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An Evolutionary Approach for Automated Optimization and Design of Vivaldi Antennas

Authors : Sahithi Yarlagadda

Abstract : The design of antenna is constrained by mathematical and geometrical parameters. Though there are diverse antenna structures with wide range of feeds yet, there are many geometries to be tried, which cannot be customized into predefined computational methods. The antenna design and optimization qualify to apply evolutionary algorithmic approach since the antenna parameters weights dependent on geometric characteristics directly. The evolutionary algorithm can be explained simply for a given quality function to be maximized. We can randomly create a set of candidate solutions, elements of the function's domain, and apply the quality function as an abstract fitness measure. Based on this fitness, some of the better candidates are chosen to seed the next generation by applying recombination and permutation to them. In conventional approach, the quality function is unaltered for any iteration. But the antenna parameters and geometries are wide to fit into single function. So, the weight coefficients are obtained for all possible antenna electrical parameters and geometries; the variation is learnt by mining the data obtained for an optimized algorithm. The weight and covariant coefficients of corresponding parameters are logged for learning and future use as datasets. This paper drafts an approach to obtain the requirements to study and methodize the evolutionary approach to automated antenna design for our past work on Vivaldi antenna as test candidate. The antenna parameters like gain, directivity, etc. are directly caged by geometries, materials, and dimensions. The design equations are to be noted here and valuated for all possible conditions to get maxima and minima for given frequency band. The boundary conditions are thus obtained prior to implementation, easing the optimization. The implementation mainly aimed to study the practical computational, processing, and design complexities that incur while simulations. HFSS is chosen for simulations and results. MATLAB is used to generate the computations, combinations, and data logging. MATLAB is also used to apply machine learning algorithms and plotting the data to design the algorithm. The number of combinations is to be tested manually, so HFSS API is used to call HFSS functions from MATLAB itself. MATLAB parallel processing tool box is used to run multiple simulations in parallel. The aim is to develop an add-in to antenna design software like HFSS, CSTor, a standalone application to optimize pre-identified common parameters of wide range of antennas available. In this paper, we have used MATLAB to calculate Vivaldi antenna parameters like slot line characteristic impedance, impedance of stripline, slot line width, flare aperture size, dielectric and K means, and Hamming window are applied to obtain the best test parameters. HFSS API is used to calculate the radiation, bandwidth, directivity, and efficiency, and data is logged for applying the Evolutionary genetic algorithm in MATLAB. The paper demonstrates the computational weights and Machine Learning approach for automated antenna optimizing for Vivaldi antenna.

Keywords : machine learning, Vivaldi, evolutionary algorithm, genetic algorithm
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