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Extract of Atmospheric Errors using Pseudo Range Measurement

Ankit Bhalla, Vaibhav and Vaibhav Kaul

Amity Institute of Space Science and Technology, Amity University, Noida, Uttar Pradesh, India.

Abstract

GLOBAL POSITIONING SYSTEM is used in this world to find the position and velocity of aircraft/missile. Satellites have surrounded the earth but still there are some problems we are facing in finding the exact position in civil usage of the GPS. These problems we are facing are either due to the ionospheric, multipath, tropospheric, weather conditions or sometimes due to message delay. Our experiment included calculating the latitude and longitude using a pair of GPS receivers kept at different positions, which were about 150m apart. We recorded a series of data in different weather conditions and calculated the difference in the different readings from two different receivers. We then compared our reading from the Google data available to find the errors and percentage of errors.

Keywords: Global Positioning System, Ionospheric Errors, Multipath Errors, Kalman Filter, Weiner Filter, Clock Error, NMEA Protocol.

1. Introduction

There are many errors in the data when we receive signal at receiver end of GPS. Errors in the Parameters Values broadcast by a satellite in its Navigation. Message, Control segment is responsible. Uncertainties associated with the Propagation medium which affect the travel time from a satellite to the receiver. Receiver noise which affects the precision of a measurement and Interference from signals reflected from surface in the vicinity of the antenna.

1.1 Effect of Atmosphere on the Signal

Atmosphere changes the velocity of the propagation of radio Signals under the process called Refraction. It Changes transit time (Basic measurement from GPS).Transit time takes the curved path due to refraction however, takes the shorter than the straight - line path.

The travel time:-

$$\tau = 1/c \int n(l)\, dl \tag{1}$$

Limits from Satellite to Receiver.

Ionosphere extending from a height of about km to about 1000km above the earth is ionized gases region. The ionization is due to the sun radiation. The Ionosphere is composed of layers at different layers at different height with different rates of production and loss of free electrons. The Ionosphere is generally well behaved in the temperate zones but can fluctuate near the equator and magnetic poles. Reign of highest ionospheric delay is $\pm 20°$ of the magnetic equator. Ionized gas is a dispersive medium for radio waves. The refractive index for a radio wave of frequency f is

$$N_p = 1 - 40.\,3\, N_e / f \wedge 2 \tag{2}$$

N_p is the phase refractive index and Ne is the electron density, f is frequency. From this we can calculate Phase delay, Group Delay. Troposphere also affects in some way or another it contains water vapors and gases. Water vapors extends 4km measured from sea level. The speed of propagation of GPS signals is lower than that in free space. This delay cannot be estimated from GPS measurement.

1.1 1 Ionospheric Propogation Errors

The ionosphere, which extends from approximately 50 to 1000 km above the surface of the earth, consists of gases that have been ionized by solar radiation. The ionization produces clouds of free electrons that act as a dispersive medium for GPS signals in which propagation velocity is a function of frequency. A relatively simple analysis shows that the group delay varies inversely as the square of the carrier frequency. This can be seen from the following model of the code pseudo range measurements at the L1 and L2 frequencies:

$$\rho_i = \rho \pm \frac{k}{f_i^2} \tag{3}$$

Where ρ is the error-free pseudo range, ρi is the measured pseudo range, and k is a constant that depends on the solution for ρ for code pseudo range measurements is

$$\rho = \frac{f_1^2}{f_1^2 - f_2^2}\rho_1 - \frac{f_2^2}{f_1^2 - f_2^2}\rho_2 \tag{4}$$

Where $f1$ and $f2$ are the L1 and L2 carrier frequencies, respectively, and $\rho 1$ and $\rho 2$ are the corresponding pseudo range measurements.

1.1.2 Tropospheric Propagation Errors

The lower part of the earth's atmosphere is composed of dry gases and water Vapor, which lengthen the propagation path due to refraction The troposphere is non-dispersive at the GPS frequencies, so that delay is not frequency dependent. In contrast to the ionosphere, tropospheric path delay is consequently the same for code and carrier signal components.

1.2 Multipath Problems

Multipath propagation of the GPS signal is a dominant source of error in differential positioning. Objects in the vicinity of a receiver antenna (notably the ground) can easily reflect GPS signals, resulting in one or more secondary propagation paths. These secondary-path signals, which are superimposed on the desired direct-path signal, always have a longer propagation time and can significantly distort the amplitude and phase of the direct-path signal.

1.2.1 How Multipath causes Ranging Errors?

To facilitate an understanding of how multipath causes ranging errors, several simplifications can be made that in no way obscure the fundamentals involved. When no multipath is present, the received waveform is represented by

$$r(t) = ae^{j\phi}c(t-\tau) + n(t), \tag{5}$$

2. Experimental Setup

The experimental setup consisted of two GPS receivers of EM-406A family connected via USB cables to two different serial monitor, kept at a distance of about 150m.

The data was collected from the two receiver simultaneously under NMEA protocol using the SIRF demo software. The two sets of data was collected in different weather conditions, the first set of reading was taken in clear weather and the second one in cloudy weather.

2.1 Simulation Result

Table 1: Difference between latitude of receiver 1 and receiver 2.

