Development and evaluation of GPS satellite orbit and clock near-realtime estimation algorithm

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For realtime precise positioning by GPS, it is necessary to provide high precision satellite orbit and clock that can be utilized immediately after the observation. One of currently available precise realtime satellite orbit and clock is IGS (International GPS Service) Ultra-Rapid products. Though it is delayed about a half day and is restricted to use because of its time resolution and precision. So we have developed a near-realtime algorithm to estimate high precision GPS satellite orbit and clock.

In the algorithm, using zero-difference ionosphere-free carrier phase as the basic observable, satellite orbit and clock are estimated by Extended Kalman Filter (EKF). Tropospheric delay (zenith total delay and horizontal gradient) and receiver clock of station are obtained as well. As option, it can provide earth rotation parameters. Carrier phase biases are estimated as float values. If cycle-slip detected, phase bias resets into initial guess value. To correct model non-linearity and improve accuracy by repeated filter, backward and iterated filter functions are provided.

In the observation model, the following corrections are incorporated : satellite antenna phase center offset, receiver antenna phase center offset/variation, relativistic effects, phase-windup effect, site displacement by earth tides, and sub-daily variation of earth rotation parameters. As satellite orbit model, it considers geo-gravity (JGM3), moon and sun gravity as point mass, and Solar Radiation Pressure (SRP) forces. CODE SRP model is employed as default and its 6 parameters are estimated. For quality control, it provides outlier detection and elimination by residual check and satellite or station exclusion by residual average and outlier rate check.

We implemented the algorithm described above as Matlab programs and evaluated estimation accuracy and performance.

Using IGS 36 stations' observation data as input, satellite orbit and clock were estimated. As a priori states of satellite orbit and clock, broadcast ephemeris were used. Station positions were fixed to ITRF2000 (IGS00) positions. Compared with IGS Final products, the RMS errors of results were below 9 cm (3D) as satellite position and 0.2 nsec as satellite clock bias. Tropospheric zenith total delay and receiver clock bias RMS errors were below 6 mm and 0.2 nsec respectively.