Hameed Ullah

Stabilization and control of aerial manipulators in contact with the environment for on-site measurements

Tutor: Fabio Ruggiero

Cycle: XXXVII   Year: Second Year

My background

- MSc in Electrical Engineering (Specialization in Control), National University of Sciences and Technology, Islamabad, Pakistan

- Research group/laboratory: PRISMA Lab

- PhD start date: 01/11/2021

- Scholarship type: Marie-Sklodowska-Curie Innovative Training Network (ITN)
- Partner company: AEROTRAIN

Research field of interest

My research is mainly focused on the designing of controller to stabilize aerial manipulators (drone with robotic arm or stick) for physical interaction with the environment for on-site measurements.

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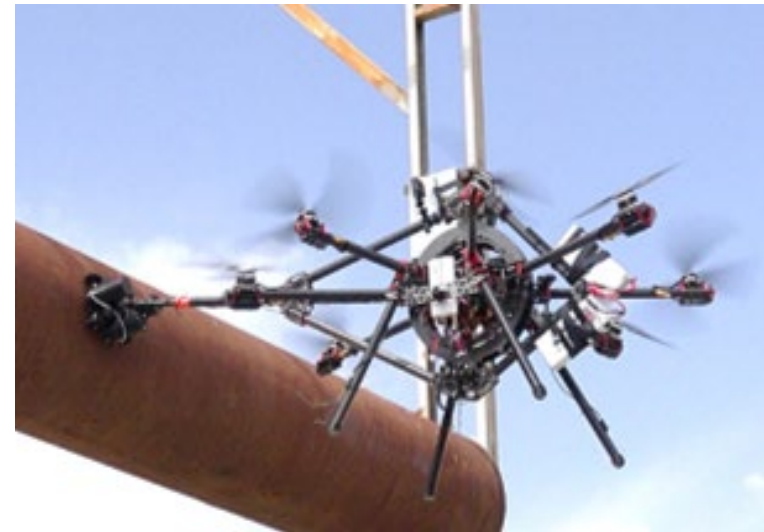
Research field of interest

As a participant of the **AEROTRAIN** project, I take part in the "**AEROTRAIN challenge**", it is a competition between 3 teams of project's PhDs for the development of an aerial manipulator, capable to perform non-destructive measurement test.

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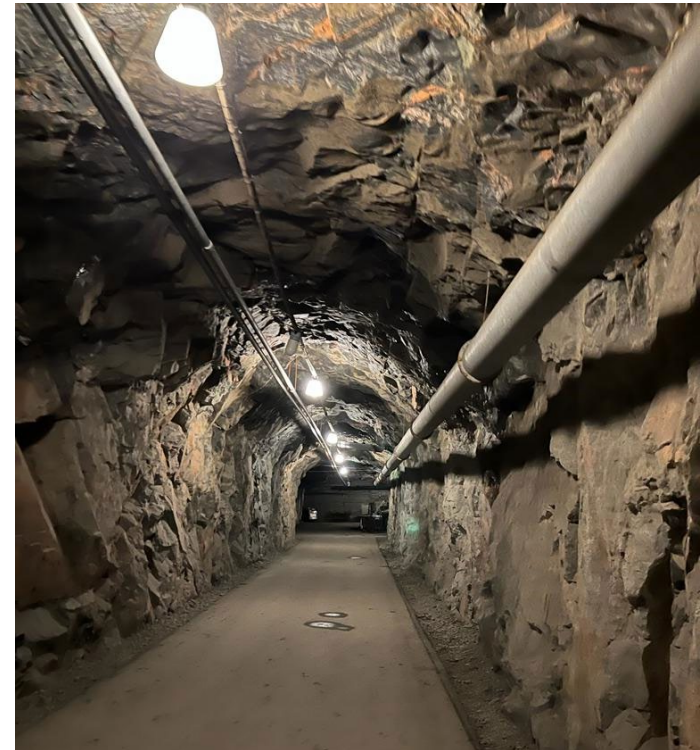
Summary of study activities

Ad hoc PhD courses / schools

International Training school:

1. Third Training School (TS-3): "**Training School on Field experimentation**" at **Luleå University of Technology (LTU)**, Sweden, organized by (George Nikolakopoulos) of the **AERO-TRAIN** project. TS 3 with a special focus on field robotics conducted in the Robotics and AI group's unique underground tunnel environment research facility.

