Development of an Algorithm to Detect Seismic Activity for the Wireless Network Based Automated Table for Kindergarten Pupils

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***Abstract*—Thousands of tremors are a common occurrence in our everyday lives. These are smaller tremors that often go unnoticed by most people. Major earthquakes, when it strikes, it may result in a massive destruction. It can strike suddenly and without a warning. The goal of the study is to develop an algorithm for the wireless network based automated table to detect seismic activities. It focuses on detecting earthquakes by measuring its peak gravitational acceleration (PGA). The system consists of four tri-axis accelerometers, base station, alarm system and GSM module. NRFL01 transceiver serves as the link of communication for the whole system. If an earthquake occurs, the accelerometers will be activated which will then communicate via wireless network with the Arduino Microcontroller to determine if it is an earthquake or not. Once it is confirmed, the system will send a message to the registered number, thereby alerting the authorities. Also, the alarm system will be activated to alert people nearby. Results showed that after a number of trials, the system established a 100-second response time. In conclusion, the developed technology is an effective tool for disaster preparedness and disaster risk reduction. This was a new step to give further innovations and ideas to Earthquake Engineering.**

Keywords—earthquake, automated system, wireless communication, alarm system, Kindergarten, disaster preparedness, disaster risk reduction

I. Introduction

Thousands of tremors are a common occurrence in our everyday lives. These are smaller tremors that often go unnoticed by most people. Although we usually consider the ground to be solid and stable, the earth is, in fact, constantly shifting under our feet [1]. Major earthquakes, when it strikes, it may result in a massive destruction. It can strike suddenly and without a warning.

An earthquake is a calamity that cannot be predicted, it happens when two tectonic plates under the Earth`s surface collides, resulting in a sudden release of energy in the Earth`s crust [2]. To predict an earthquake is impossible, but a scientist can get the interval between earthquake occurrences. For the last 1,400 years in a West Valley Fault, it has been detected that four major earthquakes have occurred in 400 to 500 years of interval. And in the year 1658, the last major earthquake that comes originally from that fault was recorded, which means sooner or later in our lifetime a big movement of the fault may happen again [3]. In the Philippines, there is the Philippine Institute of Volcanology and Seismology (PHIVOLCS), a service institute of the Department of Science and Technology (DOST) that is responsible to mitigate the disasters that may arise from volcanic eruptions, earthquakes, tsunami and other related geotectonic phenomena. Experts announced that in our lifetime, there is a threat of a great earthquake that is called The Big One [4].

II. Related Literature

A study that is made in the Philippines, the LAMESA Project – Life Saving Automated "MESA" to Endure Seismic Activity is a life-saving Kindergarten school desk [5]. This aimed to provide the education system with a resilient study desk for kindergarten. The system and program designs ensured good peak ground acceleration (PGA) and a fix response time (4 sec.) to effectively and efficiently facilitate "duck (drop), cover, hold" actions of kindergartens to shield them from debris in the eventuality of a strong seismic activity. The top portion of the automated table is a mid-separated tabletop having a plurality of corner legs and adjustable center legs with synchronous lift function to form a triangular shape for debris impact reduction actuated by a plurality of actuators while said middle portion having a main controller unit further comprising an accelerometer that detects seismic activity. It also comes with an Arduino microcontroller triggering the plurality of actuators, and a separate storage area for food and water. Characterized in that, a separate accelerometer fixedly attached to the classroom wall, triggering the emergency alarm synchronous with the plurality of actuators lifting the mid separated tabletop and an LCD monitor displaying the earthquake's intensity and an evacuation message.

III. Methodology

A. Block Diagram

Figure 1 shows the block diagram of the automated table. The system compromised of four tri-axis accelerometers, base station, alarm system and GSM module. Inputs of the system are the seismic activities which will be sensed by the four ADXL335 accelerometers. NRF24LO1 transceiver serves as the link of communication for the whole system. Based on the movements, the accelerometer will produce three sensor readings which are the x, y and z values. These values will be fed to the Arduino Nano, which will serve as the central controller of the system. The Microcontroller will then store these values and will determine if it is an earthquake or not. Once it is confirmed, the system will trigger the outputs simultaneously, which are the motors in the table, alarm system and the GSM module. The system will control the solenoid to transform the table from its main form into its protective form with the help of the limit switch. Also, the system will activate the alarm and will send a message to the registered number, thereby alerting the authorities and people nearby.

