Computation of Error Factors in GPS Signals

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Abstract: *The earth's ionosphere acts as a perturbing medium on satellite-based navigational systems like GPS. Irregularities in the ionosphere due to space weather events caused by solar flares and coronal mass ejection can scatter Trans - Ionosphere radio signals producing fluctuations in both amplitude and phase and GPS cycle slips disrupting satellite communications and navigation. The ionosphere delay is one of the main sources of error in GPS precise positioning and navigation. The magnitude of the ionosphere delay is related to the Total Electron Content (TEC) along the radio wave path from a GPS satellite to the ground receiver. A dual-frequency GPS receiver can eliminate (to the first order) the ionosphere delay through a linear combination of L1 and L2 observables. The paper outlines a method allowing to compute the TEC with a precision of about 2–3 TECU and to detect Travelling Ionosphere Disturbances using GPS measurements.*

Keywords: Epoch, GPS, ionosphere, Satellite, TEC.

1. Introduction

The satellite signal slows as it passes through the atmosphere. The GPS system uses a built-in model that calculates an average amount of delay to partially correct for this type of error. A receiver's built in clocks is not accurate as the atomic clocks onboard the GPS satellite. Therefore, it may have very slight timing errors.GPS error is a combination of noise, bias, and blunders. Noise errors are the combined effect of PRN code noise (around 1 meter) and noise within the receiver noise (around 1 meter). Bias errors are the intentional degradation of the SPS signals by a time varying bias [1]. The main objective of this work is to compute the error correction factors in the GPS signals and to develop the data processing software module to fulfil requirements in desired task. In this paper GPS data is processed and graph is calculated using MATLAB tool.

For this GPS equip mental setup is done. A dual frequency GPS receiver can eliminate (to the first order) the ionospheric delay through a linear combination of L1 and L2 observables [2]. Most of the civilians use low-cost single frequency GPS receivers that cannot use this option. Hence for accurate navigation differential GPS is selected. The source of the GPS position error and correcting method, are investigated.

2. Effect of Ionosphere on GPS Signal

The Charged particles in the Ionosphere remove energy from radio waves. Non – Uniform Electron density changes direction of propagation. The carrier phase is advanced and modulation phase is retarded. The polarization is rotated due to Faradays rotation. Ionosphere and Ionosphere Delays – The satellite Signal passes through the atmosphere due to ionosphere changes generates delay [3]. Receiver Clock Errors – Receiver Build in Clock is not accurate as that of atomic clock. Orbital Error - Inaccuracy of the satellites

reported Locations. The TEC in turn depends on the geographic latitude, longitude, local time, season, geomagnetic activity and viewing direction [4]. By forming the linear combination of the GPS measurement on L1 and L2 frequencies, the TEC can be estimated, either by using GPS carrier phase or pseudo-ranges observables. The ionosphere imposes the most detrimental effects on the radio signal passing through it. Dispersive nature of the ionosphere and use of two frequencies in GPS facilitate estimation of ionospheric TEC which is an important parameter in the study of L-Band communication though the ionosphere as in Fig. 2.1.
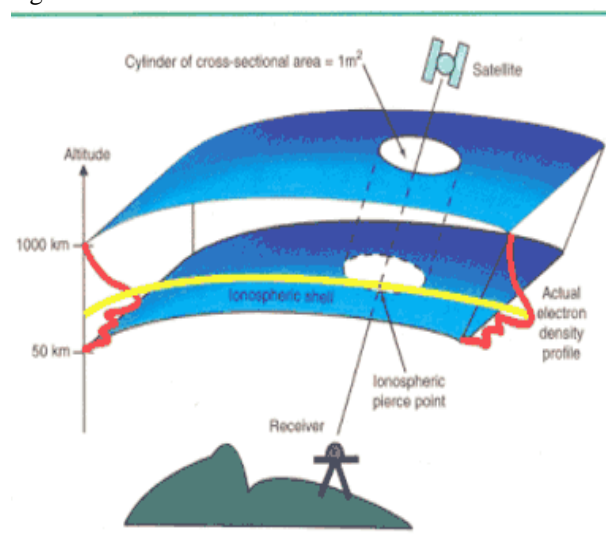

Figure 2.1 The Ionosphere effect on GPS

Rate of TEC (ROT) from GPS can illustrate the features of the ionospheric scintillations. Highly disturbed ionosphere can cause cycle slips in GPS data. Very good correlation is found between the ionospheric scintillations and the number of cycle slips in GPS data.

