Improving Well Log Data with Machine Learning: An Application from the Powder River Basin

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Abstract

Log editing is a critical part of every petrophysical workflow where the objective is to recondition well logs for formation evaluation. Unedited logs often provide spurious results, especially in regional projects. In addition to experience in petrophysics, log editing requires proper understanding in several related disciplines including tool physics, drilling practices, mathematics, signal processing and geology. The process is repetitive and tedious, demanding patience and discipline for consistent results. The challenges increase significantly in basins where hundreds of legacy wells, acquired by a variety of vendors with highly varying data quality, must be processed rapidly to meet tight project timelines. Machine learning (ML) based workflows can offer efficient and consistent solutions for log editing, with greater impact in projects involving large numbers of wells.Results from the application of a multi-zone automated ML-based log editing workflow applied to a large data set consisting of hundreds of wells in the Powder River Basin are presented in this paper. The Powder River Basin, located in northeast Wyoming, has seen a significant increase in drilling and production in recent years with a new focus on horizontal drilling in stacked tight oil sands and mudrock reservoirs. Zones of interest for this study include the Niobrara, Mowry, Frontier, and Shannon formations. While the paper focuses on the benefits of using ML, limitations are also discussed to provide a realistic and complete picture of what modern ML algorithms can do. Original log data in this basin suffer from numerous issues leading to bad data quality, notably poor calibration and frequent washouts. A multi-zone (by formation) ML workflow was designed to handle the diversity both in data quality and rock types. An important feature of the workflow is the generation of quality-control metrics to highlight the wells or intervals with higher prediction uncertainties, allowing the expert to focus on the problems. Bulk density, neutron and compressional acoustic logs were edited in a variety of mud and borehole settings, across multiple lithologies. Systematic issues occurred commonly with neutron logs, less often with sonic logs. Density logs were greatly improved in washed-out intervals. The results indicate that the workflow produces consistent and robust results efficiently and is capable of handling logs of different vintages from multiple vendors. Automated recognition and repair of bad data allow the experts to readily judge the utility of the edited data. Such expertise is still needed, but the ML workflow produces better log quality more efficiently than previous, labor-intensive workflows. The edited logs provide a vastly improved basis for formation evaluation, improving confidence in target selection and volumetrics from well log data.

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