BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY
DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

EEE 416 (January 2022) **B1**
Microprocessor and Embedded Systems Laboratory

Final Project Report

IOT Based Smart Helmet for Industrial Workers

Evaluation Form:

STEP	DESCRIPTION	MAX	SCORE
1	Report (Format, Reference)	10	
2	Design Method and Complete Design (Hardware Implementation)	15	
3	Video Demonstration	10	
4	Novelty of Design	15	
5	Project Management and Cost Analysis	10	
6	Considerations to Public Health and Safety, Environment and Cultural and Societal Needs	10	
7	Assessment of Societal, Health, Safety, Legal and Cultural issues relevant to the solution	10	
8	Evaluation of the sustainability and impact of designed solutions in societal and environmental contexts	10	
9	Individual Contribution (Viva)	20	
10	Teamwork and Diversity	10	
	TOTAL	120	

Signature of Evaluator: _____

Academic Honesty Statement:

IMPORTANT! Please carefully read and sign the Academic Honesty Statement, below. Type the student ID and Write your name in your own handwriting. *You will not receive credit for this project experiment unless this statement is signed in the presence of your lab instructor.*

"In signing this statement, We hereby certify that the work on this project is our own and that we have not copied the work of any other students (past or present), and cited all relevant sources while completing this project. We understand that if we fail to honor this agreement, We will each receive a score of ZERO for this project and be subject to failure of this course."

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Table of Contents

1 Abstract

Safety is very important in every workplace, but very often we hear about accidents in different industries causing loss of life. The labours and workers working in any factory, industries, construction site or mine is vulnerable to accidents and therefore they should be with safety guards properly. In most of the accidents, number of deaths or severe injuries is maximized because the labours and worker are not wearing safety equipment or wearing low grade safety equipment. Working environment hazards include fall due to suffocation, poisoning gas leakage and sudden temperature rise. Hence air quality, hazardous event and location detection is very important factor in industry. To achieve those safety measures, the proposed system provides wireless sensors network for monitoring real time situation of working environment from remote monitoring station.

2 Introduction

There have been more than over 400 industrial accidents in Bangladesh, killing at over 1000 workers, injuring over thousands in 2021. These numbers are based on reported incidents and the real number may be far higher. In the previous year- 2020, at least 729 wage earners died in workplace accidents in different sectors, out of which 623 were male and six female. Of the 594 workplace injury victims last year, 571 were men and 23 women. Such incidents demand a feasible solution for safety of the labor across different industries.

An Internet of Things (IoT) based smart helmet for hazardous event and location detection with notification, a prototype is proposed for detection of poisonous gas, fall, temperature rise and location. In “IoT Based Smart Helmet for Underground Mines” [?], authors proposed a system in which smart helmet consists of various sensors. The only area where this work lags is it is only specific to mining industry. On the contrary, our proposed method works not only for mining but also for different industries. Moreover, it introduces notification system along with different sensors which instantly sends message to mobile to alert about the hazardous event.

In this project we aim to make a cheap but best effective Smart Helmet based on IoT which will not only monitor the real time working conditions of workers but also alert the control center in case of accidents. Main features of the helmet include sensing workers body temperature, temperature of surroundings, detection of harmful gases, fall detection, position of the worker in the plant. The helmet can send the measured data to the cloud platform for monitoring purpose and an alert buzzer is turned on in the industry for warning against any harmful conditions, also it will send an alert via message to the supervising team. Arduino uno is used as the microcontroller for prototyping purpose and ThingSpeak is used as the cloud computing platform.

3 Design

In this project, a prototype of Smart Helmet based on IoT (Internet of Things) which is less expensive but best effective has been designed which is able to monitor the real time working conditions of workers in underground mines and alert the control center if there is anything unusual.

The block diagram of overall design of the project is given below –

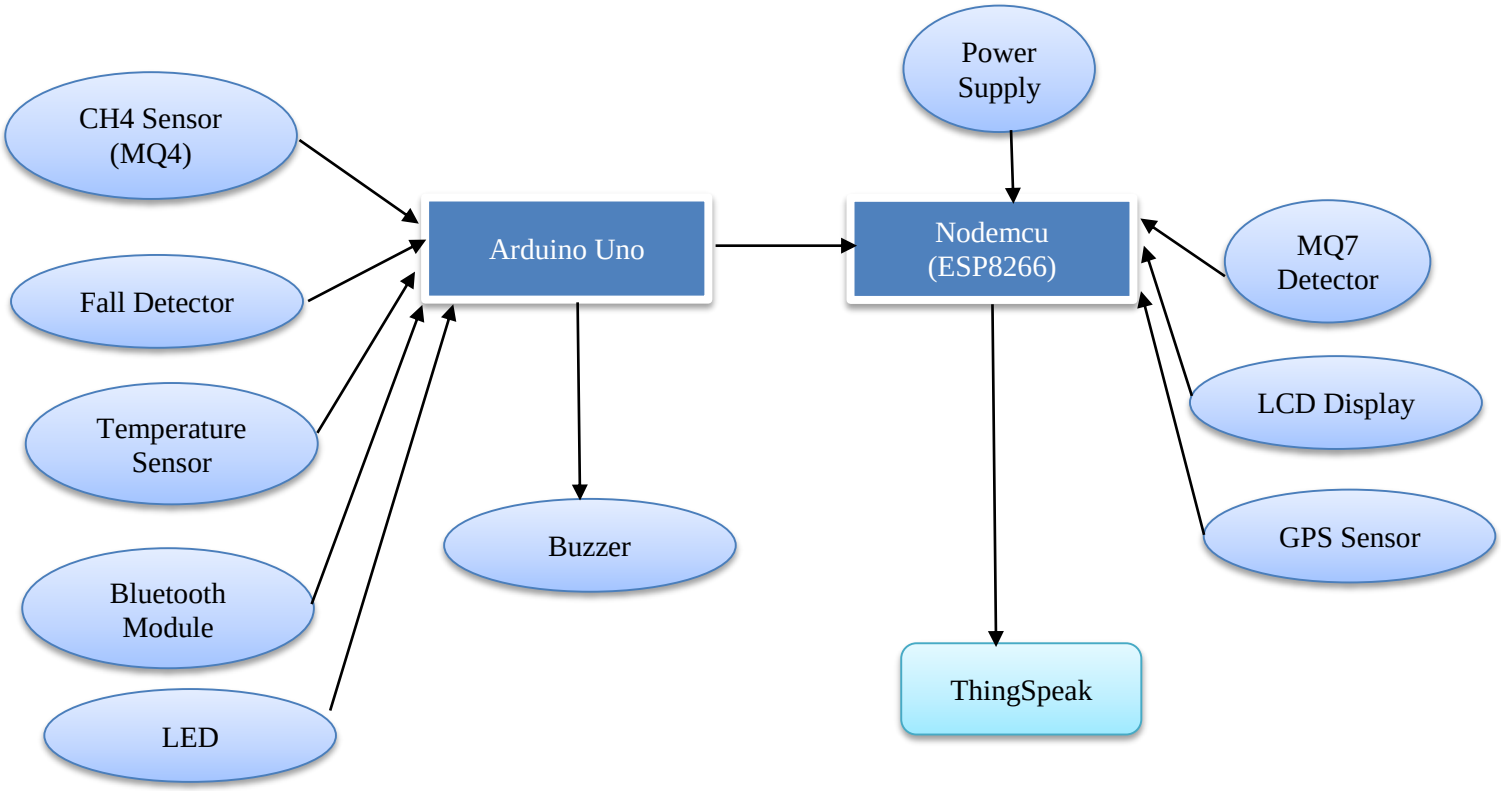
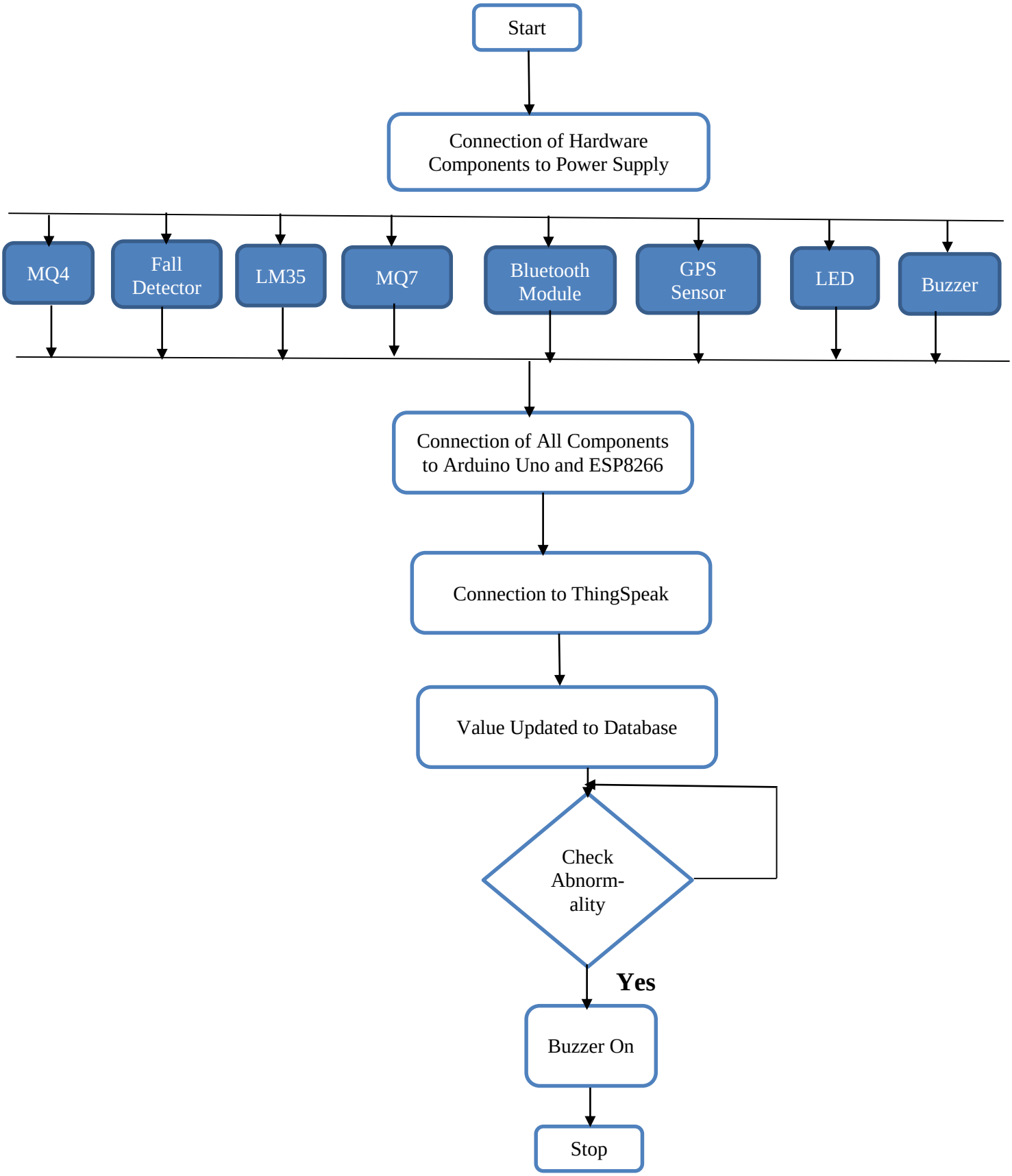


