PROGRAMMABLE EARTHQUAKE DETECTOR SENSOR USING ARDUINO

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Cogon, Compostela, Cebu

SUBMITTED BY:

ABARCA, FRANCIS ROEL L.

BORBAJO, NIÑO KYLE

SANICO, CHRISTIAN PAUL

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ABSTRACT

The project Earthquake Detector Sensor using Arduino is aimed to make an alarm when a certain earthquake is detected and automatically makes an alarm immediately. Trial and error were conducted during programming the accelerometer. In this case, the Accelerometer sends signals to the board that detects every movement of the surface, when the project is placed steadily the accelerometer sends signals to the board telling it that its steady until you move the system which sends the command to the board and then activating the buzzer telling the surrounding areas that an earthquake has been detected. During testing, a single wooden plank was used to simulate its accuracy and delay of detection. Results revealed that there is significant difference between different magnitudes detected by the program with a p-value of 0.0256 as interpreted statistically using Two Factor Analysis of Variance (ANOVA). It is less than the set level of significance $\alpha = 0.05$ thus, the result is significant. This means that there is enough evidence claiming that the Arduino-based Earthquake Detector Sensor can detect earthquakes on any surfaces and can send alarms to people in an area.

ACKNOWLEDGEMENT

I might want to accept this open door to offer my thanks and gratefulness to my family who continued and supported me as I left on this period of my training. The wellbeing challenges experienced during this period were lightened by their steadfast help in helping me meet my duties.

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I might likewise want to express my gratitude to the managers, educators, companions, and staff who contributed their time and help with such a large number of ways. My thesis board of trustees individuals, Niño Kyle Borbajo and Christian Paul Sanico for their contributed time and vitality giving criticism and consolation to improve my examination. Their important information was extraordinarily refreshing. It was through the direction and help of such a large number of that I had the option to accomplish my objective.

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Chapter I

INTRODUCTION

Background of the Study

Earthquakes are natural disasters that involves the shaking of the ground unconditionally. However, this natural disaster is unpredictable and have very devastating damages to our environment and businesses.

Earthquakes commonly occur during Tectonic Plate Movements, a Tectonic Plate is commonly found on the mantle of the Earth, these plates move all the time but there are times that these movements can actually cause Earthquakes. One of them is the Constructive type which moves away two tectonic plates separating them, then theres the Destructive which happens when 2 tectonic plates move and collide, lastly theres Conservative which occurs when they slide in opposite or similar directions with different speeds.

It also occur on Volcanic regions due to the boiling lava tying to break through the surface of the Earth by the increased pressure of the gases below, while the pressure exerted is high but the earthquakes are not devastating.

Even though there are different causes of why an Earthquake occurs but they just go back to one characteristic which is the shaking of the ground, due to its shaking nature it can be easily felt and identified but these also occur not just to humans but also to every object in your area which means that there is a possible risk of danger if not trained or alarmed of the incident.

Earthquakes actually killed over 5,000 students in China during the Sichuan Earthquake in 2008, mostly the deaths of these students are caused by the poor structural integrity of the school buildings thanks to corruption.

Earthquakes do cost financial, human and time in work. Thanks to the recent advances in Training, Data Gathering and Emergency Alarms already in place could result in a massive drop in death rates due to Earthquake-related deaths and injuries.

While PHILVOLCS or the Philippine Institute of Volcanology and Seismology already installed an Emergency Alarm trigger onto their systems to push nearby alarms to trigger seconds when they detect an Earthquake, there is a slight catch these systems will just push only to nearby alarms and mobile devices and they are amazingly expensive to implement.

Using the data gathered, the researchers would like to create an Earthquake Emergency Alarm System that aims to see if it is possible to make an alternative Alarm System which can be implemented anywhere.

Objective of the Problem

This study is aimed to make Earthquake Alarm System which can be implemented anywhere.

Moreover, the study sought to answer the following objectives:

1. To accurately record the magnitude of earthquake incurred within a time duration; and
2. To determine the significant difference of magnitude of earthquake incurred using the Earthquake Alarm System.

Scope and Limitation

This study was focused on building a cheap alternative to PHILVOLCS's Earthquake Alarm System and its ability for good implementation. The researchers opted to use Arduino instead of the much more common Raspberry Pi because of its price and the ease of development. The Accelerometer sensor of the Arduino are not yet validated and proven to be more accurate than a glass of water.

Definition of Terms

For the better understanding of the study, the following words used were hereby defined conceptually and operationally:

Earthquake. A sudden and violent shaking of the ground, sometimes causing great destruction, as a result of movements within the earth's crust or volcanic action. (Oxford 2019).

In this study, it referred as the main activity that is detected by the system thus triggering the alarm.

Earthquake Alarm. A bell signal constructed to operate on the theory that a few seconds before the occurence of an earthquake (thefreedictionary.com 2019). In this study, the Earthquake Alarm is the main idea or the main system that is used in Industrial organizations as Earthquake Alarms.

Alarm. A warning sound or device (Oxford 2019). In this study, the Alarm is used as a device that acts as an alert for the system.

Arduino. A family of open single board micro controllers from **Arduino** LLC that is used by hobbyists and engineers to build electronic products. (yourdictionary.com 2017). In this study, Arduino is used as the brain or the main system of this study.

Accelerometer. is an electromechanical device used to measure acceleration force. (livescience.com 2013). In this study, Accelerometer is one of the 2 sensors responsible for detecting seismic activity.

Gyroscope. A device consisting of a wheel or disk mounted so that it can spin rapidly about an axis which is itself free to alter in direction. (Oxford 2019). In this study, Gyroscope is one of the 2 sensors responsible for detecting seismic activity.

