UNSUPERVISED PHYSICS BASED NEURAL NETWORKS FOR SEISMIC MIGRATION

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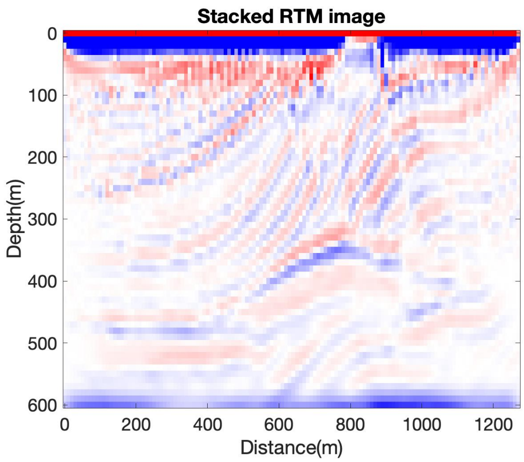
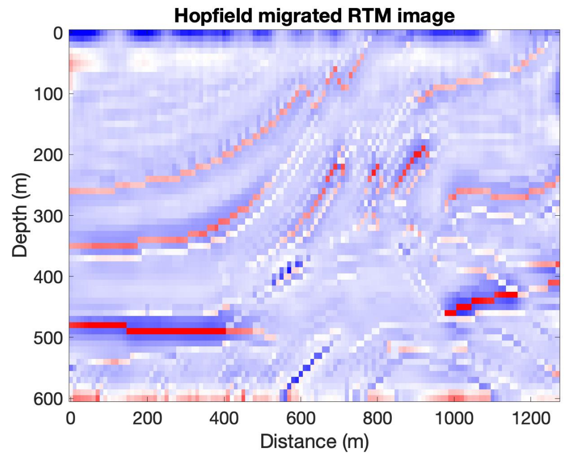
ABSTRACT

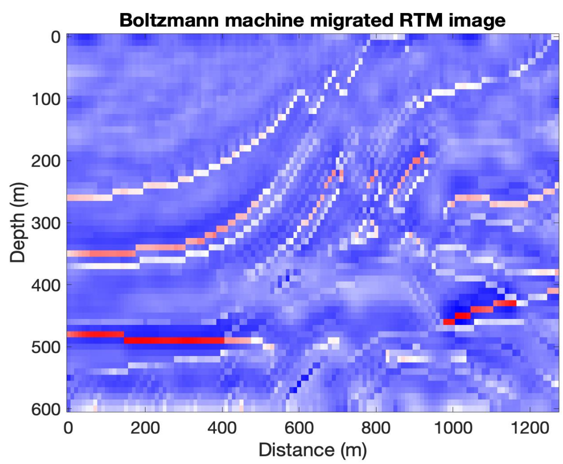
A novel framework is introduced for combining physics based forward models and neural networks to advance seismic processing and inversion algorithms. Migration is an effective tool in seismic data processing and imaging. Over the years the scope of these algorithms has broadened and today, migration is a central step in the seismic data processing workflow. However, no single migration technique is suitable for all kinds of data and all styles of acquisition. There is always a compromise on the accuracy, cost and flexibility of these algorithms. On the other hand, machine learning algorithms and artificial intelligence methods have been found immensely successful in applications where large-scale data is available. The applicability of these algorithms is being extensively investigated in scientific disciplines such as exploration geophysics with the goal of reducing exploration and development costs. In this context, a special kind of unsupervised recurrent neural network and its variant, Hopfield neural networks and Boltzmann machine is used to solve the problems of Kirchhoff and Reverse time migrations. A Hopfield neural network is employed to migrate seismic data and use simulated annealing to globally optimize the cost function of the neural network. The weights and biases of the neural network are derived from the physics based forward models that are used to generate seismic data. The optimal configuration of the neural network after training corresponds to the minimum energy of the network and thus gives the reflectivity, solution of the migration problem. Using synthetic examples, it is demonstrated that 1) Hopfield neural networks are fast and efficient, and 2) provide high resolution reflectivity images with mitigated migration artifacts and improved spatial resolution. In specific, the presented approach minimizes the artifacts that arise from limited aperture, low subsurface illumination, coarse sampling and gaps in the data.



(a)



(b)



(c)

Migrated images (Highpass filter and AGC gain applied) (a) Conventional stacked RTM migrated Image (b) Hopfield migrated image (c) Boltzmann machine migrated image