2024 SCEC Internships: Evaluation of Distributed Acoustic Sensing Phase Pick Quality and Performance for Operational Monitoring on Large Scale Earthquakes

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Abstract

This study aims to explore and assess how well DAS performs in detecting large-scale earthquakes compared to traditional manual phase picking. We utilized the pre-trained PhaseNet model to generate noisy labels of P/S arrivals in DAS data and applied the Gaussian mixture model phase association (GaMMA) method to refine these noisy labels and build training datasets. Subsequently, we developed PhaseNet-DAS, a deep learning model designed to process 2D spatio-temporal DAS data, achieving accurate phase picking and efficient earthquake detection. Data parsing and organization were conducted using Python, and our analysis included generating graphs to illustrate disparities between DAS picks and manual picks on the same seismometer station.

Introduction

Applying DAS to routine earthquake monitoring tasks remains challenging due to the lack of effective algorithms for detecting earthquakes and picking phase arrivals, coupled with the high data volume generated by thousands of channel.

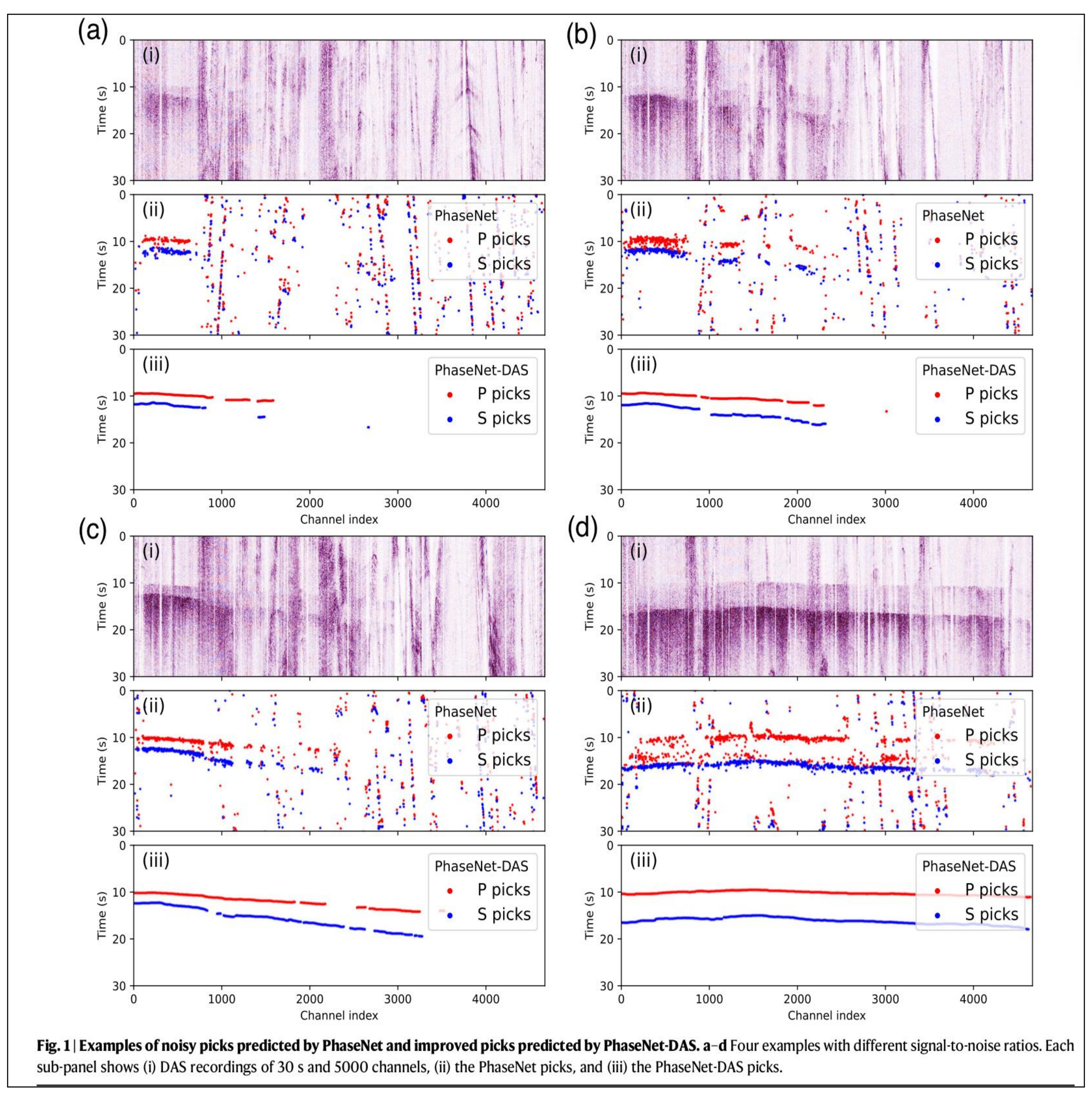

Figure 1: Taken from the primary research that was used to guide this research into understanding how well PhaseNet-DAS performs

