LABORATORY EARTHQUAKE ANALYSIS

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[2] *Add Los Alamos, USGS and or Kaggle here?*

Abstract. The technologies used in the laboratory to simulate and collect earthquake data have improved over time. In this study we predict the remaining time before *laboratory* earthquakes occur more accurately(hopefully) than a 2017 Los Alamos National Laboratory study[1]. We analyze data patterns using geophysical subject matter expertise, statistical methods and the latest technology available. We design a statistical algorithm to model the patterns and make a prediction. We compare predicted versus actual time remaining to determine our accuracy. Our results prove that our model predicted impending laboratory earthquakes with *TBD accuracy, null hypothesis, statistical results with pvalue or confidence interval and relevent scores.* The evidence of this experiment suggests *depends on final results*

1 INTRODUCTION

In August 2017 LANL conducted an experiment[1] which predicted the remaining time until *laboratory* earthquakes occur with 90% accuracy. Subsequently there have been improvements in the technology used to collect and measure laboratory seismic signal data*(additional facts to be added?)*. There have also been improvements in computing power including the software and hardware required for GPU computing. LANL is now providing data collected by more advanced technology to the public via a competition.

> "For this challenge we selected an experiment that exhibits a very aperiodic and more realistic behavior compared to the data we studied in our early work, with earthquakes occurring very irregularly.[2]"

The results of this experiment are potentially applicable to the field of real world earthquakes. Other potential applications include avalanche prediction or failure of machine parts.

> "If this challenge is solved and the physics are ultimately shown to scale from the laboratory to the field, researchers will have the potential to improve earthquake hazard assessments that could save lives and billions of dollars in infrastructure.[2]"

Given seismic signal data with considerably more a-periodic laboratory earthquake failures and modern computing hardware; we improve on the Los Alamos study[1] to determine when laboratory earthquakes will occur.

2 TUTORIAL MATERIAL

We hear about earthquakes mostly via news media when there is a large seismic event which is noticeable, causes death and destruction. These are stick–slip events that radiate seismic energy along the seams (fault lines) between tectonic plates. In this study we refer to these as *Regular Earthquakes*

Another type of earthquake we refer to in this study is a *slow slip earthquake* (SSE). SSE's are fault behaviors that occur slowly enough to make them undetectable without instrumentation. They do not shake the ground and cause widespread destruction like regular earthquakes do. They occur near the boundaries of large earthquake rupture zones[3].

There is evidence to suggest that there is a relationship between slow slip earthquakes and more noticeable regular earthquakes[4].

This study analyzes the relationship between slow slip and regular earthquakes. We use this relationship information to predict regular laboratory earthquakes.

3 DATA

Data is provided by LANL via a Kaggle competition[2]. Is consists of 629,143,480 seismic signal measurements and a record of the time remaining before the next laboratory earthquake occurred. We use these observations to train and test a model.

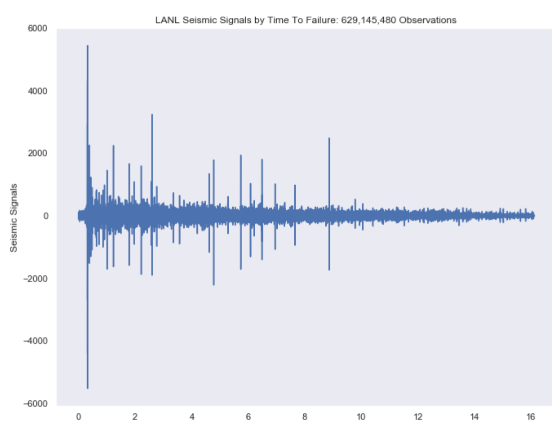

Fig. 1. The magnitude of each seismic signal and its related time remaining before the next laboratory earthquake.

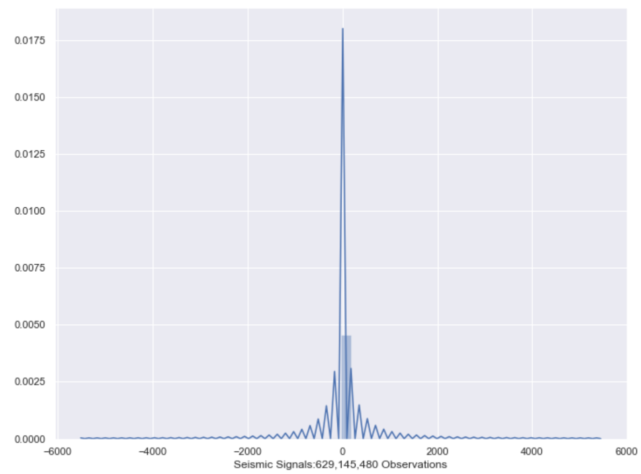

Fig. 2. The distribution of seismic signal measurements by LANL

3.1 Seismic Signal Data

The only feature we have is the seismic signal (acoustic data) which has integer values in a limited range.

4 METHODS AND EXPERIMENTS

4.1 Algorithms

Linear Regression

- Recursive Neural Network (RNN)
- Random Forest
- Autoregressive Moving Average (ARMA)

5 RESULTS

Results of experiments Use tables and graphs Use tables and graphs Use tables and graphs Don't forget explanations

6 ANALYSIS

Analyze results. These are NOT conclusions.

7 ETHICS

If people believe us and we are wrong; bad things can happen. If people believe us and we are right; good and bad things can happen.

8 CONCLUSION

Draw conclusionS (plural, more than one conclusion- minimum of 3) This is NOT a summary section.

References

1. Bertrand Rouet-Leduc, Claudia Hulbert, N.L.K.B.C.J.H.P.A.J.: Machine learning predicts laboratory earthquakes
2. Kaggle, R.: Lanl earthquake prediction
3. Ikari Matt J, Marone Chris, S.D.M.K.A.J.: Slip weakening as a mechanism for slow earthquakes
4. Baptiste Rousset, Roland Burgmann, M.C.: Slow slip events in the roots of the san andreas fault