Master in Photonics – "PHOTONICS BCN"
Master ERASMUS+ "EuroPhotonics"

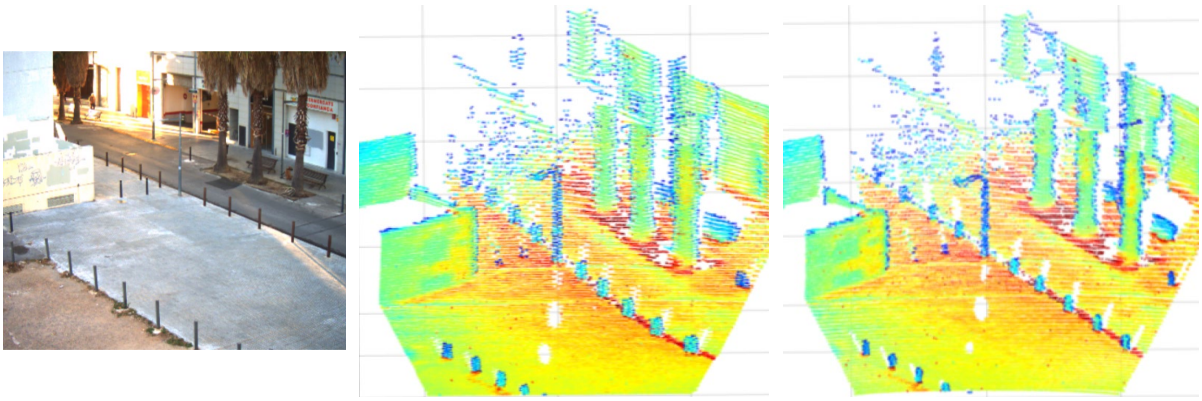
MASTER THESIS PROPOSAL

Dates: April 2020 - September 2021

Laboratory: Centre for Sensors, Instrumentation and systems Development (UPC-CD6)
Institution: Universitat Politècnica de Catalunya (UPC)
City, Country: Terrassa, Spain

Title of the master thesis:

INDUSTRY CHALLENGE: Automatic pattern detection on images for multiple-sensor calibration



(a) **(b)** **(c)**

Figure 1. (a) Scenario. (b) Distorted and (c) Calibrated 3D measures of the scenario using a LiDAR system.

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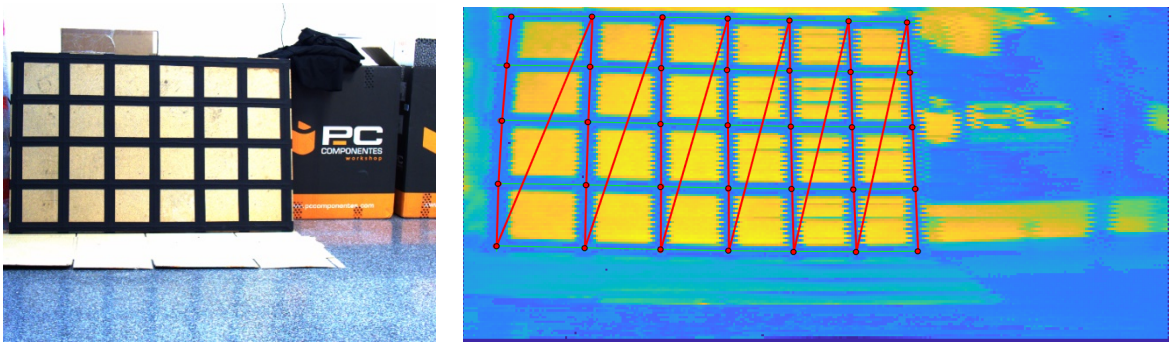
Keywords: Sensor calibration, Image Processing, LiDAR, Camera

Summary of the subject (maximum 1 page):

Which is the problem?

LiDAR imaging is a powerful measurement technique where a laser pulse is shone onto an object and the beam reflected back is recovered at some solid-state detector. The time elapsed is counted so an automated measurement of the distance to the target is obtained, without any further calculation. Then, by scanning the scenario, a whole set of 3D points known as Point Cloud is obtained. The concept is also referred to as a LADAR or time-of-flight imaging.

The current disruption of autonomous driving and robotics has forced this technology to move a step forward for meeting demanding specifications. As a result, many different scanning techniques have emerged but solid-state LiDAR systems are showing greater features than rotatory ones. However, due to fast acquisitions rates, the scanning presents a certain distortion which cannot be described by the conventional optical model. Thus, the scanning Field-of-View must be characterized and corrected so precise and accurate measurements are provided as Figure 1 presents. This is a key aspect for high-tech applications such as data fusion in autonomous driving. In order to do so, a set of known 3D points must be related with their correspondent pixel points as shown in Figure 2.



(a) **(b)**

Figure 2. (a) Checkerboard pattern used for calibrating. (b) LiDAR sensor's raw image of the pattern with its intersections detected with sub-pixel accuracy.

This TFM proposal is linked to a recently proposed and validated calibration procedure resulting from a PhD thesis between CD6 and the spin-off Beamagine, which is currently being automatized. The aim of this TFM is to detect without human action the pattern intersections for different positions and orientations of the system, as conventional cameras are calibrated.

For further information:

- Detailed discussion of the proposed LiDAR calibration model and procedure: García-Gómez, P.; Royo, S.; Rodrigo, N.; Casas, J.R. Geometric Model and Calibration Method for a Solid-State LiDAR. *Sensors* 2020, *20*, *2898*. https://doi.org/10.3390/s20102898
- Conventional Bouguet's camera calibration method: http://www.vision.caltech.edu/bouguetj/calib_doc/

- Bouguet's camera calibration MATLAB toolkit: https://es.mathworks.com/help/vision/ug/single-camera-calibrator-app.html .

Why are we interested?

Due to the direct relation between CD6 environment and the development of novel photonic products, we are used to deal with this kind of technical challenge. Currently, our LiDAR systems are solid-state MEMS based and they are being calibrated using the above technique. We are in the industry race, getting specialized know-how and participating in the designing of the tomorrow's technology in collaboration with manufacturers.

What will you do?

During the firsts weeks, you will learn and discuss the mentioned calibration procedure with technical staff of CD6 (teammates), as well as get to know the automatized process. After comprehending the overall framework of your thesis and getting confidence with basic image processing tools such as binarization and morphological operations, you will formulate the image processing algorithm. It must be capable of detecting the Region-Of-Interest of the pattern to be recognized and its intersections. You will have to make decisions on different technical aspects such as code performance, generated output, efficiency, … getting confidence and experience in working in real-world applications and getting involved in technical teams. It must be highlighted that you will be co-working with the team so you can get support from them when needed.

Is this TFM for you?

If you are willing to work with state-of-the-art tech-challenges and seeing your progress applied in a real-world application whilst working with a good and enriching environment, it is for you.

Additional information:

* Amount of the monthly allowance
* Recommended skills:
- Interest in application-driven experimental work for solving real-world problems.
- Basic concepts in optical engineering and image processing
- Programming (MatLab, C++ appreciated)
- Search of resources, both scientific and technical.
- Self-motivated, objective-driven, capable of autonomous working within a multidisciplinary team.
* Miscellaneous :
- This thesis contents will be considered confidential due to its closeness to market.
- International team with several years of experience in the topic proposed.
- Multidisciplinary environment with electronics and mechanics workshops, and specialists and technicians in metrology, optics, mechatronics, and electronics.
- Possibility of joining the Centre for a PhD/Project Manager career in case of common interest.
- Early incorporation welcome.