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Real-time GPS Satellite Clock Error Prediction Based On No-stationary Time Series Model

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Analysis Centers of the IGS provide precise satellite ephemeris for GPS data post-processing. The accuracy of orbit products is better than 5cm, and that of the satellite clock errors (SCE) approaches 0.1ns (igscb.jpl.nasa.gov), which can meet with the requirements of precise point positioning (PPP). Due to the 13 day-latency of the IGS final products, only the broadcast ephemeris and IGS ultra rapid products (predicted) are applicable for real time PPP (RT-PPP). Therefore, development of an approach to estimate high precise GPS SCE in real time is of particular importance for RT-PPP. Many studies have been carried out for forecasting the corrections using models, such as Linear Model (LM), Quadratic Polynomial Model (QPM), Quadratic Polynomial Model with Cyclic corrected Terms (QPM+CT), Grey Model (GM) and Kalman Filter Model (KFM), etc. However, the precisions of these models are generally in nanosecond level. The purpose of this study is to develop a method using which SCE forecasting for RT-PPP can be reached with a precision of sub-nanosecond.

Analysis of the last 8 years IGS SCE data shown that predicted precision depend on the stability of the individual satellite clock. The clocks of the most recent GPS satellites (BLOCK IIR and BLOCK IIR-M) are more stable than that of the former GPS satellites (BLOCK IIA). For the stable satellite clock, the next 6 hours SCE can be easily predict with LM. The residuals of unstable satellite clocks are periodic ones with noise components. Dominant periods of residuals are found by using Fourier Transform and Spectrum Analysis. For the rest part of the residuals, an auto-regression model is used to determine their systematic trends. Summarized from this study, a no-stationary time series model can be proposed to predict GPS SCE in real time. This prediction model includes: linear term, cyclic corrected terms and auto-regression term, which are used to represent SCE trend, cyclic parts and rest of the errors, respectively. Based on the numerical computations, the SCE predicted precision may reach 0.5ns, using the IGS final products as reference.