Channels Commonly Picked On

These commonly picked on channels are significant to this research because it allows further investigation into what kind of seismic data the channel is picking up on since it could be valuable earthquake data or just noise. Investigation into this will reveal what improvements are necessary for the model

station_id	
0	1
250	16
500	176
750	108
1000	88
1250	76
1500	120
1750	55
2000	74
2250	16
2500	31
2750	22
3000	14
3250	3
3500	2
3750	4
4000	4

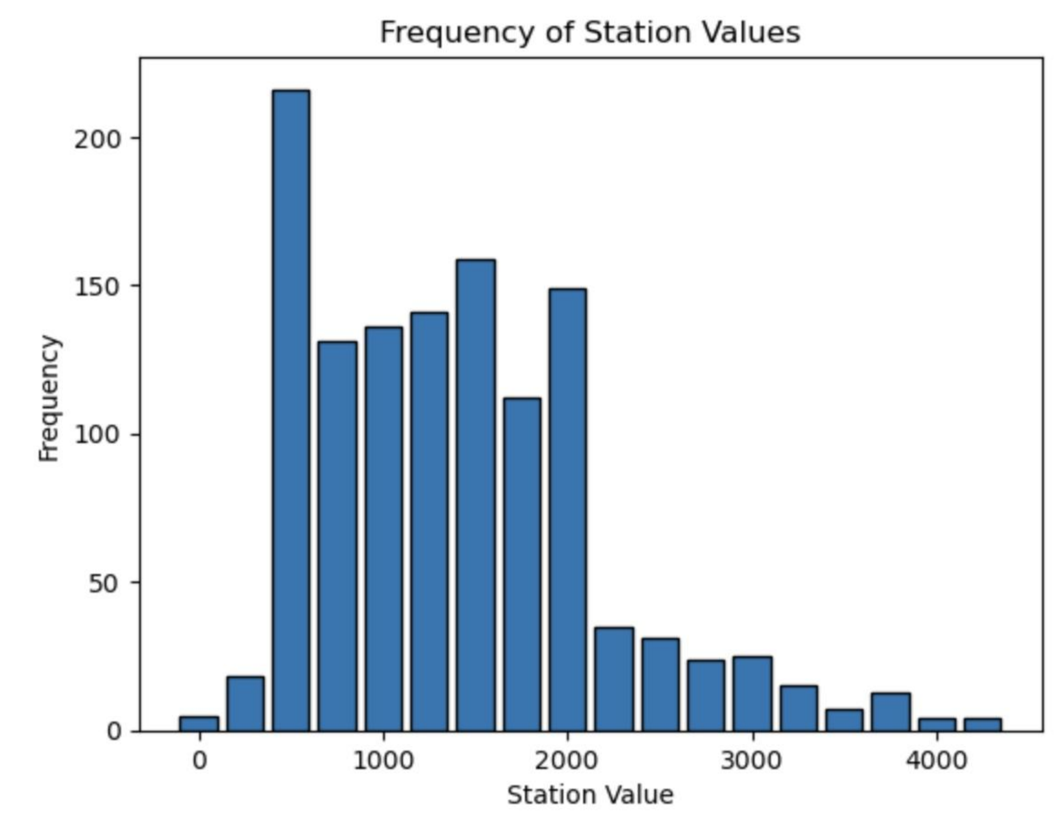

Figure 2: Table and histogram displaying the channels that were most commonly picked on. t