Figure: Block diagram of the proposed design

3.1 Design Method

The algorithm used for the design of our project is given below –



Following this algorithm, firstly schematic diagram and printed circuit board (PCB) are designed. Then circuit connection is made.

3.2 Circuit Diagram

The circuit diagram of the project is –

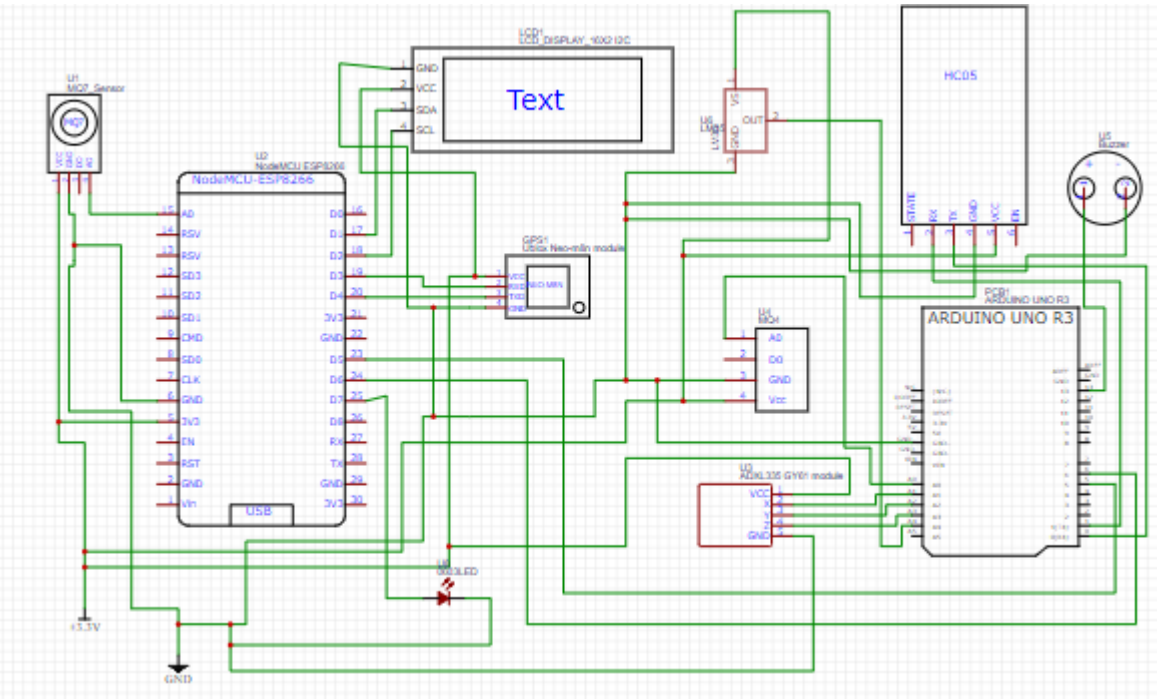


Figure: Schematic Diagram of The Proposed Project

3.3 Full Source Code of Firmware

Use small font size, Consolas Size 7, double column Test	

Table: Source Code for the main program

4 Implementation

- At first, schematic diagram of our proposed method is drawn using the software EasyEDA.

- After the completion of schematic design, PCB layout is generated.

- Then the hardware connections are implemented following the table below.

Components	**Arduino Uno (Pin No.)**	**ESP8266**
MQ4 (CH4 Detector)	Ao	-
Fall Detector	A1, A2, A3	-
LM35	A4	-
MO7 (CO Detector)	-	Ao
GPS Module	-	D3, D4
Bluetooth Module	0, 1	-
LED	D7	-
Buzzer	13	-

- After that, all the data are sent to ThingSpeak.

4.1 Description

As our target was to develop an effective safety helmet system for industry and mine workers, many important sensors and circuit components were used. They are as following:

1. **Temperature Sensor:** For measuring temperature we used LM35 sensor which gives analog output and it has output range of -25C to +125C. It has sensitivity of 10mv/C that is 1C produces 10mv change in output.

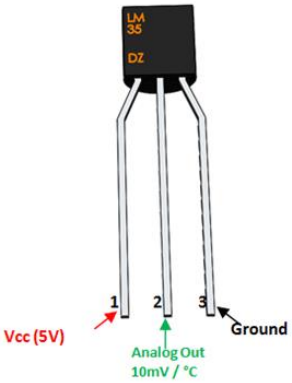


Figure: LM35 sensor

2. **Gas Sensor:** There are many types of gas sensors which detects different gases and its concentration. For workers in mining or heavy industries where methane and Carbon monoxide is maximum, we used MQ4 gas sensor which senses methane gas and the MQ7 gas sensor which senses carbon monoxide gas.

