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# GENERATING LAND GRAVITY ANOMALIES FROM SATELLITE GRAVITY OBSERVATIONS USING DEEP LEARNING IMAGE TRANSLATION

Gravity anomalies are significant for various geophysical and geodetic applications, including mineral and oil exploration, determination of orbits, and the study of geodynamic processes within the Earth among others [1, 2]. The accuracy of gravity anomalies can be increased by improving the accuracy of gravimetric and geodetic measurements and by enhancing the methodology of anomaly detection [3]. Gravity data is collected through ground surveys, and are time-consuming, labor-intensive, and often limited by accessibility issues and instrumentation. Land-based gravity surveys are often expensive and difficult to obtain in remote areas [4]. With the advent of satellite technology, it became possible to collect gravity data on a global scale. However, satellite gravity data often lacks the resolution and accuracy due to the distance from the Earth's surface [5-7]. To overcome this limitation, deep-learning-based image translation techniques can be used to enhance the satellite-based data [8] with some limitations.

Image transaltion is the process of mapping characteristics from one domain to another and is used in remote sensing imagery analysis, movement of soil and rock materials [9]. It involves translating the characteristics of one domain (in this case, satellite gravity data to another domain (ground gravity data). The goal is to leverage the global coverage of satellite data and enhance it with the resolution and accuracy of ground data. The Pix2Pix Generative Adversarial Networks (GAN) model, a type of Generative Adversarial Network known for its image-to- image translation capabilities, presents a novel approach to this challenge. Despite its proven success in various fields, the potential of Pix2Pix GAN for geophysical images, such as gravity anomaly datasets, has not been fully explored. It is used to effectively map gravity anomalies from satellite to ground and adapt the Pix2Pix GAN model for large scale data transformation. The impact of varying patch sizes on model performance is investigated using key metrics to ensure improved accuracy in gravity anomaly mapping. The model used 1376 satellite and 1376 ground Bouguer gravity anomaly images from northern and northeast part of Ethiopia. 2200 images were used for training and 552 for testing. The findings indicate that larger patch sizes, particularly 142x142 pixels, significantly enhanced model accuracy by capturing global features and contextual information. Additionally, models incorporating L2 loss with LcGAN demonstrate superior performance across quantitative metrics compared to those with L1 loss. The study contributes to the improvement of geophysical exploration by providing a method that generates more accurate gravity maps (Fig. 1), thereby enhancing the precision of geological models and related applications.

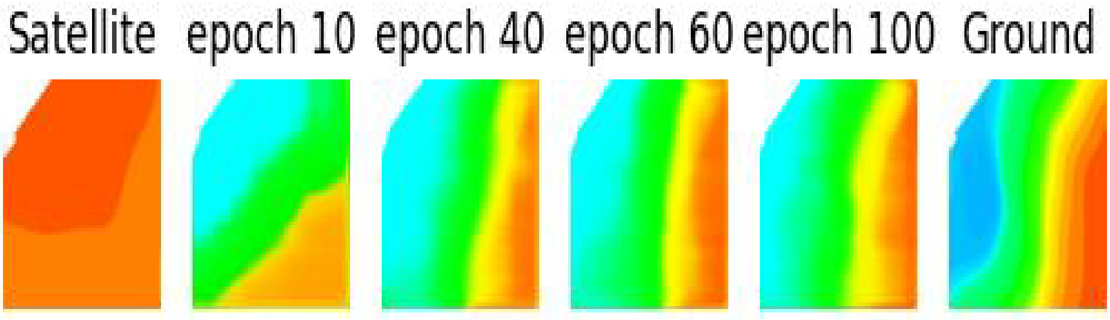


Fig. 1. Training steps for L2 + cGAN with epoch from epoch 5 to epoch 60

**References**

1. L. Luis´ Luis´alvarez-Gaumé and M. A. Vázquez-Mozo, "Anomalies and the Green-Schwarz Mechanism," Nov. 2022. DOI: https://doi.org/10.48550/ARXIV.2211.06467.
2. V. Puškorius, E. Paršeliūnas, P. Petroškevičius, and R. Obuchovski, "An analysis of choosing gravity anomalies for solving problems in geodesy, geophysics and environmental engineering," Environ. Eng., 2020. DOI: https://doi.org/10.3846/ENVIRO.2020.684.
3. S. Hikami, A. I. Larkin, and Y. Nagaoka, "Spin-Orbit Interaction and Magneto resistance in the Two Dimensional Random System," Prog. Theor. *Phys.*, vol. 63, no. 2, pp. 707-710, Feb. 1980. DOI:

https://doi.org/10.1143/PTP.63.707.
4. O. Alaofin, Y. Zhang, J. Sharma, and X. Li, “Cross-Modality Super-Resolution of Satellite Gravity Data for Geophysical Exploration,” Int. Geosci. Remote Sens. Symp., vol. 2022-July, pp. 7539-7542, Jul. 2022. DOI: https://doi.org/10.1109/IGARSS46834.2022.9883035.
5. R. Beránek and J. Mrlina, “Modelling 3D subsurface structures using gravity and enhanced gravity gradient method,” EGU23, Feb. 2023. DOI: https://doi.org/10.5194/EGUSPHERE- EGU23-6032.
6. P.P. KHATRI, R. HONDA, and H. MORIKAWA, “Separation of Gravity Anomaly Data Considering Statistical Independence of Source Signals,” J. Japan Soc. Civ. Eng. Ser. A1 76 (Structural Eng and Earthq. Eng., vol. 69, no. 4, p. I_549-I_558, 2013. DOI: https://doi.org/10.2208/jscejseee.69. i_549.
7. I. Ahmadi, A. Ghorbani, and A.H. Ansari, “3D Gravity Cross-Correlation imaging for large scale data analysis: Application to the Crustal structure of Iran,” J. Earth Sp. Phys., vol. 46, no. 4, pp. 131-145, Sep. 2020. DOI: https://doi.org/10.22059/JESPHYS.2020.298815.1007197.
8. Y. Zhang, “Deep Learning Based Super Resolution of Gravity Data for Geophysical Exploration,” no. November, 2021.
9. W.W. Choi, S.K. Hong, K.H. Kim, S.J. Park, and M.K. Kim, “A Study on the Cross-domain domain Terminology Mapping Based on Geospatial Information,” Jihyeong gong’gan jeongbo, vol. 30, no. 4, pp. 35-46, Dec. 2022. DOI: https://doi.org/10.7319/KOGSIS.2022.30.4.035.