MACHINE LEARNING FOR THE PERFORMANCE ASSESSMENT OF HIGH-SPEED LINKS

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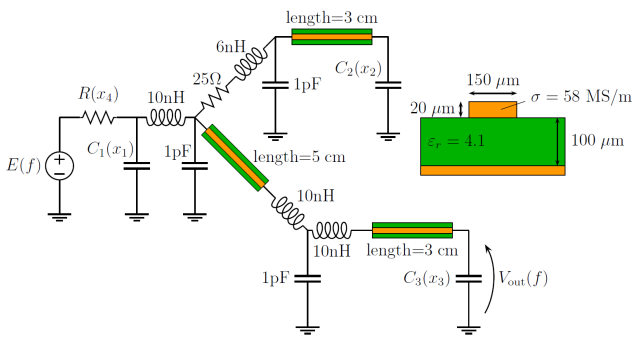
This summary takes a picture of the on-going research activities of the Torino "Elettronica" unit on the development of mathematical tools for the stochastic and parametric analysis of complex dynamical systems. This work continues and extends a research which has been carried out since several years.

In the last decades, a number of advanced techniques have been proposed for the development of parametric surrogates and the stochastic analysis of parametric systems. These include Monte Carlo (MC), parameterized macromodeling, polynomial chaos (PC), worst-case methods, and generative models. MC simulation can be considered as the natural choice for the analysis of a generic parametric system. However, even though MC is accurate, it requires a high computational cost without providing a parametric surrogate of the system responses. On the other hand, none of the above mentioned techniques provides an ultimate solution: (i) for problems with a large variability of the input parameters (e.g., 50%); (ii) to generate models starting from a very limited number of observations of the system responses; (iii) providing a parameterized macromodel; and (iv) with a proven robustness to the effect of possible noise corrupting sampled data.

The above considerations provide a strong motivation to systematically investigate the feasibility and strengths of alternative approaches. Paper [1] collects our initial results on the application of support vector machine (SVM) regression to the modeling of high-speed interconnects with largely varying uncertain design parameters. The feasibility and strength of the method are demonstrated based on the parametric analysis of the magnitude of the transfer function V_{out}/E in the printed circuit board interconnect shown in the left panel of Fig. 1 for a 50% variation of the capacitances C_1, C_2 and C_3 around their central values. Emphasis is given to the effects of the training sample size on the model accuracy. The table in the right panel of Fig. 1 compares the computational cost and the accuracy of the PC and SVM macromodels at frequency 830 MHz.

From the obtained results, the SVM regression can be considered as a viable solution that substantially outperforms the PC expansion method in terms of accuracy when a small set of training samples is available. An extensive analysis of the performance of the SVM approach w.r.t. the dimensionality of the parameter space has still to be performed.



Method	# of training samples L	Model construction [s]	Model evaluation [s]	Max rel. error%
SVM (order 5)	30	0.08s	1.60s	100%
	50	0.01s	1.63s	99%
	100	0.09s	1.64s	33%
	150	4.30s	1.66s	13%
PC (order 5)	30	0.07s	0.04s	>100%
	50	0.11s	0.04s	>100%
	100	0.22s	0.03s	>100%
	150	0.33s	0.04s	17%

Fig. 1: Schematic of a high-speed link with lossy transmission lines (left panel) and model comparison (right panel) [1].

[1] R. Trinchero, P. Manfredi, I. S. Stievano, F. G. Canavero, "Machine Learning for the Performance Assessment of High-Speed Links", IEEE Trans. EMC, 2018 (in press, Early Access).