Institut de Robòtica i Informàtica Industrial

CSIC

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

PhDday 2024

Bio-inspired event-driven intelligence for ego-motion estimation

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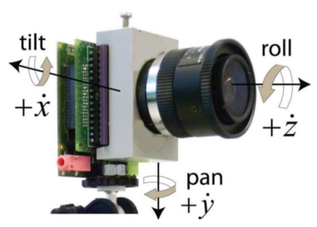
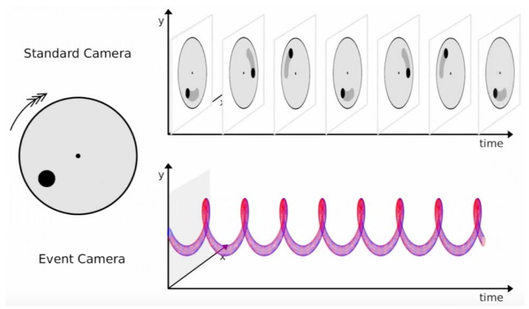
Description

Mimicking the bio visual pathway up to the retinal ganglion cells, **event-based cameras** detect independently the change of luminance in each pixel and produce an asynchronous feed of pixel coordinates where changes occur. It is well suited for fast motion estimation in challenge scenarios.



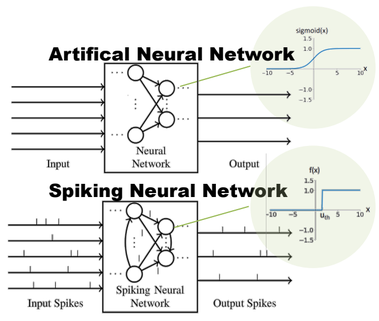
3D-motion of a camera



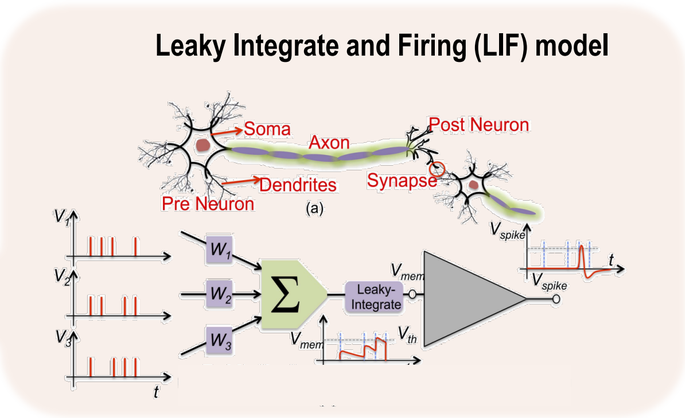
Event Camera vs Frame Camera

Objective

Design and implement a biologically-inspired system for **ego-motion estimation** from event camera data. We will explore approaches with **Spiking Neural Networks (SNN)** that are naturally adapted to event-camera. Inspired by the working principles of the brain, neurons in SNNs fire when their membrane potential reaches a threshold and further propagate the non-binary signal to other neurons through synapses. While conventional ANNs make use of the amplitude of the signals, SNNs process discrete spikes or binary events by using timing information, which allows computational and energy efficiency.



