

A
Project Report
on

**“SEISMIC DATA MONITORING WITH ESP32 AND THINGSPEAK CLOUD
INTEGRATION”**

Submitted in partial fulfillment for the award of the degree of
Bachelor of Technology
in

Robotics and Artificial Intelligence



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DECLARATION

I hereby declare that the work, being presented in the project report entitled “**Seismic Data Monitoring with ESP32 and ThingSpeak Cloud Integration**” in partial fulfillment of the requirement for the award of the Degree in Bachelor of Technology in **Robotics and Artificial Engineering** and submitted to the Department of Mechanical Engineering of J.C. Bose University of Science and Technology, YMCA, Faridabad is an authentic record of our team work carried out during a period from **FEB 2024** to **MAY 2024** under the supervision of **Dr Sanjeev Goyal (Assistant Professor)**, Department of Mechanical Engineering. No part of the matter embodied in the project has been submitted to any other University / Institute for the award of any Degree or Diploma.

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CERTIFICATE

This is to certify that the project entitled, “**Seismic Data Monitoring with ESP32 and ThingSpeak Cloud Integration**” submitted in partial fulfillment of the requirements for the degree in Bachelors of Technology in **Robotics and Artificial Intelligence** is an authentic work carried out under my supervision and guidance.

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This opportunity was taken to express our deep sense of gratitude and respect towards our supervisor **Dr Sanjeev Goyal , Assistant Professor**, Department of **Mechanical Engineering**, J.C. Bose University of Science & Technology, YMCA, Faridabad.

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ABSTRACT

The objective of this project was to design and implement a Seismic Data Monitoring system integrating an ESP32 microcontroller and an accelerometer. The system is engineered to detect seismic activity, transmit real-time data to the ThingSpeak cloud platform, and offer graphical visualization via a mobile application

The methodology involved selecting appropriate hardware components, including the ESP32 microcontroller, an accelerometer sensor for detecting vibrations, and configuring the system to transmit data to ThingSpeak for remote monitoring and analysis. Additionally, a mobile application was developed to display seismic data in the form of x, y, z coordinates, and graphical representations of seismic events.

Key components used in the project included the ESP32 microcontroller, an MPU6050 accelerometer sensor, and ThingSpeak cloud platform for data transmission and storage. The development process included writing control code in C/C++ using the Arduino IDE for the ESP32, implementing communication protocols to interact with ThingSpeak API, and creating a mobile application for Android devices using appropriate frameworks.

The outcomes of the project showcased the successful deployment of the Seismic Data Monitoring system. The ESP32 effectively detected seismic activity through the accelerometer sensor, ensuring precise data collection. Real-time transmission of data to ThingSpeak enabled remote access and monitoring. Additionally, the mobile application offered intuitive graphical representations of seismic data, enhancing the system's usability and accessibility for users.

Furthermore, the system featured an alerting mechanism in the mobile application that created notifications when earthquake events were detected. Upon detection, users received timely alerts on their mobile devices, enabling them to take appropriate actions to ensure their safety during seismic events. Simultaneously, an SMS notification feature was integrated into the system, automatically sending SMS to relevant authorities upon detecting an earthquake. This ensured that authorities were promptly informed about seismic events, enabling them to take necessary measures to respond to potential emergencies and ensure public safety.

The Seismic Data Monitoring system with ESP32 and ThingSpeak Cloud Integration offers an efficient solution for real-time seismic monitoring, alerting, and communication with authorities. Integration with ThingSpeak facilitates centralized data management, while the mobile application enhances user interaction and comprehension of seismic events through visual representations. Future endeavors may focus on enhancing system capabilities, refining data analysis algorithms, and improving user interface features for wider deployment and effectiveness.

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LIST OF ABBREVIATIONS

AICTE	All India Council of Technical Education
ESP32	Espressif System Platform 32
MPU6050	Microprocessor Unit 6050
IoT	Internet of Things
API	Application Programming Interface
I2C	Inter-Integrated Circuit
IDE	Integrated Development Environment
Wi-Fi	Wireless Fidelity
C/C++	C and C++ Programming Languages
GUI	Graphical User Interface
LED	Light-Emitting Diode
DC	Direct Current
ADC	Analog-to-Digital Converter
UART	Universal Asynchronous Receiver-Transmitter
PWM	Pulse Width Modulation
GPIO	General Purpose Input/Output
RAM	Random Access Memory
ROM	Read-Only Memory
USB	Universal Serial Bus
LCD	Liquid Crystal Display
HDMI	High-Definition Multimedia Interface
OLED	Organic Light-Emitting Diode
CPU	Central Processing Unit
HTTP	Hypertext Transfer Protocol

Chapter 1

INTRODUCTION

In recent years, the occurrence of natural disasters, particularly earthquakes, has highlighted the critical need for advanced monitoring and alert systems to mitigate their impact on human life and infrastructure. One such devastating event was the earthquake that struck Haiti in 2010, causing catastrophic damage and claiming thousands of lives due to the lack of timely alerts and response mechanisms. This tragic incident underscores the urgent necessity for reliable earthquake detection and alarm systems.

Motivated by the pressing need to enhance earthquake preparedness and response strategies, this project focuses on developing a sophisticated Seismic Data Monitoring system using modern IoT technologies. The primary objective is to create a system capable of accurately detecting seismic activity, transmitting real-time data to the cloud for remote monitoring and analysis, and providing intuitive graphical visualization through a dedicated mobile application.

Drawing inspiration from real-life incidents, such as the 2010 earthquake in Haiti, where lack of advanced monitoring systems led to significant loss of life and property, underscores the importance of proactive earthquake detection and alert mechanisms. Additionally, examining case studies from other earthquake-prone regions, such as Japan or California, where early warning systems have been successfully implemented, provides valuable insights into the potential impact of effective seismic monitoring and alert systems.

Through this project, we endeavor to demonstrate the effectiveness of integrating IoT technologies, such as the ESP32 microcontroller and MPU6050 accelerometer, with cloud-based data management and mobile applications for real-time seismic monitoring and alerting. The insights gained from this endeavor will pave the way for future advancements in earthquake detection systems, fostering safer and more resilient communities in the face of natural disasters.

Chapter 2

LITERATURE REVIEW

The literature on seismic data monitoring systems and IoT-based solutions offers valuable insights into the development of robust seismic monitoring and alert systems. This review aims to highlight key findings and advancements in the field, with a focus on integrating ESP32 microcontrollers, accelerometers, cloud platforms like ThingSpeak, and mobile applications for real-time data visualization and communication.

Previous research has demonstrated the effectiveness of accelerometer sensors, such as the MPU6050, in seismic data monitoring systems. These sensors utilize MEMS technology to detect vibrations associated with seismic activity, enabling precise measurement of ground motion and tremors.

In the realm of IoT applications for disaster management, cloud-based platforms like ThingSpeak have emerged as indispensable tools for real-time data transmission and analysis. Studies have underscored the pivotal role of IoT in bolstering disaster preparedness through remote monitoring and centralized data management.

The integration of ESP32 microcontrollers with cloud platforms like ThingSpeak offers scalable solutions for real-time data transmission from sensors to the cloud. The ESP32's versatility and low power consumption make it ideal for IoT applications, facilitating seamless connectivity and data synchronization.

Mobile applications play a crucial role in disaster response and public awareness efforts. Previous research has explored the development of mobile apps for earthquake monitoring, providing users with intuitive interfaces for visualizing seismic data and receiving timely alerts and notifications.

