

Event-Based Hough Transform in a Spiking Neural Network for Multiple Line Detection and Tracking Using a Dynamic Vision Sensor

Sajjad Seifozzakerini¹
stusajjad@i2r.a-star.edu.sg

Wei-Yun Yau¹
wyyau@i2r.a-star.edu.sg

Bo Zhao¹
zhaob@i2r.a-star.edu.sg

Kezhi Mao²
ekzmao@ntu.edu.sg

¹Institute for Infocomm Research (I2R), Agency for Science, Technology and Research (A*STAR), Singapore

²School of Electrical and Electronic Engineering, Nanyang Technological University (NTU), Singapore

In this paper, we develop an event-based Hough transform and apply it to a new type of camera, namely Dynamic Vision Sensor (DVS). DVSs are a new generation of cameras that are sensitive to logarithmic intensity change [4]. Once the change is larger than a predefined threshold, a positive or negative event will be generated depending on the direction of the change.

The main idea of Hough transform is first transforming every point from the conventional Cartesian coordinates to the parameter space, in which every point defines a specific shape, and then finding local maximums in the parameter space to obtain the shape parameters through a voting procedure [3].

In this paper, we use LIF spiking neurons [1] to build an SNN that represents the parameter space of Hough transform for line detection. every Spiking Neuron (SN) has some inputs and an output. The input is a spike train that influences the neuron's Membrane Potential (MP) which is always decaying by a fixed rate. Whenever the MP exceeds the + or - threshold, a spike with corresponding polarity is generated in the output and MP is reset to zero subsequently.

The parameter space is built up by a two dimensional SNN with one dimension for angle θ and the other for normal distance r . A local lateral inhibition strategy is adopted in our SNN which allows the SNN to suppress noise lines (or redundant lines) from being detected.

In cases that there are more than one moving line in the frame, we need a segmentation procedure to distinguish between them. Since every line is moving smoothly in Cartesian space, the corresponding spikes in parameter space are "moving" smoothly as well and they produce a cluster. We use an event-based clustering method [2] to do the segmentation and tracking of different lines.

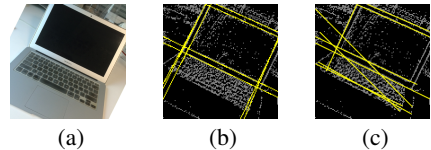


Figure 1: (a) Image captured by a conventional camera; (b) The proposed event-based algorithm's line detection results (yellow) superimposed onto DVS events (grey); (c) Conventional frame-based hough transform's results using MATLAB standard functions for line detection with the same number of the lines.

The efficacy of the proposed algorithm is shown by extensive experiments on both artificially generated events and real DVS output. SNN with local lateral inhibition is efficient in detecting correct lines and tracking them as well as suppressing incorrect ones as seen in figure 1.

- [1] A N Burkitt. A review of the integrate-and-fire neuron model: I. Homogeneous synaptic input. *Biological cybernetics*, 95(1):1–19, jul 2006. ISSN 0340-1200. doi: 10.1007/s00422-006-0068-6.
- [2] T Delbruck and P Lichtsteiner. Fast sensory motor control based on event-based hybrid neuromorphic-procedural system. *Circuits and Systems, 2007. ISCAS . . .*, (80 cm):845–848, 2007.
- [3] Richard O. Duda and Peter E. Hart. Use of the Hough transformation to detect lines and curves in pictures. *Communications of the ACM*, 15(1): 11–15, jan 1972. ISSN 00010782. doi: 10.1145/361237.361242.
- [4] Patrick Lichtsteiner, Christoph Posch, and Tobi Delbruck. A 128 X 128 120 dB 15 us latency asynchronous temporal contrast vision sensor. *IEEE Journal of Solid-State Circuits*, 43(2):566–576, feb 2008. ISSN 00189200. doi: 10.1109/JSSC.2007.914337.