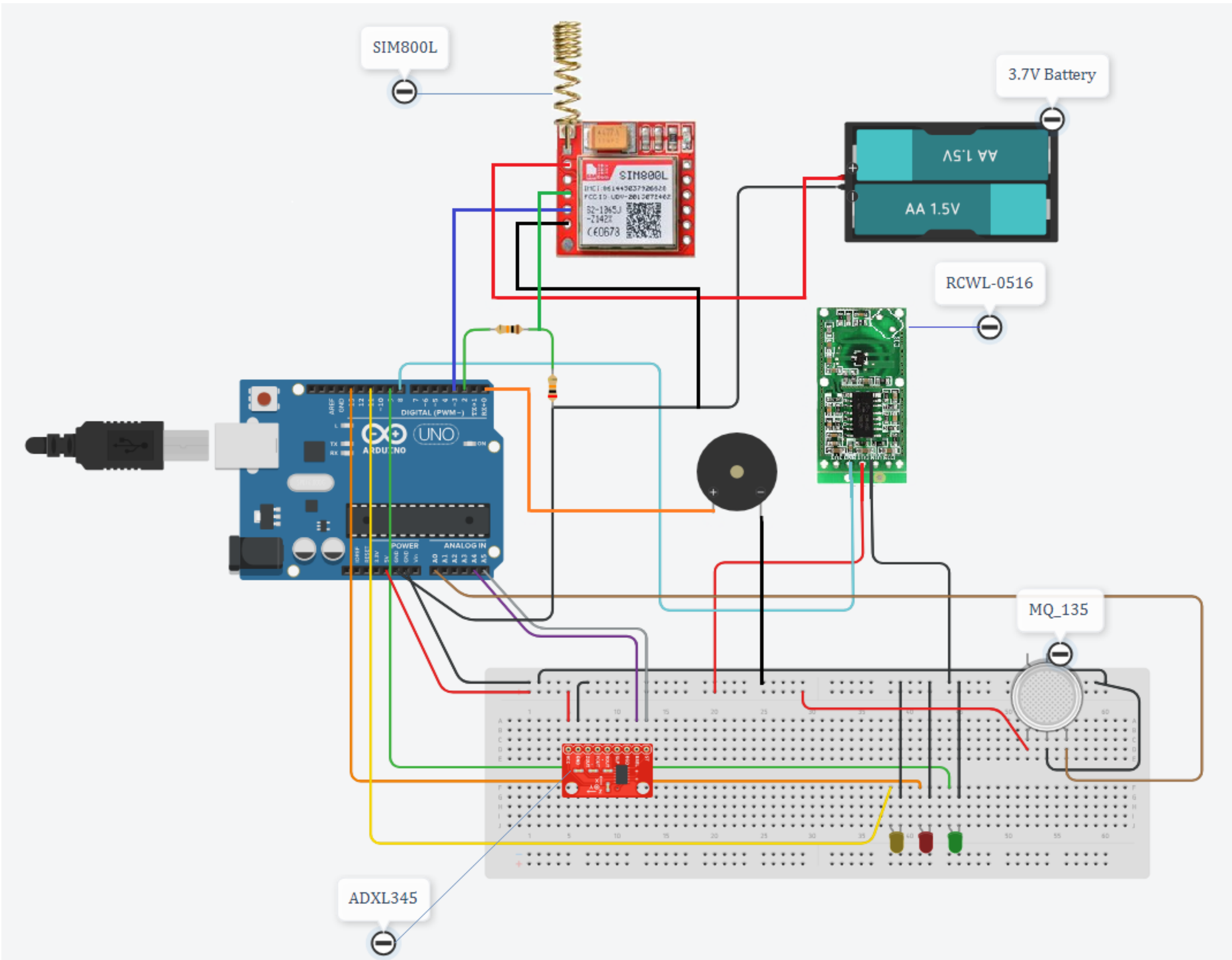

Figure: Circuit Diagram of the *DisasterGuard*

- **Connection with the IC**

For the connection, we have connected the Arduino's 5 volts and ground to the breadboard, which will work as a common ground and VCC. Then we placed the sensors and connected them accordingly to the board. Firstly, for the Microwave motion sensor, the VCC has been connected to the VCC pin of the sensor and the ground to ground. The Output pin of the sensor has been connected to the No. 8 digital pin of the Arduino. The anode points of the LED (RED) responsible for the output generated by the Microwave is connected to the 13 no digital pin of the Arduino, and the ground is connected to the common ground. For the MQ135 sensor, which has 4 pins named (Vcc, GRD, A0, and D0), the Vcc is connected to the Vcc of the breadboard, GRND to the ground, and only the A0 pin is connected to the analogue A0 pin of the Arduino. The output LED (GREEN), responsible for indicating the presence of gas, is connected (anode) to digital pin no. 9. Then the ADXL345 has four necessary pins (VCC, GRD, SDA, and SCL) to be connected. The VCC and ground are connected accordingly, and the SDA pin is connected to the A4 analogue pin, and the SCL is connected to the A5 analogue pin. The buzzer is connected to the digital pin on D11.

