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Clock Synchronization Algorithm for Pseudolite

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Abstract. A pseudolite is installed on the ground, which sends the same waves as those from a GPS satellite to enable positioning in locations where it is difficult to receive the waves from GPS satellite, such as between tall buildings, underground, and indoors. The pseudo-range measurement accuracy of pseudolite depends on the performance of clock synchronization between pseudolite and GPS satellites. This paper proposes clock synchronization algorithm for pseudolite. It is a revision and improvement of the time comparison technique based on GPS code transfer in order to determine the UTC.

Keywords: clock synchronization, GPS, pseudolite

1 Introduction

Pseudolite is a contraction of the term “pseudo-satellite,” used to refer to something that is not a satellite which performs a function commonly in the domain of satellites. Pseudolites are most often small transceivers that are used to create a local, ground-based GPS alternative[1].

A pseudolite is installed on the ground, which sends the same waves as those from a GPS satellite to enable positioning in locations where it is difficult to receive the waves from GPS satellite, such as between tall buildings, underground, and indoors. The pseudo-range measurement accuracy of pseudolite depends on the performance of clock synchronization between pseudolite and GPS(Global Positioning System) satellites.

This paper proposes clock synchronization algorithm for pseudolite. The proposed algorithm adjusts clock of psudolite by producing clock error between GPS satellites and pseudolite. It is a revision and improvement of the time comparison technique based on GPS code transfer in order to determine the UTC(Universal Time Coordinated).

The rest of this paper is organized as follows. In section 2, GPS time transfer technique is discussed. Section 3 proposes the clock synchronization algorithm for pseudolite. Finally, we conclude this paper in section 4.

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2 Time Transfer Technique Based on GPS Code Measurement

This section describes time transfer technique based on GPS code Measurement. The most important thing is calculating transmission time of GPS signal from a GPS satellite to a receiver accurately in time transfer based on GPS code measurement. However, there are various sources of errors that alter the accuracy of GPS receivers. The primary sources of errors that degrade GPS performance include satellite clock and orbit errors, atmospheric errors, multipath and receiver error as shown in figure 1.

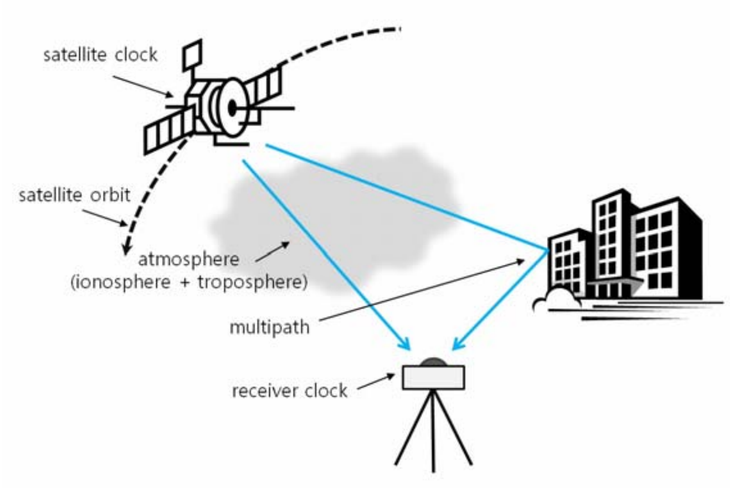

Fig. 1. GPS observation model

Satellite clock and orbit errors:

GPS satellites carry very accurate atomic clocks and follow very precise orbits. But drifts in both clock and orbit are inevitable and very small amount can cause significant errors in a receiver on the ground. Even though their clocks and orbits may not be adjusted, their offsets are computed by the GPS Ground Segment then sent back to the satellites. The satellites then broadcast the clock and ephemeris message to the end-user. There is some latency between the actual occurrence of the offsets and the time they are computed and broadcasted. Depending on the type of differential correction used, the effects of satellite clock and orbit errors can greatly be compensated[2].

Atmospheric Errors:

Atmospheric errors are the most significant source of errors of GPS. With the satellites orbiting at about 20,000km above the earth, the GPS signals have to travel through the ionosphere and the troposphere layers before reaching the receiver antenna. Ionosphere is the collective term for the various layers of ionized particles and electrons found at altitudes of 80–250 km in the atmosphere. Ionization is caused primarily by short-wavelength solar radiation during the daytime. Ionospheric activities have the biggest impact on GPS accuracy.

