Received: 9 May 2024 | Accepted: 13 November 2024

DOI: 10.1111/1365-2478.13647

Geophysical Prospecting EAGE EUROPEAN ASSOCIATION OF GEOSCIENTISTS & ENGINEERS

ORIGINAL ARTICLE

Deep learning-based inversion with discrete cosine transform discretization for two-dimensional basement relief imaging of sedimentary basins from observed gravity anomalies

Arka Roy[1] | **Yunus Levent Ekinci**[2,3] | **Çağlayan Balkaya**[4] | **Hanbing Ai**[5]

[1]National Centre for Earth Science Studies, Trivandrum, India

[2]Department of Art History, Bitlis Eren University, Bitlis, Türkiye

[3]Faculty of Applied Sciences, Muş Alparslan University, Muş, Türkiye

[4]Department of Geophysical Engineering, Süleyman Demirel University, Çünür, Isparta, Türkiye

[5]School of Geophysics and Geomatics, China University of Geosciences, Wuhan, Hubei, China

Correspondence
Yunus Levent Ekinci, Department of Art History, Bitlis Eren University, Bitlis, Türkiye.
Email: ylekinci@yahoo.com

Funding information
National Centre for Earth Science Studies; Ministry of Earth Sciences; Earth System Sciences Organization, Ministry of Earth Sciences, Grant/Award Number: (NCESS)

Abstract

Sedimentary basins, integral to Earth's geological history and energy resource exploration, undergo complex changes driven by sedimentation, subsidence and geological processes. Gravity anomaly inversion is a crucial technique offering insights into subsurface structures and density variations. Our study addresses the challenge of complex subsurface structure assessment by leveraging deep neural networks to invert observed gravity anomalies. Optimization approaches traditionally incorporate known density distributions obtained from borehole data or geological logging for inverting basement depth in sedimentary basins using observed gravity anomalies. Our study explores the application of deep neural networks in accurate architectural assessment of sedimentary basins and demonstrates their significance in mineral and hydrocarbon exploration. Recent years have witnessed a surge in the use of machine learning in geophysics, with deep learning models playing a pivotal role. Integrating deep neural networks, such as the feedforward neural networks, has revolutionized subsurface density distribution and basement depth estimation. This study introduces a deep neural network specifically tailored for inverting observed gravity anomalies to estimate two-dimensional basement relief topographies in sedimentary basins. To enhance computational efficiency, a one-dimensional discrete cosine transform based discretization approach is employed. Synthetic data, generated using non-Gaussian fractals, compensates for the scarcity of true datasets for training the deep neural network model. The algorithm's robustness is validated through noise introduction with comparisons against an efficient and traditional global optimization-based approach. Gravity anomalies of real sedimentary basins further validate the algorithm's efficacy, establishing it as a promising methodology for accurate and efficient subsurface imaging in geological exploration.

KEYWORDS

deep neural network, discrete cosine transform, gravity anomalies, density contrast, inversion, sedimentary basin, basement depth

