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Formation tops identification from wireline logs with deep convolutional neural network

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Summary

Deep Convolutional Neural Networks (CNNs), one type of Machine Learning solutions, have gained popularity in image classification, speech recognition and time series signal analysis. This type of methods has two important features: feature training and prediction. The feature training involves techniques used in the network to automatically extract the representations necessary for feature detection or classification from raw data, and the prediction is used to make inference about other data we have not yet modeled or interpreted based on the training representations.

In this paper, we present a novel deep CNN learning framework to automatically detect the referenced features from wireline logs, such as formation tops, where inputs are raw well logs and outputs are specific geological features that enable construction of cross-section in a basin. In this study, training phase takes well defined features as class labels and their spatial variation characterized by various well logs provided by “experts” as a training set for machine learning. Then the Deep Learning is performed to extract representations of the referenced features from data for feature detection and data interpretation.

The simplest way to feed data into neural network is to use raw well logs, such as gamma ray and density. However, in order to mimic the vision and cognition processes of a geologist or petrophysicist in identifying formation tops and use the computer vision for classification, our CNN framework employs the spectral decomposition techniques to decompose the well logs into the frequency slices, which are subsequently encoded as images to feed into neural networks. Well log correlation relies on personal knowledge and experience to extract the specific well logging features to define the well markers, which is very time-consuming. However, using CNN framework, feature extraction for formation tops identification can be done via deep learning automatically without human intervention.

In this study, various well logs, such as gamma ray, density, resistivity and sonic, were selected to perform feature learning and then identifying formation tops of the Devonian Duvernay shale in Western Canadian Sedimentary Basin (WCSB). The initial results demonstrate that this technology can significantly reduce subjectivity in interpretation and improve efficiency in geological mapping.