CHAPTER 2

REVIEW OF RELATED LITERATURE

Earthquake Detector

Remote detecting information and techniques are generally conveyed so as to add to the appraisal of various segments of quake chance. While for tremor peril related examinations, the utilization of remotely detected information is a set up methodological component with a long inquire about convention, quake weakness centred evaluations fusing remote detecting information are expanding basically as of late. This obliges a changing point of view of mainstream researchers which thinks about the appraisal of defenselessness and its constituent components as a crucial piece of a far reaching hazard examination. In this manner, the accessibility of new sensors frameworks empowers a considerable portion of remote detecting first. Thusly, an overview of the interdisciplinary reasonable writing managing the logical impression of hazard, danger and powerlessness uncovers the interest for a far reaching depiction of tremor risks just as an appraisal of the present and future states of the components uncovered. A survey of seismic tremor related remote detecting writing, acknowledged both in a subjective and quantitative way, demonstrates the effectively existing and distributed complex

abilities of remote detecting adding to evaluate quake chance. These incorporate seismic tremor peril related investigation, for example, recognition and estimation of lineaments and surface distortions in pre-and post-occasion applications. Moreover, pre-occasion seismic weakness centred evaluation of the constructed and regular habitat and harm appraisals for post-occasion applications are exhibited. In view of the survey and the talk of logical patterns and ebb and flow research ventures, initial moves towards a guide for remote detecting are drawn, unequivocally taking logical, specialized, multi-and transdisciplinary just as political points of view into record, which is planned to open conceivable future research exercises. Taubenböck (August 29, 2012) Remote sensing contributing to assess earthquake risk: from a literature review towards roadmap from https://link.springer.com/article/10.1007/s11069-012-0322-2

Earthquake

Seismic tremors happen because of worldwide plate movement. Be that as it may, this straightforward picture is a long way from complete. Some plate limits float past one another easily, while others are punctuated by calamitous disappointments. A few quakes stop after just a couple of hundred meters while others keep cracking for a thousand kilometers. Quakes are now and again activated by other enormous tremors a huge number of kilometers away. We address these inquiries by dismembering the perceptible marvels and isolating out the quantifiable highlights for examination crosswise over occasions. We start with an exchange of worry in the outside layer pursued by a diagram of tremor phenomenology, concentrating on the parameters that are promptly estimated by current seismic systems. We quickly talk about how these parameters are identified with the sufficiency and frequencies of the flexible waves estimated by seismometers just as immediate geodetic estimations of the Earth's misshapening. We at that

point survey the real procedures thought to be dynamic during the break and talk about their connection to the noticeable parameters. We at that point take a more drawn out range see by examining how seismic tremors collaborate as a mind boggling framework. At long last, we consolidate subjects to approach the key issue of quake commencement. This closing discourse will require utilizing the procedures presented in the investigation of break just as some novel components. As our observational database improves, our computational capacity quickens and our research centers become progressively refined, the following couple of decades guarantee to expedite more bits of knowledge seismic tremors and maybe a few answers. Kanamori (July 12, 2004) The physics of earthquakes from https://iopscience.iop.org/article/10.1088/0034-4885/67/8/R03

The task targets structuring a seismic tremor checking and cautioning framework that is fit for distinguishing quakes just as notice individuals to play it safe. This framework won't just endeavor to spare human lives, however will likewise store the information for later use by experts working at this division. The target of this task is to plan a LabVIEW based control framework by working together MEMS accelerometer sensor with Arduino microcontrollers in a ZigBee remote system. The framework additionally has telecom VAS abilities to alarm individuals and control machines. Existing tremor frameworks are in addition intended for delayed repercussion the board and they scarcely manage ongoing information. Be that as it may, this framework is mostly intended to respond when the sensor hubs go over a p-wave. Hoque (2015) Earthquake monitoring and warning system from https://ieeexplore.ieee.org/abstract/document/7506808

Arduino

The creator expects to decrease the quantity of fiascos definitely so as to think of a more secure and secure condition. This paper depicts a framework which distinguishes the potential fiascos that one can look in a family unit or work-space. It is an Arduino based Disaster Detection System that contains sensors for identifying the catastrophes. This framework is new as in it joins location of more than one calamity with one gadget and still demonstrates to be as modest as could be expected under the circumstances. It is likewise interesting as in it naturally illuminates the crisis administrations when a calamity is identified.. Mehra (2017) Disaster detection system using Arduino from https://ieeexplore.ieee.org/abstract/document/8070777

Innovation and PCs are getting to be less expensive and simpler to discover each day, yet despite everything it stays hard to learn and see how things really work. Arduino is an extraordinary case of how a basic, economical, and simple to-program gadget can help understudies of any age learn hardware and programming in only a couple of steps. Albeit such inserted gadgets and hardware have been received by the network, the obstruction of section stays high in contrast with different advancements like website composition and conventional PC programming. Moreover, coordinated effort and trade of thoughts stays hard and bound to the past. Web and cloud advancements give an answer for the abovementioned. Spreading the information and honing the expectation to absorb information is the objective of Codebender. Codebender is a web based learning and joint effort center for producers, understudies, and specialists. Understudies can profit by learning simpler and coming to the heart of the matter where they can really program a lot quicker than previously. Architects and researchers gain admittance to cutting edge improvement devices that help them code and work together with their associates quicker and without agony. Amaxilatis (September 13, 2013) Using Codebender

and Arduino in Science and Education from https://link.springer.com/chapter/10.1007/978-3-319-00663-5_7

