

Efficient Collocation Methods for Surrogate Model-Assisted GA-Based Electromagnetic Optimization

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In recent years, genetic algorithms (GAs) have extensively been used to design a variety of electromagnetic (EM) devices ranging from antennas to microwave filters and absorbers. GAs as well as other nature-inspired optimization methods have gained significant attention due to their ability to easily recover the global optimum in multimodal design spaces and their straightforward implementation. That said, GAs often require the evaluation of objective functions for a large number (tens of thousands) of design candidates. This requirement limits their applicability to the design on electrically large platforms (such as placement of antennas on electrically large platforms), for which the evaluation of each design candidate requires the execution of a CPU intensive full-wave EM simulation. For such cases, GA-based optimization frameworks are assisted by surrogate models (i.e. compact polynomial input-output representations). However, surrogate models often lack accuracy (i) when the dimensionality of design domain is high and/or (ii) when the observables pertinent to the objective functions exhibit rapid variations.

In this study, efficient collocation methods to construct accurate surrogate models for pertinent observables or objective functions are proposed. To construct surrogate models in high-dimensional design domains, the proposed technique leverages iteratively constructed high dimensional model representation (HDMR) expansions which express pertinent observables or objective functions as finite sums of component functions. The component functions of HDMR expansion are approximated via a multi-element probabilistic collocation (ME-PC) method that relies on Legendre polynomial chaos expansion. The ME-PC method effectively tailors the collocation points used for polynomial approximation to tackle the second of above mentioned concern.

Upon the construction of accurate surrogate models, the proposed method runs a classical GA to thoroughly canvass the multidimensional design domain for optimal designs. The efficiency and accuracy of the proposed method will be demonstrated via its application to the placement of sources in a non-uniformly spaced linear array, the selection of locations of stacked-patch microstrip antennas in a linear array, and the placement of monopole antennas on a ship.