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DETERMINATION OF TECTONIC DISTURBANCE USING ACCELEROMETERS FOR THE CHARACTERIZATION OF EARTHQUAKE AND REPORTING STRUCTURAL DAMAGE

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ABSTRACT

Seismic waves are the waves of energy that travels through the earth and are the result of an earth quake, explosions or a volcano that imparts low frequency acoustic energy. These seismic waves are heavily contaminated by the noise. This paper proposes a method of increased accuracy for the prediction and detection of tectonics. The system uses accelerometers to detect the slope change. The output data sections obtained from the accelerometers de -noised through the use of a time-frequency filter. Thus the noise which degrades the data sections is minimized.

I. INTRODUCTION

Earthquakes are one of the worst natural hazards causing widespread disaster and loss of human lives primarily due to collapse of structure or buildings. Earthquakes are classified as Tectonic, Volcanic and Plutonic depending on their type and place of origin. The earthquakes are mostly of tectonic origin. Tectonics earthquakes are that caused due to vibrations caused at the tectonic plates.

An accelerometer measures proper acceleration, which is the acceleration it experiences relative to freefall and is the acceleration felt by people and objects. Put another way, at any point in spacetime the equivalence principle guarantees the existence of a local inertial frame, and an accelerometer measures the acceleration relative to that frame. Such accelerations are popularly measured in terms of g-force.

An accelerometer at rest relative to the Earth's surface will indicate approximately 1 g *upwards*, because any point on the Earth's surface is accelerating upwards relative to the local inertial frame (the frame of a freely falling object near the surface). To obtain the acceleration due to motion with respect to the Earth, this "gravity offset" must be subtracted and corrections made for effects caused by the Earth's rotation relative to the inertial frame.

The reason for the appearance of a gravitational offset is Einstein's equivalence principle, which states that the effects of gravity on an object are indistinguishable from acceleration. When held fixed in a gravitational field by, for example, applying a ground reaction force or an equivalent upward thrust, the reference frame for an accelerometer (its own casing) accelerates upwards with respect to a free-falling reference frame. The effects of this acceleration are indistinguishable from any other acceleration experienced by the instrument, so that an accelerometer cannot detect the difference between sitting in a rocket on the launch pad, and being in the same rocket in deep space while it uses its engines to accelerate at 1 g. For similar reasons, an accelerometer will read *zero* during any type of free fall. This includes use in a coasting spaceship in deep space far from any mass, a spaceship orbiting the Earth, an airplane in a parabolic "zero-g" arc, or any free-fall in vacuum. Another example is free-fall at a sufficiently high altitude that atmospheric effects can be neglected.

However this does not include a (non-free) fall in which air resistance produces drag forces that reduce the acceleration, until constant terminal velocity is reached. At terminal velocity the accelerometer will indicate 1 g acceleration upwards. For the same reason a skydiver, upon reaching terminal velocity, does not feel as though he or she were in "free-fall", but rather experiences a feeling similar to being supported (at 1 g) on a "bed" of uprushing air.

Acceleration is quantified in the SI unit metres per second per second (m/s^2), in the cgs unit gal (Gal), or popularly in terms of g-force (*g*).

The movement of the accelerometer will cause the small mass to deflect proportionally to the rate of acceleration. Accelerometers can provide acceleration information in one or more axes. This becomes the major advantage of accelerometers over the sensors why because they give only relative

