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Editorial

MIMO Antennas in Radar Applications

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Conventional single-antenna radar is inherently limited in meeting the rising demands of future applications. Innovative radar technologies are thus needed to be developed. Multiple-input multiple-output (MIMO) radar allows for simultaneous transmission and reception by multiple antennas or channels. In particular, MIMO radar offers potential to gather additional information to overcome the restrictions of single-antenna radars in target radar cross section scintillation, low system gain, and poor identify capability. The multiple antennas can be placed either in a monostatic platform or in distributed platforms. This system flexibility offers opportunities to develop new radar technologies and applications. Although MIMO antennas in radar target detection and estimation applications have received much attention in recent years (see [1] and the references therein), there still are many open questions, especially in applying MIMO antennas to radar imaging applications (see [2] and the references therein).

The purpose of this special issue is to bring together MIMO antenna signal processing and application related investigations, stimulating the continuing efforts to understand MIMO radar, develop new MIMO radar imaging technologies, and evaluate their applications. From the manifold submissions, we have selected interesting papers. These papers concern different MIMO antennas and their applications in target detection, tracking, beam pattern synthesis, radar imaging, and sparse recovery. To help interested readers with a quick reference to the main themes of these papers, we briefly introduce them as follows.

Target localization in radar has been intensively studied in literature; however, the localization resolution is limited by the signal bandwidth, and usage of multiple stations is required to avoid ghost targets. On the contrary, it is possible for MIMO radar to jointly estimate the direction-of-departure (DOD) and direction-of-arrival (DOA) by applying array processing at both of the transmitting and receiving arrays. I. Pasya et al. present a joint DOD and DOA estimation in a MIMO radar utilizing ultra wideband signals for detecting targets with fluctuating radar cross sections. H. Yu et al. propose a low-complexity DOA estimation and tracking algorithm for monostatic MIMO radar. Doppler shift is also an important issue in MIMO radar, but it is often ignored in existing literatures. N. Wang et al. utilize the parallel factor (PARAFAC) algorithm to estimate the Doppler frequency and then exploit the multiple signal classification (MUSIC) to estimate the DOA. L. Xu et al. present a DOA and Doppler frequency joint estimator for bistatic MIMO radar in spatial colored noise.

Different from monostatic MIMO radar, distributed MIMO radar may provide significant performance improvement for target detection and localization. However, optimal power allocation is a challenge in distributed MIMO radar network. C. Shi et al. propose an interesting low probability of intercept (LPI) optimization framework for target tracking in distributed MIMO radar network. The authors use two information theoretic criteria, namely, Bhattacharyya distance and J-divergence, as the metrics for target detection performance.

Waveform diversity design for MIMO radar has received much attention [3]. A promising research direction is joint optimization of transmitted waveforms and receiving filters with clutter suppression. Y. Tang et al. propose a transmit waveform optimization for spatial frequency diversity MIMO radar in the presence of clutter. Besides effective clutter suppression, the proposed method also can suppress target scintillation. Furthermore, P. Gong and Z. Shaopropose a transmit beam pattern synthesis with constant beamwidth and sidelobe control for wideband MIMO radar by optimal designing of the power spectral density matrix.

This special issue focuses on MIMO radar imaging related topics, especially MIMO synthetic aperture radar (SAR) which places multiple antennas in moving platforms and employs synthetic aperture technique for two-dimensional (2D) or three-dimensional (3D) imaging. The multiple antennas in a MIMO SAR can be arranged either in elevation direction (cross-track), in azimuth direction (along-track), or in both dimensions [4]. Good operation flexibility and reconfigurability can thus be obtained by exploiting the equivalent phase centers, but optimizing the array configuration requires further investigations [5]. *H. Jiang et al.* investigate several special multiple-input single-output (MISO) and MIMO SAR modes for bidirectional imaging.

J. Zhang et al. present an efficient algorithm to reconstruct the signal of MIMO SAR using stepped frequency waveforms in spotlight and sliding spotlight modes. The authors introduce a Doppler ambiguity resolving algorithm based on subaperture division and an improved frequency-domain bandwidth synthesis method. P. Huang et al. and Z. Yang et al. present joint 2D ambiguity resolving for MIMO SAR and joint multichannel motion compensation for MIMO SAR 3D imaging, respectively. Since compressive sensing technique plays an important role in sparse array design [6], two papers exploiting compressive sensing technique for MIMO radar imaging are included in this special issue. J. Li et al. propose a sparse recovery for bistatic MIMO radar imaging in presence of array gain uncertainties, where the imaging is performed by compressive sensing with a consideration of both the transmitting and receiving array gain uncertainties. X. Ren et al. present a new strategy based on Bayesian compressive sensing theory for down-looking MIMO SAR imaging. The authors transform the cross-track imaging process into a problem of sparse signal reconstruction from noise measurements.

