An Approach to Improving GPS Positioning Accuracy Using Reflected Signals

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1. Introduction

Global Positioning System (GPS) uses the positions and distances of satellites from the receiver (which are called pseudo-ranges when they contain errors) to calculate the position of the receiver. Since there are four unknowns, the receiver's X, Y and Z, and the clock bias, four sets of satellite data are required. Theoretically, the more satellite information we get, the more accurately we can calculate the result. This article develops an approach to improving GPS positioning accuracy by using reflected signals.

2. System Model

The system model is shown in Figure 1. In a simple case, four satellites are available. In addition, we make two assumptions. The first is that the ground is flat and modeled as a Perfect Electric Conductor (PEC) plane so that the reflected signals can be accurately acquired and tracked. The second is that the height of the receiver is known so we can calculate the position equation of the ground and acquire the symmetrical image position of each satellite. Based on these assumptions we can acquire a total of eight satellite positions and pseudoranges instead of four.

3. Simulation and Results

In the simulation we apply 300 seconds of real data from four satellite positions and pseudo-ranges. The data's carrier-to-noise-density ratio is 45 dB-Hz. The initial height of the receiver is 200 m. We use the least-squares approach [1] to solve the four equations to extract the three X, Y and Z unknown coordinates identified as LS-4 in Figure 2. We add the data of the four image satellites' positions and pseudo-ranges which are generated according to the receiver's height. Since the image pseudo-ranges are correlated to the original ones, the same errors are applied to them. Similarly, using the least-squares approach, we solve the eight equations to extract the new three X, Y and Z unknown coordinates identified as LS-8. The dual frequency Real Time Kinematic (Model No. is Trimble MS750) receiver output is used as a reference for the true position. In the LS-8 approach, the root mean square error is 2.88 m, which is a decrease of 80.8% compared to the 15.02 m of the LS-4 approach.

4. Summary

We conclude that by using reflected signals we can significantly increase the GPS positioning accuracy. This is a preliminary result, and there is still further work to be done, including: (1) assuming the receiver height is unknown and estimating it later; (2) considering a in a more complicated ground surface; (3) divide the pseudo-range errors into correlated and white noise errors. These will all lead to a more precise and comprehensive model.

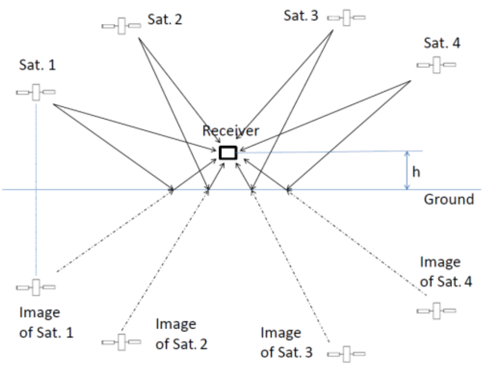

Figure 1. Schematic system model for simulation

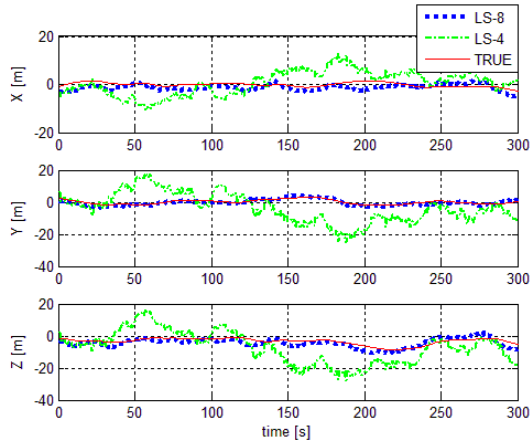

Figure 2. Receiver positions estimated by 3 approaches

Reference

[1] James Bao-yen Tsui, Fundamentals of Global Positioning System Receivers, p.12-15, John Wiley & Sons, Inc., Hoboken, New Jersey, 2005