Designing of Jamming-Resistant Global Positioning System Receiver

Rachna Kumari, Mainak Mukhopadhyay

Abstract: ***The Global Positioning System (GPS) that guarantees the perfect location and period data has mostly used steering appliance for several applications. In this paper, Designing of Jamming-resistant GPS system receiver is propose to achieve impartial developments and the parameters are utilized to correctly compute the narrowband signals in the online version. The proposed algorithm can improve the faster convergence rate and improved inference correctness. The experimental results prove that the proposed method employs a good performance compared to the related methods in terms of Mean output capacity.***

Keywords : Convergence rate, Global positioning system, Jamming-resistant, Mean output capacity and signal..

I. INTRODUCTION

Global Positioning System (GPS) guarantees location and period solutions to several real-time applications like military [1]. The satellite which uses the GPS is nearly twenty thousand kilometers long from the earth. The capacity power of the signals used in GPS to reach the earth is low power like -145 dBm [2]. The erroneous frequency band may cause the bad signal with deliberate interference called as jamming. The radio frequency receiver will degrade the received signal from the device GPS. The Jamming signals may be weakening the performance of the GPS based receiver. The Jamming to signal ratio computes the accuracy of the GPS based signal receiver [3].

Moreover, the GPS receivers have various measure of anti-jamming capacity endorsed to the system environment, their performance is reduced haphazardly if the ability of the GPS receiver's anti-jamming ability [4]. According to the bandwidth of the jamming signals, it is classified into narrow-band signals and wide-band signals [5]. The comparatively elevated jamming signals may origin the entire failure of security device on the signals based on the satellite and whole rejection of GPS service [6]. Owing to the spoofing signal's suppression, the authenticated signal power is minimized [7].

The main objective of the paper is

- Global Positioning System (GPS) is developed for capturing the perfect location and period data.
- Create the GPS receiver to overcome the power related jamming attacks.
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- Modify the jamming signal by the way of optimizing the length of the window by improving the Jamming pipe ratio.
- Parallel windowing procedure is used to increase speed of the GPS processing system.
- Finalize the time based filtering system that improves the processing speed with the time based interference system.

This paper is organized as follows. In Section 2, the literature review for the related paper is summarized. Section 3 describes proposed Jamming-resistant GPS system receiver method. In Section 4, the performance of the proposed algorithm is analyzed. Finally, the conclusion of the paper is presented in Section 5.

II. RELATED WORK

A frequency related signal detection algorithm [8] is generated to frequently measure narrow-band interference to establish the power of the output is used to illustrate the Automatic Gain Control. Jamming detection methodology [9] is the important parameter to embrace the anti-jamming techniques and afford the reliability of the GPS solution suggestion. The elevated power interference is computed using the threshold value based on the adaptive detection method with standard deviation of the received signal strength [10].

The adaptive notch filter is used to decompose the received signal strength into the narrow-band interference to be eradicated effectively [11]. Global Navigation Satellite System is a device to analyze the location, velocity and the time globally. The low level signal constructs the receivers to gather the satellite signals [12]. The Power Indication algorithm can be used to eliminate the jamming efficiently but with repeated spoofing method is implemented to design an anti-jamming device [13].

The energy reduced methodology is used to curb the effect of jamming approach in GPS [14]. The spoofing technique is the composite effect of the relationship within the received information from the antennas. The interference development methodologies are framed to improve the spoofing and jamming interference. The dissimilar kinds of members are included in the spoofing capacity of receiving the process by the algorithms. The authentication signal strength is computed for the improved transmission [15].

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III. PROPOSED WORK

A. Formation of the Jamming-resistant GPS system receiver

The proposed diagram for the Jamming-resistant GPS system receiver is demonstrated in Figure 1. The signal received in the amplified wave model is computed using the spread spectrum value, the Jamming signal and the Gaussian noise value. The COS function is used for the time period based signal strength and the final signal is integrated with the off interval value. The co-efficient value and the Gaussian Function are used to compute the Function variable. The final decision is calculated using the summation function.

