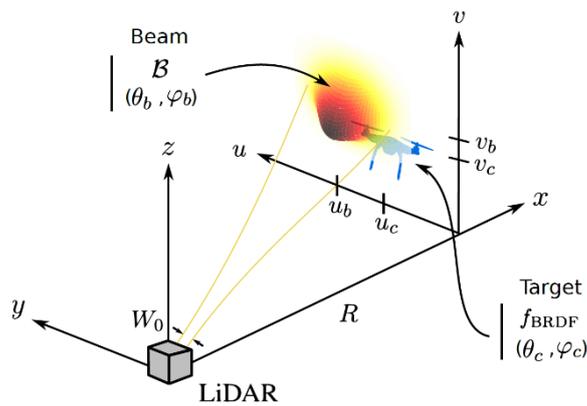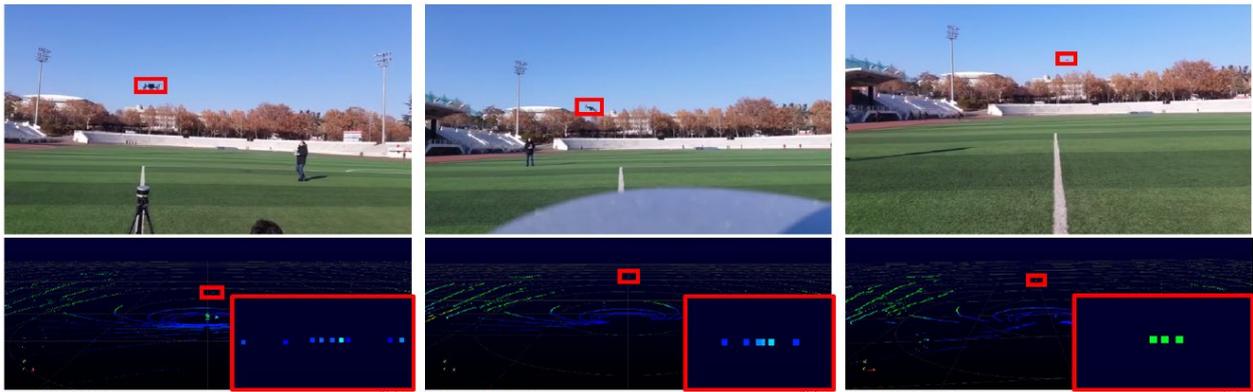# PHOTONICS - EUROPHOTONICS MASTER COURSE

PROPOSAL FOR A MASTER THESIS

Dates: February, 2025 –September 2025

Laboratory: Centre for Sensors, Instrumentation and systems Development (UPC-CD6)
City, Country: Terrassa, Spain

Title of the master thesis:

DETECTION PROBABILITY IN LIDAR SENSING FOR SMALL TARGETS

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Summary of the subject (maximum 1 page):

Our research group has in the past developed a large number of lidar prototype systems and technologies for different types of autonomous vehicles, including applications on ground, railway, boats and space vehicles. In this project, we will focus on improving the detection probability of small targets, such as drones, wildlife, or debris, using lidar systems. The main challenge is accounting for the complex reflectivity patterns of these small targets, which can vary significantly based on surface properties and environmental factors. To address this, the project will explore the integration of the Bidirectional Reflectance Distribution Function (BRDF) into the lidar range equation.

You will join our research group, receiving support in scanning lidar use, optical design, and modeling. The goal is to conduct studies that incorporate BRDF models into lidar systems and assess their impact on detection accuracy. Additionally, AI-based methods and Kalman filters will be explored to enhance detection capabilities.

The focus will be on four key areas:

1) **Inclusion of BRDF in the Lidar Range Equation**: integrating BRDF into the lidar range equation for improved target detection accuracy. This revised equation will be tested under various conditions to evaluate its impact on small target detection.
2) **Determination of the BRDF for Small Targets**: The BRDF for various small target surfaces will be determined through computational modeling and literature review. This approach will be used to predict how target surfaces reflect laser light at different angles, improving the system's ability to detect small objects under diverse conditions.
3) **Probability of Detection**: A probabilistic model will be developed to calculate detection likelihood by incorporating factors like reflectivity, noise, and signal levels. This will incorporate the revised lidar range equation with BRDF.
4) **AI and Kalman Filters for Enhanced Detection**: AI-based algorithms, such as neural networks, will be explored to improve the identification and classification of small targets. Kalman filters will be used to enhance the tracking and prediction of target movement, further improving detection probability in cluttered or dynamic environments.

This research will contribute to the field of lidar by improving detection probability for small targets. By incorporating BRDF and employing advanced signal processing techniques, the project aims to enhance the performance of lidar systems in various real-world applications.

Keywords: Lidar, Small Target, BRDF, Detection Probability, Kalman Filters, AI

Additional information :
* Amount of the monthly allowance (if it is the case):
To be discussed depending on the value of candidate.

* Required skills:
Interest in application-driven experimental work for solving real-world problems.

Basic concepts in optical metrology and optical engineering
Programming (C++ desirable, Python minimum)
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 <u>confidential</u> 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.
<u>Early incorporation welcome</u>.