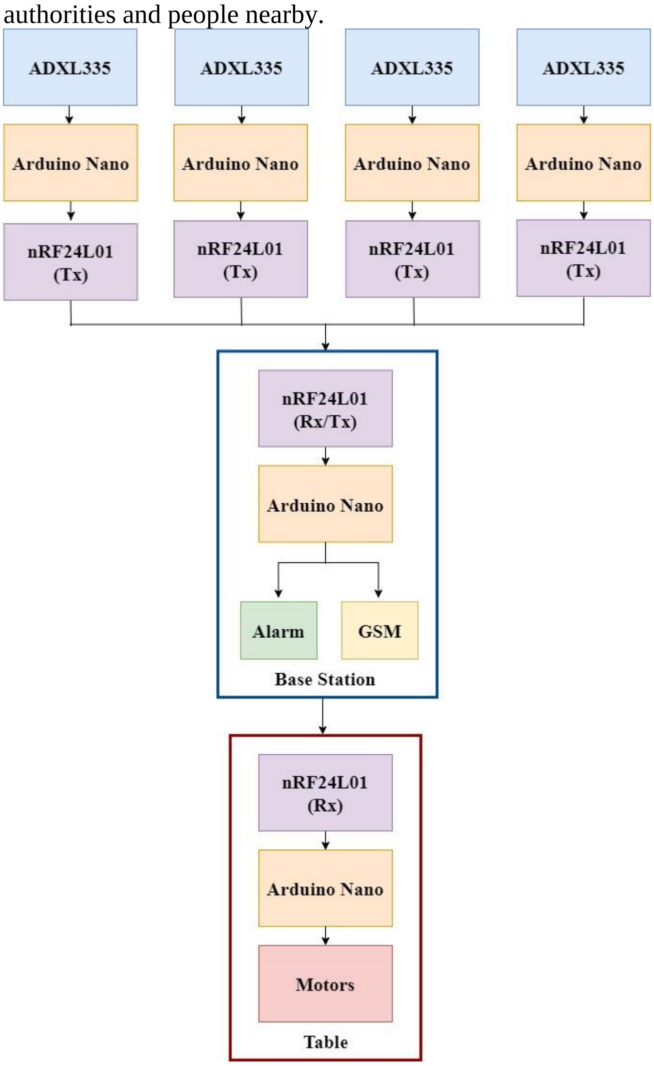
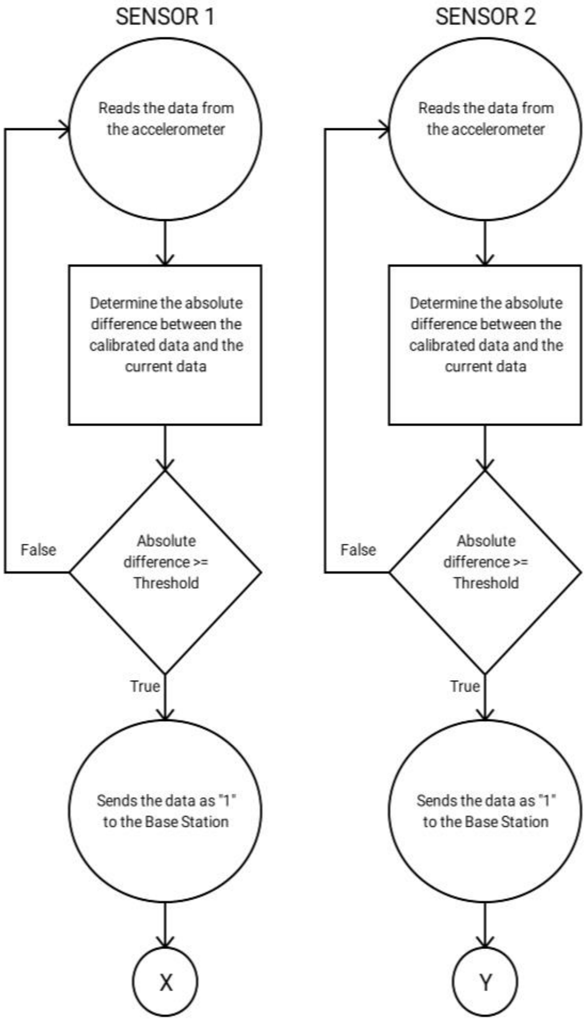


Fig 1. Block Diagram

B. *System Flow Chart*

Figure 2 shows how the system works and the process to get the output. At the beginning of the process, four accelerometers will measure the x, y, z accelerations. After reading the data from the accelerometers, the Arduino will then measure the absolute difference between the calibrated and measured data. If the difference is greater than or equal to the threshold accelerations collected, then it will send a binary 1 at the base station. If the base station receives four binary 1, then the system will categorize it as an earthquake and from then, the automated table will be activated.



