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Interpretation of potential field data using fast sigmoid function filter – A case study: Gol-e-Gohar mine, Kerman Province, Iran

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Extended Abstract

Summary

Determination of the edges of geological structures such as dykes, faults, salt domes, etc., is one of essential issues in the interpretation of gravity and magnetic data. In this paper, to determine the edges and lateral boundaries of buried geological structures, a filter is introduced that has been obtained by combining fast sigmoid function and the horizontal and vertical derivatives of the total horizontal gradient. For this purpose, first, the efficiency and capability of the fast sigmoid function is investigated on gravity and magnetic synthetic models obtained from prismatic buried sources and Bishop synthetic magnetic model, and then, the ability of the filter compared to standard filters such as total horizontal gradient (THDR), tilt angle (TDR), theta map (TM) and tilt angle of total horizontal gradient (TAHD), on the gravity and magnetic field data from Gol-e-Gohar mine located in Kerman Province is investigated. For both synthetic and field models, the fast sigmoid function method has better quality and resolution than other edge enhancement filters and is capable of simultaneously determining the boundaries of gravity and magnetic sources. Therefore, the fast sigmoid function filter can reliably be used in the qualitative interpretation of potential field anomalies and helps to identify the edges of subsurface structures.

Introduction

Gravity and magnetic methods are widely used geophysical methods for understanding the subsurface structures and tectonics. Some of the applications of these methods include mineral resource exploration, hydrocarbon exploration, crustal deformation studies, surface and subsurface structural mapping, etc. Much of the emphasis can be made on the structural feature delineation that helps us to determine the boundaries of various buried geological structures. In this regard, it is significant to determine the horizontal boundaries of these buried sources and to delineate their lateral extents. There are many filters used to determine the edges of potential field anomalies. Each filter has its own advantages as well as limitations. The filters used in this research are total horizontal gradient filter (THDR), tilt angle (TDR), theta map (TM) and tilt angle of total horizontal gradient (TAHD). These filters have been unsuccessful in determination of the boundaries of deep or narrow structures (Pham et al., 2019).

Methodology and Approaches

In this paper, we applied an edge detection filter that is based on fast sigmoid function for balancing the edges of synthetic and real magnetic and gravity sources (Oksum et al. 2021). The fast sigmoid filter (FSF) is defined by equation (1):

$$FSF = \frac{\left(\frac{\frac{\partial THDR}{\partial z}}{\sqrt{\left(\frac{\partial THDR}{\partial x}\right)^2 + \left(\frac{\partial THDR}{\partial y}\right)^2}} \right) - 1}{1 + \left| \frac{\frac{\partial THDR}{\partial z}}{\sqrt{\left(\frac{\partial THDR}{\partial x}\right)^2 + \left(\frac{\partial THDR}{\partial y}\right)^2}} \right|} \quad (1)$$

where $\frac{\partial \mathrm{THDR}}{\partial \mathrm{x}}$ and $\frac{\partial \mathrm{THDR}}{\partial \mathrm{y}}$ are the horizontal derivatives of the total horizontal gradient and $\frac{\partial \mathrm{THDR}}{\partial \mathrm{z}}$ is the vertical derivative of the total horizontal gradient. The fast sigmoid filter is tested on different synthetic gravity and magnetic models in which the gravity and magnetic sources of different properties have been buried at various depths. In addition, the fast sigmoid filter is applied on the field data from an area of the Gol-e-Gohar mine, Kerman Province in Iran, where the edges of the main anomalies are well recognized in this area. All maps and computations in this paper have been carried out using MATLAB software.

Results and Conclusions

Edge detection is a fundamental process in the subsurface structural analysis and interpretation. The accuracy increases with the reduction of noise, making the use of new filters more common. Because the edge enhancement filters are based on the data derivative, they amplify the noise in the data. However, the fast sigmoid filter can equalize the weak and strong signals at the same time and does not bring any false information to the edge map. Moreover, the fast sigmoid filter can establish a good correlation between the edge detection image and the geological map of the study area that can help to draw a structural framework of the area. Finally, the fast sigmoid filter, compared to traditional edge detection filters, has the advantages of higher resolution, removal of false edges and generates subtler geological features.