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A Novel Algorithm for Cycle Slip Detection and Repair

U. Sezen (1) and F. Arikan (2)

(1) Hacettepe University, Ankara, Turkey (U.Sezen@ee.hacettepe.edu.tr), (2) Hacettepe University, Ankara, Turkey (arikan@hacettepe.edu.tr)

Accurate and reliable estimation of ionospheric parameters are very important for correct functioning of communication, navigation and positioning satellite systems. In recent years, dual-frequency GPS receivers are widely used for estimation of Total Electron Content (TEC), which is defined as the line integral of the electron density along a ray path. Since both electron density and TEC are functions of solar, geomagnetic, gravitational and seismic activity, any disturbance along the ray path can be detected using GPS receiver observables. It is observed that, with the development of recent sophisticated receivers, disruptions due to the receiver antenna, hardware or outside obstructions are minimized. Most of the observed sudden disturbances are signal phase lock losses due to ionosphere. These sudden phase shifts are named as cycle slips and if not corrected, they may lead to positioning errors or incorrect TEC estimates. There are many methods in the literature that deal with cycle slips and their repairs, yet these methods are not matured to detect all kinds of cycle slips. Most algorithms require double differencing, and/or complicated Kalman Filters, Wavelet transforms, Neural Network models, and integration of external INS systems. In this study, we propose a fast and efficient algorithm for identifying the cycle slips on individual observables, classifying them for future investigations and finally repairing them for more accurate and reliable TEC estimates. The algorithm traces the pseudorange and phase observables and computes the geometry free combinations of L4 and P4. The sudden disturbances on L1, L2, P1, C1 and P2 are classified and noted for further use. Most of the cases, the disruptions are on phase observables, yet for a few occasions, a sudden disturbance is also observed on pseudorange observables. The algorithm, then, checks the epoch section where P4 exists continually. When a disruption on L1 or L2 occurs, it becomes evident on L4. When P4 and L4 sections are compared with each other, with the use of a common base, the sudden disruptions up to three epochs can be corrected using second order interpolation. For disruptions that continue for more than three epochs are considered to be separate sections and treated within that epoch section. Any cycle slip occuring within an epoch section is corrected efficiently using thresholds based on cumulative mean of the derivatives. With the efficient repair of cycle slips, Slant TEC (STEC) values can be reliably estimated, and by categorizing the cycle slips with respect to the observables, satellite and epoch, the reason of disturbance can be identified. The cycle slip detection and repair algorithm is incorporated into the web version of IONOLAB-TEC and they can be reached presently from the site www.ionolab.org.

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