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Deep Neural Networks to predict reservoir properties from seismic

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Summary

Neural networks have been used for some time in geophysics to quantitatively predict rock properties from seismic data. Recently there has been tremendous progress in the field of machine learning thanks to a powerful new technique called deep learning. Applications of this are showing up in everyday life including self-driving cars, image recognition, translation, recommender systems and voice recognition. The key technologies that have enabled this progress are deep learning and big data. This paper explores the use of deep neural networks (DNN) for the goal of predicting reservoir properties.

Deep Neural Networks are a form of machine learning called supervised learning, which is the task of inferring a function from a labeled training data. The learning algorithm then generalizes from the training data to unseen situations. DNN contain many layers so they can simulate any mathematical function. Typically, eight to ten layers are required to accomplish this. In addition, layers may consist of a variety of different architectures including fully connected, convolutional and pooling layers each requiring many parameters.

Training the neural network involves solving a large nonlinear inverse problem. In a deep network there are typically thousands of parameters which need to be determined. If there is not enough labelled data to train the neural network there is a danger the inverse problem will be undetermined. Practically, this limits the depth of the DNN, hence the importance of big data. In the case of image recognition millions of labelled photos are used to train the DNN.

We like to think of geophysical data as big data. Prestack seismic can easily be many terabytes in size. However we typically do not have access to large amounts of labelled training data. The training data is limited by the available well control. In predicting the reservoir properties the well data is our target variable, or the variable we would like to predict. Only seismic data lying along the well trajectory may be used to train the DNN. Depending on the amount of well control available this typically limits the training data set to be in the order of hundreds of points. This practically limits the depth of the neural network and the adoption of DNNs for reservoir geophysics.

In order to obtain more training data this paper explores the use of synthetic seismic data based on perturbations from the known well control. The basic idea is to generate new well control based on rock physics relationships. For example, new wells are created for which the reservoir thickness, porosity and fluid content are varied. Synthetic seismic gathers are then generated for each of these new wells. This data is then used to train the DNN. This flow was applied to a Gulf Coast dataset with the objective of predicting the density. Then density predicted using the DNN is comparable to that achieved using simultaneous inversion.