Physics and Deep Learning
Incorporating prior knowledge in deep neural networks

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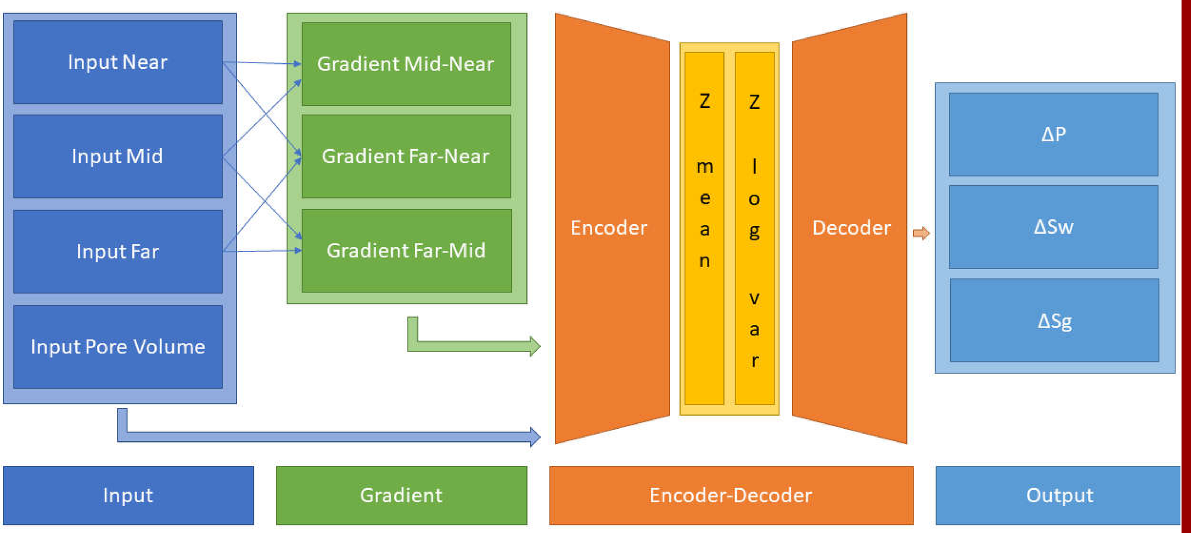
Neural Seismic Amplitude Map Inversion

