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Decision-making Optimization of Logistics Supply Chain Based on Small Target Echo Coherent Accumulation Algorithm Based on LTE Signal

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Abstract: Long-term signal accumulation is an effective method to improve the detection of weak and slow small targets. However, the accumulation time is long, and the target echoes will move away from the unit and the Doppler unit, and the coherent accumulation is difficult. In this paper, the small target detection problem based on LTE signal is studied, and the target scattering variability is introduced. The system echo model based on LTE communication system is established. On this basis, the target echo distance walking and Doppler walking characteristics are analyzed. The echo coherent accumulation technique based on keystone transform and fractional Fourier transform (FRFT) is used. Based on the typical target scattering model, the influence of the target scattering characteristics on the accumulation effect is analyzed, and the simulation experiment is carried out under typical system conditions. The validity of the proposed algorithm and analysis is verified.

1. Introduction

In recent years, there have been more and more low and low targets in urban environments, such as small drones, which have brought huge security risks to air surveillance and air safety. The detection of low and low targets in urban areas is an urgent task in the field of radar technology. Due to the complex background of low and small slow targets and the consideration of electromagnetic radiation, high requirements are placed on radar detection. The external radiation source radar based on civilian 4G communication signals basically realizes comprehensive coverage of the communication base station, and no electromagnetic pollution and can form a multi-base network detection system has become a research hotspot[1]. The 4G communication technology adopts the LTE (Long Term Evolution) standard. The literature analyzes the feasibility of whether the LTE signal can be used as the external radiation source radar source. It is feasible to obtain the LTE signal. An effective way to detect weak targets is to increase the accumulation time. However, long-term coherent accumulation will cause walking problems. Due to the dual (multiple) base configuration of the communication base station, the radial velocity of the target causes the cross-distance unit to move. When the target has a tangential velocity or has its own acceleration, it will move across the Doppler unit, and the target motion speed is faster. The more obvious the phenomenon of walking, the serious impact on the accumulation gain. In order to solve the problem of distance walking, the keystone transform is a common method for correcting the distance of the target during the coherent accumulation time. Keystone transform is one of the most common distance walk correction techniques used in the field of moving target SAR imaging. Its main advantage is that it can realize distance travel compensation of multiple targets without the specific motion information of the target. In, a weak target detection method based on keystone transform is proposed. The distance walking compensation is realized under the condition of no target motion velocity information. A long-term coherent integration algorithm based on keystone transform is proposed [2]. The long-term coherent integration algorithm is realized by using keystone transform in the frequency domain-azimuth time domain, and the long-term coherent accumulation is realized by FFT. The echo signal to noise ratio. The distance tracking correction method of OFDM radar signal based on keystone transform is studied, which realizes high-speed moving target and long-accumulated inter-pulse distance walking compensation, which improves the radar output signal-to-noise ratio. In order to compensate for Doppler walking, the literature proposes a package based The digital TV radiation source radar walking compensation algorithm based on the network interpolation and fractional Fourier transform makes the long-term coherent accumulation unrestricted with distance walking and Doppler walking. The STFT-Hough transform method is proposed. The interception of the signal by Doppler frequency without the cross-data sliding window and the peak of the Doppler frequency compensate the Doppler walking spread, and greatly reduce the computational complexity of the algorithm. A long-term coherent integration method based on space-based biostatic radar is proposed, which can realize phase compensation and improve the influence of Doppler phase. A maneuvering weak target detection algorithm based on keystone transform and FRFT is proposed. For the high-speed and high maneuvering targets, two long-term coherent integration detection methods, Radon-fractional Fourier transform and Radon-fractional fuzzy function, are proposed to compensate the distance and Doppler walking in the long-term accumulation process. , increase the accumulation gain.

Most of the above research results are for single-base radars, but the long-term coherent accumulation technique for slow and weak target echoes in dual-multi-base radar systems based on LTE signals has not been studied. Due to the dense deployment of mobile phone base stations, the distance from the target to the base station is generally short, and the relative rotation angle is large when accumulating for a long time, which causes the spatial variation of the target scattering characteristics and affects the coherent accumulation effect of the target echo. This paper studies the above problems, and the structure is as follows: Modelling the scattering characteristics of the target, giving the echo signal model of the target; theoretically analyzing the distance walking and Doppler walking characteristics of the echo signal, and proposes a keystone based transformation. And the FRFT's walking correction method, and analyze the influence of the target's scattering characteristics on the echo energy and parameter estimation. Using the proposed method, the ideal point target echo is computer simulated, and the simulation results before and after the correction are compared and simulated. The effect of the target scattering characteristics on the echo energy and parameter estimation.

