

# Project Document

## 1) Overview

This project aims to apply the concepts of cognitive robotics to implement **multi-robot exploration** and **map merging** using known initial poses, and then apply it on **Gazebo** and **RViz** simulation tools using a real-life robot model in a realistic environment. Each robot starts from an initial known pose to explore the surrounding environment and build a map given noisy motion and sensor models. Maps from different robots are aggregated and merged into a single map. Moreover, each robot receives an image of a target object and uses its installed camera to visually search for it. Finally, the system is to be deployed and tested on a single real robot after passing the simulation stage.

## 2) Robot Requirements

ROS includes a large set of real-life robot models with a variety of sensors. You are required to use AgileX's LIMO PRO robot for implementing your multi-robot exploration system. LIMO PRO integrates the NVIDIA Orin Nano alongside the EAI T-mini Pro LiDAR and Orbbec Dabai depth camera. This enables robust environmental perception and intelligence for autonomous navigation, obstacle avoidance, and visual recognition applications.

- Robot Manual: [https://github.com/agilexrobotics/limo\\_pro\\_doc](https://github.com/agilexrobotics/limo_pro_doc)
- Robot ROS Packages: [https://github.com/agilexrobotics/limo\\_ros](https://github.com/agilexrobotics/limo_ros)
- Robot Simulation Packages: [https://github.com/agilexrobotics/limo\\_cobot\\_sim](https://github.com/agilexrobotics/limo_cobot_sim)

### 3) System Requirements

You are required to create your own world file for an environment that is complex enough to test your system. Your environment should be large and complex enough to test multiple robots. **You will need to share your environment with the TA to confirm the level of complexity. You will also have to test your system on a single real robot (AgileX's LIMO PRO).**

The goal is to implement a multi-robot exploration system, where the initial pose of each robot is known. Each robot should build its own part of the map and visually search for its target object, then map parts from different robots are aggregated and merged into a single complete map. The system should operate on three or more robots. **You are allowed to use pre-implemented modules and open-source code, however you MUST understand the details of your submitted code.**

The code modules are listed as follows:

- a) **Robot navigation (exploration):** The robot should not be controlled by the user. It should operate autonomously exploring its surroundings with a noisy motion model.
- b) **Sensor reading and incorporation:** Readings from sensors (laser, odometry ..., etc) at each time step should be processed and fused together. Note that you must assume a noisy sensor model.
- c) **Mapping with known initial poses:** The robot should build parts of the map, in which it navigates, assuming that the initial pose (position + orientation) is known.
- d) **Map aggregation and merging:** Parts of the map from different robots should be aggregated and merged together into a single map covering the whole world.
- e) **Visual search:** Each robot is provided with an image of a target object that already exists in the map. The robot is required to use its installed camera to search for this specific object in the map and report whether the object is found or not. One can use any existing open-source library/implementation for visual object search and detection (e.g. OpenCV examples).
- f) **Real robot deployment:** The final system is to be deployed and tested on a single real robot.

## 4) [Optional] Research Contribution

Teams are allowed to propose a novel solution for the multi-robot navigation and map merging. Your proposed solution can modify one or more modules from the ones listed above. Moreover, you are allowed to use other sensors and robot models, under the condition of the novelty of the idea. **You will mainly be working on implementing, validating and publishing your idea as a conference paper. In case of completion, the team will receive a bonus of 25% of the project grade.**

- Related schedule:
  - Interested teams have to send their proposals by **4/11/2025**.
  - The initial paper draft should be submitted by **1/12/2025**.
  - The final paper (after the instructor's review) should be submitted by **16/12/2025**.

## 5) Deliverables

- Your designed world map (should be confirmed ahead of submission).
- Your code containing all mentioned modules (along with build and launch files).
- A document containing your system design (used modules) and sample visualizations of your outputs using three or more robots.
- A demo of your system on AgileX's LIMO PRO robot provided in the faculty laboratory.
- The deadline for environment map confirmation is **1/12/2025**.
- The deadline for submission is **21/12/2025**.