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Automated Arduino Uno earthquake detector alarm with digital clock, LED, and LCD recorded time display

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Abstract

Earthquakes are experienced everywhere, and alertness is an important method to remain safe. This study aids in keeping people safe by developing an efficient device that produces sound when motion has been detected. The researchers developed an Automated Earthquake Detector Alarm with a Digital Clock, LED, and LCD Recorded Time Display that is powered by Arduino Uno and performs automated functions with the use of the repeated looping of acceleration checks by the Arduino microcontroller due to the loop () function of the inputted code of the Arduino IDE. Each component has its specific functions; the Buzzer can produce sound that serves as an alarm. As a result, it was proven that the device is effective for alarming people when an earthquake has been detected. The 4-digit seven segment is used to show the time in Philippine Standard Time with the help of the RTC module, where it is proven that there is no significant difference in the developed device. The LCD shows the recorded time of when the movement occurs. This applied experimental research introduced the device's uses, advantages, and features. This study introduced a safer experience with earthquakes by preparing ahead of time to prevent uncertainty and evacuating the room early to avoid potential earthquake causes. This study recommends adding a memory to the device to record the earthquake's magnitude and intensity, inform the people that an earthquake occurs, and a battery in case of a power outage.

Keywords: Arduino Uno, earthquake, motion detection, automatic alarming, Philippine Standard Time

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1. Introduction

An earthquake is a natural disaster that strikes without warning and may impact land, animals, and, most crucially, people, especially if they are near or within huge structures. Earthquakes have killed millions of individuals and caused enormous property damage throughout the years. Depending on their magnitude, earthquakes may seriously damage buildings and bridges and burst gas pipelines and other infrastructure that can cause landslides, tsunamis, and volcanoes (Britannica, The Editors of Encyclopaedia, 2020). Earthquakes occur when two slabs of earth abruptly slip past one another. The fault or fault plane is the surface where they slide (Wald, n.d.). People disregard and do not take earthquakes seriously, especially if the earthquake is weak, and being unaware that an earthquake is occurring is one of the reasons why most people die as a result. The Automatic Earthquake Detector Alarm with Digital Clock, LED, and LCD Recorded Time Display, just like the other alarm systems, is intended to lessen the danger of natural disasters and to provide immediate awareness of such events (Malachovska, 2023). It is located on the seismically active Pacific "Ring of Fire," a group of volcanoes and fault lines that run along the Pacific Ocean's edge and a geological feature that stretches and thins the Earth's crust due to the force of its tectonic plates. The Philippines is prone to natural disasters and has been hit by numerous earthquakes, including a 7.1 magnitude earthquake in October 2013. Earthquakes are common because the Philippine archipelago comprises over 7,000 islands (The Philippines: A Country Prone to Earthquakes, 2022).

According to the study of Jimee et al. (2012), early warning systems are critical for efficient short-term preparation and response, matching the earliest stages of disaster management. Furthermore, using such systems might help to increase resilience since improving readiness enhances the capability to recover quickly and minimizes vulnerability. To avoid the damaging impacts of earthquakes, such as becoming wrapped around heavy objects in a structure, we must be more alert in the first second of the earthquake. Because humans seldom notice earthquakes, the earthquake detector alarm is proposed to warn when an earthquake is happening, while the digital clock tells when the earthquake occurred. It can measure the motion, acceleration, or vibration of the structure that activates the buzzer once it is detected with the help of an accelerometer. In this study, the researchers developed an earthquake detector alarm with a digital clock, LED, and LCD recorded time display to benefit DWCSJ students, office employees, people working in companies and high buildings, people in San Jose, Occidental Mindoro, and other institutions and agencies as well. An ADXL335 accelerometer helped the researchers to detect the movement. On the other hand, the 16x2 LCDs the recorded time when the movement occurred. The Arduino Uno R3, also known as microcontrollers, served as the brain of our device. The LED lights up together with the buzzer, which serves as an alarm that creates a sound once movement is detected. Lastly, the TM1637 4-digit 7-segment display was the digital clock that displays the Philippine Standard Time. To avoid confusion and possible danger, people must be aware of an earthquake to prepare themselves early to hide, go outside, and prevent panic attacks.