Another important MIMO radar topic is system implementation. The first hardware constraint is channel imbalance. Existing solutions can be classified as two categories: internal calibration and external calibration. X. Luo et al. propose an external calibration, where the channel imbalance errors are estimated from the peak of a corner reflector or a strong point target in the scenario. The second hardware constraint is motion compensation. Such problem is discussed by C. Luo and Z. He. Additionally, spaceborne MIMO SAR may be degraded by ionosphere effects. F. Zhang et al. analyze the impacts of ionosphere and troposphere refraction on spaceborne multiband SAR imaging. The authors conclude that the refraction effects should be compensated in low-frequency band.

All papers appearing in this special issue have been subject to a strict peer-reviewing process. Through this special issue, we have provided a medium of dissemination for valuable ideas and conclusions on MIMO antennas in radar applications. At the same time, we hope that more innovations can be stimulated for future advances on this exciting subject.

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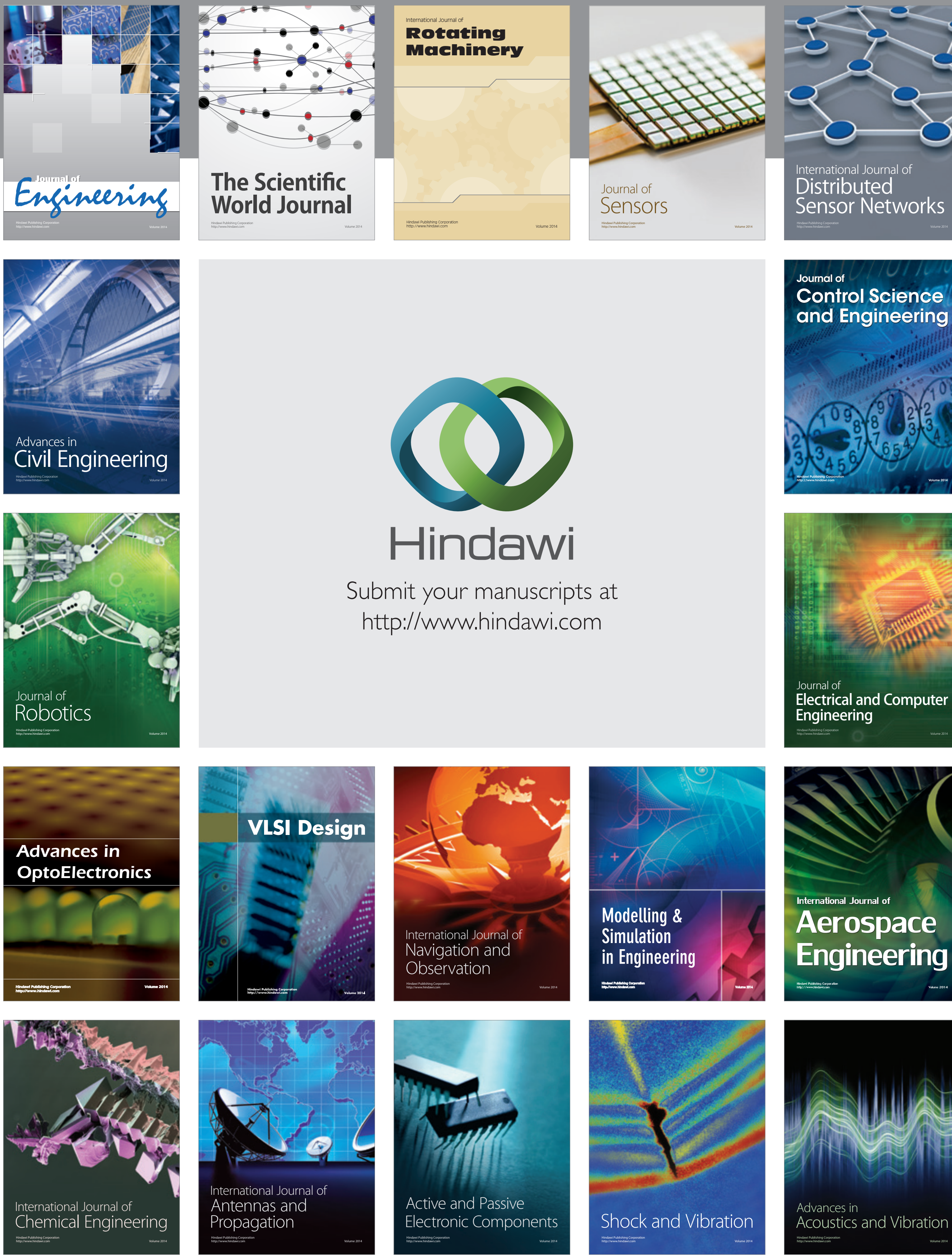
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