Master 2 Research Internship + PhD

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Modeling motion and depth processing in primate visual cortex using spiking neural networks

Keywords: ***Computational neurosciences, Vision, Artificial intelligence, Spatial perception, Depth/motion processing, Spiking neural networks.***

Type of positions: M2 internship, M2 internship followed by a PhD, or PhD directly.

Duration: 5-6 months (M2) – 3 years (PhD).

Stipend: Standard French salaries (~650€/month for the M2 and ~2130€/month gross for the PhD).

Starting date: early 2025.

Place: Centre de Recherche Cerveau et Cognition (CERCO), UMR 5549 (CNRS – Univ Toulouse 3), Pavillon Baudot CHU Purpan, Toulouse, France.

Supervisors: Benoit Cottereau, research director at CNRS (CerCo & IPAL, contact: benoit.cottereau@cnrs.fr) and Timothée Masquelier, research director at CNRS (CerCo, contact: timothee.masquelier@cnrs.fr)

In primates, neuronal processing of visual information occurs within two main pathways. The ventral pathway (or 'what' pathway) underlies cognitive functions such as faces or object recognition whereas the dorsal pathway (or 'where' pathway) allows visually guided actions such as navigation or manipulation of objects. In recent years, numerous studies in computational neurosciences used deep neural networks to model neuronal processing within the ventral pathway. Much less is known about treatments carried out along the dorsal pathway. This multidisciplinary project at the interface between AI, computational neurosciences and biological vision aims at modelling motion and depth processing along the dorsal pathway of the primate visual system. In order to reproduce the very low energy consumption of the primate brain, the developed models will be based on spiking-neural networks (SNNs) and will process data collected from event-based cameras (see figure).

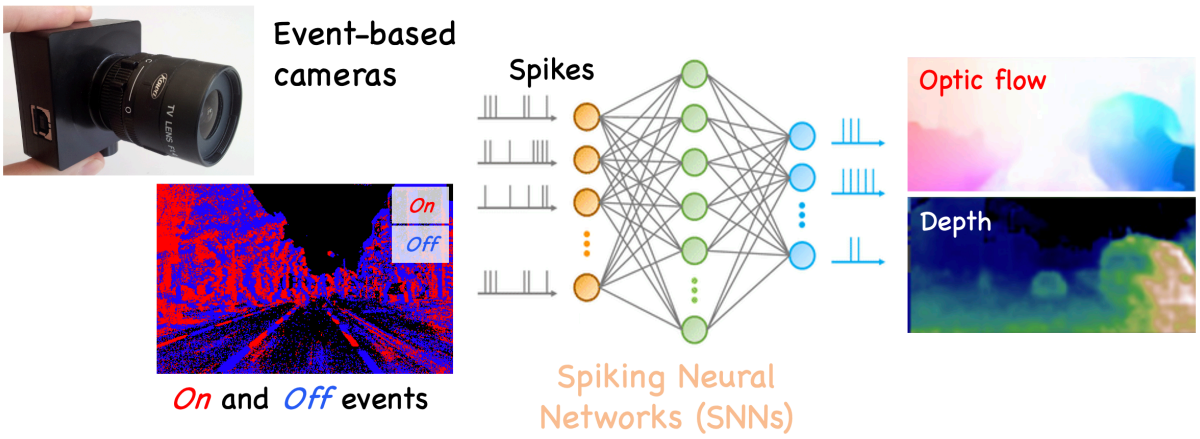

Figure: *Proposed architecture. Visual information will be captured from event-based camera(s) placed on moving vehicles or agents. The spikes generated by these cameras will be processed by spiking neural networks (SNNs) to extract the spatio-temporal properties (optic flow, depth) of the surrounding environment.*

We will be particularly interested in the processing of higher-level forms of motion (optic flow, motion-in-depth, biological motion). The responses of the neural networks after (supervised or unsupervised) training will be compared to biological data from the literature (for example with electrophysiological data recorded in non-human primates, see for example Duffy and Wurtz, 1991) or acquired in the CerCo laboratory.

The candidates should be willing to work in an international environment which involves Singapore and France, have a very good level in English (French is not mandatory), excellent mathematical and programming skills (in particular in Python) and a keen interest in the brain. Experience with deep learning libraries (e.g. PyTorch) is desirable.

The research will mainly take place in Toulouse, a student city (Toulouse is the second university hub in France) with high quality of life located in the south west of France (close to the Pyrenees, the Mediterranean Sea and the Spanish border). Long-term stays in Singapore (a multicultural and attractive city of south-east Asia) are also planned.

Applications should be sent to benoit.cottereau@cnrs.fr and timothee.masquelier@cnrs.fr

References:

- Cuadrado, J., Rançon, U., Cottereau, B. R., Barranco, F., & Masquelier, T. (2023). Optical flow estimation from event-based cameras and spiking neural networks. *Frontiers in Neuroscience*, *17*, 1160034.
- Duffy, C. J., & Wurtz, R. H. (1991). Sensitivity of MST neurons to optic flow stimuli. II. Mechanisms of response selectivity revealed by small-field stimuli. *Journal of neurophysiology*, *65*(6), 1346-1359.
- Rançon, U., Cuadrado-Anibarro, J., Cottereau, B. R., & Masquelier, T. (2022). Stereospike: Depth learning with a spiking neural network. *IEEE Access*, *10*, 127428-127439.