Early Earthquake Detection

PURPOSE

The purpose of this project is to create a system to detect low-level seismic activity. This will be done using Arduino Uno. Arduino Uno have been used in many other scientific studies and experiments. Arduino Uno are able to detect different inputs from slight movement to the highest pressure push. The inspiration for the project is to see if it is possible to detect the slightest movement in the Earth's surface in order to warn thrill-seeking hikers.

INTRODUCTION

There are an estimated 500,000 detectable earthquakes each year on Earth. The majority of these earthquakes are found at the boundary of lithospheric plates. These earthquakes are typically measured by the force and duration of the quake. Another type of mass movement of rock is a rockslide. Rockslides occur when the foundation rock is unable to support the rock resting on top. Rocky shorelines are prone to erosion as waves routinely strike against the lower rocks weakening the foundation supporting the above rock.

Shorelines are classified as either rocky or sandy and provide many human activities including hiking, fishing, sightseeing, and playing in the sand. Shorelines often create a scenic view that pleases people who take time to venture out to these places. One example of a scenic, lakeside view is Michigan's Pictured Rocks National Lakeshore, situated on the southern edge of Lake Superior. According to mlive.com, Pictured Rocks National Lakeshore greeted 815,308 visitors in 2018, an all-time record amount of visitors. The increasing amount of visitors to Pictured Rocks creates a higher demand for the upkeep of the National Lakeshore as there are many tourists who enjoy walking or hiking on the many trails.

On August 12th, 2019 a piece of the Pictured Rocks National Lakeshore sheared off into Lake Superior. As this happened, a group of kayakers was, according to kayaker tour guide Van Ouellette-Ballas, about 15 meters (50ft) away from getting crushed. The shearing occurred next to a hiking trail that is a large attraction to tourists and causes concerns for future tourism in the area. These concerns are centered around the idea of future shearing of the National Lakeshore. If hikers or kayakers were to be close to the edge of the Pictured Rocks, they could receive serious injury or even death from either falling from the top or being crushed by the sandstone from above.

There are many events that could have occurred to create the shearing of Pictured Rocks. When hikers walk across the edge of the trail, they create movement in the ground beneath them. When this happens, the ground becomes more malleable and is more prone to falling. The ground that fell into Lake Superior was made of sandstone which is eroded easier than many other types of stones. Another way that the shearing could happen is from tectonic movement. With the slow-motion of tectonic plates, there is more movement on Earth's surface. When two tectonic plates collide, there could be shaking of structures on the Earth's surface creating events like the shearing of Pictured Rocks to earthquakes. One more possible way that the shearing could have happened is water erosion. After a long time of tides hitting up against the Pictured Rocks, like the whitecaps that were present during the week before the shearing, the rocks are able to shear with much more ease.

Seismic activity encompasses the types, frequency, and size of earthquakes that occur over a given time period. To prevent damage and human deaths, scientists try to predict seismic activity by using high tech equipment. However, the United States Geological Survey has stated that no scientist has ever predicted a major earthquake but calculations can be made to find the probability that an earthquake can occur in a given area within a given period of time. On October 17, 2019, the United States Geological Survey conducted the first-ever test of the ShakeAlert Early Earthquake Warning System. This warning system was produced to rapidly detect earthquakes in order to give people in areas around the epicenter an advanced warning of a tremor.

GOAL/HYPOTHESIS

This science fair project is broken into two phases. The goal of phase I is to code an Arduino Uno that is able to detect changes in acceleration. In phase II of the experiment, the reliability of the Arduino Uno-ADXL345 accelerometer detection system will be tested. If two Arduino Uno detection systems are simultaneously used to measure changes in acceleration, then there will not be a significant difference between the two systems.

