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A Systematic Literature Review on Earthquake Detector

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Abstract: Around the world, earthquakes continue to be a significant cause for death, injury and disruption. Recently, Malaysia startled by Sabah earthquake that struck Ranau, Sabah on 5 June 2015 with moment magnitude reported 6.0 by the United States Geological Survey while the Malaysia Meteorological department has reported the magnitude to be 5.9 at a depth approximately 10 km with it is epicenter approximately 15 km North of Ranau and which lasted for 30 seconds. There are four objectives in this review paper which are review the vary keywords used in research, studies the different types of earthquakes detector that are appropriate, review the effectiveness of earthquake detectors and the effects of installation on environment and lastly examination the output produced by the earthquake detectors through the created/ existing detectors. There are four phases involved in this part which are identification, screening, eligibility, included. Each of phases shows the flow to determine references from resources search. After identify, based on all this steps, there are only 35 articles that included in qualitative synthesis. All findings studies were discussing and analyzed based on keyword used, types of detectors, output that produce from earthquake detectors and its effects on humans, technologies and environments. From studies that has been run, there are several ideas will be recommend in this part for future studies and for the benefit of researcher. Firstly, the devices will produce the location of the nearest earthquake protection center. Next, earthquake detectors can detect heat from humans or animal within a range of distances.

Keywords: Earthquake Detector, Seismic, Arduino

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1. Introduction

The world, currently, earthquakes continue to be the main cause of disruption, injury, and death[1]. In the countries developing, death from the earthquake can be extremely high, for example at the china in 2010, Haiti with 220,000 fatalities, and 88,289 fatalities in the Wenchuan because of the earthquake. According to the records of historical, there are two faults zone will influence the Malay and Singapore country, first is Sumatran fault and second is Sumatran subduction[2]. But now earthquakes are approaching Malaysia which are located at Sabah. In the year 2015 the earthquake was struck Ranau, Sabah, Malaysia with a moment magnitude of 6.0 on 5 June, which lasted for 30 seconds the earthquake was the strongest to affect Malaysia since the 1976 Sabah earthquake.

This incident had been caused damage and loss the life. Modest earthquake detector been proved that it was useful for people to warning that incident will happen. The present technology in seismic instrumentation and telecommunications needs the implementation of a computerized system for earthquake early warning. Such a system is able to provide from a few seconds to a few tens of seconds of warning before the arrival of strong ground shaking caused by a large earthquake[3]. From that the modern earthquake detector has been used to detect the earthquake and recorded the magnitude of the earthquake. The highest magnitude showed the worse earthquake. The aims of review paper are:

i). Review the vary keywords used in research.
ii). Studies the different types of earthquakes detector that are appropriate.
iii). Review the effectiveness of earthquake detectors and the effects of installation on environment.
iv). Examination the output produced by the earthquake detectors through the created or existed detectors.

2. Methodology

This subtopic indicated with guideline used, resources used, systematic review paper, flow diagram and data analytic strategy that used to determine the suitable records and related with studies. Methodology is the way for researcher provided the framework of studies before the actual studies were conducted. The first method is guideline used in these studies which are five process were involved such as familiarizing with data, assigning preliminary codes in order to describing the content or studies, searching the patterns or themes, reviewing the themes, defining the themes and producing the report. The next method is resources used in these studies such Science Direct, Scopus, Google Patent and Google Scholar which is all these resources have the advantages and disadvantages for research and researcher. For example, Scopus has the comprehensive scientific data and literature and analytical tools to keep up to date and ahead of the competition meanwhile for Science Direct is creating custom alerts tailored to the publications and topics of study that interested. Resources is important to searching the reports or articles related with studies more quality, no duplicated and safe. Systematic review paper is involved process which are identification, screening, eligibility and included process to determine the records related with studies case. Each part playing the main role to discover records properly and more efficiency.