Figure: MQ7 and MQ4 gas sensors

3. **Fall Sensor:** This will be used to detect if the working wearing the helmet has fall down. It could be because of various factors in mine and industries like unconsciousness due to low oxygen, dangerous work environment, uneven ground etc. We used ADXL335 accelerometer for the fall detection, as it gives feedback against change in gravity in any of 3 axes with analog signal output by analyzing which, we can decide how to detect a fall from rapid acceleration change.

Figure: Adxl335 sensor

4. **GPS sensor:** This is used for tracking if the worker is going out of safety zones, or if the worker is trapped or falls in any sort of distress. The Neo M8N sensor is state of the art and can be used in his case to get a pretty accurate result.

Figure: Neo M8N Gps Sensor

5. **Bluetooth Module:** HC05 module can be used to send wireless signals from worker to the monitoring station and vice versa.

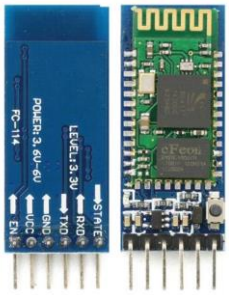


Figure: HC05 Bluetooth Module

6. **Nodemcu ESP8266 Board:** The main backbone of our project. The nodemcu board is used because of its wifi capability to send the data collected to a server, which can be accessed from anywhere. Here nodemcu is chosen because of its versatility, ease of access and cost effectiveness.

Figure: Nodemcu ESP8266 V2

7. **Arduino Uno:** A very popular micro controller board. This is used to measure the analog output from different sensors and then send it to the Nodemcu microcontroller.

Figure: Arduino Uno board

8. **16X2 LCD Display:** This is a backlit lcd display which has 2 rows and 16 columns to display characters, can be used to send any text for the workers to see.

Figure: 16X2 LCD display

9. **Buzzer and LED:** for warning and signaling purposes.

The summarized workflow of our overall system was as followed:

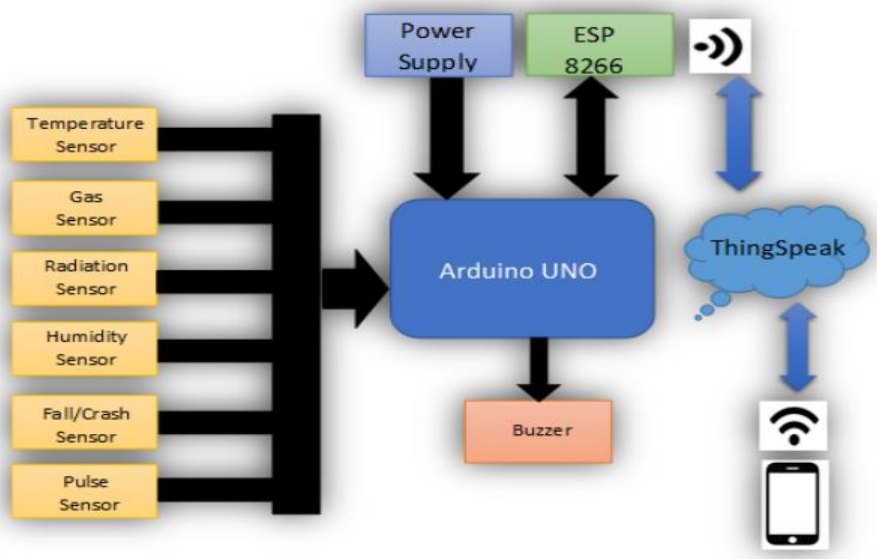


figure 1 Block Diagram of the proposed system.

At first we figured out the hazards a mining or industry worker experiences. Then ,the next stage was brainstorming how to use microcontroller and sensors to solve them. At the 2nd stage, we collected the sensors related to that and used Arduino and Nodemcu Board to connect the sensors, normalize and modify the outputs to get meaningful outcomes. As the Nodemcu had only 3 pins, we had to resort to using Arduino to get all the analog outputs. Then, difficulty came in transferring data measured in Arduino to Nodemcu. For which, we were managed to setup a serial communication between Arduino and nodemcu using serial communication protocol and Json buffer file.

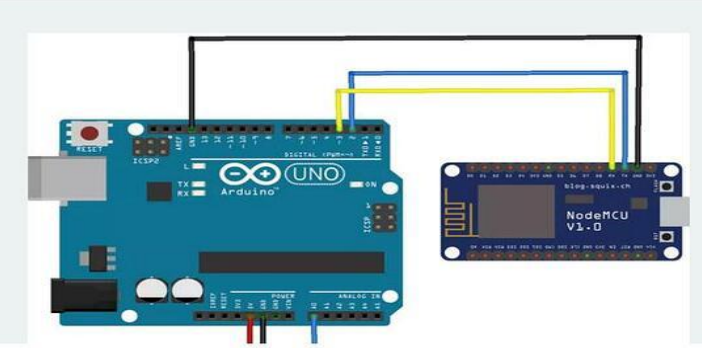


Figure: Serial Communication Between Arduino and Nodemcu

The next step was interfacing with the wifi. For that, nodemcu has built in wifi antenna. We then created an MathWorks account to log in to the ThingSpeak Server to see the results. We also Created two different channels, one to observe gas and temperature sensor data, other to observe gps data.

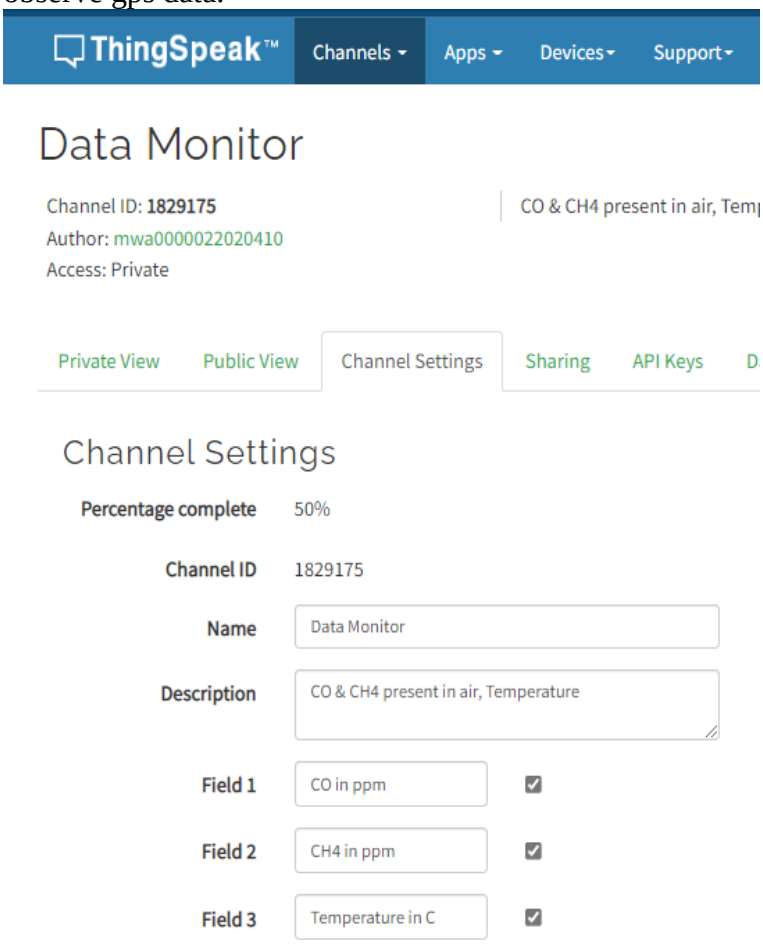
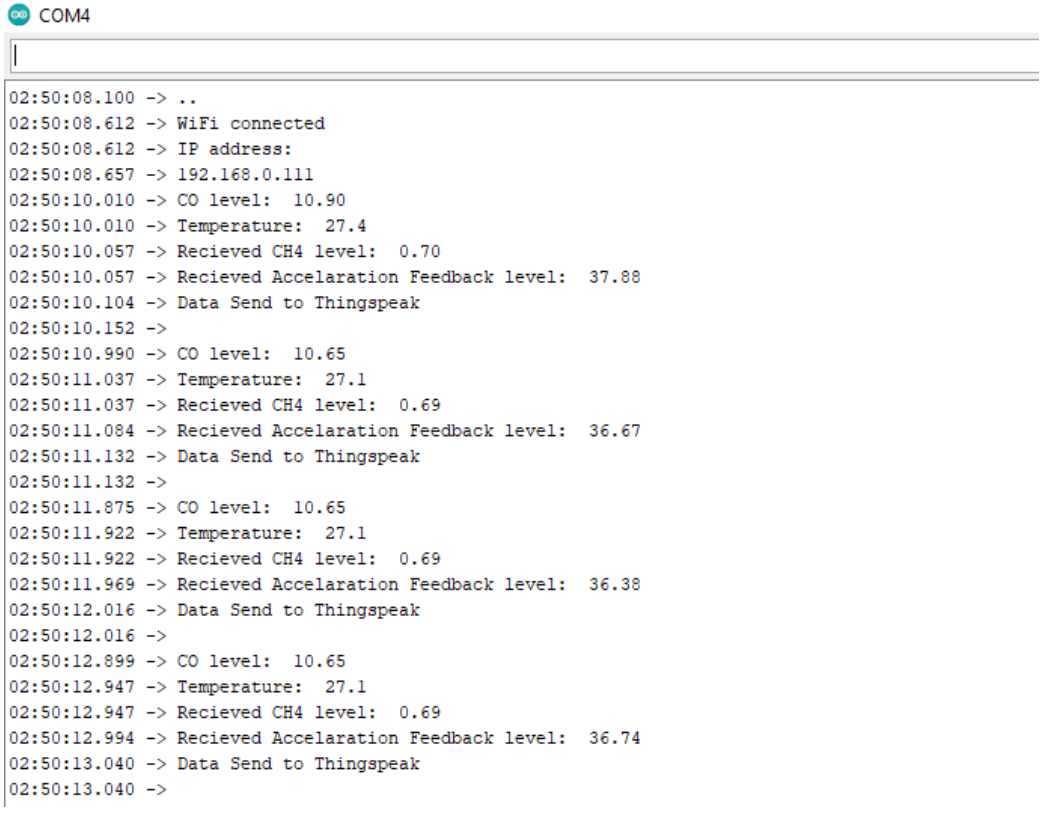


