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Direction-of-Arrival Estimation for High-Frequency Radar on a Floating Platform

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Introduction

For flexibility and wider working area, it would be a good idea to mount high-frequency radar on a floating platform. When the platform is rotating on sea surface, the direction-of-arrival would be uncertain. A description of the method called fixed-beams minimum-mean-square error beam forming is proposed to solve the problem. The method consists of two ideas: 1) the idea to convert data form rotating antenna channels into fixed beam channels; 2) the constraint of minimum-mean-square-error (MMSE) based on antenna patterns to adaptively generate the weight for the conversion. For uniform circular array (UCA) and two kinds of rotation, the simulations have been conducted. The azimuth searching spectrum around the set direction gets much sharp. And accuracy for estimated direction of the set object is greatly improved.

Methodology

We have real-time beam response as $b(h,\theta)$ with the reference response as $b_0(\theta)$ (h is the angle the platform rotates according to reference state.). The idea of fixed beam is showed as below.

$$b(h,\theta) - b_0(\theta) = 0 \tag{1}$$

It is impossible to satisfy (1) perfectly for all θ. But for global optimal solution, we could loosen the constraint as below which is also called as MMSE.

$$\underset{w(h)\in\mathbf{C}^{K\times 1}}{\operatorname{argmin}} \int_{-\pi}^{\pi} |b(h,\theta) - b_0(\theta)|^2 d\theta \tag{2}$$

So, the optimal solution under the constraint could be gotten showed below.

$$w(h)_{opt} = \left(\int_{-\pi}^{+\pi} a(\theta+h) a^H(\theta+h) d\theta \right)^{-1} \int_{-\pi}^{+\pi} a(\theta+h) b_0{}^H(\theta) d\theta \tag{3}$$

Simulation

For two kinds of rotation, simulations are conducted. One is uniform rotation (UR) and the other is uniformly accelerated rotation (UAR). The yaw of both varies from -45^{o} to $+45^{o}$. Because of the lack of aperture, azimuth searching always relies on super resolution algorithms. And the algorithm of MUSIC is widely used for radar signal processing.

We take three conditions into consideration. One is fixed-platform (FP). One is rotation-without-compensation (RWoC). And the last one is rotation-with-compensation (RWC).

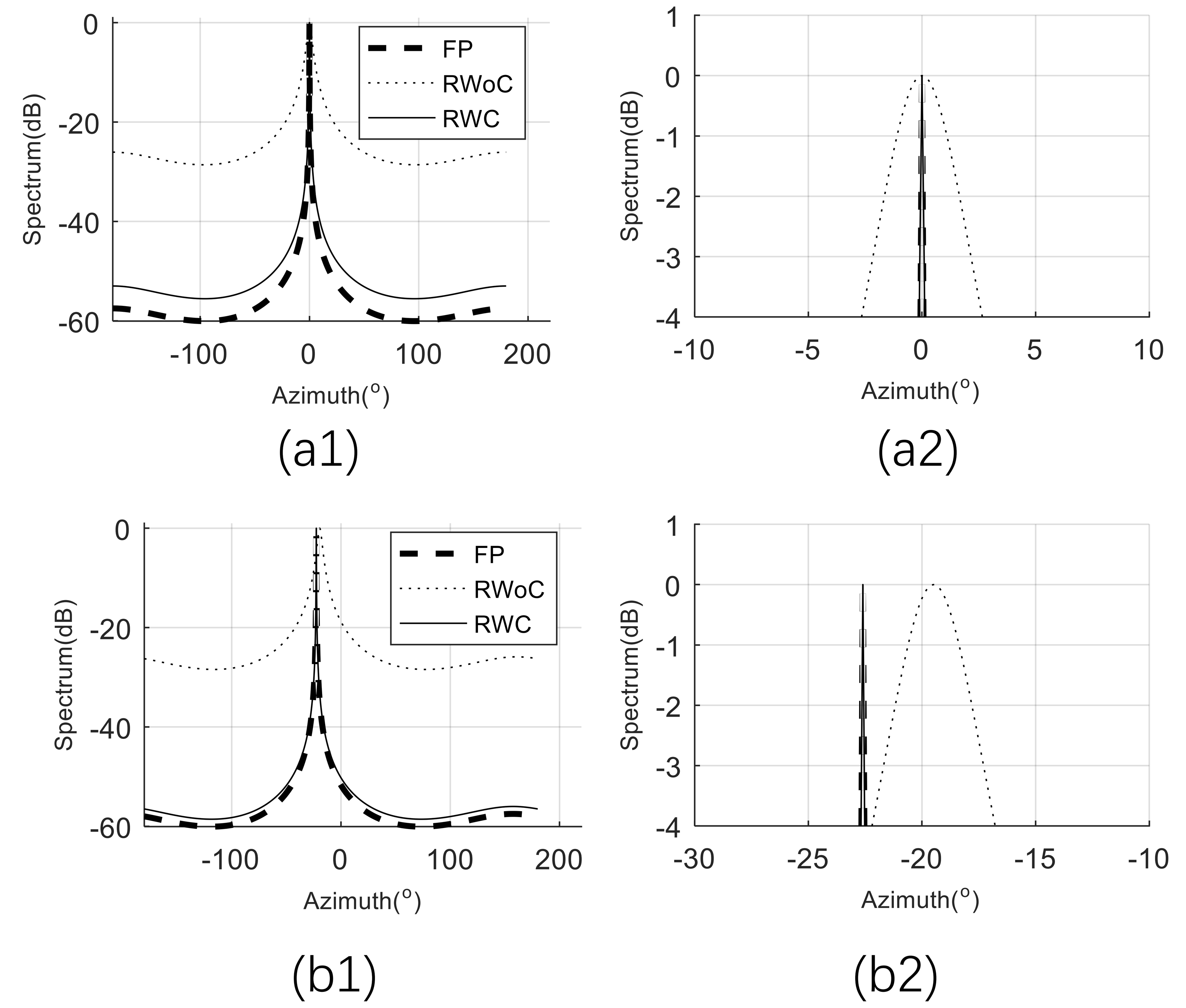

Fig. 1 Analysis of azimuth searching. (a1) and (a2) are the MUSIC searching spectrum and the partial enlarged graphic for UR; (b1) and (b2) are for UAR.

Conclusion

An algorithm is proposed to get better performance for DOA estimation on a floating platform. The simulation indicates that the uncertainty of estimated DOA could be well solved. It's easy to deploy the array as UCA. But it is impossible to make the antennas omnidirectional because of space limited platform. It needs further work to verify the effectiveness with antenna pattern distortion.

Reference

[1] D. E. Barrick. "FM/CW Radar Signal and Digital Processing," NOAA Technical Report ERL 283-WPL 26(1973).

[2] R. Schmidt, "Multiple emitter location and signal parameter estimation," IEEE Trans Antennas & Propag 34.3(1986):276-280.