Then, flow diagram representing a flow or set of dynamic relationship in a research. Each step is connected with arrow to shows relationship activities with other activities. Flow diagrams are used to structure and order a complex system to reveal the underlying structure of the elements and interaction between it. The last method is data analytic strategy which is data are divided by two either quality data or quantitative data. There are two types of data which is conceptual data and methodological data. The conceptual data is concerned with understanding from informant perspectives and assume as dynamic and negotiated reality. The methodological is data are collected through observation and interviews. The data also are analyzed by themes from descriptions by informants. Conclusion is methodology is

the methods that used to produce a full thesis and involved the process as a framework of studies and guideline for researcher to studies about it with more systematic. It is important to offers the theoretical underpinning for understanding which method, set of methods, the true procedure, or best practices can be applied to a specific case.

3. Results

Figure 1 shows the steps of records determination which are to easier the researcher knows about records that suitable related with research project. All steps involving process such as identification, screening, eligibility and included. Identification process is a first process in this flow which is the records were determined by using all resources such as Science Direct, Scopus, Google Scholar and Google Patent. The next process is screening which is all records were screen and isolated associated with topic studies, years of published and name of authors. All duplicates records will be removed in this process to prevent the researcher read the same records as well. The eligibility process which is full text records were excluded because of the reasons such as not performing the suitable data with studies. The last process is included which is the actual suitable records that associated with studies are determined then will be analyzed and discussed in these studies.

