Drones For Autonomy (D4A)

Master Thesis Projects

General Intro to the Laboratory activities

Note: This description could be put at the beginning of each master thesis proposal to give some context.

Leonardo is involved in research activities related to UAVs through the newly established research laboratory network of Leonardo Labs. The main goal of the UxV/Unmanned Research Unit is the development, system integration and field testing of autonomous flight functionalities for rotary-wing UAVs (mini/micro size).

The goal of the team is twofold and tackles the design, development and test of:

- a fleet of UAVs for indoor, outdoor and outdoor-to-indoor missions in GNSS/GNSS-denied scenarios
- autonomous flight functions (e.g., target tracking, autonomous landing, multiple UAVs tracking, formation/swarming control algorithms). These functions are propaedeutic to the functioning of the UAVs in the scenarios mentioned above and will be tested both in simulation and real-world scenarios.

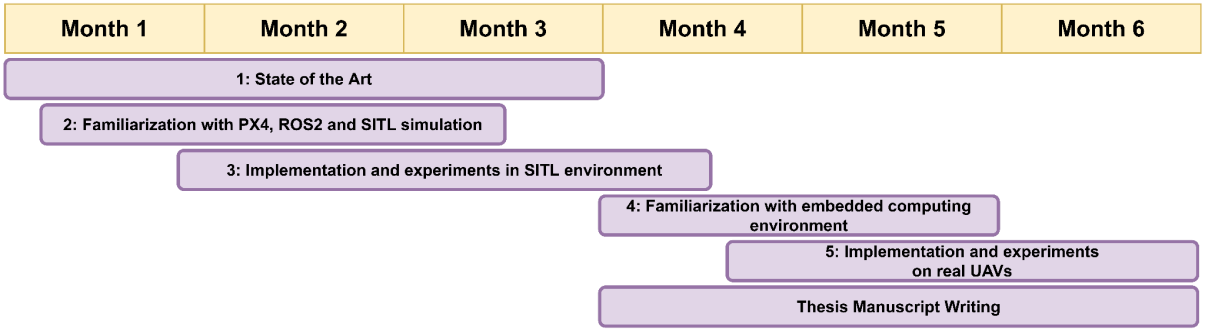
This work requires several technical skills such as, but not limited to:

- Software: knowledge of C++/Python, Docker and ROS2, PX4 flight control stack, robotic simulation environments (e.g., AirSim, Gazebo).
- Hardware: drone design, troubleshooting, functioning, and testing; CAD design and 3D printing; mechatronics prototyping; sensors testing (e.g., visible-spectrum camera, LiDAR).

General structure of the master thesis activities

Note: This description could be put at the end of each master thesis proposal to give an idea of the structure of the "ideal" master thesis.

The thesis will go through different phases. In general, we follow the workflow depicted in the figure below.



As you can see from the figure above, we try to expose each student to the opportunity to explore both simulated and real-world scenarios. We believe that this aspect is crucial to give them a compelling overview of a robotics application that they could face in their career.

PROPOSAL 1

Title: "*Development of a Fast Target following model for rotary-wing drones*"
Main goals: *An efficient target-following system for UAVs has to be implemented. In particular, the student will deal with the problem of having to chase a target moving at high speed without losing it from the field of view (FOV) of an onboard camera mounted on a rotary-wing drone. The aim is to explore and compare the performance obtained with AI-based (e.g., Reinforcement Learning) and more classic approaches (e.g., potential field-based navigation). A ROS2 Software In The Loop (SITL) simulation framework has to be implemented (Gazebo or Airsim).*
Requirements: *Basic knowledge of ROS/ROS2 (Python or C++), Reinforcement Learning, Automation, and Control Theory.*

PROPOSAL 2

Title: "*Cooperative multi-target following for Unmanned Aerial Vehicles Fleets*"
Main goals: *The objective is to manage the allocation and basic execution of one or more target following tasks to a fleet of drones. The student must first conduct a careful analysis of the state of the art of the problem. Then, an innovative AI-based approach to solve the problem should be proposed, implemented, and tested. A ROS2 Software In The Loop (SITL) simulation framework has to be implemented (Gazebo or Airsim).*
Requirements: *Basic knowledge of ROS/ROS2 (Python or C++), Cooperative Multi-Agent Robotics, Automation, and Control Theory.*

PROPOSAL 3

Possible Title: "Development of a *Multi-Camera/Multi-Agent Target Re-identification motion-based Model*"
Main goals: *Classical re-identification approaches have significant limitations on objects with similar coloration and shape. The student's goal is to exploit how to optimize information coming from a multi-camera system. It will be necessary to implement also a live dynamic object model to integrate position information in object space obtained from multiple cameras (same agent or multiple agents) to achieve better performance in critical situations.*
Requirements: *Computer Vision (OpenCv, Yolo, Yoloact/Yoloact++,...).*

PROPOSAL 4 <low priority>

Possible Title: "Hybrid (onboard/cloud) computing for UAVs". Alternative titles: Simulation of a hybrid edge/cloud drone system for disaster response; Simulation of a hybrid edge/cloud drone system for traffic management in disaster scenarios

Main goals: *Despite the recent trend of edge computing, not everything will be computed onboard UAVs. Unfortunately, there is still not enough research regarding the intersection between edge and cloud computing. 5G and now 6G is something we always hear about but it is still not clear how and when it will be crucial for UAVs. In this project, we aim at investigating how it is possible to leverage cloud computing for offboarding some heavy computing tasks (e.g., mapping, localization) and 5/6G for communication.*

Requirements: *Electronics and Telecommunications, Mechatronics, and Computer Science Skills.*

PROPOSAL 5

Possible Title: "Multi-camera system Visual-Inertial Odometry preliminary prototyping for UAVs Autonomous Flight in GPS-Denied environments"

Main goals: *After a careful study of the state of the art of these types of techniques, the student is expected to design and integrate an initial prototype of a multicamera system for navigation in GNSS-denied environments. In particular, detailed care is required in the design and choice of system components in order to achieve an accurate and stable localization result.*

Requirements: *Mechatronics/Electronics and Computer Vision skills.*

PROPOSAL 6

Title: "*Multi-agent collaborative patrolling for Unmanned Aerial Vehicles*"

Main goals: *The objective of this thesis is to devise innovative distributed strategies to determine a solution to the cooperative patrolling problem for a fleet of UAVs. The student is expected to carry out a careful analysis of the state of the art on the subject and to compare their solution with available benchmarks. The proposed solution will be implemented as a ROS2 package and tested via software-in-the-loop (SITL) simulations with Airsim (Unreal Engine 4) or Gazebo.*

Requirements: *Basic knowledge of ROS/ROS2 (Python or C++), Cooperative Multi-Agent Robotics, Control Theory, Graph Theory.*

We are open to any other interesting research project proposals!!!