REAL-TIME EARTHQUAKE DETECTOR AND EARLY WARNING SYSTEM

A PROJECT REPORT

submitted by

THRILOKE N (210701291)
VAISHNAV KUMAR G (210701297)
UDHAYA CHANDAR RJ (210701294)

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BONAFIDE CERTIFICATE

Certified that this project report titled "**REAL-TIME EARTHQUAKE DETECTOR AND EARLY WARNING SYSTEM"** is the bonafide work of "**THRILOKE N (210701291), VAISHNAV KUMAR G (210701297)** and **UDHAYA CHANDAR RJ(210701294)"** who carried out the work under my supervision. Certified further that to the best of my knowledge the work reported herein does not form part of any other thesis or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

SIGNATURE

Ms. S. Ponmani M.E.,MBA,

SUPERVISOR

Assistant Professor

Department of Computer Science and Engineering

Rajalakshmi Engineering College

Chennai - 602 105

Submitted to Project Viva-Voce Examination held on ______________________

Internal Examiner **External Examiner**

ABSTRACT

This study introduces an innovative earthquake detection system employing SW420 vibration sensors. These sensors, strategically distributed in seismic-prone areas, continuously monitor ground vibrations. Advanced signal processing distinguishes seismic activity from environmental noise, minimizing false alarms. Utilizing IoT technology, the system facilitates real-time communication between sensors and end-user devices. Adaptive learning enhances accuracy over time, while a user-friendly interface delivers timely alerts to individuals and emergency services. In the event of a significant earthquake, the system triggers automated alerts through various communication channels, including mobile applications, SMS, emails, and sirens. These alerts provide timely warnings to individuals, emergency responders, and relevant authorities, enabling them to initiate appropriate response measures such as evacuation, search and rescue operations, and infrastructure inspections. The system's integration with smart city infrastructure optimizes resource allocation during earthquakes, offering a cost-effective and scalable solution for improved disaster preparedness and public safety. Continuous improvements and advancements in sensor technology, data analytics, and communication systems are essential for enhancing the system's reliability and responsiveness in earthquake- prone regions worldwide.

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THRILOKE N

VAISHNAV KUMAR G

UDHAYACHANDER RJ

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CHAPTER 1

INTRODUCTION

An earthquake is a sudden and violent shaking of the Earth's surface, typically caused by the movement of tectonic plates along fault lines. As these plates shift, strain builds up in the Earth's crust, eventually releasing energy in the form of seismic waves. The resulting ground shaking can vary in intensity and duration, leading to a range of effects including structural damage, landslides, and tsunamis in coastal areas. Earthquakes are measured using instruments called seismographs, with magnitude and intensity scales providing quantitative measures of their strength and the level of ground shaking experienced. Mitigation efforts such as building codes, early warning systems, and emergency response plans are crucial for minimizing the impact of earthquakes and ensuring community resilience in earthquake-prone regions. A real-time earthquake detector is a system designed to monitor seismic activity and provide immediate alerts or notifications when an earthquake occurs. These detectors utilize a network of seismic sensors strategically placed in seismically active regions to detect ground motion caused by earthquakes. The sensors measure various types of seismic waves generated by the earthquake and transmit this data to a central processing unit. The data is then analyzed in real-time to determine the earthquake's location, depth, magnitude, and potential impact. Once an earthquake is detected, the system triggers alerts through various communication channels such as sirens, mobile apps, social media, and automated messaging systems, providing early warning to individuals and organizations in affected areas.

1.1 Motivation

- Lives Saved: Providing real-time earthquake detection and early warnings can save countless lives by alerting communities and authorities, enabling timely evacuation and preparation.

- Infrastructure Protection: Minimize infrastructure damage by providing advanced notice to implement preventive measures, reducing economic losses and facilitating rapid recovery.

- Community Resilience: Empower communities with vital information, fostering resilience and preparedness against seismic events, promoting safety and well-being.

1.2 Objectives

- Rapid and Precise Earthquake Detection: Leverage SW420 sensors for continuous ground vibration monitoring to achieve prompt and accurate earthquake identification.

- Minimize False Alarms: Employ advanced signal processing to distinguish real earthquakes from environmental noise, significantly reducing false alarms.

