Automating Wavelet Adjustment in Well-Tie Process: A Differential Evolution Approach for Enhanced Correlation between Seismic and Synthetic Traces

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Abstract

This research focuses on automating the wavelet adjustment step in the well-tie process using the Differential Evolution optimization method. The aim is to develop new automated techniques and compare them with existing ones in the literature. The initial step involves replicating the results obtained by Gelpi et al. (2020). The primary objective is to determine the optimal phase and frequency parameters of the wavelet, which will enhance the correlation between seismic and synthetic traces. The code used in this project will be made publicly accessible to the academic community. Differential Evolution (DE) is a population-based optimization algorithm that is commonly used to solve complex, nonlinear optimization problems. The algorithm operates by maintaining a population of candidate solutions, each represented as a vector of decision variables. At each iteration, DE generates new candidate solutions by combining existing solutions through a differential mutation operator, which creates a vector that represents the difference between two randomly selected individuals in the population. This mutation vector is then added to a third individual to create a trial solution. The trial solution is then compared to its corresponding target solution to determine whether it should replace the target solution in the population, based on a comparison of their fitness values. DE also employs a crossover operator to ensure diversity in the population and to prevent premature convergence. The algorithm continues to iterate until a stopping criterion is met, such as a maximum number of iterations or a desired level of convergence. We used an implementation of DE provided by Scipy Package. The Differential Evolution (DE) algorithm is applied to determine the optimal wavelet parameters for a synthetic Ricker source wavelet. Furthermore, the DE is also used to obtain the best adjustment on the velocity model that optimizes the correlation between the seismic data and the synthetic. The synthetic trace is obtained by convolving the optimal wavelet with the reflectivity series obtained from the well. The application of Differential Evolution significantly improves the correlation between the synthetic trace and the seismic data, increasing it from 19% to 75%. By automating the process, the goal is to increase efficiency and reduce reliance on the interpretation and expertise of the analyst. The paper also discusses the editing and calibration section for velocity and density, which led to the creation of an algorithm for calculating the Backus average. This algorithm aims to subsample velocity curves obtained by well logs while preserving the petrophysical properties of well data. To promote further research and collaboration, the data generated in this project will be made available in an online repository on GitHub at https://github.com/YagoMCastro/AutoTie.git.