N-MNIST object recognition with Spiking Neural Networks

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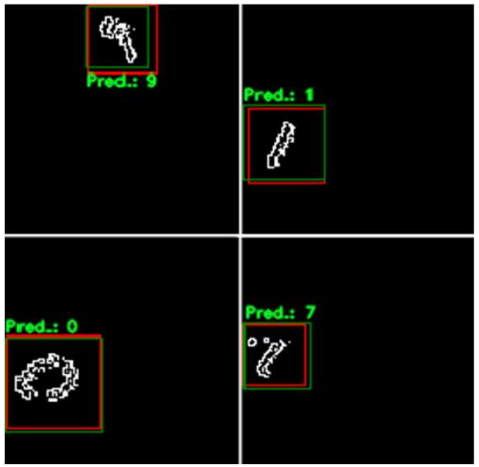
INTRODUCTION

In the modern world, energy efficiency is crucial, that is the motivation why optimization of energy use is so important. Event-based signaling and processing promises increased energy efficiency (human brain as paragon). Spiking neural networks (SNNs) are artificial neural networks that more closely mimic natural neural networks. Their use has shown interesting results in the field of energy efficiency. In this work, we explore an SNN approach for object recognition based on larger event frames from N-MNIST. We get a final accuracy of 99% on the object detection task and an accuracy of 85% on the classification task.



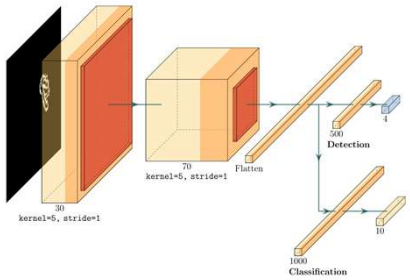
HIGHLIGHTS

- A dataset that extends N-MNIST to a higher resolution
- A network able to reach a precision of 99% and an accuracy of 85% on the given dataset
- An overview on network possibilities and further improvements

DATASET

We extend the N-MNIST dataset putting the digits in a larger frame. This means that at the end, we have a dataset where each value inside is composed by:

- A spiking sequence where each frame has a size of 128×128
- A label containing the *bounding box* coordinates and the value of the digit

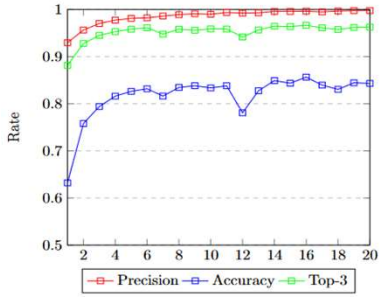


Structure of the network used for the project.

TRAINING STEP

We designed a network inspired by YOLO in its structure. So far, we have a network composed by a common stream and two sub-networks, one for detection and one for classification:

- Predicted values are stacked for each frame and sequence maximum is taken
- *MSE* and *label smoothing loss* are combined as loss function



Networks' results on the test set. Training was done over 20 epochs.

FURTHER RESEARCH

We investigated how to improve the network results and how the network behaves under different conditions. In this context, we investigate:

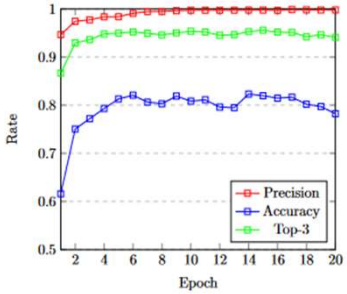
- How the network behaves with different digit size
- How noise at the end of the network helps the network
- How batch size and α in *label smoothing loss* influence network behavior

OUTLOOK AND REFERENCES

In future, we can consider various strategies to improve the quality of our results. Some ideas could be:

- Improve loss function
- Weight each frame of the spiking sequence
- Test architecture on another domain, e.g., gestures or broader objects

[1] Wolfgang Maass. Networks of spiking neurons: The third generation of neural network models. Neural Networks, 10(9):1659–1671, 1997.
[2] Joseph Redmon and Ali Farhadi. Yolov3: An incremental improvement. arXiv, 2018
[3] Garrick Orchard, Ajinkya Jayawant, Gregory K Cohen, and Nitish Thakor. Converting static image datasets to spiking neuromorphic datasets using saccades. Frontiers in neuroscience, 9:437, 2015.



Accuracy on resized input