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Using Sensors with the Internet of Thing for Earthquake Detection System : A Systematic Literature Review

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Abstract: Every human being needs safety in their lives from all disasters. However, earthquakes are the most impactful geological natural phenomena that can threaten human safety. One solution is to utilize an earthquake detection system to anticipate such disasters by utilizing sensor technology and the Internet of Thing (IoT). The purpose of this research is to evaluate the effectiveness of various earthquake detection technologies, including vibration sensors such as SW-420, MAG3110, DHT11, ADXL335 Accelerometer, HC-SRO4, and 801S vibration sensor, as well as IoT integration in early warning systems. The method used is Systematic Literature Review (SLR) with PRISMA design, including the steps of identification, screening, eligibility, and analysis of articles taken from the Google Scholar database for publications in 2018-2024. The results showed that the application of earthquake detection technology, vibration sensors, and IoT integration significantly improved the effectiveness of earthquake detection and warning.

Keywords: Earthquake detection system; internet of thing technology; vibration sensor

1. Introduction

Indonesia is one of the most vulnerable countries to earthquakes, with devastating impacts both in terms of casualties and material losses [1]. Earthquake events occur frequently because the Indonesian region, which is located between active tectonic plates, has very high earthquake activity [2]. Human safety is the top priority in dealing with natural disasters, especially earthquakes, which can occur suddenly without warning. Given the devastating impact of earthquakes, prevention and mitigation measures are crucial to reduce the risk [3]. One way to improve safety is to utilize technology that can provide early warning before a disaster occurs. This step is expected to save more lives and reduce material losses caused by earthquakes [4].

Earthquake disaster mitigation is one of the important aspects that must be considered, especially in vulnerable areas such as Indonesia. Earthquakes can occur due to shifting tectonic plates, known as tectonic earthquakes, or due to magma activity within the earth, known as

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volcanic earthquakes [5]. Tectonic earthquakes or earthquakes caused by tectonic processes are earthquakes with a source of disturbance deep within the earth, below the earth's surface [6]. Mitigation measures, such as the development of early warning systems, are essential to reduce the impact caused by earthquakes [7]. Experience from the large earthquake in the Mentawai Islands in 2007 shows that effective mitigation can reduce the number of casualties and damage incurred [8]. The faster and more accurate the early warning system, the faster the community can prepare for natural disasters [9].

One of the main problems in handling earthquakes in Indonesia is the accuracy and speed of the detection system and the dissemination of information to the public. BMKG, as the main source of earthquake-related information, often experiences delays in delivering information to affected communities, especially in remote areas [10]. In addition, public access to earthquake information is still limited, especially for those who live in hard-to-reach areas or do not have modern communication devices [11]. Several researchers have proposed innovative solutions to overcome the challenges in earthquake mitigation in Indonesia. One of the proposed solutions is the development of an Early Earthquake Warning (EAW) system based on the Internet of Things (IoT) [12]. By utilizing an increasingly widespread and stable internet network, this system allows real-time detection of ground vibrations through earthquake sensors connected to Wi-Fi or cellular networks [13].

Earthquake detection systems are a key element in disaster mitigation, serving to detect and analyze ground vibrations quickly and accurately. Typically, these systems consist of a network of sensors spread across various locations, which can detect ground vibrations and calculate seismic parameters such as magnitude, location and depth of the earthquake [5]. The speed and accuracy of these systems are critical, as they can give people time to evacuate before a stronger earthquake occurs. Earthquake detection systems can also be integrated with various communication devices to ensure that information can be disseminated quickly and widely. Development of this technology is ongoing to improve effectiveness and efficiency in dealing with unexpected earthquake disasters.

