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Regularization of Acoustic Full Waveform Inversion with Wasserstein Generative Adversarial Networks

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Introduction

Multiparameter Full Waveform Inversion (FWI) suffers from crosstalk effects, which can be mitigated by regularizing the inverse problem. The regularization with the Wasserstein Generative Adversarial Network (WGAN) is capable of mitigating crosstalk in multiparameter FWI, outperforming many conventional methods. The objective of our work is twofold. First, we employ the WGAN as a regularizer in the acoustic FWI using well-log information as a prior. Second, we compare the inversion accuracy of WGAN regularization with the standard L2 norm.

Methods

The Wasserstein distance W1 is a metric that compares two distributions by measuring the extent to which they overlap. For this reason, it is also called the Earth-Mover’s distance. Since probability distributions are normalized, this distance can be interpreted as the number of trips necessary to move one distribution into the other. In particular, this metric offers distinct advantages over others, such as the Kullback-Leibler or Jensen-Shannon divergences, due to its topological construction.

In the context of seismic inversion, there are demonstrations regarding the superiority of WGAN as a regularizer, for example, in mitigating crosstalk in a multi-parametric anisotropic FWI. In this case, p-wave velocity and Thomsen parameters are inverted, resulting in more accurate results when compared to conventional L2 regularization. In this work, we use the W1 distance between the current model parameter and that of the parameter at the well log locations using WGAN to regularize the FWI. We emphasize that the steps for training the WGAN are not computationally expensive.

Results and Conclusions

At this stage, we successfully implemented a WGAN neural network that estimates the Wasserstein distance and applied the FWI method to a simple velocity model. Our results are being fine-tuned, and we plan to make further comparisons with other regularization methods. Moreover, we intend to apply it for an elastic inversion in the future.