RESULTS

PHASE I

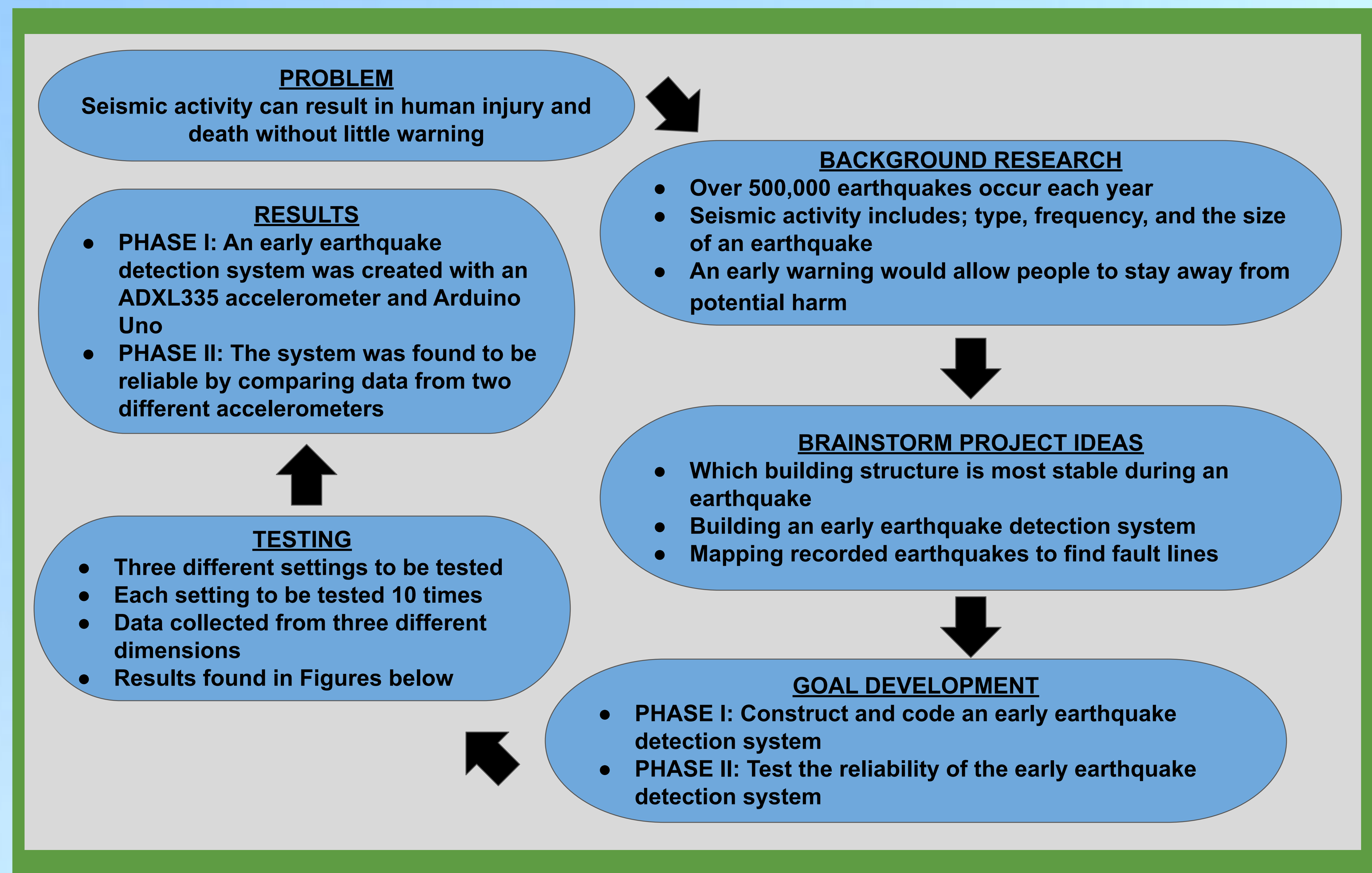

Figure 1: Engineering design process for the experiment.

