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ORIGINAL ARTICLE

Variance reduction of GNSS ambiguity in (inverse) paired Cholesky decorrelation transformation

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Abstract It has been discovered that (a) the variance of all entries of the ambiguity vector transformed by a (inverse) paired Cholesky integer transformation is reduced relative to that of the corresponding entries of the original ambiguity vector; (b) the higher the dimension of the ambiguity vector, the more significantly the transformed variance will be decreased. The property of variance reduction is explained theoretically in detail. In order to better measure the property of variance reduction, an *efficiency factor* on variance reduction of ambiguities is defined. Since the (inverse) paired Cholesky integer transformation is generally performed many times for the GNSS high-dimensional ambiguity vector, the computation formula of the efficiency factor on the multi-time (inverse) paired Cholesky integer transformation is deduced. The computation results in the example show that (a) the (inverse) paired Cholesky integer transformation has a very good property of variance reduction, especially for the GNSS high-dimensional ambiguity vector; (b) this property of variance reduction can obviously improve the success rate of the transformed ambiguity vector.

Keywords Ambiguity decorrelation · Variance reduction · (Inverse) paired Cholesky integer transformation · Efficiency factor · Success rate

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Introduction

In high-precision GNSS relative positioning, the double-differenced carrier-phase observations exist unknown integers that need to be estimated. Ambiguity fixing has been actively researched over the last two decades, and several methods for resolving GNSS carrier-phase ambiguities have been presented (Teunissen 1993, 1995; Teunissen and Kleusberg 1998; Hassibi and Boyd 1998; Grafarend 2000; Luo and Grafarend 2003; Leick 2004; Hofmann-Wellenhof et al. 2001, 2008). The LAMBDA method is the most popular among these existing methods (Teunissen 1993, 1995; Teunissen et al. 1997; Cai et al. 2009). When the LAMBDA method is applied, identifying best integer ambiguity is a continuous searching process that is treated as an integer least-squares problem (Teunissen 1993)

$$\min_{a}(\hat{a} - a)^{T} Q_{\hat{a}}^{-1} (\hat{a} - a) \tag{1}$$

where $\hat{a}$ is the real-valued solution of the ambiguity vector, a is the true value of the ambiguity vector, and $Q_{\hat{a}}$ is the variance–covariance matrix of $\hat{a}$. In this contribution, the m-dimensional real space is denoted as R^m and the m-dimensional integer space as I^m. Clearly, $\hat{a} \in R^m$ and $a \in I^m$.

When using a non-searching method, such as bootstrapping or return bootstrapping (Zhou and Liu 2006), the ambiguity decorrelation transformation can also improve the statistics of ambiguity success rate (Teunissen 2001). Since the ambiguity success rate is always inversely proportional to the variance of ambiguity (Teunissen 1998, 1999, 2000, 2001; Zhou and Liu 2006), a reduction of ambiguity variance during a decorrelation transformation can increase the ambiguity resolution success rate for the LAMBDA method and the non-searching methods.

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