Statement of the Problem - This study aimed to develop an automated Arduino Uno earthquake detector alarm with a digital clock, LED, and LCD recorded time display, test the effectiveness of its ability to alarm when detecting an earthquake and display the time the earthquake has ended. Specifically, it sought to answer the following questions: (1) What is the performance level of the Automated Arduino Uno Earthquake Detector Alarm with Digital Clock, LED, and LCD Recorded Time Display using an accelerometer and buzzer in terms of Its capacity to detect motion and the accuracy of the buzzer in producing sound? (2) What is the level of effectiveness of the RTC Module in providing the correct indication of time? (3) What is the level of effectiveness of the Automated Arduino Uno Earthquake Detector Alarm with a Digital Clock, LED, and LCD

Recorded Time Display in alarming people? (4) Is there a significant difference between using the Automated Arduino Uno Earthquake Detector Alarm with a Digital Clock, LED, and LCD Recorded Time Display with an alarm clock with Philippine Standard Time? (5) Is the Automated Arduino Uno Earthquake Detector Alarm with a Digital Clock, LED, and LCD Recorded Time Display effective when it comes to alarming people when an earthquake has been detected?

Significance of the Study - The development of this device has revolutionized the alarm detector by allowing it to detect movement and having additional components such as a digital clock, LED, and LCD. Using the accelerometer or motion detector, the buzzer started producing sound to signal people that an earthquake was occurring so that they would be prepared and aware. The results and findings are beneficial to the following: For the students of the DWCSJ, the earthquake detector alarm with a digital clock, LED, and LCD recorded time display can help the students of the Divine Word College of San Jose avoid confusion and harmful effects of earthquakes, mostly if the earthquake happens while the students are inside the building. For the workers of DWCSJ, the device is beneficial to them, primarily if they work inside the building, so they will be alerted that there is an earthquake. The development of this earthquake detector alarm helps the community serve as an alarm when an earthquake occurs in the area. Lastly, the development of this device will help future researchers, especially with the information included in this study. It will also serve as a reference for future research and can serve as a guide for future researchers conducting the same survey.

Scope and Delimitation of the Study - The general intent of this study is to develop an earthquake detector with a digital clock, LED, and LCD recorded time display using Arduino to alarm and provide the recorded time of when the first movement ends for people in different areas, such as high buildings. This study exists to help people and our environment lessen the loss of human lives due to earthquakes. This project was done with the help of an Arduino Uno to complete the creation of this device. With Arduino, the device is limited to detecting movements once the block of concrete where the device is attached starts to signal an earthquake, such as shaking. The device provided an accurate time display through the digital clock with the help of an RTC module. In contrast, the LCD recorded time display provided the exact time the natural disaster ended. This device also helped us be more aware that an earthquake is coming so we can plan early to hide, move outside, and prevent panic attacks. This device enabled us to avoid confusion and potential danger. This study aims to alarm people during earthquakes, display Philippine Standard Time, and record the time when the first movement occurs. Other aspects, such as providing instructions to escape the building and measuring the time the earthquake may occur, are not included.

2. Methodology

Research Design - The effectiveness of the study's target variable was tested using an applied experimental research design. This Automated Arduino Uno Earthquake Detector Alarm with Digital Clock, LED, and LCD Recorded Time Display is designed to help researchers evaluate its impacts. Using an experimental study design, the researchers could address their research questions and develop recommendations and results that may be used in other comparable studies in the future. Using one or more independent factors applied to one or more dependent variables, researchers can apply an experimental research design to study the impact of those variables on the dependent variables. A researcher's attempt to keep control over every element that could influence an experiment's outcome. As the study's primary source, the researchers conducted experiments and tests to compare the functionality and effectiveness of the accelerometer and the Arduino as building blocks for earthquake detectors. This allowed the researchers to define and compare the outcomes to assess the efficacy of the study's focused factors, particularly as they relate to the Arduino and seismic detectors (Roca et al., 2023).

Data Gathering Procedure - The researchers acquired the necessary data to evaluate the device's accuracy. This experimental research design only involved an automated Arduino Uno earthquake detector alarm with a digital clock, LED, and LCD recorded time display. To increase the device's probability and accuracy when an earthquake occurs, the experiment should last until the device detects movement. However, the target individuals and timing may vary owing to future challenges and problems. The researchers instructed that those small earthquakes might not be detected due to a lack of ground movement. Following that, each participant should carefully move outside the building during an earthquake to ensure safety. In the development of the device, it took the researchers three weeks or 21 days to develop and do the coding of the device, where they connected, enabled, and glued the parts of the device that will be used to make the automated Arduino Uno earthquake detector alarm with a digital clock, LED, and LCD recorded time display. The researchers asked their parents for help creating a wooden box that served as a cover for the device. After making the device, the researchers tested it to see if all the parts were working. Since an earthquake is a natural disaster where we cannot know when it will occur, the researchers made a different plan on how they could try to activate the accelerometer, buzzer, and red LED light. They placed the device under the table and shook it. With this method, they verified that the Arduino parts, such as the accelerometer, buzzer, and red LED light, worked.