Vibration sensors are one of the important components in earthquake detection systems, which function to detect vibrations or changes in frequency on the ground. Under static conditions, this sensor is normally closed and conductive, but when vibrations occur, this sensor will open or close at a speed proportional to the vibration frequency [5]. The use of vibration sensors can also be combined with other technologies, such as IoT, to improve monitoring capabilities and information dissemination. The Internet of Things (IoT) is a concept that connects various devices via the internet, enabling real-time communication and data exchange between these devices [14]. Internet of Things (IoT) systems focus on connectivity, communication, and data exchange according to protocols designed to achieve real-time monitoring, intelligent reorganization, tracking, positioning, safety, and process control [15], [16]. IoT systems consist of three basic components, namely: (a) Devices equipped with sensors to detect physical changes, record, and store or transfer data to other devices or servers (b) Software that connects hardware and the internet, used for configuration and management of IoT systems [17]; and (c) Network/Internet, which connects devices, stores data in memory or cloud, and drives and transmits data. Thus, the internet supports and integrates these components in the IoT system [18].

This review specifically analyzes the integration of earthquake detection technology, sensors, and IoT. The discussion includes a comparison of the effectiveness of different types of sensors, as well as the role of IoT in improving the performance of earthquake detection systems. In addition, this review expands the scope towards the integration of IoT with big data to analyze earthquake patterns more accurately and predictively. Aspects of sustainability, system scalability, and implementation in specific regions are also highlighted, providing new insights into the challenges and practical solutions in applying these technologies. Thus, this review is expected to serve as a reference for other researchers in selecting sensors and IoT to build faster and more accurate earthquake detection systems.

By connecting vibration sensors and other detection devices into an IoT network, early warning systems can provide faster and more accurate information to the public, thereby increasing the chances of saving lives and reducing material losses. This research aims to evaluate the effectiveness of various earthquake detection technologies including vibration sensors such as SW-420, MAG3110, DHT11, ADXL335 Accelerometer, HC-SRO4, and 801S vibration sensor, as well as IoT integration in early warning systems.

2. Materials and Method

This research uses a literature study method with a focus on research journals on earthquake detection systems that utilize vibration sensors and the Internet of Things (IoT). The method applied is Systematic Literature Review (SLR) with PRISMA design. This method aims to answer specific research questions through a series of processes, including identification, analysis, synthesis, evaluation, and comparison of all literature relevant to the formulation of the problem or topic under study [19]. According to Thorne (2004) in [20], the benefit of the Systematic Literature Review method is its ability to synthesize various concurrent research findings, so that the facts presented become more complete and balanced.

In this study, researchers collected articles from the Google Scholar database with keywords such as “earthquake detection system,” “vibration sensor,” and “Internet of Things (IoT).” Articles were selected based on the inclusion criteria, namely those that discussed earthquake detection systems with vibration sensors and IoT, and were published between 2014 and 2024.

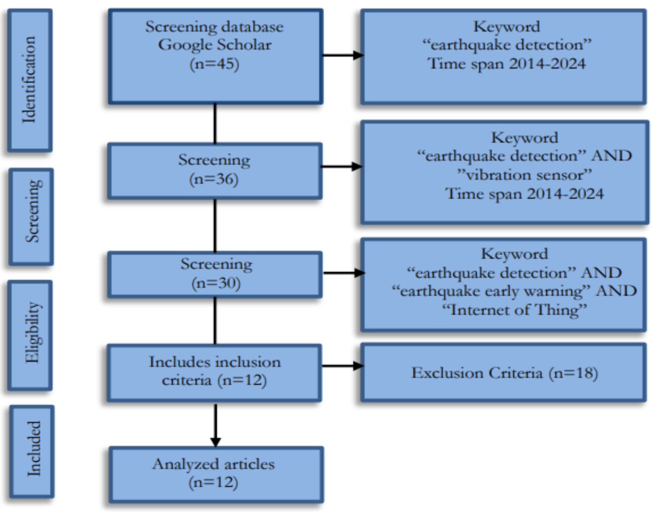

Figure 1. PRISMA stages [21]

The PRISMA steps adapted from Haddaway et al. (2018) describe the systematic process of selecting articles for the literature review. The process began with identification through a search of the Google Scholar database, resulting in 45 relevant articles based on keywords such as “earthquake detection,” “vibration sensor,” and “earthquake early warning” spanning 2014-2024. After going through the initial screening stage, the number of articles considered relevant was reduced to 36. Then, at the eligibility stage, only 30 articles met the criteria for further analysis. Of these 30 articles, 12 met all inclusion criteria and were selected for in-depth analysis, while the remaining 18 articles were excluded as ineligible. Thus, only 12 articles that passed all selection stages were finally analyzed in this systematic review. This process demonstrates the importance of rigorous screening to ensure the validity and relevance of research results.

