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ORIGINAL ARTICLE

A new coarse-time GPS positioning algorithm using combined Doppler and code-phase measurements

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Abstract A new coarse-time Global Positioning System (GPS) positioning algorithm based on the use of Doppler and code-phase measurements is proposed and described. The proposed method was demonstrated to be essential for reducing the time to first fix and the power consumption in a GPS receiver. Only 1 ms of data is required to obtain a positioning fix with accuracy comparable to that of the traditional GPS navigation algorithm. The algorithm is divided into two parts. In the first part, the Doppler measurement of the GPS signal is used to determine the coarse user position. With proper constraints, the required time accuracy for the Doppler measurements can be relaxed to be as long as 12 h. In the second part of the algorithm, the accurate user position is calculated by means of the 1 ms code-phase data. The traditional tracking process is no longer necessary in the proposed algorithm. Using the acquired 1-ms code-phase measurement, the positioning accuracy was determined to be approximately a few tens of meters in our experimental results. However, if the data length is extended to 10 ms, the positioning accuracy can be improved to within 10–20 m, which is similar to that of the traditional GPS positioning method. Various experiments were conducted to verify the usefulness of the proposed algorithm.

Keywords Tracking-free processing · Coarse-time positioning · Doppler positioning · Assisted GPS

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Introduction

For a conventional Global Positioning System (GPS) receiver, there are typically three main processes in GPS positioning algorithms: signal acquisition, signal tracking, and positioning, as depicted in Fig. 1. In the acquisition process, two measurements are typically performed, called code-phase measurements and Doppler measurements, which are then sent to the tracking process. The users can decode the navigation messages after tracking the satellite signal for at least 30 s. The navigation messages provide ephemerides, which are used for deriving satellite positions, and the time of week (TOW) counts contained in the navigation message can be used for calculating the fine pseudorange measurements. The position of the receiver can be estimated using both the ephemerides and fine pseudorange measurements. The details of the process of decoding the navigation messages and the traditional positioning algorithms can be found in Parkinson and Spilker (1996) and Misra and Enge (2006). The total time spent determining the receiver position in a cold-start situation is called the time to first fix (TTFF). The tracking process is typically most time-consuming part of the GPS positioning algorithm because of the very low frame rate of the navigation messages. Some discussions about various techniques to decrease TTFF are given in Van Diggelen (2009). Among those, we mention the concept of assisted GPS (AGPS) that is now proved to be an efficient method for reducing TTFF.

Recently, the concept of a software-defined radio (SDR) has found many applications in the manufacturing of satellite navigation devices. In an SDR receiver, the hardware that is typically the radio frequency (RF) front end is mainly used for collecting analog signals and then converting them to digital data. After that, all other

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