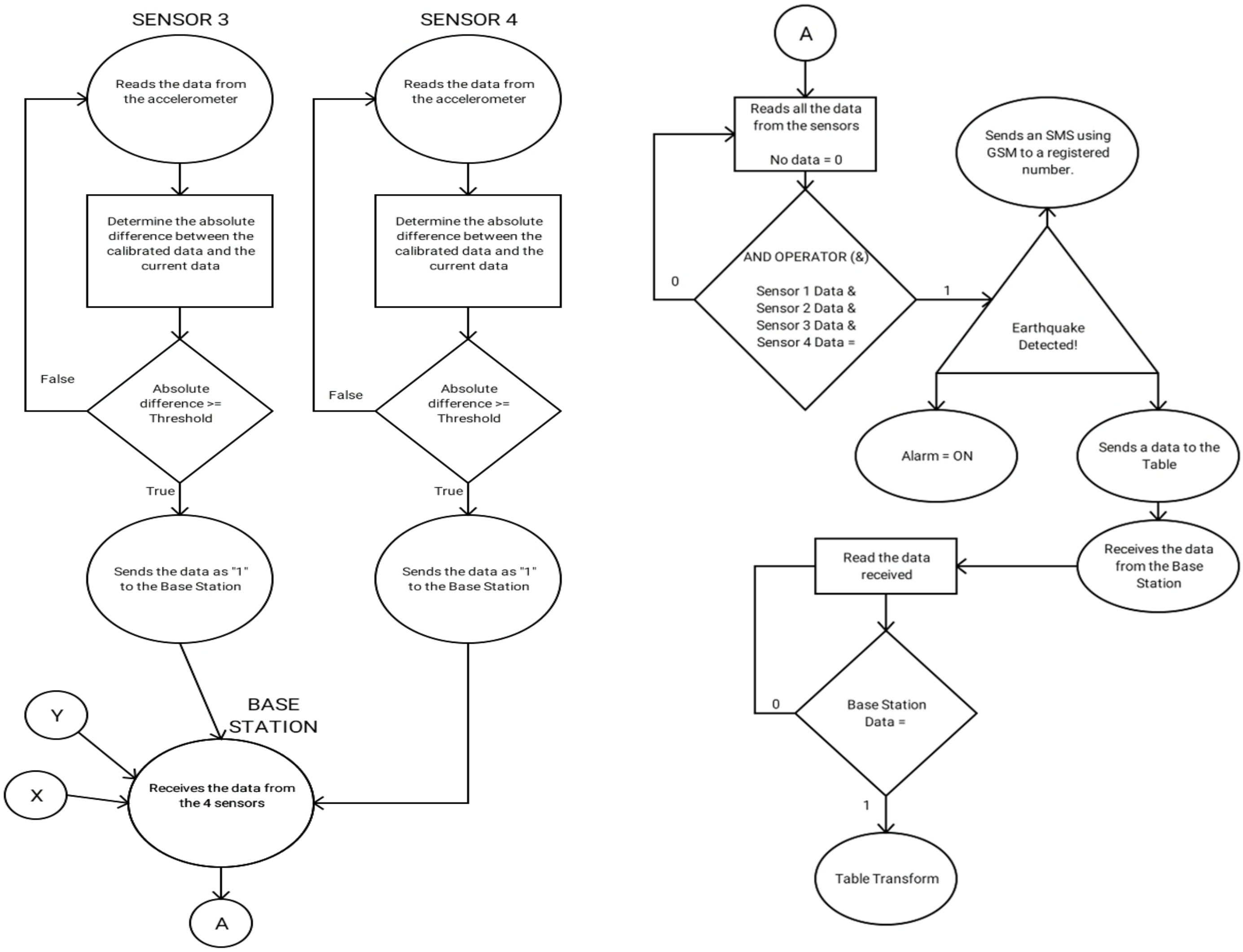


Fig 2. System Flow Chart

C. *Calibration*

Calibration for the accelerometer is done on the MMDA earthquake simulator to get the actual peak gravitational acceleration (PGA) of an earthquake. The proponents measured the peak gravitational acceleration (PGA) for the directions (x, y, z) per intensity level and still condition. Data are shown on Table 1.

