Depth estimation of the scene with neuromorphic cameras and LiDAR sensors

MSc or final project assignment internship

Neuromorphic or event-based cameras are sensors highly appreciated by the industry nowadays, in various fields such as predictive maintenance, augmented reality or driving assistance. While asynchronously reporting brightness changes at the pixel level with a temporal resolution in the order of micro-seconds, they make it possible to analyze complex dynamic scenes made up of rapidly moving objects, under lighting conditions that can vary greatly [1].

Prophesee Metavision® Evaluation Kit 4 HD
See Event-Based Concepts on:
https://docs.prophesee.ai/stable/concepts.html

Since the beginning of 2020, we have been collaborating with researchers from the Paris-based company Prophesee, which very quickly provided us with their high-resolution sensor. We first proposed a real-time optical flow estimation method adapted to this type of HD camera. A new dense representation of the sparse event flow, in the form of an "inverse exponential distance surface" allows us to reuse state-of-the-art optical flow calculation methods based on image frames. The effectiveness of the proposed approach was evaluated on car driving scenes filmed using low and high resolution event cameras [2]. In both cases, we obtain results that are often better than those of the current state of the art, while being faster (77 Hz on HD data). Secondly, we proposed a learning-based data-fusion method between a LiDAR sensor and an event camera for estimating dense depth maps of the observed driving scene [3]. For that purpose, we proposed two different approaches, one using a convolutional deep network, and another one using a transformer-based network for a better consideration of the spatial and temporal relationships between the LiDAR and the event data.

The objective of the internship is either:

(1) Event data representation and processing – Events can be processed individually or they can be converted to alternative representations, *e.g.*, event frames, time surfaces, event volumes, voxel grids, before feeding them to any computer vision algorithm~~s~~ or neural network~~s~~. In our previous works, we used both 2D frame-like event representations and event volumes. The intern will study other representations and/or encoding strategies of events and LiDAR data that could be better adapted for depth estimation.

(2) 3D scene flow estimation – Starting from the depth estimation method we have developed using LiDAR and event data, the intern will investigate and develop a method for 3D scene flow estimation, *i.e.*, the estimation of the motion field of points in the three-dimensional world (just as optical flow is the two-dimensional motion field of points in an image).

The choice of either of the two subjects is given to the candidate, based on his/her personal preferences, and can be done after the start of the internship when more familiarized with the event camera and our previous works.

References

[1] G. Gallego, T. Delbruck, G. Orchard, C. Bartolozzi, B. Taba, A. Censi, S. Leutenegger, A. Davison, J. Conradt, K. Daniilidis, D. Scaramuzza. Event-based Vision: A Survey. IEEE Transactions on Pattern Analysis and Machine Intelligence, 44(1), January 2022.

[2] *https://vbrebion.github.io/RTEF/*
V. Brebion, J. Moreau, F. Davoine. Real-time optical flow for vehicular perception with low- and high-resolution event cameras. IEEE Transactions on Intelligent Transportation Systems, 23(9), September 2022.

[3] *https://vbrebion.github.io/ALED/*
V. Brebion, J. Moreau, F. Davoine. Learning to estimate two dense depths from LiDAR and event data, SCIA- 22nd Scandinavian Conference on Image Analysis, Levi, Finland, April 18-21, 2023.

Place and allowance of the internship

LIRIS Lab., INSA Lyon, Bâtiment Blaise Pascal, Campus de la Doua, 69100 Villeurbanne.
Internship allowance is about 580 euros/month (4.05 euros per hour, 35 hours per week). The funding covers 5-6 months starting from February/March 2024.

Expected abilities

Machine learning and deep learning
Knowledge in Computer Vision
Good programming skills (Python / C++)
Good communication skills

Contact information

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Researchers, Imagine team @ LIRIS (https://liris.cnrs.fr/)

---> Application

Please provide to F. Davoine and V. Brebion your CV and transcripts with your marks for the two years of Master's degree / the last two years of engineering school.