Event-Based Attention and Tracking on Neuromorphic Hardware

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***Abstract*—We present a fully event-driven vision and processing system for selective attention and tracking implemented on Intel's neuromorphic research chip, Loihi, directly interfaced with an event-based Dynamic Vision Sensor, DAVIS. The attention mechanism is realized as a recurrent spiking neural network (SNN) that forms sustained activation-bump attractors. The network dynamics support object tracking when distractors are present and when the object slows down or stops.**

I. Introduction

Event-based sensing allows us to perform vision tasks efficiently: it reduces the amount of required computation and transmitted data. Many event-based vision algorithms have been developed over the last decade. They are typically implemented on a conventional computer, not making full use of the event-based output of the sensor. Neuromorphic hardware, in contrast to the conventional CPUs, offers a massively parallel computing substrate that is inherently event-based and matches the processing paradigm of event-based sensors.

In this demo, we show how an SNN for tracking that we recently demonstrated on recorded data [1] can be used in a real-time setup. To achieve this, we connect the event-based sensor DAVIS 240C [2] to Intel's research test chip Loihi [3] using the AER interface of Intel's Kapoho Bay device. Kapoho Bay is an embedded system that includes two neuromorphic Loihi chips. The DVS events are captured by an FPGA on Kapoho Bay, before being down-sampled and distributed to neurons on the neuromorphic cores through an x86 processor on one of the Loihi chips. We show that the SNN on-chip can track a cued object even when more salient distractor objects are present (see Fig. 1), or when the target object stops moving and ceases to produce events.

A similar network has been used to realize object tracking on SCAMP, a smart camera with an in-focal-plane processor array [4]. Here we present its realization on a generic neuromorphic device that can also support other vision, cognitive, and motor control tasks [3].

II. Model

The tracking SNN consists of two 2D winner-take-all (WTA) layers with 64x64 neurons each. The first layer has localized excitatory connections and weak all-to-all inhibition. This connectivity pattern supports multiple activity "bumps" that are self-sustained. The bumps form at the locations of the ON-events and follow them when objects move in the field of view. The OFF-events inhibit neurons in this layer, decreasing activity in the bump as the input moves away. This supports fast movement tracking. The second WTA layer is excited by one-to-one connections from the first layer. The second WTA has strong local excitation and strong global inhibition, which lead to the stabilization of a single bump. An initial excitatory input to this layer cues one of the objects at the beginning of the tracking experiment; feature-based cues can also be used. The WTA forms an activity bump over the selected object, which is moved by the excitatory input from the first layer when the selected object moves.

III. Conclusion

In our setup, we interfaced the event-based vision sensor directly to the neuromorphic computing system, combining event-driven sensing and processing. The SNN on-chip selects and tracks a single object out of several moving objects in the visual field of the sensor, based on transient events even in cases when movement stops and the event stream is interrupted. We demonstrate tracking in an interactive scenario, showing how the system can track different objects in the presence of moving distractors.

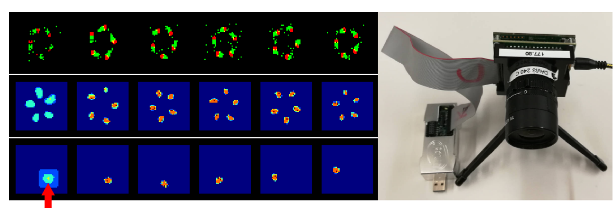

Fig. 1. **Left:** 50ms snapshots of DAVIS events **(top)**, non-selective layer **(middle)**; selective WTA layer **(bottom)**. The target object is cued initially **(arrow)**. **Right:** DAVIS connected to the neuromorphic system Kapoho Bay.

Aknowldegement

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References

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