Research Process: Stage 1 Preparation and Gathering of Materials - To achieve a successful result, the device requires proper and complete equipment:

- For the device: Arduino Uno R3, 4-digit 7-segment display, CR2016 Battery, ADXL335 Accelerometer Buzzer2023, DS3231 RTC module, Jumper wires, and 16x2 LCD.
- For Casing and Accessories: Wooden box, Breadboard, and LED.

The researchers bought the supplies online. This experiment's materials cost 2,245 PHP**.**

Stage 2: Building and Development of the Project - The device comprises different pieces that function together to carry out the intended mechanism, as shown in the pictures above. The researchers made an automated earthquake detector alarm with a digital clock, LED, and LCD recorded time display. It took 21 days for the researchers to make this device, and an accelerometer that detects movement was the most important material used to make this device. For it to function, it also transmits data to the buzzer and LED. Once the accelerometer finally detects a movement, the buzzer, LED, and LCD start functioning. We have two LED lights with blue and red colors that depend on the program when to light one of them. While the accelerometer has no movement detected, it continues to light the blue LED light. But, when the shaking begins, the red LED lights will start to light. Meanwhile, an RTC module can enable and achieve a "real-time clock" of the Philippine Standard Time functionality for the digital clock display, which is displayed through a 4-digit, 7-segment display.

The Arduino Uno R3 and a microcontroller serve as the device’s brain, receiving and sending data to the device’s various components, and is powered by electricity. The indicator of this device is the buzzer. The researchers program it, and it is connected to the breadboard and UNO R3. Researchers use it to indicate whether the device has detected movement or not. A breadboard is a path or passageway to connect the device parts, such as LED lights, buzzers, RTC module, 4-digit 7-segment, and LCD. This part of the device does not work without the help of a breadboard. For the construction of the device, the researchers connected the buzzer, LCD, RTC module, 4-digit 7-segment, and LED lights to the UNO R3 and breadboard by using male-to-male, female-to-male, and female-to-female jumper wires. To determine if the device functions well, the researchers programmed and tested each part of the device until they successfully combined all of the materials and finally developed the automated Arduino Uno earthquake detector alarm with a digital clock, LED, and LCD recorded time display.

Stage 3: Experimental Stage, Observation and Data Recording - The researchers experimented to test the accuracy and effectiveness of the accelerometer and RTC module in detecting motion, displaying the real-time effectiveness of the alarm. First, the researchers used the Arduino IDE application to encode and program the system. Then, assemble the Arduino Uno R3 by connecting the accelerometer, breadboard, buzzer, RTC module, jumper wires, LCD, LED lights, 4-digit 7-segment display, and wood to build and create the device. The encoded and programmed data is applied to the Arduino to run and test the device. After doing so, testing the device came next. It took the researchers 21 days to make the device. After that, the researchers observed its effectiveness and accuracy in detecting motion, displaying real-time, and the effectiveness of the alarm. There are 24 random participants from grade 10 at St. Arnold, students of the Divine Word College of San Jose, who witnessed how the device would alarm when the buzzer would sound and if the time displayed by the 4-digit 7-segment was correct. In this study, the researchers collected primary data on the device's construction, recording every step, procedure, material preparation, and construction. They also took photos and videos to demonstrate the device's creation by the researchers. The researchers thoroughly tested the device's functionality and recorded all information, ensuring accuracy and honesty in the data gathered.

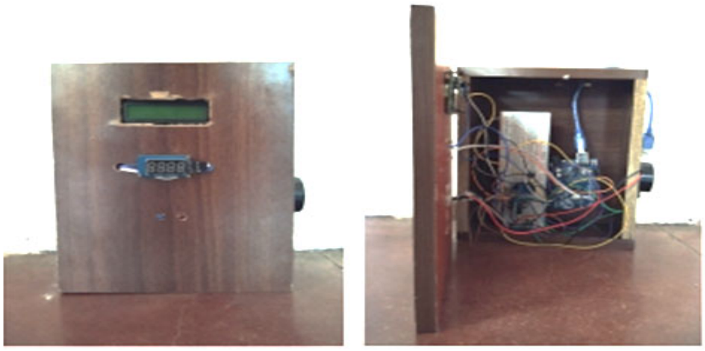

Figure 1. Actual Product of Automated Arduino Uno earthquake detector alarm with digital clock, LED, and LCD recorded time display

Statistical Treatment of the Data - The researchers used a statistical treatment, such as the T-test, correlation coefficient analysis, and regression analysis, to determine if there is a significant difference and relationship between the Automated Arduino Uno Earthquake Detector Alarm with Digital Clock, LED, and LCD Recorded Time Display and other alarm systems, and a descriptive analysis using a weighted mean to determine the level of effectiveness of the device. Every research question is addressed by creating tables and justifying how the data was interpreted. These offer support and evidence that the Automated Arduino Uno Earthquake Detector Alarm with a Digital Clock, LED, and LCD Recorded Time Display may be enhanced further to yield better-functioning devices. Each piece of information clarified how this device may help the community stay earthquake-safe.