Despite notable advancements, there remains a discernible gap in the literature concerning the comprehensive integration of ESP32 microcontrollers, accelerometers, cloud platforms, and mobile applications in seismic data monitoring systems. This project aims to address this gap by developing a functional Seismic Data Monitoring system that harnesses these components to detect seismic activity in real-time, transmit data to the cloud for remote monitoring, and offer intuitive graphical visualization via a dedicated mobile application.

Chapter 3

OBJECTIVES OF PROJECT

The primary objective of "Seismic Data Monitoring with ESP32 and ThingSpeak Cloud Integration" is to design and implement an Earthquake Detector Alarm system using an ESP32 microcontroller integrated with an MPU6050 accelerometer. The system aims to accurately detect seismic activity, transmit real-time data to the cloud using ThingSpeak, and provide graphical visualization through a dedicated mobile application. By seamlessly integrating SMS alerts, the system ensures prompt notification of relevant authorities upon detecting seismic events. This holistic approach aims to contribute to the field of disaster management by developing a functional and effective solution for earthquake detection and monitoring, facilitating timely response and mitigation of potential risks.

Objectives of the Project:

1. Design and assemble a hardware system comprising an ESP32 microcontroller and MPU6050 accelerometer for detecting seismic vibrations.
2. Develop control code in C++ using the Arduino IDE to interface with the MPU6050 sensor and process accelerometer data.
3. Configure the ESP32 microcontroller to establish a connection with the ThingSpeak cloud platform for real-time data transmission.
4. Implement communication protocols (e.g., MQTT, HTTP) to transmit seismic data to ThingSpeak for remote monitoring and analysis.
5. Build an Android mobile app for graphical representation of seismic data, featuring acceleration data on all axes and seismic event visualization.
6. Enable SMS alerts to promptly notify authorities in case of an earthquake, ensuring swift response and effective emergency management.
7. Ensure seamless operation and reliability of the Earthquake Detector Alarm system under varying environmental conditions.

Chapter 4

COMPONENTS USED

The following components are required for this project:

1. ESP32 Microcontroller
2. MPU6050 Accelerometer Sensor
3. IIC/I2C Serial Interface Adapter Module Port For 5V Arduino 1602 LCD
4. 16 x 2 LCD Display
5. Buzzer
6. LED

In assembling our 'Seismic Data Monitoring with ESP32 and ThingSpeak Cloud Integration' project, each component plays a crucial role in ensuring seamless functionality. The ESP32 Microcontroller acts as the central processing unit, managing data analysis, communication, and transmission. Paired with the MPU6050 Accelerometer Sensor, the system accurately detects vibrations and measures acceleration across multiple axes, facilitating precise earthquake detection. Upon detection, the Buzzer emits audible alerts, complemented by visual feedback from the 16 x 2 LCD Display and LED indicators, ensuring timely user notification. Enabling smooth integration, the IIC/I2C Serial Interface Adapter Module Port facilitates communication between the microcontroller and the LCD display.

This comprehensive system significantly enhances disaster preparedness by promptly notifying users of potential seismic events, thereby contributing to risk mitigation and ensuring safety. Users can monitor and analyze seismic data, gaining valuable insights into earthquake patterns and trends, ultimately enhancing overall safety and well-being. Together, these components and functionalities form a cohesive system that not only accurately detects earthquakes but also empowers users with actionable insights to respond effectively, ensuring the well-being of individuals and communities.

Chapter 5

COMPONENT DESCRIPTION

1. ESP32 Microcontroller:

The ESP32 Microcontroller is a versatile and powerful component widely used in IoT (Internet of Things) applications. With its dual-core processor, built-in Wi-Fi and Bluetooth connectivity, and a wide array of peripherals, the ESP32 offers robust capabilities for various embedded projects. Its low power consumption and high performance make it suitable for handling complex tasks efficiently.



Figure 1: ESP32 Microcontroller

In our project, the ESP32 Microcontroller serves as the central processing unit, responsible for data analysis, communication, and transmission. Leveraging its built-in Wi-Fi connectivity, the ESP32 facilitates real-time transmission of seismic data to cloud platforms like ThingSpeak, ensuring timely alerts and notifications. Additionally, its compatibility with a diverse range of sensors and peripherals allows for seamless integration and functionality enhancement. By incorporating the ESP32 into our Earthquake Detector Alarm system, we ensure reliable and efficient operation, empowering users with accurate information to respond effectively to seismic events.

2. MPU6050 Accelerometer Sensor:

The MPU6050 Accelerometer Sensor is a MEMS (Microelectromechanical Systems) device designed to measure acceleration along multiple axes. It features a tri-axial accelerometer capable of sensing vibrations and motion in three-dimensional space. The sensor also includes a gyroscope for measuring rotational motion, providing comprehensive motion sensing capabilities. With its small form factor and low power consumption, the MPU6050 is suitable for various applications requiring precise motion detection.

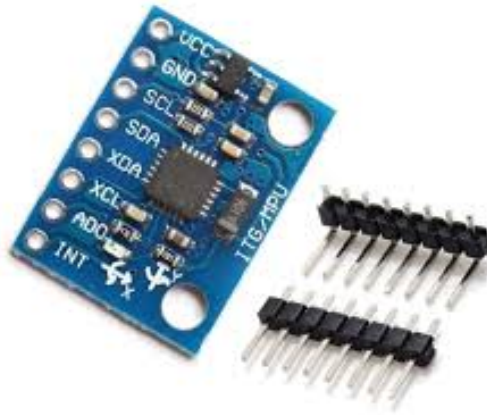


Figure 2: MPU6050 Accelerometer Sensor

In our project, we use the MPU6050 Accelerometer Sensor for precise seismic activity detection. With its tri-axial accelerometer, it measures ground motion along multiple axes, providing comprehensive earthquake data. Interfacing with the ESP32 Microcontroller enables real-time capture and analysis of acceleration data. The MPU6050's sensitivity detects subtle vibrations, ensuring prompt event detection. Integrated into our system, it enhances disaster preparedness, ensuring community safety.

3. IIC/I2C Serial Interface Adapter Module Port For 5V Arduino 1602 LCD:

The IIC/I2C Serial Interface Adapter Module Port For 5V Arduino 1602 LCD serves as a communication bridge between the Arduino microcontroller and the 16x2 LCD display. It simplifies the connection process by converting parallel data output from the LCD screen into serial data compatible with the I2C protocol. This module reduces wiring complexity and conserves digital pins on the Arduino board, making it easier to integrate the LCD display into projects.

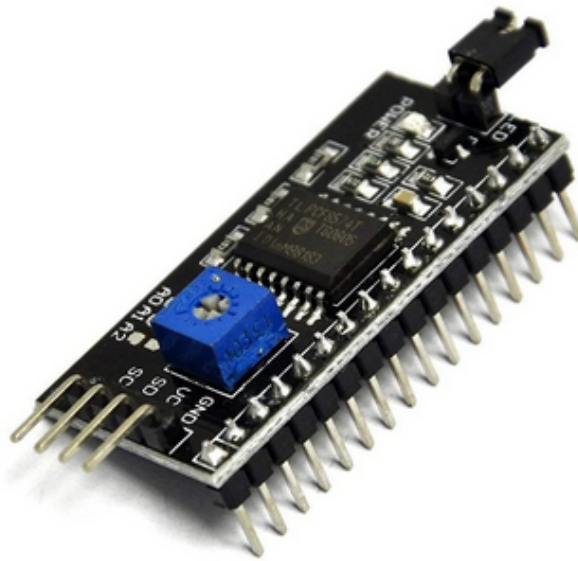


Figure 3 : I2C Adapter Module 1602 LCD

In our project, we utilize the IIC/I2C Serial Interface Adapter Module Port to interface the 16x2 LCD screen with the ESP32 microcontroller. By connecting the module to the ESP32's I2C bus, we establish communication with the LCD screen using only two wires. This streamlined connection method simplifies the setup process and allows for seamless integration of the LCD display into our Earthquake Detector Alarm system, enhancing its functionality and usability.

