

*PhD position open*  
**Flash-based visual SLAM for UAV**

DARK-Nav project funded by the French National Research Agency (ANR)

## 1 Context

The aim of the ANR Dark-NAV project is to equip a multirotor UAV with flash-based photolocation system inspired by the flashlight fish for navigation purpose. The flashlight fish illuminates its visual scene by triggering and modulating a striking bioluminescent flash as it swims through coral reefs (Fig 1-left).

The scientific objectives of this project will be the development of a powerful flash-based stereo active photolocation sensor, of aperiodic visual *Simultaneous Localization And Mapping* (SLAM) algorithms and of the corresponding stabilization and navigation strategies. The key strategy will consist, in piloting the flashing frequency of the sensor according to the external illumination, the distance to obstacles, and the current speed of the UAV. The targeted application context carried by the industrial partner (SUEZ) is the autonomous inspection of empty water pipelines or tanks. This inspection is crucial for the maintenance of drinkable water infrastructures and to prevent unwanted pollution. This PhD will focus on the aperiodic and self-triggered SLAM part of this project.

The Dark-NAV project is supported by a consortium of three laboratories (GIPSA-Lab in Grenoble, ISM in Marseille and ICube in Strasbourg) have strong experiences in vision and advanced robotics control. The project also include the industrial partner SUEZ-SERAMM that uses drones for inspection and maintenance of water pipes (Fig 1-right).



Figure 1: Left) Flashlight fish. Right) Inspection of water tunnel with UAV by SUEZ (typical application of the Dark-NAV project).

## 2 Objectives

The objective of the thesis is to study and designed new vision based SLAM algorithms using aperiodic flash based camera images available only after an external trigger (generated by the navigation module) or a self-triggering event (decided by the SLAM module itself).

The first task will focus on the visual inertial SLAM itself and will rely on the "SuperSurfelFusion" algorithm developed at Gipsa-Lab [1, 2] illustrated on figure 2. This method uses a RGB+Depth camera, like the Intel RealSense camera, to represents the environment as a set of planar patches, called "supersurfels", and localize the camera by minimizing an error combining interest points and supersurfels reprojection. To maintain a good estimation between two images and to avoid camera tracking failure, it will be necessary to integrate the inertial data in the "SuperSurfelFusion" approach as it can be done in visual-inertial odometry [3, 4, 5]. As the SLAM method uses interest points, it will also be necessary to study the robustness of interest points detection and tracking relatively to the flash illumination (particularly to the fact that the light source will move with the UAV). The second task will be to study the self triggering generation. The developed

SLAM system will be able to predict a localization failure or a drop in localization accuracy in order to command new flashed image acquisition. The approach will rely on geometric and dynamic modelisation of the problem (for example covariance matrices of the localization state) or on machine learning methods like reinforcement learning.



Figure 2: Left) Intel RealSense Depth Camera D455 . Right) Example of a supersurfel based reconstruction with a stereo camera.

### 3 Environment

The PhD student will be integrated to the COPERNIC team, in the GIPSA-Lab laboratory, in Grenoble and will have strong interaction with the BIOROB team, in the ISM laboratory and with all other partners of the Dark-NAV project. The thesis will begin in October 2021 for a duration of 3 years. The gross salary is from 2135€ monthly. The doctoral student will be registered at the EEATS doctoral school in Grenoble.

#### Supervisors

- Michèle ROMBAUT, Professor Univ. Grenoble Alpes, GIPSA-Lab, Grenoble, France
- Franck RUFFIER, CNRS senior research scientist, ISM, Marseille, France
- Amaury Nègre, CNRS Research Engineer, GIPSA-Lab, Grenoble, France

### 4 Contact

To apply, send an e-mail to Amaury Nègre ([amaury.negre@gipsa-lab.fr](mailto:amaury.negre@gipsa-lab.fr)) with a CV, a cover letter and the last transcripts of the Master (or equivalent). A letter of recommendation from your M2 internship supervisor can also be attached.

### References

- [1] B. Canovas, M. Rombaut, A. Nègre, S. Olympieff, and D. Pellerin. A Coarse and Relevant 3D Representation for Fast and Lightweight RGB-D Mapping. In *VISAPP - Int. Conf. on Computer Vision Theory and Applications*, 2019.
- [2] Bruce Canovas, Michèle Rombaut, Amaury Nègre, Denis Pellerin, and Serge Olympieff. Speed and Memory Efficient Dense RGB-D SLAM in Dynamic Scenes. In *IROS 2020 - IEEE/RSJ International Conference on Intelligent Robots and Systems*, pages 4996–5001, Las Vegas, United States, October 2020. IEEE.
- [3] T. Qin, P. Li, and S. Shen. VINS-Mono: A Robust and Versatile Monocular Visual-Inertial State Estimator. *IEEE Transactions on Robotics*, 34(4):1004–1020, August 2018. arXiv: 1708.03852.
- [4] M. Li and A. I. Mourikis. High-precision, consistent EKF-based visual-inertial odometry. *The International Journal of Robotics Research*, 32(6):690–711, May 2013.
- [5] Tristan Laidlow, Michael Bloesch, Wenbin Li, and Stefan Leutenegger. Dense RGB-D-inertial SLAM with map deformations. In *2017 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, pages 6741–6748, Vancouver, BC, September 2017. IEEE.