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Prior-Knowledge-based ANN Hyperparameters Optimization using Evolutionary Algorithms

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The Multilayer perceptron (MLP) model is a widely used artificial neural network (ANN) based modeling technique to reduce the computational time required by full wave electromagnetic simulators. The right selection of various hyperparameters impacting the network's structure is essential to ensure accurate and efficient prediction performance of the MLP model. Usually, the hyperparameter values are chosen using a trial-and-error method, grid or random search. The trial-and-error method is the traditional strategy, but it is not practical for determining a large number of parameters. Also, these approaches are time-consuming and may fail to predict a near-optimal solution. In recent years, evolutionary algorithms have been widely used to determine the optimum hyperparameters of the MLP model. Among the various evolutionary algorithms, the particle swarm optimization (PSO) is a robust and efficient method requiring less computational effort.

The MLP model requires a large number of datasets for giving better accuracy which can be improved by incorporating prior knowledge into the network. The priori knowledge helps to avoid local minima, increases speed of finding global minima and at the same time works well with comparatively smaller number of datasets. In this article, a prior knowledge input (PKI) based ANN model has been developed. The prior knowledge has been incorporated into the network using a trained MLP model. The PSO algorithm is utilized for the hyperparameter tuning of the MLP model. The hyperparameters tuned using the PSO are the number of hidden layers, neurons in each hidden layer, and the activation function. The proposed modeling technique has been validated using an ultra-wideband (UWB) band-notched antenna. An f-shaped UWB antenna loaded with electromagnetic bandgap (EBG) structure and rectangular split ring resonator (RSRR) is considered as a modeling example. The proposed PKI model optimized utilizing the PSO algorithm, has been used for inverse modeling the UWB antenna. The geometrical variables of the antenna are predicted using the cut-off and notch frequencies. For a comparative analysis, the genetic algorithm (GA) is also employed for tuning the hyperparameters of the PKI model. Performances of all the models will be evaluated using different quantitative assessment metrics to establish an accurate and efficient prediction capability of the proposed model. The comparative analysis will demonstrate the effectiveness of the PKI model in mapping the relationship between the antenna geometry and its corresponding electrical response.