Adaptive Acquisition of PN Sequence in Nonfading AWGN Channel

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In this paper, we consider an adaptive single dwell serial search system of pseudo-noise (PN) sequences for direct sequences spread-spectrum (DS-SS) systems in no fading additive white Gaussian noise channels. Since the received signal levels in mobile communications are unknown and location varying, the acquisition schemes for pseudo-noise (PN) sequences with fixed thresholds may cause too many false alarms. Therefore, adaptively varying threshold schemes are proposed through the use of a constant false alarm rate (CFAR) algorithm. From the simulation results, we observe that the DS/CDMA systems with CFAR processor outperforms the conventional scheme with fixed threshold.

1. Introduction

To communicate with code-division multiple-access (CDMA), a pseudo-noise (PN) code acquisition should be performed first. In conventional systems, only the structure of the acquisition system is changed to gain a better performance. However, since conventional systems use a fixed threshold that is adjusted under specific conditions, it is difficult to produce a high quality communication services under varying channel conditions.

Many researchers have studied an acquisition system with an adaptive threshold relative to the communication environment to realize fast acquisition [1-6]. In such studies, the system uses the outputs of a correlator to estimate the background noise level when an input signal does not match the phase of the receiver. If the level of the output signal is low, then the system is assumed to be a low noise environment and the threshold level is reduced. Conversely, if the level of the output signal is high, the system raises the threshold level. In this manner, the system can gain a stable detection probability or false alarm rate in varying environments.

The system under consideration is a single dwell serial search scheme with a non-coherent detection as shown in Fig. 1 [7].

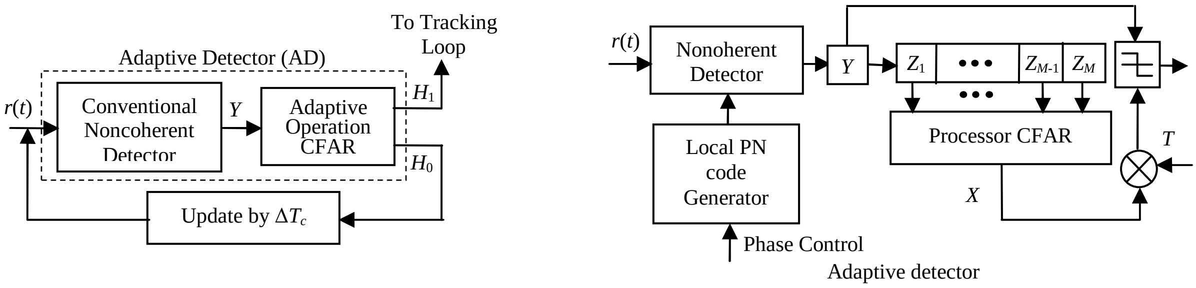

Fig.1: Adaptive serial search acquisition scheme.

The received PN signal plus noise and any interference are arriving at the input of the adaptive detector. If the AD declares that the present cell is the correct one, the tracking loop is activated and the relative time delay of the local PN signal is retarded by ΔT_C, where T_c is the chip time to examine the next cell. The whole testing procedure is repeated. Usually the value of Δ is 0.25, 0.5 or 1. In our case, Δ is set to 1. On the other hand, if the AD declares H_0 cell, the phases of the two codes (incoming and local) are automatically adjusted to the next offset position and the test is repeated.

For the adaptive operation of the decision processor, the cell-averaging false alarm rate (CA-CFAR) is used from several CFAR algorithms due to its low hardware complexity. The threshold value of the comparator in the AD is adapted in accordance with the magnitude of the incoming signals. Accordingly, the outputs of the correlator are sent serially into a shift register of length M+1.

The first register, denoted as *Y*, stores the output of the test phase. The following *M* registers, denoted by Z_j, $j = 1, 2, \ldots M$ and called reference window, store the output of the previous *M* phases. The variable *X* is the summation of the value in the window. Using variable *X*, the system estimates the background noise power level of the incoming signals.

The values in the window are summed and scaled by *T*, where *T* is set according to the desired false alarm rate from the CA-CFAR algorithm. Therefore, the adaptive threshold value of the adaptive detector is *TX*.

2. Main results

To study the performance of the proposed adaptive system, the probabilities of detection and false alarm, and the mean acquisition time are determined with various parameters. We assume an AWGN channel, a chip time 10^{-6}sec, a PN sequence of length 1023 and penalty time $K = 1000$.

In Figs. 2 and 3, we present the comparison between the adaptive system with the CA-CFAR detector and the conventional one. The conventional system uses a sub-optimum threshold value for an $\text{SNR/chip} = -5\,\text{dB}$. We observe that the detection probability of the proposed system is superior to that of the conventional one all over SNR per chip ranges.

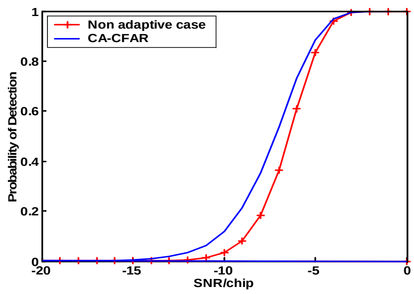

Fig.2: Comparison of probability of detection between proposed system using CA-CFAR and conventional one.

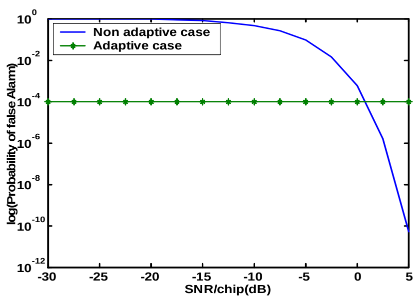

Fig.3: Comparison of probability of false alarm between proposed and conventional system.

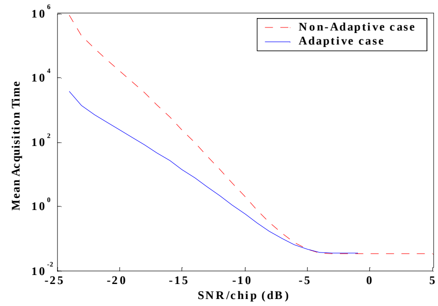

Fig.4: Comparison of mean acquisition time between proposed system using CA-CFAR and conventional one.

Note also that the probability of false alarm of the conventional system is seriously increased as the noise power varies. Fig. 4, presents the comparison of the mean acquisition time between proposed and conventional systems. The proposed system has better performance almost over all the range. Although, a conventional system shows better performance when E_b / N_0 is over -5dB, this is because the term related to the false alarm rate has been removed when the false alarm rate of the conventional system goes to 0 over -5dB, while the false alarm rate of the proposed system is fixed, 10^{-4}, by CA-CFAR algorithm.

3. Conclusion

Form the results, we can conclude that the proposed system gives better performance and outperforms the conventional system with fixed threshold. If the first step of synchronization is successfully obtained, the tracking loop is activated to demodulate data.

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