PHASE II

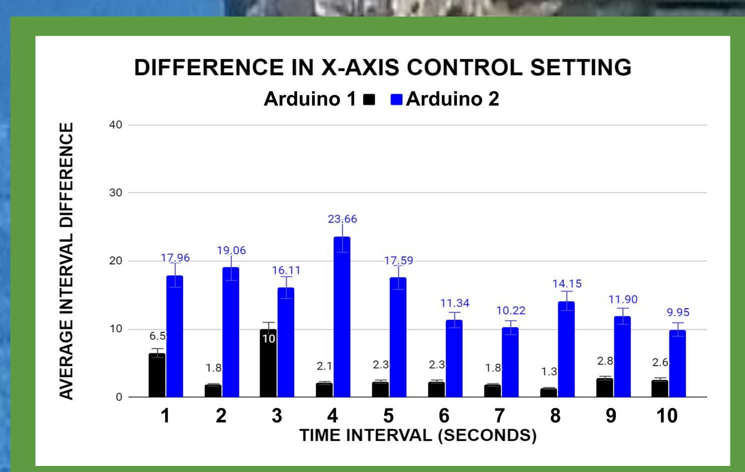

Figure 2. A comparison of average x-axis output (mean + standard error) between two accelerometers over a 10-second interval. No significant differences were found using a Paired t-Test (p<0.05).

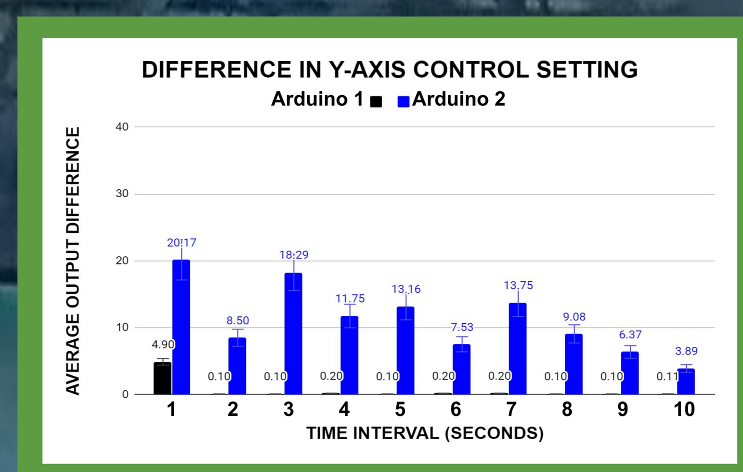

Figure 3. A comparison of average y-axis output (mean + standard error) between two accelerometers over a 10-second interval. No significant differences were found using a Paired t-Test (p<0.05).

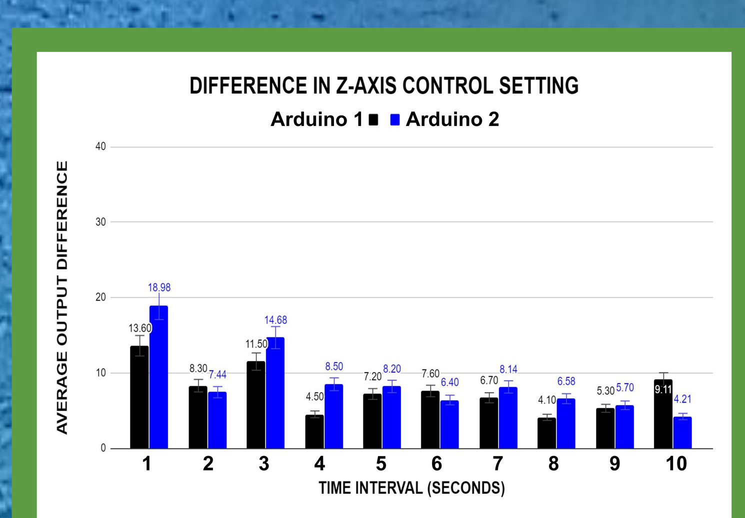

Figure 4. A comparison of average z-axis output (mean + standard error) between two accelerometers over a 10-second interval. No significant differences were found using a Paired t-Test (p<0.05).