3. GPS Data Processing

a. Need of differential GPS

A GPS receiver is able to take these signals and determine a position in three dimensional spaces. Standard civilian GPS receivers are accurate to within 25 meters, but the Defence Department reserves the right to distort the satellite signals to reduce this accuracy to about 100 meters. For accurate navigation this distortion can be overcome by using differential systems. A differential system uses an accurate signal from a known location to correct the distorted satellite systems. Differential GPS systems have an accuracy of about 10 meters.

A. GPS equipmental set-up

The receiver equipment consists of an antenna, a receiving unit, a processor, an input/ output device and a power supply shown in Fig.3.1. GPS antennas can be single frequency or dual frequency antennas. The physical design of the antenna can vary from helical coils to a thin micro strip. There are a number of factors that need to be considered for antenna selection such as antenna gain pattern, available mounting area, aerodynamic performance, multipath performance, and stability of the electrical phase censer of the antenna [5].

GPS receivers can either track only C/A codes or both C/A and P(Y) codes. Most receivers have multiple channels, where each channel tracks transmission from a single satellite. There can be a maximum of 12 such channels. The receiving unit forwards the signals to the processor. The processor performs position, velocity, and time estimation from the signals received from the receiving unit. The processor is responsible for issuing commands to the receiving and input/output units.
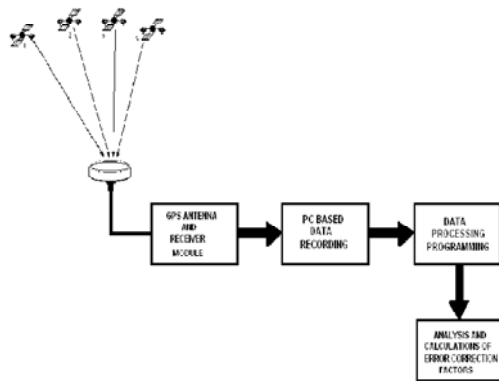

Figure 3.1 Overview of Research Work

The I/O device acts as an interface between the receiver equipment and other user equipment. In most cases the I/O devices is a simple display unit that displays the instantaneous position while in configurations where the GPS is used along with other sensors, the interface could be a RS-232, RS-422 or ARINC 429.

The power supply could be either be external or integrated into the receiver. It may even be a combination of both. Typically, alkaline or lithium batteries are used for integrated

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4. Graphical Representation Of Error Computed

GPS processing starts with time issues. Fig. 4.1 shows the conversion of given epoch, originating from one of the rinex observation files (o-files), to gps week and seconds of week (sow). The time_itr.pdf files which are a text file which gives an overview of relevant timescales and reference frames useful for gps.
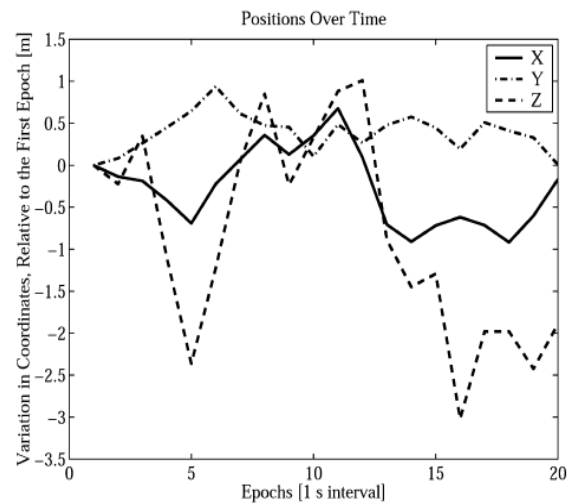

