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An Improved Approach for Tackling Signal Interruptions in Real-time Precise Point Positioning

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GNSS precise point positioning (PPP) requires continuous carrier phase observations to achieve a converged solution of high-precision. However, this continuity cannot be always guaranteed due to obstructions, such as trees, buildings and bridges, especially in urban environment. To precisely correct cycle slips caused by signal interruptions is crucial for recovering the data continuity. Although a number of studies have been carried out, it is still a challenging issue in real-time PPP.

Most of the existing approaches are based on the fact that the atmosphere delays change slowly and can be well predicted for the data after the signal interruption. Usually, they either estimate the cycle slips satellite by satellite separately, or employ only one epoch data after the interruption by using the epoch-differential observations.

In this study, we propose a new but easily realized approach to precisely determine the cycle slips. The cycle slip parameters are introduced and estimated together with the standard PPP parameters, such as position, receiver clock, and ambiguities in the case that possible cycle slips are detected. Then, the LAMBDA method is applied to the cycle slip parameters to obtain their best integer estimates. In the cases it fails to fix the whole cycle slip vector, the concept of partial ambiguity resolution is employed to repair as many cycle slips or their linear combinations as possible. Subsequently, the integer estimates of the partial resolution would be used as tight constraints to improve the remaining parameters. In order to reduce the probability of wrong fixing, a strict integer validation threshold is suggested. As a result, it is usually not easy to fix all cycle slips with only one-epoch data, the new approach is extended for using multi-epoch observations to enhance the cycle slip estimation. Once the cycle slips are correctly determined, continuous PPP positioning can be achieved instantaneously.

The new approach is tested and validated with GPS+GLONASS data at a number of IGS stations, and data of a moving vehicle. The results show that the proposed approach can correctly determine almost all the cycle slips with about 1.5 epochs of observations on average. Consequently, the positioning performance is significantly improved.