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Moving target detection in the cepstrum domain for passive coherent location (PCL) radar

Key words: Moving target detection, Cepstrum techniques, Cross ambiguity function (CAF), Passive coherent location (PCL) radar

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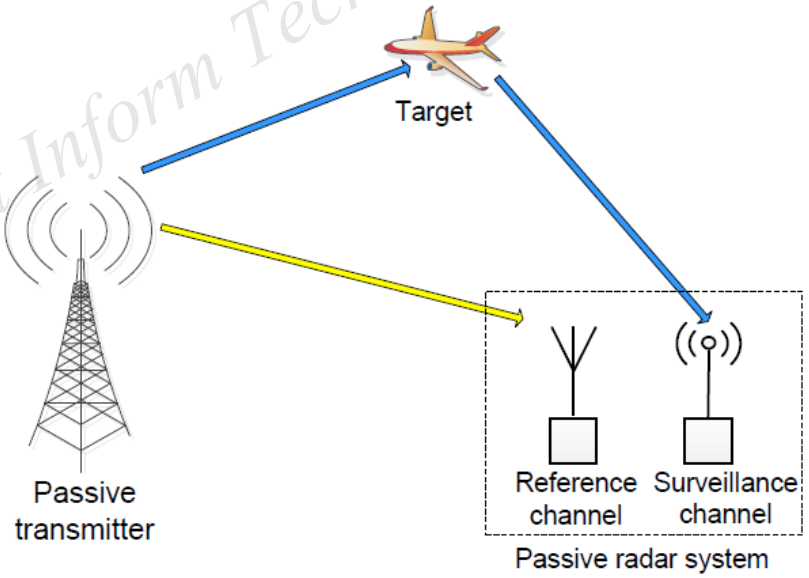
Introduction

- The passive coherent location (PCL) radar systems, operating with transmitters of opportunity, were originally designed for other purposes, such as GSM, GPS, and television broadcasting.
- There are two receiving channels in the PCL radar system, named the surveillance channel and the reference channel.



Introduction (Con'd)

- The classical moving target detection method is the radar cross ambiguity function (CAF) calculated with the reference signal and the target echoes.

- In this paper, a cepstrum moving target detection (CEPMTD) algorithm based on cepstrum techniques is proposed for PCL radar systems, which is the first attempt to detect moving targets with cepstrum techniques.