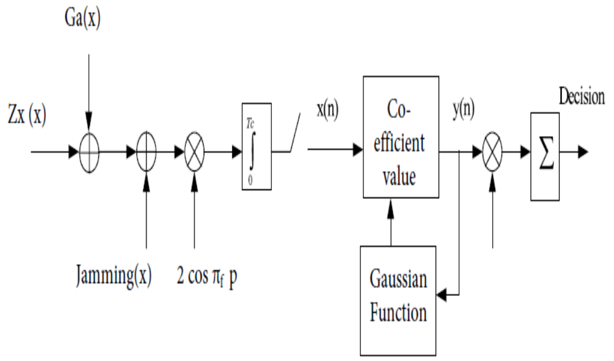

Fig. 1. Jamming-resistant GPS system receiver

The signal which is transmitted in the spread spectrum Zx(P) is computed using Eq. (1).

$$Zx(p) = [Br(p) \oplus Co(p)] \cos(\pi_f p) \quad (1)$$

Where, Br (P) is the navigation for broadcasted broadband information within the time period p. Co (P) is the course acquisition for the GPS signal, f is the GPS frequency

The jamming for single wave spectrum signal for time period p Jamming g_{sw} (P) is computed using Eq. (2).

$$Jamming_{sw}(p) = Amp \; Cos\,[(\pi_f + \pi_\Delta)p + \theta] \quad (2)$$

The jamming for multi wave spectrum signal for time period p Jamming g_{pw} (P) is computed using Eq. (3).

$$Jamming_{mw}(p) = \sum_{i=1}^{m} Amp_i \; Cos\,[(\pi_f + \pi_\Delta)p + \theta] \quad (3)$$

The jamming for pulse wave spectrum signal for time period p Jamming g_p(P) is computed using Eq. (4).

$$Jamming_{pw}(p) = \begin{cases} Amp \; Cos\,[(\pi_f + \pi_\Delta)p + \theta & off\ interval \\ 0 & otherwise \end{cases} \quad (4)$$

The jamming for linear wave spectrum signal for time period p Jamming g_{lw} (P) is computed using Eq. (5).

$$Jamming_{lw}(p) = Amp \; Cos\,[0.50 \, x \, \beta_\Delta \, p^2 + (\pi_f + \pi_\Delta)p + \theta] \quad (5)$$

The signal received in the amplified wave model Re is computed with spread spectrum, Jamming signal and Gaussian noise using Eq. (6).

$$Re(x) = Zx(x) + Jamming(x) + Ga(x) \quad (6)$$

Figure 2 illustrates the notch filter which is used to approximate the received frequencies and accordingly removes the appropriate waveforms with its frequencies. The notch filter is computed in Eq. (7).

$$NF_1(n) = \frac{1}{2}[1 + Amp_1(n)] \quad (7)$$

The $Amp_i(n)$ value is computed using the Eq. (8).

$$Amp_1(n) = \frac{x_2 - x_1 n^{-1} + n^{-2}}{1 - x_1 n^{-1} + x_2 n^{-2}} \quad (8)$$

The value of x_1 is computed using Eq. (9)

$$x_1 = \frac{2\cos \pi_x}{1 + \tan\left(\frac{bandwidth}{2}\right)} \quad (9)$$

The value of x_1 is computed using Eq. (10)

$$x_1 = \frac{1 - \tan\left(\frac{bandwidth}{2}\right)}{1 + \tan\left(\frac{bandwidth}{2}\right)} \quad (10)$$

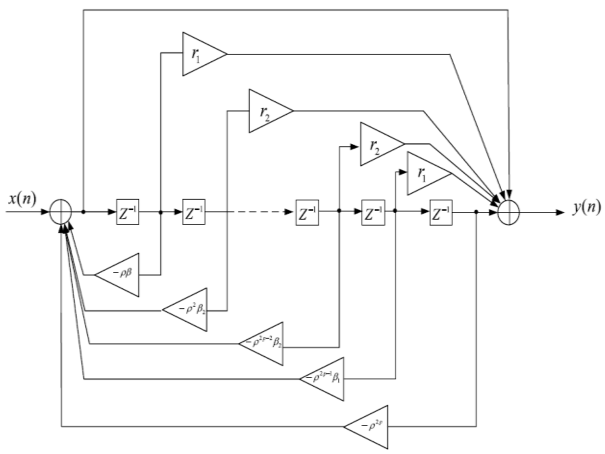

Fig. 2. Architecture for notch filter

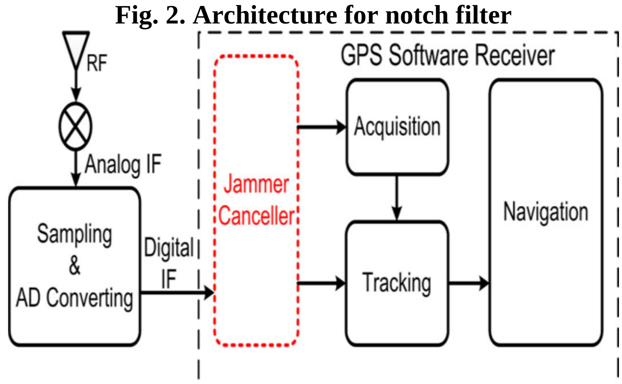

Fig. 3. Formation of GPS Software Receiver

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The computerized IF flag which is separated from the 2-bit analog-to-digital converter (A/D) of the recipient is connected as the information of the GPS programming beneficiary. It is portrayed in Figure 3 that the procurement, subsequent, and route forms are practiced in the software receiver.

