A Data Science approach for Identifying Bright Spot Oil Formation Using Modified Extreme Learning Machines

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Abstract Generating 3D geographical models of seismic data have helped geologists perform robust geological interpretations and enhance hydrocarbon exploration. However, modeling seismic data involves a plethora of techniques such as the seismic reflection method [1]. The resulting volume is processed to extract meaningful features that help interpreters predict and estimate diverse physical, geometrical, frequency domain and other information to identify many geo-logical structures such as bright spots, lithology, rock and fluid properties. Previous studies have extracted diverse seismic attributes [2]–[4] that helped visualize and distinguish different geological structures beneath the subsurface [5], [6]. 3D features were also developed to enhance the resolution of results for visualizing and mapping subsurface structures and stratigraphy [7]. All these advances have increased the success rate of hydrocarbon exploration.

In particular, bright spots are local seismic attribute anomalies that result from the increase in acoustic impedance difference when hydrocarbon accumulations, which usually have lower impedance than their surroundings, are present within the studied region [8]. Since the early 1970's, bright spots have been used as direct hydrocarbon indicator although not all bright spots are conclusive evidence of hydrocarbon accumulation [9]. Using two dimensional (2D) texture analysis, [10] concluded that regions indicative of hydrocarbon accumulations generally exhibit high energy, low contrast, and low entropy when compared with non-hydrocarbon sediments.

Seismic data's volume, which may reach few terabytes [11], not only makes the preprocessing computationally expensive but the extraction of the needed features as well. While 3D and 4D for real time monitoring exhibit higher resolution when compared to 2D texture analysis [12, 13] , they are computationally very demanding since they involve processing a sub-volume N*N*N each time. Modern advances in technology provide different solutions for reducing the computational cost of complex algorithms and big data analysis including parallel platforms such as Hadoop [14], Spark [15], MPI [16], and Matlab [17]. Many of the processes and workflows involved in seismic data analysis have already been migrated to distributed frameworks such as [18], resulting in faster computational times.

Achieving fast calculations yet accurate assessment with seismic data is highly desirable since this impacts decision strategies such as well placement, well management and seismic exploration. In an effort to achieve accurate and real time processing for seismic analysis in a computationally efficient matter, we plan in this research to implement a parallel workflow that relies on selected 2D statistical and texture features and modified Extreme learning machines (ELM). After analyzing the computational costs over large volumes of data, we aim to propose specific features derived from 2D wavelet transform of seismic slices and compare them to the statistical and texture features from an accuracy and a computational perspective. For the identification of bright spot formation, we will modify ELM because they are a type of deep learning networks that have gained popularity due to their efficient, non-iterative training algorithm as opposed to other iterative ones.