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ESTIMATION AND VALIDATION OF INTEGER AMBIGUITY IN CARRIER PHASE GPS POSITIONING

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Abstract. *This paper proposes an integer ambiguity estimation and validation method in carrier phase differential GPS/GNSS positioning in order to attain continuous precise positioning. Firstly the mathematical models of the GPS carrier phase measurement and the method of the existing positioning algorithm are briefly reviewed especially by focusing on the integer ambiguity estimation. For the estimation, in this paper, Kalman filter and the LAMBDA (Leastsquares AMBiguity Decorrelation Adjustment) method are applied, and the candidates of the integer ambiguity are obtained. Then the sequential probability ratio test is applied to select, with a given probability, the most likely integer ambiguity. Results of experiments by using real receiver data are also shown.*
Keywords: GPS, GNSS, Integer ambiguity, Kalman filter

1. **Introduction.** In this paper, a method of the estimation and validation of the integer ambiguity in the carrier phase GPS/GNSS (Global Positioning System/Global Navigation Satellite System) is studied. By using two or more receivers, the positioning method is able to provide high accuracy (sub-centimeter level) positioning results as a relative position from known to unknown positions with so-called double differenced carrier phase measurements of the GPS signal [1]. Generally, measuring the phase of the incoming carrier signal from a satellite involves the ambiguous whole cycles, because a GPS receiver cannot distinguish one carrier cycle from another. These cycles always take integers, thus they are called "integer ambiguity" and it is constant as long as the receiver tracks the signal continuously. Once the integer ambiguity is correctly resolved, it can be completely removed from the carrier phase measurement. Therefore the ambiguity resolution is one of the most important keys to hold the positioning accuracy high.

The ambiguity resolution, in this paper, consists of the following three steps. First, with an appropriate state equation, the real-valued estimate of the integer ambiguity is obtained by Kalman filter as $\hat{\boldsymbol{n}}$. Next, the integer solution is searched around the real valued estimate. In this step, the LAMBDA (Least squares AMBiguity Decorrelation Adjustment) method [2, 3, 4] which is known to be an efficient tool for searching the integer solution is utilized. The last step is the validation of the estimated integer ambiguity. There are various integer ambiguity validation methods based on statistical theory, e.g. [5, 6, 7, 8]. One of the most popular and simple methods is based on the ratio of the least-squares residuals of the second best estimate to the best solution. Also in [6, 7], the probability that the estimated ambiguity is correct ambiguity is approximately evaluated. However it is also reported that specifying an appropriate threshold for judging the best solution $\check{\boldsymbol{n}}_1$ as the correct integer is a difficult problem.