Seismic Sensors

The 26 August 2012 Brawley seismic swarm of many occasions running from M1.4 to M5.5 in the Salton Trough, California gives a remarkable informational index to research another seismogeodetic approach that consolidates Global Positioning System (GPS) and accelerometer perceptions to appraise relocation and speed waveforms. First in recreated real−time mode, we examined 1–5 Hz GPS information gathered by 17 stations completely circling the swarm zone at near−source separations up to around 40 km utilizing exact point situating with vagueness goals (PPP−AR). We utilized a reference system of North American GPS stations well outside the district of distortion to appraise fractional−cycle inclinations and satellite clock parameters, which were then joined with ultrarapid circles from the International GNSS Service to gauge positions during the Brawley seismic swarm. Next, we evaluated seismogeodetic relocations and speeds from GPS stage and pseudorange perceptions and 100–200 Hz increasing velocities gathered at three sets of GPS and seismic stations in closeness utilizing another firmly coupled Kalman channel approach as an expansion of the PPP−AR procedure. We can unmistakably observe body waves in the speed waveforms, including P−wave entries not perceivable with the GPS−only approach for seismic tremor sizes as low as Mw 4.6 and noteworthy static counterbalances for sizes as low as Mw 5.4. Our investigation demonstrates that GPS systems overhauled with solid movement accelerometers can give new data to improved comprehension of the seismic tremor crack procedure and be of basic incentive in making a hearty early cautioning framework for any quake of cultural importance. Geng

(April 15, 2013) A new seismogeodetic approach to GPS and accelerometer observations of the 2012 Brawley seismiic swarm: Implications for earthquake early warning from https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/ggge.20144

Real−time discovery and exact estimation of solid ground movement are vital for fast appraisal and early cautioning of geohazards, for example, seismic tremors, avalanches, and volcanic action. This difficult errand can be practiced by joining GPS and accelerometer estimations as a result of their integral abilities to determine broadband ground movement signals. In any case, for actualizing an operational observing system of such joint estimation frameworks, cost−effective methods should be created and thoroughly tried. We propose another methodology for joint handling of single−frequency GPS and MEMS (microelectromechanical frameworks) accelerometer information progressively. To show the presentation of our strategy, we portray results from open air tests under controlled conditions. For approval, we investigated dual−frequency GPS information and pictures recorded by a camcorder. The consequences of the various sensors concur great, proposing that real−time broadband data of ground movement can be given by utilizing single−frequency GPS and MEMS accelerometers. Tu (June 13, 2013) Cost-effective monitoring of ground motion related to earthquakes, landslides, or volcanic activity by joint use of a single-frequency GPS and a MEMS accelerometer from https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/grl.50653

Parallel controllers are progressively utilized in new applications by abusing their idiosyncrasies. The particular movement recreation capacity of CaPaMan (Cassino parallel controller) can be utilized for a seismic tremor test system. In this paper, an investigation of achievability of such novel utilization of a 3-DOF CaPaMan model has been introduced by

looking tentatively at point seismograms as well as even to 3D tremor movement. Albeit 3-DOFs don't allow careful reiteration of genuine 3D seismic tremor movement, the outcomes have been acceptable since a plan quake recreation has been resolved and tried with the essential quake attributes. Ceccarelli (December 2, 2002) A 3-DOF parallel manipulator as earthquake motion simulator from https://ieeexplore.ieee.org/abstract/document/1238551

Indonesia is one of the numerous nations with one of the most regular seismic tremors. For the most part, in Indonesia tremor harm level estimation is lead by direct perception. Nonetheless, the vibration force level of a tremor could bring about various degrees of harm. Henceforth, a harm force scaling framework assumes significant jobs as estimating harm effect brought about by a seismic tremor. Along these lines, in this paper we proposes a plan and improvement of a minimal effort harm power scaling framework dependent on microcontroller and microcomputer. The proposed thought is to record the harm level force information, appropriate a substantial information, and send an early cautioning if the tremor harms is serious. This framework equipment configuration using MPU6050 Accelerometer sensor and a potentiometer as a vibration indicator. This framework use Telegram API and MQTT convention to send sensors information to end client. The consequences of the examination demonstrates that our framework has a normal 3.17% of contrast with the more refined framework possessed by Meteorology, Climatology, and Geophysics Agency (BMKG) of Republic Indonesia. Crisnapati (2018) Earthquake Damage Intensity Scaling System based on Raspberry Pi and Arduino Uno from https://search.proquest.com/docview/2200847997/EDA3C392EAF745B9PQ/1?accountid=47253.

At the point when the arrangement is controlled, and keeping in mind that it is still, it

peruses and stores current accelerometer esteems in Arduino inner EEPROM paying little heed to its direction. Since the ADC is 10-piece, unique header document has been given the code. Ghosh (January 1, 2016) Do-It-yourself: Earthquake Indicator from https://search.proquest.com/docview/1754510141/abstract/EDA3C392EAF745B9PQ/2?accountid=47253

Could mobile phones be utilized to recognize tremors? The Community Seismic Network (CSN) is building a thick sensor arrange from reasonable and network possessed sensors, for example, mobile phones and USB accelerometers. Identifying uncommon occasions, for example, tremors is a troublesome detecting issue, and is aggravated by the wide varieties among sensors in a heterogeneous network organize. We exhibit a start to finish framework utilizing Android phones and a cloud combination focus that enables members to make "mock seismic tremors". After distinguishing such an occasion, the cloud combination focus issues continuous cautions to the telephones. A guide based interface to the combination focus is anticipated adjacent, showing the data detailed by the telephones. Faulkner (May 27, 2011) The next big one: Detecting earthquakes and other rare events from community-based sensors from https://ieeexplore.ieee.org/abstract/document/5779061.

