Neuromorphic X-ray radiographic and tomographic imaging

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Synchrotron-based X-ray micro-computed tomography has been a reference technique for many studies investigating fundamental properties and functions of materials and organisms. However, the increased use of imaging technologies is becoming more challenging, as high-speed dynamic imaging experiments either produce exorbitant amounts of data or remain limited in temporal resolution. Recently, bio-inspired neuromorphic event cameras have been introduced as an alternative approach to conventional frame-based cameras, in the sense that they detect per-pixel brightness changes asynchronously and generate a stream of events encoding the triggering time, location, and polarity of each pixel [1]. With the encoded high-frequency information in the events, event-based vision has recently gained popularity in various applications; however, its realization in X-ray imaging remains largelyunexplored.

At the TOMCAT beamline of the Swiss Light Source, Paul Scherrer Institute, we have recently demonstrated an inline dual-camera X-ray imaging setup combining a high-speed frame-based CMOS detector [2] with a neuromorphic event camera, Prophesee Metavision Evaluation Kit 4. Both cameras were coupled to magnifying visible-light optics with an effective pixel size of approximately 1.1 µm and synchronized by an external 1 MHz TTL signal using a PandABox. The setup enables simultaneous acquisition of conventional X-ray projection frames and asynchronous event streams under the same imaging conditions.

Here, we report the first characterization of the system by imaging a live sandclock in radiographic mode and present the necessary post-processing steps for achieving more than fivefold temporal super-resolution [3]. We further showfirst results from our ongoing work in extending the framework to CT acquisitions, which are often limited to sparse angular views. A data-acquisition and reconstruction pipeline based on implicit neural represented is designed to complement the fine-grained angular information from events to enhance tomographic reconstruction. The result is demonstrated both in simulation and real-world validation, showcasing the potential of using only 5 views and events for a CT reconstruction as a future potential measurement protocol. Overall, this work represents an early exploration of neuromorphic sensing for X-ray radiography and computed tomography, with potential benefits for data-rate reduction, improved temporal resolution, and real-time processing in future ultrafast time-resolved synchrotron X-ray imaging experiments.

References

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