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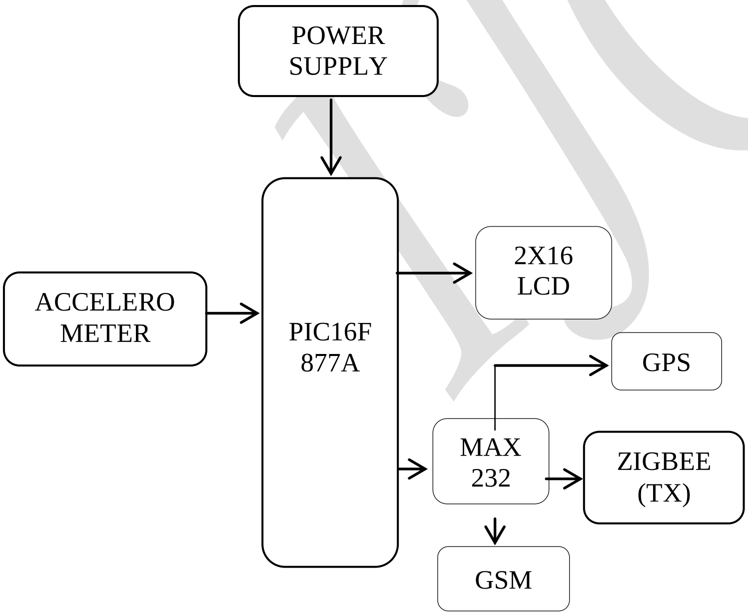
vibration measurements and also only in single axis. The seismic interference is the major cause for the contamination of the seismic signal and the paper will propose the method in order to attenuate such noise.

II.INVESTIGATION

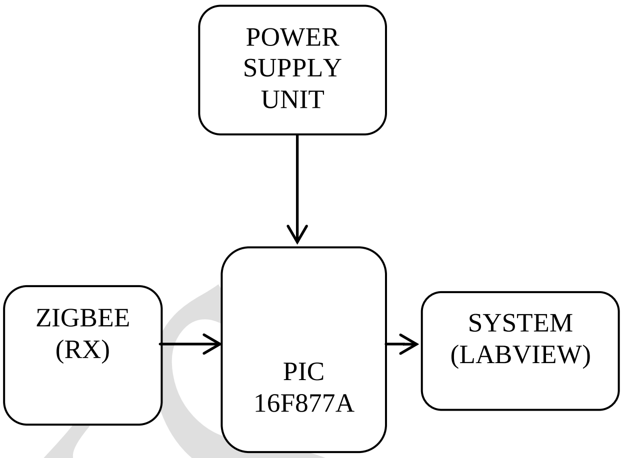
The development of earthquake detection systems are of much importance today. The most important opinion that this paper proposes is regarding the usage of accelerometers in this system. The two events that occur vigorously during an earthquake are the vibration and slope change of the region. This slope change is identified here. Because the vibrations may not be caused only because of the earthquake and also the vibration sensors that are widely used to detect an earth quake will react to all sorts of vibrations. In order to overcome this particular issue this we make use of accelerometers (MEMS) in order to detect the minute slope changes. The accelerometers are capable of detecting the slope changes in three dimensions namely X, Y, and Z.
In case of abnormality which corresponds to the earthquake detections, the information will be communicated to the multiple users of the system. The further section of the paper will deal with the modes of communication regarding the earthquake information.

III. SYSTEM DESIGN

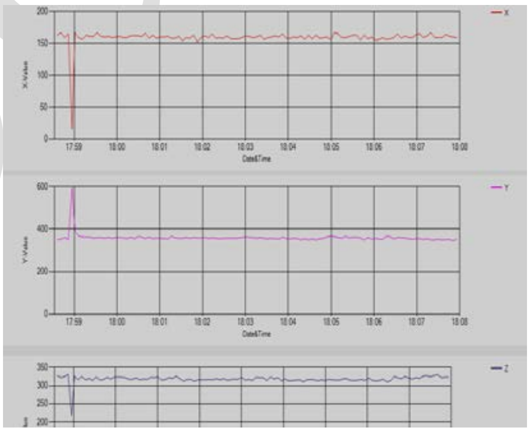
TRNSMITTER NODE:



RECEIVER NODE:



In this paper, a particular area is considered for the earthquake prediction. The P-waves are the fastest kind of seismic wave and they are felt by the tectonics initially. The accelerometer will detect the slope change caused by the P-waves in three dimension and w illgive the data's to the PIC16F877A microcontroller. The GPS is used to know the exact location of the slope change which in turn is the location of the earthquake occurrence. The information will be displayed in the LCD and also the users of the system can get the alert regarding the



abnormality (earthquake) in their mobile phones through the GSM module. Also the server updation will help the communication to be more faster to a large number of users. The use of LabVIEW will show the region that will be affected drastically by the earthquake and also the magnitude of it. So that an early alert for the earthquake is given to the users of the system. It is important to note that the alert will be given only at the time of abnormality.The detection system and the waves of seismic in 3D are shown below:

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IV. SIGNAL ANALYSIS AND ATTENUATION OF NOISE

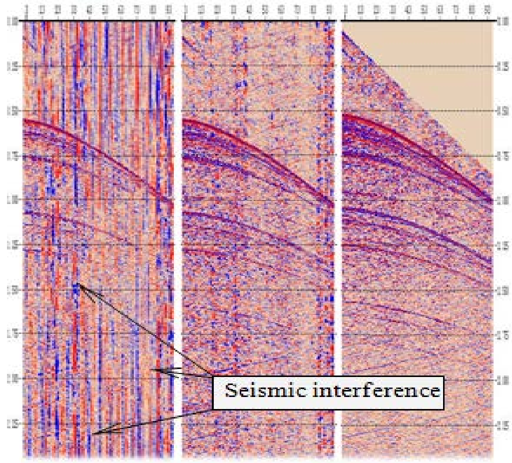

Figure 1

A common approach for removing SI is to take advantage of the different move-out behavior(dip and/or curvature) of SI compared to the reflection data. When transformed to the Radon or τ- *p* domain, SI will often map into an area that can be muted.

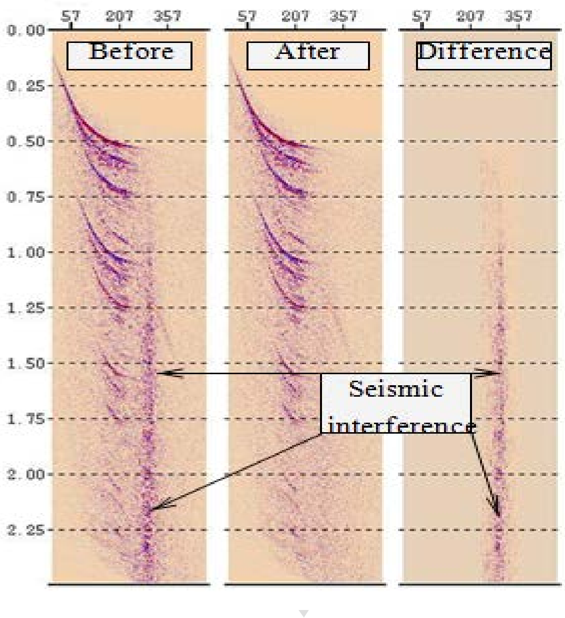

Figure 2: Part of shot gather before and after SI removal

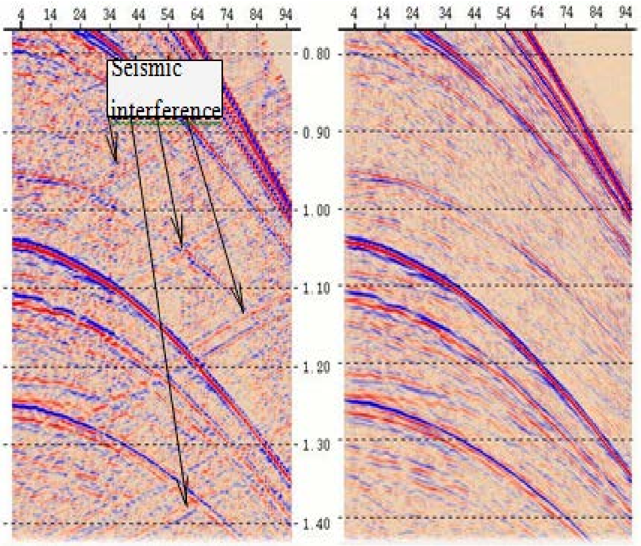

Figure 3: From left to right: Before, after and difference τ-

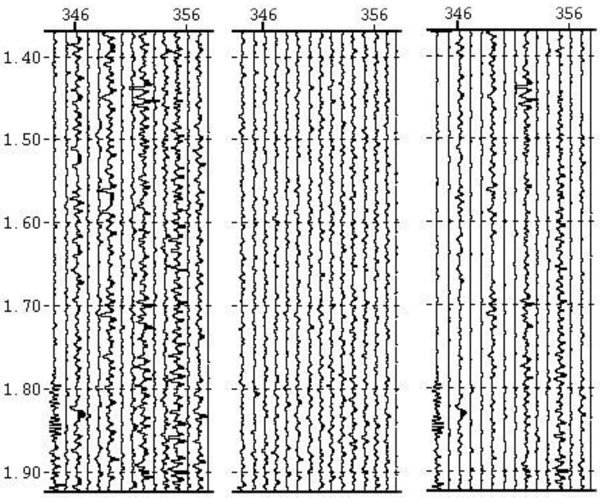

Figure.5 *p* shots from de-noising. Notice the vertical noise train caused by SI. It is removed by the de-noising.

The problem in this data was that the move-out of the SI was very close to the move-out of the seismic signal.Traditional muting was therefore not possible. Another approach used forSI attenuation is variants of f-x prediction filtering. In Gulunay et al. (2004) and Gulunay (2008) a number of such algorithms are discussed. The general idea is to attack SI by sorting it into a domain where it is random, compared to the reflection signal. In this new domain f-x prediction filtering is applied to suppress the SI, before the data is sorted back. This approach could also work for our data. However, the geology in the area where the data was acquired contains a number of dipping features. Such features are unfortunately

