Learning through inference: from inversion to prediction

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Geophysicists want to learn about the Earth's interior from indirect measurements collected at or above the Earth's surface. All observations only indirectly constrain subsurface properties of interest, and so for the past 40 years geophysicists have created numerous methods to predict subsurface properties from surface observables. This field has become known as geophysical inverse theory. What is the future of this field given that we are now in the age of Machine Learning? Does a geophysicist abandon tried and trusted, and at times cumbersome, physics-based approaches in favour of the new panacea of data driven science, or does she reject the band-wagon and adhere to established algorithms based on well understood physical principles? Here we argue that neither should be the case. Rather the future lies in developing new creative ways to forge new subsurface imaging and prediction methods taking advantage of the power of both paradigms.

This talk will chart some aspects of geophysical inversion and how they might be related to and integrated with data driven science. A focus will be on future directions in geophysical inversion and where the biggest bang for buck might be achieved utilizing algorithms and insights from Machine Learning.

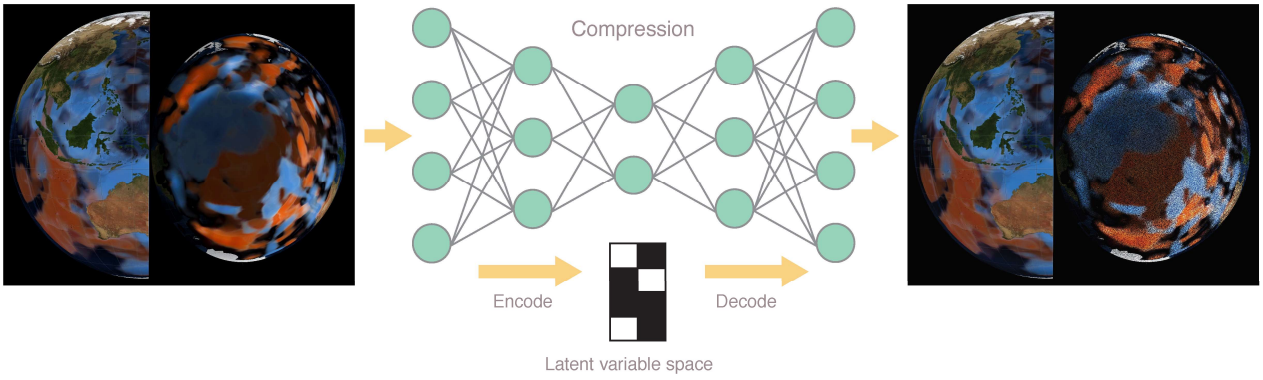

Figure 1. Conceptual illustration of how an Auto-encoder Neural network might compress a large scale 3-D model of the Earth into a latent variable space. The number of Latent variables would be much less than for the original Earth representation, but capture most of the significant features. Using such Machine learning tools it seems likely that large scale inversion problems could be projected into the much smaller latent space. However, is this cost efficient in general, and if it were, is the inverse problem in the latent space more or less difficult to solve than in the original parametrization?

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