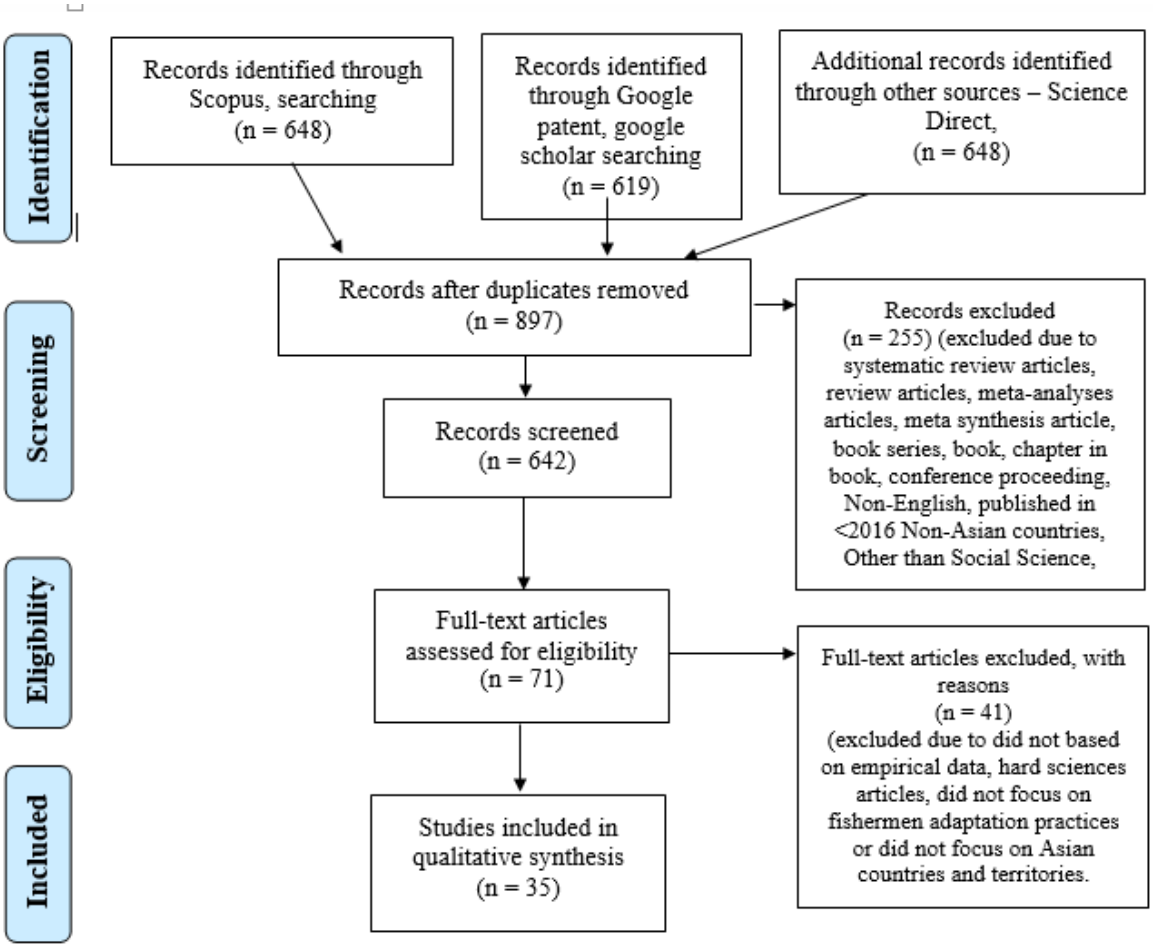

Figure 1: Determination of records

4. Discussion

The data were obtained from the analysis of the journal and it analyze into four (4) sections based on the keyword, type of earthquake detector, the output and the effect of an earthquake. The result will be discussed in more detail in order for the study to be quality and achieve the objective of review paper.

4.1 Analysis based on earthquake keyword

From data **Figure 2** below, there five terms used to present earthquake term which are vibration, seismology, tremor, seismic and soil mechanism. Here, one author which is Unjoh et al., 2012 was used soil mechanism term in studies of earthquake. Three authors which are Chakraborty et al., 2019; Akhoondzadeh et al., 2016; Huayong et al., 2019 were used seismology term in their studies. Six authors using vibration in their studies which are H. Balucan et al., 2016; B.C, et al., 2019; Priyana et al., 2018; Shukor et al., 2016; Crisnapati et al., 2019; Rambabu et al., 2020. There are two authors using tremor term in their earthquake studies which are Van Nguyen et al., 2020 and Ahangar-asr et al., 2012. Lastly, the most popular term that often used is seismic which are eighteen authors Pathak et al., 2019; B.C et al., 2019; Priyana et al., 2017; Satriano et al., 2011; Doubravová et al., 2016; Cremen et al., 2020; Alfonsi et al., 2017; Gibbons et al., 2017; Zhu et al., 2019; Sevilla et al., 2020; Akhoondzadeh et al., 2020; Foti et al., 2017; Aczel et al., 2019; Zhang et al., 2013; Liu et al., 2018a; Cakir et al., 2013a and Chaudhary et al., 2017.

