LABO - Axe et Equipe : Institut Pascal - UMR 6602 CNRS – équipe CEM

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Title of PhD subject: Frugal database generation for solving electromagnetic compatibility problems using artificial intelligence methods

Summary :

Recently, artificial intelligence methods have demonstrated their potential for solving electromagnetic compatibility (EMC) problems [1]. These approaches, mainly based on the use of neural networks (reinforced learning, regression, metamodeling, classification, PINN, etc.), have delivered promising results, whether for optimizing EMC configurations, accelerating numerical codes or anomalies detection. What all these applications have in common, however, is the need for very large databases for model training [2].

Obtaining these databases is often a technical, financial and environmental challenge in itself. This is particularly true in EMC, where experiments are costly, energy-intensive and time-consuming. A typical EMC numerical simulation can take several hours for a single case. Therefore, one of the challenges is to find solutions to train neural networks on small-scale, but accurate, databases built beforehand.

The aim of this thesis is to develop new approaches for obtaining and using frugal databases. One of the objectives will be to minimize the necessary data associated with a deterministic or stochastic EMC problem, with a view to solving it using neural networks.

The research work will draw on recent developments in domain decomposition techniques [3-4]. These approaches, for both one and three-dimensional problems, not only drastically reduce computational costs but also preserve the confidentiality of the various models used. Experimental validation in a mode-stirred reverberation chamber (MSRC) is envisaged.

Expected skills: Electromagnetic compatibility, numerical methods in time and frequency domain, MSRC, notions of artificial intelligence.

References:

[1] AI, Machine Learning, and Deep Learning: Advances and Applications for EMC," in IEEE Letters on Electromagnetic Compatibility Practice and Applications, vol. 5, no. 4, pp. 159-160, Dec. 2023, doi: 10.1109/LEMCPA.2023.3325491.

[2] O. Osman, S. Sallem, L. Sommervogel, M. O. Carrion, P. Bonnet and F. Paladian, "Distributed Reflectometry for Soft Fault Identification in Wired Networks Using Neural Network and Genetic Algorithm," in IEEE Sensors Journal, vol. 20, no. 9, pp. 4850-4858, 1 May1, 2020.

[3] Imane Massaoudi. Domain Decomposition Approach for Deterministic/Stochastic EMC Time-Domain Numerical and Experimental Applications. Alleviating the Curse of Dimensionality. Thèse de doctorat, Université Clermont Auvergne, 2023.

[4] I. Massaoudi and P. Bonnet, "A Domain Decomposition Approach for Cost Effective Transmission Lines Time Domain Stochastic Simulations," in IEEE Transactions on Electromagnetic Compatibility, vol. 66, no. 1, pp. 180-188, Feb. 2024, doi: 10.1109/TEMC.2023.3342275.