Integrating GNSS and Gravity Data with Machine Learning to Improve Geoid Modeling Accuracy in Sri Lanka

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SUMMARY

Reliable height determination is essential for geodetic, engineering, and land management activities. In Sri Lanka, the conversion of GNSS-derived ellipsoidal heights to orthometric heights remains challenging due to variations in the local gravity field and the absence of a high-resolution geoid model. This study aims to develop an improved local geoid model by integrating GNSS and gravity data through advanced machine learning techniques. Gravity-derived undulation values were extracted from the XGM2019e_2159 global gravity model (ICGEM), while GNSS/orthometric undulation data were computed from established national control point networks. A Gradient Boosting Regressor (GBR) algorithm was used to model the nonlinear relationship between gravity anomalies and geoid undulations. The model was trained using 3,425 control points (80% of the dataset) and tested on 857 points (20%). The results achieved a root mean square error (RMSE) of ±0.080 m for the training dataset and ±0.085 m for testing, with 97% of test points within ±0.200 m. These findings demonstrate the potential of machine learning to enhance geoid model precision, particularly in regions with limited gravimetric coverage. The study supports the establishment of a refined national geoid model for Sri Lanka to improve GNSS-based elevation accuracy and support national spatial data infrastructure development.