The baseline-length dependence of the performance of short-term integer ambiguity resolution in GPS/GNSS carrier-phase positioning

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Abstract: _ This study investigates the baseline-length dependence of the theoretical success rate of the short-term and reliable integer ambiguity resolution in GPS/GNSS carrier-phase relative positioning. The (single-differentiated) ionospheric delay is regarded as an error under the condition of the non-zero-long baseline with regard to a reference receiver and a rover one.

The calculation result shows that the few-millimeter ionospheric-delay error largely degrades the success rate, where the delay is represented as the retardation length of the signal propagation at GPS-L1 frequency, i.e., the one-millimeter delay corresponds to 0.006 slant-TECU.

Introduction and background

The realization of the simultaneous short-term and reliable initialization, or integer ambiguity resolution, is indispensable in the real-time and highly precise carrier-phase satellite positioning such as real-time-kinematic (RTK) GPS. Although this kind of positioning has been employed in the practical field of survey, the resolution often suffers from long initialization time or large error rate under some actual conditions, and furthermore, this problem seems not to have been thoroughly investigated either experimentally or theoretically.

On the other hand, the several-kilometer length of the baseline is empirically known to degrade these performances of resolution considerably, and some spatially-interpolating techniques based on the network of reference receivers have been developed to mitigate the degradation.

Calculation and result

This study used fixed-sample and parametric statistical optimal decision and calculated the maximized success rate of integer ambiguity resolution (K. Kondo, 2003). The (single-differentiated) ionospheric delay is assumed to be statistically distributed, and its variance is presumed to be roughly equal to the length of the baseline multiplied by the coefficient of 10^-6.

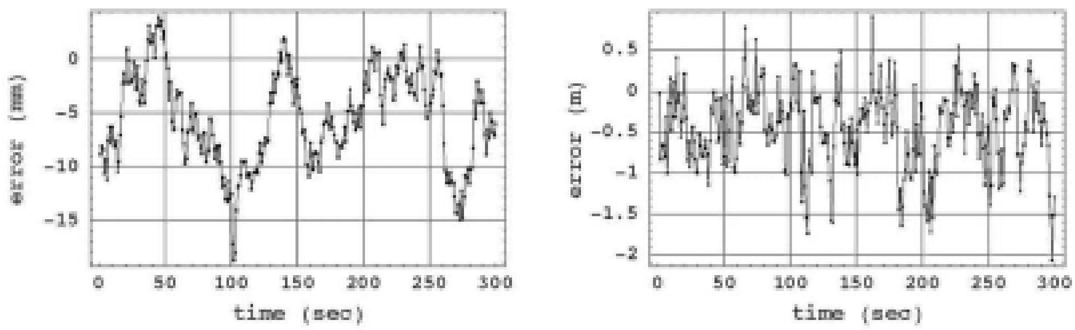
The conditions of the calculation were based on the data collected in experiments done in urban environments (K. Kondo, 2001), where the errors in the measurements were strongly time-correlated and large. These errors were modeled as the sum of the first-order-autoregressive-process term and stationary one, and examples of the simulated error are shown in Figure 1. Table 1 summarizes the conditions of the calculation. Ten-epoch, i.e., ten-second measurements were used to investigate the short-term resolutions. The satellites' constellation and its movement were calculated by using a broadcast ephemeris.

The calculation result, Figure 2, indicates that the few-millimeter increase in (single-differentiated) ionospheric delay degrades the success rate considerably under each frequency's condition. It also indicates that the high reliability of 10^-6 error rate will be attainable under the condition of dual/triple frequencies and several-millimeter or less (single-differentiated) delay, which will be roughly estimated to be several kilometers or less of the baseline length.

Future problem: _ A further quantitative study will be required to obtain the detailed statistical correspondence between the (single-differentiated) ionospheric delay and the baseline length.

Table 1: Common parameters of the calculations.

number of satellites	7
variance of error in single-differentiated carrier phase measurements	
• time-varying component	0.02 cycle
• time-constant component	0.02 cycle
variance of error in single-differentiated code pseudorange measurements	
• time-varying component	0.5 m
• time-constant component	0.5 m
AR(1) coefficient in time-varying component	
• carrier phase measurements	0.95
• code pseudorange measurements	0.5
measurement rate	1 epoch/sec
measurement time	10 sec



(a) carrier phase (b) code pseudorange

Figure 1: Simulated errors in observations.

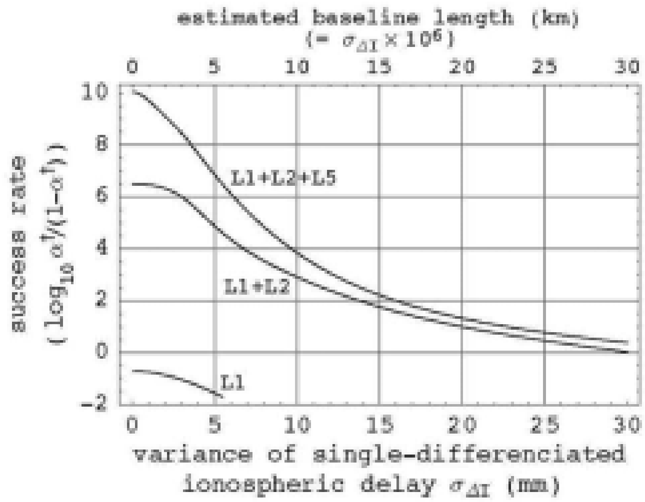


Figure 2: The performances of integer ambiguity resolution.