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Target parameter estimation for OTFS-integrated radar and communications based on sparse reconstruction preprocessing

Key words: Integrated radar and communications system; Orthogonal time–frequency space; Target parameter estimation; Sparse reconstruction; Weighted subspace fitting

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Motivation

1. Radar communication integration technology can share hardware resources, reduce the cost of the system, and improve the frequency spectrum efficiency. Compared with the traditional orthogonal frequency division multiplexing (OFDM) system, orthogonal time–frequency space (OTFS) system has better performance in the high-speed mobile environment, and can better cope with the channel changes caused by the Doppler effect.

2. Traditional radar communication integrated target parameter estimation algorithms are generally divided into two classes, i.e., solution estimation (such as ESPRIT) and spectral peak search (such as MUSIC and ML). The computational complexity of solution estimation is low, but the estimation error is large. The estimation accuracy of spectral peak search is high, but the computation time of traversal search is long.

Main idea

1. In this study, we propose a two-step estimation method to solve the parameter estimation problem of OTFS-integrated radar and communications system.

2. In this study, by finding the sparsity of signals, the problem of target location is transformed into the problem of signal sparse spectrum reconstruction for the joint estimation of angle and range.

3. The weighted subspace fitting (WSF) algorithm is based on the same signal subspace and array manifold vector to search spectral peaks.

Method

First, an OTFS-integrated echo signal model is constructed. Then, the echo signal is transformed to the time domain to separate the target angle from the range, and the range and angle of the detected target are coarsely estimated by using the sparse reconstruction algorithm. Finally, the WSF algorithm is used to refine the search with the coarse estimate at the center to obtain an accurate estimate.

