Year: 2020

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DOI: https://doi.org/10.1109/ISCAS45731.2020.9181259

Originally published at:
Piñero-Fuentes, Enrique; Rios-Navarro, Antonio; Tapiador-Morales, Ricardo; Delbruck, Tobi; Linares-Barranco, Alejandro (2020). Live Demonstration: CNN Edge Computing for Mobile Robot Navigation. In: IEEE International Symposium on Circuits and Systems (ISCAS) 2020, Seville, Spain, 10 October 2020 - 21 October 2020, IEEE.
DOI: https://doi.org/10.1109/ISCAS45731.2020.9181259

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"Live Demonstration: CNN Edge Computing for Mobile Robot Navigation."
In 2020 IEEE International Symposium on Circuits and Systems (ISCAS), 1–1. IEEE, 2020.
https://doi.org/10.1109/ISCAS45731.2020.9181259.

Live demonstration: CNN edge computing for mobile robot navigation

Enrique Pinero-Fuentes*‡, Antonio Rios-Navarro*, Ricardo Tapiador-Morales*, Tobi Delbruck†, Alejandro Linares-Barranco
*Robotic and Technology of Computers Lab, Universidad de Sevilla, Seville, Spain
†Institute of Neuroinformatics, University of Zurich and ETH Zurich, Zurich, Switzerland

***Abstract*—The brain cortex processes visual information to classify it following a scheme that has been mimicked by Convolutional Neural Networks (CNN). Specialised hardware accelerators are currently used as CPU co-processors for mobile applications. These accelerators are getting closer to the sensors for an edge computation of its output towards a faster and lower power consumption improvements. In this demonstration we use a dynamic vision sensor (inspired in the retina neural cells) as a visual source of the NullHop CNN accelerator deployed on a MPSoC FPGA and placed into a mobile robot for edge-computing the visual information and classify it to properly command a Summit-XL mobile robot for a target destiny. The reduced latency of the used CNN accelerator allows to process several histograms before taking a movement decision. A distance sensor mounted on the robot ensures that the direction change is done at the right distance for a proper path following.**

I. Introduction

CNNs have become one of the most powerful vision algorithms for object detection and object recognition in terms of accuracy. These algorithms compute a huge amount of operations, basically multiplications and accumulations (MACs). For this reason, a powerful computing system is needed if low latency response is required. There exist cloud computing solutions that acquire data from the device, send it to the cloud, where the CNN is deployed, and wait until receiving the data already processed. These solutions introduce a huge latency for some specific applications, because of the communication latency. In contrast, in edge-computing the processing is done locally on end-user devices to reduce latency, save power and protect user's privacy [1]. This demonstration presents a mobile robot system which acquires visual information using the DAVIS346[2] neuromorphic sensor and computes, in the NullHop accelerator, a trained CNN to classify four different signs. These signs are used to send four different commands to the robot to perform a particular movement.

II. Demonstration setup

The demonstration setup includes the following devices and software: 1) the DAVIS346 [2] neuromorphic vision sensor; 2) NullHop CNN accelerator [3] implemented on the logic part of a MPSoC (based on a Xilinx Zynq Ultrascale+ family); 3) the SUMMIT-XL [4] mobile robot operated by the Robotic Operating System (ROS) running on an embedded computer; 4) the cAER event-based computing software for embedded devices, running at the MPSoC ARMs, which reads the DVS

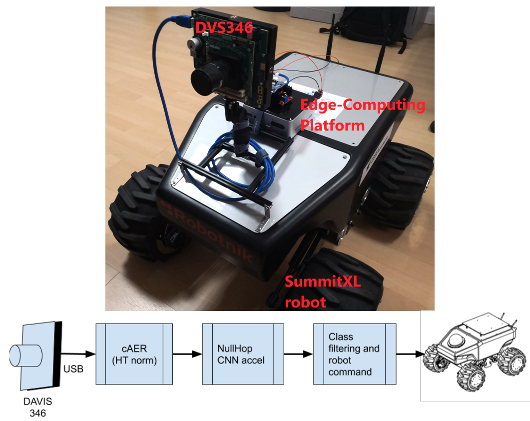

Fig. 1. Demo robot & hardware setup (top): A DVS sensor is directly connected to a CNN accelerator that talks to an embedded computer running ROS, which commands the SummitXL robot. Block diagram (bottom): cAER takes 2k event histograms and NullHop does the classification before commanding the robot.

output, prepare normalized frames for the CNN and talks to ROS.

III. Visitor experience

Visitors will be able to configure the path to be followed by moving and placing the direction signals. The CNN accelerator will take histograms of 2k events from the DVS sensor for signs classification. Detected signs will be filtered and accumulated until the distance of the robot to that signal is closer enough to command a turn. The direction and angle of the turn depends on the detected signal. A last symbol will be used to indicate the end of the path. The speed of the robotic platform could be increased or decreased to demonstrate the efficiency of the hardware and the accuracy of the used CNN.

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