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A Modular Data Acquisition System for Reconstruction of Radiation Dose Spatial Distribution in Radiotherapy Treatment Planning

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In this paper, a highly customisable and comprehensive data acquisition system (DAQ) is presented. It is applied to a novel reconfigurable Dose-3D detector intended for a full spatial therapeutic dose reconstruction to improve radiotherapy treatment planning by providing a breakthrough detector with active voxels (more details are provided in another contribution).

The basic element of the DAQ is a slice housing a multianode photomultiplier tube (PMT), readout ASIC with 64 channels and an FPGA. The slices are assembled in a crate. In a single crate, there are eight slices and Precision Time Protocol (PTP) Unit providing synchronisation between slices. The modularity of the system is enhanced with the possibility of crate stacking. Moreover, the FPGA firmware is based on the open-source eXtensible FPGA Control Platform.

This firmware enables mapping of ASIC readout logic and access to continuous data streams through UDP/IP over Ethernet communication. For each functional block of the ASIC, a set of data upstreams, configuration storage and ASIC-specific modules were created, resulting in independent control of each part of the firmware.

The operation of all slices is managed by the dedicated software running on the central computer. First, it asks each slice about the firmware modules hierarchy to create entities maintaining seamless input-output communication between hardware and software. These entities can be subscribed by any consumer process through a TCP/IP connection. This way users can prepare tools distributed over the network checking the online status of each slice or gathering data from all available data channels to prepare the 3D data reconstruction.

This firmware and software combination proved to be working effectively and efficiently assuring high performance and reliability. Moreover, the presented DAQ architecture is extremely customisable requiring a reduced effort to be adapted to other systems based on different front-end ASICs and design requirements.

Collaboration

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