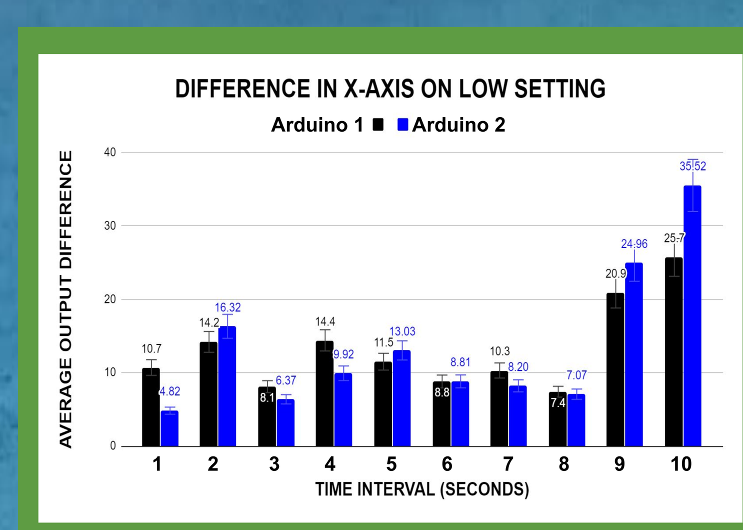

Figure 5. A comparison of average x-axis output (mean + standard error) between two accelerometers over a 10-second interval on low setting. No significant differences were found using a Paired t-Test (p<0.05).

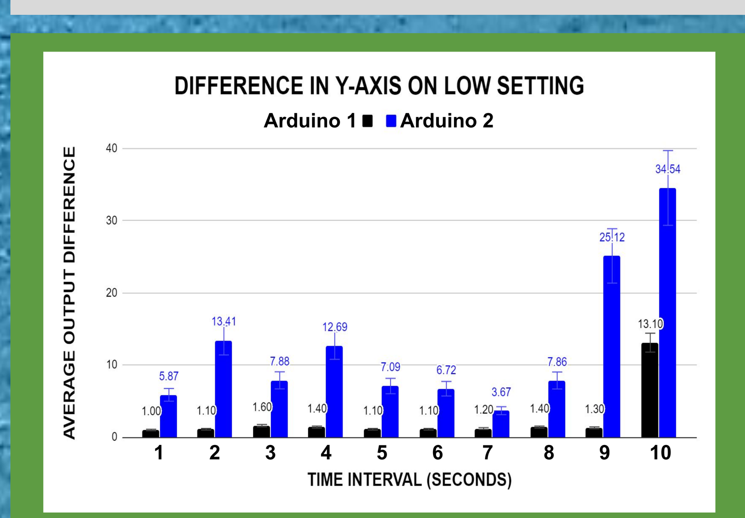

Figure 6. A comparison of average y-axis output (mean + standard error) between two accelerometers over a 10-second interval on low setting. No significant differences were found using a Paired t-Test (p<0.05).

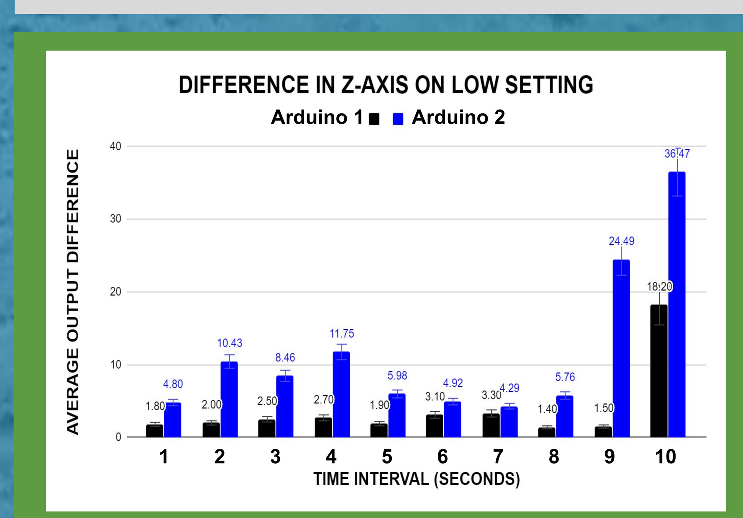

Figure 7. A comparison of average z-axis output (mean + standard error) between two accelerometers over a 10-second interval on low setting. No significant differences were found using a Paired t-Test (p<0.05).

