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Application of optimization and parameterization algorithms for the integration of seismic and well logging data in the process of building and updating lithofacies models.

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Extended Abstract

Summary

In this research, integration of well logging and 2D/3D seismic data in the reservoir lithofacies modeling process has been considered. For this purpose, two methods from the so-called seismic matching loop class have been used. In the first method, the particle swarm optimization (PSO) algorithm is implemented to find the optimal value of the probability perturbation method (PPM) deformation parameter. The PPM is used to convert an N-parameter optimization problem to a problem with one parameter. In the second method, in the absence of parametrization methods, the problem of updating lithofacies models will be considered as an optimization problem with the N-unknown parameter. Obviously as the number of optimization unknown parameters increases, the optimization algorithms ability in finding the optimum solution decreases. One way to overcome this problem is to design optimization algorithms with higher capabilities. In the second method, an attempt has been made to establish a proper balance between the exploration and exploitation capabilities of the optimization algorithm. In this research, the crossover and mutation operators of the genetic algorithm (GA) optimization method have been used to improve the exploration and exploitation capabilities of the PSO and artificial bee colony (ABC) algorithms. To evaluate the performance of the proposed methods, a 3D synthetic reservoir model (reference model) has been used. The obtained results show that reservoir lithofacies models generated by "PPM-PSO", "PSO-GA" and "ABC-GA" methods have 6.65%, 10.44%, and 0.99% mismatches compared with the reference lithofacies model, respectively. To highlight the ability of the proposed algorithms in generating and updating the reservoir lithofacies models, two traditional geostatistical methods have also been applied to the specified problem. The results indicate that using the "PPM-PSO", "PSO-GA" and "ABC-GA" algorithms, respectively, leads to 18.8%, 15.27%, and 24.46% improvement on mismatch values compared to the traditional geostatistical methods. Finally, the performance of "ABC-GA" method has been evaluated on two larger and more complex synthetic reservoir models.

Introduction

The realistic and optimal management of the hydrocarbon reservoirs requires maximum understanding of their characteristics, which can be achieved through the integration of various data sources in the reservoir modeling process. Seismic data, due to its extensive areal coverage and high lateral resolution compared to well-based data, have always been of interest in static property estimation at locations among wells. In order to use more of the seismic data in the facies modeling process, the seismic matching loop approach, which is based on geostatistical techniques and optimization algorithms, can be used. Obviously, by increasing the number of reservoir model grid blocks, the ability of the algorithm to generate the optimal facies model decreases. The main focus of this research is to introduce two approaches to solve this problem. The first approach is the integration of PSO algorithm into PPM, which is a parameterization technique. The innovation of this method is the integration of the PSO algorithm into the PPM to find the optimal value of its deformation parameter. In the second approach, the unknown parameters of the optimization problem are equal to the number of grid blocks in the reservoir model. The innovation of the second proposed method is the integration of the GA crossover operator in the ABC optimization algorithm and the complete elimination of the scout bees phase.

Methodology and Approaches

The first method is the integration of the PSO algorithm into PPM. In this method, the goal is to determine the probability distribution function of facies in each grid block using well logs and seismic data. The innovation of this method is the integration of the PSO into the PPM to find the optimal value of the deformation parameter. The second method is the combination of the GA crossover operator with the ABC algorithm.

The ABC exploration capability is the responsibility of scouts and employed bees, and the onlooker bees are responsible for exploitation capability of the ABC algorithm. In the GA, the crossover operator tries to generate better solutions (offspring) by focusing on the best solutions (parents). Through the integration of this operator into the ABC algorithm, it is expected to achieve some improvement in the exploration capability of the method.

Results and Conclusions

To evaluate the performance of the proposed methods, a 3D synthetic reservoir model has been generated. First, it is assumed that the facies indicator in all the model grid blocks is unknown except in the well locations. In addition to the well logs and P-wave impedance, the average values of porosity, fluid saturation and the elastic properties of the facies are also available. Finally, by comparing the obtained models with the reference model, the performance of the proposed approaches can be evaluated, both quantitatively and qualitatively.