3. Results and Discussion

3.1 Comparison of Sensor Types in the System

The following presents a comparison of various types of sensors that are often used in monitoring systems and IoT applications. The sensors listed, such as Gyro Accelerometer, SW-420 Sensor, MAG3110 & ADXL345, and ADXL335 Accelerometer, are analyzed based on accuracy, ease of integration, power consumption, and implementation complexity. A comparison of sensor types is in Table 1.

Table 1. Comparison of Sensor Types in the System.

No	Sensor Type	Specifications	Advantages	Disadvantages
1	Gyro Accelerometer	Measures angular acceleration and linear acceleration, often used in motion control and stabilization applications	- Allows monitoring of data from multiple sensor nodes - Suitable for applications that require high accuracy	- Implementation complexity is higher - Requires periodic calibration
2	SW-420 Sensor	A simple vibration sensor, detecting mechanical vibration or shock	- Easy to integrate with Wi-Fi-based IoT platforms such as ESP8266 - Affordable price	- It only detects the presence or absence of vibration without providing an amplitude value - Sensitivity is limited to strong vibrations
3	MAG3110 Sensor	MAG3110: 3-axis magnetic field sensor	- Good combination of sensors for environmental monitoring and remote orientation - High accuracy and low power consumption	- Telemetry implementation requires additional resources and hardware
4	ADXL335 Accelerometer	A 3-axis analog accelerometer sensor, used to detect motion and orientation	- Low power consumption and fast response - Easy to use with ATmega328	- Susceptible to environmental noise and unwanted vibration

			microcontroller	
5	DHT11 Sensor	Temperature & humidity sensor	- A complete solution for environmental monitoring with Wi-Fi connectivity	- DHT11 has low accuracy compared to other sensors
6	801S Vibration Sensor	High-sensitivity vibration sensor	- Easy to use with ATmega328 microcontroller	- Does not provide analog output, only binary detection (vibration present or not)
7	HC-SR04 Sensor	Ultrasonic proximity sensor used with SIM900 GSM module for remote application	- Can be used for remote monitoring using GSM communication	- SIM900 requires a stable GSM network - HC-SR04 is limited in detection of smaller objects

Table 1 shows that each type of sensor has specific applications supported by their respective advantages and disadvantages. Gyro Accelerometers excel in accuracy and motion monitoring, but their implementation complexity is high and they require regular calibration. The SW-420 sensor, while affordable and easy to integrate with IoT platforms, has limitations in detecting vibration intensity. Meanwhile, MAG3110 and ADXL335 offer high accuracy and low power consumption, but each has challenges in terms of sensitivity and susceptibility to noise.

The DHT11 sensor, while easy to integrate in IoT projects, has lower accuracy than other sensors. The 801S vibration sensor, while sensitive, only provides a binary output, which may be less informative in certain applications. Finally, the HC-SR04, coupled with the SIM900 GSM module, offers a solution for remote monitoring, but has limitations in detecting small objects and reliance on the stability of the GSM network. Overall, sensor selection should consider the balance between the specific needs of the application and the characteristics of the sensor offered.

Vibration sensors used in earthquake detection systems come in various types with their own advantages. Gyro Accelerometer sensors are accurate and fast monitoring sensors. It is capable of monitoring data from multiple sensor nodes. It enables the detection of ground vibrations and rotational movements such as deformation of ground structures with high accuracy. Gyro accelerometer sensors, such as the one used by Tisnadinata et al. (2019), are effective in detecting P and S waves and identifying earthquake strength with high accuracy. It is suitable for large-scale earthquake sensor networks and is easily integrated with monitoring systems.

