Using a mixed CNN-RNN for earthquake prediction

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1 Background

- An earthquake is a sudden shake of the earth surface realizing energy and thereby creating seismic waves
- Earthquakes could do great harm to the environment and people's daily lives
- Predicting earthquakes with data of seismic waves measured by stations could avoid or reduce damage
- Traditional methods are not successful yet for predicting the occurrence of an earthquake moments before it strikes
- Therefore, there is a growing interest in using deep learning techniques for this task
- A convolutional neural network (CNN) mixed with a recurrent neural network (RNN) has been a prior success [1]

2 Research question

- "How do multichannel CNNs mixed with RNN methods compare with an individual model for earthquake prediction?"
- Determine how to preprocess data
- Find optimal architecture for mixed CNN-RNN
- Evaluate the performance of predicting occurrences of earthquakes in the short term

3 Methodology

Dataset:

- Data from 58 stations in New Zealand measuring seismic waves [2]
- ~45000 earthquakes in our dataset after filtering, and balanced with normal seismic behavior
- Each sample is 30 seconds, downsampled to 25Hz
- Data presented as a matrix with on one dimension the stations and the other the time steps

Experimentation:

- 70% training, 20% validation and 10% test set
- Hyperparameters and architecture adjusted by balancing overfitting and training rate; validation set not used because of no correlation to changes
- Measures used to prevent overfitting: regularization, dropout, and batch normalization
- Compare performance measures to the individual RNN model researched by [3]

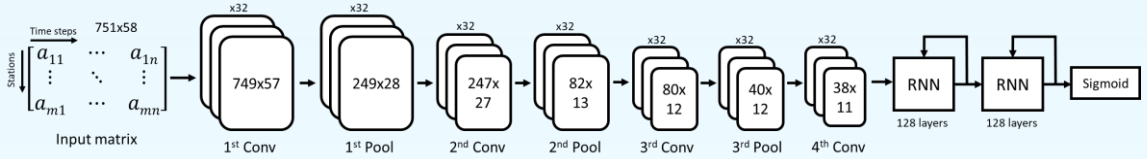

Figure 1: Architecture of our mixed CNN-RNN

4 Results

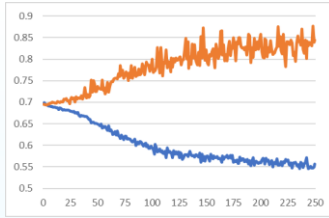

Figure 2: cross entropy losses of train set (blue) and validation set (orange), against the number of epochs during training of CNN-RNN

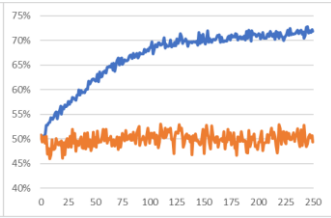

Figure 3: accuracies of train set (blue) and validation set (orange) in percentage point against the number of epochs during training of CNN-RNN

- Accuracy, specificity, and sensitivity of mixed CNN-RNN are ~0.50
- Figures 2 and 3 indicate no generalization but do indicate overfitting
- Overfitting measures did not help to combat overfitting and generalize patterns
- More overfitting measures eventually makes the model not adjust at all during the training phase
- However, the individual RNN model seems to show slightly positive results compared to mixed CNN-RNN

5 Conclusion

- Mixed CNN-RNN shows equal performance to guessing for predicting the occurrence of an earthquake in the short term
- Therefore, the mixed CNN-RNN is not suitable for earthquake prediction, and so not better than the individual RNN model
- Predicting occurrences of earthquakes remains a very hard problem, even for the newest techniques

6 Limitations

- Only seismic data was used, not other measurements such as temperature
- The individual RNN model includes a location bias in the preprocessing of earthquakes, which could influence its performance for comparisons

References

[1] Daoud, H., & Bayoumi, M. A. (2019). Efficient epileptic seizure prediction based on deep learning. *IEEE transactions on biomedical circuits and systems, 13*(5), 804-813.
[2] FDSN web services for New Zealand. (n.d.). Retrieved November 14, 2021, from https://www.geonet.org.nz/data/tools/FDSN.
[3] Du, X. (2022). *Evaluation Between Time Series Models, vanilla RNN, LSTM, Bi-LSTM on Earthquake Prediction.* TU Delft.