The Output is shown by the LED (YELLOW), which is connected to digital pin 11. Lastly, to send SMS, there is a GSM module (SIM800L), which has 4 pins to be connected (VCC, RXD, TXD, and GRD). The connection of the VCC is to an external 3.7 volt lithium-ion battery, and the ground is connected to the battery and the ground of the Arduino in a parallel connection. The TXD pin is connected directly to the Digital pin no. 3, and the RXD is connected to a resistor of 20 kOhms, which is then connected to the digital pin no. 2, and another resistor of 10 kOhms is connected to the ground. This will fulfill the circuit and make the whole system work seamlessly.

3.2.2 Data flow from sensor through ICs to I/O devices

The flow of data is a part of the system, and it is necessary to make sure everything is working properly. In this system, the dataflow is to the sensors, which are both analogue and digital, as well as output LEDs and a GSM module. The Microwave motion sensor sends its data through its output pin to the digital pin (D8) of the Arduino. If any motion is detected, it sends a high value(3-5v), which can be changed using the potentiometer on the sensor. When there is no object present, the output becomes a low signal. The signal is processed, and when the output of the sensor is high, using a digital pin (D13), the processor sends a high value to the LED (red) responsible for the output of the motion as well as sending an SMS by the GSM module. When the Gas sensor detects gas, the A0 pin on the sensor sends a high value signal denoting the presence of gas, which is received by the processor by analogue pins (A0), and it sends an output high signal (by pin 9) to the LED (green) and sounds the buzzer. For the accelerometer sensor, it sends two analogue signals (using pins SDA and SCL) to the Arduino (by pins A4, A5), which are then processed by the processor, and if the value is above the safe threshold, the processor sends a digital high signal (by D11) to the LED (yellow) to show the output as well as ring the buzzer. In all cases, data from the GSM module is sent through the TDX pin to the processor and received by the digital pin D3. The processor sends data as a digital signal from the digital pin (D2) to the RDX pin of the GSM module.

4. Project Cost Analysis

Estimated Cost Analysis

No.	Components	Quantity	Unit Price	Total
1	**MQ135**	**1**	**BDT 174**	**BDT 174**
2	**Microwave sensor**	**1**	**BDT 150**	**BDT 150**
3	**ADXL345**	**1**	**BDT 479**	**BDT 479**
4	**SIM800L GSM module**	**1**	**BDT 450**	**BDT 450**
5	**Jumper Wire 40 Pcs Set - Jumper Wire Type: Male to Female**	**1**	**BDT 100**	**BDT 100**
6	**Battery 3.7volt lithium ion**	**1**	**BDT 90**	**BDT 90**

7	**Piezo buzzer alarm**	**1**	**BDT 20**	**BDT 20**
8	**Lithium Battery Charger USB Micro-B**	**1**	**BDT 145**	**BDT 145**
9	**MB102 Breadboard**	**1**	**BDT 159**	**BDT 159**
10	**RGB 2 Pin LED 5mm (pack of 5)**	**1**	**BDT 10**	**BDT 10**
11	**Arduino Uno R3**	**1**	**BDT 1,100**	**BDT 1,100**
	Sub Total			**BDT 2,887**

Although our project serves multiple purposes, the overall cost remains notably low. Scaling up the implementation might result in higher costs, but in general, it remains a cost-effective solution.

5. Conclusion and future work

In conclusion, *DisasterGuard* presents a system that is efficient and reliable. *DisasterGuard* has the ability to detect multiple disasters like earthquakes and toxic gas. Along with that it can detect intruders and notify users about danger. In short, it is an all-in-one safety-device ensuring the safety of the users. Its real-time monitoring capabilities and quick response mechanism contribute to the safety and well-being of individuals and their properties. In future, we can furthermore increase its optimization for better accuracy.

In future we will make sure that *DisasterGuard* will have the ability to detect a wider range of toxic gas. Along with that it will have camera features and the ability to for remote monitoring and control. Additionally, it will have smart integrations, voice commands and mobile applications for ease of use. The *DisasterGuard* system provides individuals confidence, knowing that their safety and security are well-protected in the face of potential hazards.

6. Responsibilities of the Members

- Individual Contributions

  1. Ariyan Hossain:
     - Connection with the IC
     - Data flow from sensors through ICs to I/O devices
     - Programming Language
     - Assembling the circuit

  2. Raufar Mostafa:
     - Circuit Diagram
     - Connection with the IC
     - Data flow from sensors through ICs to I/O devices
     - Programming Language

  3. Maliha Jahan Maisha:
     - Cover Page
     - Introduction
     - System Functionalities
     - Circuit Diagram

  4. Rubayet Mahjabin:
     - Hardware Components
     - Software Components
     - Technology Choices
     - Project Cost Analysis

  5. Mansur Mahi:
     - Working Mechanism of the system and sensors
     - Application Area
     - Project Cost Analysis
     - Conclusion and future work

- Collaborative Efforts

In the project, our success was rooted in effective collaboration, driven by consistent and open communication among team members. We exchanged updates, challenges, and insights since regular conversations kept us all updated. This active exchange of ideas allowed us to provide fast feedback to each other, creating a dynamic setting where changes and adjustments were made quickly. This seamless communication and rapid feedback loop improved our combined efforts.

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