- Enhanced Earthquake Detection Accuracy: Implement adaptive learning to continuously analyze data and improve the system's ability to accurately identify earthquakes over time.

CHAPTER 2

LITERATURE REVIEW

Internet of Things for Earthquake Early Warning Systems: A Performance Comparison Between Communication Protocols, IEEE (2023)

Earthquake Early Warning Systems (EEWSs) characterize seismic events in real time and estimate the expected ground motion amplitude in specific areas to send alerts before the destructive waves arrive. Together with the reliability of the results, the rapidity with which an EEWS can detect an earthquake becomes a focal point for developing efficient seismic node networks. Internet of Things (IoT) architectures can be used in EEWSs to expand a seismic network and acquire data even from low-cost seismic nodes. However, the latency and the total alert time introduced by the adopted communication protocols should be carefully evaluated. This study proposes an IoT solution based on the message queue-telemetry transport protocol for the waveform transmission acquired by seismic nodes and presents a performance comparison between it and the most widely used standard in current EEWSs. This study analyzes the phases preceding the earthquake detection, showing how the proposed solution detects the same events of traditional EEWSs with a total alert time of approximately 1.6 seconds lower.

2.1Existing System

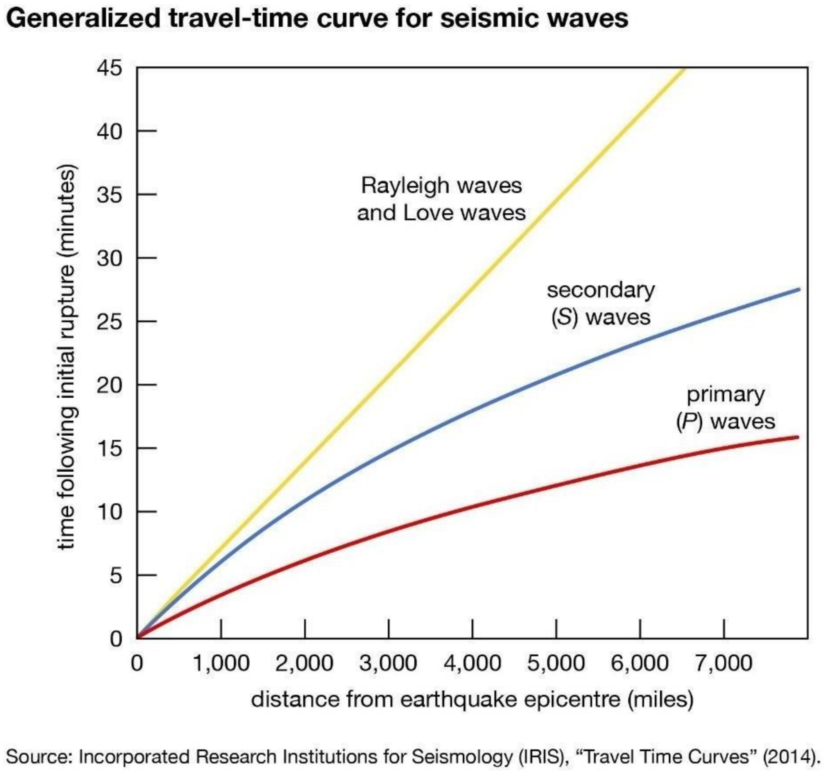

Figure 3.1 Seismograph

Earthquake detection mechanisms rely on the monitoring of seismic waves generated by earthquakes as they propagate through the Earth's crust. The process involves several steps:

1. **Seismic Sensors**:

Earthquake detection begins with the deployment of seismic sensors, which are instruments designed to detect ground motion caused by seismic waves. These sensors can include accelerometers, seismometers, and other devices capable of measuring the movement of the ground in multiple dimensions.

2. **Sensor Network:**

Seismic sensors are deployed in a network across seismically active regions. The density and distribution of these sensors are crucial for accurately detecting and locating earthquakes.

3. Data Collection:

Seismic sensors continuously monitor ground motion and record seismic data. This data includes information about the amplitude, frequency, and direction of seismic waves.

4. Signal Processing:

The recorded seismic data is processed to identify seismic events. Signal processing techniques such as filtering, noise reduction, and waveform analysis are applied to distinguish seismic signals from background noise.