2. Signal model

It is assumed that the external radiation source radar system consists of K mobile phone base stations (radiation sources) and one receiving node, wherein each mobile phone base station is located at Tk, k = 1, ..., K, and the receiving node is located at R, and the target is assumed to be at a constant velocity V. For motion, the schematic diagram of the radar system is shown in Figure 1.

The radar receiving node performs low-low target detection by receiving the OFDM signal of the LTE communication system radiated by the mobile phone base station reflected by the target. Suppose the signals transmitted by K mobile base stations are orthogonal to each other, ie sti(t) = stj(t) =1, i = j0, i≠j { , where sti(t) and stj(t) represent the ith mobile phone respectively. The base station and the j-th mobile base station transmit signals, and the time synchronization error of the mobile base stations Tk and T1 is Δ#k, the frequency synchronization error is Δfk, and the phase synchronization error is Δθk, k = 1,..., K, where Δ#1 =Δf1 = Δθ1 = 0[2].

Assume that the mobile base station repeatedly transmits the pulse signal at intervals of Tr, where N represents the total number of pulses transmitted by the mobile base station during the coherent accumulation time, n = 0, …, N-1. With RTk, RRe and RTa, n respectively represent the position vector of the kth mobile phone base station and the receiving node and the position vector of the target when the nth pulse is transmitted. Then the expression of the propagation delay #kn between the kth mobile phone base station, the target and the receiving node is: $P_t^c = \left[(1-o_c) P_t^{d(1-\eta_c)} + o_c P_t^{m(1-\eta_c)} \right]^{1/(1-\eta_c)}$ .Assuming that the space-varying characteristics of the target scatter are represented by Θ(k,n), the echo signals received by the radar receiving node are: $Y_t = A_t (\mu_t K_t)^a H_t^{1-a}$.

3. Signal processing method

3.1. Model Construction

The following formula derives the generation of echo signals and Doppler shifts during the accumulation time. Constructing the transmitted signal stp(t) of the pth mobile phone base station, and performing matching filtering processing to obtain: $Y_t^d = \left[\int_0^1 Y_t^d (i)^{1/\lambda_t^d} di \right]^{\lambda_t^d}$ .Since the relative distance between the target and the radar station is short and the accumulation time is long, it is necessary to use Taylor second-order expansion for the above formula to improve the approximation accuracy: $Y_t^d (i) = \left(\frac{P_t^d (i)}{P_t^d} \right)^{-\lambda_t^d / (\lambda_t^d - 1)} Y_t^d$.

3.2. Echo signal walking correction

Let Θ(p,n) = a(nTr) +b(nTr) 2, introduce a keystone transformation on (8): (f+fc-Δfp) n = fcm, due to keystone compensation, first order and second of The order is small and negligible, so there are: $P_t^d = \left[\int_0^1 P_t^d (i)^{\frac{1}{1-\lambda_t^d}} di \right]^{(1-\lambda_t^d)}$ .Where ! = c /fc, the corresponding distance time domain signal is: $Y_t^m = \left[\int_0^1 Y_t^m (i)^{1/\lambda_t^m} di \right]^{\lambda_t^m}$. It can be seen from the above formula that the peak position of the signal is always located at ΔRp /c, that is, the keystone transform corrects the echo signals originally located in different distance units to the same distance unit, compensating for the distance walking, and the echo energy is focused in the distance direction.

