Investigating Automated Well Tie Adjustment Techniques with Dynamic Time Warping

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Abstract

The present study was conducted to investigate the efficacy of automated well-tie adjustment techniques through the development of a Jupyter notebook. The well-tying method is used to match a synthetic trace to the seismic trace, providing analysts with the necessary information to identify horizons. To generate the synthetic trace, it is necessary to estimate a wavelet and obtain values of acoustic impedance. The process can be divided into three main steps: data preparation, synthetic trace calculation, and alignment. The well-tying technique is essential for interpreting seismic data in complex areas with significant variations in physical and geological properties. Additionally, it is useful for verifying the quality of seismic data and detecting possible errors or artifacts in data acquisition and processing. Velocity curve smoothing was achieved using Backus averaging algorithm, while the estimation of wavelets for synthetic data production was performed using spectral division and least squares techniques, resulting in enhanced quality and correlation with the seismic trace. The stretching and squeezing phase of the well-tie procedure was performed by the warping path provided by the dynamic time warping (DTW) algorithm. DTW is a method used to measure the similarity between two temporal sequences that may vary in speed, acceleration, or compression. It is commonly used in signal processing and pattern recognition to align and compare time series data, such as speech recognition, handwriting recognition, and image recognition. DTW achieves this by warping one sequence non-linearly in the time dimension, such that it matches the timing of the other sequence as closely as possible while minimizing the distance between the two sequences. The well-tying alignment step can be semi-automated from the warping path, which indicates how the synthetic data can be stretched or compressed to maximize correlation with the seismic data. It is important to note that the distortion may not have physical meaning, so quality control is necessary, analyzing the disturbance in the velocity that would be equivalent to the calculated distortion. The semi-automated alignment between the seismic trace and synthetic data led to a significant increase in correlation from 60% to 93%. The study results demonstrated the utility of the proposed techniques for both the oil and gas industry and academic research in geophysics, as they allow for more precise and efficient analysis of temporal series. The codes will be publicly available at https://github.com/YagoMCastro/AutoTie.git, consistent with the principles of research reproducibility.