The task targets structuring a seismic tremor observing and cautioning framework that is fit for recognizing quakes just as notice individuals to avoid potential risk. This framework won't just endeavor to spare human lives, yet will likewise store the information for later use by experts working at this division. The goal of this undertaking is to structure a LabVIEW based control framework by teaming up MEMS accelerometer sensor with Arduino microcontrollers in a ZigBee remote system. The framework additionally has telecom VAS capacities to alarm individuals and control machines. Existing tremor frameworks are also intended for

consequential convulsion the board and they scarcely manage continuous information. In any case, this framework is for the most part intended to respond when the sensor hubs go over a p-wave. Hoque, et. al (July 11, 2016) Earthquake monitoring and warning system from https://ieeexplore.ieee.org/abstract/document/7506808.

Seismic tremor is one of the real common cataclysm. So expectation of the compass of quake occasion to the different areas could bring about limiting the debacle because of it. An early cautioning framework for seismic tremor primarily issues an alert to have a period edge for emptying people groups to the protected spot or closing down key offices like major mechanical work and so forth to maintain a strategic distance from significant results [1]. This paper contains the structure of sensor framework and the strategies utilized for location and handling of the got flag progressively. The principle distinction between our technique and traditional strategies for tremor area following is expansion of two planer Azimuth edge. Ordinarily the separation triangulation technique is utilized for following the tremor area. Be that as it may, this strategy isn't much precise since it considers the normal velocities of the P and S waves. Speed of seismic waves shifts monstrously relying on sort of soil, shakes or water and so on underneath the earth surface. The expansion of utilizing the two planer Azimuth edge gives 3-dimensional edge of approaching seismic waves at the sensor framework. So utilizing two planer Azimuth point alongside separation triangulation strategy we can follow area of seismic tremor all the more precisely by utilizing at any rate three sensors information. Sherki, et. al (September 24, 2015) Design of real time sensor system for detection and processing of seismic waves for earthquake early warning system from https://ieeexplore.ieee.org/abstract/document/7274959.

Indonesia is an archipelago situated at three quake belts. This condition cause a quake

can happen whenever and undermine human life. A fast and precise early cautioning framework by utilizing the seismic wave information preparing is required along these lines, the quantity of exploited people influenced by the tremor can be abbreviated. Here, ADXL335 accelerometers are utilized as seismic sensors with an Arduino least framework. The outcomes demonstrate that when the principal seismic tremor's vibration happens, P wave information distinguished by the ADXL335 sensor is effectively cradled, adjusted, transmitted and showed on the server. At the point when there are mistakes on the transmission, server will demand for retransmission. The alert of the seismic tremor early cautioning framework will be actuated if there are at any rate three sensors from various areas effectively transmit P wave information with a similar scale. This is expected to forestall counterfeit seismic waves. Laumal (2018, March 27). Development of Earthquake Early Warning System Using ADXL335 Accelerometer from https://doi.org/10.31227/osf.io/sq9xr.

Debacle the board is the field managing or sorting out appropriate administration and utilization of assets, innovation, and data to manage any sad occasion or crisis. Debacle the executives is the best possible wanting to facilitate regular and any man-made awful occasion and is estimated how proficiently and adequately is one's readiness to react to catastrophe and recuperation so as to decrease the effect of such occasions. The motivation behind this paper is to structure a framework to identify a seismic tremor and give a notice message for home and industry. The structure utilizes Arduino (ATmega328p), accelerometer (ADXL335), LEDs, and signal. Sinha (August 02, 2018) Design of Earthquake Indicator System Using ATmega328p and ADXL335 for Disaster Management from https://link.springer.com/chapter/10.1007/978-981-13-0776-8_53.

The framework location casualties of a seismic tremor are a trial following up on the premise that in the event that you knows the definite position of a man spare to turn out to be quicker. This framework works uniquely in contrast to customary frameworks scan for exploited people since it requires usage in structures before a catastrophe with the goal that when this happens, the framework will give rescuers the area and the accurate number of survivors. Buzduga (2015) System for the detection earthquake victims – construction and principle of operation from http://inase.org/library/2015/vienna/bypaper/CSSCC/CSSCC-15.pdf.

The conveyance of lead-times for all conceivable compromising seismic hotspots for every district in the locale under examination by separating the lead-time worth relating to the fifth, tenth and 25th percentiles of the dispersions. We examine the outcomes for the fifth percentile so as to break down the most dire outcome imaginable: on account of a solitary site, the lead-time is required to be bigger than this incentive in the 95 % of the cases. Since the populace appropriation in Campania is uneven and the vast majority of the individuals live adjacent the coast, while the most ruinous quakes happen along the Apennine chain, we can presume that an effective EEWS can permit the majority of the schools in the territory to attempt some alleviating activities. Emolo (January 14, 2016) Earthquake early warning feasibility in the Campania region (southern Italy) and demonstration system for public school buildings from https://link.springer.com/article/10.1007/s10518-016-9865-z.

Certain early on exercises in PC sciences and hardware were required for the understudies to obtain the fundamental aptitudes and to fill holes in their experience information. Likewise, addresses by seismologists and explicit research center exercises enabled the class to investigate various parts of the material science of quakes, especially of the seismic waves, and

to get comfortable with seismic−hazard themes through inquiry−based learning. We accept that this activity is a genuine case of how tremor issues can be educated through a multidisciplinary approach in subjects customarily secured by logical and innovative orders. Saraò (2016) Using an Arduino Seismograph to Raise Awareness of Earthquake Hazard Through a Multidisciplinary Approach from https://pubs.geoscienceworld.org/ssa/srl/article-abstract/87/1/186/315662.

Evaluating culmination is getting to be conceivable in locales of inadequate information where strategies dependent on parametric seismic tremor lists fall flat. We find that the inventory of the Southern California Seismic Network (SCSN) has, for the majority of the area, a lower greatness of fulfillment than that registered utilizing customary strategies, despite the fact that in certain spots conventional methods give lower gauges. Schorlemmer (2008) Probability of Detecting an Earthquake from https://pubs.geoscienceworld.org/ssa/bssa/article-abstract/98/5/2103/341891.