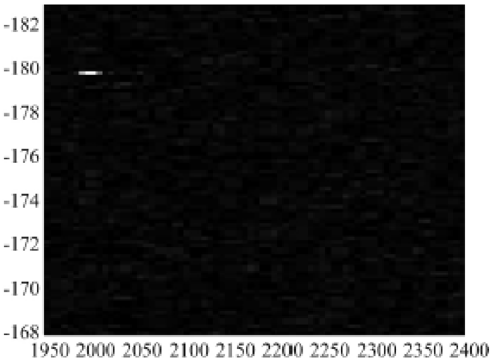
3.3. Analysis of the influence of target scattering characteristics

Performing FRFT on the slow time domain signal, the signal energy forms a two-dimensional distribution on the parameter plane α, u), and the peak value of the two-dimensional plane is searched by the threshold value to determine the optimal rotation angle of the signal, namely: $Y_t^m(i)=\left(\frac{P_t^m(i)}{P_t^m}\right)^{-\lambda_t^m/(\lambda_t^m-1)} Y_t^m$,According to the peak point coordinates (α0, u0) of the FRFT domain, the target scattering space characteristic model parameters can be expressed as: $I_t=\left[(1-o_i)^{1/\eta_i} I_t^{d(\eta_i-1)/\eta_i}+o_i^{1/\eta_i} I_t^{m(\eta_i-1)/\eta_i}\right]^{\eta_i/(\eta_i-1)}$.

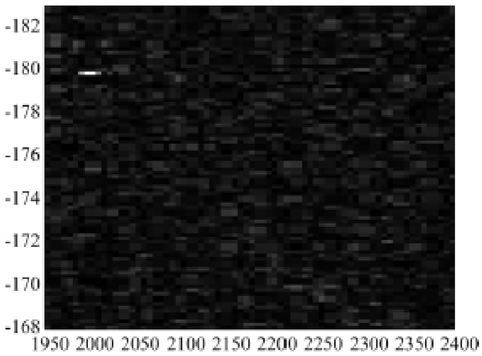
4. Computer simulation and analysis

In the simulation, consider a detection system consisting of a mobile phone base station T and a receiver R, assuming that T, R and the target are distributed in the same biostatic plane, and the target is at a position of 1 /2 accumulation time and T and R form a positive The triangle, T and R are 1000 m apart, and the target moves away from the mobile base station and the receiving node in the 60° direction [3-4].

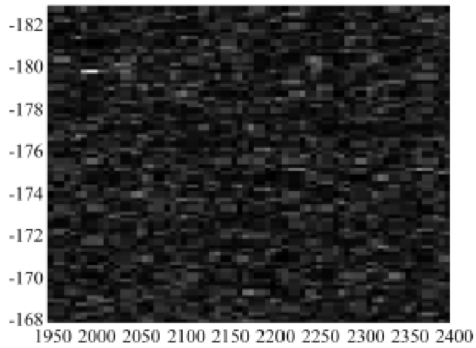
Figure 1 shows the echo distance Doppler map obtained by applying the algorithm under different SNR conditions. As a comparison, the FFT coherent processing results before compensation are given. It can be seen that the target performance is obviously moving before the compensation. And Doppler walks, after compensation (as shown in Figure 1 (a), Figure 1 (b) and Figure 1 (c)), the walking phenomenon disappears, the target echo energy is focused, and the echo peak appears, which indicates that the proposed the algorithm can effectively perform the walking correction and increase the accumulation gain. When the SNR is low, as shown in Figure 1(c), due to the higher noise energy, the target peak is not easy to obtain compared to Figure 1(a) and Figure 1(b). If the SNR is lower, FRFT After the treatment, the target is completely submerged in the noise, and the detection is difficult. Eight Monte Carlo simulations were performed under each SNR condition.



(a)



(b)



(C)

Figure 1: Echo distance Doppler map under different SNR conditions

5. Conclusions

Aiming at the detection problem of weak and slow small targets in urban environment, this paper proposes a long-term coherent integration algorithm based on LTE signals. Firstly, the target scattering model satisfying the polynomial is introduced into the echo model. Secondly, the target distance walking and Doppler walking characteristics are theoretically analyzed. The distance travel is corrected by keystone transform, and the long-time of Doppler walking with FRFT is proposed. The coherent accumulation algorithm is used to analyze the influence of the target scattering variability on the echo energy and velocity parameters. Finally, the simulation results verify the effectiveness of the proposed method and show that the objective of the polynomial scattering model has a certain influence on the dispersion. . Since the keystone transform and FRFT are both linear, the proposed algorithm can also be extended to multiple target environments.

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