Target detection method in passive bistatic radar

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Abstract: Owing to the advantages in detecting the low altitude and stealth target, passive bistatic radar (PBR) has received much attention in surveillance purposes. Due to the uncontrollable characteristic of the transmitted signal, a high level range or Doppler sidelobes may exist in the ambiguity function which will degrade the target detection performance. Mismatched filtering is a common method to deal with the ambiguity sidelobe problem. However, when mismatched filtering is applied, sidelobes cannot be eliminated completely. The residual sidelobes will cause false-alarm when the constant false alarm ratio (CFAR) is applied. To deal with this problem, a new target detection method based on preprocessing is proposed. In this new method, the ambiguity range and Doppler sidelobes are recognized and eliminated by the preprocessing method according to the prior information. CFAR is also employed to obtain the information of the target echo. Simulation results and results on real data illustrate the effectiveness of the proposed method.

Keywords: passive bistatic radar (PBR), mismatched filtering, ambiguity sidelobe, target detection.

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1. Introduction

Recently, passive bistatic radar (PBR) has received increasing attention in surveillance proposes. Unlike the conventional monostatic radar, PBR contains no co-located transmitters but uses the commercial broadcaster as the illuminator of the opportunity which has already existed in the environment. Because of the working pattern, PBR has many advantages over the conventional radar. Most importantly, PBR works silently which avoids being disturbed by the hostile radar jammer and attacked by the anti-radiation missile. In most cases, the receiver is smaller and more portable with the lower cost compared with the conventional radar. Besides, the non-cooperative illuminators of the opportunity are usually at a low frequency band and covering low altitude airspace which means that PBR also has advantages on detecting the stealth and low altitude target. Frequency modulation (FM) [1 – 3], analogy television (ATV) [4 – 6], digital television (DTV) [7 – 9], global system for mobile communication (GSM) [10,11], long term evolution (LTE) [12,13], Wi-Fi [14,15] and global navigation satellite system (GNSS) [16 – 18] have been used or considered as a radar waveform.

These illuminators usually transmit continuous wave signals, and the signals reflected by the target are very weak. Long time coherent integration is used to raise the energy level of the weak target echo. Unfortunately, owing to the uncontrollable characteristic of the transmitted signal, a high level ambiguity range or Doppler sidelobes may exist in the ambiguity function. The energy level of these sidelobes is usually strong which is almost as strong as the main lobe. When the constant false alarm ratio (CFAR) is applied, these ambiguity ranges or Doppler sidelobes will be detected as targets which will degrade the target detection performance. Among these illuminators of opportunity, ambiguity sidelobes are typical in ATV signals. In this paper, the ATV signal is discussed in detail. It should be noted that this method could also be applied to other illuminators of the opportunity. The ATV signal is chosen because of its high transmitted power and wide coverage area.

The ATV signal consists of an audio signal that is frequency modulated and a video signal that utilizes amplitude modulation vestigial sideband as its modulation mode. In this paper, the video signal of the ATV is discussed in detail. For convenience, the video signal is called as the ATV signal. Caused by the fly-back of 64 μs, high level ambiguity range sidelobes appear at every 19.2 km, which are very close to the main lobe. These sidelobes have a serious effect on the target detection.

Many algorithms have been proposed to solve the ambiguity range or Doppler problem. By minimizing the integrated sidelobe level, the mismatched filtering algorithm in [19] performs well in sidelobe suppression. However, when the range ambiguity sidelobes are suppressed, the energy level of the main lobe is decreased simultaneously.

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To deal with the energy loss problem in the main lobe, the mismatched filtering algorithm in [20] was proposed. In this improved mismatched filtering algorithm, an extra restrict condition which is used to restrict the energy loss in the main lobe is added in the cost function. Although the mismatched filtering algorithm does well in solving the sidelobe problem, these sidelobes can only be suppressed in a certain extent to distinguish the main lobe from the sidelobe, not fully. There are still sidelobes residual. When CFAR is applied, these residual sidelobes will be detected as targets, which will surely degrade the target detection performance. Thus, these sidelobes need to be further suppressed by the preprocessing method before CFAR is applied. Aiming at this problem, a new target detection method in PBR is proposed in this paper. In this new method, mismatched filtering is used to suppress the ambiguity sidelobes in a certain extent, firstly. Then, the ambiguity range and Doppler sidelobes are recognized and eliminated by the preprocessing method. Finally, the cell averaging CFAR (CA-CFAR) detection method is used to extract the parameter of the moving target. Simulation results and results on real data illustrate the effectiveness of the proposed method in PBR.

