Optimal Design of Partially Reflected Surfaces Using Various Nature-Inspired Optimization Techniques

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As it is well-known, partially reflective surfaces (PRS) are highly reflective frequency-selective surfaces (FSS) that have been reported in design of antennas for beamforming and high gain wireless applications. For high gain antenna applications, a simple implementation of the PRS includes a periodic array of narrow printed strips placed in front of a feeder antenna at a resonant distance corresponding to an equivalent Fabry-Perot structure. The strip array acts as a leaky wave surface that significantly enhances the directivity of the feeder antenna. Such an antenna system results in a high gain beam, but with no control on other parameters of the radiation pattern. In particular, the use of such a uniformly spaced PRS array may result in a relatively high side-lobe-level that may not be desirable in many high gain communication and radar applications. The non-uniformly spaced (aperiodic) PRS, however, has been proposed to optimize the side-lobe-level of a printed antenna for a given beam width and/or shape its far-field pattern [*A. Hoorfar, J. Zhu, N. Engheta, International Conference on Electromagnetics in Advanced Applications, Torino, Italy, pp. 675-678, September, 2003*].

In this work, we revisit the concept of aperiodic PRS and extend it to other novel antenna applications using some of the recent advances in nature-inspired optimization and synthesis techniques. The degrees of freedom provided by different spacing and length of PRS elements allow us to control the amplitude and phase variations across the PRS plane, and as a result, synthesize various radiation parameters of the feeder antenna. To begin with, we first perform a comparative study of various forms of Evolutionary Programming (EP), Genetic Algorithms (GAs), Particle Swarm Optimization (PSO), and recently proposed Covariance Matrix Adaptation Evolution Strategy (CMA-ES) [*D. Gregory, Z. Bayraktar and D. H. Werner, IEEE Trans. Antennas Propag., vol. 59, no. 4, pp. 1275-1285, 2011*] and mixed-parameter and multi-objective CMA-ES [*E. Bou-Daher and A. Hoorfar, IEEE Trans. Antennas Propag., to appear in 2015*] as applied to beamshaping of a microstrip antenna utilizing a MoM based forward model of the PRS antenna structure. To that end we discuss the integration of these codes with both the in-house and commercial moment method based modeling tools. We then discuss the extension of the concept to PRS composed of array of other geometrical shapes, and investigate the aperiodic or randomly positioned PRS elements for dual polarization and/or multi-band antenna designs. Results of various optimized designs together a sensitivity analysis of selected designs will be given in the presentation.