4. 16 x 2 LCD Display:

The 16x2 LCD Display is a common type of liquid crystal display screen that can display 16 characters in each of its two rows. It is widely used in various electronic projects for displaying text-based information in a compact format. The display consists of a grid of pixels arranged in a 16x2 configuration, where each pixel can be individually controlled to show characters, numbers, or symbols.



Figure 4 : 16*2 LCD Display

In our project, we leverage the 16x2 LCD Display to visualize acceleration data along the X, Y, and Z axes. Through the integration of the MPU6050 Accelerometer Sensor with the ESP32 Microcontroller, real-time acceleration data is captured and processed. The 16x2 LCD Display serves as an intuitive interface for users to monitor ground motion along each axis, providing valuable insights into seismic activity levels. This visualization of acceleration data enhances the user's understanding of seismic events, enabling them to respond effectively to potential threats.

5. BUZZER:

The Buzzer is designed to emit a loud, attention-grabbing sound when activated. It consists of a coil of wire around a magnet, producing vibrations that generate sound waves. The Buzzer's primary function is to provide auditory alerts to users upon detecting seismic activity, ensuring immediate notification even in noisy environments.



Figure 5: Buzzer

In our project, the Buzzer serves as an essential alarm mechanism to promptly notify users of detected seismic activity. When triggered by the Earthquake Detector Alarm system, the Buzzer emits a distinct sound, alerting users to potential seismic events. This auditory alert enhances user awareness and enables swift response measures, contributing to improved safety and preparedness during seismic events.

6. LED

The LED (Light Emitting Diode) is a semiconductor device that emits light when an electric current passes through it. LEDs are commonly used as indicators in electronic circuits due to their low power consumption, small size, and long lifespan.



Figure 6 : LED

In our project, we employ the LED as a visual indicator to signal various states of the Earthquake Detector Alarm system. For example, the LED may illuminate to indicate the system is armed and actively monitoring for seismic activity. Alternatively, it may flash or change color to alert users of detected earthquakes or system malfunctions. The LED provides a simple yet effective means of conveying important information to users in real-time.

Chapter 6

TECHNOLOGIES USED

1. ThingSpeak Cloud

ThingSpeak is a cloud platform designed for IoT applications, providing capabilities for storing, analyzing, and visualizing sensor data in real-time. It offers easy integration with IoT devices and supports various communication protocols, making it suitable for a wide range of applications.

Purpose:

In our project, we utilize ThingSpeak as the central hub for storing and visualizing seismic data collected by the ESP32 microcontroller. ThingSpeak enables us to access real-time updates on seismic activity and provides visualization tools for analyzing the data. Additionally, ThingSpeak channels allow for seamless sharing of data with stakeholders and authorities, enhancing collaboration and decision-making.

Usage:

We leverage ThingSpeak channels to store and display seismic data transmitted from the ESP32 microcontroller. The ESP32 makes HTTP requests to the ThingSpeak API endpoint, sending data packets containing x, y, and z-axis acceleration values, along with earthquake alerts, at regular intervals. ThingSpeak processes these data packets and updates the corresponding fields in the designated channel, allowing users to monitor seismic activity in real-time. The ThingSpeak platform also provides customizable visualization tools, such as charts and graphs, enabling users to analyze trends and patterns in the seismic data. Overall, ThingSpeak serves as a reliable and efficient cloud platform for our earthquake detection and monitoring system, facilitating seamless data management and analysis.

ESP32 HTTP Request Implementation for ThingSpeak Integration:

```
// Domain Name with full URL Path for HTTP POST Request
const char* serverName = "http://api.thingspeak.com/update";

// write API Key provided by thingspeak
String apiKey = "EDFQ7NOOBUTH1MS5";

//Sending data to ThingsSpeak
if(WiFi.status()== WL_CONNECTED && currentMillis - previousMillis >=
interval){
    WiFiClient client;
    HTTPClient http;

    // Your Domain name with URL path or IP address with path
    http.begin(client, serverName);

    // Specify content-type header
    http.addHeader("Content-Type", "application/x-www-form-urlencoded");

    // Data to send with HTTP POST
    String httpRequestData = "api_key=" + apiKey + "&field1=" + String
(ex_val) + "&field2=" + String(ey_val) + "&field3=" + String
(ez_val) + "&field4=" + String(earthquake_detect);

    // Send HTTP POST request
    int httpResponseCode = http.POST(httpRequestData);
    if(earthquake_detect == 1){
        earthquake_detect = 0;
    }
    ex_val = 0;
    ey_val = 0;
    ez_val = 0;
    previousMillis = currentMillis;
    Serial.print("HTTP Response code: ");
    Serial.println(httpResponseCode);
    http.end();
}
```

ThingSpeak Channel View:

