

Deep Learning-Based Recognition and Phase Detection of Microseismic Events: Real-World Application and Validation with Synthetic Elastic Seismic Models

Davood Nowroozi

Marie Macquet (CMC)

Don Lawton (CMC)

Summary

In this research, we enhance the identification of microseismic events through the application of machine learning techniques. A pivotal advantage of employing machine learning in seismic and microseismic detection lies in its capability to accurately classify seismic phases as either P-waves or S-waves, utilizing highly sophisticated models. Our study specifically focuses on distinguishing phase types in field data associated with CO₂ injection, underpinned by validation through an elastic seismic model that leverages precise petrophysical data. Furthermore, this paper delves into the detection of microseismic events within real-world data through the implementation of deep learning methodologies. We explore the efficacy of deep learning in discriminating phase types within local events—defined as those originating within a 300-meter radius from the geophone—and contrast these findings against phase detection performance in synthetic datasets devoid of noise.

Theory / Method / Workflow

To make a seismic model, a precise model with a 1m grid size was generated, and a Ricker wavelet was injected at a depth of three hundred meters. The model used a finite difference time domain (FDTD) for modelling in no-noise conditions.

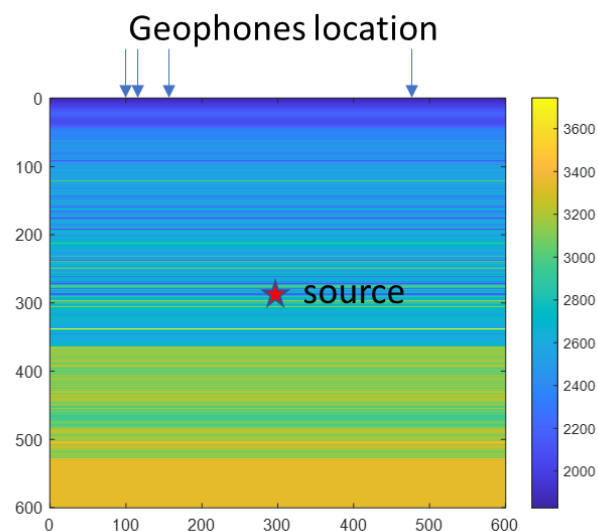


Figure 1. A precise geomodel for density, p wave, and s wave velocity is made using refined petrophysical data.

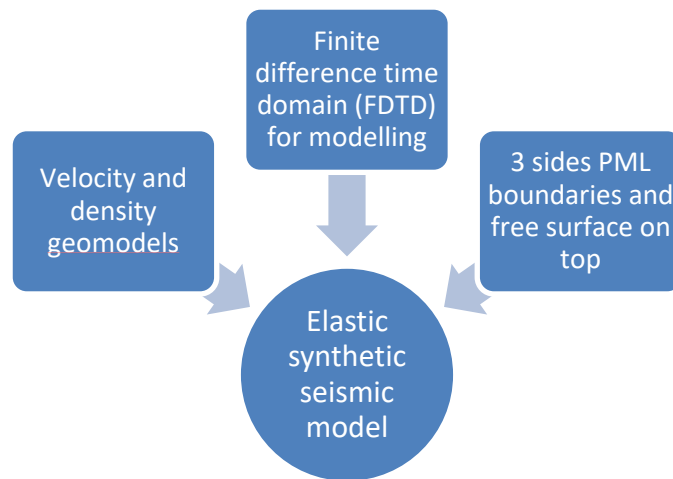


Figure 2. The diagrams demonstrate the procedure to generate the elastic synthetic seismic model.

Results, Observations, Conclusions

The comparative analysis of field and synthetic data is illustrated in Figures 3 and 4. This analysis underscores the potential of developing a robust methodology for accurately identifying real P and S waves within a reservoir context, marking a pivotal advancement for reservoir characterization and geomechanical investigations in both injection and production domains. The primary distinctions observed between field and synthetic datasets can be attributed to variations in source types and ambient noise levels. Nonetheless, the underlying principle regarding the timing of P and S waves remains consistent, directly correlating with subsurface velocity profiles.

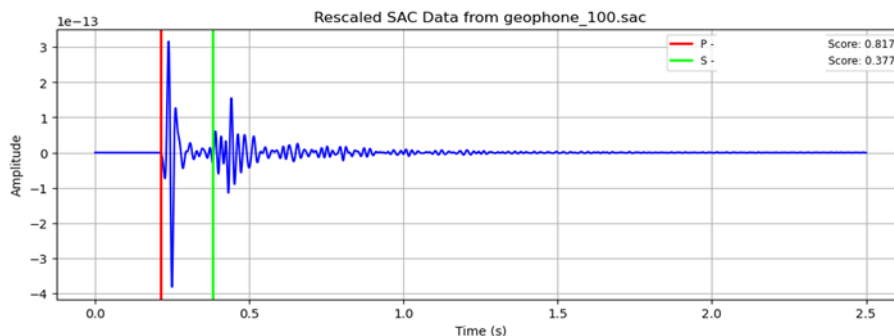


Figure 3. A synthetic elastic model in the surface (200 m lateral distance of source and source in 300 m depth). P and s waves are recognized by the deep learning method in the accurate time.

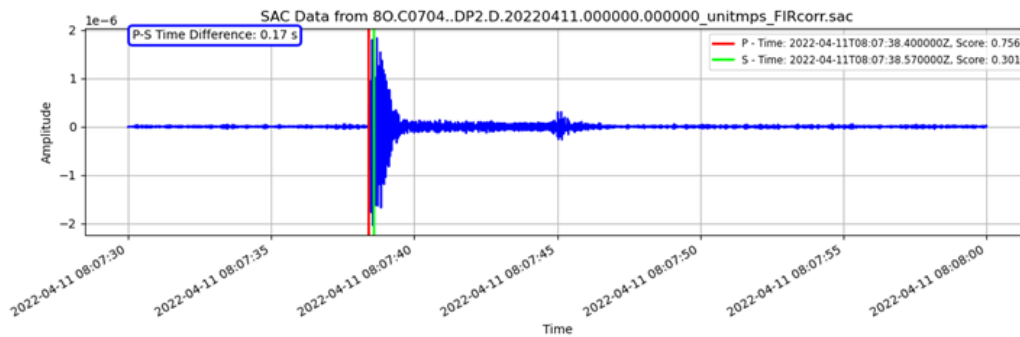


Figure 4. A microseismic event found and marked by the DL method shows a p and s wave in the DP2 component of geophone C0704.

Novel/Additive Information

Acknowledgements

- Dr. Marie Macquet and Dr. Don Lawton for preparing access to data and discussing the results
- Kirk Osadetz for negotiating and improving ideas about microseismic events
- Mitacs, CMCRI and the University of Calgary for supporting the research