Figure 4.1 Graph 1

The second basic computation is to calculate the position in the earth-centered, earth-fixed frame (ecef) of a given prn at a given time. For a given time and an ephemeris obtained from a rinex navigation message file (n-file), Fig.4.2 does the job. The main function is satpos which is an implementation of the procedure described in the GPS interface. We read a rinex n-file and reformat it into matlab's internal format, namely, a matrix named Eph. Furthermore, we relate each PRN to a column of Eph. Each column contains 21 variables; these comprise a complete ephemeris for one satellite.
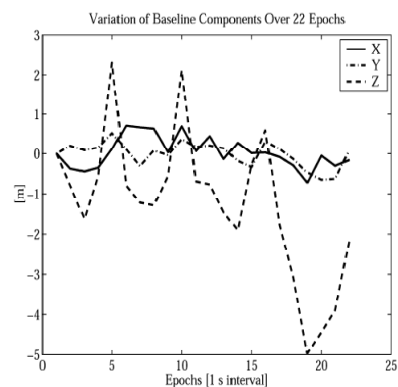

Figure 4.2 Graph 2

In Fig.4.3 we compute a receiver's ecef position from rinex o-and n-files. Only pseudo ranges are used. The computation is repeated over 20 epochs. Each position is the result of an

iterative least-squares procedure. The variation of the position relative to the first epoch is shown in fig. 1. the variation in coordinate values is typically less than 5 m. we open a rinex o-file and read all the pseudo ranges given at an epoch. With given satellite positions from program2, we compute the receiver position.
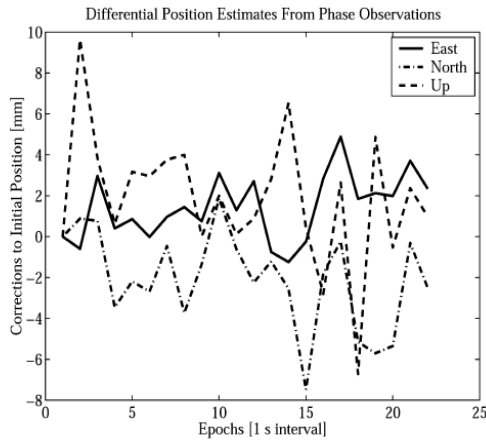

Figure 4.3 Graph 3

The Fig.4.4 file deals with simultaneous observations of C/A pseudo ranges from two receivers. We estimate the baseline between the two antennas and plot the baseline components in Fig. 2. We obtain variations in the components of up to 10 m. So, an antenna point position and a baseline, both estimated from pseudo ranges alone, do have the same noise level. This statement is valid only for observations taken after 2 May 2000.
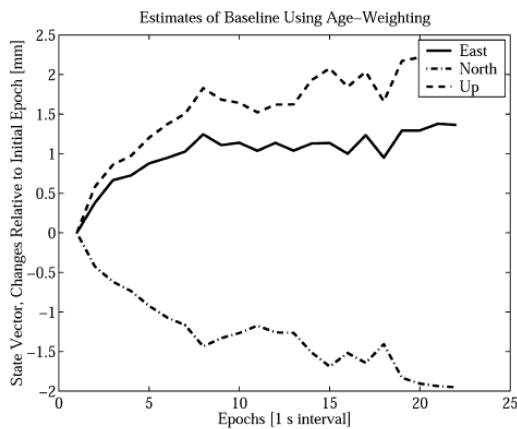

