A new Transmitted-Reference Automotive UWB Radar using Unequaled Amplitude

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Abstract

This paper analyzes the detection performance of new Transmitted-Reference (TR) automotive UWB radar using unequaled amplitude for vehicles. To improve the detection performance of a traditional TR-UWB system, the amplitude of a reference pulse can be changed to increase the energy-to-noise ratio. Finally, the characteristics of the proposed TR-UWB radar are evaluated by simulation. And the performances of the proposed radar are compared with a coherent matched filter and a traditional TR-UWB system. For special case when SNR=3dB and α *=6, we can assert that the detection probability of the proposed TR receiver is approximately a 19% increase compared with that of the conventional TR receiver when the probability of false alarm is 0.5.*

Keywords: *Transmitted-Reference Automotive UWB Radar, Unequaled Amplitude, UWB Radar*

1. Introduction

UWB impulse radar is used for short range measurements in the Intelligent Transport System (ITS) [1]. Since Short-Range Radar (SRR) [2,3] is used in vehicles, the Federal Communications Commission (FCC) has confirmed the spectrum from 22 to 29GHz for UWB radar with a limit power of –41.3dBm/MHz [4-6]. Here, the UWB signal defines an absolute bandwidth larger than 500MHz or a relative bandwidth up to 20%. The UWB radar mentioned above should generate reference pulse adapted channel estimation and exact timing [7]. But, UWB radar with a wide spectrum has difficulty finding channel estimation and exact timing. As an alternative to this radar, many kinds of TR-UWB research studies have been undertaken to solve the problems mentioned above [8-11].

Fig. 1 represents a signaling scheme generated in TR-UWB. As shown in Fig. 1, TR-UWB consists of transmitted pairs, separated by a time delay T_D, known to both the TX and RX [8]. Here, the first pulse defines the reference pulse and the second pulse defines the transmitted pulse. The principle of TR-UWB measures a time interval from the time the transmitted pulse is generated to the time the inputted transmitted pulse is reflected. The time of the inputted reflected pulse in the RX can be measured using a correlator with a simple time delay block.

A conventional TR-UWB has the disadvantage of reduced detection probability because of noise-cross-noise in the reference pulse with additional noise [12-15]. Therefore, UWB radar needs to be studied to improve detection performance, in order to enhance conventional TR methods. This paper continues with Section II, in which a TR-UWB radar system with unequaled amplitude pulse is proposed. In Section III, the simulation results of the proposed method are represented. Finally, Section IV comprises conclusion.

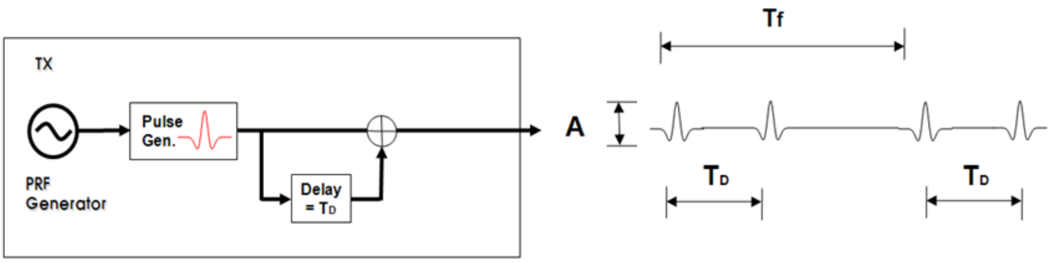

Figure 1. The signal scheme of traditional transmitted reference UWB radar

2. Proposed TR-UWB radar using unequaled amplitude

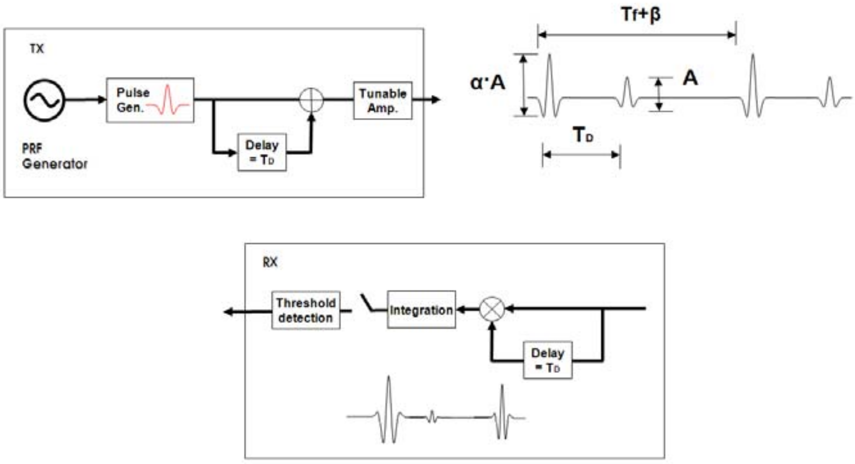

Figure 2. The T/RX architecture of the proposed transmitted reference UWB radar

This chapter proposes TR-UWB with unequaled amplitude pulse for improved detection performance [11]. The proposed method suggests that TR-UWB radar amplifies the reference pulse in order to improve the energy-to-noise ratio (ENR) of the reference pulse. Fig. 2 represents the block diagram of the proposed TR-UWB radar. And, the transmitted signal $s_{TX}(t)$ can be written as