Figure: Setting up ThingSpeak Channel

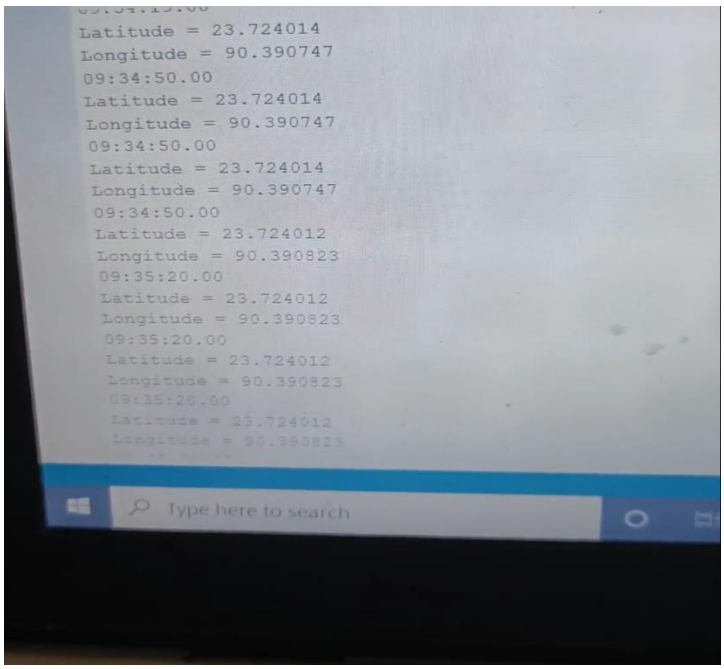
Then, next hurdle was to create an effective algorithm for fall detection. While free falling, ADXL gives outputs closer to zero value, and after the fall when a body hits the floor a spike is found from the ADXL output. This idea was used to make the fall detection algorithm. Whenever a fall is detected, a signal is sent to IFTTT server who then send a message to Mobile phone about the accident. Also, if any of the other sensor value crosses threshold, thingspeak send a warning Mail.
While viewing the GPS data, the person in charge of observation can send emergency buzzer signal using the Bluetooth module, which can save many lives. The LCD display will show the workers the state of their environment and whether it is safe to work under the present conditions.

4.2 Results

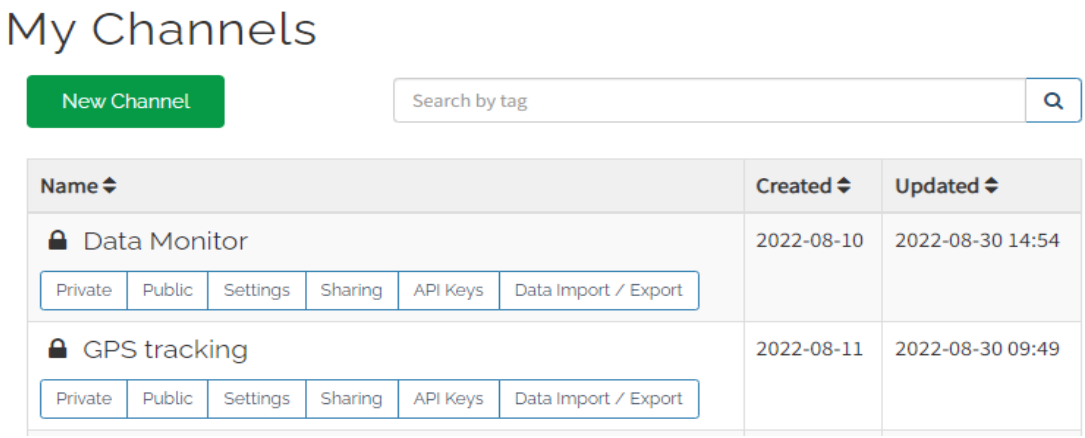
After Running the code, the nodemcu serial monitor output will be as following:



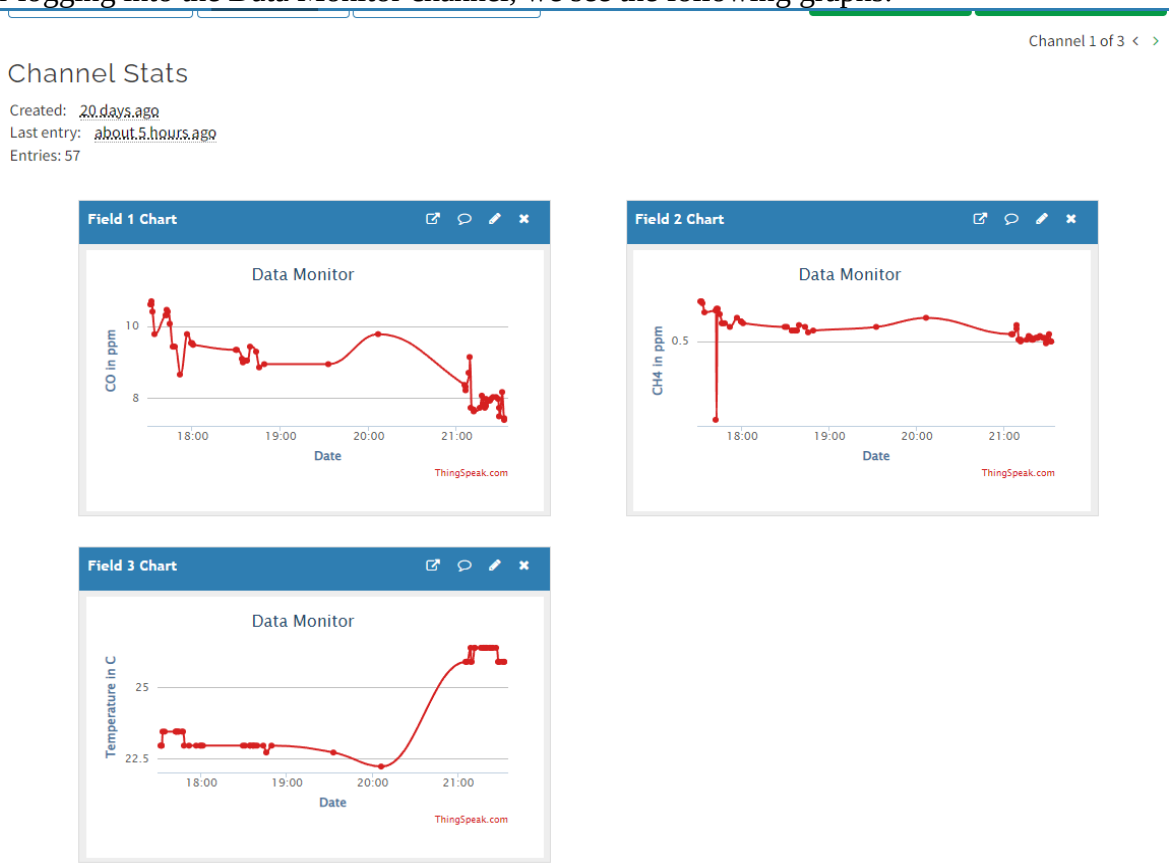
We see that, the Wifi was connected and the data: CO level, Temperature, CH4 level and Acceleration from ADXL is measured and also being sent to ThingSpeak. The GPS data is being sent to another channel.



