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Real time data acquisition for billion pixel x-ray imaging

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The design of a billion-pixel X-ray camera (BiPC-X) is based on the tiling of several CMOS sensors, each having a few million pixels. Both direct low-energy (< 10 keV) and indirect higher energy detection (> 20 keV) are possible, where the camera can achieve frame rates of 1 MHz and possibly higher depending on the settings [1].

With an image size of a billion pixels, the camera generates a data throughput of 100 GB/s to 100 TB/s, which largely exceeds the capabilities of recent acquisition systems. To handle real-time processing, we require an intelligent compression technique that determines useful information within an image and discards the rest. To achieve this, we propose a multistep solution to reduce the amount of incoming data right at the sensor readout electronics. By combining sparse compression and entropy coding techniques, we are able to decrease the data size for each image by a factor of 10. Furthermore, approximating the resulting code with machine learning [2] has sped up the originally slow sparse compression process by a factor of 100. Ongoing tests leverage the low latency of FPGAs and the fast inference of the optimized ML model to reach even faster compression times. In the presentation, we will discuss the compression strategy and the preliminary results obtained with the FPGA implementation of the ML model.

[1] Chen Hu, Liyuan Zhang, Ren-Yuan Zhu, Marcel Demarteau, Robert Wagner, Lei Xia, Junqi Xie, Xuan Li, Zhehui Wang, Yanhua Shih, Thomas Smith. Ultrafast inorganic scintillator-based front imager for Gigahertz Hard X-ray imaging, Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, Volume 940, 2019.
[2] Karol Gregor and Yann LeCun. 2010. Learning fast approximations of sparse coding. In Proceedings of the 27th International Conference on International Conference on Machine Learning (ICML'10). Omnipress, Madison, WI, USA, 399–406.

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