PhD position - early October 2019

Registration of 3D optical biopsies: *application to medical imaging of high-resolution and wide field-of-view*

Location

- FEMTO-ST Institute (UMR 6174), AS2M Department
- 25000, Besançon, France

Duration

- 36 months

Scientific context

FEMTO-ST Institute (Besançon, France), develop several research activities related to surgical robotics, medical imaging, and image-guided intracorporeal interventions. In particular, we are addressing the clinical problem of performing of in-situ 3D optical biopsies, i.e. the optical analysis at the micrometer resolution of biological tissues thanks to highly efficient medical imaging without the traditional physical sampling of suspected tissues (physical biopsy). However, tissue analysis at micrometric resolution, using for example optical coherence tomography (OCT) or confocal microscopy, raises the problem of the limited field of view. Actually, this is the recurring dilemma of a wide field of view and micrometric resolution. To remedy this, it is necessary to perform several high-resolution 3D optical biopsies based on the micrometric motion of the imaging probe and to assemble them to reconstruct a single high-resolution biopsy over a large area.

Clinical context

The clinical objectives of this investigation are numerous, among them, achieving of 3D optical biopsies with micrometric resolution and wide field of view as part of the in-situ characterization of the olfactory mucosa in human subjects. The idea to find a precursor sign (earlier diagnosis) of a future neurodegenerative disease (Alzheimer's and Parkinson's disease) by studying the odor operating in its healthy and pathological states. The diagnosis is intended to be as early as possible (5 to 10 years) before the first signs of motor impairment or memory loss. In fact, it has been statistically demonstrated (post-mortem studies) that loss of smell with no apparent causes (trauma, cancer, etc.) is generally correlated with dementia (neurodegenerative diseases, such as Alzheimer).

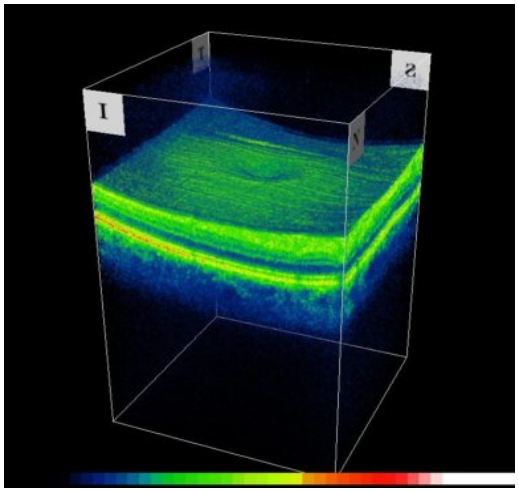

Figure 1: example of a 3D optical biopsy obtained by un OCT device within the digestive tract.

Consequently, the aim is to understand what is happening in vivo in the olfactory mucosa without taking a sampling process of tissues (physical biopsy), which is clinically difficult to achieve. However, the in-situ characterization of the olfactory mucosa can be carried out thanks to 3D optical biopsies approaches. An example of a 3D optical biopsy (OCT) can be shown in Fig. 1.

Scientific content

The scientific work concerns the development of accurate and robust registration methods between 3D visual information (optical biopsies). The PhD student will first focus on the development of calibration methods based on local visual features (e.g., geometric type information), matching methods, computing rigid transformations as well as reconstruction and mapping all the acquired data on the same final volume. This first work will provide a basis for extending these methods in aim to use global information such as pixel/voxel intensities, wavelet coefficients or any other global image information. In addition, several parameters and external disturbances will be considered within this work such as physiological motion, … in order to limit potential artifacts.

This work will then be extended to non-rigid registration in which the observed tissue is subjected to a global (or a local minimum) deformation resulting, for instance, from the contact between the tissue and the imaging probe.

Required knowledges

- (medical) imaging, computer vision, robotics and applied mathematics
- Advanced programing skills (C++, Matlab, Python)
- Knowledges of computer vision libraries (OpenCV, PCL) will be appreciated

Supervision team

- Guillaume Laurent (Associate-Prof, ENSMM) - https://gjlaurent.github.io/
- Brahim Tamadazte (Senior Scientist, CNRS) - https://sites.google.com/site/tamadazte/home

Application procedure

Interested candidates should send a cover letter, a CV and transcripts (M1 and M2 or equivalent) as a single PDF file to the supervisors **before 1 September 2019**.

References

[1] Rosa, B., Dahroug, B., Tamadazte, B., Rabenorosoa, K., Rougeot, P., Andreff, N., & Renaud, P. (2018). Online robust endomicroscopy video mosaicking using robot prior. *IEEE Robotics and Automation Letters*, *3*(4), 4163-4170.

[2] Ourak, M., Tamadazte, B., & Andreff, N. Partitioned camera-OCT based 6 DOF visual servoing for automatic repetitive optical biopsies. In *2016 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)* (pp. 2337-2342). 2016.

[3] Ourak, Mouloud, Tamadazte, Brahim, Laurent, Guillaume J., *et al.* Geometric Calibration of an OCT Imaging System. In: *2018 IEEE International Conference on Robotics and Automation (ICRA)*, 2018. p. 3993-3999.