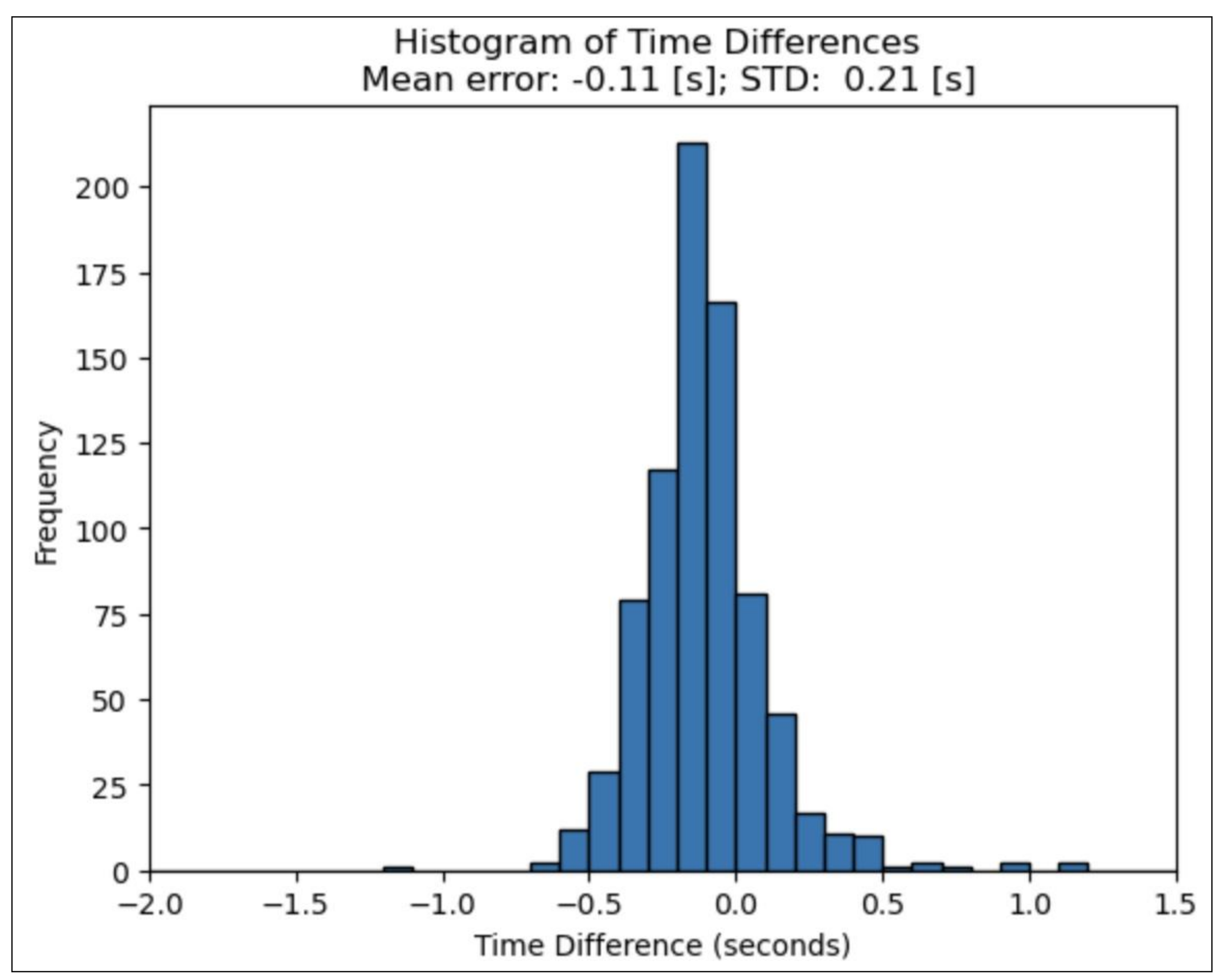

Figure 3: Histogram showing time difference in seconds between manual phase picks and PhaseNet-DAS picks at the same locations. Chart reveals that several picks fall just under .25 seconds

Secondary Phase Picks

Sometimes PhaseNet-DAS picks a secondary phase that is a true S-wave and other times the data and waveforms reveal that the model is picking surface waves, reflected phases, or converted phases. Further research will provide insight into channels this happened on most frequently and what qualities of the event could possibly lead to this outcome.

How Accurate Are PhaseNet-DAS Picks

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Mean: -0.11
Median: -0.12
Standard Deviation: 0.21
Range: 2.26
Minimum Value: -1.12
Maximum Value: 1.14
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Figure 4: Summary statistics of phase pick time differences for seismic events

PhaseNet-DAS Waveform

The waveform of event 72135727.