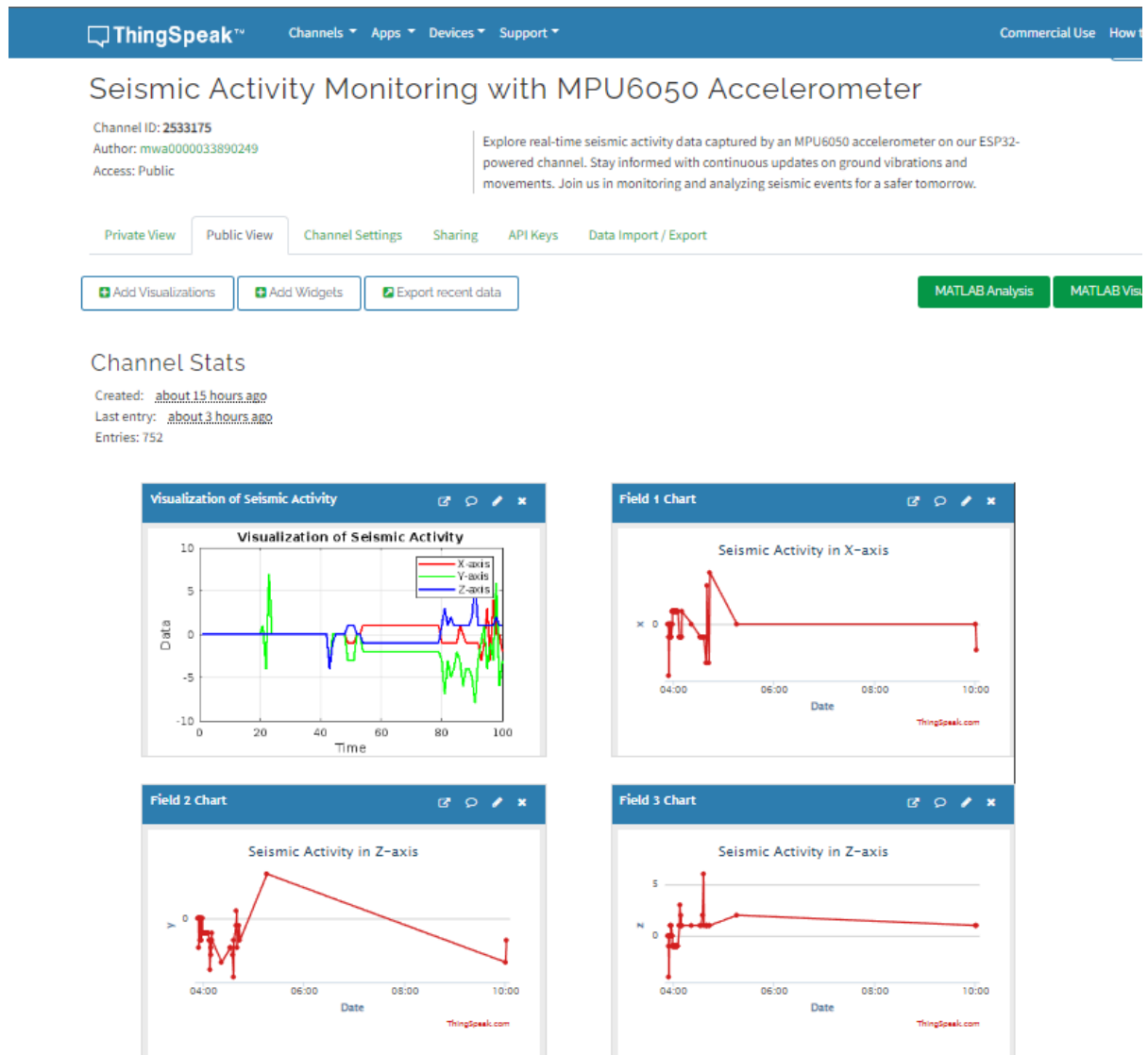


Figure 7 : ThingSpeak Channel View

2. ThingShow Android Application

ThingShow is an Android application designed to visualize real-time seismic data from ThingSpeak channels. It provides users with an intuitive interface to monitor seismic activity on their Android devices, facilitating easy access to critical information about earthquakes.

Purpose:

The ThingShow Android application serves as a user-friendly interface for accessing seismic data stored on ThingSpeak channels. It allows users to view graphical representations of seismic activity, including charts and graphs of acceleration data measured by sensors. By providing real-time updates and visualization tools, ThingShow enhances user awareness and understanding of seismic events.

Usage:

Users can download the ThingShow application from the Google Play Store and access seismic data by entering the corresponding ThingSpeak channel ID. The application retrieves data from ThingSpeak channels using HTTP requests and displays it in a visually appealing format. Users can customize the display settings and view historical data to analyze trends over time. ThingShow also supports push notifications for earthquake alerts, ensuring timely updates on seismic activity. Overall, the ThingShow Android application complements our earthquake detection system by providing users with a convenient way to monitor and analyze seismic data on their mobile devices.

Mobile Application Channel View:

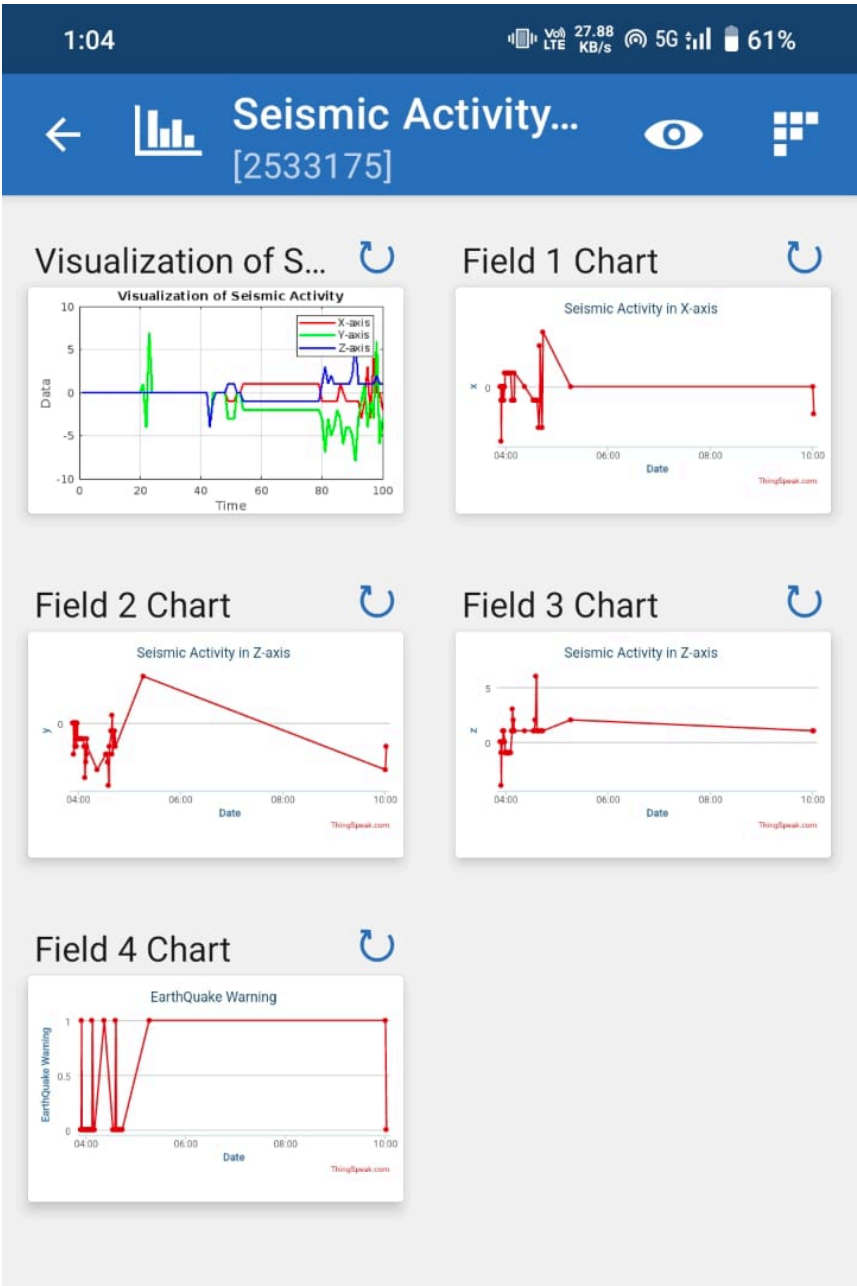


Figure 8 : Mobile Application Channel View

3. ThingSpeak React and ThingHTTP

ThingSpeak React and ThingHTTP are two powerful features of the ThingSpeak platform that enable users to automate actions and integrate external services with their IoT applications. ThingSpeak React allows users to define rules or reactions based on incoming data streams, while ThingHTTP facilitates communication with external APIs or web services.

Purpose:

The purpose of ThingSpeak React is to provide users with a mechanism for automating tasks or responses based on specific conditions detected in their IoT data streams. ThingHTTP, on the other hand, enables users to interact with external services or APIs by making HTTP requests triggered by events in their ThingSpeak channels. Together, these features enable seamless integration between IoT devices and external systems, enhancing the functionality and versatility of IoT applications.

