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A Novel Multipath Estimation algorithm in GPS Receivers under adverse conditions

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Abstract *- The multipath problem still persists in GPS receiver under challenged conditions. The multipath occurs in the GPS receiver due to several reasons may be in the form of recian when LOS present and Rayleigh fading environment when the absence of LOS. In this paper, three multipaths are simulated in the model of Jakes fading simulator and the paths are estimated using the SParse based Singular Spectral Analysis technique (SPSSA). This technique estimates the amplitude and the angle of arrival of the path by converting the raw GPS as a sparse signal then applied the rank-based reduction in the acquisition stage of the GPS receiver. The simulation results confirm the effectiveness of the proposed method by determining the visible satellites in the CAF (Carrier Ambiguity Function) and determines the code phase and doppler effect in precise manner.*

Keywords *- (Size 10, Italic) Component, formatting, style, styling, insert. (atleast 5 to 6 keywords should be mentioned)*

1. Introduction

Multipath fading is the major source for degradation of GPS accuracy and reliability. This becomes paramount importance when the GPS is being used for safety critical applications. Due to radio frequency interference and multipath fading, the radio frequency signals transmitted by Global Positioning Systems (GPS) have very low power and are easily affected by the position error. Multipath fading can lead to poor receiver positioning performance and, if severe, such as in a jamming environment, complete positioning failure. The Multipath signals should be avoided to stop the GPS receiver from giving falsifying information about the user position. There are several stages of removal of Multipath signals in GPS receiver. It can be filtered out either by the GPS antenna or the front-end section of the GPS receiver. The GPS signal processing and navigation algorithms can be modified for the mitigation of the multipath effects. For this, the system has to incorporate sophisticated technique to improve the SNR of the signal for the further processing. There are several methods to resolve the problem illustrated in the literature [1-3,4-7,9,11,12].

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1.1 *Influence of signal and receiver parameters on multipath error*

The way multipath affects the tracking and navigation performance of a receiver depends on a number of signal and receiver parameters. Among them, the most influential parameters
are

- signal modulation types
- Spacing used in the code tracking Correlator
- Type of discriminator used to run the DLL (i.e., nEML, HRC, etc.)
- Code chipping rate
- Number of multipath signals
- Amplitudes, delays and phases of multipath signals with respect to the LOS signal, etc.
- Front-end filter bandwidth (i.e., precorrelation bandwidth)

2. Multipath estimation using SPSSA algorithm

The major objective of this algorithm is to find out the path amplitude and the phase of the paths. Initially the GPS signal in digitized manner is taken as the input from the recian faded model is subjected to the nominal signal. The compressed sensing-based technique [2,8,10] is applied here to convert the sparse signal then in the form of amplitude and the phase parts are obtained. After this step, the second method of estimating the amplitude is determined. The SSA is the recursive method which use the lower rank and

based on this only dominant eigen value of the signal with the help of SVD decomposition is considered then after the significant value of the peaks are observed and this peak amplitude are compared with the specified threshold values. If the number times during the interval the peaks cross the threshold value It is determined as the number of path observables. Similarly, the phase observation is estimated by taking the decomposition of the singular values in the form of upper and lower triangular matrix and the number of rows which are in the upper QR factorization of the triangle leading the diagonal values then it is determined as the number of phase observables, the values which are converted in the form of exponential factor which gives the angle of arrival path that may be inaccurate one so it has to be enhanced with the help of rank restoration technique which preservers the size and the structure of the matrix otherwise it collapses the size which may cause the signal degradation that will be very hard to estimate even number of iterations are equal to the number of samples of the input signal. The flowchart of SPSSA is shown in figure 1. If the observation of the paths is determined then the reacquisition is avoided in the GPS receiver otherwise it enters in to a cold start condition. The position of the receiver is calculated further to reduce the horizontal and vertical positioning error.

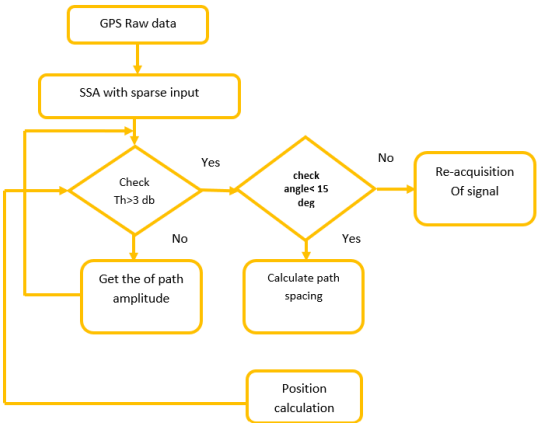

Figure 1: Multipath estimation algorithm using SPSSA

3. Results and discussion

3.1 Determination of GPS faded and reconstructed signal with different SNR values at different paths

To effectively reconstruct the faded signal in GPS receiver the SPSSA algorithm is implemented in GPS acquisition module. Along with the faded GPS signal is tested with a faded SNR values -15dB. The simulations are taken at the regular intervals, for 3 paths using MATLAB. For each and recovered signals the amplitude of the path is plotted in In figure 3 and 4, the simulation results of the multipath affected and sparse reconstructed signal using SPSSA are shown for identifying the satellites 5 and 7 which are indicated as dark reddish in color.

