CT image reconstruction on MPSoC

Bachelor/Master Thesis/Research Project

Research field

Nowadays, *Computer tomography* (CT) are self-contained devices that only function as stand-alone systems. Promising approaches in research show that the integration of preliminary information into the imaging parameters and reconstruction data of CT can lead to a reduction in the dosage in imaging. By using an open-interface CT is possible to add modules and explore new reconstruction optimizations, directly implemented internally the device. In literature, there are a plethora of CT reconstruction algorithms, such as iterative algorithms, Filtered-Back Projection (FBP) and AI-based reconstruction algorithms. These algorithms have different usage based on two requirements, image quality and timing performance in the reconstruction process, with the aim to have low-dose X-ray and real-time reconstructed images. To fulfil the hard-real time requirements of this application Multi-Processor System-on-Chips (MPSoC) architectures are utilized, which are suitable controlling and data acquisition tasks, running under a single system[1, 2]. Nowadays MPSoCs can have Application Processing Units (APU), Real=Time Processing Units (RPU), GPUs, DSPs and AI Engine, and FPGAs. The main challenge is given by the utilization of all these processing units for controlling and data processing.

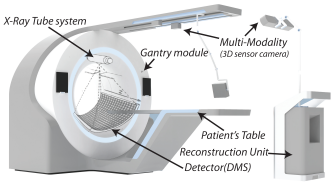

Figure 1: Computed Tomography

Research topic and working hypothesis

The goal is to implement a real-time image reconstruction algorithm for CT on MPSoC. For doing it, should be utilized the different components inside the MPSoC (e.g., APU, RPU, DSP, FPGA). The student, starting from a provided FBP CT reconstruction algorithm for GPU, should analyse it and propose a SoC solution that implements it or part of it in real-time. The research steps comprehend the study of real-time reconstruction algorithms for CT in according to the related hardware architecture utilized (e.g, Xilinx ZC706, ZCU102, Versal VCK190). For example, the student can focus on a step of the reconstruction algorithm or an image filter to integrate in an MPSoC where the control and acquisition is already provide and implemented.

Work plan

- Study of the problem: real-time reconstruction algorithms for CT and Heterogeneous Computing on MPSoC.
- Based on the profiling results of the CT reconstruction algorithm, an enhancement should be proposed.
- Implementation of the proposed enhancement.
- Evaluation of their work compared with the original algorithm and the state of the art in terms of performance
- Success!

Required skills

- Knowledge in Heterogeneous Computing.
- Based on the chosen MPSoC platform (Xilinx ZC706, ZCU102, Versal VCK190) and related architecture inside to use (FPGA, CPU, GPU, AI Engine), knowledge of the related programming model and language, e.g., HLS, C/C++, Matlab scripting, OpenCL, Tensor Flow.

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References

[1] W. Zhang, L. Qiao, W. Hsu, Y. Cui, M. Jiang and G. Luo, "FPGA Acceleration for 3-D Low-Dose Tomographic Reconstruction," in IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems, vol. 40, no. 4, pp. 666-679, April 2021, doi: 10.1109/TCAD.2020.3006183.W.

[2] Scherl, Holger, et al. "Evaluation of state-of-the-art hardware architectures for fast cone-beam CT reconstruction." Parallel computing 38.3 (2012): 111-124.