Proposition de sujet de Stage

Programme d'initiation à la recherche Polytech Nice Sophia

Titre du stage	**Neuromorphic Stereo Vision with Event Cameras**
Laboratoire d'accueil	i3S
Département Polytech concerné	SI
Encadrant principal	Jean Martinet
Fonction	PU
Adresse mail	jean.martinet@univ-cotedazur.fr
Date de démarrage	A partir du 1/2/21
Durée	6 mois
Autres encadrants	Amélie Gruel, Andrew Comport

Objectifs du stage

Stereopsis enables depth perception of the world, which is a key feature for both artificial and human visual processing systems. Besides, depth is an essential requirement for many practical applications, ranging from fine object manipulation in robotics, to autonomous driving for vehicles. In this 6-month internship project, we wish to design and implement a neuromorphic model for stereo matching using event cameras. The project will extend a previous internship work done in the lab in 2020.

Mots-clés

Neuromorphic computing, Spiking neural nets, Event camera, Stereo matching, Computer Vision.

Compétences demandées

Strong interest for research, proficiency in computer vision and machine learning, strong programming skills in Python. Good knowledge of Linux (Ubuntu 18.04).

Positionnement scientifique - Etat de l'art

Event cameras are bio-inspired vision sensors that work in radically different ways from traditional cameras. Instead of capturing images at a fixed rate, they measure changes in brightness per pixel asynchronously. It results in a flow of events, which encode the instant, location and sign of brightness changes. These cameras have exceptional properties compared to traditional cameras: very high dynamic range (140 dB against 60 dB), high temporal resolution (order of microseconds), low latency, low energy consumption and no motion blur (see this example). Therefore, these sensors bring a great potential for computer vision and robotics in challenging scenarios. However,

new computing methods are needed to deal with the unconventional output of these sensors in order to unlock their potential.

Spiking Neural Networks (SNN) are a specific class of artificial neural networks, where neurons communicate by sequences of spikes. Contrary to deep convolutional networks, spiking neurons do not fire at each propagation cycle, but rather fire only when their activation level (or membrane potential, an intrinsic quality of the neuron related to its membrane electrical charge) reaches a specific threshold value. Therefore, the network is asynchronous and allegedly likely to handle well temporal data such as event cameras' output. When a neuron fires, it generates a non-binary signal that travels to other neurons, which in turn increases their potentials. The activation level either increases with incoming spikes, or decays over time. Regarding inference, SNN does not rely on stochastic gradient descent and backpropagation. Instead, neurons are connected through synapses, that implement learning mechanisms inspired from biology for updating synaptic weights (strength of connections) or delays (propagation time for an action potential).

The supervisors belong i3S lab, in the topics of bio-inspired machine learning, vision, and robotics. This internship takes place with the EU program APROVIS3D) that started in April 2020, and that targets embedded bio-inspired machine learning and computer vision, with an application to autonomous drone navigation.

Programme de travail

After a study of existing neuromorphic methods (namely by Osswald, Dikov, Haessig, and Risi) and the selection of one of them, the work will start by implementing the method to obtain a functional prototype (3 months). The implementation will use existing stereo event datasets such as MVSEC, as well as a pair of Prophesee cameras (that will be provided) for live input. In a second step, we will extend the prototype using advanced features and stereo matching techniques, e.g. HOTS, PatchMatch Stereo (3 months).

Bibliographie

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[Haessig et al., 2019] G. Haessig, X. Berthelon, S.-H. Ieng, and R. Benosman, 'A Spiking Neural Network Model of Depth from Defocus for Event-based Neuromorphic Vision', Scientific Reports, vol. 9, no. 1, Art. no. 1, Mar. 2019, doi: 10.1038/s41598-019-40064-0.
[Dikov et al., 2017] G. Dikov, M. Firouzi, F. Röhrbein, J. Conradt, and C. Richter, 'Spiking Cooperative Stereo-Matching at 2 ms Latency with Neuromorphic Hardware', 2017, doi: 10.1007/978-3-319-63537-8_11.
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[Prophessee] URL: https://www.prophesee.ai
[MVSEC] URL: https://daniilidis-group.github.io/mvsec/