IF we now log into our account in the ThingSpeak, we can see there are two channels for taking inputs:



After logging into the Data Monitor channel, we see the following graphs:



And if we log into GPS channel, we see the following:

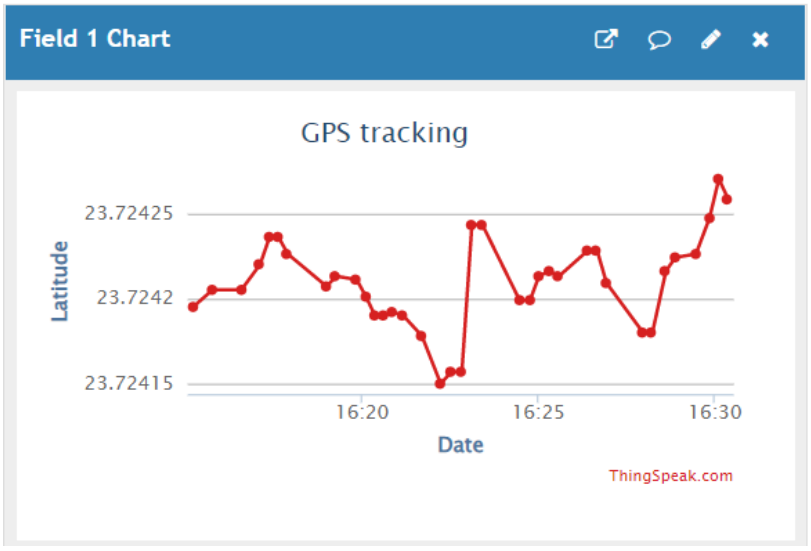


Figure: Data of Latitude

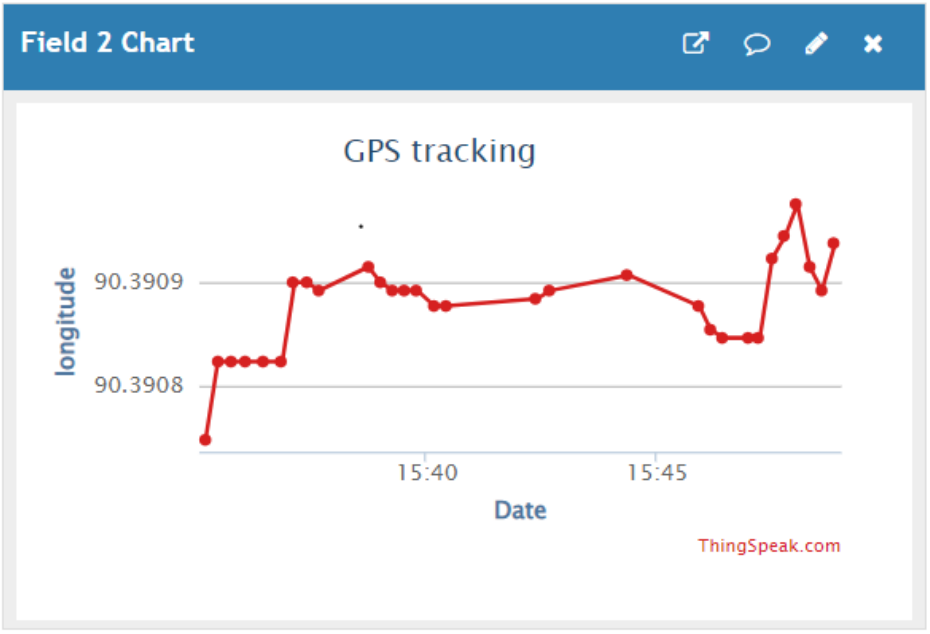


Figure: Data of Longitude

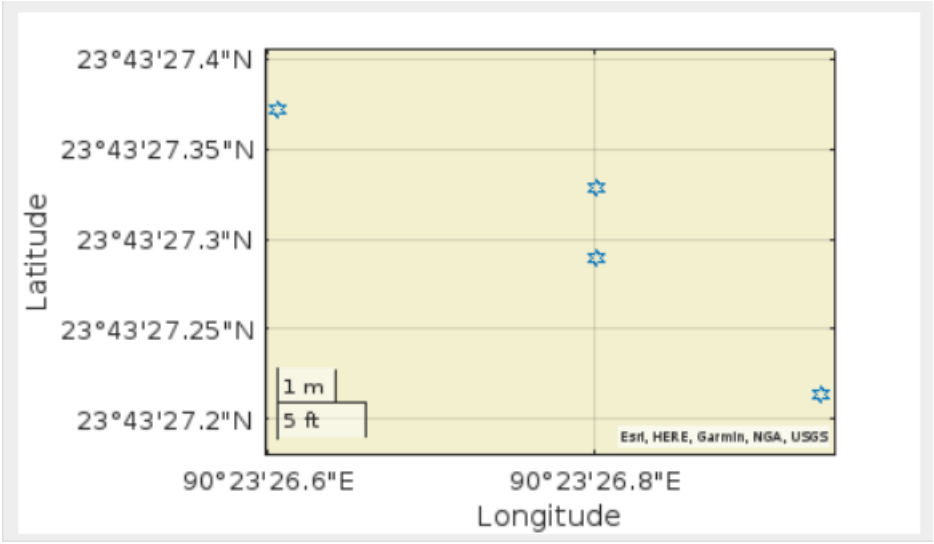
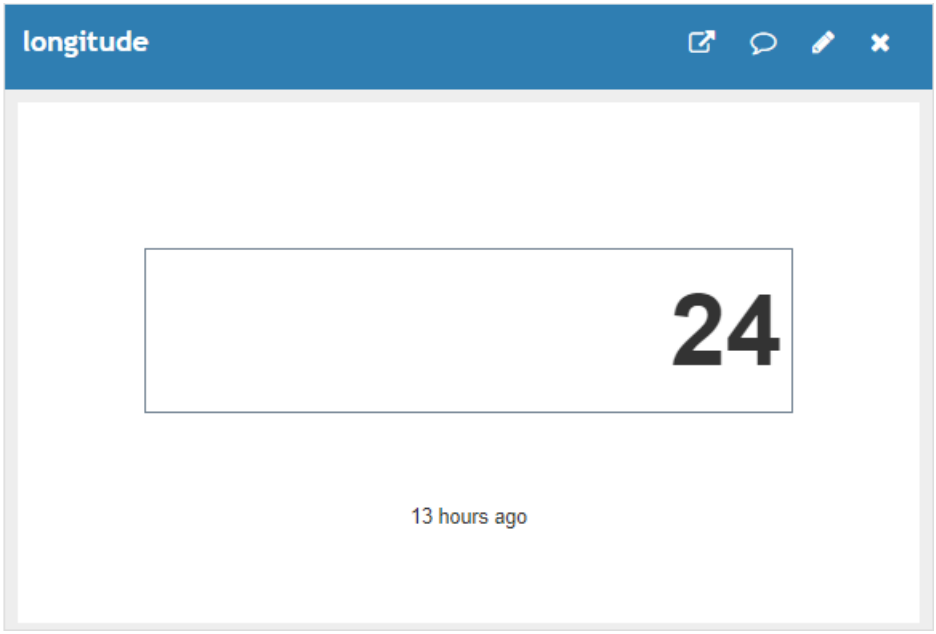


