A NOVEL DESIGN METHODOLOGY FOR APERIODIC ANTENNA ARRAYS USING PARTICLE SWARM OPTIMIZATION

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Aperiodic antenna arrays have received great attention since 1960's with the advances in both radio astronomy and radar techniques. Using uniform-amplitude excitations, a narrow beamwidth and a low peak SLL can be achieved by an aperiodic array with much fewer elements than using a conventional periodic antenna array, due to the flexibility in its element spacings. Aperiodic arrays can be categorized into *sparse arrays* and *thinned arrays*. In the last forty years, many efforts have been expanded on the design of aperiodic arrays (either sparse arrays or thinned arrays) with the lowest peak SLL, yet all fail in approaching the optimum design obtained by brute-force investigations. A strategy that trades off multiple factors (the peak SLL, the beamwidth and the number of elements) of an aperiodic antenna array also remains unavailable, which results in a very challenging engineering problem.

This paper presents a novel design methodology for aperiodic antenna arrays using particle swarm optimization (PSO) technique. A randomized Newtonian mechanics model is proposed to describe the swarm behavior, which is formulated as an iterative process and applied to different types of optimizations. In aperiodic array applications, an attractive feature of PSO algorithm is that the variables to be optimized can be either real numbers (RPSO) or binary strings (BPSO). This enables the algorithm to be applied in the design of sparse arrays and thinned arrays, respectively. Specifically, RPSO determines the position of each element in a sparse array, and BPSO determines the on/off state of each element in a thinned array. The objective of both optimizations is to achieve the lowest peak SLL. The effectiveness of the algorithm is validated by comparing the optimized aperiodic arrays to some representative designs of existing methodologies.

The applicability of the PSO algorithm in aperiodic antenna array designs is further expanded by its multi-objective implementations (MORPSO and MOBPSO). With multiple design criteria defined by appropriate fitness functions, a sparse array is optimized to achieve a lower peak SLL with a narrow beam, and a thinned array is designed for a lower SLL using the least number of elements. For instance, A 10-element, 10λ linear sparse array is observed to have a -19dB peak SLL while keeping the same beamwidth as a periodic array. The non-dominated designs obtained on the pareto front is shown to be substantially advantageous to some existing aperiodic array designs, and dramatically improve the limit between multiple design criteria given by the probabilistic-based method. It is believed by the authors that this paper is the first systematical study of aperiodic antenna arrays using an evolutionary algorithm, and the methodology can be applied to design arbitrary, multi-dimensional aperiodic antenna arrays with steered beams and directional elements for practical applications.

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2. B - Fields and Waves

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