Learned one-shot imaging

Mathias Louboutin[2], Rafael Orozco[1], Ali Siahkoohi[3], and Felix J. Herrmann[1]
[1]Georgia Institute of Technology, [2]Devito Codes Ltd, [3]Rice University

Introduction

Seismic imaging's main limiting factor is the scale of the involved dataset and the number of independent wave-equation solves required to migrate thousands of shots. To tackle this dimensionality curse, we introduce a learned framework that extends the conventional computationally reductive linear source superposition (e.g., via random simultaneous-source encoding) to a nonlinear learned source superposition and its corresponding learned supershot. With this method, we can image the subsurface at the cost of a one-shot migration by learning the most informative superposition of shots.

Methodology

Objectives:

- Learn non-linear supershot
- Learn corresponding simultaneous source
- Maximally inform subsurface reflectivity

Simultaneous learning of two networks.

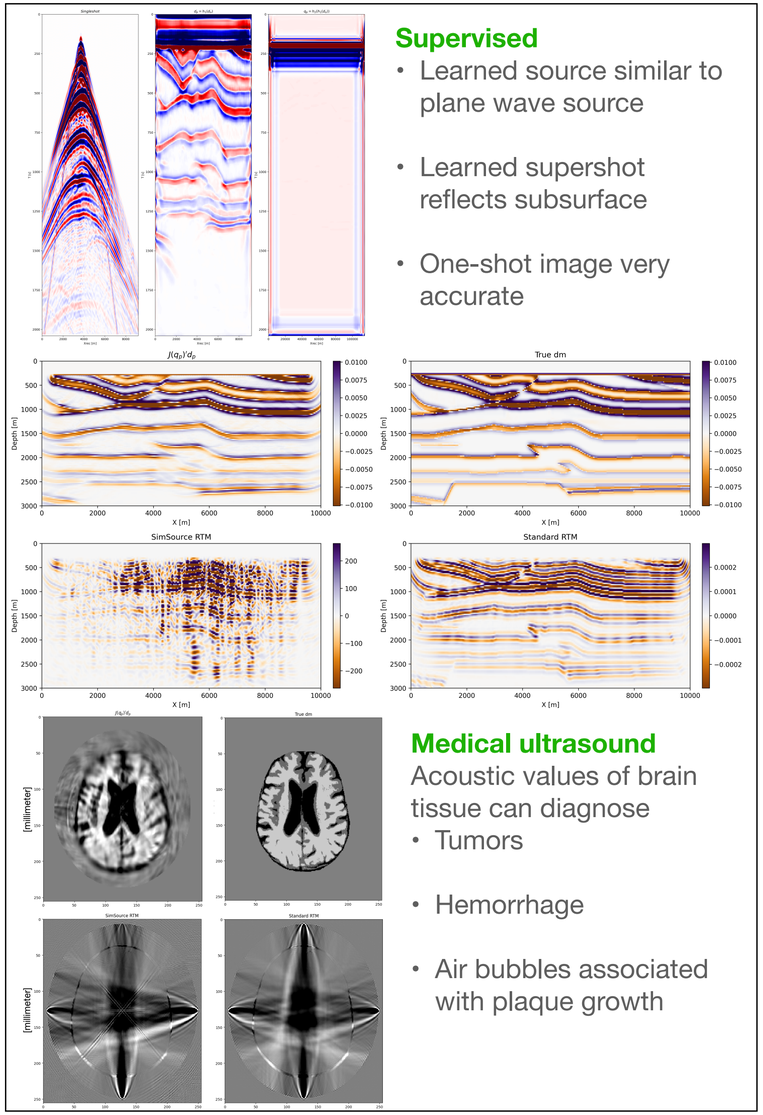
Supervised learning trains on pairs of known subsurface image (synthetics or legacy images) and corresponding data.

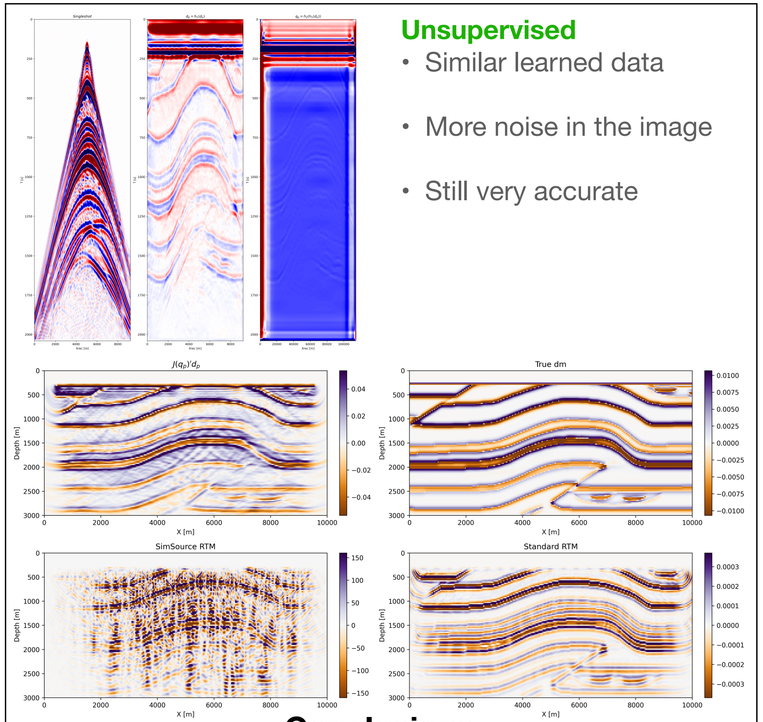
$$\min_{\boldsymbol{\theta},\boldsymbol{\phi}} \mathbb{E}_{(\mathbf{d},\delta\mathbf{m})\sim p(\mathbf{d},\delta\mathbf{m})} \left[\frac{1}{2} \left\| \mathbf{J}\left(\mathscr{H}_{\phi} \circ \mathscr{G}_{\theta}(\mathbf{d})\right)^{\top} \mathscr{G}_{\theta}(\mathbf{d}) - \delta\mathbf{m} \right\|_2^2 \right]$$

Unsupervised learning trains on data only through migration-demigration. **Only requires data and a subsurface background model.**

$$\min_{\boldsymbol{\theta},\boldsymbol{\phi}} \mathbb{E}_{\mathbf{d}\sim p(\mathbf{d})} \left[\frac{1}{2} \left\| \tilde{\mathbf{J}}\mathbf{J}\left(\mathscr{H}_{\phi} \circ \mathscr{G}_{\theta}(\mathbf{d})\right)^{\top} \mathscr{G}_{\theta}(\mathbf{d}) - \tilde{\mathbf{d}} \right\|_2^2 \right],$$

Only migrate supershots. Training us cheaper than standard migration of all shots.





Conclusions

- Data-domain learning method that provides high accuracy imagies
- Subsurface through one-shot imaging
- Supervised and unsupervised methods
- Reduced crosstalk

References

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