1. Physical Inversion in presence of noise
2. Commonly a “Bayesian problem”
3. Non-Unique solution

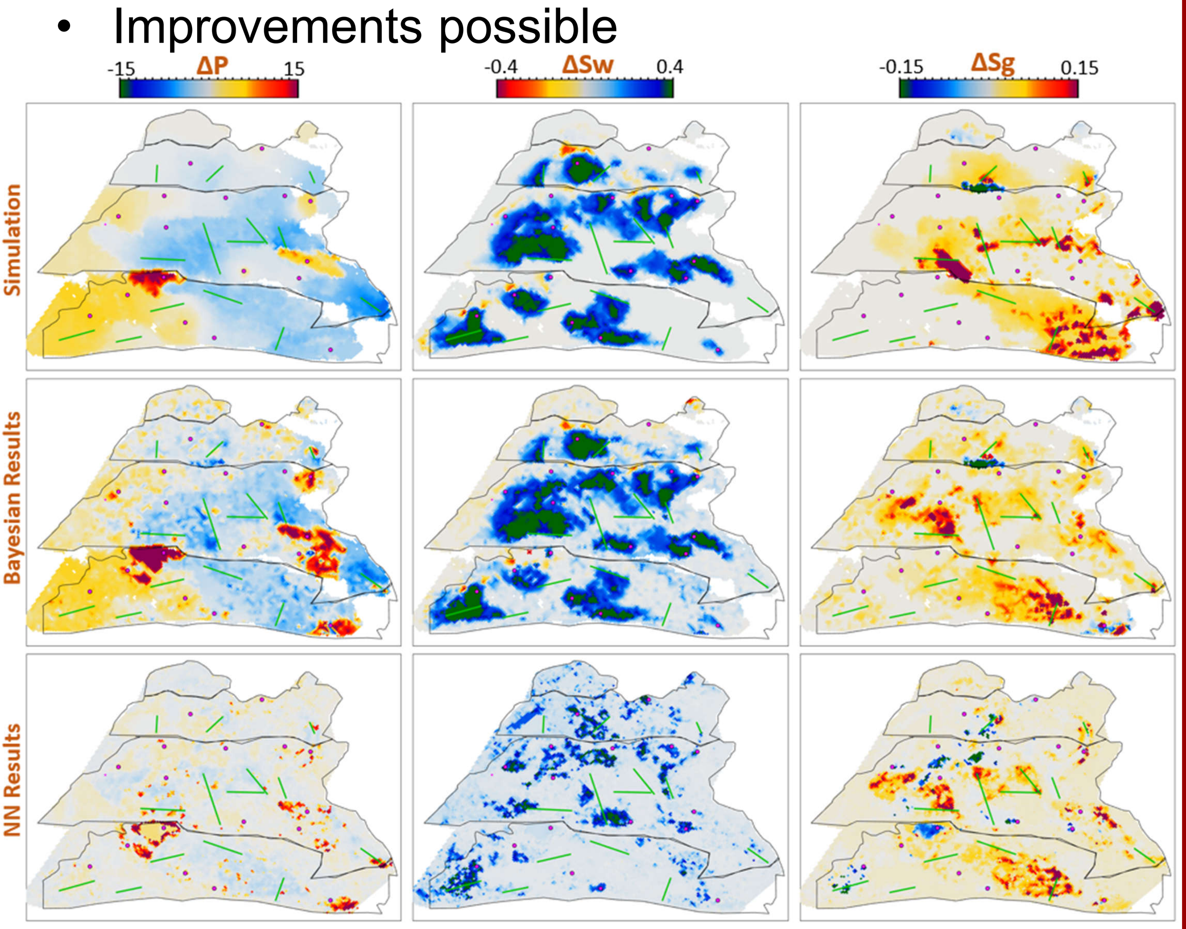
Method



- Dense neural network (no spatial context)
- Network includes AVO in the network
- Learns noisy gradient on synthetics
- Transfer to unseen field data
- Comparison to Bayesian inversion

Results

- Good Pressure Saturation Separation
- Improvements possible



DISCUSSION

- AVO-formulation in network makes network noise-robust and improves pressure saturation inversion
- Complex-valued neural networks sharpen faults and reduce smearing
- Domain knowledge beneficial in ML

Including **robust insights** from **signal processing, physics** and **geoscience** improves key metrics in **deep neural network** training and inference.

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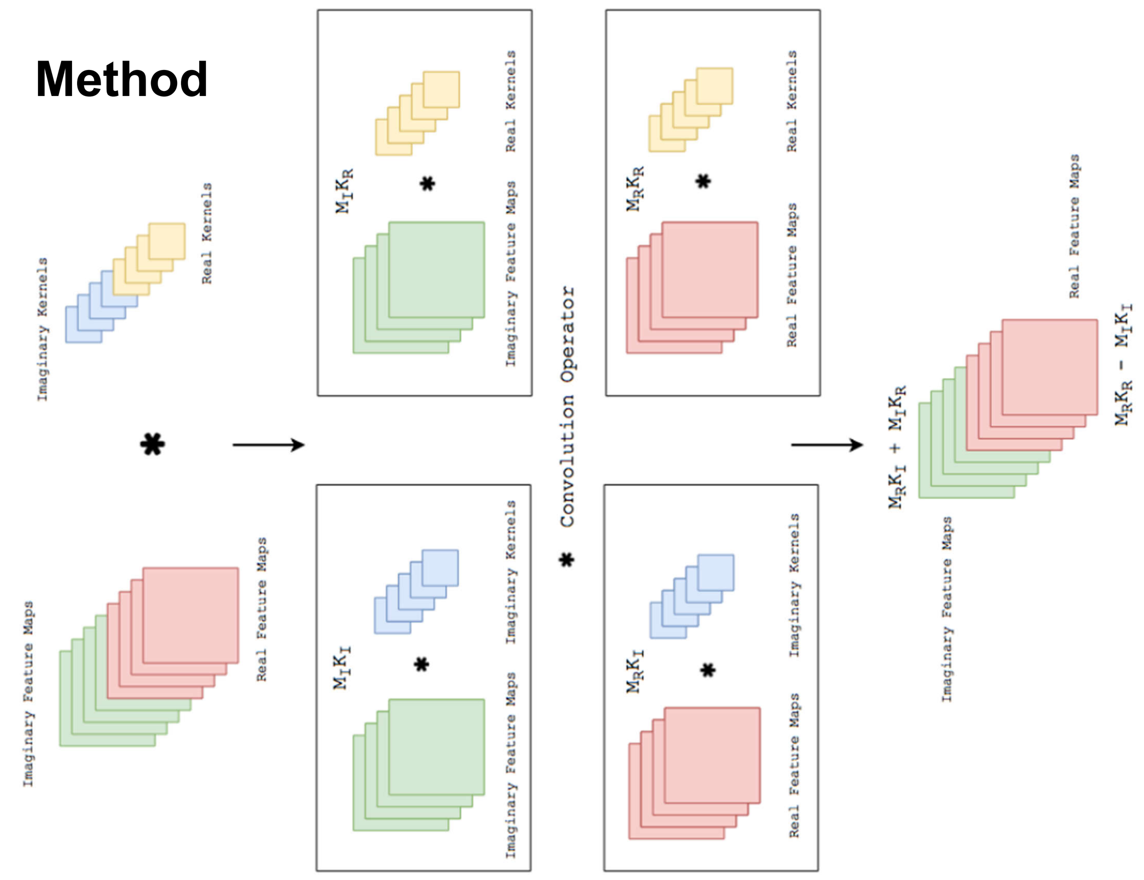
INTRODUCTION

- Neural networks are black box algorithms
- Deep neural networks are powerful yet not trivial to inspect and interpret
- We conduct two experiments that include physical domain knowledge and digital signal processing knowledge.

Complex-valued Convolutional Networks

1. Convolutional Neural Networks are real-valued operations on data
2. Convolution can be complex-valued
3. Seismic phase can be encoded in complex-valued traces

Method



$$K = \{M_\Re * K_\Re - M_\Im * K_\Im\} + i\{M_\Re * K_\Im + M_\Im * K_\Re\}$$

Results

- Phase information beneficial for “crisp” seismic data, esp. faults and fractures
- Misfit per parameter better