If there should be an occurrence of a seismic occasion, a quick and draft harm guide of the hit urban regions can be exceptionally helpful, specifically when the focal point of the quake is situated in remote locales, or the fundamental correspondence frameworks are harmed. Stramondo (2006) Satellite radar and optical remote sensing for earthquake damage detection: results from different case studies from https://www.tandfonline.com/doi/full/10.1080/01431160600675895?scroll=top&needAccess=true&cookieSet=1.

To distinguish potential tremors, we utilize a transient normal, long haul normal calculation. At the point when tuned to a moderate affectability, the identifier finds 48 universally disseminated tremors with just two false triggers in five months of information. The quantity of identifications is little contrasted with the 5,175 tremors in the USGS worldwide

seismic tremor inventory for a similar five-month timeframe, and no precise area or extent can be appointed dependent on tweet information alone. Earle (2011) Twitter earthquake detection: earthquake monitoring in a social world from https://www.annalsofgeophysics.eu/index.php/annals/article/view/5364.

This letter shows the plausibility of recognizing seismic tremors (EQs) from microwaves produced when shake cracks. The strategy depends on an analysis where microwave outflow was recognized from shake breaking in a research facility without precedent for the world. Initially, the strategy for aligning produced microwave control from test information is introduced. A model of microwave discharge and spread to a satellite is then proposed. A bit of leeway of microwaves is that they enter the Earth's ionosphere, dissimilar to radiowaves of frequencies lower than a few several megahertz. The power gotten by a satelliteborne beneficiary is evaluated by accepting parameters of a radiometer right now working in circle. The outcome shows that a satelliteborne beneficiary can recognize microwave sign produced by an EQ. In view of this outcome, we endeavored to recognize a few highlights related with a real EQ from the information of the Advanced Microwave Scanning Radiometer for Earth Observation System on board the remote detecting satellite Aqua. Takano (2011) Experiment and Theoretical Study of Earthquake Detection Capability by Means of Microwave Passive Sensors on a Satellite from https://ieeexplore.ieee.org/abstract/document/4711143/metrics.

One usually utilized parameter to portray the account ability of a system is the greatness of fulfillment (Mc), comprehended as the extent above which quakes are recorded with a specific likelihood near 1. The outcomes demonstrate that the vulnerabilities in culmination sizes are commonly under 0.1 size units, suggesting that the strategy produces stable appraisals of

fulfillment sizes. Nanjo (2010) Earthquake detection capability of the Swiss Seismic Network from https://academic.oup.com/gji/article/181/3/1713/606473.

An ideal performing EEWS can be characterized as the framework giving simultaneously the biggest 'lead-time' (for example the time interim between the landing of the harming waves and ready notice) and least forecast blunder on pinnacle ground movement (for example contrast among watched and anticipated logarithmic pinnacle movement adequacy). The primary favorable position of a system based EEWS is that a constantly refreshed and progressively exact estimation of source parameters (area and greatness) is accessible continuously, as new information are obtained by the system. The exactness on pinnacle ground movement expectation at removed locales is basically identified with the parameter vulnerability of the utilized ground movement forecast condition (GMPE). Then again, for an on location EEWS, the alarm on an approaching quake harm at the objective site is mostly issued dependent on a neighborhood estimation of P-wave ground movement, with no requirement for precise estimation of source parameters. As far as lead-time, a system based framework can give a potential cautioning time a factor of around two longer than for a site-explicit, as it very well may be evaluated by hypothetical counts of P-and S-wave travel times at stations situated in the source locale and far away, utilizing a standard crustal speed model. Zollo (2010) A threshold-based earthquake early warning using dense accelerometer networks from https://academic.oup.com/gji/article/183/2/963/657752?searchresult=1.

The circulations of co-seismic weight on this zone, just as on the neighboring, vertical strike–slip Sumatra shortcoming, and discover an expansion in weight on the two structures that altogether helps the officially significant tremor peril presented by them. McCloskey (2005)

Earthquake risk from co-seismic stress from https://www.nature.com/articles/434291a.

Remote detecting systems assume a significant job in acquiring building harm data as a result of their non-contact, minimal effort, wide field of view, and quick reaction limits. Since more and differing kinds of remote detecting information become accessible, different strategies are planned and detailed for structure harm appraisal. Dong (2013) A comprehensive review of earthquake-induced building damage detection with remote sensing techniques from https://www.sciencedirect.com/science/article/abs/pii/S0924271613001627.

A P-wave detecting device including a printed circuit board having mounted consequently from one to three symmetrically arranged small sensors that capacity as dormancy checking gadgets concerning movement of the outer supporting structures, a majority of enhancing and separating circuits for intensifying and sifting the yields produced by the sensors, and a focal preparing unit receptive to the intensified sign and usable to create yield signals which can be utilized to drive optical and capable of being heard annunciators, computerized information recording frameworks, or other gadget activating frameworks. Webb (2003) Sensor apparatus and method for detecting earthquake generated P-waves and generating a responsive control signal from https://patents.google.com/patent/US7005993B2/en.

An aggregate of 603 speed and increasing speed sensors at 383 locales over the state stream waveform information to ElarmS handling modules at three system preparing focuses where waveforms are decreased to a couple of parameters. These parameters are then gathered and prepared at UC Berkeley to give a solitary statewide expectation of future ground shaking that is refreshed each second. The framework effectively recognized the Mw 5.4 Alum Rock seismic tremor in northern California for which it produced a precise risk forecast before

pinnacle shaking started in San Francisco. It likewise identified the Mw 5.4 Chino Hills seismic tremor in southern California. The middle framework dormancy is as of now 11.8 sec; the middle waveform information inertness is 6.5 sec. Allen (2009) Real−time earthquake detection and hazard assessment by ElarmS across California from https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2008GL036766.