The SW-420 sensor is a simple vibration sensor designed to detect vibrations. It is only capable of detecting small vibrations. However, this sensor is easy to integrate with IoT. The SW-420 sensor only detects the presence or absence of vibration. When vibration or shock is detected, the internal connection of the SW-420 is short-circuited, resulting in a change in signal. The SW-420 sensor, as in Siswanto's (2022) study, relies on changes in logic output and offers the flexibility of detection from multiple directions.

DHT11 is a sensor used to detect temperature while measuring changes in humidity in a place [22], [23]. DHT11 has a fairly good level of stability and a fairly accurate calibration feature [24]. Earthquake sensors are sensors that detect seismic activity and ground vibrations. They can be used together to determine changes in temperature and humidity that affect ground conditions that can increase the risk of earthquakes. For example, high humidity can weaken the soil structure, which is detected by changes in vibration patterns by earthquake sensors.

The relationship between DHT11 and earthquake sensors is the relationship between environmental conditions and soil behavior that can potentially affect seismic activity. The use of environmental sensors together with earthquake sensors can provide additional data that is useful in analyzing conditions before, during, and after an earthquake. With the correlation of DHT11 with earthquake sensors, it can monitor environmental conditions that affect soil stability in certain areas [10], [25].

Land movement, often triggered by heavy rainfall, is a predictable disaster. Very high rainfall increases soil moisture, which reduces soil stability. While other factors such as seasonal changes also affect soil stability [26]. Environmental temperature and humidity affect soil stability and weaken soil structure. Thus the DHT11 can monitor earthquakes. In line with previous research, the DHT11 sensor can be used to monitor earthquakes through changes in soil temperature [10].

The DHT11 and earthquake sensor work together in the system to provide earthquake detection through the earthquake sensor and environmental information through the DHT11. Although not directly related in their main functions, they support each other in providing richer and more relevant data for monitoring and disaster mitigation needs. The working principle of the earthquake detection system with DHT11 and earthquake sensor combines the measurement of environmental parameters (such as temperature and humidity) with the detection of seismic activity. The presence of DHT11 provides additional information for disaster mitigation systems on the state of the environment before, during and after an earthquake.

The 801S vibration sensor is a sensor designed to detect vibration or mechanical shock. It works by detecting physical changes or vibrations in its surroundings. It can also detect small to large shocks or vibrations. The 801S vibration sensor used by Ghifari (2018) has high sensitivity with adjustable output, allowing for good accuracy even under low vibration conditions. The 801S vibration sensor is suitable for earthquake detection as an early warning system for vibrations or shocks. Research by Alam (2020) adds an inverter for continuous detection, while the accelerometer in Nasution (2022) and Kristanto (2023)'s research is effective for detecting gravity changes, although it requires special attention to battery maintenance.

3.2 Comparison of Signal Processing Circuit Types

Various components such as Sensor Nodes, ESP 8266 MCU Nodes, and Arduino Uno ATmega328 have different specifications and characteristics, which may affect system performance and applications. The following is a comparison of the signal processing modules in the system in Table 2.

Table 2. Comparison of Signal Processing Circuits in the System

Signal Processing Circuit	Specifications	Advantages	Disadvantages
Node MCU ESP 8266	- Microcontroller with Wi-Fi - 4MB memory	- Built-in Wi-Fi connectivity - Compatible with	- Limited memory capacity - Low processing ability

	- GPIO: 16 pin	Arduino IDE - Affordable price	
Arduino Uno ATmega328	- ATmega328 microcontroller - 14 GPIO pin - 6 ADC - 16MHz Speed	- Easy to use and program - Great community support - Many shields and modules are compatible	- Memory and processing speed limitations - Connection without built-in wireless capability

Analysis of the data in the table shows significant differences in the specifications, advantages, and disadvantages of the Sensor Node, ESP 8266 MCU Node, and Arduino Uno ATmega328. Sensor Nodes, with their ability to accurately measure various parameters, are essential in applications where precision data is required, although they require periodic calibration and depend on the type of sensor used. In contrast, the ESP 8266 MCU Node offers a practical solution with built-in Wi-Fi connectivity, enabling easy integration in IoT systems, but has limitations in memory and processing that may restrict its use in more complex applications. On the other hand, the Arduino Uno ATmega328 provides ease of use and extensive community support, as well as compatibility with various shields and modules, but shortcomings in memory and processing speed and the absence of built-in wireless connectivity may limit its flexibility and performance.