Table 1. PGA Averages

INTENSITY	PEAK GRAVITATIONAL ACCELERATION (PGA)		
	x	y	z
STILL	-0.29 to -0.24	-0.25 to -0.22	0.27 to 0.32
4	-0.47 to -0.12	-1.22 to 0.34	-0.32 to 1.11
5	-0.58 to 0.01	-1.28 to 0.41	-0.32 to 1.11
6	-0.61 to 0.22	-1.46 to 0.53	-0.26 to 1.45
7	-0.62 to 0.06	-1.93 to 0.91	-0.38 to 1.28
8	-0.57 to 0.04	-1.51 to 0.56	-0.3 to 1.42

IV. Results and Discussion

A. Functionality Test

The automated table was tested by shaking the sensors to test if it automatically serves its purpose. We tested its functionality randomly 10 times per intensity level. Below is the summary of trials made. Table 2 shows the results of the trials as per intensity level. Intensity 4 shows the least accurate response compared to other intensity levels.

Table 2. Functionality Test

INTENSITY	TRIALS									
	1	2	3	4	5	6	7	8	9	10
4	/	X	/	/	X	X	/	X	/	/
5	/	/	/	/	X	/	/	/	X	/
6	/	/	/	/	/	/	/	/	/	/
7	/	/	/	/	/	/	/	/	/	/
8	/	/	/	/	/	/	/	/	/	/

B. Response Time

The automated table was tested by shaking the sensors to gather its response time. This testing shows the response time of the following parameters: table mechanism, a notification system via GSM and an alarm system.

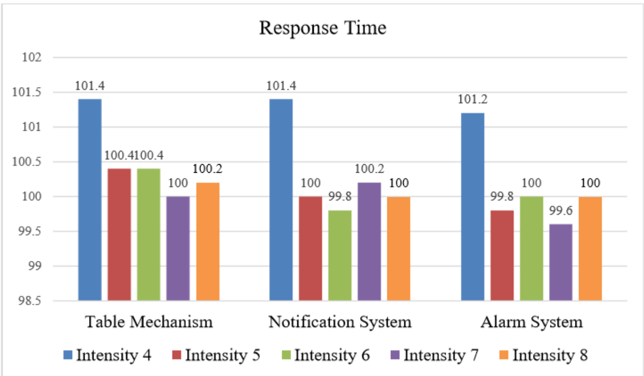


Fig. 3. Response Time Summary

Based on the results in figure 3, intensity 4 shows the longest response time. Furthermore, the fixed response time is about 100 seconds. These seconds provides enough time to shield the students from falling debris. Having a much lesser time will efficiently execute the duck, cover and hold actions of the Kindergarten students to shield themselves from falling debris in case of an earthquake.

C. Evaluation

The proponents sought the help of experts in the field of engineering and disaster management (engineers with specialization in electronics, and mechanical and authorities of MMDA and PHIVOLCS) and stakeholders (Kindergarten teacher, principal, and parents) to evaluate the automated table on the following criteria: Usability, Mechanism Functionality and System Functionality. The assessment of experts and stakeholders on the automated table was shown on the table below.

Table 3. Assessment of Experts and Stakeholders

	Expert's Rating				Stakeholder's Rating				
Indicators	**A**	**B**	**C**	**D**	**Principal**	**Teacher**	**Parent 1**	**Parent 2**	**Parent 3**
Usability	-	-	-	-	5	5	5	5	5
Mechanism Functionality	-	-	-	-	5	5	5	5	5
System Functionality	-	-	-	-	5	5	5	5	5

Overall, stakeholders rated the system Excellent Quality (EQ) in terms of usability, mechanism functionality and system functionality. The stakeholders assessed that the automated table possesses all the indicators and observed just minor problems.

V. Conclusion

In terms of the automated system, the technology has the capabilities to identify whether a movement is an earthquake or not.

Considering the wireless communication, the sensors and transceivers can gather, transmit and receive accelerations accurately.

Based on the gathered data, the system established a 100-second fixed response time in terms of table mechanism, notification system and alarm system. Stakeholders rated the system Excellent Quality (EQ) in terms of usability, mechanism functionality and system functionality.

In conclusion, the developed technology is an effective tool for disaster preparedness and disaster risk reduction. This was a new step to give further innovations and ideas to Earthquake Engineering

VI. Acknowledgment

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VII. References

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