The structure of this paper is shown as follows. In Section 2, the signal model and the signal characteristic are described in detail. The mismatched filtering algorithm is introduced in Section 3. Then in Section 4, the conventional method is introduced. The proposed preprocessing method is discussed in Section 5. Next, simulation results and the target detection performance are shown in Section 6 and Section 7. Section 8 shows the detection result on real data. Conclusions are drawn in Section 9.

2. Signal model and characteristic

A typical PBR system usually consists of two sets of antennas: one is the reference antenna which is pointed toward the transmitter of the illuminator of the opportunity; the other one is the surveillance antenna which is pointed at the airspace to be monitored. The geometry of a typical PBR system is shown in Fig. 1.

![Fig. 1 PBR geometry](image)

The surveillance antenna is mainly used to collect the target echo, but it is inevitably contaminated by the direct signal and multipath [21]. Thus, the signal received by the surveillance antenna can be represented as

\[
\mathbf{s}_{\text{sur}}(t) = A_{\text{sur}} \mathbf{d}(t) + \sum_{m=1}^{N_m} A_m \mathbf{d}(t - \tau_m) + \sum_{k=1}^{N_k} A_k \mathbf{d}(t - \tau_k) e^{j2\pi f_k t} + \mathbf{n}_{\text{sur}}(t)
\]  

(1)

where \(\mathbf{d}(t)\) is the complex envelope of the direct signal; \(A_{\text{sur}}\) is the complex amplitude of the direct signal received by the surveillance antenna; \(N_m\) is the total number of the multipath; \(A_m\) and \(\tau_m\) are the complex amplitude and the temporal delay (with respect to the direct signal) of the \(m\)th stationary ground scatterer \((m = 1, 2, \ldots, N_m)\) respectively; \(N_k\) is the total number of the target echo; \(A_k, \tau_k\) and \(f_k\) are the complex amplitude, temporal delay (with respect to the direct signal) and Doppler frequency of the \(k\)th target echo \((k = 1, 2, \ldots, N_k)\) respectively; \(\mathbf{n}_{\text{sur}}(t)\) is the thermal noise in the surveillance channel.

The reference antenna is used to obtain the direct signal as the reference signal for matched filtering or mismatched filtering. The target echo and the multipath are usually at a very low energy level in the reference channel compared with the direct signal. Thus it is reasonable to assume that the contributions of the target echo and the multipath are negligible [22]. Thus, the reference signal can be written as

\[
\mathbf{s}_{\text{ref}}(t) = A_{\text{ref}} \mathbf{d}(t) + \mathbf{n}_{\text{ref}}(t).
\]  

(2)

where \(A_{\text{ref}}\) is the complex amplitude of the direct signal received by the reference antenna; \(\mathbf{n}_{\text{ref}}(t)\) is the thermal noise in the surveillance channel.

In the PBR system, the target echo is usually weaker than the stationary clutter echo. In order to detect the target echo, the temporal clutter cancellation algorithm [23–25] is used to remove the stationary clutter echo from the surveillance signal.

When clutter echoes are removed from the surveillance signal, target echoes are still weaker than the thermal noise. Usually matched filtering is used to raise the energy level of the weak target echo. This step can be represented as

\[
A(\tau, f) = \int_{0}^{T_0} \mathbf{s}_{\text{sur}}(t) \mathbf{s}_{\text{ref}}^*(t - \tau) e^{-j2\pi f t} dt
\]  

(3)

where \(T_0\) is the coherent integration time, \(\tau\) and \(f\) are the temporal delay and the Doppler frequency respectively.

Assuming that the received signals are sampled by a digital receiving system with a sampling rate of \(f_s\) which satisfies the Nyquist theorem. The samples obtained by the
surveillance channel are arranged in an $N \times 1$ vector which is represented as

$$s_{\text{sur}} = [s_{\text{sur}}[0] \ s_{\text{sur}}[1] \ \cdots \ s_{\text{sur}}[N-1]]^T$$  \hspace{1cm} (4)

where $N$ is the number of samples that need to be integrated.

Similarly, the reference signal observed by the reference channel is represented as

$$s_{\text{ref}} = [s_{\text{ref}}[-R+1] \ \cdots \ s_{\text{ref}}[0] \ \cdots \ s_{\text{ref}}[N-1]]^T$$  \hspace{1cm} (5)

where $R$ is the number of additional reference signal samples which are considered to obtain the desired integration over an extent of $R$ time bin.

