Interactive Deep Learning Assisted Seismic Interpretation Technology Applied to Reservoir Characterization: A Case Study From Offshore Santos Basin in Brazil

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Abstract

Currently 90% of Brazil's oil production is in the post- and pre-salt reservoirs of the Campos and Santos Basins. The proportion of pre-salt production has been increasing steadily over the past few years, and according to the Brazilian National Agency of Petroleum, more than 50% of the country's total hydrocarbon production is now related to pre-salt reservoirs. The resolution of seismic data in the deeper strata below salt is key for the development of these plays. Seismic imaging of offshore Brazil data has improved significantly with state-of-the-art technologies employed in acquisition, processing, and interpretation. In this study, we propose a method to accelerate seismic interpretation using an interactive approach to deep learning that allows geoscientists to be in complete control. Using a combination of already available software innovations that include seismic data compression, random data access, and a series of optimized Convolutional Neural Networks (CNN), the deep neural network acts as an extension of the interpreter to assist in mapping sub-surface geological features, using single amplitude or co-rendered attribute volumes. Deep learning approaches with sophisticated neural network architecture has a lot of promise for seismic interpretation tasks. Our interactive approach to machine learning assists interpreters in mapping subsurface features in real-time. Because the interpreter can keep training until the desired inference is reached, the additional burden of intensive QC is avoided and removes

the disadvantage of rigorous data preparation. The mapping of evaporitic sequences and fault surfaces is a binary classification and the mapping of facies is a multi-class classification. The areas without salt or faults will be classified as zero and areas with salt or faults are classified as one. The most optimal input to the CNN requires patches from the seismic and input label by the seismic interpreter; random access to the seismic features and interpreter label pairs. The latter must be three-dimensional; equal and sequential number of truth and non-truth samples. We present a custom deep learning model that is designed to have a small number of layers that allows for fast and accurate results. We can operate it interactively, giving quick responses to the interpreter. The loss function is also built to give positive feedback to the network. The deep learning methodology presented here acts as an extension of an experienced seismic interpreter. The interpreter keeps training and observing the inference in real-time until the result is desirable. These tools have a potential to accelerate day-to-day E&P operations, ultimately reducing human error and cost. In our case study located offshore in the Santos Basin, Brazil, we have been able to fast-track mapping of evaporitic sequences as well as fault features and facies by at least 20-times compared to human interpretation.