The signal processing circuit plays an important role in the earthquake detection system. Research by Tisnadinata (2019) uses a Gyro Accelerometer sensor with a Multi Node Sensor microcontroller that utilizes a Fuzzy Logic algorithm, thus enabling data processing with low complexity and high speed, producing early warnings within 10-15 seconds. Research by Siswanto et al. (2022) implements the ESP8266 microcontroller, SW-420 sensor, and additional components such as LED and buzzer modules, with the Blynk application for notification, requiring a minimum bandwidth of 7 Mbps and an Android smartphone 10 and above. Effendi et al.'s (2021) research uses NodeMCU ESP8255 and SW-420 sensors, signal processing with a 16x2 screen and buzzer for local notification, as well as the Blynk application for notification to smartphones.

The NodeMCU ESP8266 is an ideal choice for small to medium-scale earthquake detection systems. The NodeMCU ESP8266 can send sensor data to the server via a Wi-Fi network. In earthquake detection projects, data from sensors can be directly forwarded to the monitoring system for further analysis. NodeMCU ESP8266 is compatible with various sensors such as accelerometers to detect ground vibrations. The NodeMCU ESP8266 makes it easy to integrate into an IoT-based earthquake detection system with high scalability.

Research by Setyawan (2021) and Nasution (2022) used Arduino Uno and Raspberry Pi with MAG3110 and ADXL345 sensors, incorporating LCD and Blynk for data display and alerts, with varying processing speed and accuracy. Arduino Uno has the main advantage of ease of programming. Arduino Uno is suitable for use in earthquake detection devices. Arduino Uno can detect changes in ground motion that indicate earthquake activity. Thus, the use of NodeMCU ESP8255 and Arduino Uno is recommended and an option for signal processing for earthquake detection systems.

3.3 Comparison of Display on System

Different types of displays and communication methods offer different features and benefits. The following table compares five major device types-LCD, DO (Digital Output), Telegram, 16x2 LCD with I2C, and LED-based on their respective specifications, advantages, and disadvantages. Comparison of Display Types in the System is in Table 3.

Table 3. Comparison of Display Types in the System

Display Type	Specifications	Advantages	Disadvantages
LCD	- Liquid Crystal Display - Generally 16x2 or 20x4 characters	- Provides clear text display	- Limited to text display Less suitable for graphical display
DO (Digital Output)	- Digital signal with two states (ON/OFF)	- Can directly control devices without signal conversion	- Does not provide visual feedback or additional information
Telegram	- Platform messaging - Can be used for remote notification or communication	- Supports real-time messaging	- Depends on the internet connection - Does not provide physical displays or visual information
LCD 16x2 With IC2c	- 16x2 LCD with I2C module for connectivity - Requires only two pins (SDA, SCL)	- Simplifies the connection with the microcontroller - Reduces the number of cables and pins required	- Slightly higher cost compared to standard LCDs - Still limited to text display
LED	- Light Emitting Diode, can be a single or matrix LED	- Can display colors and simple graphics	- Limited to a simple dot or indicator display

Analysis of the data in the table shows significant differences in the functionality and applications of the different types of displays and outputs. LCDs, such as the 16x2 LCD with I2C, offer clear text display and low power consumption, but are limited to text information and are not suitable for graphical display. DO (Digital Output) provides a simple solution for controlling external devices with ON/OFF status, but does not provide visual feedback or additional information. Telegram, as a messaging platform, supports real-time messaging and can be integrated with various bots, but relies on an internet connection and does not provide a physical display. LEDs, whether in single or matrix form, offer the ability to display color and simple graphics, but are limited to simple indicators or dot displays.