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also easily removed by prediction filters. It was therefore decided to try out another SI-removal approach.

The left image in Figure 3 shows the shot gather from the right image in Figure 1 transformed into the τ-*p* domain. The'blobby' area that stands out is caused by SI. The seismic vessel causing the SI has a shot point interval of around 10s, while the data presented here was acquired with a shot interval of 4s. When sorting τ- *p* gathers to the 'common' slowness domain, less than half of the traces were affected by SI.

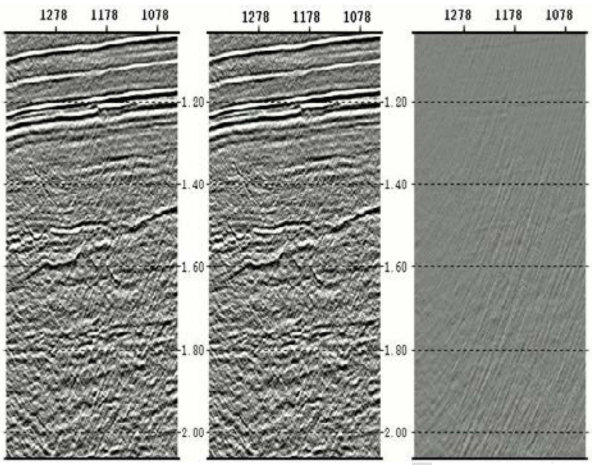

Figure 4: Part of a typical slowness gather from the dataset we have processed. From left to right: Before, After and Difference plot of time-frequency de-noising applied to the gather. Notice that only traces affected by SI are attenuated.

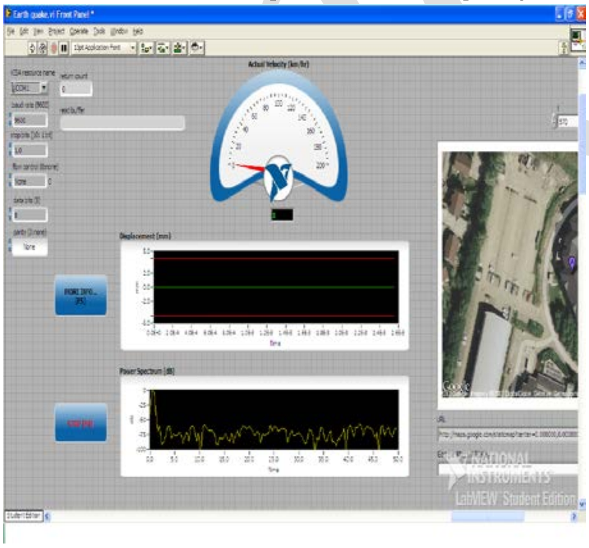

Figure 5: Part of stack between 1 and 2s after de-multiple and migration. Left: After de-noising (excluding SI-removal). Middle: After de-noising (including SI-removal). Right: Difference plot.

