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Application of Artificial Bee Colony Algorithm for Estimation of Reservoir Rock Physics Properties

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Extended Abstract

Summary

It is necessary to have enough data from a reservoir to predict its performance and develop it as accurate as possible. Nowadays, it is a common practice to combine direct and indirect methods to achieve the optimal process of data gathering while considering time, cost and precision. Empirical relationships and optimization algorithms are the two most used indirect methods and recently, numerous researches have focused on the latter one. One of the newest and most powerful optimization algorithms is artificial bee colony (ABC) algorithm. In this paper, we have explained its application for reservoir characterization by estimating shear wave velocity (V_s) using some series of recorded well logs. We have carried out a study on a sandstone and a carbonate reservoir using the ABC algorithm and Greenberg-Castagna relationships. We have chosen three logs among the available ones and used a polynomial to derive their relationship with V_s. In both cases, the ABC has acted more efficiently, indicating that it can be employed to estimate V_s in reservoirs with the lithology similar to the one in our cases when we have no recorded data.

Introduction

Vs is a useful quantity for interpreting seismic data, and is used for identifying lithology and calculating some important mechanical, petrophysical, geophysical and geomechanical properties of the reservoir rock. Hence, it is intended to be measured/caluculated by either direct (e.g. DSI tool) or indirect (e.g. experimental Greenberg-Castagna relationship and artificial intelligence) methods. One of the most novel and robust artificial intelligence algorithms is the ABC algorithm. It is a swarm-based metaheuristic global optimization algorithm based on the behavior of bee colonies when they are looking for food. In addition, one of the most used experimental relationships for predicting Vs is Greenberg-Castagna relationship. The accuracy of these two methods, i.e. the ABC algorithm and the Greenberg-Castagna relationship, to predict Vs in sandstone and carbonate case studies is compared in this paper.

Methodology and Approaches

The ABC algorithm is implemented in 4 phases of initialization, employed bees, onlooker bees and scout bees to find the optimal point in a constraint search. In this study, a first-order multivariate polynomial relates V_s to neutron porosity, bulk density, and P-wave velocity logs, and the objective function is mean absolute error or MAE (based on the values measured by DSI tool) because the data contains numerous spikes. The algorithm is coded and run in MATLAB®. The derived polynomial is then used to estimate another set of data to evaluate its ability to be generalized. A modified form of Greenberg-Castagna relationship is also used to estimate V_s in brine saturated multi-mineral rocks. The values of V_p used in this relationship must be corrected based on fluid saturations by Gassmann's equation. Finally, a comparison between the results of these two methods is made both graphically and quantitatively.

Results and Conclusions

After implementing the written code to our specified problem, we found out that the MAE of the result vector in training phase was 0.023 for the sandstone case and was 0.077 for the carbonate one, therefor, relative errors were in range of [1.3%, 1.7%] and [2.9%, 4%], respectively. In the evaluation phase, the MAEs were 0.028 and 0.070, corresponding to relative errors ranging [1.9%, 2.1%] and [2.5%, 3.6%] for sandstone and carbonate case studies, respectively. On the other hand, the MAEs for predictions obtained from the experimental Greenberg-Castagna

relationship were 0.043 and 0.091 for sandstone case and carbonate one, respectively. From these results, it can be concluded that the ABC algorithm is capable to be used for the purpose of our study here. Hence, these obtained relationships for predicting V_s can be used in other reservoirs with the same lithology in the lack of measured data.