Mean(degree)	*Receiver 1*	*Receiver 2*
Set 1	*19.1316*	*19.1312*
Set 2	*19.1315*	*19.1312*
Average	*19.1316*	*19.1312*
Data from Google	*19.1336*	*19.1336*
Error %	*0.01*	*.013*

Table 2: difference between longitude of receiver 1 and receiver 2.

Mean(degree)	*Receiver 1*	*Receiver 2*
Set 1	*72.9181*	*72.918*
Set 2	*72.918*	*72.9179*
Average	*72.918*	*72.919*
Data from Google	*72.9154*	*72.9154*
Error %		

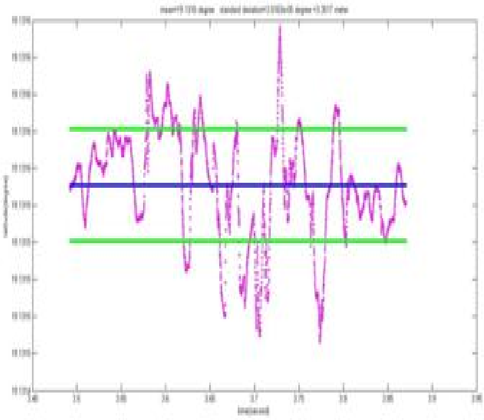

Fig. 1: Latitude v/s time (receiver 1) set1.

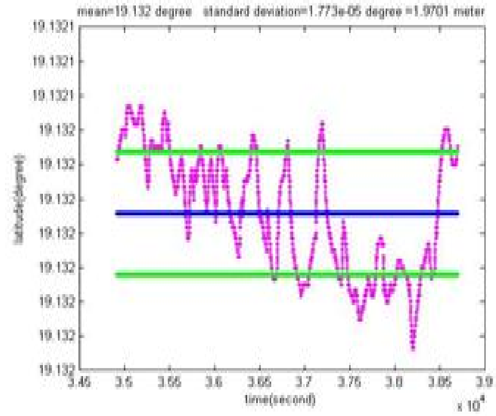

Fig. 2: Latitude v/s time (receiver 2) set1.

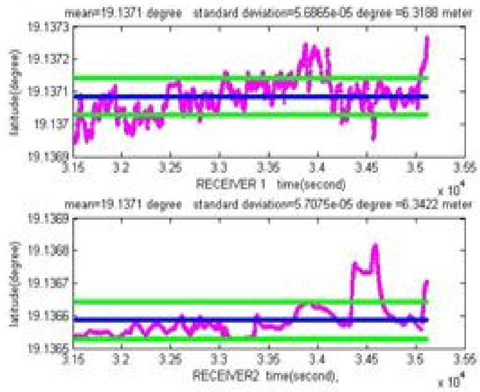

Fig. 3: Latitude v/s time (set 1 and set 2)

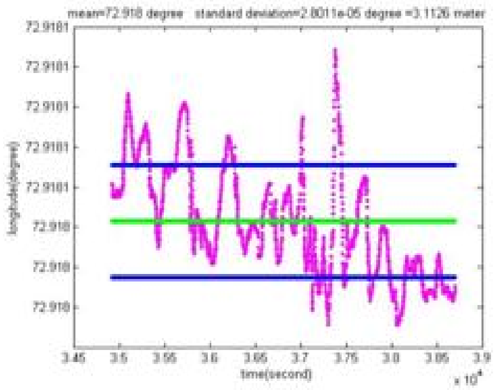

Fig. 4: Longitude versus time (receiver 1)set 1

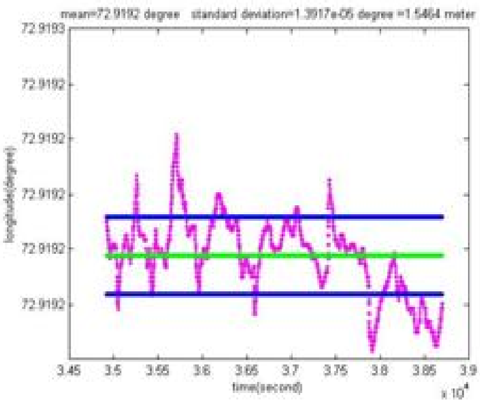

Fig. 5: Longitude versus time (receiver 2) set 1

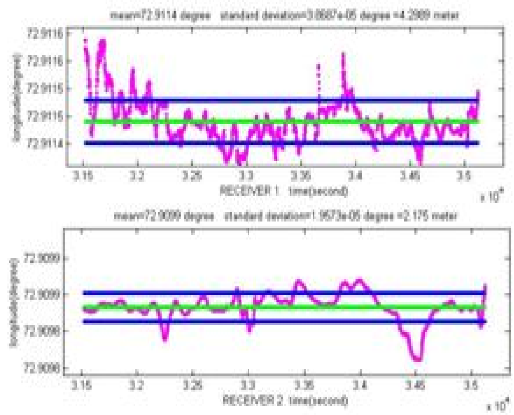

Fig. 6: Longitude versus time (receiver 1 and receiver 2) set 2

3. Conclusion

The main goal of this paper is to establish analysis of atmospheric error at global positioning system receiver end. In this study we have proposed a new tabular chart of global positioning system receiver at Indian institute of Technology Powai. In this paper we are considering constant internal noise factor. Clock error, ephemeris error at receiver end. The simulation results of the experiment are quite promising. Our object in the future is to remove all atmospheric error with the help of filters like extended Kalman filter and wiener filter at global positioning system receiver.

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