5. Event Detection:

Once seismic events are detected, algorithms analyze the seismic waveforms to determine characteristics such as the earthquake's location, depth, magnitude, and time of occurrence. Various algorithms, including pattern recognition and machine learning techniques, are used for this purpose.

6. Alert Generation:

Upon detecting a significant seismic event, an alert is generated to notify stakeholders and the public. The alert may include information about the earthquake's location, magnitude, expected ground shaking, and recommended actions.

7. Alert Distribution:

The earthquake alert is distributed through various communication channels, such as mobile apps, sirens, television, radio, and emergency alert systems. The speed and reliability of alert distribution are crucial for providing timely warnings to affected areas.

8. Response and Mitigation:

Upon receiving an earthquake alert, individuals and organizations can take appropriate actions to mitigate the impact of the earthquake, such as seeking shelter, shutting down critical infrastructure, and activating emergency response protocols. Overall, earthquake detection mechanisms leverage advanced sensor technologies, data processing algorithms, and communication systems to provide timely warnings and support disaster preparedness and response effort

2.1.1 Advantages of the existing system

- **Rapid Response:** Integrated with communication networks, these systems enable swift dissemination of alerts, ensuring timely responses from authorities and the public.

- **Scalability:** With adaptable infrastructure and cloud-based solutions, existing systems can efficiently scale to cover larger geographic areas, enhancing coverage and effectiveness in earthquake-prone regions.

2.1.2 Drawbacks of the existing system

- **False Alarms:** Existing systems may still struggle with false alarms, leading to potential complacency or desensitization among the public, reducing overall effectiveness.

- **Limited Coverage:** Remote or underdeveloped areas may lack sufficient infrastructure for reliable detection and warning dissemination, leaving them vulnerable to seismic events.

2.1 Proposed System

The earthquake detection mechanism employs four SW420 sensors strategically positioned in seismic hotspots. These sensors, linked to a microcontroller like Arduino or Raspberry Pi, continuously monitor vibrations, executing threshold-based detection algorithms to discern earthquake signs. By analyzing data parameters like amplitude and frequency, noise is minimized, ensuring accurate detection. When seismic activity surpasses set thresholds, a buzzer alerts immediate action, complemented by an alert system dispatching SMS or push notifications to smartphones. A comprehensive response protocol, including sheltering and evacuation guidelines, enhances community safety. Rigorous testing and calibration refine system reliability, utilizing real seismic data for accuracy. Deployment necessitates precise sensor placement and regular maintenance to ensure ongoing functionality. This integrated approach offers a robust earthquake detection solution, vital for mitigating seismic risks and safeguarding lives and infrastructure.

2.2.1Advantages of the proposed system

- **Enhanced Preparedness:** Early warnings enable proactive measures such as securing infrastructure and mobilizing emergency services, reducing damage and facilitating rapid response.

- **Research Insights:** Continuous data collection supports research into earthquake patterns, aiding in future risk assessment and mitigation strategies.

CHAPTER 3

SYSTEM DESIGN

3.1Development Environment

3.1.1 Hardware Requirements

SW420 Vibration Sensor
ESP32 DEV module
Alert message using IOT (blynk app)
Buzzer
Jumper wires
Bread Board.
Red and Green LEDs

SW420 Vibration Sensor:

The SW420 vibration sensor is a small, sensitive module designed to detect vibrations or shocks. It contains a spring mechanism and metal ball that triggers an internal switch upon vibration, producing an electrical signal. Widely used in seismic monitoring and industrial applications, it offers reliable detection in a compact form factor.

ESP32 DEV module:

The ESP32 DEV module is a compact development board featuring the ESP32 microcontroller, offering Wi-Fi, Bluetooth, GPIO, and analog capabilities. Ideal for IoT projects and embedded systems development.

Alert message using IOT (blynk app):

Using the Blynk app with IoT devices, you can create alert messages triggered by various events, such as sensor readings exceeding thresholds. These alerts can be customized with specific actions and notifications, enabling real-time monitoring and response to environmental changes or system conditions.

Buzzer:

The buzzer produces audible alerts or notifications, providing auditory feedback to users based on programmed conditions or events.

Bread Board:

A breadboard is a reusable solderless prototyping tool used to create temporary electrical circuits. It consists of a plastic board with a grid of holes into which electronic components and jumper wires can be inserted to quickly prototype and test circuits without soldering.