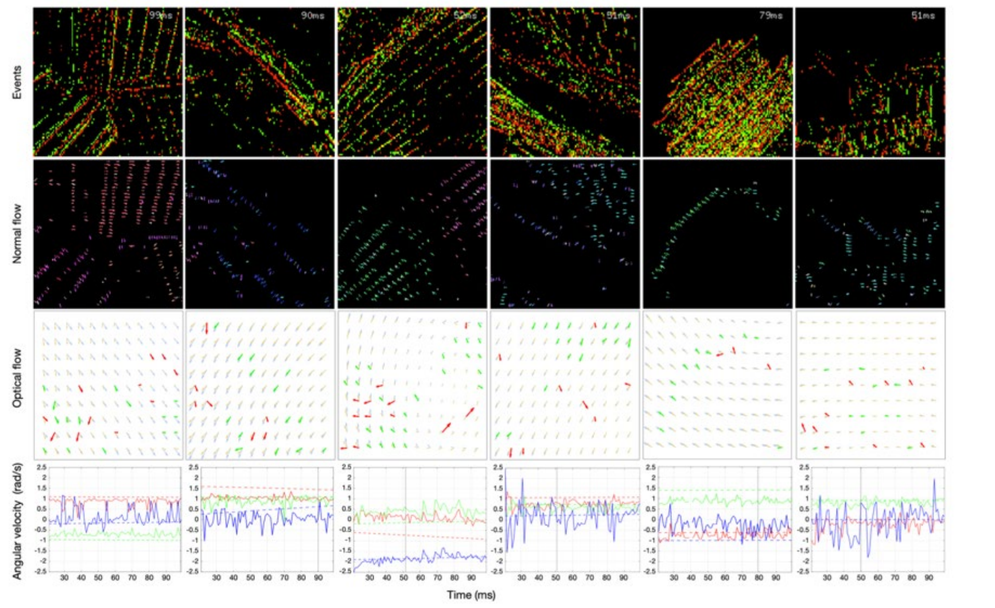
ANN vs SNN



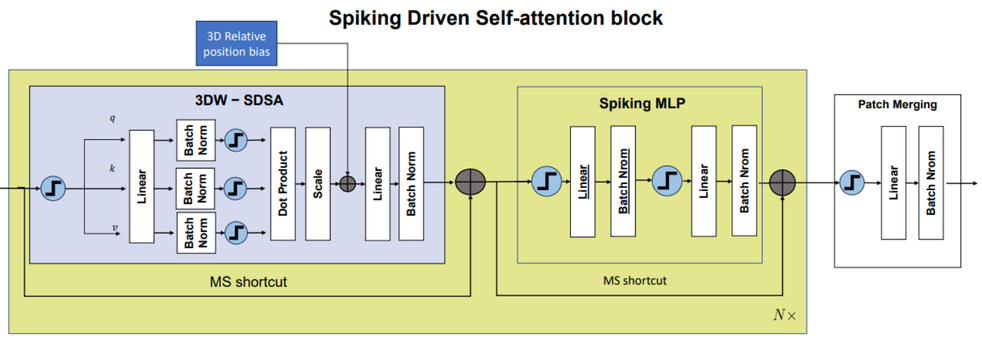
Angular velocity estimation from pretrained optical flow [1]

Results

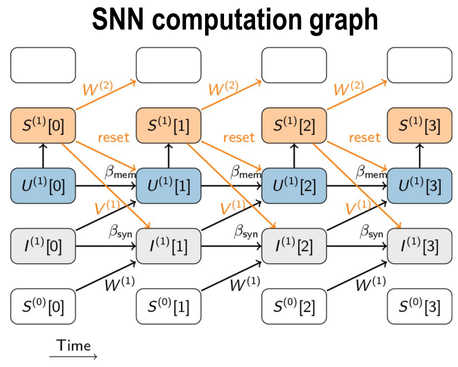
- **Egomotion estimation from SNN optical flow:** In this work [1], We computes egomotion using event camera with a pre-trained optical flow spiking neural network (SNN). Our method includes a sliding-window bin-based pooling layer that computes a fused full flow by optimizing the intersection of constraints of the flow vector. The method also includes a RANSAC step to robustly deal with outlier flow estimates in the pooling.
- **Self-supervised learning for sparse event-based optical flow**: Next steps, we try to improve the optical flow estimation part. We explores a RNN transformer architecture with self-supervised learning with contrast maximization loss to estimate sparse optical flow [2].
- **Spikeformer for dense flow estimation**: Finally, we propose a fully spiking spatio-temporal swin Transformer architecture: SDformeFlow, trained by supervised learning using surrogate gradient method. Our method can estimate dense flow from events data only.



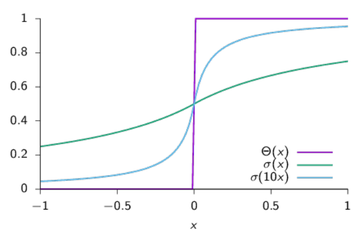
Sparse event-based flow using self-supervised contrast maximization loss[2]

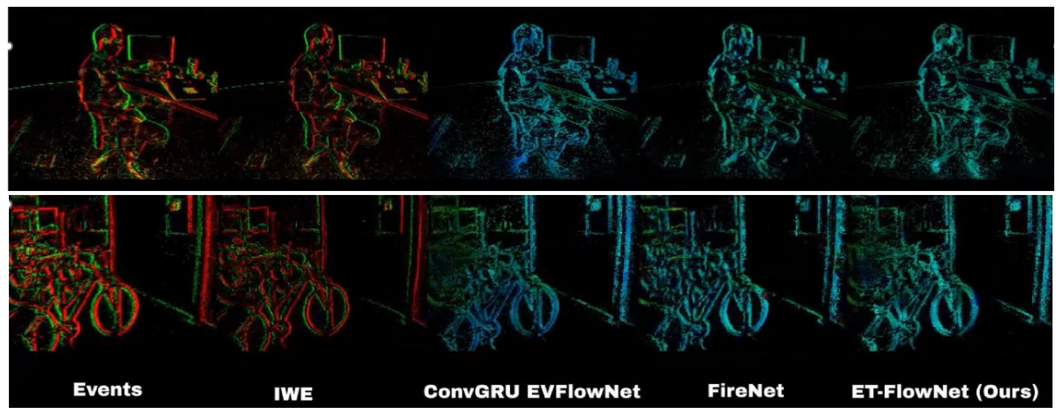


SNN computation graph



Surrogate gradients (SG)





Dense event-based flow on DSEC test dataset [3]

(a) events (c) EVFlowNet (d) STTFlowNet (ours) (e) SDformerFlow(ours)

Start date: 23/01/2020

Thesis Project defense: 04/10/2021

Funding

FI AGAUR PhD grant

Spanish National Project: RAADICAL PLEC2021-007817

Publications

[1] Y. Tian and J. Andrade-Cetto. Egomotion from event-based SNN optical flow. In ACM Int. Conf. Neuromorphic Systems, 2023, Santa Fe.

[2] Y. Tian and J. Andrade-Cetto. Event transformer FlowNet for optical flow estimation, 2022 British Machine Vision Conference, 2022, London.

[3] Y. Tian and J. Andrade-Cetto. SDformer-Flow: Spiking Neural Network Transformer for Event-based Optical Flow, 2024 (under review).