Deep Learning Phase Picking of Large-N Experiments

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EXTENDED ABSTRACT

A. Introduction

The popularization of the use large-N arrays of seismometers has resulted in a significant increase of the size of the datasets recorded during these experiments. Therefore, new challenges have arisen on how to process all these data efficiently, and in an automated fashion. This is particularly true in the case of induced seismicity monitoring, where often a large number of number of events are recorded at high frequency sampling rates.

Several methods of automatic picking have been developed during recent years, from triggering algorithms (e.g. STA/LTA) to higher order statistics or waveform similarity. Latest development in computational power and the popularization of GPUs have made possible to apply machine learning methods to several problems, from arrival picking and phase detection to earthquake location.

B. Materials and Methods

We have developed a deep neural network to detect the arrivals of seismic body waves, using an architecture based on convolutional layers. This type of models are widely used in computer vision applications, which is the most similar case to the phase picking by an operator. The network was trained using the data of the Southern California Seismic Network, consisting in 4.8 Million seismograms labelled as P-waves, S-waves and pre-event noise. The data was divided into Training data (70%), Validation data (10%) and Test data (20%).

C. Results

This network is able to differentiate P and S waves from background noise with a precision of 98.3 %. The results obtained over the Test Data are shown in Table 1.

TABLE I
RESULTS OVER TEST DATA

	P-wave	**S-wave**	**Noise**
True positives	32.72 %	32.79 %	32.77 %
True negatives	66.13 %	66.13 %	66.01 %
False positives	0.56 %	0.51 %	0.66 %
False negatives	0.59 %	0.57 %	0.56 %

D. Conclusions

We have applied this neural network to other large-N experiments in other regions (Europe and Asia) and found that the network localizes the events with a precision comparable or superior to an human operator, even in the case of low signal-noise ratio and superposition of earthquakes. Also, the network is able to correctly identify non-seismic signals as noise, even if their amplitude is greater than the seismic events present.

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References

[1] S. Chevrot and M. Sylvander, "Maupasacq" International Federation of Digital Seismograph Networks. Dataset/Seismic Network, 2017.

[2] Z. E. Ross, M. Meier, E. Hauksson, and T. H. Heaton, "Generalized Seismic Phase Detection with Deep Learning", Bulletin of the Seismological Society of America, Vol 108, No. 5A, Pp. 2894–2901, Sept. 2018.

[3] V. Salinas, A. Ugalde, A. Kamayestani, M. Jokar, M. M. Gharibvand, A. Villaseñor, and G. Heidari, "Designing and testing a network of passive seismic surveying and monitoring in Dehdasht (South Western Iran)", Geophysical Prospecting, Feb. 2019

[4] SCEDC, Southern California Earthquake Data Center, California Institute of Technology. Dataset, 2013.

Author biography

Luis Fernandez-Prieto was born in Madrid, Spain, in 1985. He received the degree in physics from the Universidad Complutense de Madrid, Spain, in 2015, and the master's degree in geophysics from the Universidad Complutense de Madrid, Spain, in 2018.
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