Figure: Plot of Latitude vs. Longitude



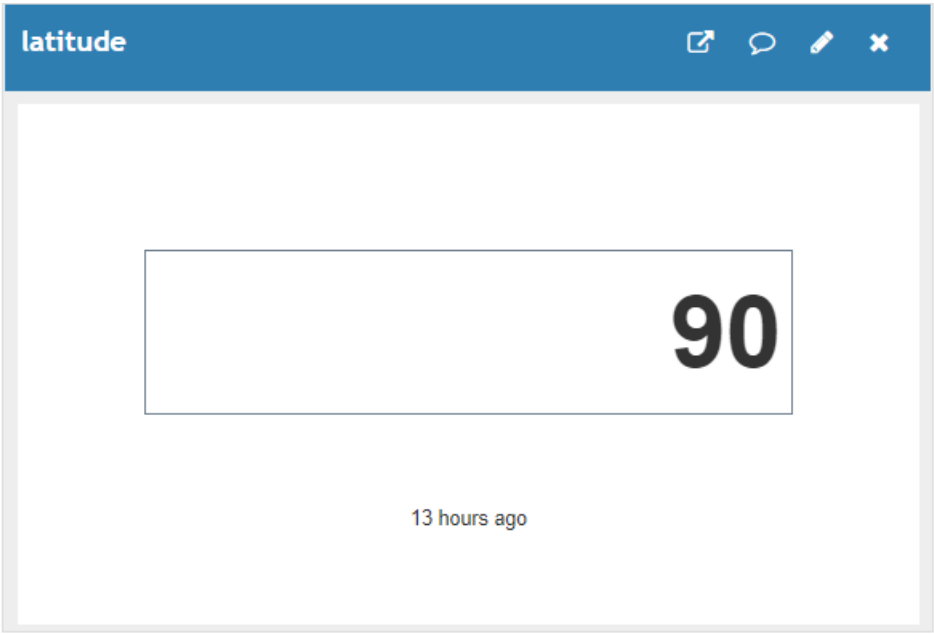
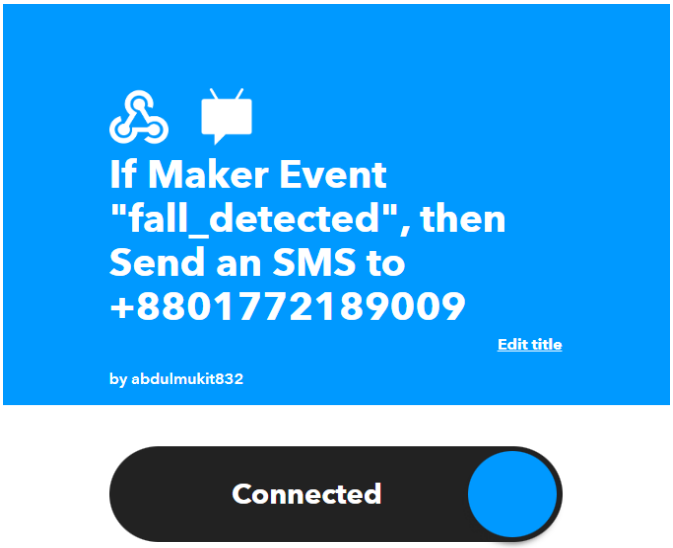


Figure: Plot of Latitude vs. Longitude

We can clearly see the latitude longitude, time and date data from the GPS and also our location pinpointed in the map.

Our event created for fall detection in IFTTT was:



Which sends this message whenever a fall is detected:

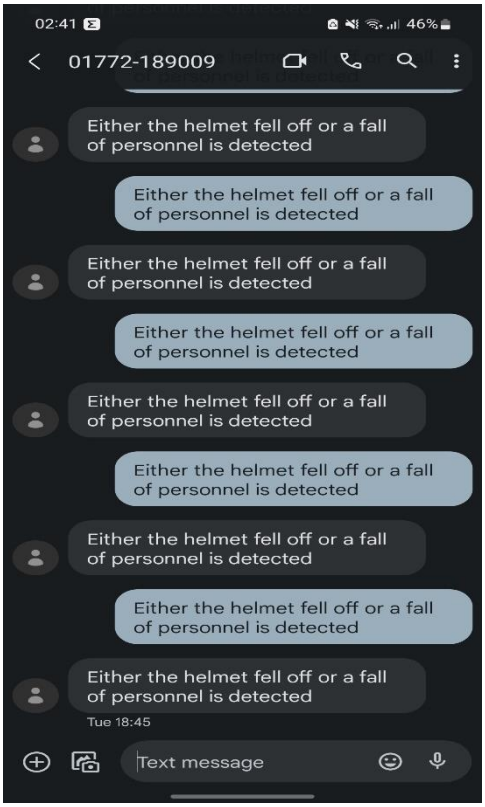
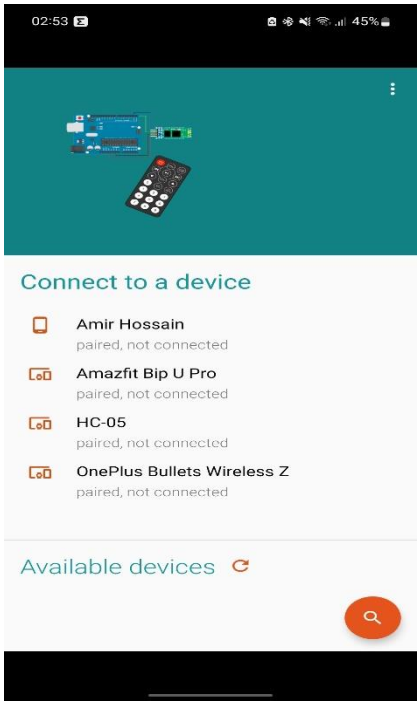


Figure: Text message received from the server as warning

The LCD shows the environment level and the Bluetooth terminal (HC05) is used to alarm the buzzer.



4.3 Github Link

Link: https://github.com/awsaf49/eee416

4.4 YouTube Link

Link: https://www.youtube.com/watch?v=c-Nd0cgPz-w

5 Design Analysis and Evaluation

❖ Schematic Diagram:

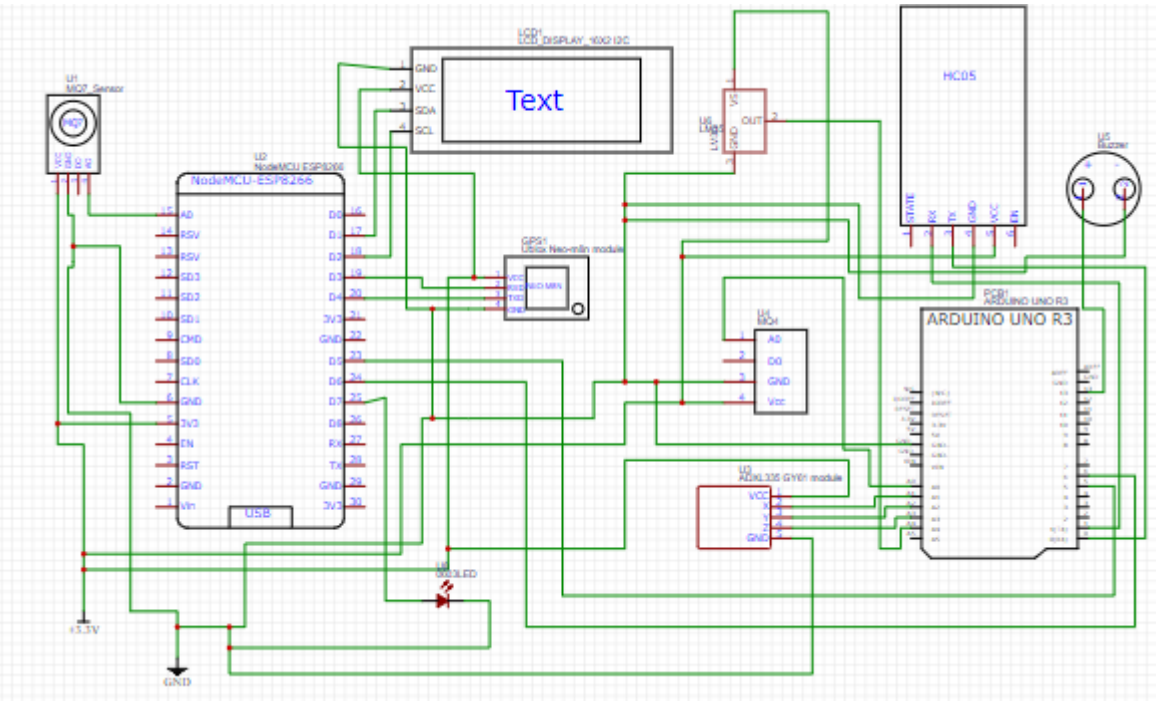


Figure: Schematic Diagram of The Proposed Project

❖ PCB Layout:

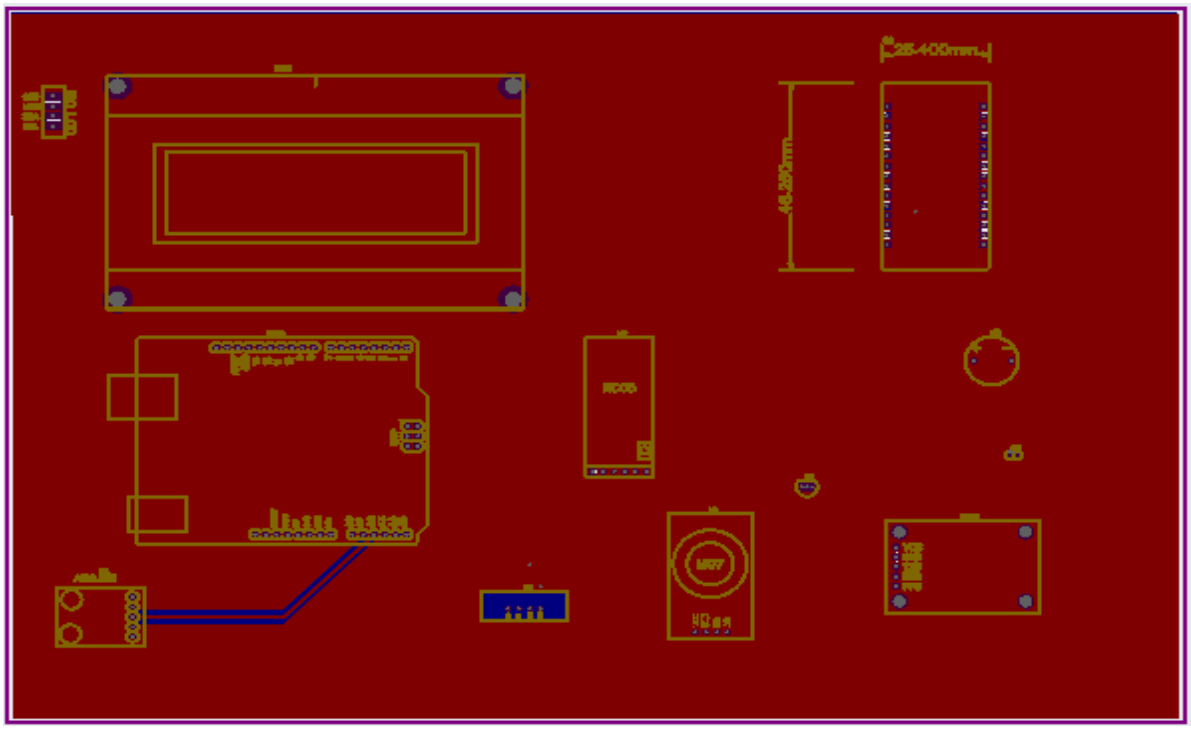


Figure: PCB Layout of The Proposed Project

❖ 3D View:

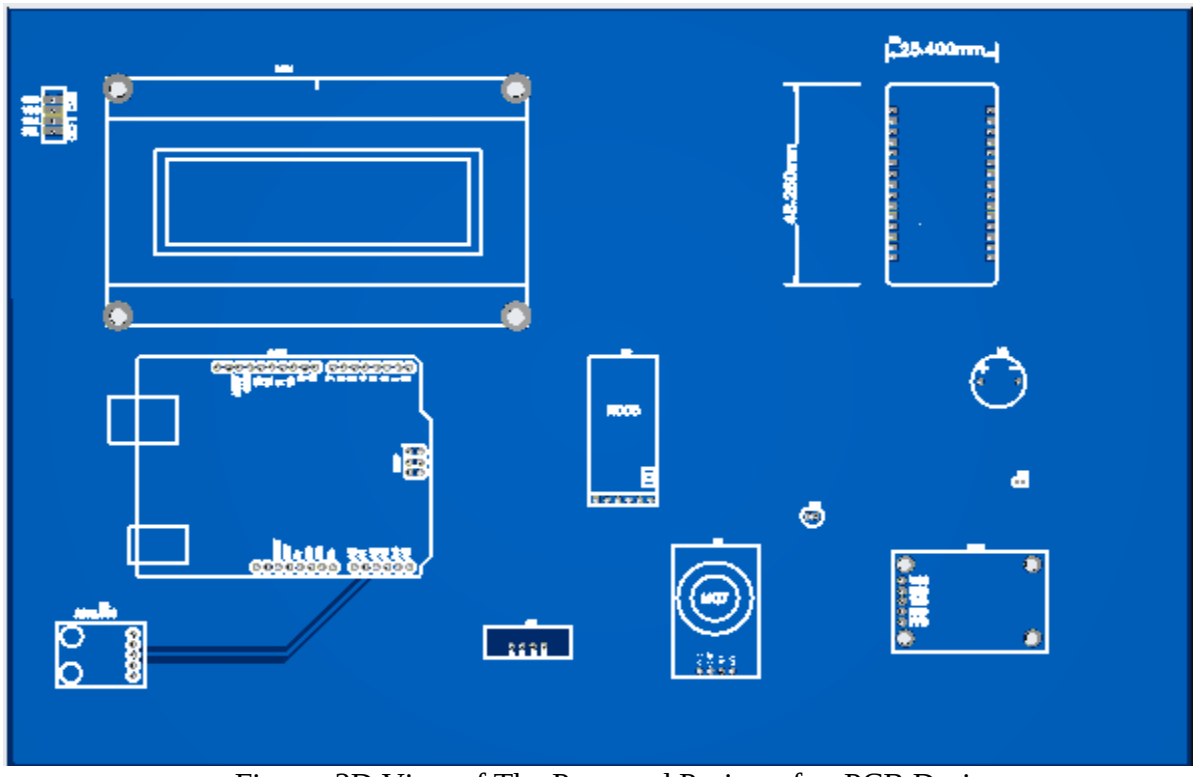


Figure: 3D View of The Proposed Project after PCB Design

- **Challenges:**

    - In this project, GPS tracking sensor does not work properly in indoor. So, we have to take the data of this sensor at an open space.

    - The accelerometer cannot provide the proper value of gravity at indoor. So, it is also necessary to take the data of it from an open space.