The left image in Figure 4 shows part of a typical slowness gather from this line. Notice that the traces that come from τ-*p* gathers affected by SI stand out. The challenge now is what to do with the noisy traces. The approach chosen here was to apply time-frequency de-noising to the data in this slowness domain. This effectively attenuated the amplitudes of 'noisy' traces down to the level of the traces unaffected by SI. The middle image in Figure 4 shows the result of this, while the right image is the difference plot. Notice that unlike prediction filtering, time-frequency de-noising is amplitude preserving. It does not affect the traces that are assumed to be good.

The results of the time-frequency SI removal approach on a shot gather can be seen in the right image in Figure 2. Notice how the SI has been attenuated in this image compared to the original data. The final test of our SI de-noising is to compare stacked data, after de-multiple and migration. Figure 5 shows two versions of a final stack from the processing. The left image shows the data after de-noising, but excluding the new SI-removal approach. The middle image show the same data, where the new SI-removal approach was applied, while the right image shows the difference. It is clear that the SI-removal has attenuated lots of energy that otherwise was smeared out by the migration, and appears as strongly dipping events all over the data. We observe that SI de-noising significantly improved the quality of the data.

IV. TECHNIQUES TO SPEED UP THE PROCESS

As described in this paper, we want to estimate location of events quickly as soon as possible because one objective of this research is to develop a real-time earthquake detection system. Therefore, we must decrease the time complexity of methods used for location estimation.

The time complexity of a normal particle filter is expressed as $O(N_pN_m)$ (N_p, number of particles; N_m, number of observations). The time complexity of the weighted particle filter is expressed as $O(N_pN_mN_s)$ (N_s, number of sensors to calculate the geographic distribu-tion). In the pre-examination, we set N_p = 2,000; N_m = 20; N_s = 6,421. It takes less than 1 s to estimate the location of an earthquake center using a normal particle filter. It takes less from 1 minute to 3 minute to estimate the location of an

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earthquake center by weighted particle filter. Therefore, we want to decrease N_s to calculate the location of earthquake centers more quickly. These attributes can be carried out using LabVIEW and GPS. They give the location of the event accurately and also its displacement and power spectrum. This improves the overall speed of the system. Seismic migration is the process by which seismic events are geometrically re-located in either space or time to the location the event occurred in the subsurface rather than the location that it was recorded at the surface, thereby creating a more accurate image of the subsurface. This process is necessary to overcome the limitations of geophysical methods imposed by areas of complex geology, such as: faults, salt bodies, folding, etc. Migration moves dipping reflectors to their true subsurface positions and collapses diffractions,[1] resulting in a migrated image that typically has an increased spatial resolution and resolves areas of complex geology much better than non-migrated images. A form of migration is one of the standard data processing techniques for reflection-based geophysical methods (seismic reflection and ground-penetrating radar). Thus the accurate effect of the seismic wave and its epicenter can be determined at a very fast rate which helps us to know which region of people have to be evacuated such that lives on earth and the resources could be saved.

V.CONCLUSIONS AND FURTHER RESEARCH

In general, this paper gives the solution for the prediction and detection of tectonics that causes the seismic waves to generate. De-noising of seismic data is important to obtain good quality seismic sections. The general idea is to transform each type of noise into a domain where it somehow stands out, and then to attenuate it. A good physical understanding of how the noise is created helps us in choosing suitable domains for the attenuation, and provides a guide for the choice of de-noising parameters. We have also introduced a new approach to attenuate SI. SI attenuation on slowness gathers using time-frequency de-noising is especially suited when the move-out of the SI (linear noise) is close to that of the actual data. This is also a case where other de-noising algorithms often have problems. The structural damage can be reported accurately with the help of seismic migration and de-noising. Further research will be on early detection of the earthquake.

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