

Comparison of improved particle swarm optimization with Marquardt Algorithm for simulation of sedimentary basin with parabolic density contrast using gravity data

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ABSTRACT

In this paper, Improved Particle Swarm Optimization (IPSO) and Marquardt algorithms are used to estimate the depth of the sedimentary basin, leading to the determination of the basement and simulation of sedimentary basin. In these methods, the sedimentary basin is simulated by using the density contrast that changes parabolically with depth and several prisms aligned with the same width and different lengths. The proficiency of the mentioned algorithms has been investigated by considering a hypothetical sedimentary basin. Depth estimation of the sedimentary basin using the calculated gravity field is performed by both mentioned methods and their results compared. By comparing the observed model parameters range with the calculated value of the model parameters and also by analyzing the misfit between the observed and calculated gravity, we concluded that the IPSO algorithm is a reliable method for estimating the sedimentary basin depth and simulating it. The IPSO algorithm has also been applied for the gravity inverse modeling of a sedimentary basin in the Northeast region of Iran.

Keywords: Marquardt algorithm, IPSO, sedimentary basin, gravity anomaly, 2.5-D rectangular prism

INTRODUCTION

Gravity inversion is a conventional tool that is used for evaluating the structure of sedimentary basins in applied geophysics. The primary aim of the inversion of gravity is to determine the parameters of the subsurface anomalies, for example, amplitude coefficient, location of origin, depth, and parameter of shape. Nowadays, because of the progression of software engineering and artificial intelligence, the developmental algorithm based on collective intelligence is intended to upgrade building forms superior to conventional methods (Kennedy and Eberhart, 1995). Gravity inversion of sedimentary basin basement can be suggested as a 2-D or 3-D issue, depending on the design of the model. The 2-D model is extremely popular and includes the reversal of at least one different profiles along the basin to reach its most extreme depth. While the basin is extended, a typical methodology for the semi 3-D model involves the reversal of several orthogonal profiles with the longest lengths. The 2-D technique considers the anomalous body with an infinite extension that is perpendicular to a gravimetric profile. The literature has suggested different nonlinear modeling approaches for simulating the sedimentary basin:

The construction of sedimentary basin has been simulated using juxtaposed rectangular prisms with specific density (Chakravarthi, 1995; Barbosa et al., 1997; Silva et al., 2006), polygons with arbitrary vertices (Chakravarthi et al., 2001), polynomial functions (Martín Atienza, 2001), or a trapezoid (Rao, 1990). To resolve this ambiguousness in gravity anomaly, the source of an anomaly with a particular density contrast can be assumed to have an appropriate geometric shape (Rao and Murthy, 1978). In order to depict the sedimentary basin with 2-D cross-segment, Bott (1960) utilized the cubic model and Tolwani et al. (1959) utilized

the polygon model. Chakravarthi and Sundarajan (2005, 2007) modeled a 2.5-D sedimentary basin using the Marquardt algorithm and variable density contrast with depth. Additionally, the sedimentary basin was simulated using the cubic density function (García-Abdeslem, 2005), quadratic density function (Gallardo-Delgado et al., 2003), and exponential density function (Cordel, 1973). Karcol (2018) generalized the solution for the gravitational potential and its derivatives of the right rectangular prism with depth-dependent density that can be approximated by an n -th degree polynomial.

The PSO algorithm utilizes the principle of community optimization to solve issues in different contexts and can be used to improve issues that are relatively irregular and change over time. The PSO is used in different fields. Based on the neuro-fuzzy network, an immune PSO for image backlight amends with a functional link was suggested by Lin and Liu (2009). In order to accomplish the threshold of optimality for multi-level image distribution, Zahara et al. (2005) utilized the PSO. Zhang et al. (2010a) suggested a versatile turbulent PSO to the categorization of the magnetic resonance brain image. Samanta and Nataraj (2009) incorporated Artificial Neural Networks (ANN) into PSO and Support Vector Machine (SVM) for fault detection, and results of the PSO were better than genetic algorithm results. A neural network for remote-sensing image categorization was suggested by Zhang et al. (2010b) using the PSO.

The PSO algorithm is a new method that has been effectively utilized in some of the fields of geophysics, such as inversion of self-potential of idealized bodies' anomalies (Monteiro Santos, 2010), gravity assessment of a fault, and estimation of its parameters such as angle of the fault, thickness of the sheet, and left and right distances to