The component fundamental the age of tremor and its relationship to aseismic slip are, be that as it may, up 'til now uncertain. Here we exhibit that tremor underneath Shikoku, Japan, can be clarified as a swarm of little, low-recurrence quakes, every one of which happens as shear blaming on the subduction-zone plate interface. This recommends tremor and moderate slip are various signs of a solitary procedure. Shelly (2007) Non-volcanic tremor and low-frequency earthquake swarms from https://www.nature.com/articles/nature05666.

CHAPTER 3

MATERIALS AND METHODS

Research Design

In this study, the researchers used the Posttest Only Design in gathering the data on the accuracy of the system. There are three setups in the process and that setup is comprised with a single Seismic Table. The researchers were able to gather the data for the project which was its responsiveness and its accuracy of determining an earthquake.

Materials/Equipments

The materials used in this study were a Laptop for programming, an Arduino Uno for the main system, Accelerometer ADXL335 for motion detection, Buzzer, BC547 Transistor for the electronic switch, 1K Resistors for controlling power delivery, LED as light indicator, and Power Supply 9V/12V for power.

Procedures

Preparation of the System. First, we gathered all the materials and equipments needed for the project, we prepped the materials on a Static-free table. We started by assembling the Arduino board itself then plugging it into power and USB Data to the Laptop as checking if the system is ok and stable. Next, preparing the accelerometer for calibration by taking samples of surrounding vibrations during startup. After calibration we installed a Buzzer first for checking if it worked then the Alarm. Lastly, we installed the LEDs for checking if the program would work independently from the Laptop.

Testing the accuracy of the System. The accuracy of the system was tested by a three

setup method, the first setup uses a Seismic Table with a good shake to determine its accuracy sat down flat on the table, the second setup uses the same Seismic Table but with a wooden plank placed 90 degrees bolted to the table to simulate shaking when its placed on a wall, and the third setup uses the same Seismic Table but placed under the table with a 180 degree angle. The researchers were able go gather a single type of data out of the setup shown.

Data Gathering and Analysis. The researchers will gather data by measuring its response time on different magnitudes. The researchers will collect and analyze the data using the Two Factor Analysis of Variance (ANOVA) Without Replication considering a 0.05 level of significance.

CHAPTER IV

RESULTS AND DISCUSSION

This chapter presented the results and discussion obtained after the gathering of data.

Responsiveness

Table 1. Results.

Set-ups	Sensitivity (±)	Magnitude (M_L)	Response Time (ms)
A	3±	0.81 M_L	23.41 ms
B	3±	1.34 M_L	17.33 ms
C	3±	2.67 M_L	9.14 ms

Table 1 shows the magnitude of the three (3) configurations with different magnitudes used as a basis for the testing of the project. Based on the table presented, Setup C with a strong magnitude that registers the fastest detection speed among the attempts on different magnitudes with an overall response time of 9.14 ms.

The finding somehow affirms with the study of Sherki et. al(2017) stating that most sensor systems get more accurate and instant readings on stronger seismic waves than weaker and less noticeable seismic waves.

Variables Tested	N	Mean	Level of Significance	Computed p-value	Interpretation
Response time of the Sensor	16	0.74	0.05	0.0256	There is a significant difference

Table 2. Significant Difference of the Response time of the sensor Detected by the project.

Table 2 presented the significant difference among the speed of sensor detection of the seismic waves detected by the program. This means that there is sufficient evidence claiming that stronger earthquakes can affect the detection speed of the device.

This significant difference corroborates with the result of the study of Hoque, et. al(2015) stating that common frameworks are mostly intended to respond when the sensor hubs go over a stronger p-wave. This finding leads them to conduct a study using different devices to send warnings to people on different areas.

CHAPTER V

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATION

Significant Findings

This project is aimed to determine the accuracy of our Earthquake Detector Sensor as an alternative system. Moreover, this study intended to answer the following questions: Is the system accurate enough to be a good alternative?

Conclusion

The Arduino-based Earthquake Detector project aims to create an alternative or cheaper version to industrial and more expensive models. Based on the result, the project can detect incoming earthquakes at 30 milliseconds max at different magnitudes. However, the project cannot actually tell if a certain surface its placed in is created by an earthquake or by a vibrating object. It takes another sensor to correctly tell and identify the actual object creating it.

Recommendation

In accordance with the results & findings, the researchers recommend possible alterations and improvements of the study. These would serve as a guide to enhance future researchers' knowledge about this study.

In order to obtain the accurate data needed for the study, conduct experimentation in an actual earthquake simulator room to accurately measure its effectiveness in the real world. Also, use different Types of Tests to ensure consistency of the data.

The researchers can make a website or a program that can remotely communicate with the sensor to gather data and software maintenance.

Instead of using a ADXL335 accelerometer, it would be best for the future researchers to use a Laser System instead for better accuracy and lesser chances of false positives.

Try to use a Raspberry Pi instead of an Arduino as the main system board.

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Appendix I

Republic of the Philippines

Division of Cebu Province

Compostela Science and Technology High School

Cogon, Compostela, Cebu

Mrs. Maria P. Selanoba

Principal III

Compostela Science and Technology High School

Cogon, Compostela Cebu

Dear Madam,

Greetings in the name of Holy Triune God,

The researchers are currently working in a study entitled **Programmable Earthquake Detector Sensor using Arduino.** In line with this, we would like to ask permission to conduct experimentation as part of the study.

We believe that you are with us in our enthusiasm to finish the requirement of our project as compliance for our graduation and to develop our well-being. We hope for your positive response on this humble matter.

