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WiggleCam: a method to cope with inter-sensor gaps for high-framerate tiled sensor arrays

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In order to keep down costs and control yields, large area hybrid detectors are commonly implemented using multiple sensor tiles in various geometries. Due to the presence of guard rings, readout connections and other design considerations it is practically impossible to make tiled sensor arrays where the tiles meet up exactly. Even in the case of four side buttable sensors, arrays will still have some measure of dead space between the tiles. A variety of hardware and software techniques currently exist to fill in the inactive space, such as roof tile arrangements of sensor tiles, software interpolation to fill in gaps, and stitching together multiple overlapping but shifted exposures. All of these techniques present their own drawbacks, from greatly increasing hardware complexity, introducing undesirable artefacts in certain applications, or increasing measurement times and experimental overhead.

The authors propose a novel technique, called WiggleCam, for mitigating inactive regions and malfunctioning pixels in X-ray cameras which use very high frame rates (often exceeding 1 kHz). This is commonly the case in hyperspectral imagers, which provide raw ADC output frames at very high time resolution for energy dispersive single photon detection. In this work we present the results of a proof-of-concept implementation of the method using a HEXITEC 2x2 camera[1] mounted on an XY-stage, with all data processing done using SpeXIDAQ, the in-house developed framework for hyperspectral imagers[2]. A practical implementation requires access to the raw high-framerate camera output before it is integrated into the final exposure. By moving the detector such that every section of the region of interest is imaged at least part of the desired exposure time, and shifting the individual photon events using the coincident detector position in the lab frame before integration, any inactive areas are fully covered. By then compensating for the non-uniform exposure time no deterministic motion path is required, and a final image output is obtained free from gaps, without temporal overhead, and with no further post-processing required by the end-user.

The method is shown to accurately compensate for the inter-tile gaps without compromising the spatial and spectral resolution. It also provides a way to increase the effective spatial resolution without physically reducing the pixel pitch. This presentation will conclude by demonstrating a new camera device under development using multiple HEXITEC sensors, designed to include the Wigglecam method in the camera construction itself for a more compact and useful implementation.

[1] Wilson, Matthew D., et al. “Multiple module pixelated CdTe spectroscopic X-ray detector” IEEE Transactions on nuclear science 60.2 (2013): 1197-1200
[2] Van Assche, Frederic, et al. “The Spectral X-ray Imaging Data Acquisition (SpeXIDAQ) Framework” Sensors 21(2) (2021): 563

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