Centre for Oil and Gas - DTU
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Deep Learning: From Cats to 4D Seismic

Reducing cycle time and model training cost in asset management

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The Challenges

1. Modelling seismic data accurately is computationally very expensive, yet essential in the sim2seis process.

2. Reservoir changes in 4D seismic can be attributed to pressure changes and saturation changes. These are difficult to separate in the presence of noise.

3. Training deep neural networks is very challenging. Without an abundance of training data, the model may overfit and perform subpar.

4. Ground truth for labelling is often based on human interpretations that contain inherent biases and inaccuracies.

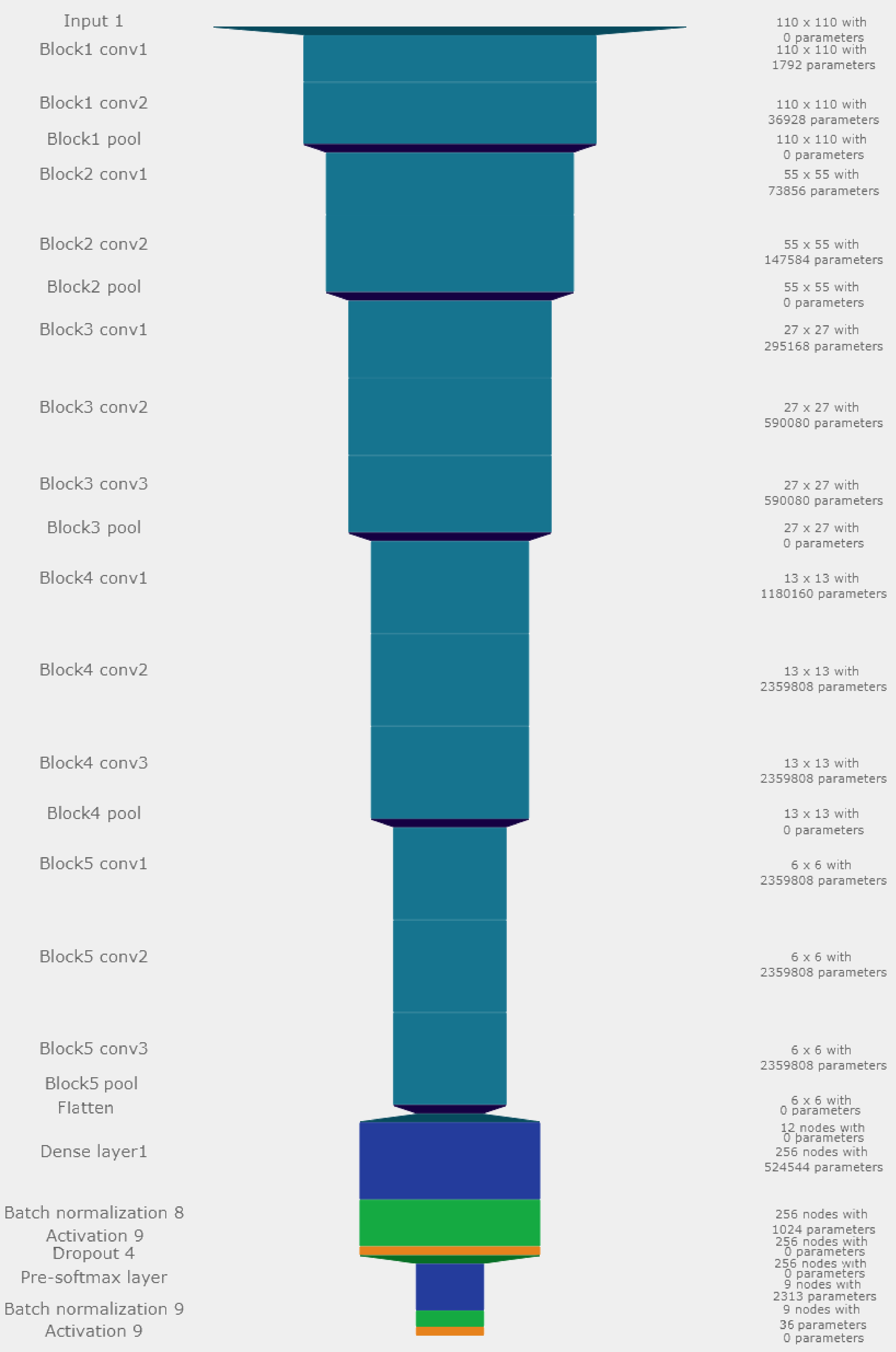
Summary

4D Seismic data has proven invaluable in O&G asset management, however, it's engineering challenges are still plentiful. These challenges include non-repeatable noise, tie-in and match with production curves, as well as, separation of imaging, pressure and saturation effects. Deep learning has proven robust at separating effects [1] with a strong data-dependent prior and has been shown effective in modelling physics-based systems [2]. We present work that reduces training times and thus reduces cost of implementation and enables rapid prototyping of experiments. This can be used in seismic modelling, physical effect separation, time series alignment and automatic seismic interpretation.