Respectfully yours,
Francis Roel L. Abarca
Niño Kyle Borbajo
Christian Paul Sanico

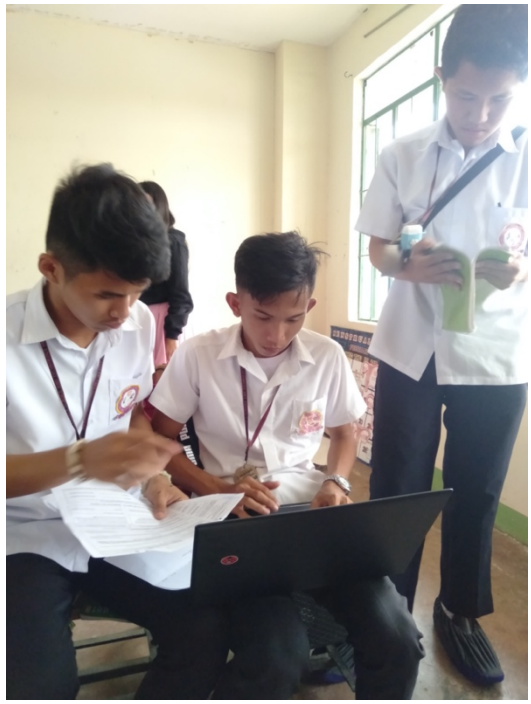
Noted by:
James Ulysses A. Gastador
Research Advisor

Approved by:
Maria Teresa P. Selanoba
Principal III

Appendix F

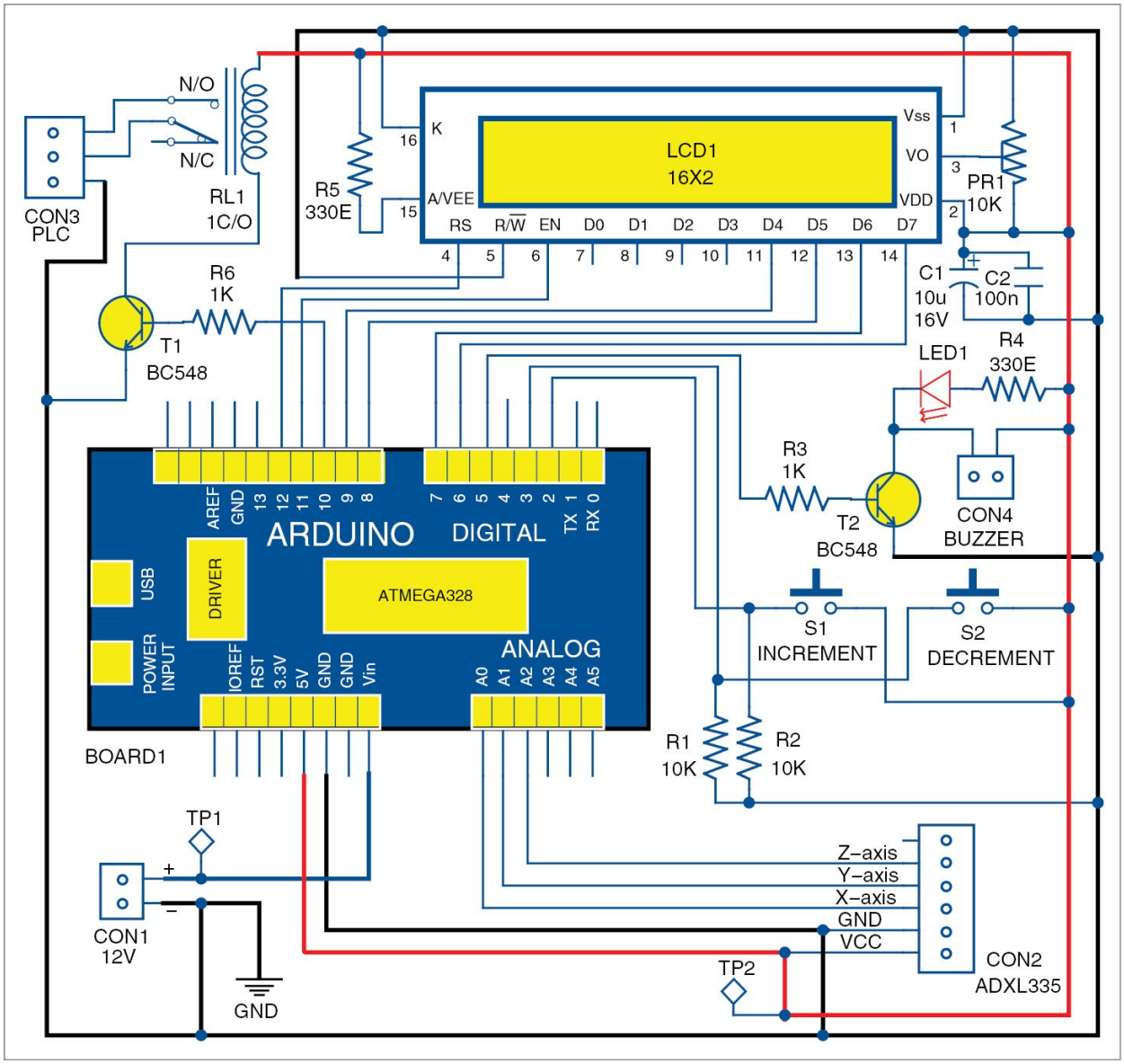
Documentation in the Making of the Proposal Project