Usage:

In our earthquake detection system, we leverage ThingSpeak React to define rules for triggering alerts or notifications based on seismic data received from the ESP32 microcontroller. For example, we configure ThingSpeak React to monitor the seismic data stream and initiate SMS alerts using ThingHTTP when earthquake alerts are detected. ThingHTTP is then used to communicate with external services, such as Twilio for SMS notifications, by making HTTP requests with predefined parameters. By combining ThingSpeak React and ThingHTTP, we can automate the response to seismic events and seamlessly integrate with external communication channels, ensuring timely notifications and alerts. Specifically, we utilize ThingHTTP to send SMS messages to relevant authorities, informing them about detected earthquakes and facilitating prompt response and mitigation efforts.

ThingSpeak React Configuration:

ThingSpeak™

Channels ▾ Apps ▾ Devices ▾ Support ▾

Apps / React / Earthquake Alert

Edit React

Name:	Earthquake Alert
Condition Type:	Numeric
Test Frequency:	On data insertion
Last Ran:	2024-05-03 04:30
Channel:	Seismic Activity Monitoring with MPU6050 Accelerometer
Condition:	Field 4 (EarthQuake Warning) is equal to 1
ThingHTTP:	Inform Relevant Authorities
Run:	Each time the condition is met
Created:	2024-05-02 6:56 pm

Figure 9: ThingSpeak React Configuration

ThingHTTP Configuration:

ThingSpeak™

Channels ▾ Apps ▾ Devices ▾ Support ▾

Apps / ThingHTTP / Inform Relevant Authorities

Edit ThingHTTP

Name:	Inform Relevant Authorities
API Key:	0XXHF9PK5W36MC80
	Regenerate API Key
URL:	https://api.twilio.com/2010-04-01/Accounts/ACd6a75ffbdd eaa640876fda1ebef1fddc/Messages.json
HTTP Auth Username:	ACd6a75ffbddeaa640876fda1ebef1fddc
HTTP Auth Password:	5df5141d816ada67bca751c6a110b204
Method:	POST
Content Type:	application/x-www-form-urlencoded
HTTP Version:	1.1
Host:	
Headers:	
Body:	From={+12569989899}&To={+919817900451}&Body=Earth quake Alert: Drop to hands and knees, cover head and nec k, hold onto sturdy furniture, move away from windows, st ay indoors until shaking stops.
Parse String:	
Created:	2024-05-02 6:38 pm

Figure 10: ThingHTTP Configuration

4. Twilio

Twilio is a cloud communications platform that enables developers to integrate various communication channels, including SMS, voice, and email, into their applications and services via simple APIs.

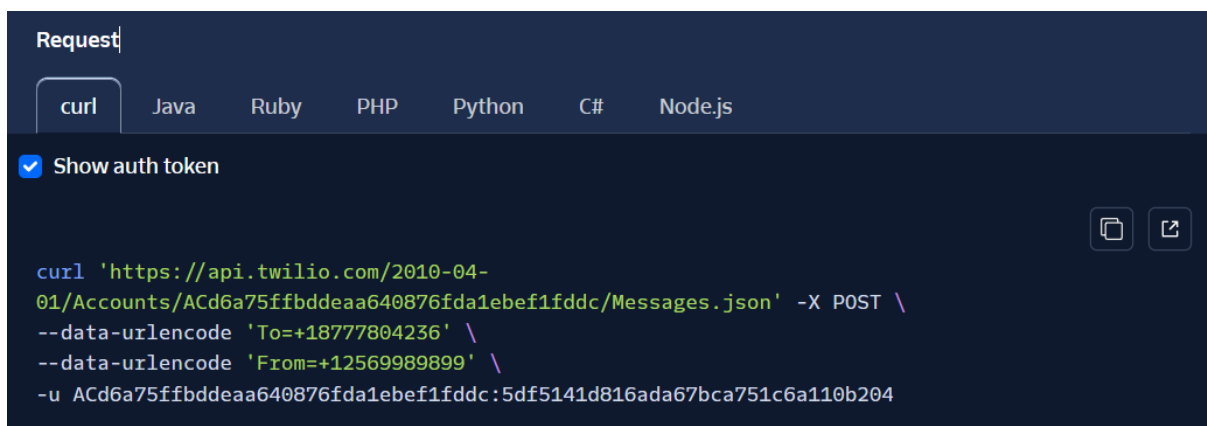
Purpose:

In our earthquake detection system, Twilio serves as the communication gateway for sending SMS notifications to relevant authorities when seismic activity is detected. By leveraging Twilio's API, we can programmatically trigger SMS messages to predefined phone numbers, ensuring timely alerts in the event of an earthquake.

Usage:

We utilize Twilio's API within our system to initiate SMS notifications to designated recipients, such as emergency response teams or local authorities, when seismic events are detected. This integration allows for seamless communication and ensures that relevant stakeholders are promptly informed about potential emergencies, facilitating swift response and mitigation efforts.

API Request:



The screenshot shows a web interface for constructing an API request. At the top, there's a tabbed menu with 'curl' selected, and other options like 'Java', 'Ruby', 'PHP', 'Python', 'C#', and 'Node.js'. Below the tabs, there's a checkbox labeled 'Show auth token' which is checked. The main area displays a curl command for sending an SMS via Twilio's API. The command includes the Twilio API endpoint, the account SID, the message body, the recipient's phone number, and the sender's phone number, along with the authentication token.

```
Request

curl  Java  Ruby  PHP  Python  C#  Node.js

☒ Show auth token

curl 'https://api.twilio.com/2010-04-01/Accounts/ACd6a75ffbddeaa640876fda1ebef1fddc/Messages.json' -X POST \
--data-urlencode 'To='+18777804236' \
--data-urlencode 'From='+12569989899' \
-u ACd6a75ffbddeaa640876fda1ebef1fddc:5df5141d816ada67bca751c6a110b204
```

Figure 11: Twilio API Request

Twilio SMS View:

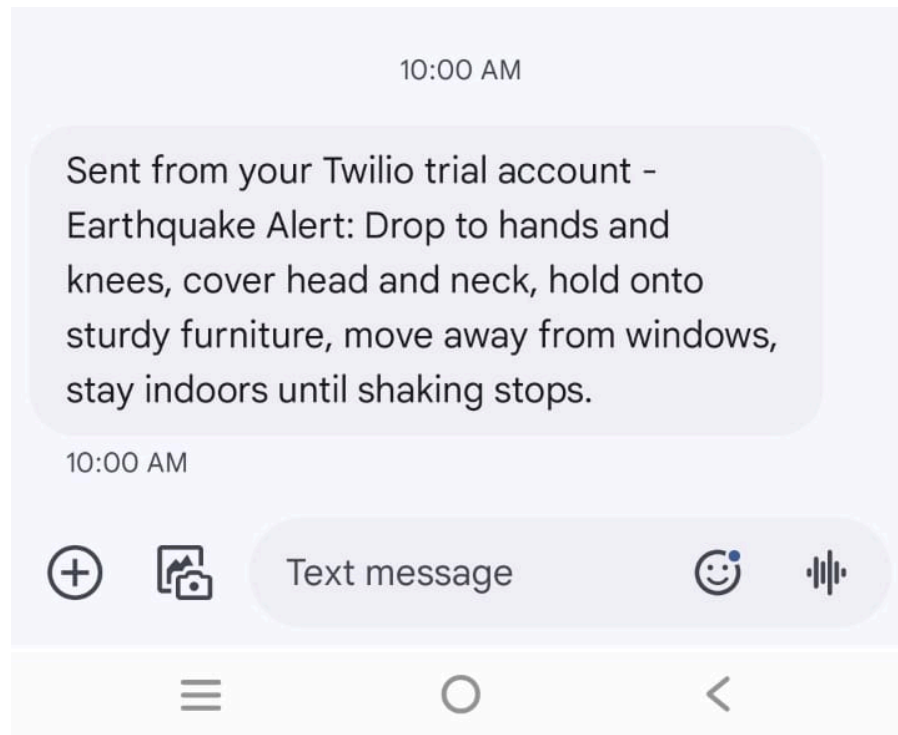


Figure 12: Twilio SMS View

Chapter 7

PROCEDURE

The procedure for the “Seismic Data Monitoring with ESP32 and ThingSpeak Cloud Integration” project can be divided into the following steps:

1. **Research and Planning:** The inception of the Seismic Data Monitoring system involved thorough research on earthquake detection methodologies, sensor technologies, microcontroller platforms, and cloud integration strategies. This research aimed to establish project objectives, requirements, and constraints, considering factors such as detection accuracy, power efficiency, portability, and real-time data transmission necessities
2. **Circuit Design and Breadboard Assembly:** In this step, the Circuit Design and Breadboard Assembly phase, a schematic diagram was created to illustrate the connections between components, emphasizing the integration of the ESP32 microcontroller and MPU6050 accelerometer sensor. This design aimed to optimize sensor placement and ensure efficient data transmission and control. The components were then assembled on a breadboard according to the schematic, allowing for practical testing and validation of the hardware setup.

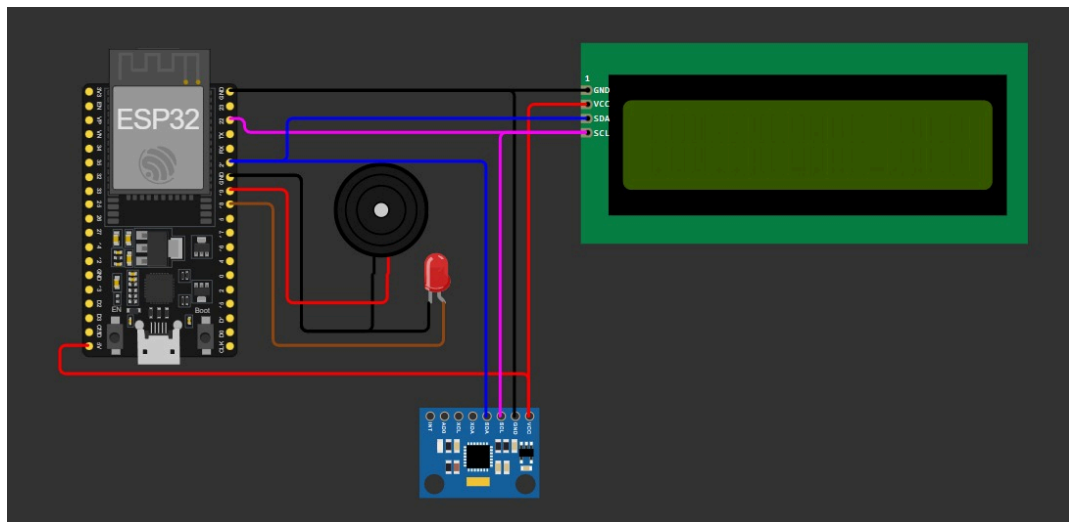


Figure 13 : Circuit Diagram

3. **Programming:** Programming for this project involves writing and uploading firmware code to the ESP32 microcontroller using the Arduino IDE (Integrated Development Environment). The code is written in C/C++ and utilizes libraries specific to the ESP32 and connected components such as the MPU6050 accelerometer sensor and I2C peripherals. The firmware code implements functionality for data acquisition from the accelerometer sensor, real-time data processing, and communication with ThingSpeak for cloud integration. Additionally, the code controls the behavior of output components like the LCD display, buzzer, and LEDs based on sensor readings and system conditions.

```
#include <Adafruit_MPU6050.h>
#include <Adafruit_Sensor.h>
#include <LiquidCrystal_I2C.h> // lcd Header
#include <WiFi.h>
#include <HTTPClient.h>

// Set the I2C address for your specific LCD module
int lcdAddress = 0x27; // Change this to your LCD's address
(usually 0x27 or 0x3F)

int earthquake_detect = 0;
int ex_val = 0;
int ey_val = 0;
int ez_val = 0;
unsigned long previousMillis = 0; // Stores the last time the
parameter was updated
const long interval = 15000; // Interval in milliseconds
(e.g., 1000ms = 1 second)

// Initialize the LiquidCrystal_I2C library with the LCD's
address and the number of columns and rows
LiquidCrystal_I2C lcd(lcdAddress, 16, 2);
Adafruit_MPU6050 mpu;

#define buzzer 19 // buzzer pin
#define led 18 //led pin
```

```

/*variables*/

int xsample=0;
int ysample=0;
int zsample=0;
long start;

/*Macros*/
#define samples 30
#define maxVal 5 // max change limit
#define minVal -5 // min change limit
#define buzTime 1000 // buzzer on time

const char* ssid = "Admin";
const char* password = "alita123";
// Domain Name with full URL Path for HTTP POST Request
const char* serverName = "http://api.thingspeak.com/update";
// write API Key provided by thingspeak
String apiKey = "EDFQ7NOOBUTH1MS5";

void setup()
{
    Serial.begin(115200);
    delay(1000);
    lcd.init(); //initializing lcd
    lcd.backlight();
    delay(1000);
    lcd.print("EarthQuake ");
    lcd.setCursor(0,1);
    lcd.print("Detector ");
    delay(2000);
    lcd.clear();
    WiFi.mode(WIFI_STA); //Optional
    WiFi.begin(ssid, password);
    Serial.println("Connecting");
    lcd.print("Connecting to");
    lcd.setCursor(0,1);
    lcd.print("Wifi ... ..");
    while(WiFi.status() != WL_CONNECTED) {
        delay(500);
        Serial.print(".");
    }
    Serial.println("");
}

```

```

    lcd.clear();
    Serial.print("Connected to WiFi network with IP Address: ");
    Serial.println(WiFi.localIP());
    lcd.print("Conected to:");
    lcd.setCursor(0,1);
    lcd.print(WiFi.localIP());
    delay(2000);
    lcd.clear();

// Try to initialize!
    if (!mpu.begin()) {
        Serial.println("Failed to find MPU6050 chip");
        lcd.print("MPU6050");
        lcd.setCursor(0,1);
        lcd.print("not found");
        delay(2000);
        while(1)
        {
            delay(10);
        }
    }
    else
    {
        Serial.println("MPU6050 Found!");
    }
    lcd.print("Calibrating.....");
    lcd.setCursor(0,1);
    lcd.print("Please wait...");
    pinMode(buzzer, OUTPUT);
    pinMode(led, OUTPUT);
    digitalWrite(buzzer, 0);
    digitalWrite(led, 0);
    mpu.setAccelerometerRange(MPU6050_RANGE_2_G);
    for(int i=0;i<samples;i++) // taking samples for calibration
    {
        /* Get new sensor events with the readings */
        sensors_event_t a, g, temp;
        mpu.getEvent(&a, &g, &temp);
        xsample+= a.acceleration.x; // X axis data
        ysample+= a.acceleration.y;
        zsample+= a.acceleration.z; // Y axis data
    }