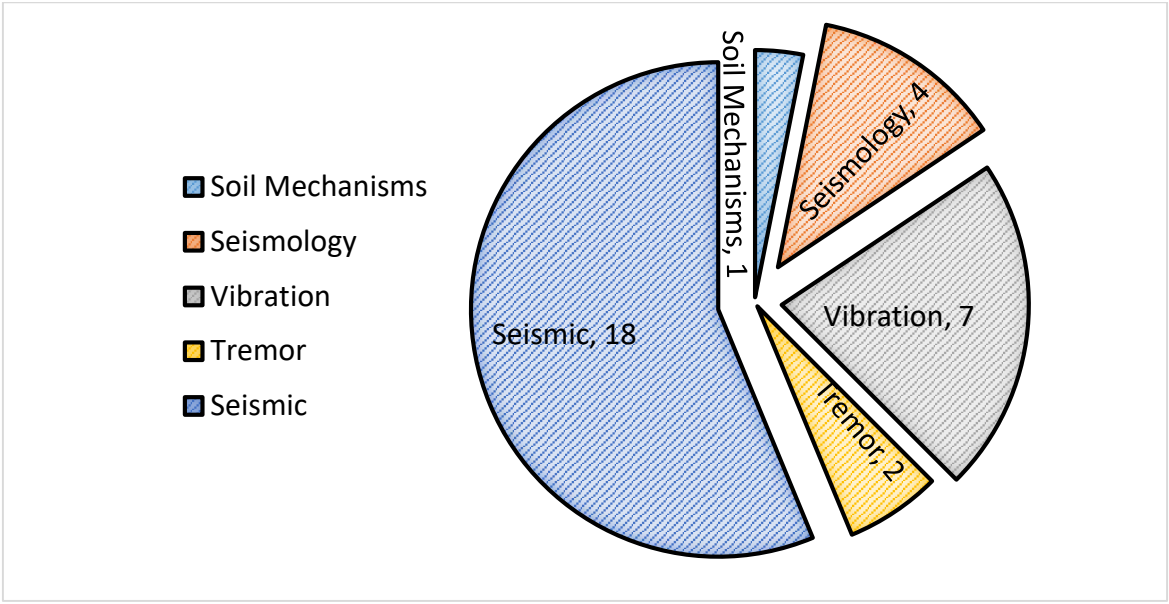

Figure 2: Based on earthquake keyword

4.2 Analysis based on detector keyword

Figure 3 show the thirteen authors used vary terms of detector the rest of authors using directly detector term in their studies. There eight authors use sensor in their studies which are B.C et al., 2019: Dutta et al., 2017b; Priyana et al., 2018; Shukor et al., 2016; Crisnapati et al., 2018; Mar et al.,2019; Huang et al., 2012 and Indiano et al., 2002. In the other hand, five authors using alarm term in their studies which are Pathak et al., 2019; Sharma et al., 2017b; B.C et al., 2019; Priyana et al., 2017 and Baser et al.,2020.

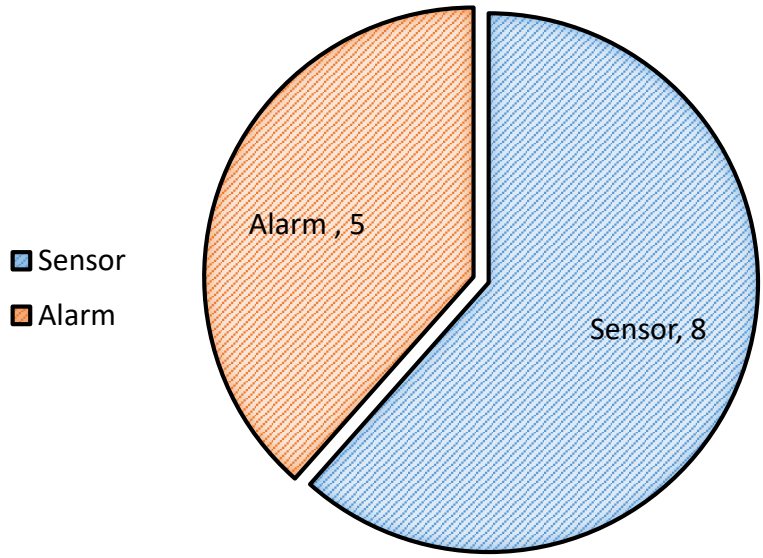

Figure 3: Based on keyword detector

4.3 Finding based on types of earthquake detectors

Figure 4 below show the results obtained from the type of an earthquake detector analysis. Each journal will be analyzed into several section which are S waves or P wave or both, detector, vibration, early warning, Arduino, alarm and level. S wave and P wave were mostly used in design an earthquake detector because it can reduce the destructive aftershock. the effectiveness of an earthquake detector is influenced by the type of material selected. Vibration is most appropriately used to measure the level and magnitude of earthquakes. Vibration sensors also prevent false alarms in humans. In addition, an earthquake detector has a positive impact after its installation on humans, providing early warning to humans. Thus, humans can be prepared in advance and the loss of life can be reduced.

