Validation of Short-Term GPS PPP Multipath Mitigation Using Machine Learning

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SUMMARY

Short-term multipath represents a dominant error source in high-precision Global Navigation Satellite Systems (GNSS) positioning, yet its stochastic nature challenges conventional mitigation techniques. This study presents a machine learning (ML) framework for predicting both code and carrier phase multipath corrections, using multipath hemispherical map (MHM) outputs derived from Precise Point Positioning with Ambiguity Resolution (PPP-AR) solutions at high-rate Global Positioning System (GPS) stations. The models use satellite azimuth and elevation, together with trigonometric transformations of azimuth, to characterise short-term multipath behaviour. Optional sample weighting based on PPP-derived elimination rates is applied during training to prioritise high-confidence observations. Independent Random Forest models are trained and validated per station, providing a realistic assessment of short-term multipath modelling capabilities. For stations with abundant and consistent observations, the ML models capture multipath trends effectively, achieving sub-1.5 m root-mean-square error (RMSE) on code multipath predictions and measurable reductions in carrier phase residuals. In contrast, stations with sparse data exhibit limited predictive performance, emphasising the necessity of representative training datasets for robust ML-based mitigation. These results demonstrate that data-driven approaches can complement traditional MHM corrections, delivering fine-grained, high-resolution multipath mitigation. By integrating station-specific ML predictors, next-generation GNSS receivers and PPP services could achieve adaptive multipath correction, particularly in challenging environments where short-term multipath dominates. Overall, this work shows that ML-based multipath mitigation is feasible, scalable, and capable of providing measurable accuracy improvements in high-rate GPS observations. The findings provide a foundation for further research into real-time implementation, advanced feature engineering, and the integration of ML corrections into operational GNSS workflows.