$$s_{TX}(t) = \sqrt{E}\sum_{i=-\infty}^{\infty} \alpha \cdot p(t - i(T_f + \beta)) + p(t - i(T_f + \beta) - T_D) \qquad (1)$$

where p(t) is a second derivative of a Gaussian pulse, T_D is the interval between the reference pulse and the transmitted pulse, T_f represents the pulse repetition interval (PRI), α is an amplitude scale factor to improve the ENR of the reference pulse, β is an increment of the PRI required to maintain average power.

The received signal through the multipath channel can be written as

$$r(t) = \sqrt{E}\sum_{i=-\infty}^{\infty} \alpha \cdot p(t - i(T_f + \beta) - \tau) + p(t - i(T_f + \beta) - T_D - \tau) + n(t) \qquad (2)$$

where τ are the delay length, n(t) is a zero-mean additive white Gaussian noise (AWGN) process with power spectral density (PSD) $N_0/2$. When D_j is the integration window output of the j-th pulse and T_{corr} is the integration time, then the decision can be determined through D_j by the threshold as follow,

$$D_j = \int_{jT_f+T_d}^{jT_f+T_d+T_{corr}} r(t-T_D)r(t)dt \gtrless threshold \qquad (3)$$

3. Simulation results

In this section, we present the detection probability of the coherent matched filter, the non-coherent matched filter, the conventional TR receiver and the proposed TR receiver for the UWB radar. Fig. 3 represents the detection probability of the coherent matched filter, the traditional TR receiver and the proposed TR receiver when threshold is set to 0.50 of the normalized value in AWGN channel. As shown in the results, the detection probability of the proposed TR receiver with α =6 is about 3 dB better than that of the conventional TR receiver. In the case that threshold is set to 0.9 in Fig. 4, the detection probability of the conventional TR receiver is about 3 dB worse than that of the proposed TR receiver with α =6.

Fig. 5 represents the Receiver Operating Characteristics (ROC) of the coherent matched filter, the non-coherent matched filter, the traditional TR receiver and the proposed TR receiver when SNR is 3dB in AWGN channel. As shown in the results, the detection probability of the proposed TR receiver with α =6 is approximately a 19% increase compared with that of the conventional TR receiver when Pf is 0.5.

Fig. 6 represents the ROC of the coherent matched filter, the non-coherent matched filter, the traditional TR receiver and the proposed TR receiver when SNR is 6dB. And, the detection performance of the proposed TR is about a 13% increase compared with that of the traditional TR receiver with α =6 when Pf is 0.5.

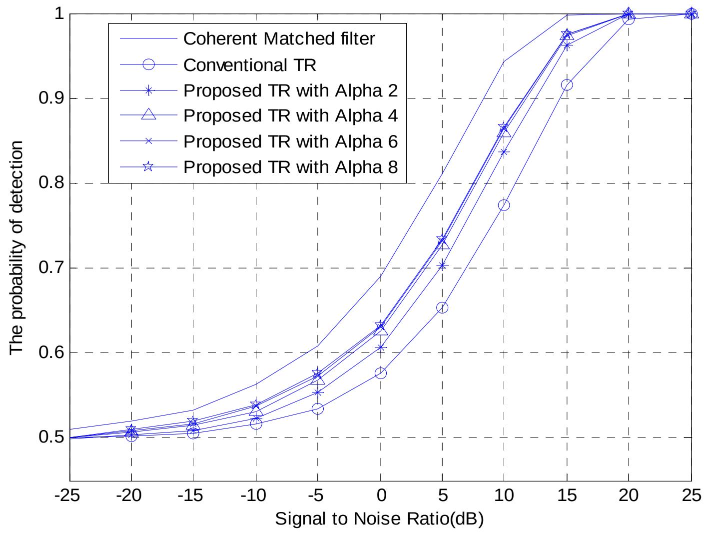

Figure 3. The detection probability when threshold is set to 0.50 of the normalized in AWGN channel