Thus, the discrete implementation of the matched filtering can be represented as

$$A[l, p] = \sum_{i=0}^{N-1} s_{\text{sur}}[i] s_{\text{ref}}[i - l] e^{-j2\pi pl/N}$$  \hspace{1cm} (6)

where $l$ is the time bin representing the time delay and $p$ is the Doppler bin representing the Doppler frequency.

In order to evaluate the performance of the proposed target detection method, we consider a simulated scenario where signals from an ATV transmission are sampled. The spectrum of the ATV signal is shown in Fig. 2.

![Fig. 2 Spectrum of ATV signal](image)

It can be seen from Fig. 2 that the bandwidth of the ATV signal is 6 MHz. However, the major energy of the signal is distributed within $\pm200$ kHz close to the carrier frequency. To lower the sampling rate and the system complexity, it is feasible to use the $\pm200$ kHz frequency bandwidth close to the carrier frequency for signal processing. The spectrum of the ATV signal of the 400 kHz bandwidth is shown in Fig. 3.

![Fig. 3 Spectrum when only the $\pm200$ kHz bandwidth close to the carrier frequency has been reserved](image)

It can be clearly seen that the spectrum of the ATV signal possesses high level peaks at every 15 625 Hz which corresponds to the 64 $\mu$s line fly-back of the signal. The 64 $\mu$s line fly-back will cause ambiguity range sidelobes in the ambiguity function. The ambiguity diagram of the ATV signal collected from an ATV based PBR system is shown in Fig. 4.
From Fig. 4, it can be seen that the output of the matched filter contains high level ambiguity range sidelobes at every 19.2 km, which are almost as high as the main lobe. It is difficult to extract the range information of the target. To improve the detection performance of the PBR system, the mismatched filtering algorithm was proposed in [20] to deal with the ambiguity sidelobe problem. Then the mismatched filtering algorithm is introduced in Section 3.

3. Mismatched filtering algorithm

The mismatched filtering algorithm was proposed to deal with the problem of ambiguity range sidelobes. Assuming that $s_{\text{ref}}[k]$ is the sampled and down converted ATV signal, the mismatched filtering weights can be obtained by solving the following cost function:

$$J = \min_{W} \|W - W_0\|^H [W - W_0] + \sum_{k} cW^H S[k] S^H[k] W$$  \hspace{1cm} (7)

where $W$ is the mismatched filter weight to be solved; $W_0$ is the matched filter weight which is equal to the reference signal itself; $c$ is a weight factor which is designed to make a trade-off between the range ambiguity sidelobe suppression performance and the signal to noise ratio (SNR) loss in the main lobe; $k$ is the index of the ambiguity range sidelobe and $k$ values from $-K$ to $K$. $2K$ is the total number of sidelobes to be suppressed. In addition, $S[k] = [s_{\text{ref}}[1 + k], \ldots, s_{\text{ref}}[N + k]]$.

The cost function in (7) can be divided into two parts: the first part of the cost function represents the SNR loss in the mismatched filter compared with the matched filter; the second part of the cost function is the total energy of the range sidelobe. A better suppression performance means a larger SNR loss. Only considering the suppression performance, but neglecting the SNR loss, is improper. Usually, a trade-off between the SNR loss and the suppression performance is achieved by the weight factor $c$. The larger the $c$ is, the better the suppression performance will be. Conversely, less SNR loss means a smaller $c$.

It is easy to prove that (7) is a convex problem. Thus, the optimal solution of (7) can be obtained by solving the following equation:

$$\frac{\partial J}{\partial W^H} = W - W_0 + \sum_{k} cS[k] S^H[k] W = 0. \hspace{1cm} (8)$$

After solving (8), the optimal weights of the mismatched filter can be represented as

$$W = \left(I_N + \sum_{k} cS[k] S^H[k]\right)^{-1} W_0 \hspace{1cm} (9)$$

where $I_N$ is an identity matrix whose dimension is $N \times N$. The outputs of the mismatched filter are shown in Fig. 5(a), Fig. 5(b) and Fig. 5(c), respectively. It can be seen from Fig. 5 that the ambiguity range sidelobes have been suppressed by about 5 dB. However, the ambiguity range sidelobes are still at a high energy level. At the same time, the ambiguity Doppler sidelobes caused by the 50 Hz field frequency also have influence on the target detection.
Although the ambiguity sidelobes are suppressed in a certain extent, they are still higher than the detection platform. The residual sidelobes may be detected as targets, which will raise the false-alarm of the system. This problem needs to be solved before the target detection method is employed. Before discussing the proposed preprocessing method, the conventional detection method is introduced in Section 4.

