Live Demonstration: Real-time Event-based Speed Detection using Spiking Neural Networks

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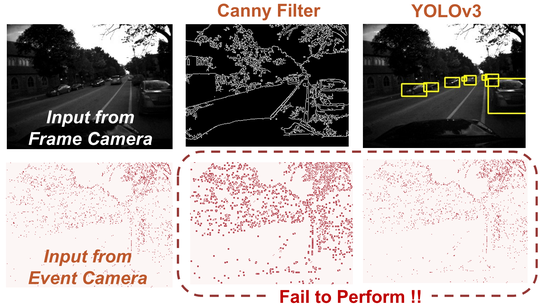
OBJECT DETECTION IN VISION-BASED AUTONOMOUS SYSTEMS

Object detection algorithms for vision-based navigation systems must be
- Fast
- Robust to lighting conditions

Event Cameras provide these features with energy efficiency



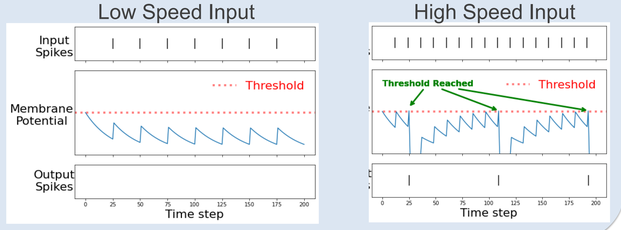
Traditional feature and object detection algorithms fail on events, as they rely on photometric characteristics such as light intensity and texture.

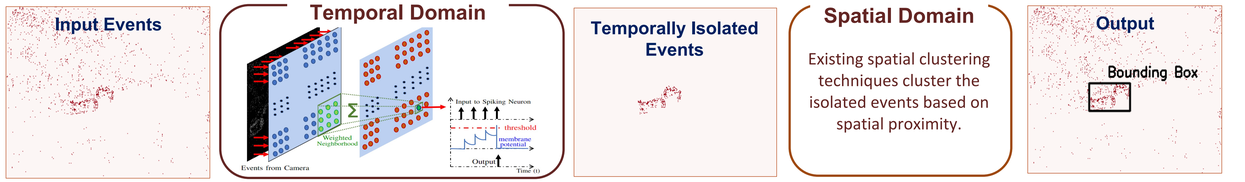
We identify two important properties that help in object detection:
- Events generated by the same object are *temporally close* to each other.
- Events generated by the same object are *spatially close* to each other.

OUR APPROACH – DOTIE (DETECTING OBJECTS THROUGH TEMPORAL ISOLATION OF EVENTS)

Leaky Integrate and Fire neurons can capture temporal information

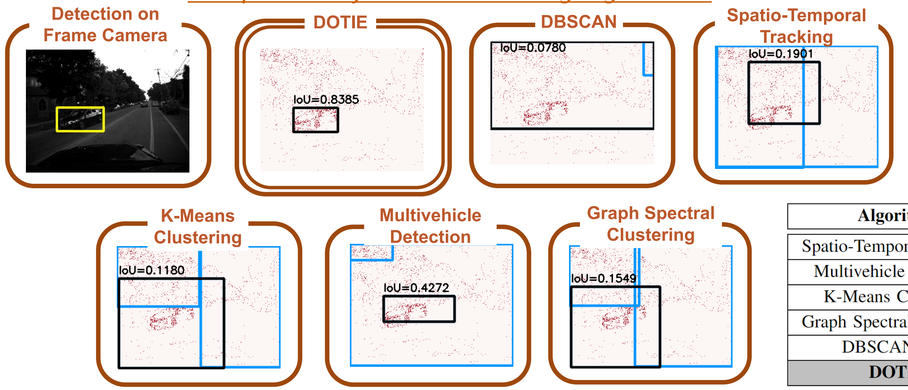
By adjusting the neuron parameters, it is possible to identify inputs generated faster than a particular speed.
- We design each neuron to connect to a group of pixels spatially close to each other on the event camera.
- This spiking architecture acts as a temporal filter and isolates events corresponding to fast-moving objects.





OBJECT DETECTION RESULTS

Comparison of DOTIE to existing algorithms



For algorithms that generate multiple bounding boxes, the box with the highest Intersection over Union (IoU) with respect to the ground truth is considered. These boxes are highlighted in black, and the other bounding boxes are highlighted in blue.

Algorithm	Mean IoU	Recall	Precision
Spatio-Temporal Tracking	0.2154	0.08	1.00
Multivehicle Detection	0.3986	0.23	1.00
K-Means Clustering	0.0997	0.00	0.00
Graph Spectral Clustering	0.1071	0.00	0.00
DBSCAN only	0.1244	0.00	0.00
DOTIE	**0.8593**	**1.00**	**1.00**

- The ground truth bounding boxes were generated using YOLOv3 on grayscale frames
- We calculated certain metrics as follows:
  - *True Positive (TP)* = # of generated bounding boxes with IoU >= 0.5
  - *False Negative (FN)* = # of generated bounding boxes with IoU < 0.5
  - *False Positive (FP)* = # bounding boxes generated when no ground truth was detected.

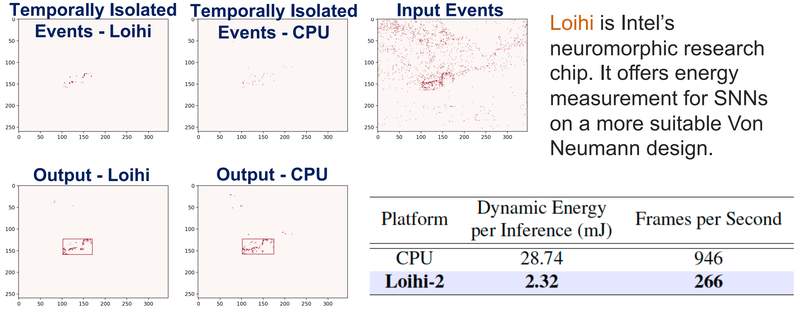
$$\text{Precision} = \frac{TP}{TP + FP}$$

$$\text{Recall} = \frac{TP}{TP + FN}$$

COMPUTE EFFICIENCY ON NEUROMORPHIC HARDWARE

~14x improvement in energy efficiency and ~4x reduced throughput running on Loihi-2

- Loihi platforms come with an energy profiling chipset that allows direct power measurement during runtime
- Models need to be ported to Lava framework (Intel's library for neuromorphic algorithm development)



Loihi is Intel's neuromorphic research chip. It offers energy measurement for SNNs on a more suitable Von Neumann design.

Platform	Dynamic Energy per Inference (mJ)	Frames per Second
CPU	28.74	946
Loihi-2	**2.32**	**266**