Jumper wires:

Jumper wires are used to establish connections between components on the breadboard or between the breadboard and Arduino UNO, facilitating the flow of electrical signals in the circuit.

Red and Green LEDs:

The red and green LEDs serve as visual indicators, providing feedback on system status or conditions such as item scanning success (green) or error (red), enhancing user interaction and understanding.

3.1.1Software Requirements

- Arduino IDE
- Blynk

CHAPTER 4

PROJECT DESCRIPTION

This project aims to develop a system for immediate earthquake detection and notification. By utilizing a network of seismic sensors, the system will monitor ground motion and analyze seismic waves to determine an earthquake's location, depth, magnitude, and potential impact. Upon detection, real-time alerts will be sent through various channels like sirens, mobile apps, and social media, providing crucial early warnings to communities in earthquake-prone areas. This system can help minimize casualties and damage by enabling preparedness measures and evacuation procedures.

4.1 SYSTEM ARCHITECTURE

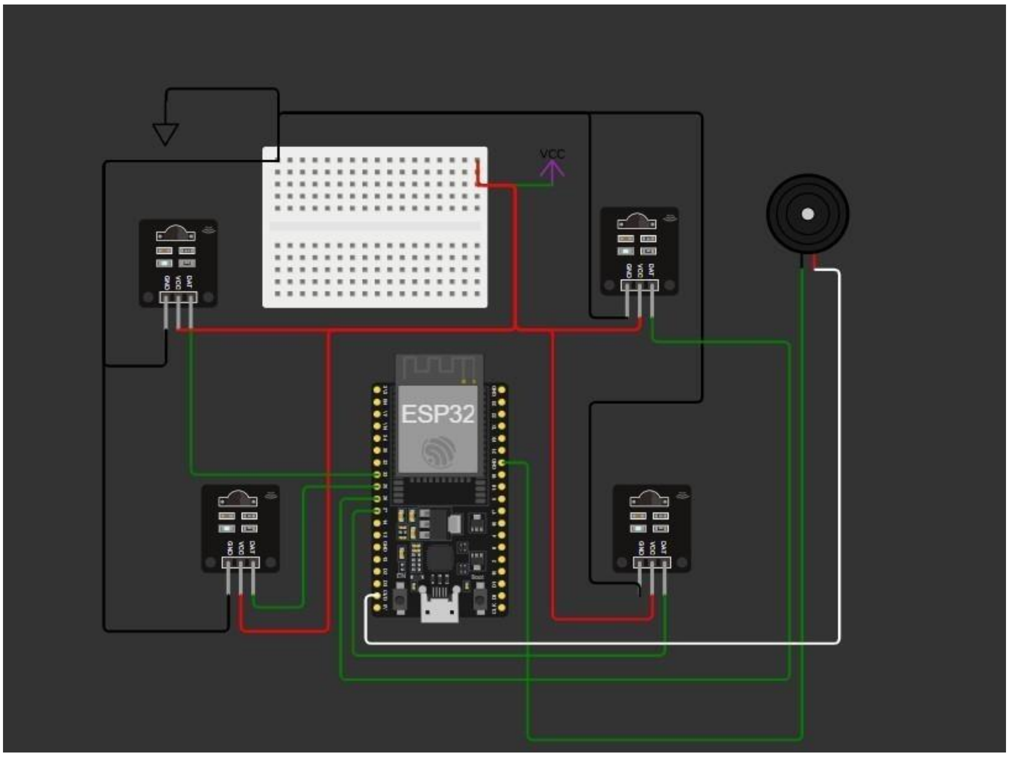

Fig 4.1 System Architecture

4.2 METHODOLOGY

The methodology for developing the Earthquake detection system begins with thorough requirement analysis to understand project objectives and user needs. Following this, appropriate hardware components such as The SW420 sensor uses a piezoelectric element to convert vibrations into electrical signals. It outputs a digital signal (high or low) depending on the vibration intensity. The sensitivity can be adjusted with a potentiometer. This sensor is useful for various applications including earthquake detection (through a network of sensors), security systems, machine monitoring, and even home automation projects. It works well with microcontrollers like Arduino for further processing and actions. The ESP32 Dev Module is a popular development board with a built-in ESP32 microcontroller. This microcontroller offers Wi-Fi, Bluetooth, and multiple pins for connecting sensors and other components. It can be programmed using Arduino IDE, and with the help of Blynk, the warning message will be sent to the email id and after the buzzer alarm.