```



```

xsample/=samples; // taking avg for x
ysample/=samples; // taking avg for y
zsample/=samples; // taking avg for z

delay(2000);
lcd.clear();
lcd.print("Calibrated");
delay(1000);
lcd.clear();
lcd.print("Device Ready");
delay(1000);
lcd.clear();
lcd.print(" X    Y    Z ");
}

void loop()
{
    // Current time
    unsigned long currentMillis = millis();

    /* Get new sensor events with the readings */
    sensors_event_t a, g, temp;
    mpu.getEvent(&a, &g, &temp);
    int value1 = a.acceleration.x; // X axis data
    int value2 = a.acceleration.y;
    int value3 = a.acceleration.z; // Y axis data

    int xValue=xsample-value1; // finding change in x
    int yValue=ysample-value2; // finding change in y
    int zValue=zsample-value3; // finding change in z

    /*displaying change in x,y and z axis values over lcd*/
    lcd.setCursor(0,1);
    lcd.print(xValue);
    lcd.setCursor(6,1);
    lcd.print(yValue);
    lcd.setCursor(12,1);
    lcd.print(zValue);
    delay(100);
}

```

```

/* comparing change with predefined limits*/
    if(xValue < minVal || xValue > maxVal || yValue < minVal ||
yValue > maxVal || zValue < minVal || zValue > maxVal)
    {
        Serial.println("Earthquake Alert");
        earthquake_detect = 1;
        ex_val = xValue;
        ey_val = yValue;
        ez_val = zValue;
        lcd.setCursor(0,0);
        lcd.print("Earthquake Alert ");
        digitalWrite(buzzer, 1); // buzzer on and off command
        digitalWrite(led, 1); // led on and off command
    }

    if(earthquake_detect == 0 && xValue != 0 && yValue != 0 &&
zValue != 0){
        ex_val = xValue;
        ey_val = yValue;
        ez_val = zValue;
    }
    delay(1000);
    lcd.clear();
    lcd.print(" X    Y    Z ");
    digitalWrite(buzzer, 0); // buzzer on and off command
    digitalWrite(led, 0); // led on and off command

    /*sending values to processing for plot over the graph*/
    Serial.print("x=");
    Serial.println(xValue);
    Serial.print("y=");
    Serial.println(yValue);
    Serial.print("z=");
    Serial.println(zValue);
    Serial.print("$");
    Serial.println(currentMillis);
    if(earthquake_detect == 0 && ex_val == 0 && ey_val == 0 &&
ez_val == 0){
        return;
    }

```

```

//Sending data to ThingsSpeak
    if(WiFi.status()== WL_CONNECTED && currentMillis -
previousMillis >= interval){
        WiFiClient client;
        HTTPClient http;
        // Your Domain name with URL path or IP address with
path
        http.begin(client, serverName);
        // Specify content-type header
        http.addHeader("Content-Type",
"application/x-www-form-urlencoded");
        // Data to send with HTTP POST
        String httpRequestData = "api_key=" + apiKey + "&field1="
+ String(ex_val) + "&field2=" + String(ey_val) + "&field3=" +
String(ez_val) + "&field4=" + String(earthquake_detect);
        // Send HTTP POST request
        int httpResponseCode = http.POST(httpRequestData);
        if(earthquake_detect == 1){
            earthquake_detect = 0;
        }
        ex_val = 0;
        ey_val = 0;
        ez_val = 0;
        previousMillis = currentMillis;
        Serial.print("HTTP Response code: ");
        Serial.println(httpResponseCode);
        http.end();
    }
}

```

4. **Mechanical Assembly:** In this step, the mechanical assembly for this project involves integrating all electronic components, including the ESP32 microcontroller, MPU6050 accelerometer sensor, and display modules, into a compact and portable enclosure. Careful attention is given to component placement to optimize sensor performance and ensure ease of use.

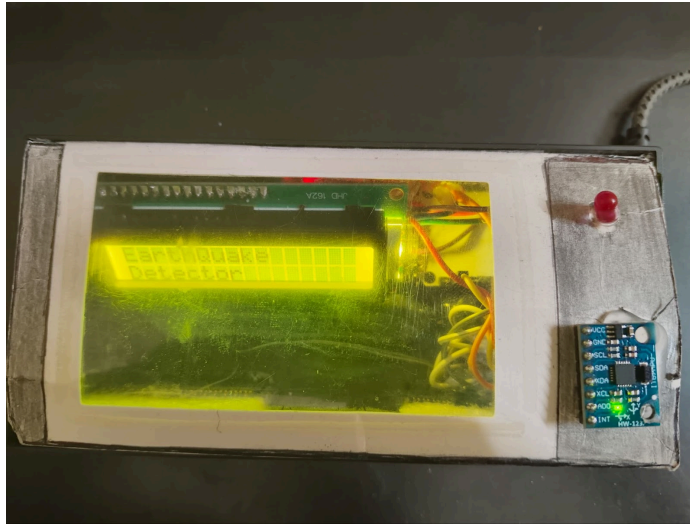


Figure 14: Mechanical Assembly

5. **Power Supply:** For power supply, a USB cable is used to connect the ESP32 microcontroller to a computer or USB power adapter, providing a convenient and reliable source of 5V DC power. This USB connection simplifies power management and eliminates the need for external power supplies, enhancing the portability and usability of the Earthquake Detector Alarm system.

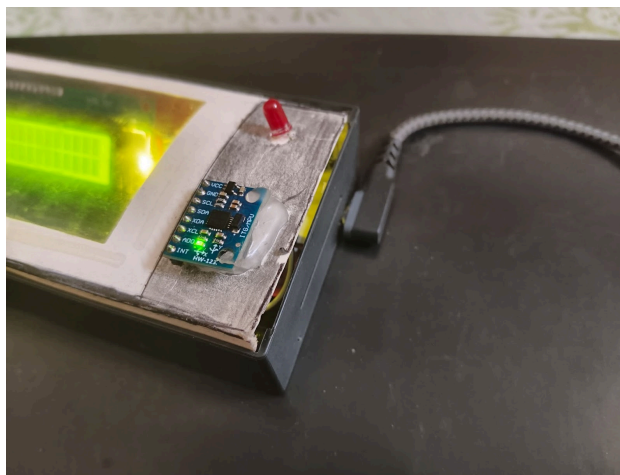


Figure 15: Power Supply

6. Testing and Evaluation: During the testing and evaluation phase, the Seismic Data Monitoring system's functionality is validated through simulated seismic events to ensure accurate detection and notification performance. Real-time data transmission to ThingSpeak and visual feedback on the mobile application are assessed to confirm system reliability and user interaction effectiveness."

Chapter 8

OPERATION

In this section, we delve into the operational mechanisms of our seismic data monitoring system. We explore how the system operates, from data acquisition to alert generation, emphasizing the integration of hardware components, data processing algorithms, and communication protocols.

Sensor Data Acquisition:

The operational process commences with the acquisition of sensor data from the MPU6050 accelerometer sensor. This sensor captures acceleration along the x, y, and z axes, providing essential input for earthquake detection. The ESP32 microcontroller retrieves data from the sensor at regular intervals, facilitating real-time monitoring of seismic activity.

