How long before strike can we predict earthquakes with an LSTM neural network?

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1. Introduction

- Predicting earthquakes is difficult
- Precursor-based prediction
  - Uses seismic data preceding earthquakes
- Research suggests NN's can be useful
- Where is the useful information in the data?
  - ➢ Investigate how long before strike we can predict earthquake

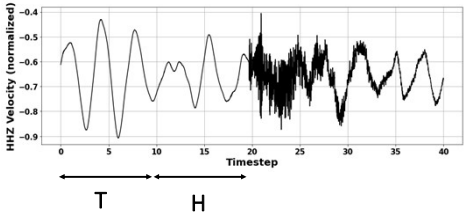
2. Research question

"How many seconds before strike can we accurately predict low-magnitude earthquakes?"

3. Methodology

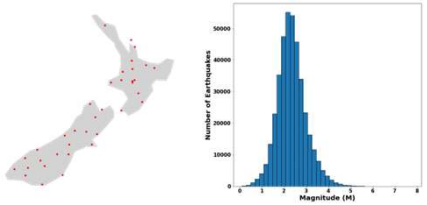
3.1 Problem modelling

Given the seismic wave recordings of N stations during T seconds, does an earthquake happen after H seconds?



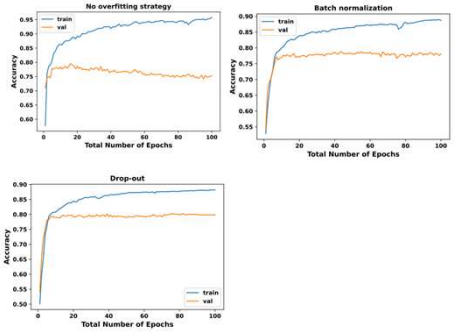
3.2 Data

- Dataset from FDSN, earthquakes in New-Zealand from 2000 to 2019
- Depth <5km, magnitude 1-2.5
  - ➢ 5674 earthquakes
- Seismic waves preceding these → 1
- Seismic waves of 'normal' behavior → 0
  - Was retrieved from times in between 2 earthquakes, minimum 71 minutes before an earthquake



3.3 Model

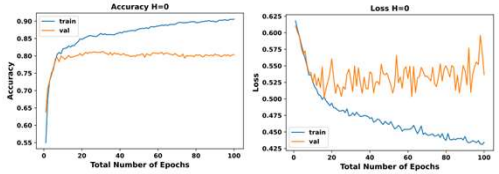
- LSTM
  - Ideal for time-series
  - Proposed in literature
- Strategies against oversoverfitting:
  - Drop-out
  - Batch normalization

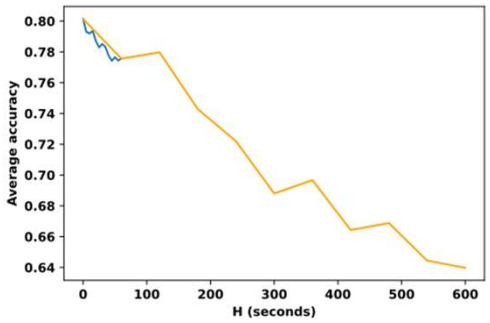


4. Experiment

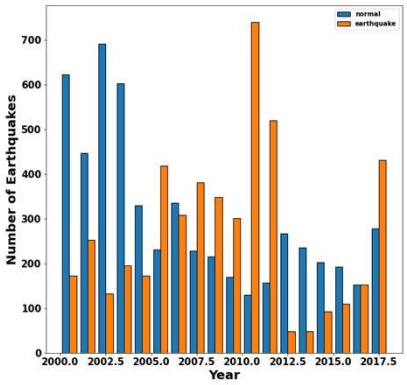
- N = 36 stations, T = 30 seconds
- H varies
  - From 0 to 60 seconds
  - From 0 to 600 seconds
- One LSTM layer, hidden size 2, learning rate 0.001, downsampled at 25 Hz
- Ran for 100 epochs, 5 times per H then averaged
- Training/test/validation set : 60/20/20 %

5. Results





- Accuracy indeed diminishes when H gets higher
- 0.801 for H=0, 0.639 for H=600
- Could mean up to 15 minutes can be accurate
  - ➢ Tested H=900; acc = 0.573
  - ➢ But H=3600 → acc = 0.554
  - ➢ Indicates bias, possibly because of year distribution difference (see figure below)



6. Conclusion

- Seismic data preceding an earthquake contains precursor signals in the short-term:
  - 10 to 15 minutes before strike contains sensitive data
- LSTM can be a good option