Figure 2 and the acquisition results are shown in Table 1.

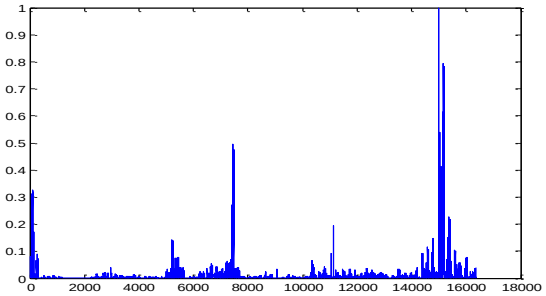

Figure 2: Absolute amplitude crossing the Threshold (3 paths)

If the observation of the paths is determined then the reacquisition is avoided in the GPS receiver otherwise it enters in to a cold start condition. The position of the receiver is calculated further to reduce the horizontal and vertical positioning error.

Table1: Acquisition results

GPS reconstructed Signal using SPSSA			Multipath affected Signal		
Satellite vehicle number	Doppler Frequency (MHz)	Code phase (chips)	Satellite vehicle number	Doppler Frequency (MHz)	Code phase (chips)
5	4.1338	605	5	-	-
7	4.1286	965	7	-	-
15	4.1350	200	15	-	-
17	4.1325	487	17	-	-

Since in the fig 4 are affected by the multipath, it is very difficult to find the visibility of satellites such that it would not give position location properly. In figure 3 using the proposed system, the satellites 5 and 7 are easily visible. Therefore, the visibility has enhanced and this in turn will result better location determination and accuracy of the GPS system.

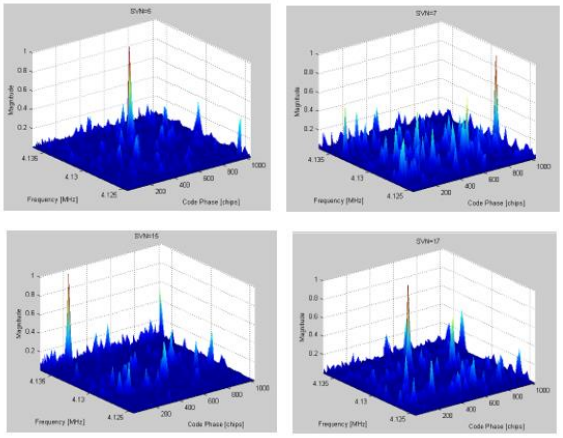

Figure 3: Acquisition output of SVN 5,7,15,17 after Multipath estimation using SPSSA

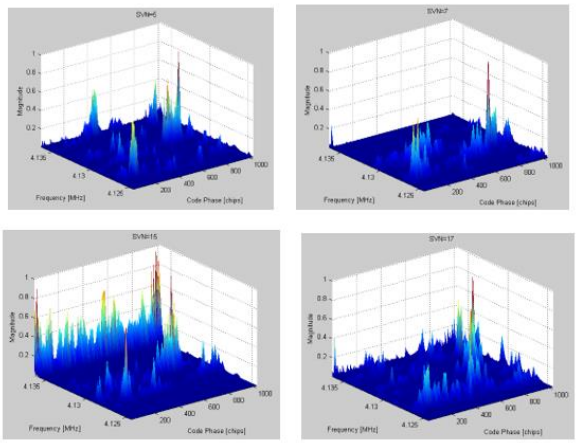

Figure 4: Acquisition output of SVN 5,7,15,17 before Multipath estimation using SPSSA

4. Conclusion

In this paper, a pre-processing GPS software receiver was implemented in MATLAB capable of performing GPS satellite acquisition. The results and discussion show that the proposed system works well in order to obtain the Line of Sight (LOS) or direct path in the indoor environment. The proposed system inherits the compressive sensing based sparse low rank algorithm to mitigate the multipath effects. The SPSSA algorithm implements the linear algebra and vector derivatives concepts by introducing L_1 norm optimization schemes. It effectively degrades the noise and provides the sense of energy packing in the presence of noise without affecting the signal spectrum Thus it can decorrelate the noise and pass the signal without affecting the spectrum. This provides the proposed system to detect the signal which is affected by the multipath fading. After the signal has been detected, it is able to provide the proper detection of satellites at the acquisition stage of GPS receiver.

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