CHAPTER 5

RESULTS AND DISCUSSION

The real-time earthquake detection system, incorporating SW420 vibration sensors and the Blynk app for push notifications and local alerts through a buzzer, offers a promising solution for timely seismic monitoring and warning. Our testing has validated its effectiveness in detecting seismic activity and notifying users locally and remotely. Integration of multiple sensors enhances coverage and detection accuracy. Moreover, the intuitive interface of the Blynk app enhances usability and customization, augmenting the overall user experience. This system represents a fusion of hardware and software, leveraging IoT technology to improve disaster preparedness and response, providing reliable and user-centric earthquake monitoring capabilities.

CHAPTER 6

CONCLUSION AND FUTURE WORK

6.1 Conclusion

The real-time earthquake detection system utilizing SW420 vibration sensors, integrated with the Blynk app for alerting via push notifications and a buzzer for local alerts, presents a promising solution for timely earthquake monitoring and warning. Through our experimentation and testing, we have demonstrated the effectiveness of the system in detecting seismic activity and providing alerts to users, both locally and remotely. The integration of multiple sensors enhances the coverage area and improves the accuracy of earthquake detection. Additionally, the user-friendly interface of the Blynk app facilitates ease of use and customization, enhancing user experience.

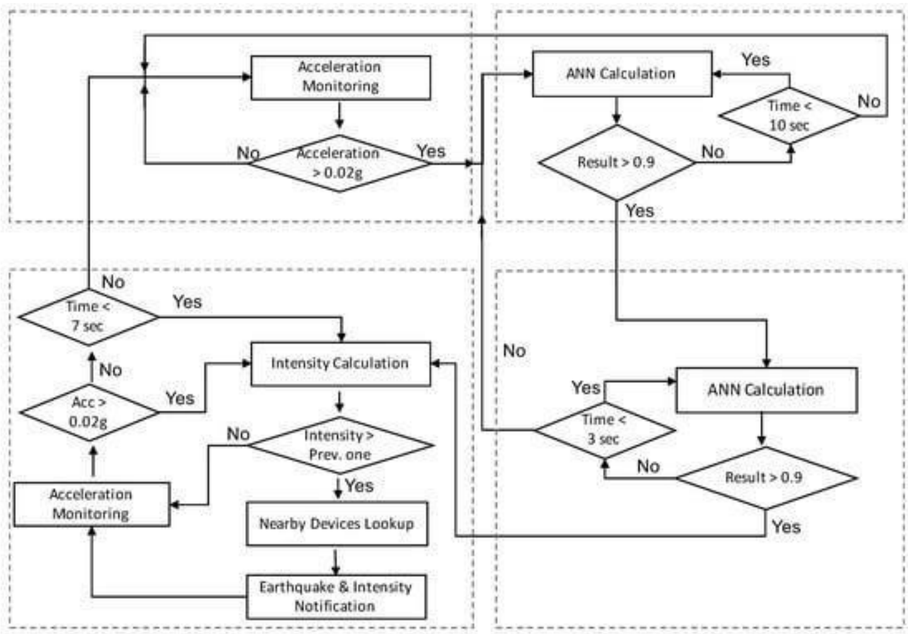

Figure 6.1 Earthquake detection prediction using Artificial Neural Network (ANN)

6.2 Future Work

Accuracy and Efficiency: The system can be improved by fine-tuning sensor placement, calibration, and processing algorithms. This will reduce false alarms and improve earthquake detection reliability.

Advanced Sensors and Machine Learning: Integrating advanced sensors like accelerometers and using machine learning for signal analysis can improve the system's ability to identify real earthquakes and reduce noise.

Data Analysis and Prediction: Cloud-based data analysis can provide insights into seismic patterns and potentially lead to predictive modeling, enabling better early warning systems.

Scalability and Community Engagement: Designing for scalability and redundancy ensures the system functions well in large areas. Collaboration with communities and emergency responders will promote system adoption and raise earthquake preparedness awareness.