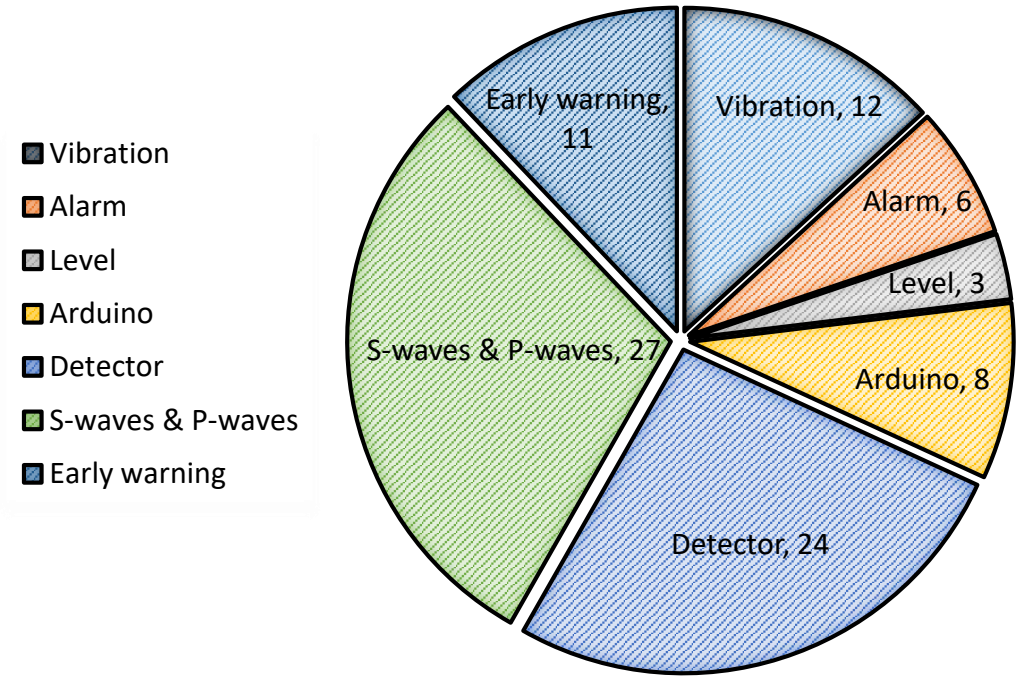

Figure 4: Types of earthquake detectors

P wave, particles move in the same direction that the wave is moving in, which is the direction that the energy is traveling in, and is sometimes called the 'direction of wave propagation'. The second type of body wave is the S wave or secondary wave. S waves move rock particles up and down, or side-to-side-perpendicular to the direction that the wave is traveling in (the direction of wave propagation). In other words, P waves help to determine the fake signal early warning by sound waves which push and pull the air. According to [32] and [40] an electronic device have designed which will help to identify the detection of the initial tremor due to fracture on the surface and identification of the primary wave and the surface wave respectively in the elastic rock medium.

The present invention relates to the field of earthquake detection. More particularly, the invention relates to an earthquake detector and method for filtering and detecting earthquakes. An earthquake detector can be installed to a main structural component of a building or other structure involved in shakes or vibrates when the building vibrates, to generate a signal that sets off an alarm. An earthquake detector which could generate a signal upon the detection of a moderate earthquake, but which was resistant to the generation of false alarms, would be of considerable valuable. Specifically, the present invention relates to an earthquake filtering and detection method and earthquake detector for selected intensities of earthquakes, with accurate verification, over a wide area and relatively early detection [41]. Patents et al., 2020a reported the basis of an earthquake detector that can detect the occurrence of noticeable earthquakes is useful to awake persons who sleep through during earthquake shock, and shut off gas and or electricity to minimize the possibility of risk.

Based on the research Sagarino et al., 2019 vibration sensor is a sensor for measuring, displaying, and analyzing linear velocity, displacement and proximity, or acceleration. In this study, the sensor was connected to the Arduino and detected an earthquake. Then it sent electric signals to the prototype earthquake-proof container that automatically close when it reached a magnitude level of 5 and above. It can be wrapped that the vibration sensor was used as detected the earthquake and display the output in the screen. ADXL335 accelerometers are used as seismic sensors with an Arduino minimum system. The results show that when the first earthquake's vibration occurs, P wave data detected by the ADXL335 sensor is successfully buffered, calibrated, transmitted and displayed on the server [17], [40]. Vibration sensor and electrical power shut off device including a pendulum switch constructed for universal movement whereby vibration in any direction causes the pendulum switch to close and actuate a solenoid that shuts off electrical power at a switch point in an electrical power line, a low voltage circuit remaining energized to indicate power interruption [44].