Power and complex cepstrums

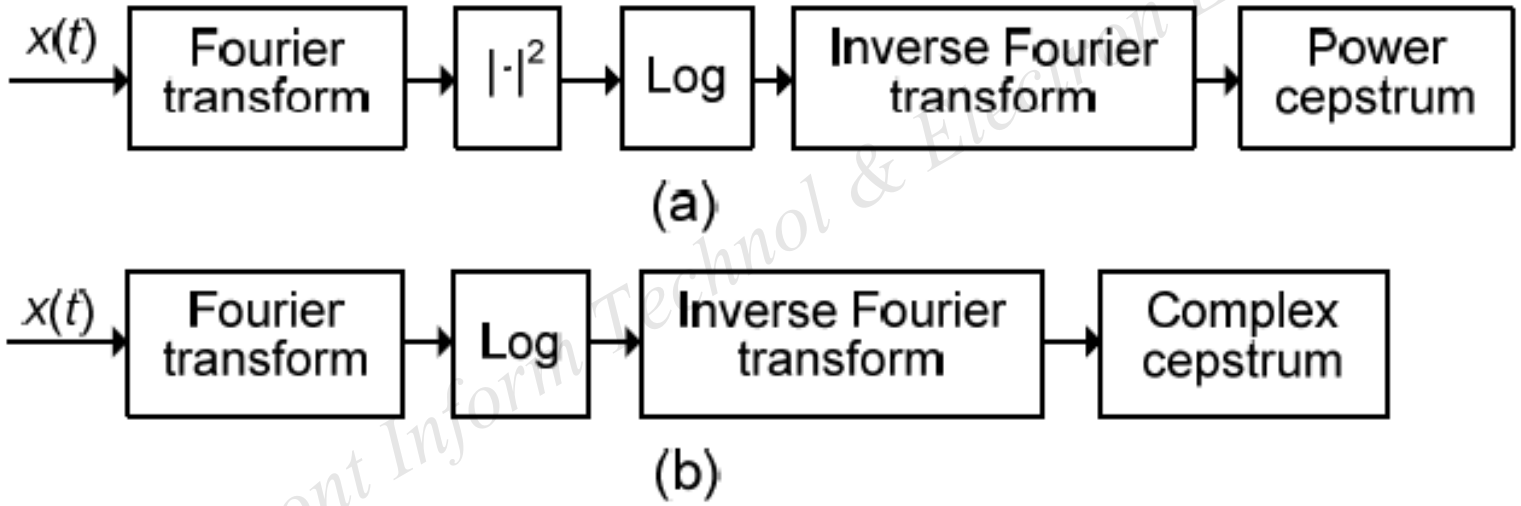


Fig. 2 Block diagrams of power (a) and complex (b) cepstrums

Moving target detection algorithm: CEPMTD

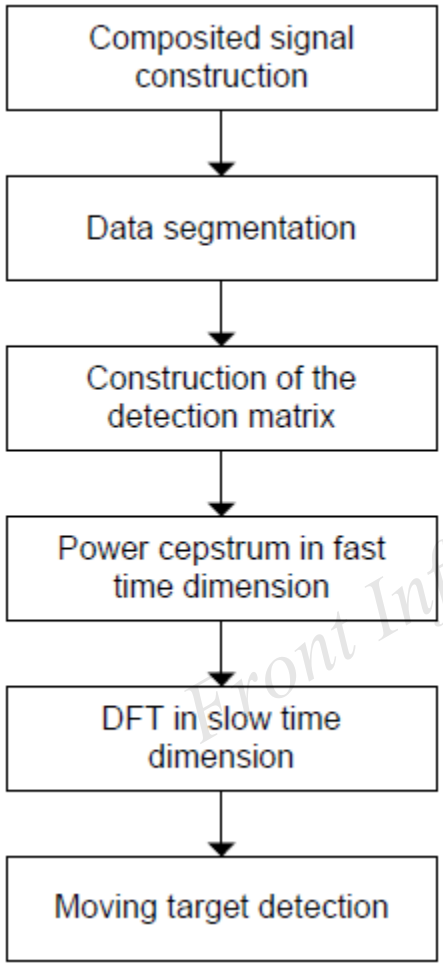


Fig. 3 Block diagram of the CEPMTD algorithm

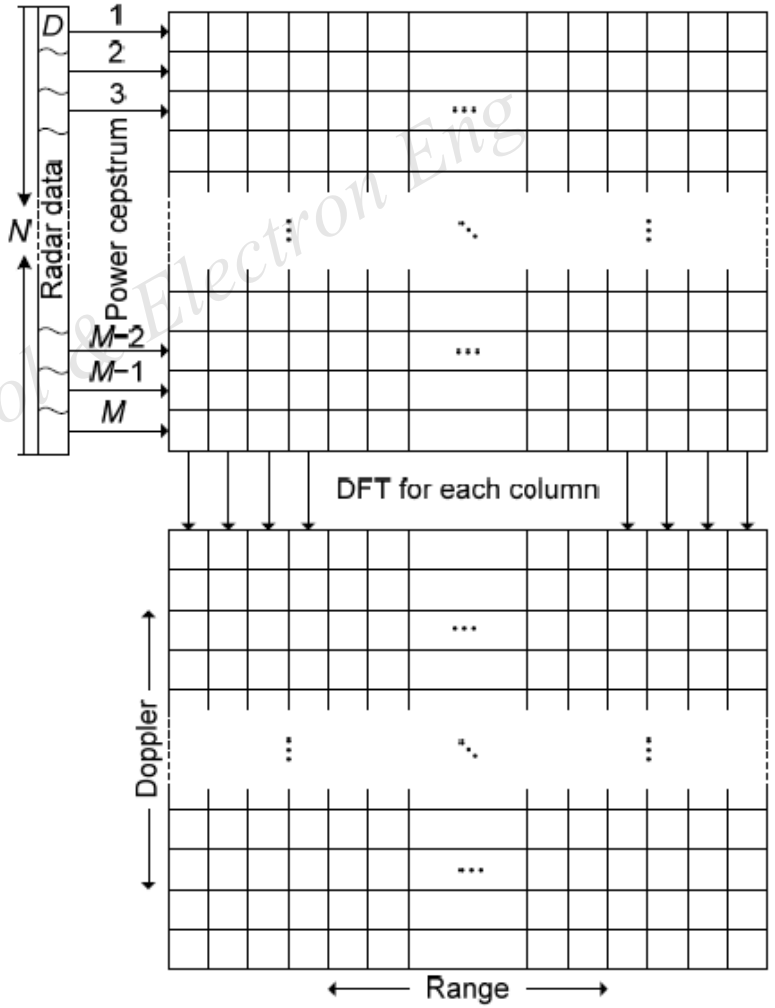


Fig. 4 Signal flow diagram of the detection algorithm

Improved CEPMTD algorithm

The true peak can be coherently added. However, the other terms cannot be coherently added.