International Integration Weeks:

1. First Integration Week (IW-1): First integration week of AERO-TRAIN project at Tampere University, Finland, organized by (Erdem Sahin) **AERO-TRAIN** project. The main aim was that the project PhDs to gained knowledge on the fundamentals of 3D scene capture, representation, processing and visualization, the programme included theoretical lectures and technology demonstrations.

1. Second Integration Week (IW-2): Second integration week of AERO-TRAIN project at Eurecat, Centre Tecnològic de Catalunya, Barcelona Spain, organized by (Julian Cayero) **AERO-TRAIN** project. Main aim of the event is to showcased the project PhDs ability to enable drones with augmented navigation and contact capabilities, culminating in flight tests in two remarkable scenarios.

Research activity: Overview

Problem:

- UAVs/drone work very well in various field, but limitation involves to perform some physical tasks.

- For physical interaction, we need **Unmanned Aerial Manipulators (UAM)**, but it is a challenging task to control it.
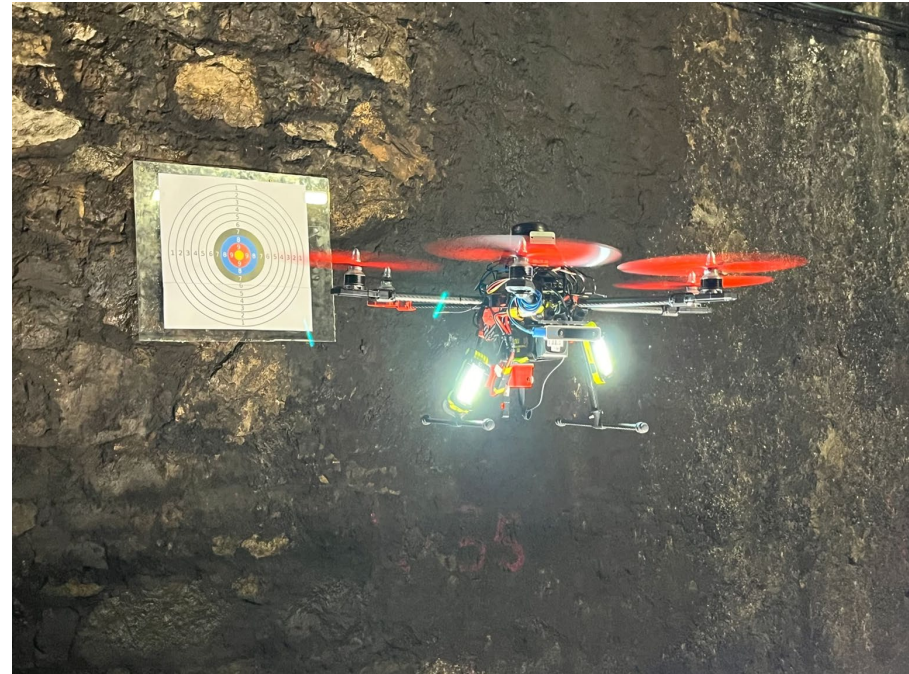
Research activity: Overview

Objective:

- To design a robust controller that can stabilize the aerial manipulators while performing physical tasks.

Methodology:

- Design of a model-based controller that can properly stabilize the aerial manipulators while interacting with the external surface.