### 4. Conventional detection method

CFAR [26,27] is the common method for the target detection to extract the information of the moving target from the noise and clutters. There are many kinds of CFAR methods. Among all the CFAR methods, CA-CFAR [28–30] is widely used in a real radar system. Thus, the CA-CFAR method is discussed in this paper. The principle of the CA-CFAR method is shown in Fig. 6.

![Fig. 6 Principle of CA-CFAR](image)

From Fig. 6, it can be seen that serval protect cells between the clutter under test (CUT) and the reference cell are required to prevent the target existing in the reference cell when choosing reference cells. The size of the reference cell depends on the size of the target and the resolution bin. The specific realization method of CA-CFAR is introduced as follows.

After clutter cancellation and R-D correlation, a two-dimensional detection matrix is obtained. The CA-CFAR method is done in serval range bins or Doppler bins. \( M \) reference cells have been chosen to obtain the estimation value \( Z \) of the noise and interference in the CUT. The detection threshold is obtained when the estimation value \( Z \) multiplies a constant number \( K_0 \). \( K_0 \) is the detection factor which is used to adjust the detection threshold. Then the amplitude of the CUT is compared with the detection threshold, if the amplitude of the CUT is satisfied with

\[
Y \geq K_0 Z. \tag{10}
\]

Then, it is considered that the target is detected in the CUT. It should be noted that CA-CFAR is usually applied to the range bin since the Doppler resolution is higher than the range resolution.

The CA-CFAR method satisfies most cases in the PBR system but not illuminators of opportunity whose ambiguity function contains ambiguity sidelobes. Since the residual ambiguity sidelobes are at a high energy level, these sidelobes will be treated as targets which will cause false-alarm. Thus, it is required to suppress these residual sidelobes before CFAR to obtain a better detection performance.

### 5. Proposed preprocessing method

Mismatched filtering is used to suppress the ambiguity sidelobes in a certain extent rather than eliminating them completely. The residual ambiguity sidelobes will be treated as targets when the conventional target detection method is applied. To solve this problem, a preprocessing method for target detection according to the prior information is proposed in this paper. By sorting the numerical value of each Doppler channel and range channel, these ambiguity sidelobes can be recognized and eliminated. The flow chart of the preprocessing method is shown in Fig. 7.

![Fig. 7 Flow chart of the preprocessing method](image)

It can be seen from Fig. 7 that the clutter echoes are firstly removed from the surveillance signal by the clutter cancellation method. Then the mismatched filtering is used to get the R-D correlation result. The R-D result is represented as \( A \), and \( A \) is an \( M \times N \) matrix, where \( M \) is the number of range bins, the \( N \) is the number of Doppler bins.

The R-D correlation result \( A \) is firstly rearranged according to the amplitude in each Doppler channel. At the same time, the position of each element is recorded. By traversing the Doppler channel, the judgement is done in each Doppler channel. The position distance between the
main lobe and the ambiguity sidelobes in the R-D result can be calculated as

$$ P = T_e f_s $$

where $T_e$ is the 64 μs line fly-back of the signal.

If the position of the rest value is $P$ or the integer multiples of $P$ (except 0), this value is set to a very small value close to zero; otherwise the value is kept. Next, the position of each value is restored according to the position of the element which is recorded in prior. By this step, the ambiguity range sidelobes can be eliminated in a high extent and we note this result as $B$. The residual ambiguity range sidelobes can be further eliminated by CA-CFAR. After this step, the Doppler ambiguity sidelobes are the main disturbance to the target detection. Then in the following analysis, the method to recognize and eliminate the Doppler sidelobes is introduced.

