

Deep Learning for Depth Registration of DAS in VSP

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Summary

Depth registration is a persistent issue with Distributed Acoustic Sensing (DAS) data. While the depth of DAS channels can be determined along the optical fiber, the depth of the DAS channels with respect to the formation is unknown due to several factors. This makes it difficult for DAS data to be calibrated and synthesized with other datasets, despite it being a powerful sensing technology. In this study we investigate two different deep learning architectures, a Long Short-Term Memory (LSTM) with attention-based model and the second one, a transformer, to map DAS channels to the correct formation depths. We used DAS and accelerometer data collected from a Vertical Seismic Profile survey in a carbon dioxide storage monitoring facility. At common depths, DAS and accelerometer traces should have some correlation in pattern between them as the same geology is sampled. Originally developed for language processing, we modified deep learning models to be able to understand time series data and predict depths given a time series. The models were trained using accelerometer data with known depths and the resulting model was used to predict depths of DAS channels.

Data

The dataset used in this study comes from the Newell County Field Research Station., located near Brooks, Alberta. The research hub monitors carbon dioxide stored in the Basal Belly River Sandstone formation from the late Cretaceous period, situated 300 meters beneath the surface (Lawton et al., 2018; Macquet et al., 2019; Spackman, 2019). The facility has three wells: a principal carbon dioxide injection well and two ancillary observational wells. The VSP data used in this study, referred to as Snowflake II, were acquired during a 2022 survey at one of the wells (Observation Well 2). Accelerometer data were recorded at 1 meter spacing first, then switched to 2 meter spacing at a depth of 140.3 meters. The DAS fiber runs for 5 kilometers, with channel spacing of 1.02 meters on the surface and in two different observation wells.

Theory / Method / Workflow

The workflow for this study is as follows:

1. Accelerometer data is measured in the units of acceleration. It is first converted to strain rate to be consistent with DAS domain.
2. Accelerometer shot gathers that have offset between 60-70m is selected for training.

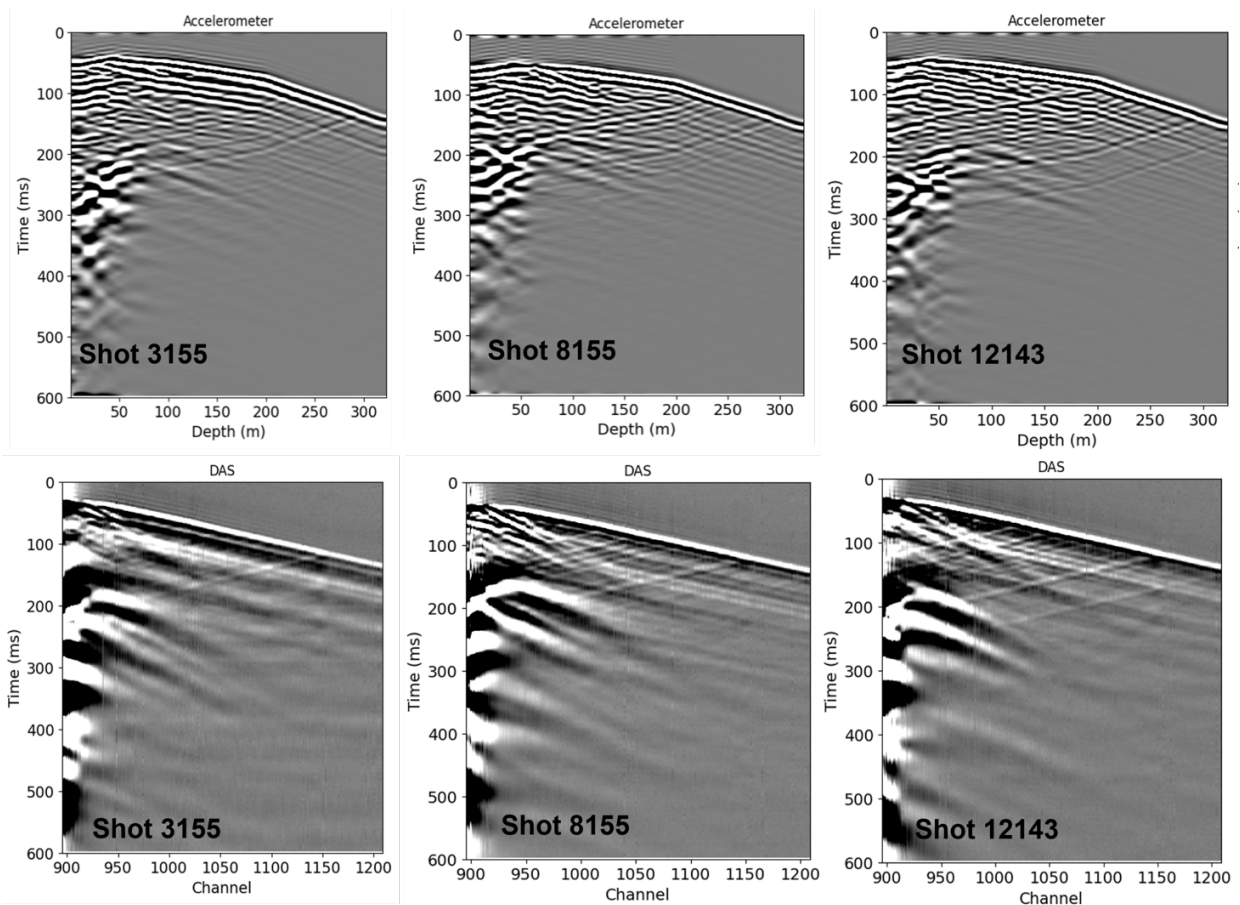


Figure 1: Accelerometer shot gathers and corresponding DAS gathers

3. Run a sliding window of length 20 and stride 5 for each time series, extracting 34 different time and frequency domain features from each trace. Each accelerometer trace is given the depth as its label.
4. Train the dataset with 2 different deep learning models; Long-Short Term Memory + attention and a transformer