Research activity: Overview

ROS Toolbox in MATLAB/Simulink

- ROS Toolbox in MATLAB/Simulink interfacing with GAZEBO through ROS.
- GAZEBO is an open-source 3D robotic simulator with dynamical joints.
- Designing of the controller in Simulink (easier to connect the blocks).
- Control a device in the dynamical simulation environment to get feedback from the environment and send them.
- ROS is communication protocol (using rosnode).
- To perform some physical tasks like push-and-slide operations.
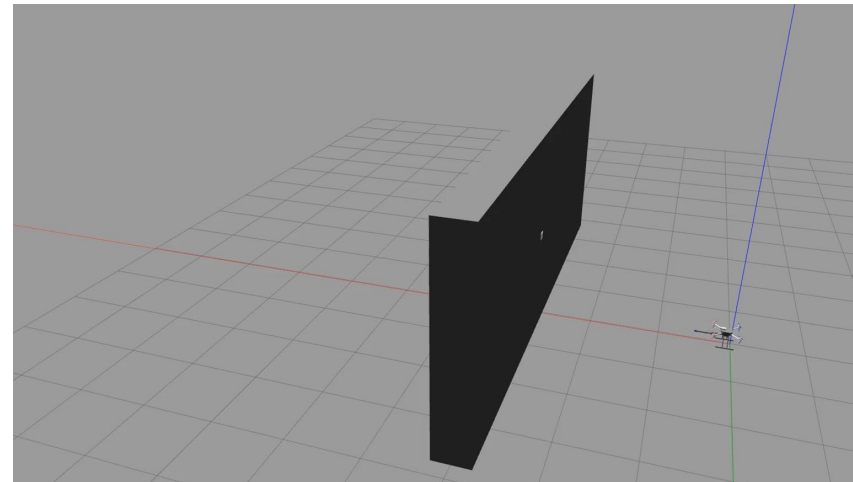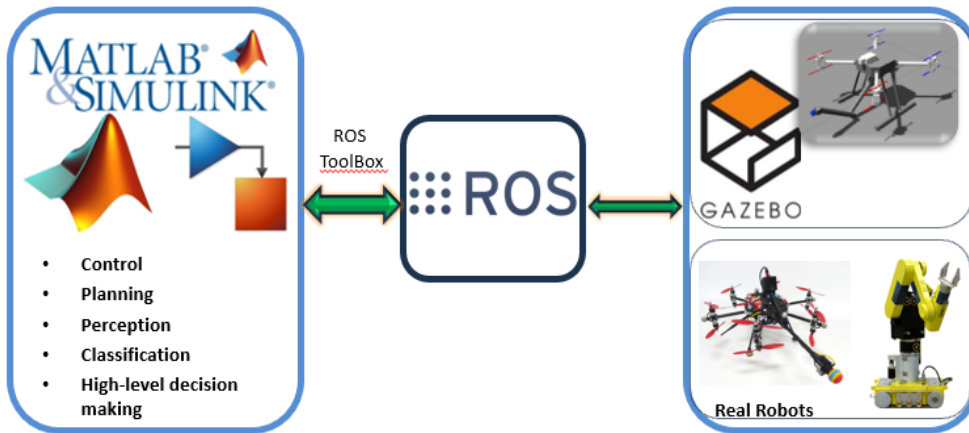
Research activity: Overview

Activities toward grand challenge:

- Inside the project we have **grand challenge,** which is a competition between three teams of project's PhDs for the development of an aerial manipulator.

- To achieve these goal, the project organized various **training schools** and **integration weeks**.

- Working in a team, as my responsibilities, I have worked on the designing of the controller for physical contact.

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Research activity: Overview

Activities toward grand challenge:

Working with other PhDs of the project, our team progress during these activities/project meetings for the final grand challenge as;
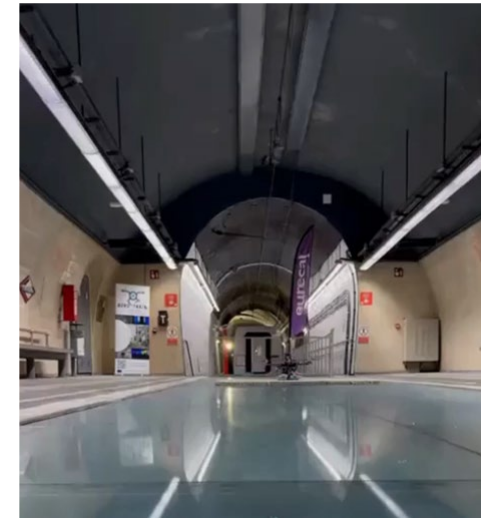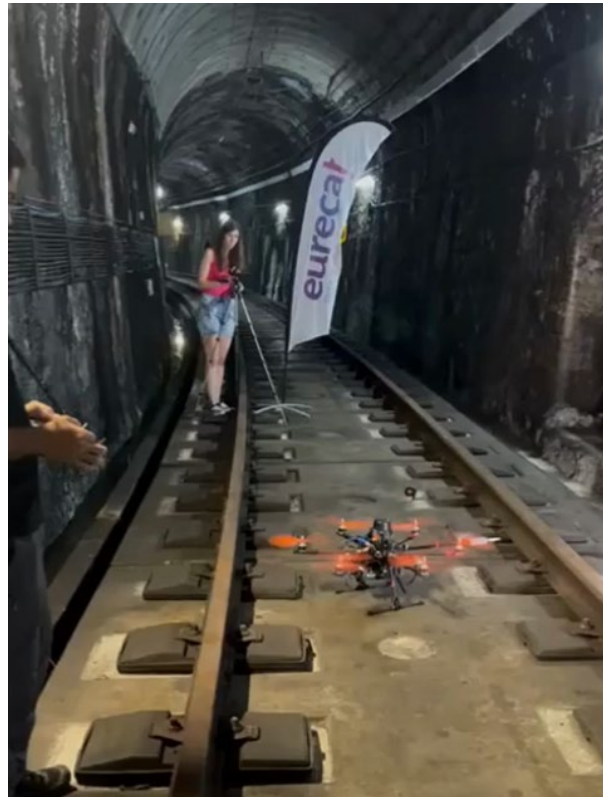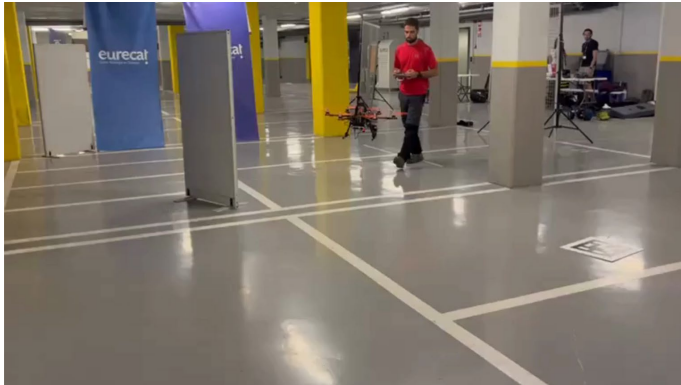
- Setting up and flying for the first time

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Research activity: Overview

Activities toward grand challenge:

Experiments in challenging environments

- Parking Lot
- Tunnel

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Research activity: Overview

Research activity during the Second Year

- Worked on the different software, learn to work on **ROS** and **GAZEBO** to simulate the system and test the environment and controller before implementation on the real hardware.

- Attended the project activities (TS 3, IW-1 and IW-2), successfully completed the tasks and challenges provided during these international activities.

- Worked on ROS Toolbox in MATLAB/Simulink interfacing with GAZEBO through ROS.

- Detail literature on the of recent research work on Nonlinear Model Predictive Control (NMPC), aerial manipulators and the implementation of NMPC on the aerial manipulator.

Research activity: Overview

Future work:

- Prepare for **Integration week 3,** and **Final Grand Challenge** to be organized by **UNINA** through the AEROTRAIN project.

- Organizing an AERO-TRAIN Workshop (Summer School) at ERF2024, (European Robotics Forum), in the June 2024, at Chania, Crete, **Greece**.

- Complete the Simulation in MATLAB/Simulink interfacing with Gazebo through ROS.

- Implementation of the nonlinear model predictive control on the aerial manipulator in simulation and on the practical hardware.

- The main goal is to complete **push-&-slide** operation of the aerial manipulator while interaction with the environment.

- Secondment at DTU (**Denmark)**.

- Thesis write up.

Thank you all for your attention