It can be known in Section 3 that the ambiguity Doppler sidelobes are 50 Hz away from the main lobe in ATV signals. In reality, the Doppler bin corresponds to the Doppler frequency but not equal. Suppose that the ATV signal is sampled with a sampling rate of $f_s$ and observed for an integration time of $T$. To lower the computation of the system, the correlation result is usually extracted with a rate of $E$. Then the total number of the data which is used to obtain the Doppler frequency of the target by Fourier transform can be represented as

$$ N_m = f_s \frac{T}{E} $$

Usually the value $N_m$ is not an integer power of 2. Thus, several zero values which suppose to be $D$ are required to be added to the end of the data. Thus, the relationship between the Doppler bin and the Doppler frequency is given by

$$ Q = \frac{f_s}{f_s \frac{T}{E} + D} $$

Thus, the position of 50 Hz Doppler ambiguity sidelobes is $\frac{50}{Q}$ Doppler bin away from the main lobe. Similar to eliminating the ambiguity range sidelobes, the matrix $B$ obtained in prior is also rearranged according to the amplitude in each range channel. The position of each element is also recorded. By traversing the range channel, the judgement is done in each range channel. If the position of the rest value is $\frac{50}{Q}$ or the integer multiples of $\frac{50}{Q}$ (except 0), this value is set to a very small value close to zero; otherwise the value is kept. Next, the position of each value is restored according to the position of the element which is recorded in prior. By this step, the ambiguity Doppler sidelobes can be eliminated in a high extent and we note this result as $C$. Then the CA-CFAR introduced in Section 4 is used to further eliminate the residual ambiguity sidelobes. In the next section, simulations are given to illustrate the performance of the proposed method.

6. Simulation result

In this section, simulations are given to illustrate the performance of the proposed method. Three target echoes are considered to be received by the surveillance antenna. The received signals are sampled with 400 kHz and observed for 1 s. The related simulation parameters of three target echoes are listed in Table 1.

| Signal   | SNR/dB | Range/km | Doppler/Hz |
|----------|--------|----------|------------|
| Target 1 | $-15$  | 16.8     | $-155$     |
| Target 2 | $-17$  | 31.5     | $85$       |
| Target 3 | $-19$  | 60.7     | $-155$     |

In Table 1, the definition of the SNR is the energy difference between the target echo and the thermal noise in the surveillance channel. Then the conventional processing method and the proposed method are applied. The detection results of three moving targets are shown in Fig. 8.
From Fig. 8(a), it can be clearly seen that the output of the mismatched filter contains high ambiguity range side-lobes, at the same time, the ambiguity Doppler side-lobes are also at a high energy level. It is difficult to obtain the exact range information of three targets. Then the conventional detection results with different detection thresholds are shown in Fig. 8(b) and Fig. 8(c), respectively. It can be seen from Fig. 8(b) that two targets have been detected by applying the conventional method with detection threshold of 3. However, target 3 which is at the same Doppler bin of target 1 cannot be detected, but the ambiguity Doppler side-lobes of target 3 are kept. There is false-alarm in the radar system. To lower the false-alarm ratio, the detection threshold is set to 4 which is shown in Fig. 8(c). It can be seen that the false-alarm ratio is truly reduced, but only target 1 is detected which means a higher missing-alarm ratio. Thus, it cannot just lower the false-alarm ratio or the missing-alarm ratio by adjusting the detection threshold in the radar system. Then the detection result of the proposed method is shown in Fig. 8(d). It can be seen that three proposed targets have been detected. At the same time the false-alarm ratio is less than the result shown in Fig. 8(b). Comparing the results shown in Fig. 8, it can be concluded that the proposed method holds a better performance on the target detection.

7. Performance

In this section, the simulation analysis is presented. The reference signal that is used in the simulation is taken as the ATV signal collected in an actual environment with a sampling rate of 400 kHz and an integration time of 1 s. Three target echoes are also supposed to be received and the information of the target is listed in Table 1. To illuminate the performance of the detection method, the detection threshold of the conventional method is set to 3 and 4. Meanwhile, the detection threshold of the proposed method is set to 3.

The ambiguity range sidelobes caused by the 64 μs fly-back of the ATV signal appears 15 625 times in a second which corresponds to the line frequency of 15 625 Hz. Thus, it can be known that ambiguity range sidelobes are 25.6 or the multiples of 25.6 range bin away from the main lobe with a sampling rate of 400 kHz. For convenience, the range ambiguity bin is set to 26.

Similar to the ambiguity range sidelobes, the ambiguity Doppler side-lobes are 50 Hz away from the main lobe which is caused by the field frequency of the ATV signal. Thus it can be also known that the Doppler ambiguity side-lobes are 51.2 or the multiples of 51.2 Doppler bin away from the main lobe with a sampling rate of 400 kHz. For convenience, the Doppler ambiguity bin is set to 51.

