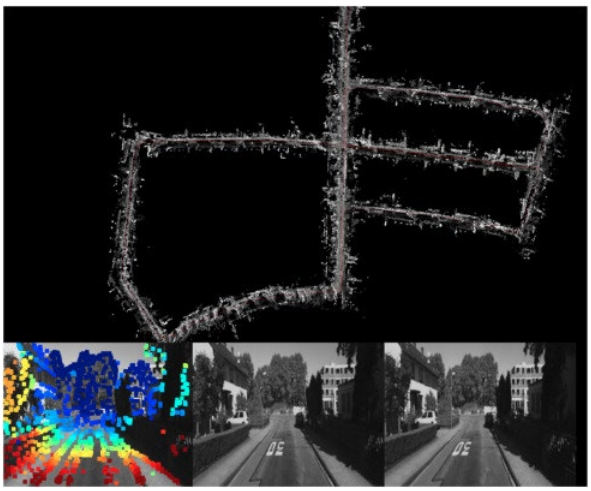
PROPOSAL FOR A MASTER THESIS

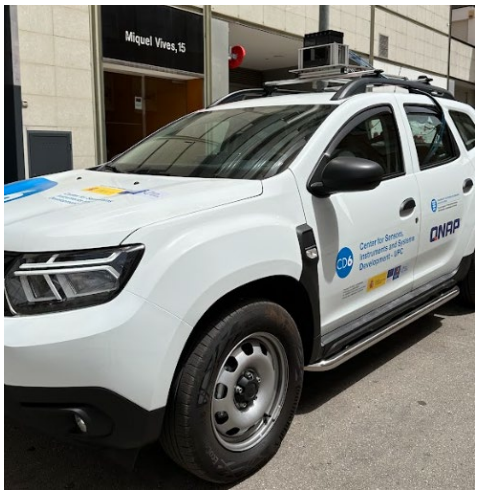
Dates: February 1st, 2025 – September 30th, 2025

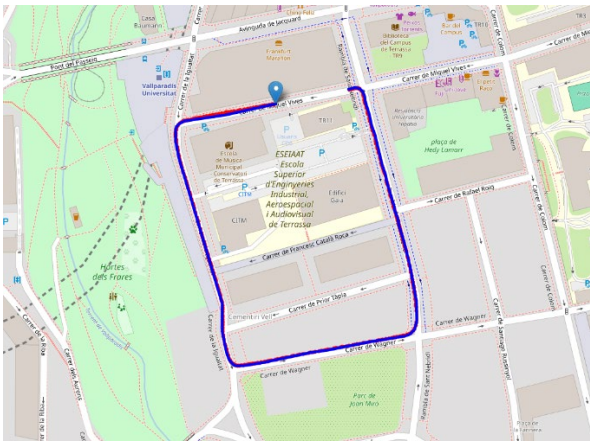
Laboratory: Centre for Sensors, Instrumentation and systems Development (UPC-CD6)
City, Country: Terrassa, Spain

Title of the master thesis:

VISUAL 2D+3D MAPPING SLAM FOR TERRESTRIAL AND UNDERWATER VEHICLES







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Summary of the subject (maximum 1 page):

Simultaneous Localization and Mapping (SLAM) plays a critical role in enabling autonomous vehicles to navigate complex and dynamic environments autonomously. Visual SLAM, a subset of SLAM that uses LiDAR and camera-based input, is particularly important due to its ability to provide rich, high-resolution environmental data. By using visual sensors, unmanned vehicles can accurately map their surroundings and localize themselves in real-time, which is

essential for safe navigation and effective decision-making. Unlike traditional GPS-based navigation systems, visual SLAM allows vehicles to operate effectively in GPS-denied environments such as dense urban areas, forests, or indoors.

The importance of visual SLAM extends to various applications, including autonomous drones, self-driving cars, and even underwater exploration. It enables these vehicles to detect obstacles, recognize landmarks, and create detailed 3D maps. This capability is especially valuable for ensuring precision in tasks like delivery, surveillance, and search and rescue operations. By leveraging visual SLAM, unmanned vehicles can achieve a higher level of autonomy and situational awareness, paving the way for more advanced and reliable automated systems.

The project is therefore focused on the study of SLAM techniques and to develop them towards accepting multimodal data from multiple sensors (LiDAR and different camera modes) to enhance the accuracy and precision of the localization under any working condition.

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

This thesis aims to develop a visual SLAM method using the multimodal LiDAR devices proprietary of the centre for terrestrial and underwater environments. The focus will be on four key areas:

1) **Sensor Fusion Background:** Understanding the algebraic principles about data fusion (both spatial and temporal) is crucial to properly feed the visual SLAM algorithm and to understand its localization and pose estimation output.
2) **State-of-the-Art Review:** Exploring the current state-of-the art about SLAM and visual SLAM techniques to establish a benchmark and to determine the necessary parameters of the algorithm.
3) **Dataset generation:** Acquiring the necessary data to train the algorithm, validate it and test it. Within this context, the research group has a vehicle equipped with different sensors including the LiDAR, the visual sensors and an IMU+GPS device to acquire datasets in urban scenarios.
4) **Robustness in Diverse and Challenging Environments:** Ensuring reliable visual SLAM performance under any condition is critical for deployment in GPS-denied and feature-scarce areas like urban areas and underwater environments.

This project will provide the center with a novel situational awareness capability to map and obtain accurate localization of unmanned devices even in GPS-denied environments like dense urban areas or underwater. Basic programming skills (fluent Matlab or Python) and basic knowledge of electronics and optical system design are desirable, but not strictly required.

Keywords: integration, metrology,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.