A Novel Workflow on Unsupervised Deep Learning Extraction of High-Resolution Image Texture for Building Automated Image Morphofacies in Siliciclastic Depositional Environments

Ivan Wu, Sarvagya Parashar

Halliburton

Abstract

A thorough understanding of the nature and significance of sedimentary textures is fundamental to interpretation of ancient depositional environments and transport conditions. Texture includes the shape, roundness, surface features, grain size, and fabric of the components-principally the detrital deposits along with the pore system of a sandstone. High resolution micro resistivity borehole images offer critical information about the structure and texture of the rock, which reflect hydrodynamic mechanisms and biological activities at the time of deposition and the diagenetic imprints. A novel workflow explained in the present work entails four major steps which helps in removing the restrictive assumptions about the texture types. The first step deals with a statistical model based on histogram and autocovariance functions to extract textural parameters from the images. This creates a synthetic image which is comparable to the actual, so that representative textures can be extracted.. The second step includes the utilization of high-resolution resistivity values distributed circumferentially around the well bore; where the histogram is being analysed and stacked in various groups based on resistivity variance population. We then calculate an “image sorting index” based on percentile distribution from the resistivity histogram. The variations in image sorting index is similar to the grain size sorting in clastic rocks in an outcrop. The image sorting index calculation is essentially a simple function of the percentile distribution. The sorting index is independent of the absolute resistivity values and will have a similar response in low resistivity and high resistivity formations as it identifies the changes radially-rather than the values. The third step involves the clustering of high-resolution micro resistivity spectrum to define the conductivity index which is related to the bioturbation. Along with the sorting index, this helps to make the “bioturbation index” for the entire sequence. The fourth step involves using the unsupervised self-organizing map to classify textural parameter and open hole log data in making representative compressive electrofacies models with essence of both geological and petrophysical attributes The presented novel methodology has advantages as it reduces the dependency on having a contextual knowledge about textures from images or from the core. This rules out the possible bias introduced by interpreters and results in a faster output. This procedure generates high resolution image based morphofacies or electrofacies which can be integrated with other advanced wireline logs to assess the complex rock typing in a typical sedimentary sequence. These can improve the accuracy and consistency for multiwell facies mapping in the geomodelling during field appraisal and development.