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A Deep Learning Approach to Quantitatively Characterising the Marine Near-Surface

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Summary

In this paper, we present a Deep Learning workflow developed specifically for inverting marine site investigation data, comparing and contrasting it against the results obtained using traditional stochastic inversion algorithms with both synthetic and field data. In particular, we assess its potential for rapidly deriving a range of subsurface parameterisations, including geotechnical engineering properties of direct interest for various site investigation problems.

Abstract

Characterization of the top 10–50 m of the sub-seabed is key for a range of different applications, including: landslide hazard assessment; offshore infrastructure engineering design; cable and pipeline route planning and installation; as well as shallow hydrocarbon reservoir assessment and/or greenhouse gas storage monitoring. While the application of inversion techniques to near-surface marine geophysical data can be traced back over 25 years, it has seen a recent resurgence, driven by a ready availability of high-performance computing infrastructure and a commercial need for more flexible ground modelling solutions.

However, while a broad range of inversion methods are well developed and understood for hydrocarbon reservoir problems, their application to high-resolution site survey data is not a straightforward translation of existing methods/algorithms. Limited source-receiver offsets, lower source powers, higher source frequencies, and greater sensitivity to inconsistencies in the acquisition geometry (e.g., swell, irregular feather) mean that the inversion of high-resolution site survey data is even more of an ill-posed problem than it is at the exploration-scale. In addition, the end-product of interest is typically a geotechnical/engineering characterisation of the sub-surface and therefore does not consist of properties that can be easily mapped into the seismic parameter-space.

Various solutions to these problems have been proposed and progress has been made over the last 5 – 10 years, with some promising results. However, progress has often come by casting the inversion as a stochastic process, using one or more advanced optimisation methods, such as: Genetic Algorithms; Simulated Annealing; Bayesian theory; and/or Artificial Neural Networks. While these methods have clear and significant benefits to the reliability and robustness of the inversion, they come at a cost of increased computational time, making them difficult to use with large-scale applications on big data sets and/or spatially ill-constrained problems. In contrast, Deep Learning methods, once trained, scale very slowly with increasing data size, providing an option for inverting large data sets rapidly and efficiently. In this paper, we present a Deep Learning workflow developed specifically for inverting marine site investigation data, comparing and contrasting it against the results obtained using traditional stochastic inversion algorithms with both synthetic and field data. In particular, we assess its potential for rapidly deriving a range of subsurface parameterisations, including geotechnical engineering properties of direct interest for various site investigation problems.