Proposed Solutions

1. Modelling seismic data using Generative Adversarial Networks has been shown to work. Seismic can be generated within seconds or minutes, rivalling full physics modelling and can replace convolution synthetic [3]
2. Separation of "content" and "style" has been achieved on various tasks [1]. Is this possible for physical effect separation?
3. Pre-trained neural networks exist that have been trained on natural images such as cats and dogs. We show that contrary to intuition, these networks generalize well to seismic data.
4. Unsupervised and self-supervised methods are achievable, using pre-trained networks and fine-tuning. Additionally, we can utilize existing seismic modelling pipelines to generate (full) physics-based training data.

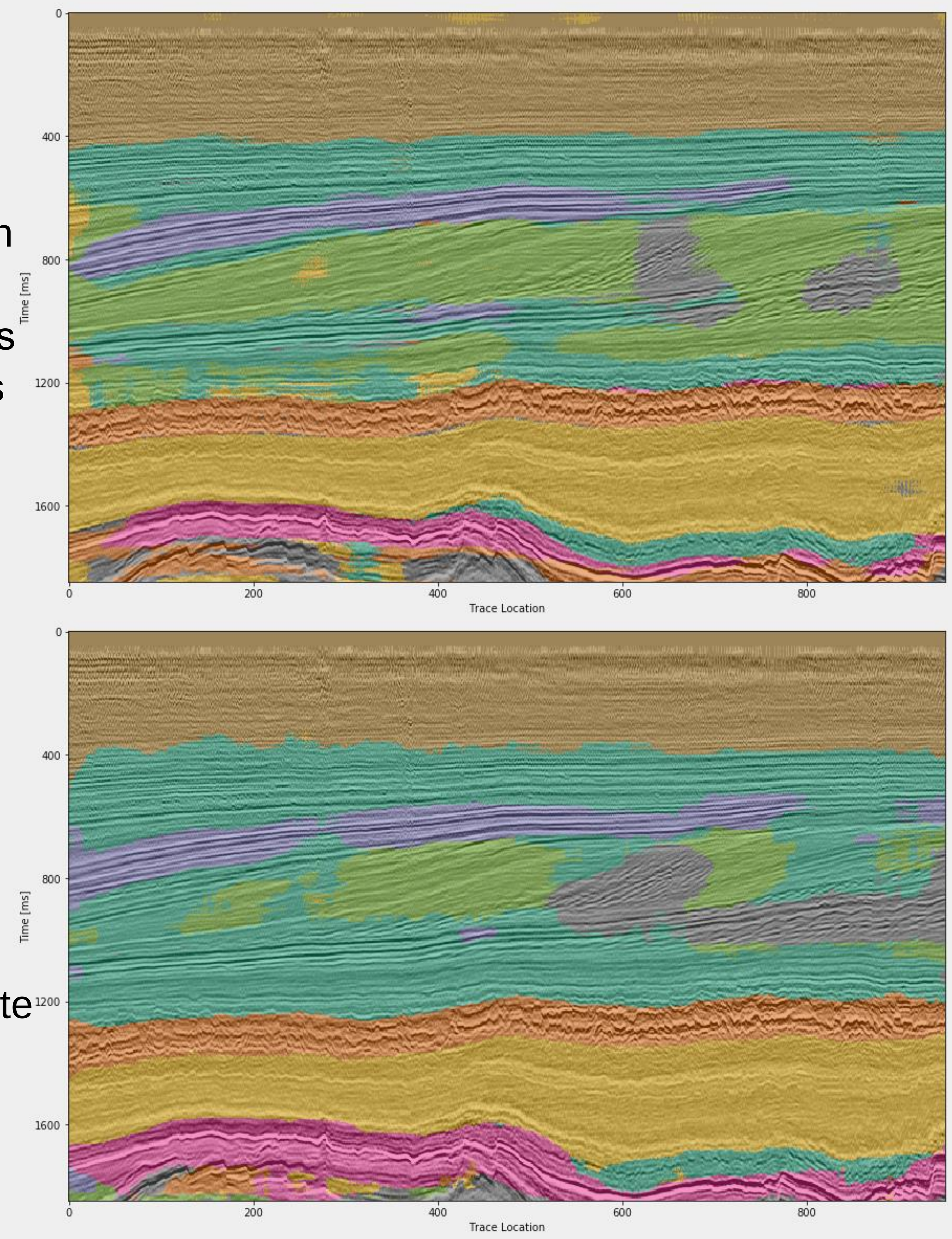
VGG16 Model Architecture



A deep neural network that was a contestant in the ImageNet challenge [4] and is generally considered to do exceptional in transfer learning.

But will a network trained on cats do well on seismic data?

