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Editorial

Recent Advances in Array Antenna and Array Signal Processing for Radar

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Beside the fact that array antenna design and array processing have experienced five decades of research, they are still an active and open topic in the field of radar. As a matter of fact, the recent technological advances have made the realization of array systems (ground/air/space borne) and real-time processing possible.

Riding on the wave of electronic hardware and computer system advances, the scientific interest in the realization of complex systems such as array antenna and real-time signal processing has grown enormously in the recent years.

So far, array antenna design as well as array signal processing has obtained fruitful achievements in theory, algorithm, and hardware. However, the need for faster and more accurate signal processing routines as well as the need for more efficient and miniaturized antenna and sensors still continues.

The purpose of this special issue is to publish high-quality contributions and reviews that investigate the most relevant research activities on array antenna subsystems and array signal processing for radar applications, as well as address challenges and opportunities ahead.

A substantial number of papers have been submitted, and after a thorough peer review process, eleven papers have been selected to be included in this special issue.

These papers cover important applications including antenna array design and array signal processing for direction of arrival (DoA), direction of departure (DoD) estimation, and clutter mitigation though space-time adaptive processing (STAP) to cite a few.

We believe that the papers collected in this special issue well address the contemporary topics in research related to array antenna design and array signal processing for radar systems and well introduce the reader in recent advances in such a research field.

The paper by T. Meng et al. presents an algorithm for DoA estimation of noncircular signals which is based on the use of quaternions. In this paper, the authors show that the use of quaternions allows for a computation cost reduction and a fine enough estimation accuracy since the quaternions have stronger orthogonality with respect to complex numbers.

The paper by J. Wang et al. presents a method to estimate the DoA by means of a two-dimensional state space balance (2D-SSB) method and uniformly rectangular array (URA). The proposed approach is proven to perform well in case of nonstationary environment, and its performance is compared with other methods (matrix pencil and unitary matrix pencil methods).

The paper by J. Wang et al. proposes an algorithm for the joint estimation of the DoA and DoD for a partially calibrated bistatic MIMO radar. By exploiting the multidimensional nature of the received signal, the gain-phase uncertainties of the transmit and receive arrays are estimated in a closed-form solution. These gain-phase uncertainties are used to calibrate the arrays, and the DoA and DoD of the sources can be estimated accurately.

The paper by D. Zhang et al. proposes a method for the source DoA and DoD estimation when using MIMO radars and makes use of compressive sensing approach. In particular, a "joint" sparse matrix reconstruction method is proposed and implemented through the 2D-SL0 algorithm. In this paper, the term "joint" refers to the estimates.

The paper by J.-H. Lin et al. considers the use of circular polarized (CP) dielectric resonator antenna (DRA) coupled by a fractal cross-slot. By adjusting the dimension of the fractal cross-slot property, the resonances of the fractal cross-slot, and the dielectric resonator, two different CP-DRA arrays are designed, specifically a wideband circularly polarized (CP) dielectric resonator antenna (DRA) array and a low-sidelobe-level DRA array. The designed CP DRA arrays have been also realized and measured.

The paper by F.-G. Yan et al. proposes a low-complexity algorithm for the estimation of the source DoA. The proposed algorithm aims at providing estimation accuracy comparable with that of standard MUSIC algorithm but a drastically lower complexity. The underpinning concept relies on an efficient real-valued computation of both the eigenvalue decomposition (EVD) and spectral search.

The paper by D. Zhang et al. proposes a method for the 2D DoA estimation. The idea behind the proposed approach is to exploit the relationship between three parallel uniform linear arrays (ULAs). An ambiguous estimate of the DoA at each array is obtained firstly by using the propagator method (PM). The ambiguity is due to the large spacing between the array elements. The ambiguity is then solved by triangulating the three DoA estimates. Proceeding in this way, there is no need to use subarrays or eigenspace to resolve ambiguity.

The paper by T. Pető and R. Seller proposes an algorithm for clutter cancellation in passive radar systems. The proposed algorithm jointly exploits spatial and temporal information of a receiving array in a passive radar system. The proposed approach differs however from STAP processing since the clutter is cancelled before applying any beamspace processing, and this allows to detect targets even in the direction of the direct signal, coming from the illuminator of opportunity (IO). The proposed approach is named space-time adaptive cancellation (STAC).

The paper by C. Chen et al. reports a modified STAP processing algorithm for colocated MIMO radars. The proposed method provides good detection performance even in low SNR (signal to noise ratio) level. The algorithm makes use of the worst-case performance optimization (WCPO) for avoiding target self-nulling effect. Moreover, in the proposed approach, a modified objective function (with respect to D^3 approach) is used to enhance the output signal to interference plus noise ratio (SINR) even in low SNR conditions. The analysis of the proposed method is performed by using simulated dataset.

The paper by D. Yao et al. presents an algorithm for efficient detection of a target embedded in strong radio and clutter interferences in high-frequency surface wave radar (HFSWR). In the proposed approach, the radio and clutter interferences in the main beam are estimated and suppressed through the dataset collected from auxiliary beams. The robustness versus array amplitude-phase errors is also analyzed in details.

The paper by Y. Lai et al. proposes to use a dual monopole cross-loop (MCL) antenna array to improve the performance of sea clutter echo DoA estimation of a HFR system for sea current measures. An analysis on pointing errors with respect to the number of array elements has shown that a MLC antenna with 2 or 3 elements provides significant improvement in the sea clutter echo DoA estimation. Moreover, the examination of the interelement spacing against performance shows that a spacing greater than the theoretical limits of half a wavelength is allowed. The performance improvement has been validated through on-field trials.

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