PROPOSAL FOR A MASTER THESIS

Dates: February 1st, 2025 – September 30th, 2025

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

Title of the master thesis:

SYNTHETIC DATASET GENERATION IN NVIDIA OMNIVERSE WITH A MULTIMODAL LIDAR DIGITAL TWIN FOR AI-BASED PERCEPTION

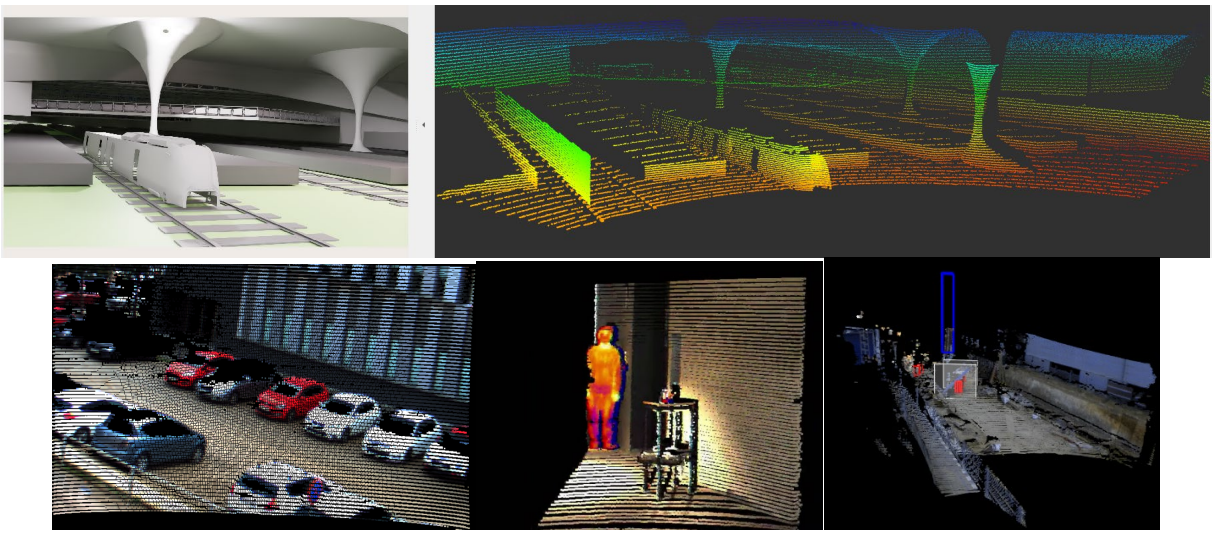

Figure. (Top) The digital twin of a train station in Nvidia Omniverse and the generated synthetic Point Cloud. (Bottom) Some examples of real point clouds (3D images) combined with colour and temperature information from our multimodal LiDAR system and our current 3D AI-perception.

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Summary of the subject (maximum 1 page):

Artificial Intelligence (AI) based perception requires large volumes of data to train and validate their performance (accuracy, robustness, failure modes, etc) under all conditions. This is extremely important for critical applications that do not permit false alarms or failure modes such as autonomous driving, railway, aircraft and security. Acquiring real-world datasets is time-consuming, but above all, it is difficult to control the repetitiveness of the conditions.

To mitigate the risks and accelerate the development of novel AI applications, the current trend in Computer Vision (CV) is to parametrize and create digital models that mimic sensors' behaviour. Then, sensors can be simulated under a controlled environment using simulation engines such as Unreal Engine. They are known as **Digital Twins** and they are becoming crucial in the field of AI-based perception.

In the CD6, we have started to create the Digital Twin of our multimodal LiDAR devices that combine 3D data with different 2D images (colour, thermal, polarimetric, …) in one of the most promising simulation environments: the Nvidia Omniverse. The goal of this project is to improve the current Digital Twin by introducing more realistic effects and phenomena with the aim of increasing data robustness and fidelity.

You will join our research group, where you'll have support on the use of scanning lidars, computer vision, optical design and modelling, coding and simulation, etc.

This thesis aims to enhance our multimodal Digital Twin in the Nvidia Omniverse environment. The focus will be on three key areas:

1) **Radiometric and projection model:** Understanding the physics and the underlying models that explain the different sensors' behavior (how they sense).
2) **Noise sources:** Introducing realistic noise sources to the measurements based on the abovementioned models.
3) **Software development:** Improving our current Digital Twin by introducing the more realistic parameters and algorithms as add-ons.

This project will tackle a real challenge present in the current AI revolution, becoming of high interest and impact for real-world applications like autonomous vehicles. Basic programming skills (fluent Matlab, Python or C++) and basic knowledge of electronics and optical system design are desirable, but not strictly required.

Keywords: LiDAR, simulation, autonomous vehicles, ROS, Python, deep learning, datasets

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 or Matlab minimum) and use of scientific software packages.
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.