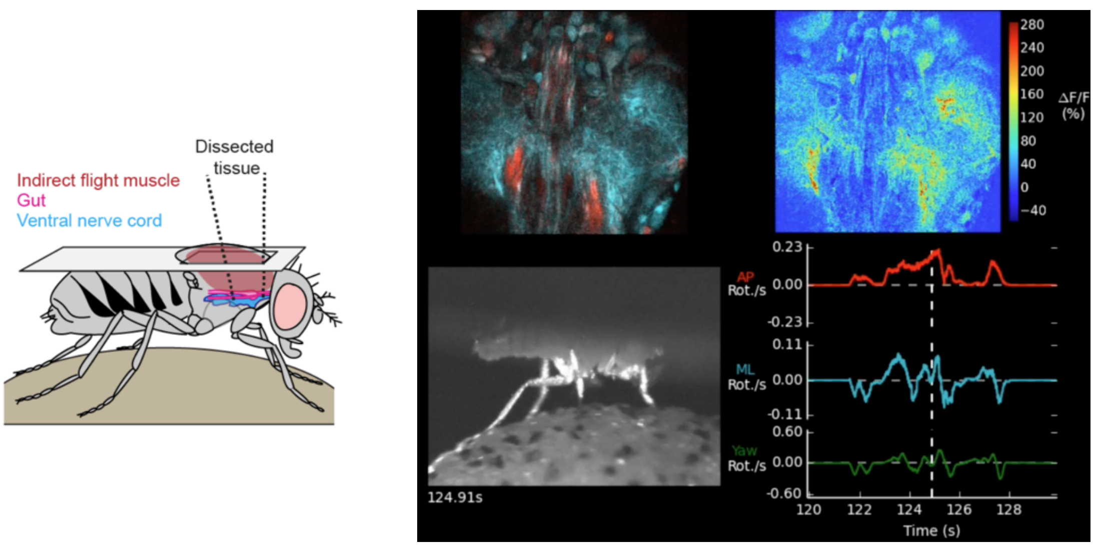
Master Internship – 6 months

Three-dimensional motion estimation for the analysis of the neural activity of drosophilia

Monitoring the activity of neural circuits that control limbs during dynamic behaviour is crucial to understand the organization of the neural system. This has been achieved recently with an experimental setup that enables to analyze the role of the ventral nerve cord (VNC) during motion of an adult *Drosophilia melanogaster* [2] (Fig. 1). A two-photons microscope records in real time the expression of a genetically encoded calcium indicator GCaMP that reveals the activity of the VNC in the moving Drosophilia. The temporal analysis of the expression of GCaMP enables to identify activation patterns that correspond to different types of dynamic behaviour. The difficulty is that the motion of the fly in the raw data prevents from accurate localization of the activated region, which compromises all the subsequent analyses. Therefore, it is crucial to estimate and compensate the deformation of the Drosophilia. The goal of this Master project is to develop a motion estimation method to realize this task.



(a) (b)

FIGURE 1 – (a) Schematic of the dorsal thorac dissection. The body of the Drosophilia is fixed, but it can move limbs to create a rotation of the spherical support. (b) Visual analysis interface. Bottom-left : video recording ; top-left : Fluorescence image sequence of GCaMP (in blue) and tdTomato (an anatomical fiduciary, in red) with a two-photon microscope ; top right : heat map of an activation descriptor of GCaMP ; bottom-right : angular speed of the spherical support.

Motion estimation in 2D image sequences has been extensively studied in computer vision for various applications from autonomous driving to video compression [3]. We have developed a 2D motion estimation method inspired by computer vision techniques that was integrated in the analysis toolbox of the experimental setup described in [2]. The challenge is now to extend the method to 3D data. The trivial adaptation of standard 2D motion estimation methods leads to a prohibitively large computational cost. Moreover, another effect has to be taken into account : the 3D volumes are acquired slice by slice, such that an undesirable motion of the fly can occur between two slices and produce distortions. The trainee will first implement a simple approach based on variational principles [1], that will be integrated in the software tool used in the experiment. In a second part of the internship, we will investigate the adaptation in 3D of more advanced methods based on feature correspondences and motion interpolation [4].

Working environment

The student will be a member of the IMAGeS team (`http://images.icube.unistra.fr/`) in the ICube laboratory in Illkirch. The internship will begin between January and May 2019, for a period of 6 months.
Supervisor : Denis Fortun (`dfortun@unistra.fr`)

Profile of the candidate

— Last year of Master studies in one of the following fields : computer science, applied mathematics, biomedical engineering
— Strong background in signal and/or image processing
— Good programming skills (the coding language will be Python)
— Interest for biomedical applications

Application

Send a CV and a short description of your motivation to Denis Fortun : `dfortun@unistra.fr`

Références

[1] T. Brox, A. Bruhn, N. Papenberg, and J. Weickert. High accuracy optical flow estimation based on a theory for warping. In *European Conference on Computer Vision (ECCV)*, pages 25–36. Springer, 2004.

[2] C.-L. Chen, L. Hermans, M. C. Viswanathan, D. Fortun, F. Aymanns, M. Unser, A. Cammarato, M. H. Dickinson, and P. Ramdya. Imaging neural activity in the ventral nerve cord of behaving adult drosophila. *Nature Communications*, 9(1) :4390, 2018.

[3] D. Fortun, P. Bouthemy, and C. Kervrann. Optical flow modeling and computation : a survey. *Computer Vision and Image Understanding*, 134 :1–21, 2015.

[4] J. Revaud, P. Weinzaepfel, Z. Harchaoui, and C. Schmid. Deepmatching : Hierarchical deformable dense matching. *International Journal of Computer Vision (IJCV)*, 120(3) :300–323, 2016.