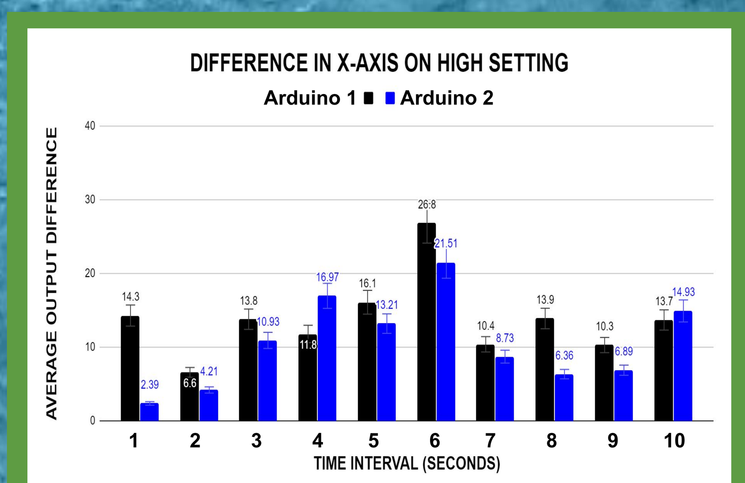

Figure 8. A comparison of average x-axis output (mean + standard error) between two accelerometers over a 10-second interval on high setting. No significant differences were found using a Paired t-Test (p<0.05).

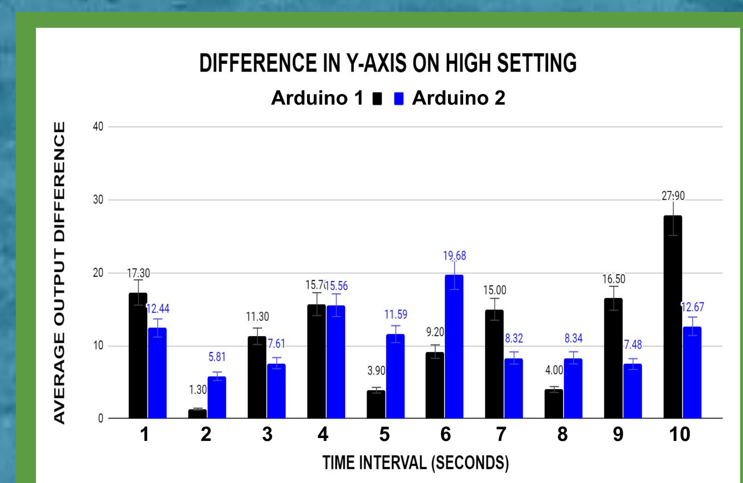

Figure 9. A comparison of average y-axis output (mean + standard error) between two accelerometers over a 10-second interval on high setting. No significant differences were found using a Paired t-Test (p<0.05).

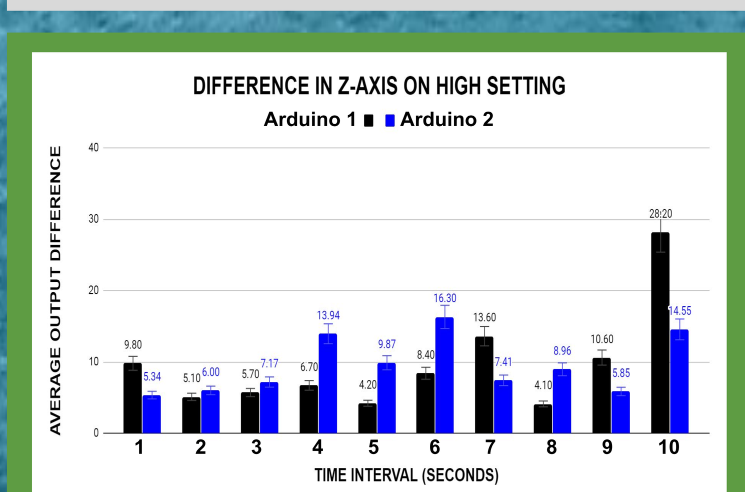

Figure 10. A comparison of average x-axis output (mean + standard error) between two accelerometers over a 10-second interval on high setting. No significant differences were found using a Paired t-Test (p<0.05).

