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Non-linear inversion modeling of gravity data using grey wolf algorithm for estimating the depth of a sedimentary basin

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Extended Abstract

Summary

Inverse modeling is a classical tool in applied geophysics that is divided into two forms: linear (for unknown density) and nonlinear (for unknown geometry). In this paper, the gray wolf optimization (GWO) algorithm is employed for the nonlinear inverse modeling of two-dimensional gravity data to assess and estimate the depth of a sedimentary basin. GWO is an artificial intelligence algorithm inspired by the hunting and group behavior of wolves. This algorithm is used to enhance the methods of basement characteristics determination in sedimentary basins inversion modeling. In this method, first, a two-dimensional gravity field data is obtained using data collection techniques and specialized equipment. Then, by employing the GWO algorithm, various parameters of the basement in sedimentary basin model, including depth, shape, and other characteristics, are estimated. The GWO algorithm is used to optimize the inversion modeling process and to obtain the best-fit parameters for the basement model based on the collected gravity data. In this modeling process, a basement is typically represented by a series of adjacent corner blocks arranged together, and then, their thickness is calculated. In order to demonstrate the effectiveness of this method, an inverse modeling of synthetic gravity data with and without noise was performed. As a result, the calculated depth and gravity of the synthetic model showed little deviation from the assumed values due to the defined search range for model parameters and consistently fell within the specified range. Furthermore, the proposed method was employed for inversion modeling of a portion of gravity data from Moghan basin in the northwest of Iran, and consequently, the obtained results were consistent with other relevant studies and the geological understanding of the region. The maximum depth obtained for this sedimentary basin was 2800 meters.

Introduction

Estimating the depth of sedimentary basins is a crucial goal in geophysics, and for this purpose, gravity data inversion is utilized. Non-linear inversion methods can be categorized into two groups: local search methods and global search methods. The primary issue with local search methods is getting trapped in local minima and their dependency on the initial model. Global optimization methods, particularly those based on artificial intelligence algorithms, provide promising alternatives to local search methods since they are not reliant on the initial model and do not require the use of derivative information. In this paper, the GWO algorithm is employed as one of the novel evolutionary algorithms to tackle the non-linear gravity data inversion problem.

Methodology and Approaches

The GWO algorithm is an optimization technique inspired by the collective behavior of wolf packs to solve optimization problems. In this research, the GWO algorithm has been employed for inverting two-dimensional nonlinear gravity data. To validate the algorithm, it has been applied to a synthetic model (containing noise-free data and data with random noise) as well as a real-world model from northwestern Iran (i.e. Moghan region).

Results and Conclusions

Modeling of the gravity data from the synthetic model using the GWO algorithm was performed, and as a result, satisfactory results were obtained. Consequently, the topography of the basement in the synthetic model was accurately reconstructed using this method. Furthermore, the outcomes of applying this algorithm to noisy synthetic data demonstrate its robustness against data noise. Ultimately, the credibility of the proposed approach was tested for inverting and estimating the depth of a real gravity profile in the northwest of Iran, and the results were corroborated as the outcomes of this modeling aligned well with previously published results from this region.