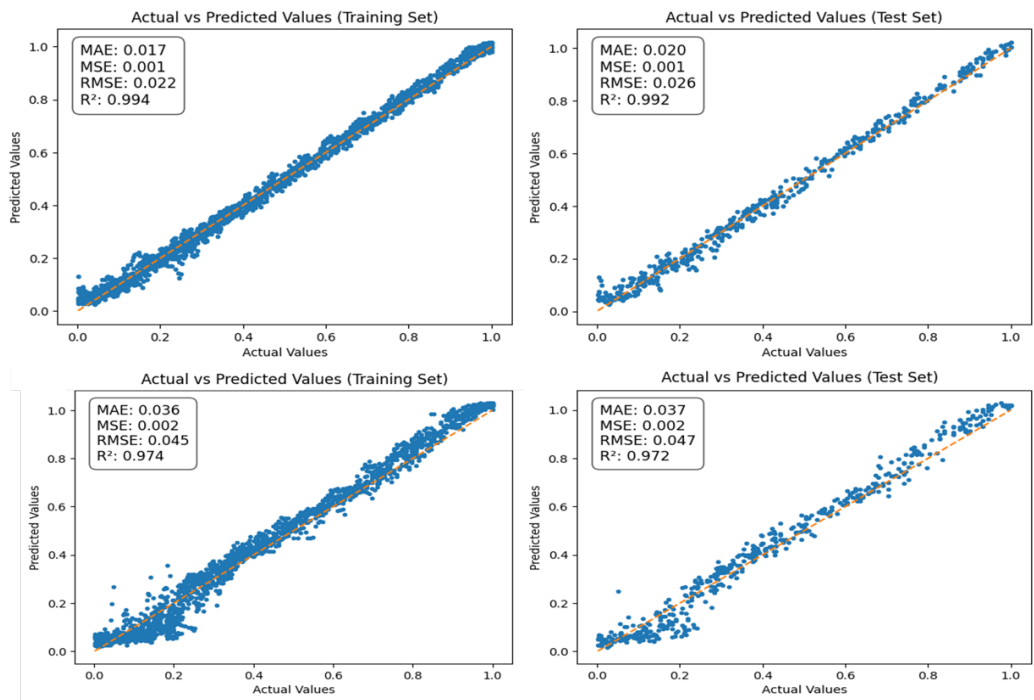
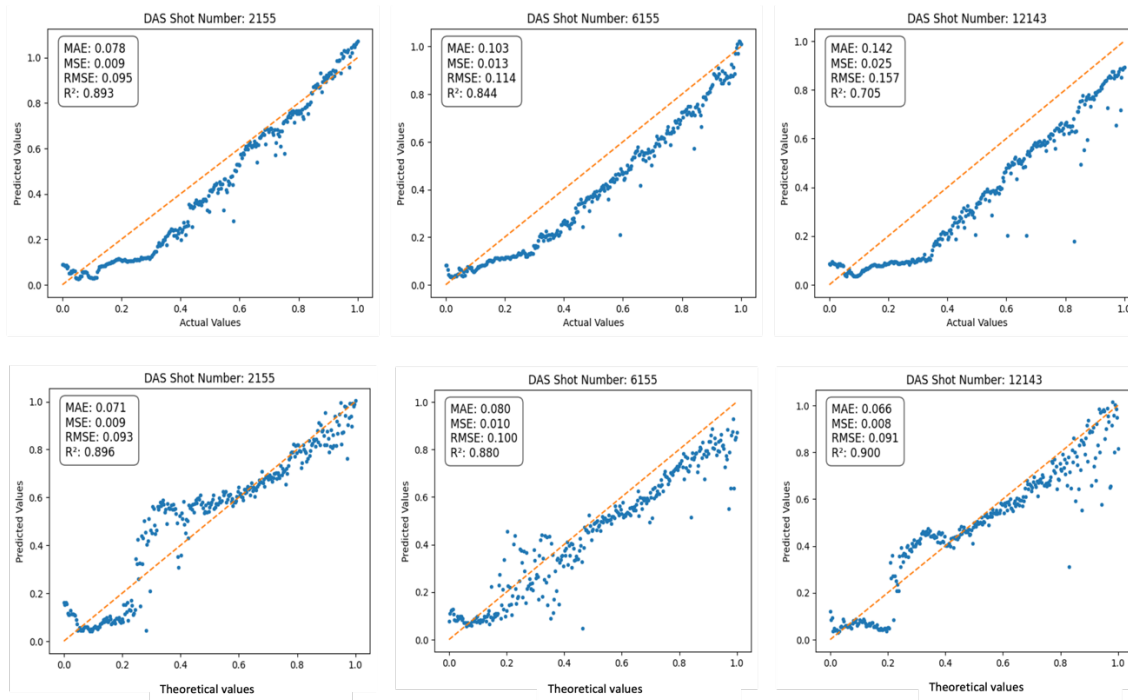


Figure 2: Training (left) and testing (right) performance for LSTM+attention. Bottom panel: training (left) and testing (right) performance for transformer.

Results



Conclusion

We have shown that deep learning models have the potential to learn from a type of time series data (accelerometer) and predict depths of a different type of data (DAS). This study is currently ongoing to further process the data prior to training, select relevant features and modify deep learning architectures to improve results.

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References

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