Dutta et al. [32] reported the earthquake early warning system can be developed for earthquake risk mitigation for the region. There are three basic reasons that feel an earthquake prediction analysis has suffered due to the absence of reliable diagnostic precursors for different geo-tectonic settings responsible for earthquake genesis. According to Priyana et al., 2017 the alarm of the earthquake early warning system will be activated if there are at least three sensors from different locations successfully transmit P wave data with the same scale. This is needed to prevent fake seismic waves and this method is used as avoiding a fake signal.

4.4 Analysis based on earthquake effects on environment

Earthquake do affect environment. From overall in the chosen articles show that they are talking variety of effects. There are many new future things like Arduino detector, advance apps that can give an early warning, new design of structures than resistant to earthquake and others. This shows that public are more concern about this situation than before. Because of there are many unwanted cases during this mother nature creation, professional people come out new and fresh ideas to at least can be facilitates to public. In this paper focus more on research about earthquake detector so with these scientific articles, gain the knowledge on how to produce the detector or making an innovation on the existing detector. Generally, all these 35 articles do discuss about effects on environment in many ways. **Figure 5** show the summarize of all the articles in term of earthquake effects on the environmental.

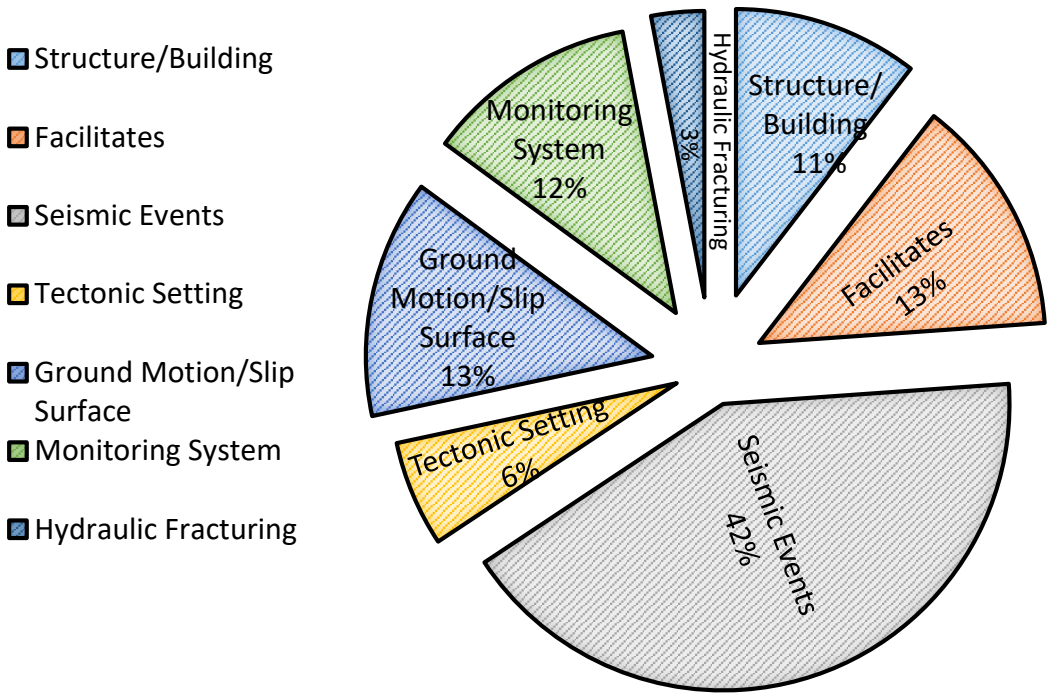

Figure 5: Earthquake effects on environment

Seismic events are occurrences in which energy is briefly released in the Earth's crust, resulting in a series of seismic waves which move through the crust. In some cases, the energy can be intense enough that it is felt in the form of an earthquake, while in other seismic events, the energy is so mild that it can only be identified with specialized equipment.