5.1 Novelty

Unlike existing approach, this project incorporates different sensors namely, MQ7 (CO gas), MQ4 (CH4 gas) LM35 (Temperature), Neo M8N (GPS), ADXL (Accelerometer) efficiently. This project requires less expense to produce hence makes it suitable for industrial use. Existing approaches limit themselves in only IoT platform whereas we introduce a mobile notification system which will notify user of any hazardous event. Unlike existing approaches, monitoring data in our system is very easy and requires no previous knowledge. Unlike existing approaches our project doesn't use any heavy sensor hence poses less threat to the worker who will wear it.

5.2 Project Management and Cost Analysis

5.2.1 Bill of Materials

Name	Quantity	Price (BDT)
MQ7	1	178
MQ4	1	180
LM35	1	95
Neo M8N	1	1,180
ADXL	1	479
Arduino Uno	1	1,180
Node MCU ESP8266	1	500
HC-05 Bluetooth Module	1	300
Buzzer	1	15
Breadboard	1	200

Wire	1	100
LCD Display	1	250
LED Light	1	20
Helmet	1	2,000
Total	**14**	**6,677**

5.2.2 Calculation of Per Unit Cost of Prototype

Per Unit cost of the prototype helmet is 7,000 BDT

5.2.3 Calculation of Per Unit Cost of Mass-Produced Unit

Mass-Produced Unit cost is 4,200 BDT.

5.2.4 Timeline of Project Implementation

Timeline of the project is nearly 3 to 4 months.

5.3 Practical Considerations of the Design to Address Public Health and Safety, Environment, Cultural, and Societal Needs

5.3.1 Considerations to public health and safety

The main components that are used in our project are different type of sensors like temperature sensor, gas sensors , gps module etc which are not harmful for public health or do not have any safety issue.

5.3.2 Considerations to environment

Our project is totally environment friendly. It does not produce any harmful element or interrupt any biological chain of the environment.

5.3.3 Considerations to cultural and societal needs

Our project is for the workers who are mass number of people of our society. This product is basically for their safety and in most case it is their one of the fundamental needs that they want to be ensured. If this social need is fulfilled and their involvement in social and cultural practice also increased which is a good impact on the society.

5.4 Assessment of the Impact of the Project on Societal, Health, Safety, Legal and Cultural Issues

5.4.1 Assessment of Societal Issues

As we are working on ensuring the safety issue which is a basic concern of the workers who are in a great percentage of our country population, it can be said that our project is basically solving a societal issue.

5.4.2 Assessment of Health and Safety Issues

During work in the industries, there always can occur some accidents, or leakage of gas or any chemical products which is harmful to health. As our project determines the presence of harmful gas which are generally produced as side product in most of the chemical industries or coal factory, it is very much helpful make the workers alerts against the harmful gases. Also we determines the fall of the workers or the safety helmet which is very much important for safety.

5.4.3 Assessment of Legal Issues

Our project is totally avoidable for any illegal issues.

5.4.4 Assessment of Cultural Issues

As our project is based on the safety of the workers and our product is a helmet so it does not harm any kind of work ethics or cultural practice.

5.5 Evaluation of the Sustainability the and Impact of the Designed Solution in the Societal and Environmental Contexts

5.5.1 Evaluation of Sustainability

Our project is sustainable as we have tested the results a good number of times and it provides an approximately correct result so it can be said that our design of product is sustainable.

5.5.2 Evaluation of Impact of Design in Societal Context

Thinking about the social context, it can be ensured that our product has a good impact as it is a helmet that the workers use in their work field on daily basis and our objective is to modify it keeping its design same and make it smart and technology based.

5.5.3 Evaluation of Impact of Design in Environmental Context

This design is not harmful for any environmental process as it is fully technology based which does not use any kind of harmful chemical reaction or radiation or does not emit any harmful gas or chemical substrate.

6 Reflection on Individual and Team work

The Teamwork was often difficult to co-ordinate, as two of our group members were staying in their resident home (170607, 1706068) and other two were staying at Sony Hall and Rashid Hall (1706069 and 1706066 respectively). Also, being in different major groups i.e. power and Communication increased difficulty in our teamwork. Sill, we worked around this by working together in the library and by using video meeting in Google Meet or Zoom. Also we created a messenger group to stay in touch and to discuss our own parts of the project and to share our workload. In this way, performing tasks individually also became not much difficult.

6.1 Individual Contribution of Each Member

Roll and Name	Contribution
Md. Awsafur Rahamn (1706067)	Circuit parts and component shopping. Smoldering. Interfacing with Wifi to upload data to ThingSpeak. Making model of the proposed finished product
Abdul Mukit (1706067)	Circuit parts and component shopping. Gas Sensors, Bluetooth Module, Accelerometer interfacing Making the backbone of the codes Stablishing Serial communication between Nodemcu and Arduino Creating SMS update system
Nabila Tasnim (1706068)	Making online orders Designing the warning system using Buzzer and LED LCD interfacing Making the Circuit Schematic Making the PCB design
Joyita Halder (1706067)	Interfacing GPS sensor with Nodemcu to pinpoint location and show live time and date Creating the Thingspeak Channel Interfacing Temperature sensor Choosing sensors and Designing the Circuit

6.2 Mode of Team Work

When we're working together as a team, here are 4 modes of teamwork that help us to make the most of our time together:

1) COULD DO - Sharing ideas and generating many different possible courses of action like brainstorming, collaborating.

2) SHOULD DO - Reflecting on what's working, where we're getting stuck, and what adjustments we should make like learning sessions and retrospectives.

3) WILL DO - Deciding and committing to a specific course of action, with clear ownership like decision and action meetings.

4) DOING - Actually making and creating stuff, and moving the work forward.

6.3 Diversity Statement of Team

Among the 4 team members there are diversities like

1) Diversity in major subjects of the members

2) Diversities is of area as 4 members are from 4 different cities of our country

3) Diversity of personality and thinking prospect and gender.

4) Diversity of working skills as one is expert in coding sector and other is comfortable with hardware sections.

6.4 **Log Book of Project Implementation**

Date	**Milestone achieved**	**Individual Role**	**Team Role**	**Comments**
7/7/22	no	Working on sensors individually		Not all the sensors were giving results
8/7/22	yes	Working on temperature sensor		It was working properly
13/7/22	yes		Working on two gas sensors	It was working properly

14/7/22	No		Working on gps module	It was not working properly
28/7/22	Yes		ADXL initializing	Was initialized successfully
29/7/22	Yes	Working on LCD display to show the adxl results		It was working properly
3/8/22	No	Working on gps module	Working on gps module	Sowing invalid location
4/8/22	Yes	Uploading the achieved results on cloud		It was working properly
5/8/22	No	The NodeMcu	The NodeMcu	It was not sending multiple data together on cloud server
11/8/22	Yes	Designing a 3D model on powerpoint		It was completed
12/8/22	No	PCB design		Some schematics were not completed
18/8/22	yes	GPS module and uploading it on cloud server		It was working properly in outdoor
19/8/22	Yes	Bluetooth		Successfully sending message to cellphone
24/8/22	No		Merging all the sensors	It was not working properly
28/8/22	Yes		Merging all the sensors and codes and including the buzzer	It was working properly
30/8/22	Yes		Sending alert from phone and making the buzzer sound and showing the result on LCD and Demonstrating video shoot	Successfully result generated and report writing was completed

7 References

1.https://www.ijert.org/research/iot-based-smart-helmet-for-ensuring-safety-in-industries-IJERTCONV6IS04068.pdf

2.https://www.researchgate.net/publication/353742561_Internet_of_Things_IoT_based_Smart_Helmet_for_Construction

3. https://www.youtube.com/watch?v=KO-_zxESO18

4. https://create.arduino.cc/projecthub/ashraf_minhaj/iot-light-control-over-internet-arduino-or-nodemcu-esp8266-8a89d4?ref=user&ref_id=507819&offset=1

5. https://www.youtube.com/watch?v=6wPHxrXsvq8

6. https://lastminuteengineers.com/adxl335-accelerometer-arduino-tutorial/

7. https://www.hackster.io/RoboticaDIY/send-data-from-arduino-to-nodemcu-and-nodemcu-to-arduino-17d47a

8. https://iotdesignpro.com/projects/iot-based-gps-tracking-using-nodemcu-and-visualization-on-thingspeak