Documentation in Making of the Paper



Schematic Diagram of the Project

Figure 1. Circuit diagram of the Earthquake Detector



Appendix G

Total Expenses

Equipment	Price
3x Arduino Uno R3	**₱900.00**

3x ADXL335 Accelerometer	**₱927.00**
3x 1K Resistor	**₱3.00**
3x Breadboards	**₱255.00**
3x Buzzer	**₱99.00**
100pcs of Jumper Wires	**₱236.00**
1x 16x2 LCD Display	**₱130.00**
TOTAL	**₱2,550.00**

APPENDIX H

Statistical Results

Anova: Two-Factor Without Replication						
SUMMARY	*Count*	*Sum*	*Average*	*Variance*		
Row 1	3	27.22	9.073333333	155.3540333		
Row 2	3	21.67	7.223333333	77.29743333		
Row 3	3	14.81	4.936666667	13.27823333		
Column 1	3	9	3	0		
Column 2	3	4.82	1.606666667	0.918233333		
Column 3	3	49.88	16.62666667	51.27923333		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	25.76335556	2	12.88167778	0.655292855	0.567329201	6.94427191
Columns	413.2278222	2	206.6139111	10.51048024	0.025557127	6.94427191
Error	78.63157778	4	19.65789444			
Total	517.6227556	8				

Appendix I

Timeline of Making the Paper

February 20, 2019	Making of Chapter I
March 17, 2019	Making of Chapter II
August 8, 2019	Making of Chapter III
September 18, 2019	Making of Chapter IV
October 29, 2019	Making of Chapter V

Name	:	James Ulysses A. Gastador
Date of Birth	:	July 17, 1992
Place of Birth	:	Cogon, Compostela, Cebu
Sex	:	Male
Civil Status	:	Single
Religion	:	Roman Catholic
Permanent Address	:	Cogon, Compostela, Cebu
Parents	:	Ulysses R. Gastador Santiaga Arioja-Gastador

Educational Background

Graduate Studies	:	University of the Philippines-Cebu Master of Education – Biology August 2016 – June 2019
Tertiary	:	University of Cebu-Main Campus Bachelor of Secondary Education – Physical Sciences 2009-2013 Cebu Technological University-Danao Campus Bachelor of Secondary Education (TLE) 2008-2009
Secondary	:	Compostela National High School 2004-2008
Primary	:	Compostela Central School 1998-2004

Eligibility

Licensure Examination for Teachers (LET) – September 2013

Work Experience

Teacher 1	:	Department of Education-Cebu Province Compostela Science and Technology High School Cogon, Compostela, Cebu December 2017-Present
Part Time College Instructor	:	University of the Visayas-Danao City Campus Danao City, Cebu November 2017-March 2018
Part Time College Instructor	:	Department of Mathematics and Sciences University of San Jose-Recoletos Cebu City, Philippines November 2016-March 2017
Senior High School Teacher (Full Time)	:	University of San Jose-Recoletos Cebu City, Philippines June 2016-March 2017
College Instructor	:	College of Technological Sciences-Cebu N.Bacalso Ave., Cebu City, Philippines October 2015-March 2016
Substitute Public School Teacher	:	Department of Education-Cebu City Don Vicente Rama Memorial National High School Macopa St., Basak Pardo, Cebu City, Philippines June 2015-September 2015
Private School Teacher	:	St. Scholastica Academy Tabunok, Talisay City, Cebu June 2014 – March 2015

Substitute High School Teacher	:	University of San Carlos-South Campus P. Alcantara St., Urgello, Cebu City, Philippines December 2013 – February 2014

Memberships and Organization

Public School Teachers Association of Compostela (PUSTAC)	:	Member June 2018-Present
Philippine Society for Youth Science Club (PSYSC)	:	Member (Club Adviser) August 2018-Present
National Association for Cultural Educators and Scholars (NACES)	:	Member July 17, 2018-Present
Philippine Association of Researchers and Statistical Software Users (PARSSU)	:	Member March 2017- Present

Seminars/Trainings Attended Recently Attended

Division Training of Trainers on Cross Specialization in Science for Non-Science Major	:	April 29-May 3, 2019 DEPED Ecotech Sudlon, Lahug, Cebu City
Seminar on Gender and Development (GAD) Based Investigatory Project Writeshop for Teachers and Students	:	April 21-25, 2019 DEPED Ecotech Sudlon, Lahug, Cebu City

National Seminar Workshop on Research, Measurement and Evaluation	:	December 21-23, 2018 Kew Hotel Tagbilaran City, Bohol

Name	:	Francis Roel L. Abarca
Date of Birth	:	March 12, 2003
Place of Birth	:	Cebu City
Sex	:	Male
Civil Status	:	Single
Religion	:	Roman Catholic
Permanent Address	:	Cogon, Compostela, Cebu
Parents	:	Elenito Garces Abarca
		Rosannasum Laude Abarca

Educational Background

Secondary	:	Compostela Science and Technology High School 2016-2020

Primary	:	Araneta Learning Center 2006-2016

Name	:	Niño Kyle J. Borbajo
Date of Birth	:	January 26,2003
Place of Birth	:	Compostela, Cebu
Sex	:	Male
Civil Status	:	Single
Religion	:	Roman Catholic
Permanent Address	:	Dapdap, Compostela, Cebu
Parents	:	Crisanto S. Borbajo Ledamie J. Borbajo

Educational Background

Secondary	:	Compostela Science and Technology High School 2016-2020
Primary	:	Luke Christian Institute 2006-2016

Name	:	Christian Paul C. Sanico
Date of Birth	:	December 22,2003
Place of Birth	:	Compostela, Cebu
Sex	:	Male
Civil Status	:	Single
Religion	:	Roman Catholic
Permanent Address	:	Canamucan 2, Compostela, Cebu
Parents	:	Oscar P. Sanico
		Evangelince C. Sanico

Educational Background

Secondary	:	Compostela Science and Technology High School 2016-2020
Primary	:	St. Louisse Academy 2006-2016