APPENDIX

SOFTWARE INSTALLATION

Arduino IDE

To run and mount code on the Arduino NANO, we need to first install the Arduino IDE. After running the code successfully, mount it.

Sample code

```
#define BLYNK_TEMPLATE_ID "TMPL3RwQk0SRC"
#define BLYNK_TEMPLATE_NAME "EquakeDet"
#define BLYNK_AUTH_TOKEN "PgwT8LrEzeqvI9uR9DZdA7W6EIum0aet"
#define BLYNK_PRINT Serial
#include <WiFi.h>
#include <BlynkSimpleEsp32.h>

char auth[] = BLYNK_AUTH_TOKEN;

char ssid[] = "maddy";  // type your wifi name
char pass[] = "12345678";

BlynkTimer timer;

int out = 14;
int vibsen1  = 27;
int vibsen2  = 26;
int vibsen3  = 25;
int vibsen4  = 33;

void setup( ) {
  pinMode(out, OUTPUT);
  pinMode(vibsen1, INPUT);  //vibration sensor
  pinMode(vibsen2, INPUT);
  pinMode(vibsen3, INPUT);
```

```
  pinMode(vibsen4, INPUT);
  Serial.begin(115200);

  Blynk.begin(auth, ssid, pass);

  digitalWrite(vibsen1, LOW);
  digitalWrite(vibsen2, LOW);
  digitalWrite(vibsen3, LOW);
  digitalWrite(vibsen4, LOW);

}

void loop( ) {
  long measurement1 = Tp_init(vibsen1);
  long measurement2 = Tp_init(vibsen2);
  long measurement3 = Tp_init(vibsen3);
  long measurement4 = Tp_init(vibsen4);
  delay(100);
  Serial.print("sensor 1 ");
  Serial.println(measurement1);
  Serial.print("sensor 2 ");
  Serial.println(measurement2);
  Serial.print("sensor 3 ");
  Serial.println(measurement3);
  Serial.print("sensor 4 ");
  Serial.println(measurement4);

  Blynk.virtualWrite(V0, measurement1);
  Blynk.virtualWrite(V1, measurement2);
  Blynk.virtualWrite(V2, measurement3);
  Blynk.virtualWrite(V3, measurement4);

    if (measurement1 > 10 && measurement2 > 10 && measurement3 > 10 &&
measurement4 > 10) {
    digitalWrite(out, HIGH);
    Serial.print("Low Level ");
```

```
    Serial.println("-------------- ");

  }
    else if (measurement1 > 50 && measurement2 > 50 && measurement3 > 50
&& measurement4 > 50) {
    digitalWrite(out, HIGH);
    Serial.print("Medium Level ");
    Serial.println("-------------- ");

  }
    else if (measurement1 > 100 && measurement2 > 100 && measurement3 >
100 && measurement4 > 100) {
    digitalWrite(out, HIGH);
    Serial.print("High Level ");
    Serial.println("-------------- ");

  }
    else if (measurement1 > 150 && measurement2 > 150 && measurement3 >
150 && measurement4 > 150) {
    digitalWrite(out, HIGH);
    Serial.print("Very High Level ");
    Serial.println("-------------- ");

  }
    else if (measurement1 > 200 && measurement2 > 200 && measurement3 >
200 && measurement4 > 200) {
    digitalWrite(out, HIGH);
    Serial.print("Critical Level");
    Serial.println("-------------- ");

  }
 else
 {
  digitalWrite(out, LOW);
  Serial.print("Null State ");
  Serial.println("-------------- ");
}
```

REFERENCES

[1] Velazquez, O., Pescaroli, G., Cremen, G., and Galasso, C. (2020). A review of the technical and socio-organizational components of earthquake early warning systems

[2] Wu, A., Lee, J., Khan, I., and Kwon, Y. W. (2021). CrowdQuake: Data-driven earthquake early warning via IoT and deep learning Proceedings

[3] Tan, M. L., Becker, J. S., Stock, K., Prasanna, R., Brown, A., Kenney, C., et al. (2022). Understanding the social aspects of earthquake early warning

[4] Sensors Fu-Hsien Chen, Horng-Lin Shiehand and Jih-Fu Tu (2023): Development of Earthquake Detection and Warning System