B. Algorithm – Gaussian Noise Estimation

The Gaussian Noise Estimation algorithm is constructed to compute the filter metrics of the jamming-resistant receiver formation. Some modified values can be implemented to improve the speed of the convergence signal. The input and output based notch filter is supported for the efficiency of the algorithm. The detailed algorithm is expressed as follows:

Step 1: Compute the signal value $\tau(n) = [\tau_1(n)\ \tau_2(n) \dots \dots \tau_n(n)]^T$

Step 2: Compute the filter metric vector value $\rho(n) = [s_n(n)\ s_n(n) \dots \dots s_n(n)]^T$

Step 3: Compute the gradient vector value $\delta(n) = [\delta_1(n)\ \delta_2(n)\ \dots \dots \ \delta_n(n)]$

Step 4: compute the value of mean output capacity and convergence rate.

In Table I demonstrates the symbols used in the proposed work.

Table I. Symbols used in the proposed work

Symbol	Description
$Zx(p)$	spread spectrum
$Br(p)$	navigation for broadcasted broadband information
p	time period
$Co(p)$	course acquisition for the GPS signal, f is the GPS frequency
$Jamming_{sw}(p)$	jamming for single wave spectrum signal for time period p
$Jamming_{mw}(p)$	jamming for multi wave spectrum signal for time period p
$Jamming_{pw}(p)$	jamming for pulse wave spectrum signal for time period p
Amp	Amplitude
$Jamming_{lw}(p)$	jamming for linear wave spectrum signal for time period p
$Re(x)$	The signal received in the amplified wave model
$NF_1(n)$	notch filter
$\tau(n)$	signal value
$\rho(n)$	filter metric vector value
$\delta(n)$	gradient vector value
$\emptyset_{MOC}(x)$	mean output capacity
bandwidth	bandwidth
x_1	jamming-resistant receiver formation
$Prob_{dis}(x)$	distribution of Probability
Len_{opt}	length of optimization
Max_{time}	time of maximization

IV. PERFORMANCE EVALUATION

The proposed Jamming-resistant Global Positioning System is implemented in a MATLAB. The GPS receiver is tested with the frequency and the signal values. Figure 4 illustrates the ambiguity function.

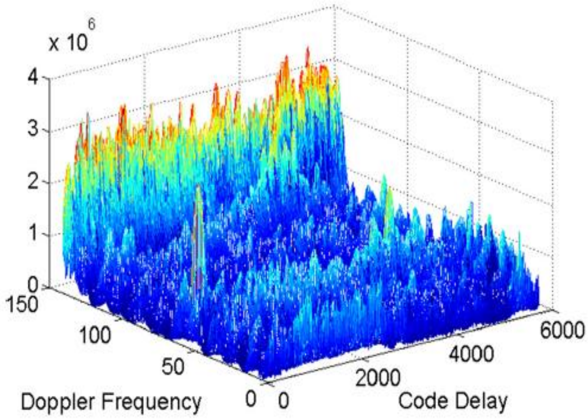

Fig. 4. Ambiguity function

The simulation results of the proposed work is acquired to corroborate the jamming-resistant and frequency of the received signal computation. Two metrics are used to validate the performance in case by case. The metrics are the Mean output capacity and the convergence rate. Figure 5 demonstrates the acquisition signals received for the proposed system.

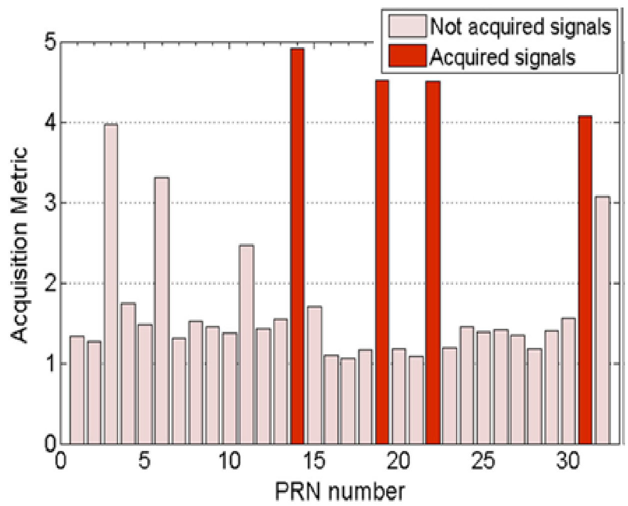

Fig. 5. Acquisition signals received for the proposed system

The mean output capacity $\emptyset_{MOC}(x)$ is computed using Eq. 11.

