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Topic1: Machine-Learning Approaches for Future Emerging Technologies

Description: The continuous scaling in transistors' feature sizes is approaching its end soon. It is therefore expected that semiconductor industry will replace existing CMOS technology in the near future. Ferroelectric FET (FET) and Negative Capacitance Transistor (NCFET) are one of the leading emerging technologies that have been recently proposed to replace conventional CMOS. They have great potentials when it comes to power saving and performance optimization of processors. In this research field, the student will be engaged in research activities in collaboration with other top international institutes. The focus will be exploring how NCFET technology will improve the efficiency and accuracy of future neural networks in both inference as well as training part. Concisely, the research will aim at investigating several aspects like the power, temperature, energy and accuracy of neural networks in the in the scope of emerging technologies.

Topic2: Approximate Computing to Accelerate Deep Neural Networks (DNNs)

Description: Deep Neural Networks (DNNs) are expected to play a major role in our daily life in the coming years. However, one of the biggest challenges in DNNs is the large complexity of the required underlying hardware. This holds even more when it comes to online training for machine learning. DNNs hardware are very power and area hungry. This, in turn, largely limits their applicability to only high-end and high-performance processors. On the other hand, approximate computing is new paradigm in computing in which designers can trade off precision of computing with area, power and speed. In this research field, we will explore how existing hardware implementation of DNNs can be accelerated using different techniques from approximate computing. We will also explore how the accuracy of executed machine learning algorithms can be affected due to the reduced precision in computation. The student will have the option to implement the ideas either in simulation-based environments or in advanced FPGA-based platforms.

Topic3: In-Memory Computing for Future Computers Architectures

Description: Communications with memories is one of the largest bottlenecks in recent computers' architectures. It has a considerable impact on the efficiency of computing and more importantly on the required time to train complex machine learning. Near-memory and In-memory computing is one of very promising solutions that have been very recently proposed. The concept is about pushing some of frequent computations, which often need memory accesses, from the CPU (where traditionally is done) towards the memory itself (i.e. near-memory and in-memory computing) to minimize memory communications that are responsible for the bottleneck. This is a large paradigm shift, which will have far-reaching consequences on the efficiency of computing and on the future computers architectures. Importantly, the latest advances in emerging technologies - especially FerroFET (FeFET) devices will play a major role in enabling such a new paradigm. In this research area, we will also explore future computer architectures that will not employ the traditional Von-Neumann architecture anymore like Neuromorphic Computing, which is expected to largely reshape the future of Artificial Intelligence.

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