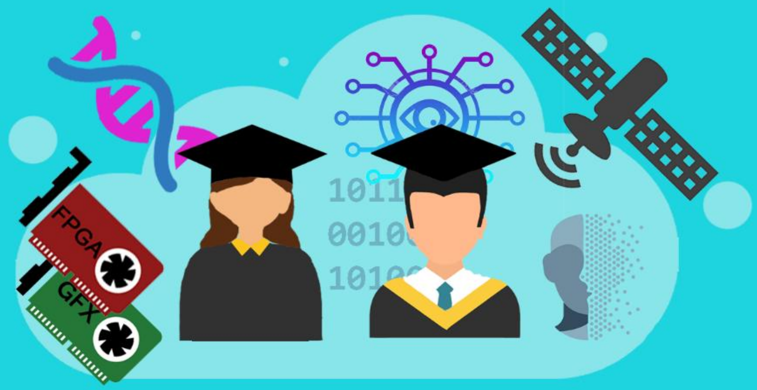
Diploma Thesis

Microprocessors and Digital Systems Laboratory

Academic Year 2019-2020



Implementation of Approximate Convolutional Filters and Floating-Point Components for CNN Applications

Approximate Computing is considered as a promising paradigm shift for energy-efficient systems design, exploiting the inherent resilience of various applications. This relaxation in the requirements for exactness is evident in several emerging domains, e.g., machine learning, multimedia processing, etc. Thus, error is considered as a commodity that can be traded for significant gains in performance, power/energy consumption. Massive research has been reported in the field of approximate computing at various layers of software and hardware. Focusing on the hardware level, approximations can be applied at different design layers of abstraction, i.e., the application, algorithmic, gate and transistor layers. Regarding circuit designs, the main targets are the adders and the multipliers, i.e., the core units of hardware accelerators. Extensive research has also been conducted in approximate processors, using neural networks, quality programmable vectors and approximate custom instructions.
Convolutional Neural Networks (CNNs) are a class of Deep Learning, which excels in computer vision tasks, such as object recognition and classification. Such applications belong to the Internet of Things (IoT) and high-end embedded systems domain, meaning that speed together with energy-efficiency and scalability are of high importance. A CNN consists of an input and an output layer, as well as multiple hidden layers, which typically include convolutional layers that convolve with a multiplication or other dot product.
Floating-point arithmetic provides a larger range of values and higher precision vs. fixed-point arithmetic (for the same bit-width), but lacks in circuit complexity and hardware cost. At the same time, numerous computationally intensive applications use a wide range of values and require increased precision. Therefore, floating-point computations are favored in such applications (e.g., CNN), which handle real numbers and produce results with unpredictable range. However, the large hardware cost of the floating-point units has limited their usage.
The **goal of the diploma thesis** is to exploit the efficiency of approximate computing, and design & implement inexact optimized floating-point circuits (e.g., adders, multipliers, etc.) that will be employed in larger processing components (filters, convolutional components). Overall, new approximate techniques will be explored, and approximate energy-efficient circuits/components will be implemented.

Useful Links:
https://en.wikipedia.org/wiki/Approximate_computing
https://en.wikipedia.org/wiki/Convolutional_neural_network
https://en.wikipedia.org/wiki/Floating-point_arithmetic

Prerequisites: basic knowledge of Digital Design, Verilog, Matlab,

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