3. Results and Discussions

Table 1

Performance level of the Automated Arduino Uno Earthquake Detector Alarm with a Digital Clock, LED, and LCD Recorded Time Display using an accelerometer and buzzer

Indicators	Weighted Mean	Descriptive Indicator
1. The device is capable of detecting capacity and motion.	3.54	Strongly Agree
2. It is accurate for the buzzer to produce the sound simultaneously with the movement.	3.33	Strongly Agree
Overall Mean	3.44	Strongly Agree

Legend: 3.26 - 4.00 Strongly Agree, 2.51 - 3.25 Agree, 1.76 - 2.50 Disagree, 1.00 - 1.75 Strongly Disagree

The information in the table above demonstrates the performance level of the Automated Arduino Uno Earthquake Detector Alarm with a Digital Clock, LED, and LCD Recorded Time Display using an accelerometer and buzzer. The buzzer produced a sound when our device began to shake; the accelerometer would sense the motion and relay information to the buzzer a few milliseconds later. The red LED light is turned on while our device is still shaking, and the blue LED light is turned on when no more movement is detected. These results are supported by Pathak et al. (2019), who found that acceleration is simultaneously measured by the Arduino pin and the accelerometer. A buzzer warns of an earthquake in the building's seismic zone if motion is strong enough during an earthquake and surpasses the threshold value of the alert light LED lights.

Table 2

Mean Level of Effectiveness of RTC module in providing the correct indication of time

Indicators	Weighted Mean	Descriptive Indicator
1. The Real Time Clock provides the correct indication of time.	3.75	Strongly Agree
2. The device is effective in alerting people.	3.54	Strongly Agree
Overall Mean	3.65	Strongly Agree

Legend: 3.26 - 4.00 Strongly Agree, 2.51 - 3.25 Agree, 1.76 - 2.50 Disagree, 1.00 - 1.75 Strongly Disagree

The experiment's results are displayed in the table above, as determined by the participants' responses. They checked the device’s time display versus their clock when we showed it. The participants strongly agree that the device uses Philippine Standard Time (PST) to provide accurate time. However, because the device detects movement once the shaking has begun, participants agree it helps alert people. The researchers placed the device under the table's surface and shook it. People get notified that there is an earthquake or movement by the buzzer's sound. According to El-Mowafy (2019), real-time exact point placement is one of the most widely used positioning techniques for natural hazard warning systems like earthquakes and tsunamis. Clock adjustments and exact orbits are necessary for accurate point location. Although it would result in low positioning accuracy, using the International Global Navigation Satellite Systems Service ultra-rapid (IGU) orbits and clocks would be the best option. This implies that it is possible for an automated clock to display the same time as a manual clock if any controlling elements control it.

Table 3

The time displayed on the Clock and the Automated Arduino Uno Earthquake Detector Alarm with a Digital Clock, LED, and LCD Recorded Time Display

Time displayed on the Clock (Philippine Standard Time)	Time displayed in the Automated Arduino Uno Earthquake Detector Alarm with a Digital Clock, LED, and LCD Recorded Time Display
3:09	3:09
3:19	3:19
3:29	3:29
3:39	3:39
3:49	3:49

Several trials were conducted to examine whether the LCD time was accurate. Every ten minutes, the researchers checked if the time displayed in the Automated Arduino Uno Earthquake Detector Alarm with a Digital Clock, LED, and LCD Recorded Time Display matched the time displayed on the clock. The data above indicates how consistently the time is displayed on the device. It also coincided with the time on the clock. That is why the Automated Arduino Uno Earthquake Detector Alarm with a Digital Clock, LED, and LCD Recorded Time Display provides the correct indication of time in Philippine Standard Time.

