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ORIGINAL ARTICLE

A new method to mitigate multipath error in single-frequency GPS receiver with wavelet transform

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Abstract One of the major errors in high-precision GPS positioning is multipath. Multipath effect modeling and reduction have been a challenging issue in high-accuracy GPS positioning applications due to its special properties. Different methods have been employed to mitigate this error including hardware and software approaches. We reduce C/A code multipath error by adopting an efficient software method which uses wavelet transform as a basic data processing trend. The key idea of the proposed method is using stationary wavelet transform (SWT) in GPS signal data processing. Since we have used SWT, there is complete access to high-frequency and low-frequency terms in both time and frequency domains, and we can apply appropriated procedures to mitigate this error. The multipath error mostly is a low-frequency term. In our proposed method, the double difference (DD) residuals are applied to the SWT to identify the multipath disturbance. The extracted multipath is then used to correct DD observations. Our experiments include three data sets to investigate the proposed method and compare it with existing algorithms. We used simulations for two of these data sets. The results indicate the efficiency of the proposed method over existing algorithms.

Keywords Mitigate · Multipath error · GPS receiver · Wavelet transform · Least squares

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Introduction

Different error sources such as orbital error, atmospheric biases, multipath error, receiver and satellite clock errors and receiver noise affect GPS positioning. Multipath has been proven to be a limiting error which is considered difficult to deal with. In most GPS applications, surrounding objects cause many signal replicas that create a large multipath disturbances in received signals, causing large positioning errors. The importance of multipath error has led to extensive investigations and implementation of various mitigation methods.

GPS data processing techniques normally use least square (LS) methods in kinematic and static applications. In relative positioning of short baselines, the double difference (DD) method causes some errors to be eliminated or decreased, such as receiver and satellite clock errors, orbital errors and ionosphere and troposphere errors, whereas the multipath error is the main error in DD residual of LS solutions (Mosavi 2006). Multipath errors differ from receiver to receiver and are not correlated. Therefore, this lack of correlation causes the DD technique to be unable to reduce multipath disturbances. Most algorithms for reducing multipath manipulate the DD residual as input signal (Dammalage et al. 2010; Satirapod et al. 2001).

The received signal in a GPS receiver may come from several directions and are referred to as multipath signals. In practice, there are objects near the receiver which create replicas of the signal. These replicas go through a longer path than the original signal causing the large propagation delay for these replicas (Erickson et al. 2005).

If the elapsed time is more than a code chip, the receiver usually can cope with multipath disturbance, and multipath signals have a slight effect on the receiver positioning accuracy. Multipath signals with short delay caused by

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