Neuromorphic image sensors for future particle detectors

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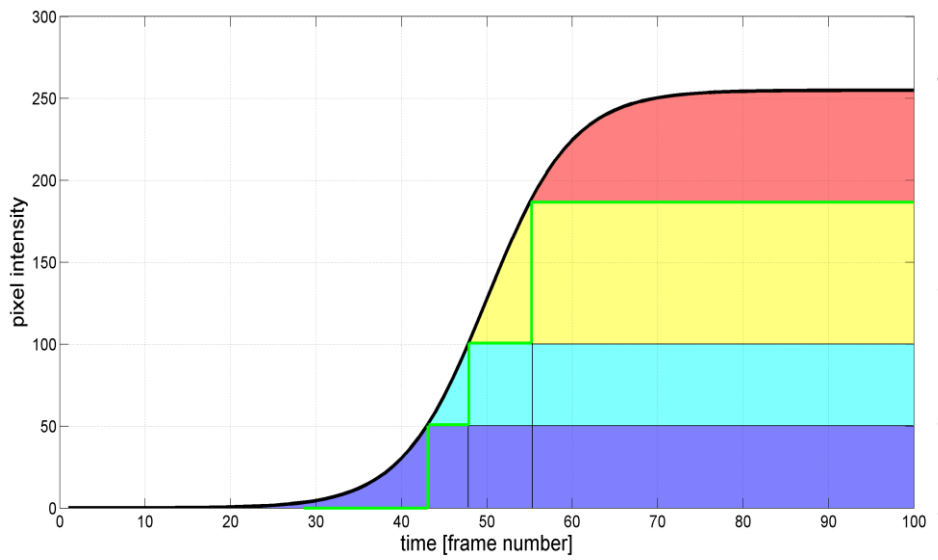
Introduction

The concept of neuromorphic vision sensors exist since early 2000s. Such sensors continuously track the amplitude of each pixel and record changes of only those pixels that modify their brightness level above pre-defined thresholds. This approach is called level-crossing sampling [1]. This particular type of sensors is thus event-based, as opposed to the frame-based classical sensors with low and fixed sampling rate. Implementations are already commercially available at iniLabs, Switzerland [http://inilabs.com/].



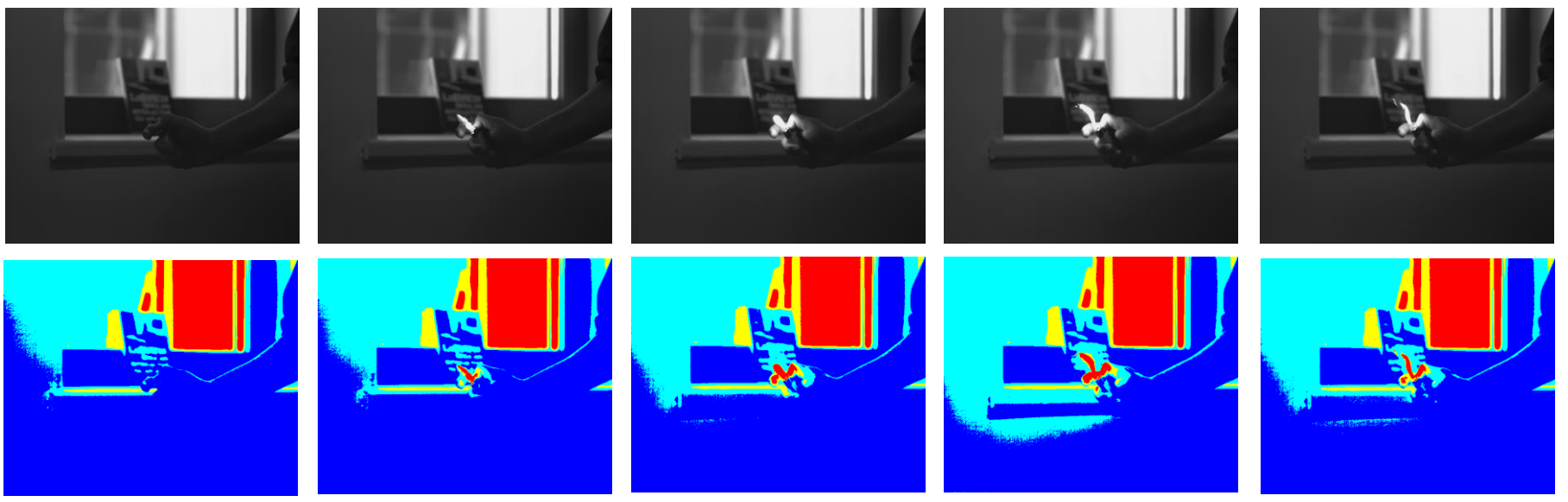
The Idea/Concept

The idea is to investigate the possibility of using neuromorphic image sensors for future particle detectors within the ATLAS experiment at CERN.

Consider the following hypothetical example in the left figure: the sigmoid signal in black represents the variation of a pixel intensity in time. Three triggers are set at intensity levels 50, 100 and 180 (the scenario is valid also for the results in the images below): for instance, the red pixels are activated only if their values exceeds the third threshold. The corresponding output signal is in green.

Experiments –neuromorphic vision sensors emulation

With this poster, we present our preliminary results on emulating neuromorphic image sensors using a high frame rate (500 fps) Basler digital camera. A sequence of five frames in visible spectrum (top) and their corresponding 4 level quantization for the fore mentioned thresholds (bottom). Interpretation: red regions are active pixels (if flame area is of interest, thus the window area is just noise), the only pixels that deliver information that should be read by the front-end electronics.



Potential Impact

The intrinsic parallelism of such sensors as well as the associated speed capabilities and extremely-low power consumption, make them interesting candidates for future particle detectors. We envisage the design and implementation of an acquisition system, using reconfigurable hardware (FPGAs) and a neuromorphic vision sensor, allowing us to investigate the possibilities of using such system for future particle detectors. This may impact the design of high-speed asynchronous parallel interfaces for real-time acquisition and processing.

[1] C. Posch, R. Benosman, R.E. Cummings, *Giving Machines Humanlike Eyes*, IEEE Spectrum magazine December 2015, http://dx.doi.org/10.1109/MSPEC.2015.7335800