Major results

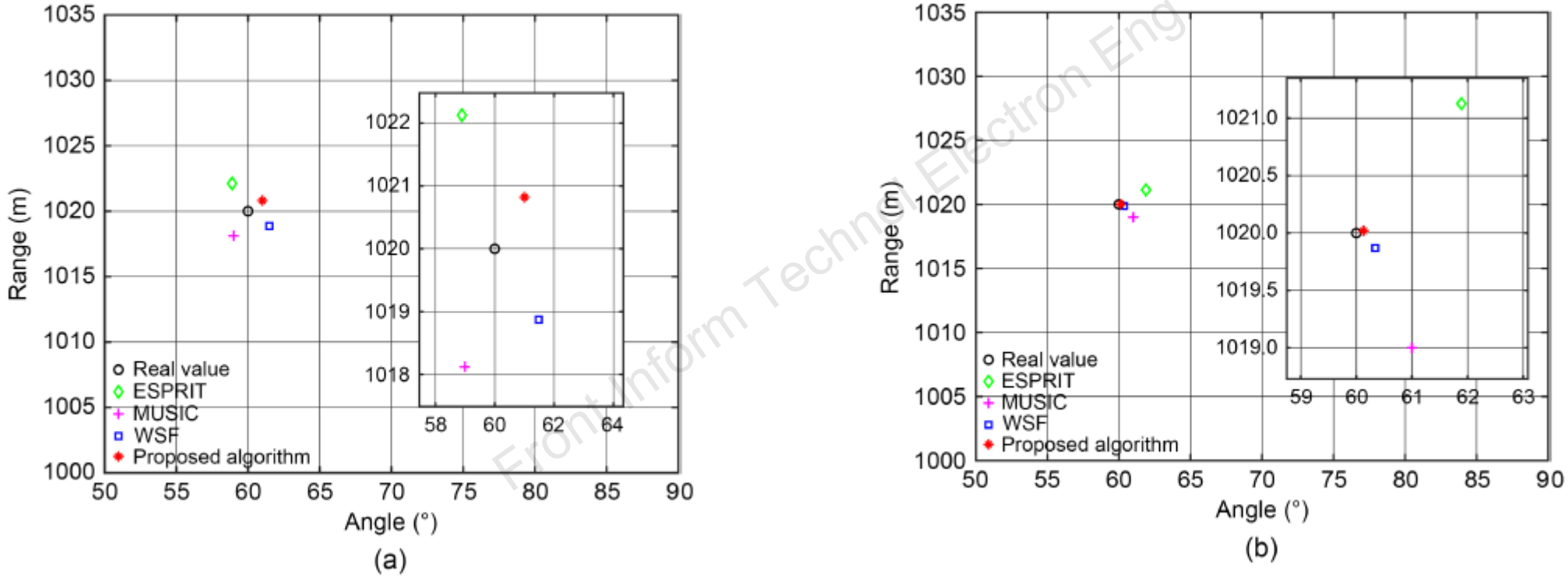

Fig. 1 Comparison of the target parameter estimation results for SNR=−5 dB (a) and SNR=5 dB (b) (SNR: signal-to-noise ratio)

Major results (Cont'd)

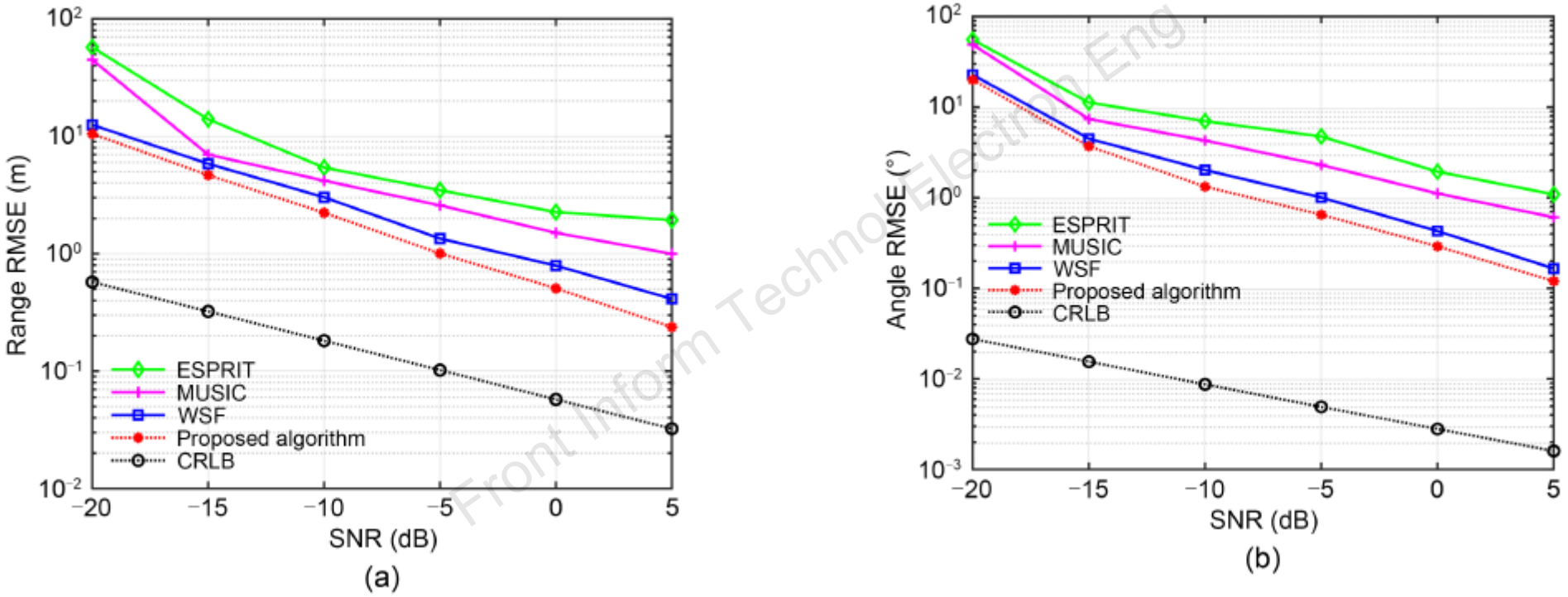

Fig. 2 Multi-target estimation performance versus SNR: (a) range estimation RMSE versus SNR; (b) angle estimation RMSE versus SNR (SNR: signal-to-noise ratio; RMSE: root mean square error)

Major results (Cont'd)