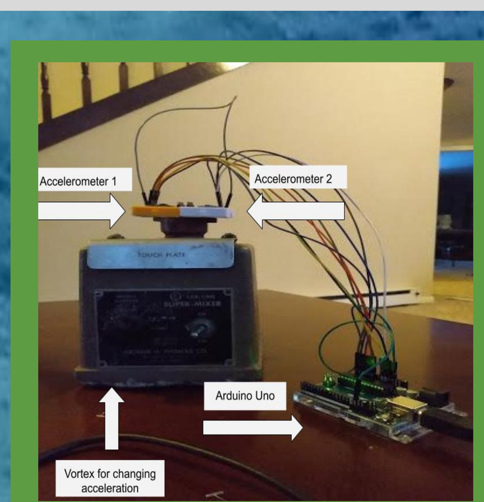

Figure 11. Testing apparatus used for testing the reliability of the Arduino Uno-ADXL345 accelerometer system.

PROCEDURE

PHASE I. Coding the Detection System

1. Obtain an Arduino Uno, an ADXL335 accelerometer, and a printer cable
2. Download the Arduino IDE Software
3. Plug Arduino Uno into USB port of a computer
4. Write Code for ADXL335 accelerometer (Figure 1)
5. Connect ADXL335 accelerometer to Breadboard and Arduino Uno by jumper wires
6. Connect one jumper wire from the 5V connection point on the Arduino Uno to the Vin connection point on the ADXL335 accelerometer
7. Connect one jumper wire from the GND connection point on the Arduino Uno to the GND connection point on the ADXL335 accelerometer
8. Connect one jumper wire from the AREF connection point on the Arduino Uno to the 3.3V connection point on the Arduino Uno
9. Connect one jumper wire from the A0 connection point on the Arduino Uno to the Xout on the ADXL335 accelerometer
10. Connect one jumper wire from the A1 connection point on the Arduino Uno to the Yout on the ADXL335 accelerometer
11. Connect one jumper wire from the A2 connection point on the Arduino Uno to the Zout on the ADXL335 accelerometer
12. Upload the code from the Arduino IDE Software onto the Arduino Uno

PHASE II. Measuring the Reliability of the Detection System

1. Obtain another Arduino Uno, another ADXL335 accelerometer, a vortex, and another printer cable
2. Repeat steps 5-12 from Part I
3. Place both breadboards onto the vortex securely
4. Turn the dial to setting 0 on the vortex
5. Flip the power switch on
6. Monitor the variables for 10 seconds with the Arduino IDE Software, then record
7. Repeat steps 4-6 for another 9 trials for a total of 10 trials
8. Flip the power switch off
9. Turn the dial to setting 1 on the vortex
10. Flip the power switch on
11. Monitor the variables for 10 seconds with the Arduino IDE Software, then record
12. Repeat steps 9-11 for another 9 trials for a total of 10 trials
13. Flip the power switch off
14. Turn the dial to setting 2 on the vortex
15. Flip the power switch on
16. Monitor the variables for 10 seconds with the Arduino IDE Software, then record
17. Repeat steps 14-16 for another 9 trials for a total of 10 trials
18. Flip the power switch off

CONCLUSION

This experiment was conducted to see if a reliable acceleration detection system could be constructed using an Arduino Uno and an ADXL335 accelerometer. In phase I of this experiment, an acceleration detection system was constructed and outputs were able to be collected from X, Y and Z data points. In phase II of this experiment, two acceleration detection systems were compared to find the reliability of the created system. The hypothesis that there will not be a significant difference between the two systems was supported by comparing the X, Y and Z outputs at rest, at a low setting, and at a high setting.

Figures created by Jett Miller

Pictures taken by Jett Miller