Automatic Seismic Interpretations

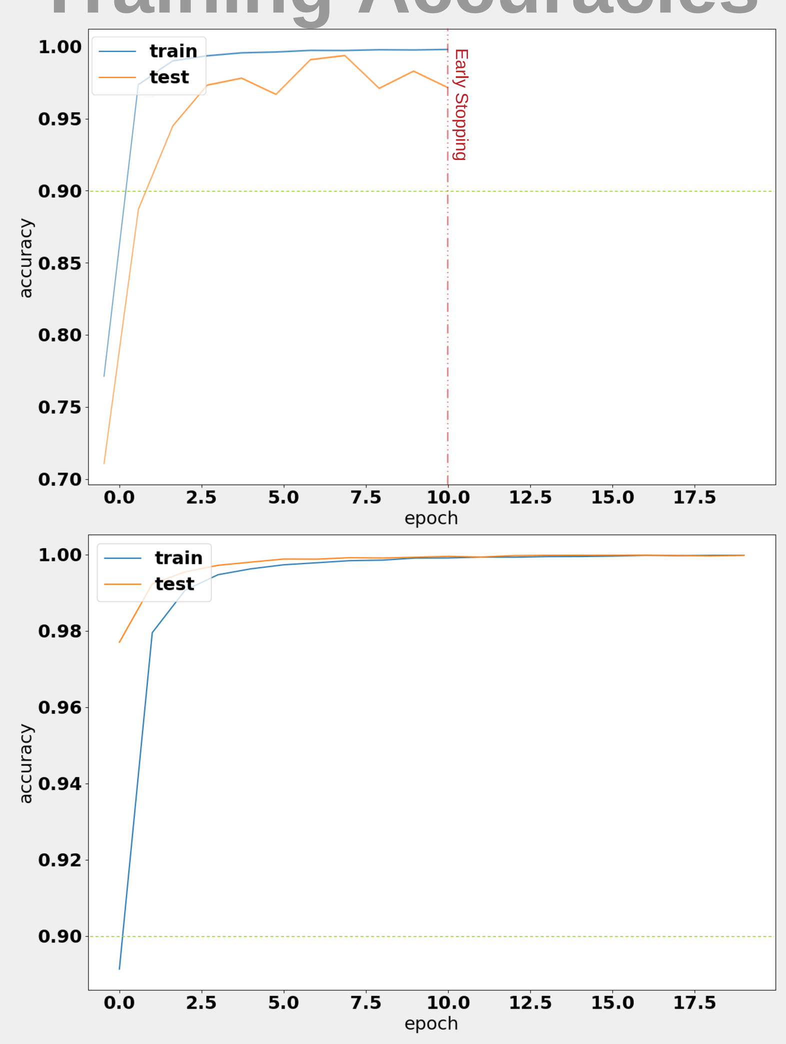


Top: End-to-End trained automatic interpretation on F3 seismic (Waldeland CNN)

Bottom: Transfer learned automatic interpretation on F3 seismic (VGG16)

The interpretations are comparable, but transfer learned interpretation is more consistent (less blotchy).

Training Accuracies



The end-to-end (top) Waldeland CNN is outperformed by out-of-the box the transferred network (bottom), and overfitting is present.

The Conclusion

We explored, whether pre-trained neural networks outperform end-to-end trained neural networks [5]. VGG16 performed remarkable without fine-tuning. ResNet52 overfit strongly in our experiment, but using fine-tuning has been shown to outperform end-to-end training.

We can transfer VGG16 to perform rapid efficient experiments on seismic data with recent advances in deep learning.

References

[1] Isola, Phillip, et al. "Image-to-image translation with conditional adversarial networks." *arXiv preprint* (2017).
[2] de Oliveira, Luke, Michela Paganini, and Benjamin Nachman. "Learning particle physics by example: location-aware generative adversarial networks for physics synthesis." Computing and Software for Big Science 1.1 (2017): 4.
[3] Mosser, Lukas, et al. "Rapid seismic domain transfer: Seismic velocity inversion and modeling using deep generative neural networks." 80th EAGE Conference and Exhibition 2018. 2018.
[4] Simonyan, Karen, and Andrew Zisserman. "Very deep convolutional networks for large-scale image recognition." arXiv preprint arXiv:1409.1556 (2014).
[5] Dramsch, Jesper S., and Mikael Lüthje. "Deep-learning seismic facies on state-of-the-art CNN architectures." SEG Technical Program Expanded Abstracts 2018. Society of Exploration Geophysicists, 2018. 2036-2040.

Thanks to my co-supervisor Anders Nymark Christensen for suggestions to improve this poster, dgb for the F3 seismic data and Oxford for the VGG model.

Link to article explaining reproducible sources and presentation and personal copy of research.

Link to our work [5] in conference proceedings at Society of Exploration Geophysicists 2018 Annual Meeting.