

# PhD thesis position - starting october 2020

Calibration and application to mobile robotics of a polarimetric RGB fish-eye camera

## Hosting lab

The VIBOT ERL CNRS 6000 team is a small dynamic team of 12 people located in Le Creusot, France. Its research activities are mainly focused on vision applications in mobile robotics: 3D reconstruction, localisation, obstacle detection, etc. The team is hosted by the ImViA EA laboratory of the University of Burgundy. It is currently involved in ANR projects such as CLARA (CoupLage Apprentissage & vision for the control of Air Robots) in partnership with the I3S, INRIA CHORALE, LITIS laboratories, or in the iCUB project (Imagerie non conventionnelle pour une mobilité sécurisée en milieu Urbain) with the LITIS, Stereolabs, PSA.

## Context

For navigation and localisation tasks in a dynamic and unconstrained environment, a mobile robot must be able to perceive and interpret the environment. Vision sensors have proven to be the most suitable for this purpose, as they are inexpensive and allow the detection and recognition of objects in the scene, the localisation of the robot, as well as the reconstruction of the environment from images or videos [5, 3]. Polarimetric imagery is currently undergoing a major development in the field of mobile robotics, as the introduction of polarimetric cameras now makes it possible to consider real-time and robot-embedded applications. In a previous ANR VIPeR project, we had shown the interest of using such a sensor for the detection of water bodies as well as for the attitude estimation of a drone like many insects that are sensitive to the polarization of light [4].

## Scientific objectives

We wish to go further and develop algorithms to establish the complete attitude of the robot through vision. This information is crucial to enable mobile or aerial robots to move autonomously in various environments. Currently, inertial control units are involved in this task but have many drawbacks due to the drift caused by the measurements over time. Moreover, when the vehicle moves over metal manholes, the measurement is completely distorted. Thus, polarimetric vision could replace conventional vision by offering both the characteristics of a conventional imager and providing attitude information. This is now possible with RGB polarimetric cameras.

The thesis work will first consist in instrumenting the sensor on one of our robots using the ROS environment. A calibration method will have to be developed in order to be able to associate this new type of sensor with a fish-eye wide angle lens. The objective of this first part is to propose a simple system (similar to [2]) to optimize the measurement of polarization parameters according to the different wavelengths of the sensor and according to the optical characteristics of the lens.

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The second part will extend previous work on the use of polarimetric imaging in vision for robotics. On the one hand, we will be able to work on extending our work on attitude estimation by combining polarization measurements with the extraction of geometric information. On the other hand, we will investigate how to improve the latest visual odometry techniques by incorporating polarization information to correct the drifts obtained classically in the image of the recalibration performed by some animals [1].

## Required qualifications

- Computer vision
- Robotics
- Python programming skills, ROS environment

## Supervision

- Olivier Morel (MCF HdR) [olivier.morel@u-bourgogne.fr](mailto:olivier.morel@u-bourgogne.fr)
- Lew-Fock-Chong Lew-Yan-Voon (MCF HdR) [Lew-Fock-Chong.Lew-Yan-Voon01@u-bourgogne.fr](mailto:Lew-Fock-Chong.Lew-Yan-Voon01@u-bourgogne.fr)

## How to apply

Applicants should send a cover letter, a CV and their transcripts (master's degree or equivalent) as well as the name of one or two referees in the form of a single PDF file to the email addresses of the supervisors before June 1st, 2020.

## References

- [1] William W. Cochran, Henrik Mouritsen, and Martin Wikelski. "Migrating Songbirds Recalibrate Their Magnetic Compass Daily from Twilight Cues". In: *Science* (2004).
- [2] Olivier Morel, Ralph Seulin, and David Fofi. "Handy method to calibrate division-of-amplitude polarimeters for the first three Stokes parameters". In: *Optics Express* 24.12 (June 2016), pp. 13634–13646.
- [3] Nathan Piasco et al. "A survey on visual-based localization: On the benefit of heterogeneous data". In: *Pattern Recognition* 74 (2018), pp. 90–109.
- [4] Mojdeh Rastgoo et al. "Attitude estimation from polarimetric cameras". In: *IROS - IEEE/RSJ Int. Conf. on Intelligent Robots and Systems*. Madrid, Spain, Oct. 2018.
- [5] Sebastian Scherer et al. "River mapping from a flying robot: state estimation, river detection, and obstacle mapping". In: *Autonomous Robots* 33.1-2 (2012), pp. 189–214.