Simple system displays an alert message on LED display to make people aware of the earthquake and take necessary action to save their lives were used by the author. Since this system is small and compact, it can be installed in many areas to detect earthquakes [45]. So, in order to produce all those apps, tools or even any facilitates for earthquake, a detail research on how other professional person have done it need to be done. Then, this will help for the collecting data and so on.

Buildings can be the easiest structure to collapse during an earthquake. Earthquake can be defined as any sudden shaking of the ground caused by the passage of seismic waves through earth's rocks. Earthquakes occur most often along geologic faults, narrow zones where rock masses move in relation to one another. So, it is clearly can make any structure easily collapsed. The steel bars in the actual structure buildings are always partially corroded with the loss of the reinforcement cross-sectional area and the steel-concrete interface bonding strength, which decrease the safety degree and seismic behaviour of the structures greatly. With the features of easiness of site handling, corrosion resistance and strength-to-weight ratio, carbon fibre reinforced plastic (CFRP) has been widely used to strengthen and retrofit the reinforced concrete structures, and the corresponding studies have been extensively conducted [46].

During an earthquake situation, it can risk to the environment and public, including potential impacts on ground and surface water, air quality. So, this must be preventing and well prepared during that time. It is important to note that seismicity does not just occur during production itself, but during the end stage, when produced water (wastewater), or flow back, is often disposed of in underground injection pits. Once the pressure is released, fracking fluids pumped deep underground, the produced or wastewater flows back to the surface, allowing liberated oil and gas to flow to wells. But the produced water is frequently disposed of by injecting the wastewater deep into underground formations.

Wastewater injection an industrial process similar to fracking and implemented to dispose of fluid wastes from hydraulic fracturing and other activities has been shown to be linked to seismic activity [27].

4.5 Analysis based on output produced of earthquake detector

Figure 6 below show the output produced of earthquake detector. There are four authors released the result about immediate output, nine authors released result about sensitivity detectors. Next, the highest is twelve authors are discussed result about prepared information after events followed by nine authors are discuss the results about level of magnitude and frequency of detectors. Then, three authors discuss the results about error detection and four authors which are two authors discuss the output about visual inspection and the rest are discuss the output about the acceleration and velocity response spectra.

