ELECTRICAL, ELECTRONICS AND COMMUNICATIONS ENGINEERING

Continental Automotive Technologies - Surrogate models for design optimization under Signal and Power Integrity constraints

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Context of the research activity	This PhD scholarship focuses on developing machine learning-based surrogate models for the design optimization of high-speed systems, and more generally for first-pass design validation under signal and power integrity constraints. Model order reduction and uncertainty quantification methods will be exploited to enhance the efficiency and accuracy of design processes in high-speed electronic systems, through advanced computational techniques and machine learning.

	This research activity is conducted in collaboration with Continental Automotive Technologies GmbH, Germany. ### Research Objectives: The PhD research will build on the concepts presented in recent studies exploring behavioral modeling approaches for digital integrated circuit (IC) buffers, particularly for fast and accurate transient simulation of high-speed links. The main objective is to develop and optimize machine learning-based surrogate models that improve the design process of high-speed electronic systems. These models will focus on enhancing signal integrity, power integrity through robust design techniques and algorithms exploiting model order reduction and uncertainty quantification. ### Background and Motivation: The need for accurate and efficient simulation models of digital IC buffers has been a critical focus for the signal and power integrity community since the early 1990s. Traditional modeling approaches, such as those inspired by the Input/Output Buffer Information Specification (IBIS), have dominated the field. These models assume a specific two-piece structure, simplifying the model

Objectives	estimation process but potentially limiting flexibility and generalizability. Recent advancements have explored fully behavioral and black-box approaches using Artificial Neural Networks (ANNs) and kernel-based machine learning methods. These approaches offer a promising alternative to classical methods by not assuming a rigid model structure. Despite their potential, these methods face challenges, such as the complexity of training processes, the need for large datasets, and the difficulty in maintaining physical consistency in the models. ### Research Objectives: 1. **Development of Surrogate Models:** - The research will focus on creating surrogate models using advanced machine learning techniques, particularly kernel-based methods and other state-of-the-art algorithms. These models will be designed to capture the nonlinear dynamics of terminated high-speed links (and more generally high-speed systems) more efficiently and accurately than traditional methods. 2. **Signal and Power Integrity:** - A key objective is to enhance signal and power integrity in high-speed systems by using the developed surrogate models to predict and mitigate integrity issues. This involves accurately modeling the transient responses of IC buffers and interconnects under various operating conditions. 3. **Model Order Reduction:** - The research will explore model order reduction techniques to develop compact surrogate models without sacrificing accuracy. This will make the models more computationally efficient and suitable for real-time applications in electronic design automation (EDA). 4. **Uncertainty Quantification:** - To ensure robustness and reliability, the research will incorporate uncertainty quantification capabilities into the surrogate models. This will involve assessing the impact of variability in manufacturing processes and environmental conditions on the performance of high-speed links and systems. 5. **Optimization of Design Processes:** - Finally, the research aims to integrate the surrogate models into the design optimization process of high-speed systems. This will involve using the models to guide design decisions, reducing the need for extensive simulations and experiments, and ultimately improving the quality and performance of high-speed electronic systems. By addressing these objectives, the research will contribute to the development of more flexible, accurate, and efficient modeling frameworks for the design optimization of high-speed systems, advancing the field of signal and power integrity in electronic systems.

Skills and competencies for the development of the activity	A solid background in electrical/electronic engineering; well-developed skill in both analytical and numerical math; proficiency in Matlab/Octave/Python or other high-level scientific software. Experience in machine learning and AI algorithms and tools is welcome.