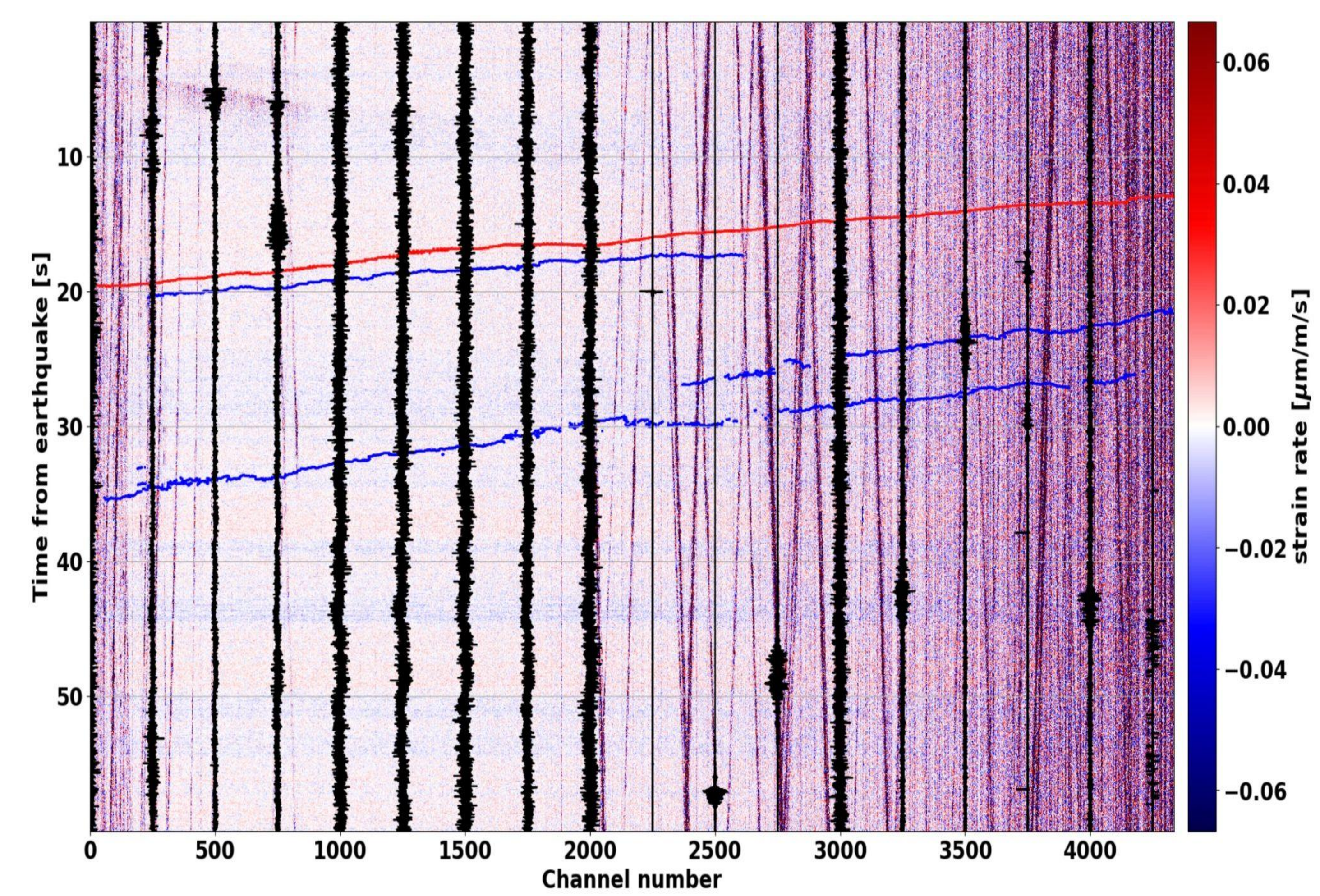

Figure 5: Event 72135727 is a legitimate outlier since the time difference between the manual pick and PhaseNet-DAS pick is greater than 8s and less than 15s.

References

Zhongwen Zhan; Distributed Acoustic Sensing Turns Fiber-Optic Cables into Sensitive Seismic Antennas. *Seismological Research Letters* 2019;; 91 (1): 1–15. doi: https://doi.org/10.1785/0220190112

Zhu, W., Biondi, E., Li, J. *et al.* Seismic arrival-time picking on distributed acoustic sensing data using semi-supervised learning. *Nat Commun* 14, 8192 (2023). https://doi.org/10.1038/s41467-023-43355-3

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