Each device has its own strengths and limitations, which influence their selection based on the specific needs of the application or project. A combination of these devices may be the best solution for a reliable earthquake detection system. Use a 16x2 LCD with I2C to display local data such as earthquake magnitude and system status, as it is pin-efficient and sufficient for basic needs. Add LEDs as live visual indicators to provide quick signals, such as red for danger and green for safe. Digital Output (DO) can be used to activate external devices such as sirens or emergency lights. Additionally, integrate Telegram to provide real-time remote notifications to users or authorities, so information can be quickly accessed anywhere. This combination will provide an efficient and reliable solution for early earthquake detection systems.

The display of earthquake detection systems varies based on the device and application used. Research by Kristanto (2023) used an Arduino Uno R3 microcontroller with a SW-420 sensor to display vibration data on a Richter scale, relying on the speed of the internet connection for data transmission. Research by Setyawan (2021), Siswanto et al. (2022), and Effendi (2021) used the Blynk application and a 16x2 screen to display real-time vibration data and system status, including an LED indicator for earthquake notification. Research by Nasution (2022) displays data on the LCD with the Blynk application for vibration detection information. Research by Wikantama (2024) uses ESP32 and Telegram to deliver real-time notifications through the SIGEMPA system, making it easier to communicate risk information to the public. The main difference lies in the method of delivering information, from local displays to modern notifications through communication applications.

3.4 Comparison of Earthquake Detection Results

The following table summarizes research results from various studies on technology-based earthquake detection systems, including the use of sensors, microcontrollers and communication platforms. This research includes IoT-based systems that integrate various components, from vibration sensors to messaging applications such as Telegram, to provide real-time detection and warning. Some previous research results on technology-based earthquake detection systems are listed in Table 4.

Table 4. Comparison of Research Results

No	Title	Research Results	Disadvantages
1	Fuzzy-based Multi Node Sensor Earthquake Early Warning System and IoT Communication [27]	The system detected the earthquake with 81.8% accuracy within 11-12 seconds	Requires a stable internet connection for information to spread faster than BMKG
2	Internet Of Things-Based Earthquake And Tsunami Early Warning System Prototype [28]	ESP8266-based IoT prototype detects earthquake and tsunami with Blynk application	Further trials in real conditions are needed
3	Use of Vibration Sensors to Anticipate Earthquakes [8]	The system detects vertical and horizontal vibrations, and uses a power backup inverter	It may not detect small or low-frequency vibrations
4	Earthquake: Relationship between MAG3110 Sensor Data and ADXL345 Sensor Data Based on IoT [10]	The system detected the vibration anomaly within 400 seconds with a range of 395-404 μT	The average response time of 400 seconds may be too long
5	Implementation of Accelerometer Sensor as IoT-	The accelerometer sensor detects the earthquake and	Requires a battery that is always charged

	Based Earthquake Detection Alarm System [1]	displays the Richter scale through the LCD and Blynk app	
6	Design of Internet Of Things-Based Earthquake Detection Information System at Tarumanagara University [5]	The system uses Arduino Uno R3, SW-420 and ADXL335 sensors, and MySQL and Firebase data storage	Component complexity increases setup and maintenance difficulties
7	SIGEMPA: IoT-based Earthquake Early Warning System with ESP32 [13]	The system detects earthquakes and sends real-time notifications via Telegram	ESP32 may be limited in battery life in the field
8	Earthquake Vibration Detection Design Based on Arduino IoT Microcontroller [29]	The system uses NodeMCU ESP8255, SW-420 sensor, 16x2 display, and buzzer, with notification through Blynk application	The NodeMCU ESP8255 may be limited in Wi-Fi network reliability
9	Earthquake Detection Tool Design Using Vibration Sensors [11]	The accuracy value of the 801S sensor is above 90% with a small error value	The sensor only detects binary vibrations
10	Simulation of Earthquake Detection Using Arduino Uno-Based Vibration Sensor [30]	Simulation of the device detecting an earthquake and providing a warning of the earthquake's direction	Simulation results may not be accurate in real situations
11	Prototype of Iot (Internet of Things) Based Early Warning System for Tsunami Disaster Mitigation in Pancer Beach, Puger, Jember [3]	Tsunami system prototype with accurate sensors and effective communication module	Gradient analysis is not accurate for tsunami detection
12	An internet of things belief rule base smart system to predict earthquake [7]	The IoT-based Intelligent BRB system predicts earthquake intensity with better accuracy than BRBES and fuzzy	Environmental uncertainties still affect prediction accuracy