Thus, the performance of the improved CEPMTD algorithm can theoretically exceed that of the radar CAF when there is no noise in the radar data.

$$
\begin{aligned}
U(n,\omega) &= \sum_{i=0}^{P-1} U_{\mathrm{XID}}(n,\omega) \\
&= \sum_{i=0}^{P-1} U_S(n+i\cdot l_{\mathrm{d}},\omega) + Pa\delta(n-l)\delta(\omega-\omega_{\mathrm{d}}) \\
&\quad + a\sum_{i=0}^{P-1}\delta(n+l+2i\cdot l_{\mathrm{d}})\delta(\omega+\omega_{\mathrm{d}}) \\
&\quad - 0.5a^2\sum_{i=0}^{P-1}\delta(n-2l-i\cdot l_{\mathrm{d}})\delta(\omega-2\omega_{\mathrm{d}}) \\
&\quad - 0.5a^2\sum_{i=0}^{P-1}\delta(n+2l+3i\cdot l_{\mathrm{d}})\delta(\omega+2\omega_{\mathrm{d}}).
\end{aligned}
$$

Simulation of improved CEPMTD

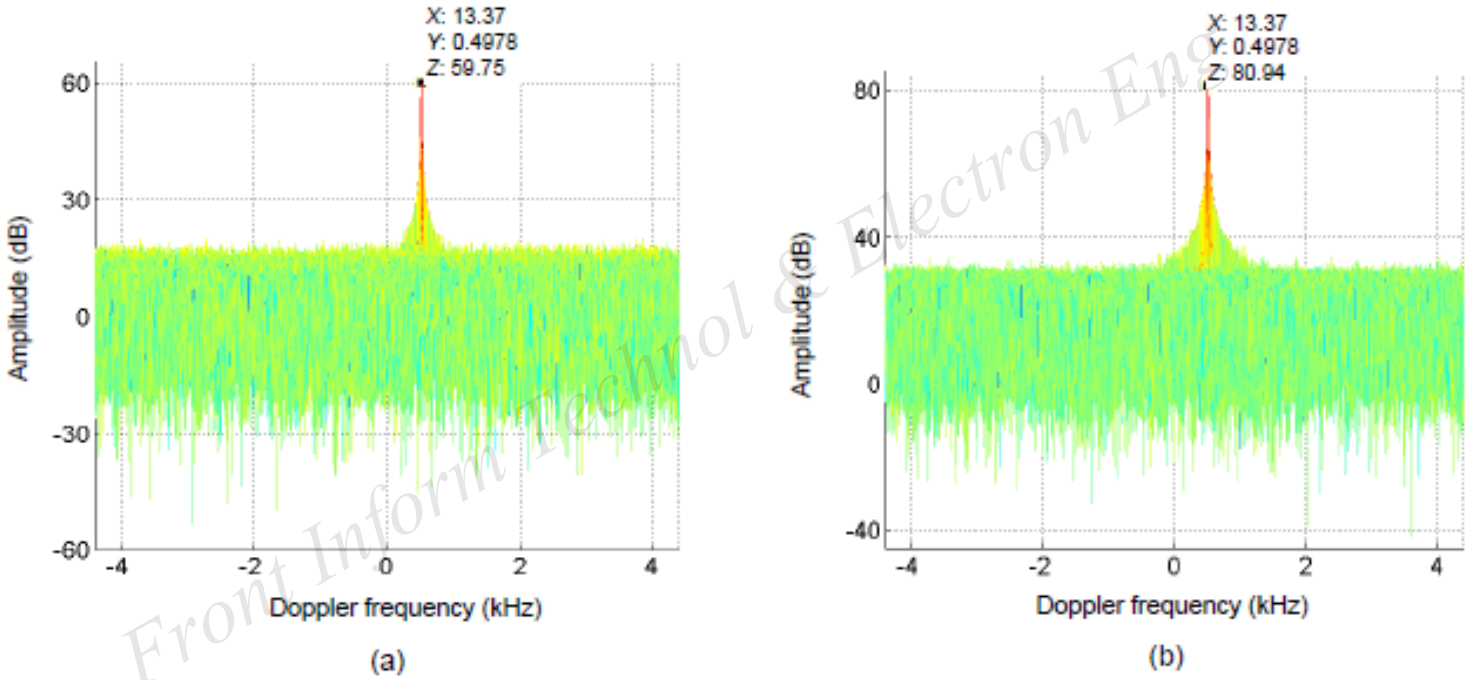


Fig. 7 Simulation results of the improved CEPMTD algorithm: (a) P=10; (b) P=100

Simulation of improved CEPMTD

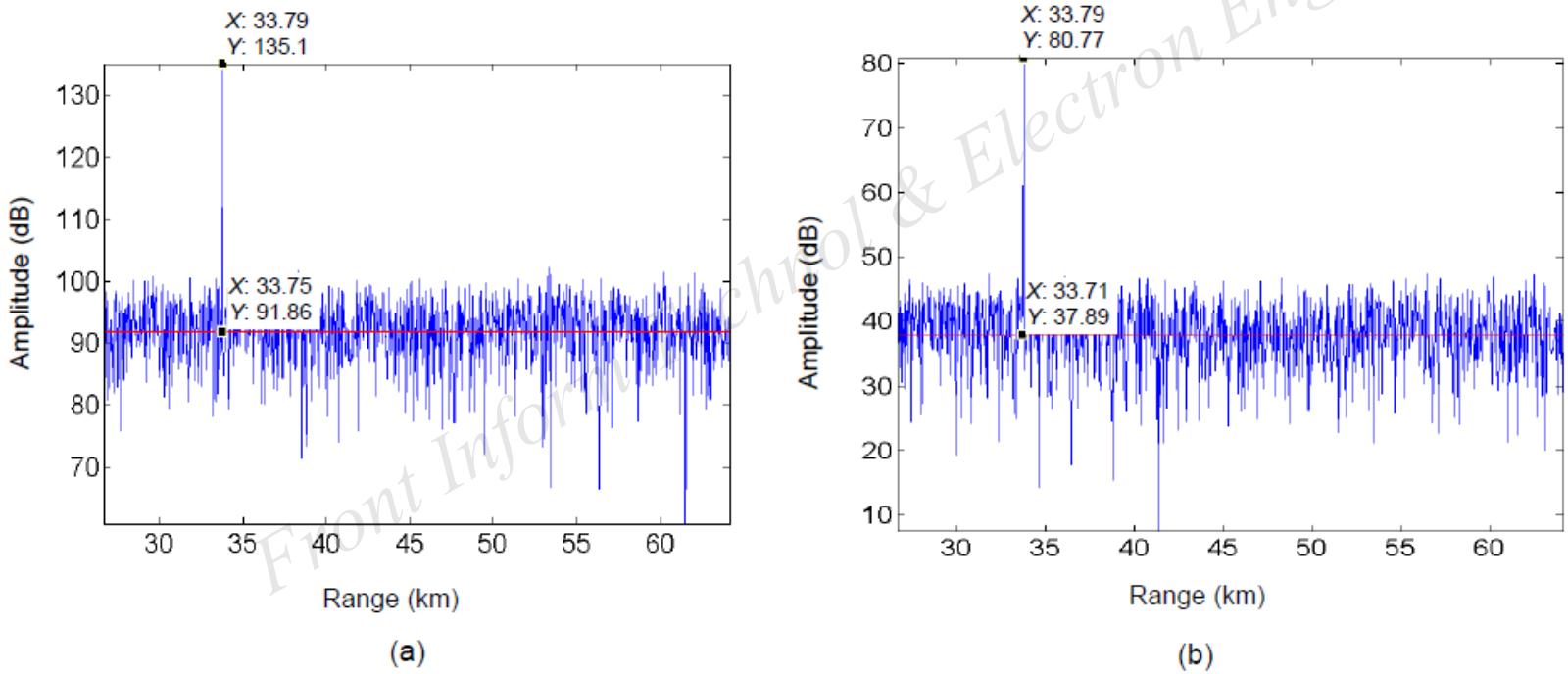
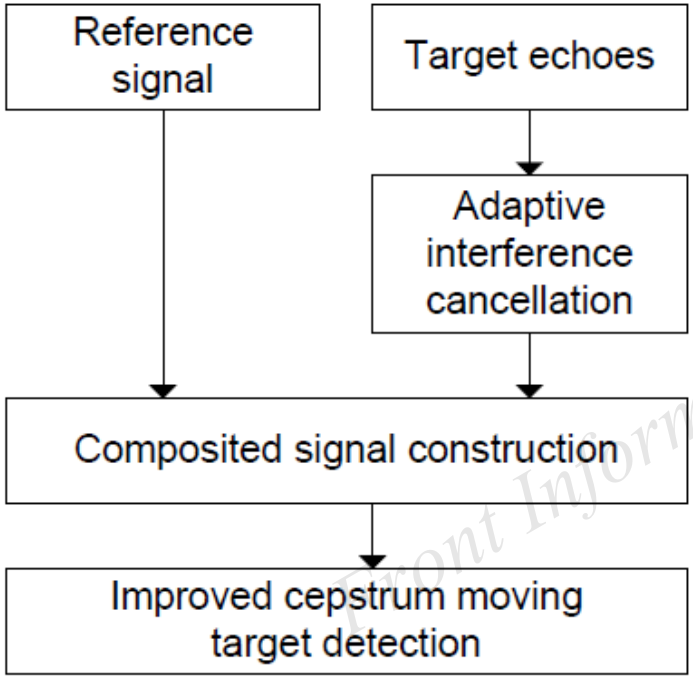
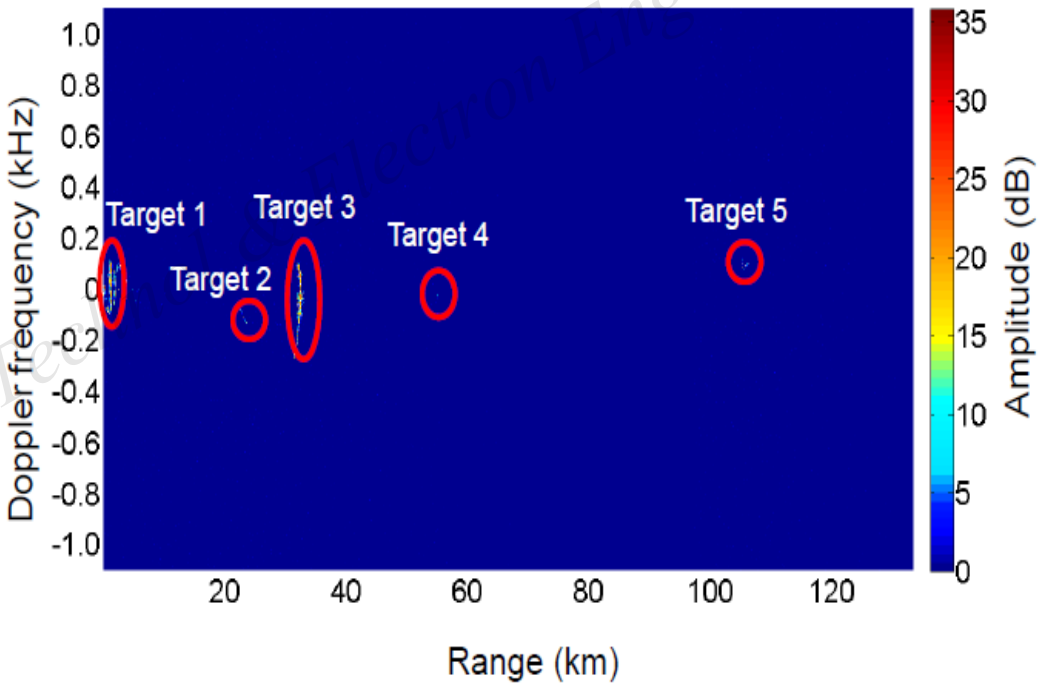


Fig. 8 Results of the Doppler profiles of radar CAF (a) and the improved CEPMTD algorithm (b)

Experimental results





Conclusions

- This paper presents a novel moving target detection algorithm based on cepstrum techniques for PCL radar systems, named CEPMTD.
- Based on the proposed CEPMTD algorithm, an improved CEPMTD algorithm is proposed to improve the detection capacity.
- The experimental results show that the detection performance of the improved CEPMTD is 1.63 dB better than that of the radar CAF when P=100.
- The improved CEPMTD algorithm can also be applied to moving target detection for other detection systems. It is certain that we have not seen the end of the applications of the improved CEPMTD algorithm.