Surface Reservoir Characteristics from Subsurface Seismic Images with Deep Learning Methodologies

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Abstract

"As far as the laws of mathematics refer to reality, they are not certain, and as far as they are certain, they do not refer to reality." A. Einstein (1879-1955). Reservoir characterization is the process of calibrating or mapping reservoir thickness, net-to-gross ratio, porosity, permeability and water saturation. Well logs have habitually provided the source of the data to generate the maps, but piecemeal seismic attributes have gained popularity when calibrated with extant well control. The seismic data can be used to interpolate and extrapolate between and beyond sparse well control, which provides only localized knowledge. This paper presents supervised and unsupervised pattern recognition techniques using a suite of data-driven analytical workflows that lend credence and support reservoir characterization by adopting advanced analytical methodologies on seismic profiles. We shall define workflows integrating seismic images and derived attributes as input space for a Deep Learning (DL) solution. A simple preprocessing technique creates many small image patches from larger images. These patches reduce the number of features required to represent an image and can decrease the training time needed by algorithms to learn from the images. If a training label is available, a classifier is trained to identify patches of interest. In the unsupervised case, a stacked autoencoder network is used to generate a dictionary of representative patches, which can be used to locate areas of interest in new images. While this technique can be applied to pattern recognition problems in general, this paper will present a specific example in upstream oil and gas exploration extracting important hidden patterns in seismic profiles. Thus, marrying traditional seismic interpretation with a suite of DL workflows, we surface meaningful patterns to identify Direct Hydrocarbon Indicators efficiently across 3D seismic datasets.