This analysis shows that IoT-based earthquake early warning systems have progressed in detection and response, with some studies such as by Tisnadinata et al. (2019) and Siswanto et al. (2022) highlighting good speed and accuracy, although still facing challenges of internet stability and testing in real conditions. Other studies, such as those by Setyawan (2021) and Nasution (2022), show effectiveness in detection, but experience response delays or specialized resource requirements. Meanwhile, studies by Ghifari (2018) and Ramadhan & Royhan (2017) noted limitations in vibration intensity details and simulation of real conditions. Finally, recent studies such as those by Wikantama (2024) and Akbar (2023) show progress in real-time notification, but still face battery life and accuracy issues, while the Intelligent BRB system by Atiqur (2021) shows potential for improved prediction accuracy with additional sensors.

Earthquake detection results vary depending on the system and sensors used. Tisnadinata's (2018) research with the Gyro Accelerometer sensor and Fuzzy Logic algorithm showed high detection accuracy, with an average data validation process speed of around 10-15 seconds and a final accuracy of 81.8% in the BMKG GIS scale. In contrast, Kristanto (2023) reported that the SW-420 sensor connected to an Arduino Uno R3 was able to detect vibrations in the range of 0 to 2.89 on the Richter Scale, although the speed of data transmission was affected by the internet connection. Research by Siswanto (2022) and Effendi et al. (2021) also showed good results with the use of the SW-420 sensor, which provides early warning through the Blynk application.

Meanwhile, Setyawan (2021) found that the average time to detect vibration anomalies was 400 seconds with a range of 395 μT to 404 μT. Nasution (2022) demonstrated the effectiveness of accelerometer sensors in detecting gravity changes. The 801S sensor used in Ghifari's (2018) research showed more than 90% accuracy with a small error. While Wikantama's (2024) research successfully developed an ESP32-based system that provides real-time earthquake notifications.

As a result of previous research, the Gyro Accelerometer sensor and ESP 8266 MCU Node as the sensor and signal processing circuit are the most superior. The integration of IoT in earthquake detection systems lies in its ability to integrate various devices and technologies in real-time, allowing the system to be more responsive, efficient and accurate. IoT allows earthquake sensors to continuously monitor seismic activity and transmit data directly to the server. Thus, from several studies that have been conducted, the results of earthquake detection vary.

Variations in earthquake detection results depend on the system and sensors used in the detector. Then the integration of IoT can detect small earthquake activity and send early warnings to user devices. Based on the results of the analysis conducted, it is recommended to use sensors with IoT integration for earthquake detection systems. It is recommended to other researchers to create an earthquake detection system using sensors integrated with IoT. Proper selection of sensors, signal processing circuits, and IoT integration can increase the effectiveness of earthquake detection and warning.

4. Conclusion

From the analysis conducted, it can be concluded that the application of earthquake detection technology, vibration sensors, as well as IoT integration, significantly improves the effectiveness of earthquake detection and warning. Various types of vibration sensors offer their own advantages in detecting earthquakes, both in terms of accuracy and flexibility. The use of IoT is helpful in creating signal processing circuits with algorithms that speed up data processing. Conveying the detection results to the public is easy with the help of applications. Thus, the accuracy of earthquake detection depends on the system and the type of sensor used.

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