$$\emptyset_{MOC}(x) = \frac{1}{100}\left[\sum_{n=((x-1)\times 100)+1}^{100\,x} \emptyset^2(n)\right] \qquad (11)$$

Figure 6 demonstrates the Jamming signal frequency computation using the proposed system within the frequency using the multiple signal values 3 kinds of Jamming is received in the jamming-resistant GPS receiver system. The Jamming1, Jamming2 and Jamming3 within the time period for the multiple CWI signal is computed for better performance.

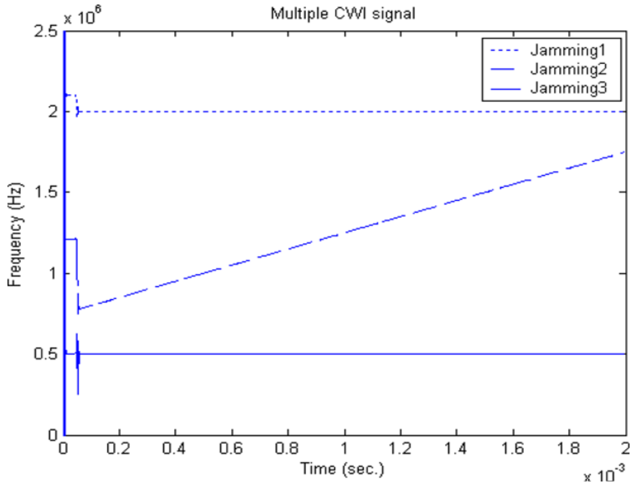

Fig. 6. Jamming signal frequency computation using the proposed system

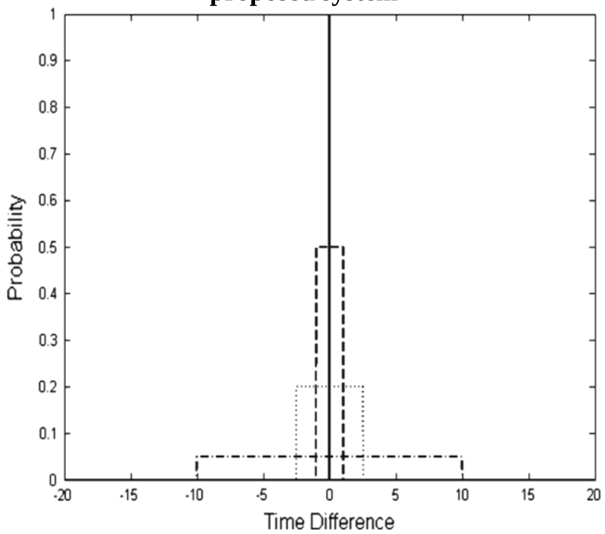

Fig. 7. Distribution of Probability using the proposed system

The distribution of probability by means of time period for the proposed system is illustrated in Figure 7. The distribution of Probability $Prob_{dis}($ is computed using the length of optimization Len_c and time of maximization Max_{ti} and illustrated in Eq. (12).

$$Prob_{dis}(x) = \frac{1}{Len_{opt}} \prod \frac{Max_{time}}{Len_{opt}} \qquad (12)$$

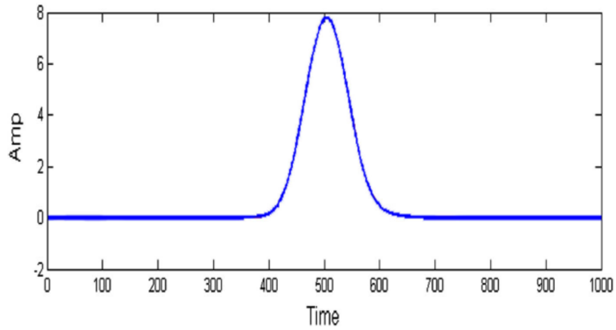

Fig. 8. Amplitude value within time period

V. CONCLUSION

In this paper, the Designing of Jamming-resistant GPS system receiver employed for Global Positioning System interference computation and frequency metric computation. The Mean Output Capacity is computed to estimate the speed of convergence and increase the capacity of tracking the signals. The proposed method achieves the better Signal-to-Noise Ratio and minimized interference intensity compared to the related methods.

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