Similar to the ambiguity range sidelobes, the ambiguity Doppler side-lobes are 50 Hz away from the main lobe which is caused by the field frequency of the ATV signal. Thus it can be also known that the Doppler ambiguity side-lobes are 51.2 or the multiples of 51.2 Doppler bin away from the main lobe with a sampling rate of 400 kHz, an integration time of 1 s and an extract ratio of 100. Similarly, the Doppler ambiguity bin is set to 51. Then the result of one target in a single Doppler bin and two targets in a single Doppler bin are shown in Fig. 9.
It can be seen from Fig. 9(a) that when one target exists in a single Doppler bin, the target can be detected by applying the conventional method with detection thresholds of 3 and 4. However, ambiguity range sidelobes also exceed the detection threshold which will cause false-alarm. However, the proposed method does not suffer from the influence of ambiguity range sidelobes. The detection threshold does not change with the ambiguity sidelobes since the preprocessing has been applied to eliminate the influence of ambiguity sidelobes. As for two targets existing in a single Doppler bin shown in Fig. 9(b), the conventional method cannot distinguish the second target. The detection threshold keeps at a higher value which will cause the miss-alarm of the small target. Owing to the preprocessing method, the detection threshold is raised only at several range bins where targets locate.

Furthermore, the detection ability is also examined to evaluate the performance of the proposed method. One hundred independent trials have been conducted to get the detection probability with different SNRs of the target echo. The SNR of the target echo varies from $-40$ dB to 0 dB to obtain the detection probability of two methods, and the result is shown in Fig. 10.

![Detection threshold of two detection methods](image)

**Fig. 9** Detection threshold of two detection methods

From Fig. 10, it can be seen that the detection probability of the original method and that of the proposed method with a detection threshold of 3 are basically the same, whereas the detection probability of the original method with a threshold of 4 is worse than the two results mentioned above. Besides, several points may be noted: (i) Although the detection ability of the original method with a threshold of 3 and that of the proposed method are basically the same, there is more false-alarm in the system by the original method with the threshold of 3. This has been shown in Fig. 8(b) and Fig. 8(d). (ii) To lower the false-alarm ratio, the detection threshold of the original method is added to 4. However, the detection ability is declined sharply. (iii) When several targets exist in a single Doppler bin, the detection ability of the original method becomes worse due to the sidelobes of other targets.

### 8. Result on real data

In order to further demonstrate the effectiveness of the proposed method in this paper, real data which is obtained from an experimental ATV based PBR system is applied. Through digital beam forming (DBF), 15 beams are formed by the surveillance antenna to cover the space area to be monitored. Besides, another single antenna is set to point at the direction of the ATV signal transmitter. Outputs from beams are collected and sampled by an A/D converter with a sampling rate of 400 kHz. Fig. 11 shows the position of the PBR system and the ATV station in Shaanxi, China. Table 2 gives the specific position of the experimental system.
To examine the two processing methods, a sequence of 26 frame data lasting approximately 26 s is used. After clutter cancellation and mismatched filtering, CFAR results of the conventional and the proposed methods are shown in Fig. 12(a) and Fig. 12(b), respectively. The detection threshold of the two methods is set to 3. It can be seen from Fig. 12(a) that the moving target has been detected in several frames, but there are more false points exceeding the detection threshold which results in serious false-alarm. As for Fig. 12(b), though the moving target has not been detected in some frames, the track of the target is still formed which can be used for target tracking. Besides, there are fewer false points exceeding the detection threshold which means a low false-alarm ratio of the PBR system.

Comparing the detection result in Fig. 12, it can be known that the proposed method holds a better performance for the target detection in the PBR system which verifies the effectiveness of the proposed method.

9. Conclusions

A new target detection method which is used to deal with the ambiguity sidelobe problem in the PBR system is proposed. In this method, the ambiguity sidelobes are suppressed by the mismatched filtering, firstly. Then residual sidelobes are recognized and eliminated by the preprocessing method. Finally, CA-CFAR is used to extract the parameter of the moving target. Simulation results show that the proposed method can lower the false-alarm and miss-alarm ratio of the system, which illustrates that the proposed method holds a better target detection performance in the PBR system over the conventional method.

Besides, the result on real data also supports the conclusion. In reality, ambiguity sidelobes cannot be eliminated completely by the mismatched filtering method. When CFAR is applied, ambiguity sidelobes which exceed the detection threshold will result in false-alarm. Therefore, it is essential to eliminate the ambiguity sidelobe before CFAR is used to obtain a better target detection performance.

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