Live Demonstration: Hardware Implementation of Convolutional STDP for On-line Visual Feature Learning

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***Abstract*— This is a proposal for live demonstration of a hardware that can learn visual feature online and in real-time during presentation of an object. Input Spikes are coming from a bio-inspired silicon retina or Dynamic Vision Sensor (DVS) and will be processed in a Spiking Convolutional Neural Network (SCNN) that is equipped with Synaptic Time Dependent Plasticity (STDP) learning rule and has been implemented in FPGA.**

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I. Demonestration setup

STDP is a learning rule for unsupervised feature extraction in Spiking Neural Networks. In this work we implemented a hardware friendly version of STDP in FPGA that can learn visual features in real-time using multiple parallel convolutional populations. These neural populations learn the most common visual features from input stimulus.

Fig. 1 shows hardware setup for this demonstration. Input spikes is generated by moving an object in front of Silicon Retina (DVS) [1] . A USB-AER board [2] is sending a copy of DVS spikes to computer. Then an AER-Node board [3] is used to implement SCNN in its Spartan-6 FPGA. Then another USB-AER board sends output spikes to computer for visualization.

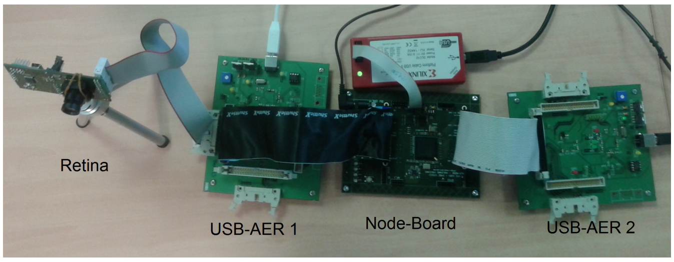
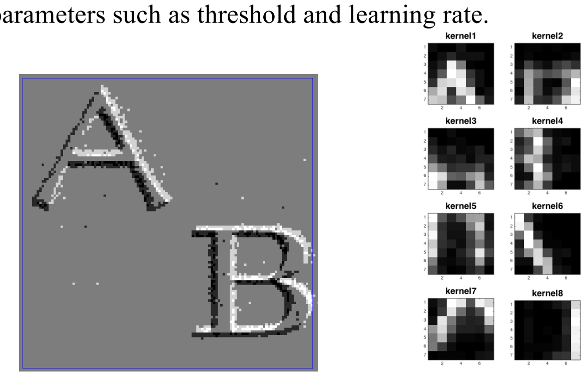


Fig. 1. Hardware setup for demonestration

For this demonstration we implemented one layer of SCNN with kernel size of 9x9. Number of Convolutional populations can change based on the number of features that need to be extracted. Initial kernel weights are random and they change smoothly by receiving spikes from DVS in real-time based-on STDP rule.

II. Visitor's Experience

Visitors can learn about new plasticity rule in SCNNs and they can move an object in front of DVS to see the extracted features or reconstructed kernel weights. Fig. 2 (a) shows a screenshot of jAER software to visualize spikes from DVS by moving letters 'A' and 'B' in the same time in front of DVS. Fig. 2 (b) shows the reconstructed of 8 kernel weights that contain features from letters 'A' and 'B'. Visitors can try different objects and see the kernel evolutions when using different numbers of convolutional populations and different parameters such as threshold and learning rate.



(a) (b)

Fig. 2. Visualization of input and output of the system. To see the complete recording video and online evolution of kernel refer to [4]

III. Refrences

[1] T. Serrano-Gotarredona and B. Linares-Barranco, "A 128x128 1.5% Contrast Sensitivity 0.9% FPN 3us Latency 4mW Asynchronous Frame- Free Dynamic Vision Sensor Using Transimpedance Amplifiers," *IEEE J. Solid-State Circuits,* 2013.

[2] Rafael Serrano-Gotarredona et al, "CAVIAR: A 45k Neuron, 5M Synapse, 12G Connects/s AER Hardware Sensory–Processing– Learning–Actuating System for High-Speed Visual Object Recognition and Tracking," *IEEE Transactions on Neural Networks* , no. 9, Sep. 2009.

[3] T. Iakymchuk et al, "An AER handshake-less modular infrastructure PCB with x8 2.5Gbps LVDS serial links," in *IEEE International Symposium on Circuits and Systems (ISCAS)*, Melbourne, 2014.

[4] A. Yousefzadeh, "Online unsupervised visual feature extraction," 2016. [Online]. Available:https://youtu.be/VRz1uLXa4KA.