Using the data in Table 3 regarding the time displayed on the clock in Philippine Standard Time, Table 4 reveals the computed generated results, examining the difference between two variables; the t-critical value is 2.31 while the computed T-stat is 0. It can be seen that the value of T-critical is higher than the value of T-stat, which indicates the acceptance of the null hypothesis. Therefore, no significant difference exists between the Automated Arduino Uno Earthquake Detector Alarm with a digital clock and an LED and LCD recorded time display with an alarm clock in Philippine Standard Time. Additionally, the p-value (1) is greater than the alpha level, proving that the null hypothesis that says there is no significant difference between using the Automated Arduino Uno Earthquake Detector Alarm with a Digital Clock LED and LCD Recorded Time Display with an alarm clock with Philippine Standard Time is accepted. This study proved the correct indication of time as observed and tested by the researchers and participants. The findings also demonstrated that alarm systems are essential to contemporary industrial facilities' practical and safe running. Nevertheless, the majority of industrial alarm systems currently in use operate poorly, notably raising too many alarms for control room workers to handle (Wang et al., 2016).

Table 4

T-Test: Two-Sample Assuming Unequal Variances

	Variable 1	Variable 2
Mean	0.1451398889	0.145138889
Variance	0.000120563	0.000120563
Observations	5	5
Hypothesized Mean Difference	0	
df	8	
t Stat	0	
P(T<=t) one-tail	0.5	
t Critical one-tail	1.859548038	
P(T<=t) two-tail	1	
T Critical two-tail	2.306004135	

Legend: *Highly Significant at p≤0.01 *Significant at p≤0.05

Table 5

Correlation Analysis on the Performance Level of Automated Uno Earthquake Detector and Its Level Effectiveness

Independent Variable	Dependent Variable	R-value	R^2(Effect Size)	t-value	P value	Interpretation
Earthquake Alarm	Motion Detection	-0.429	0.184	-2.228	0.036	Significant
Earthquake Alarm	Length of time the buzzer will produce sound	-0.793	0.628	-6.098	0.000	Highly Significant

Legend: *Highly Significant at p≤0.01 *Significant at p≤0.05

Table 5 shows the correlation analysis between the performance level of the automated Arduino Uno earthquake detector and its effectiveness. The independent variable is the earthquake alarm, while the dependent variable is motion detection, which has a p-value of 0.036. Since the p-value is less than 0.05 at the alpha level, it rejects the null hypothesis. Another dependent variable is the time the buzzer will produce sound, with a p-value of 0.000. We can see that it is less than 0.01. Therefore, H is highly significant. As a result, the Automated Arduino Uno Earthquake Detector Alarm with a Digital Clock, LED, and LCD Recorded Time Display is effective for alarming people when an earthquake has been detected. Moreover, the findings proved that the device made by the researchers is effective, especially in motion detection and the length of time the buzzer will produce sound. Furthermore, Gerber (2020) found that alarm systems alert workers and customers in airports, train stations, logistics centers, and office buildings to potential dangers so they can take self-rescue action.

4. Conclusions

The researchers concluded the following conclusions based on their collected data: To determine if the device can reliably detect motion and emit sound using a buzzer, the researchers performed multiple trials. The participants strongly agreed that using a buzzer, the device can accurately detect motion and produce sound. The responses from the participants determine the experiment's outcomes. The responders compared their clock with the time display on our device. After the researchers showed it to them, nearly all strongly agreed that the device uses Philippine Standard Time (PST) to provide accurate time. The participants agreed that the device helps warn people by detecting movement once the shaking starts. We placed the device under the table's surface and shook it. The buzzer notifies people when there is movement or an earthquake. The researchers evaluated if the time displayed on the alarm clock and the Automated Arduino Uno Earthquake Detector Alarm with a Digital Clock, LED, and LCD Recorded Time Display matched. It showed how accurately the device displays the time. It also matched the alarm clock's time. Because of this, the Automated Arduino Uno Earthquake Detector Alarm with Digital Clock, LED, and LCD Recorded Time Display accurately indicates the current time in Philippine Standard Time. The researchers conducted ten trials using different shaking rates per second. It demonstrates that the device alerts people if the shaking continues for three seconds.

Recommendation - The researchers suggest the following as a result of the conclusions they drew from their findings: To improve further the device’s accuracy in detecting motion, the researchers suggest that future researchers may use a seismic application to determine the earthquake’s magnitude and intensity to add to the device. To further improve the device’s clock’s visibility, future researchers may use a bigger 4-digit 7-segment in their experiment, may add a buzzer to enhance its sound, may compare the Automated Arduino Uno Earthquake Detector Alarm with a Digital Clock, LED, and LCD Recorded Time Display to an existing alarm system like a smoke detector alarm for periodic testing and evaluation of results thereafter with improvements in the maintenance of the earthquake detector alarm and may add a memory to the device to record the earthquake's magnitude and intensity and its time, a sim card to inform the people that an earthquake occurs, and a battery in case of a power outage.

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