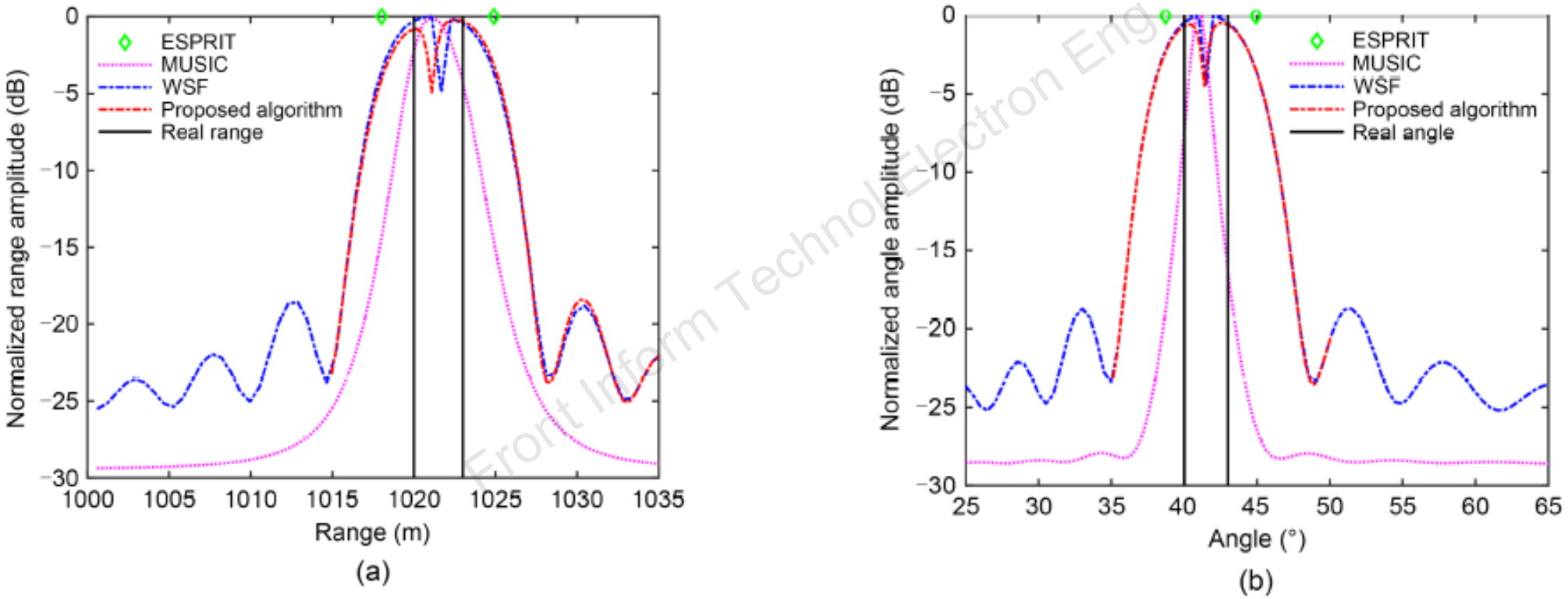

Fig. 8 Range (a) and angle (b) resolution cross-sections

Conclusions

1. A two-step estimation algorithm based on sparse reconstruction preprocessing is proposed to estimate target angle and range parameters.

2. Theoretical analysis and simulation results show that the proposed algorithm can reduce the computational load and improve the estimation accuracy and resolution.

Zhenkai ZHANG received the M.S. and Ph.D. degrees from Jiangnan University and Nanjing University of Aeronautics and Astronautics (NUAA) in 2007 and 2013, respectively. He is currently a professor of Jiangsu University of Science and Technology. He was a visiting scholar at Durham University in the UK and the University of Calgary in Canada. His main research interests include radar signal processing, radar and communications integration, radar resource management, and target tracking. He has published more than 80 scientific articles in refereed journals, such as *Signal Processing* and *IET Radar Sonar and Navigation*. He was entitled “The Backbone Teacher of Qinglan Project in Jiangsu Province” and “333 High-Level Talents in Jiangsu Province”.