Figure. 4.4 Graph 4

In Fig.4.5 the ''pseudo'' part of the word pseudo range alludes to the receiver clock offset dt. Most often it is a parameter of less interest [6]. However, in certain situations it is desirable to know dt. We supply an algorithm which delivers dt. The actual data yield dt@0.38 ms, as shown in Fig. 5. One can see that the receiver clock is fairly stable over a short period of time.
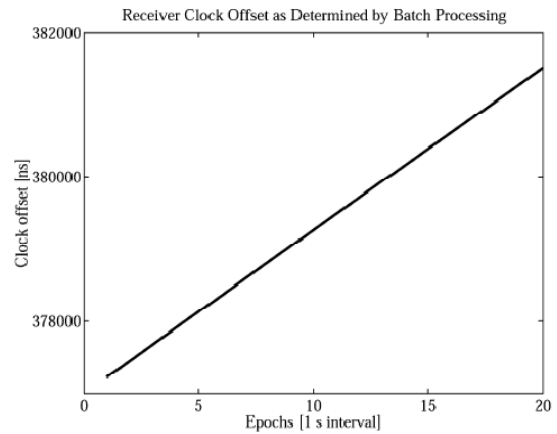

Figure 4.5 Graph 5

Any professional GPS software needs to check for cycle slips and resets of the receiver clock (Fig. 5.6). The reset amount of receiver clock is typically one millisecond, and it influences the pseudo ranges alone, while cycle slips spoil the carrier phase observations. The preliminary data validation can be based on the single differenced observations (i.e., differences between two receivers). The goal is to detect cycle slips and outliers in the GPS single difference observations without using any external information with regard to satellite and receiver dynamics, their clock behavior and atmospheric effects. It is done independently for each satellite [7]. There is therefore no minimum number of satellites required for this so-called integrity monitoring to work. The following is based on an idea by Kees de Jong (de Jong 1998). The dual-frequency single difference measurement model cannot be used directly as it is, since this model is singular. In order to make it regular, a re-parameterization has to be performed.

With the given measurement model and dynamic model, it is possible to detect cycle slips as small as one cycle in the carrier observations, without using any external information, even for relatively large observation intervals (or data gaps).

5. Significance of Research Work

There are many reasons for computations of error corrections factors in GPS signals but some major factors that affect the GPS signals significantly are explained as follows (1) GPS errors are a combination of noise, bias, and blunders. (2) Noise errors are the combined effect of PRN code noise (around 1 meter) and noise within the receiver noise (around 1 meter). (3) Selective Ability (SA) is the intentional degradation of the SPS signals by a time varying bias. SA is controlled by the DOD to limit accuracy for non-U. S. military and government users. The potential accuracy of the C/A code of around 30 meters is reduced to 100 meters (two standard deviations). The SA bias on each satellite signal is different, and so the resulting position solution is a function of the combined SA bias from each SV used in the navigation solution. Because SA is a changing bias with low frequency terms in excess of a few hours, position solutions or individual SV pseudo-ranges cannot be effectively averaged over periods shorter than a few hours. Differential corrections must be updated at a rate less than the correlation time of SA (and other bias errors). (4) Troposphere delays: 1 meter. The troposphere is the lower part (ground level to from 8 to 13 km) of the atmosphere that experiences the changes in temperature, pressure, and humidity associated

with weather changes. Complex models of Troposphere delay require estimates or measurements of these parameters. (5) Ionospheres delays: 10 meters. The ionosphere is the layer of the atmosphere from 50 to 500 km that consists of ionized air. The transmitted model can only remove about half of the possible 70 ns of delay leaving a ten meter un-modelled residual.

6. Conclusion

The signals from the GPS Satellites will be gained by antenna and the receiver assembly. The GPS receiver may contain the inbuilt data recording and storage facility but this recorded data again reformatted and uploaded in the PC (for example-Navigation and Observation Data). This data contains all the terms of the navigational and observational structures of the standards used in the GPS system. The computational task for the algorithm and software for data processing will be implemented in the next step. Finally the obtained results will be analysed and the performance of the system will be observed. The computed error correction factors may be utilized to correct various GPS parameters which will be helpful to obtain the error free corrected GPS data.

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