Another deviation from the vacuum speed of light is caused by the troposphere. Variations in temperature, pressure, and humidity all contribute to variations in the speed of light of radio waves[2,3].

Multipath:

Multipath is the propagation phenomenon that results in radio signals reaching the receiving antenna by two or more paths. Causes of multipath include atmospheric ducting, ionospheric reflection and refraction, and reflection from water bodies, mountains, trees and buildings[2].

Receiver errors:

Despite the synchronization of the receiver clock with the satellite time during the position determination, the remaining inaccuracy of the time still leads to an error. Rounding and calculation errors of the receiver also affect the accuracy.

CCTF(Consultative Committee for Time and Frequency) advocated in its Recommendations S 5 (2001) that the manufacturers of receivers used for timing with GNSS(Global Navigation Satellite Systems) implement the technical guidelines for receiver hardware compiled by the CGGTTS(CCTF Group on GNSS Time Transfer Standards). CGGTTS is an international standard format for time comparison and provides data about clock error with an accuracy of 1 ns or better. These data are achieved by compensating prior mentioned error budget. CGGTTS is generated by GPS timing receivers or can be produced by utilizing RINEX(Receiver Independent Exchange Format) data from geodetic receivers[4,5].

3 Clock Synchronization Algorithm

In this section, we propose clock synchronization algorithm for pseudolite. This algorithm compare CGGTTS from a GPS receiver with CGGTTS from a pseudolite receiver in order to produce clock error between GPS satellite and pseudolite. Figure 2 shows the architecture of the proposed algorithm.

In this process, the same procedure can be applied to pseudolites and pseudolite receivers as in GPS time transfer. By the way, there is no need to consider the errors such as satellite orbit error and atmospheric errors, since puseolites are installed in a fixed location on the ground.

Finally, synchronization station produces clock error between GPS and psueolite by comparison their clock offset and pseudolite can synchronize with GPS by adjusting the clock error.

In the proposed method, it is required to determine data link of pseudolite and to define the format of broadcasting data. And pseudolite receivers which support RINEX data are also required. Thus, it can be considered that a pseudolite itself works as a synchronization station by adopting GPS receiver to the pseudolite.

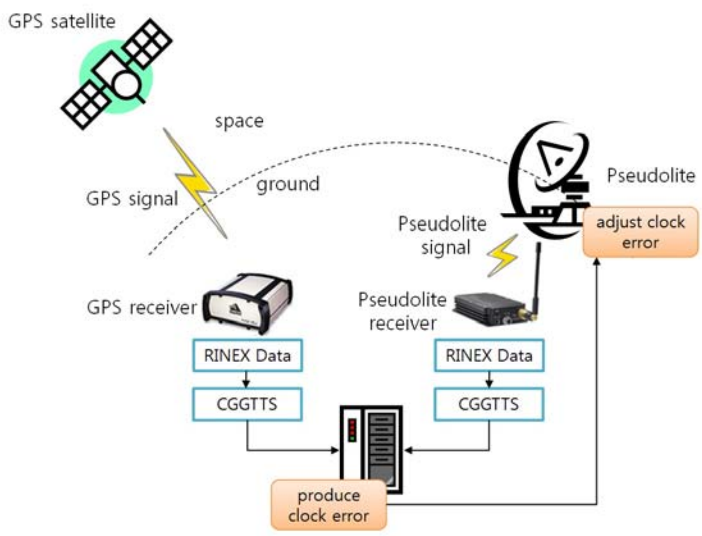

Fig. 2. Architecture of clock synchronization algorithm for pseudolite

4 Conclusions

The pseudo-range measurement accuracy of pseudolite depends on the performance of clock synchronization between pseudolite and GPS satellites. In this paper, we proposed clock synchronization algorithm for pseudolite. The proposed algorithm adjusts clock of psudolite by producing clock error between GPS satellites and pseudolite. It is a revision and improvement of the time comparison technique based on GPS code transfer in order to determine the UTC. As a future work, we consider performance evaluation of the proposed algorithm in a software simulation platform.

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