Data Processing:

Upon receiving sensor data, the ESP32 microcontroller employs sophisticated algorithms to process and analyze the data. These algorithms are designed to detect patterns indicative of seismic events, enabling the system to differentiate between regular vibrations and actual earthquakes. By analyzing acceleration values and comparing them to predefined thresholds, the system identifies potential seismic activity.

Alert Generation:

When seismic activity is detected, the system initiates alert mechanisms to notify users and relevant authorities. Visual indicators such as LEDs and LCD displays are activated to provide immediate feedback to users, alerting them to the presence of seismic events. Additionally, the system sends SMS notifications to designated recipients using Twilio's API.

Cloud Integration:

Our earthquake detection system leverages ThingSpeak, a cloud platform, for data storage, visualization, and remote access. Data collected by the ESP32 microcontroller is transmitted to ThingSpeak via HTTP requests, facilitating seamless integration. Users can view real-time seismic data on their smartphones from anywhere, enhancing situational awareness and enabling timely response to seismic events.

Conclusion:

The operational framework of our seismic data monitoring system underscores its effectiveness in real-time monitoring and alerting. By seamlessly integrating hardware components, data processing algorithms, and communication protocols, the system ensures timely and accurate detection of seismic activity, thereby enhancing disaster preparedness and response efforts.

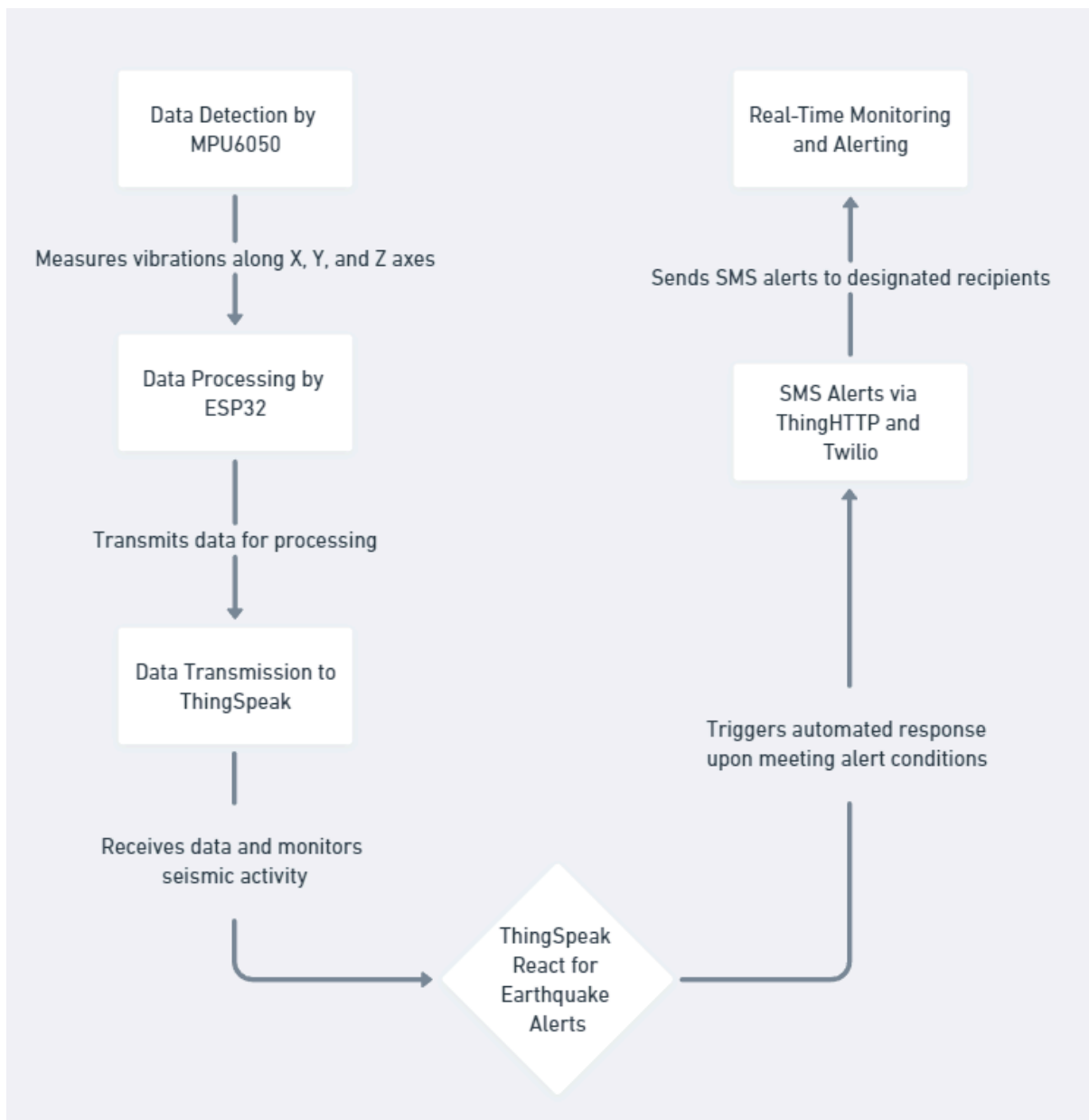


Figure 16: Flowchart

Chapter 9

RESULTS & DISCUSSION

The outcomes of the Seismic Data Monitoring system showcased effective seismic event detection and notification capabilities. Leveraging the MPU6050 accelerometer sensor integrated with the ESP32 microcontroller, the system accurately identified simulated earthquakes. Real-time data transmission to the ThingSpeak cloud platform facilitated remote monitoring and analysis of seismic activity.

The system integrated SMS alerts using Twilio's ThingHTTP service, ensuring prompt notification of relevant authorities upon earthquake detection. The mobile application efficiently presented x, y, z coordinates of detected seismic events alongside graphical representations, enriching user comprehension and visualization of seismic data. The system's alert mechanisms, including LED indicators and a buzzer, delivered immediate feedback to users upon earthquake detection.

During the discussion, the system's performance was scrutinized in terms of detection accuracy, response time, and user-friendliness. Challenges such as sensor calibration and cloud integration were confronted, indicating areas for potential refinement. Future advancements might involve fine-tuning data analysis algorithms, optimizing power consumption, and incorporating additional alerting features to bolster user safety and system reliability. Overall, the outcomes suggest a functional and promising Seismic Data Monitoring system with scope for further development and enhancement.

Chapter

CONCLUSION & FUTURE SCOPE

Conclusion: The Seismic Data Monitoring system, incorporating the ESP32 microcontroller and MPU6050 accelerometer sensor, effectively detected and notified users of seismic events. Integration with ThingSpeak facilitated real-time data transmission and remote monitoring, enhancing system usability. Despite overall success, challenges were encountered in efficiently detecting earthquakes. Future efforts will focus on refining detection algorithms and enhancing sensor calibration for improved accuracy and reliability.

Future Scope: The Seismic Data Monitoring system holds promising prospects for expansion and enhancement. Future iterations will prioritize refining sensor calibration and detection algorithms to enhance earthquake detection efficiency. Additionally, integrating advanced machine learning algorithms will further refine seismic event recognition and bolster system reliability. Exploring IoT integration for real-time alerts and expanding compatibility with additional cloud platforms will broaden the system's reach in earthquake-prone regions. Continuous development and innovation will drive improvements, ensuring the system's effectiveness and usability in real-world applications.

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