Short-Term Earthquake Prediction with Deep Neural Networks

Finding the optimal time prior to earthquake strikes to use in predictions

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Research Project CSE3000

Research method step by step

Description

Trying to predict high magnitude earthquakes

- Earthquake prediction can potentially save lots of harm

Implement a deep learning model

- Binary classifier
- Long Short Term Memory model [1]

FDSN New Zealand earthquake dataset [2]

- 6000 samples, 50% 'flat' events and 50% earthquake events, all shuffled
- 38 Measurements stations

Preprocessing data [3]

- Sanitise
- Downsample
- Normalisation

Consider trade-offs

- Length of recordings equals 60 seconds

Find the optimal time prior to earthquake strikes

Difficulties

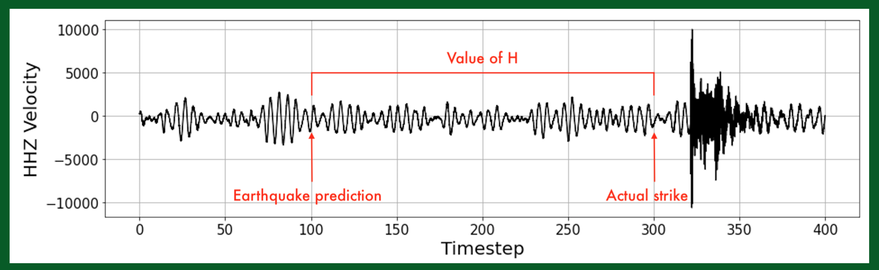
Earthquakes are very nonlinear and random

Requires a lot of data to train

Raw data needs to be processed

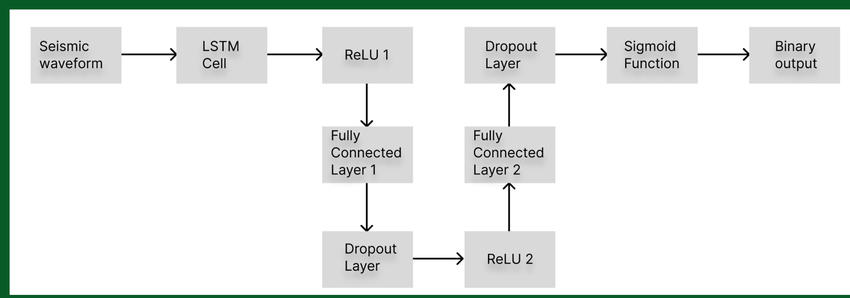
Trade-offs arise

Data example



Seismic waveform recording with an earthquake prediction at time step 100, the earthquake strike at time step 300, and an H-value of 200 seconds

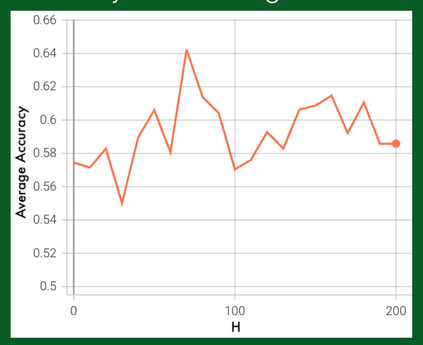
The LSTM Model



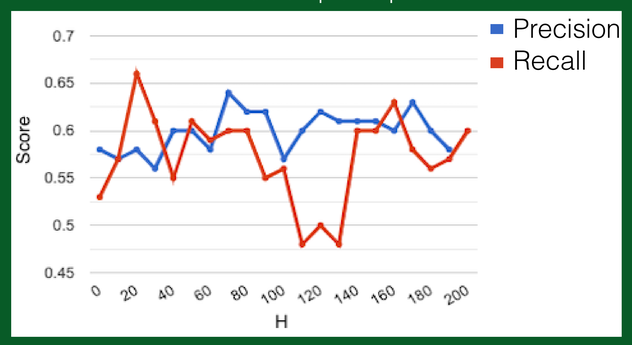
- Binary Cross-Entropy loss function
- 100 epochs
- Batch sizes of 50
- Learning Rate equals 0.001

Results

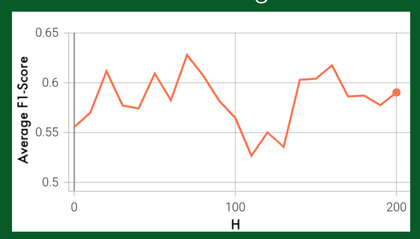
Accuracy of 10 averaged iterations



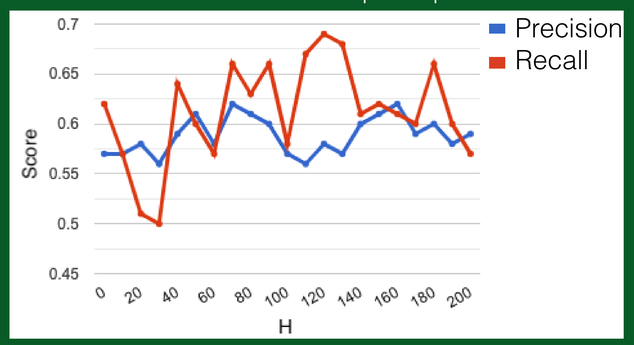
Precision and recall earthquake predictions



F1-Score of 10 averaged iterations



Precision and recall no-earthquake predictions



Discussion

- Unexpected patterns within dataset
- Different forms of data within dataset
- Cause of high performance at H = 70 due to reduce of false positives

Conclusion

- H negatively influences performance when close to 0
- Performance peak at H = 70
- Performance stabilises for H values of 100 and above

Future work

- Improve performance of the model
- Investigate why the model performs differently on various subsets of dataset

Reference list

1. Xiangyu Du. "Short-term Earthquake Prediction via Recurrent Neural Network Models". MA thesis. x.du-1@student.tudelft.nl: Delft University of Technology, Jan. 2022
2. GeoNet. FDSN webservice. url: https://www.geonet.org.nz/data/tools/FDSN (visited on 04/19/2022)
3. G. Mazzola. "Graph-Time Convolutional Neural Network". PhD thesis. TU Delft, July 2020, pp. 38, 61–77.