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Pix2Geomodel: Domain-to-Domain Translation for Nextgeneration Reservoir Geomodeling

Abdulrahman Al-Fakih[1], Ardiansyah Koeshidayatullah[1], Nabil A. Saraih[1], Tapan Mukerji[2], Rayan Kanfar[3], AbdulMohsen Alali[3], and SanLinn I. Kaka[1]

[1]Geosciences Department, College of Petroleum Engineering and Geosciences, King Fahd University of Petroleum and Minerals, Building 76, Dhahran, 31261, Saudi Arabia.
[2]Departments of Energy Science & Engineering, Earth & Planetary Sciences, and Geophysics, Stanford University, Stanford, CA,94305, USA
[3]EXPEC Advanced Research Center, Saudi Aramco, Dhahran, Saudi Arabia

Abstract

Accurate reservoir modeling is essential but challenging due to the complexity of subsurface heterogeneities and the integration of observational data. We introduce Pix2Geomodel, a novel conditional generative adversarial network (cGAN) framework based on Pix2Pix, designed to predict key reservoir properties, including facies, porosity, permeability, and water saturation, in the Groningen gas field's Rotliegend reservoir. The framework utilized a large dataset (7.6 million grid cells) provided by Nederlandse Aardolie Maatschappij through EPOS-NL, undergoing preprocessing and augmentation to create 2,350 images per property. Training involved a U-Net generator and a PatchGAN discriminator over 19,000 iterations.

Performance was evaluated using pixel accuracy (PA), mean intersection over union (mIoU), and frequencyweighted intersection over union (FWIoU). Results indicated high accuracy for facies (PA 0.88, FWIoU 0.85) and water saturation (PA 0.96, FWIoU 0.95), with moderate success for porosity and permeability. The property-to-property translation task, especially facies-to-water saturation, showed excellent performance (PA 0.98, FWIoU 0.97).

Beyond its application in static modeling, Pix2Geomodel can serve as a core enabler for Live Earth Modeling by rapidly updating subsurface models in response to new data streams. Its ability to capture spatial variability and geological realism—validated through variogram analysis and monitored training loss curves—positions it for integration with real-time data acquisition systems. This would allow near-instantaneous adjustments to reservoir models, enhancing decision-making in production optimization, drilling, and reservoir management. Although Pix2Geomodel significantly improves upon traditional methods, limitations include microstructural variability and the 2D modeling constraint, suggesting future enhancements such as multimodal integration and 3D modeling in Pix2Geomodel v2.0. This study highlights the potential of generative AI in reservoir geomodelling, supporting both improved reservoir management and real-time, continuously updated Live Earth Modeling workflows.