Response feature-based modeling for small-data machine learning in electromagnetic design

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Machine learning (ML) techniques have attracted a lot of attention in the area of modeling and design of electromagnetic systems. Deep neural networks (DNNs), a subset of ML, are particularly effective in learning complex functions. However, a large number of data samples might be needed to train and validate complex DNNs and therefore the potential speed-up in a design flow offered by these models can be drastically reduced. This work focuses on a set of techniques that can be used to model frequency-dependent responses without requiring a massive amount of data and complex model architectures. The frequency-dependent responses can be properly pre-processed in different ways before training deep learning models, e.g. by extracting response features and avoiding a very fine discretization over the frequency axis by adaptive frequency sampling. A design space reduction is proposed to focus on a feasible design space related to a set of design specifications of interest. These techniques are validated by numerical results that illustrate all these aspects in detail.