Shahrood University of Technology

JOURNAL OF RESEARCH ON APPLIED GEOPHYSICS

(JRAG)

2016, VOL 2, NO 1

(DOI): 10.22044/JRAG.2016.742

Iranian Geophysical Society - 1975

Sparse inversion of magnetic data in data space, application of the method on the data from Tigh Nou Ab area in south of Birjand

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Received: 24 July 2016; Accepted: 3 October 2016

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Keywords

Magnetic Survey
3D Inversion
Data Space
Conjugate Gradient
Tigh Nuo Ab

Extended Abstract

Summary

This paper introduces a sparse inversion methodology for large-scale magnetic survey data. The minimum support constraint is used in the stabilizer term and leads to models with sharp boundaries. The subsurface under the survey area is divided into a large number of cubes with fixed geometry and unknown susceptibility. In this case, the number of model parameters is much larger than the number of data. Then, transforming from the model space to the data space yields a much smaller system of equations that can be solved quickly. The conjugate gradient algorithm is used to obtain the numerical solution of this system of equations. The proposed algorithm has been applied on a synthetic model consisting of multiple bodies, and also, on real data from Tigh Nuo Ab area in south of Birjand, Iran. Both synthetic and real cases have demonstrated the efficiency of the presented algorithm.

Introduction

Nowadays, inversion algorithms are widely used for the interpretation of magnetic survey data. The associated formulation for the inversion of the data is ill-posed so that regularization is needed. This introduces reasonable stabilizing conditions on the solution and leads to a unique solution. Furthermore, desired characteristics for a reconstructed solution can be obtained by incorporating specific constraints in the stabilization term. Specifically, for potential field data inversion, it is standard to use a compactness constraint introduced by Last and Kubik (1983) or its extension known as the minimum support constraint, which has been developed by Portniaguine and Zhdanov (1999). In this paper, we adopt the use of the minimum support constraint that leads to a model with sharp boundaries and blocky features. For large-scale magnetic data, the inversion process is always challenging and powerful computational algorithm are required to make the solution process feasible. Here, the data-space inversion methodology is used to reduce the computational time.

Methodology and Approaches

The subsurface domain is divided into a large number of fixed cubes with unknown susceptibility values. Here, the number of the cubes is M and the number of the data is N, in which $N << M$. A general objective function that includes the data misfit and stabilizer terms is minimized and yields the regularized inverse solution. Depth weighting matrix and minimum support constraint are incorporated in the stabilizer term, so that the recovered model is not emphasized near the surface and will have sharp boundaries and blocky features. To deal with the non-linearity introduced by the minimum support constraint, a model-space iteratively reweighted least squares algorithm is used. We transform the solution of the inverse problem from the model space to the data space, which leads to a system of equations with dimension $N \times N$ rather than the original $M \times M$. This makes it possible to obtain a solution of the large-scale magnetic inverse problem. Furthermore, the numerical solution of the resulting linear systems is obtained using the conjugate gradient algorithm.

Results and Conclusions

A model, comprising of four different bodies, is used to test the efficiency of the presented algorithm. The data are generated at 3500 stations and are contaminated with random noise. The subsurface domain is discretized into 52500 cubes. The data-space inversion process is completed in less than one minute. The recovered model has sharp boundaries and is close to the original model. Finally, the algorithm is used on magnetic data over Tigh Nuo Ab area located in south of Birjand, Iran. The results show that the subsurface anomaly is extended to a depth of 80 m.