Random Forest-Based Surrogate Modeling in RF Optimizations

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Design and optimization of radio frequency (RF) structures require numerous full-wave simulations for structural optimization. Often heuristic optimization algorithms are used for this design process, and many intermediate design solutions are simulated before converging to a final design. Typically, such optimization processes are computationally expensive in terms of time and memory, especially when finely discretized full-wave simulations are needed. In this context, computationally inexpensive yet reliable models, which are known as surrogate models, can be used to replace/reduce time and memory consuming full-wave simulations that are needed during optimizations. Also, surrogate models enable parametric tuning of RF designs, as they learn the dependency of the RF performance of designs on their geometrical parameters. Popular surrogate modeling techniques in RF structure optimization include Kriging interpolation (S. Koziel and S. Ogurtsov, IEEE Trans. Antennas Propag., vol. 61, no. 12, pp. 5931-5939), gaussian process regression (Q. Wu, H. Wang and W. Hong, IEEE Trans. Antennas Propag., vol. 68, no. 5, pp. 3397-3409), support vector regression (D. R. Prado, J. A. López-Fernández, M. Arrebola and G. Goussetis, IEEE Trans. Antennas Propag., vol. 67, no. 3, pp. 1659-1668), and artificial neural networks (J. Dong, W. Qin and M. Wang, IEEE Access, vol. 7, pp. 77692-77701).

In this work, we propose the use of random forest (Mendes-Moreira, J., Soares, C., Jorge, A. M., & Sousa, J. F. D., ACM Comput. Surv. 45, 1, Article 10) approach to perform surrogate model-assisted optimizations. Specifically, we apply our proposed method to optimize the directivity for end-fire arrays. Random forest is an ensemble-based machine learning technique that creates several models combined to perform a particular task. This technique is commonly used in solving classification and regression problems and to our knowledge, its potential in solving electromagnetic optimization problems through surrogate modeling has not been studied before. To demonstrate the effectiveness of our proposed approach, we compare the performance of random forest with support vector regression in building surrogate models for the optimization of end-fire arrays. Our results indicate that the random forest surrogate models are competitive to other surrogate modeling techniques, e.g., support vector regression, thereby proving their potential in antenna surrogate modeling. A complete analysis of our proposed technique will be presented along with its comparison with other surrogate modeling techniques at the conference.