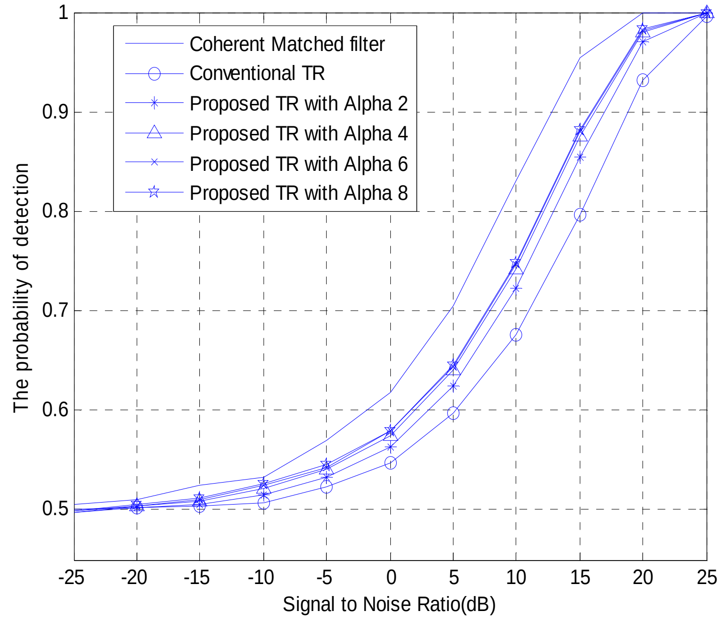

Figure 4. The detection probability when threshold is set to 0.70 of the normalized in AWGN channel

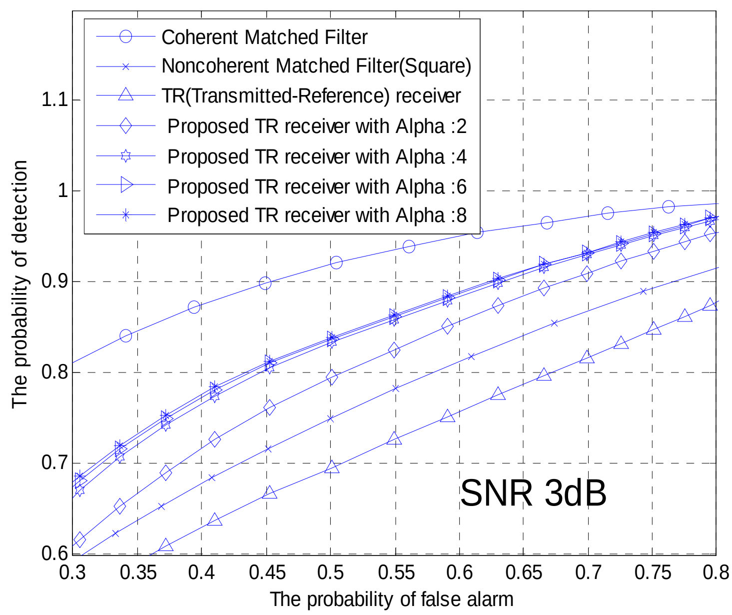

Figure 5. The ROC when SNR is 3dB with AWGN channel

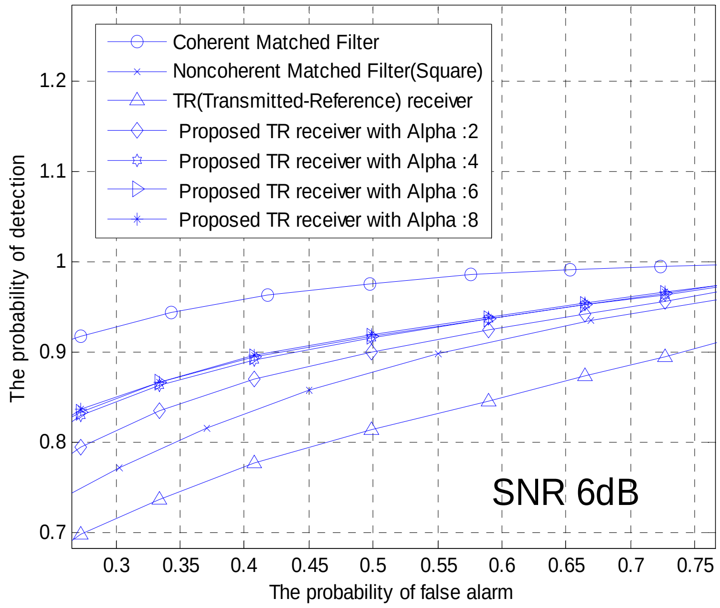

Figure 6. The ROC when SNR is 6dB with AWGN channel

4. Conclusion

This paper analyzed the performance of Transmitted-Reference (TR) UWB radar with unequaled amplitude pulse for vehicles. To improve the detection performance of conventional TR-UWB systems, the amplitude of a reference pulse was changed to order to increase the energy-to-noise ratio of that reference pulse. And the performances of the proposed radar were compared with a coherent matched filter, non-coherent matched filter and a traditional TR-UWB system. From Monte-Carlo computer simulations, we can assert that the proposed TR system is superior to the conventional TR system in AWGN channel. Above all, an accuracy of time of arrival (TOA) of the proposed TR-UWB radar is remarkably improved under AWGN channel environment.

Acknowledgment

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