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

MASTER THESIS PROPOSAL
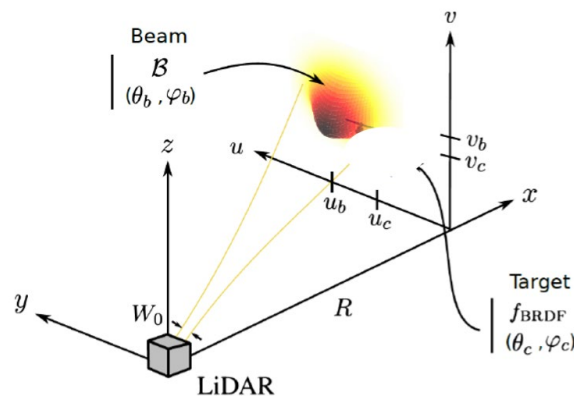
Dates: February 2024 - September 2024

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:

Detection model for a long-range LIDAR targeting small and agile targets

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Keywords: LiDAR, long-range, modelling, simulation, detection, tracking, artificial intelligence

Summary of the subject (maximum 1 page):

With the disruption of autonomous vehicles in recent years, LiDAR (Light Detection And Ranging) devices have aroused lots of interest for becoming the "eyes" of the vehicles for perceiving their environment. However, there are several other applications where LIDAR may be used for detection of targets at very long distances. In these cases, only a few hits of the scanning lidar are impinging at the target. This adds on to the different types of noise usually found in LIDAR systems. When such systems are far away, and in particular if they are small and mobile (such as birds) their footprint at the LIDAR side is very small, changing with time, and different to separate from false hits and spurious noise. However, information on the detection is critical to further use the detection to point a long-range imager, such as a telescope or a telephoto lens.

The approach is challenging as it involves a long-range radiometric model with noise estimations, broadening the laser pulse with propagation, the inclusion of statistics for the detection, and further refinements such as including the atmospheric effects, turbulence or the likelihood of localization. All of these are intended to be optimized to the geometry and features of the resultant LIDAR system, from mechanical setup to electronics. The student involved will thus have a complete overview of LIDAR systems and their limitations, including different configurations, effects on optical systems and limitations of the electronic. Use of strategies based on neural networks for detection of object will be considered, as well as using the statistics of detection for target tracking.

The project thus will be oriented towards the construction of a detailed model of detection for a long range LIDAR supported by hardware and software developments. The expected development includes a thorough revision of the state of the art in the first two months of project, the programming in Matlab/Python of a radiometric model to understand the radiometric issues involved, and the further investigation on the involved detection model, with clear hypotheses and some identified validation means. A tentative project development timing is proposed next, which should be considered as something to be confirmed.

	February	March	April	May	June	July
Analysis of the state of the art	██	██				
Definition of scope of the model		██	██			
Radiometric model		██				
Detection model		██	██	██	██	
Hardware considerations				██	██	██
Validation (software)					██	██
Memory and defence						██

Additional information:

- CD6 offers internship allowances for BSc and MSc students with grants depending on the value of the interns, given full time dedication is granted.
- Interns join a consolidated research team with several PhDs and Postdocs related, involving an international team with several years of experience in the topic proposed.
- CD6 offers a multidisciplinary environment with electronics and mechanics workshops, and specialists and technicians in metrology, optics, mechatronics, and electronics.

- Necessary skills (Must have):
  - Full-time dedication.
  - Proactive attitude to do research in a market-oriented environment.
  - Collaborative work and communication skills.
  - Critical thinking and problem-solving.

- Recommended skills (Nice to have):
  - Interest in application-driven experimental work for solving real-world problems.
  - Programming (MatLab, Python and the DNN packages, 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 developed in collaboration with a company and will be considered confidential.
  - Possibility of joining the Centre for a PhD/Project Manager career in case of common interest.
  - Early incorporation recommended.