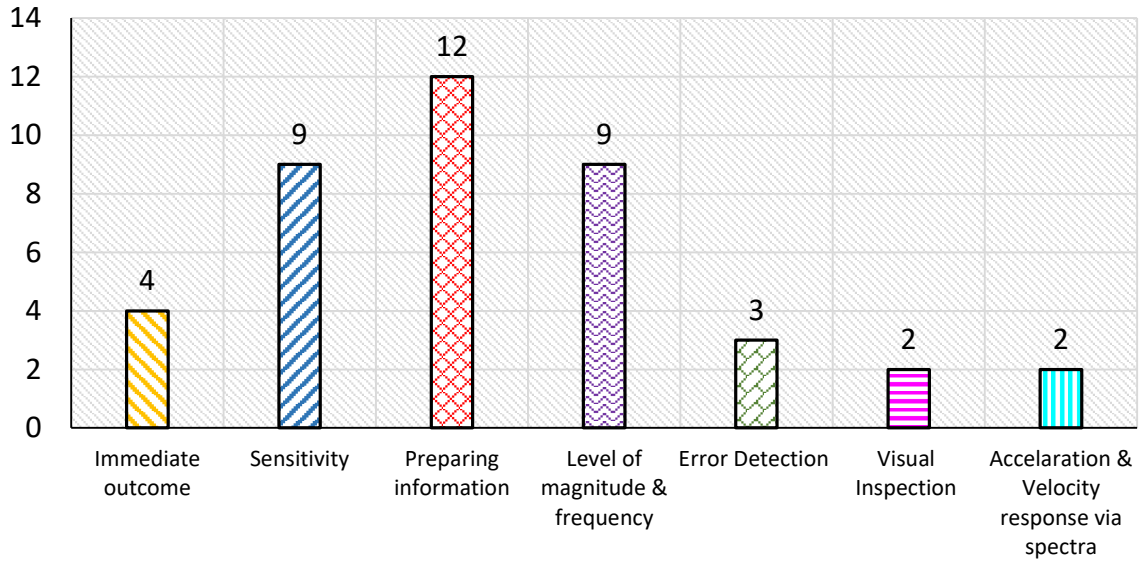

Figure 6: Output produced

There are four authors, studies that earthquake detectors have release immediate outcomes. According to Priyana et al.,2018 there were 3 seconds time delay given to adjusting the data to other sensors. If 2 other sensor data show the same P-wave value with the same scale, then the server will give early warning and activate the alarm. But if one of the sensors is different, then the server assumes nothing happened. Total time for sending the first vibration data from the sensor to the server and alarm activated is 0.01s + 0.01s + 0.01s + 3 s = 3.03 s.

Next, there are nine authors are produced good sensitivity of detector. Pathak et al.,2019 reported that detector have a motion tracking that increasing the sensor to detect seismic. Accelerometer senses the vibration whenever earthquake occur[9]. Sensing model have a sensor node to detect an event of earthquake in certain range [32].

In the other hand, there are twelve authors' states that results were prepared information such as data algorithms and waveforms. Provides a list of the steps to be carried out for earthquake prediction, including from how the analogue information has to be transferred by the accelerometer which is further converted into digital using microcontroller and then data is sent to the data centre through wireless medium [37]. Then Arduino triggers the buzzer and shows the status of alert and sends alert messages to the registered numbers in the device. The output of the accelerometer circuit should be more than the default value. Then the system should send a warning message on the registered phone. A message is directly sent to the user's phone alerting him/her via SMS. The microcontroller is connected to the smart phone using GSM [9].

Then, there are nine authors displays the data magnitude and frequency. Testing of MPU sensor with Arduino UNO on the circuit board and when it was successfully worked, the monitor was displayed the amplitude and magnitude in millimetres [34]. All the stress energy is not released at the time of the main shock. This causes numerous aftershocks with magnitude somewhat less than and around the epicenter of the main shock for almost all the earthquakes[5].

Another more, there are four authors in each output released which are two authors from visual inspection and two authors from acceleration or velocity response spectra. The X-axis represents the days relative to the earthquake day. The Y-axis represents the universal time coordinate. By visual inspection and without performing any special analysis, unusual TEC values are clearly seen around the earthquake day, especially between 1 to 5 days after the earthquake. In this study, geomagnetic and solar indices were used to distinguish seismic anomalies from the other anomalies related to the geomagnetic and solar activities [6].

5. Conclusion

There has an evolution of earthquake detectors in scientific terms to detect an earthquake and also introducing the new research method and collecting as much data as possible from past studies should be implemented so that more information related to the study is obtained based on the objectives about this study. All questions that has been created were provided with significant answers from this thesis studies. Also, each objective was provide a conclusion about it. First objective is reviewing the vary keywords used in research which is use of all keywords were represented the same meaning as earthquake and detector. Second objective is studying the different types of earthquakes detector that are appropriate which is there are different of earthquake types now days were produced with various function and shape.

Next, the third objective is reviewing the effectiveness of earthquake detectors and the effects of installation on humans which is the effects of earthquake have given a big impact of technological advances on environments and construction facilities. Lastly, the fourth objective is examination the output produced by the earthquake detectors through the created or existing detectors which is the different types of detector, will be produces the different output or result from device. There are two recommendations to these studies which are the devices will produce the location of the nearest earthquake protection center and earthquake detectors can detect heat from humans or animal within a range of distances.

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