Earthquake prediction: A comparison between MLP and SVM

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1 BACKGROUND

- **Multi-Layer Perceptron (MLP) and Support Vector Machine (SVM) are machine learning models used for binary classification tasks.**
- **Earthquakes are sudden and patterns varry per location.**
- **Dataset is seismic events in New Zealand resourced from GeoNet.gov.nz [1].**
- **Past earthquake forcasts have used: statistcal modeling, geophysical traits and earthquake precursors.**

2 QUESTION

How does a MLP compare with SVM when operating on individual time series?

- Using 30 seconds of seismic waveform, determine the ocurrance of an earthquake.
- Classification done per station.
- Determine the optimal performence for MLP and SVM.

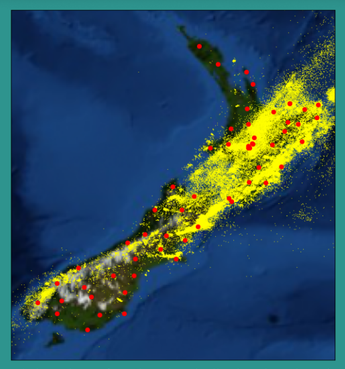

Figure 1: Locations of earthquakes (yellow) and stations (red).

3 METHODS

Data collection

- Dataset comprised of earthquakes events from 2016 to 2020 and 30 seconds of seismic waveforms recorded by from 58 stations.
- Earthquake seismic waveforms are divided to the closest station with a distance up to 270km.
- Normal seismic waveforms were chosen that were furthest from earthquakes.
- 50% earhtquake waveforms, 50% normal wavforms.

Data preprocessing

- Filter out earthquakes outside of magnitude range 1-3 and depth > 200km.

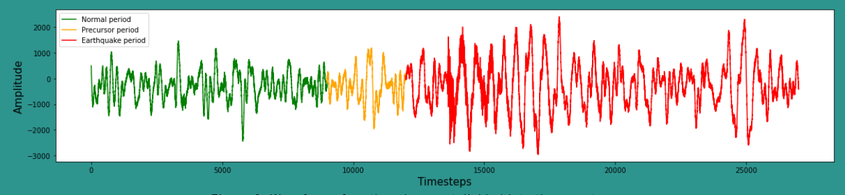

Figure 2: Waveform of earthquake event divided into three parts.

- Trim data; stations with incomplete or too few data points removed.
- Downsample the 30 second seismic waveforms from 100HZ to 50HZ.
- Normalize the amplitude of the seismic waveforms.

Labelling

- For each station, seismic activity recorded 30 seconds prior to an earthquake event is labeled as 1, otherwise 0.

Evaluation

70% training, 20% testing, 10% validation.
Accuracy, precision, recall and F1-score.

SVM

Creates a hyperplane to seperate the classes and often tries to maximize the distance from the hyperplane to the nearest data point of any class.

Kernel functions:

- Linear
- Polynomial
- Radial Basis Function (RBF)

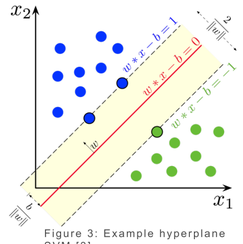

Figure 3: Example hyperplane SVM [3].

MLP

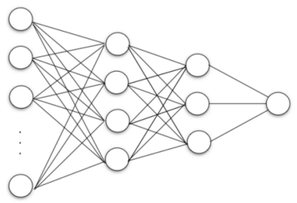

Figure 4: Structure of MLP [3].

Stacked hidden layers and non-linear activation functions allowa to distinguish classes that are not linearly-seperable. Has 3 types of layers: Input, hidden, output layers.

Hyperparameters:
Optimizer, dropout, batch normalization, regularization, number and size of hidden layers and number of epochs.

4 RESULTS

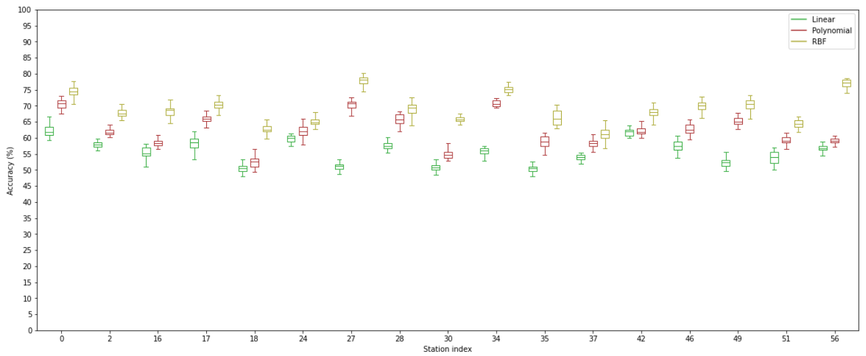

Figure 3: Accuracy SVM in each station using different kernel functions.

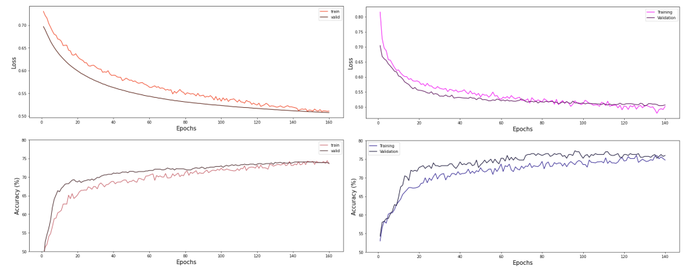

Figure 5: MLP Training and validation losses and accuracies for station indices 0 (left) and 34 (right).

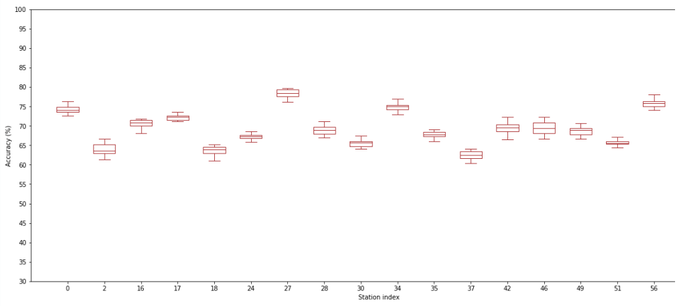

Figure 6: MLP accuracy per station.

5 DISCUSSION

- Inherent classification error.
- Sensor might detect earthquakes outside of the bounding box.
- Sample size needs to support the number of features.
- Noise brought on by enviornmental factors.
- Criteria for earthquake too similar to normal activity.

6 CONCLUSION

- RBF kernel function highest accuracy for SVM.
- The most accurate model is station dependent.

[1] *FDSN webservice for New Zealand*. https://www.geonet.org.nz/data/tools/FDSN. Accessed: 06-12-2021.
[2] Larhmam (2018). *Maximum-margin hyperplane and margins for an SVM trained with samples from two classes. Samples on the margin are called the support vectors.* [PNG]. Wikipedia. https://en.wikipedia.org/wiki/Support-vector_machine#/media/File:SVM_margin.png
[3] Paola Benedetti (2020). *"representation of a multi-layer perceptron network"* [PNG]. Medium. https://miro.medium.com/max/700/1*v2B34-GRYvmc2qFUKPoZZQ.png