PhD in Information Technology and Electrical Engineering
Università degli Studi di Napoli Federico II

PhD Student: Julien Mellet

Cycle: XXXVII

Training and Research Activities Report

Year: First

Tutor: prof. Lippiello

Date: October 21, 2022

1. Information:

➢ **PhD student: Julien Mellet**
➢ **DR number: 155251**
➢ **Date of birth: 15/08/1994**
➢ **Master Science degree: Engineering: Navigation, Guidance & Control**
   University: Northwestern Polytechnical University, Xi'an, China
➢ **Doctoral Cycle: XXXVII**
➢ **Scholarship type: European Union fund with AERO-TRAIN project under the Horizon 2020 Research and Innovation Program and within the Marie Skłodowska-Curie (MC) Innovative Training Network (ITN), with Grant Agreement No 953454**
➢ **Tutor: Prof. Vincenzo Lippiello**

2. Study and training activities:

Activity	Type[1]	Hours	Credits	Dates	Organizer	Certificate[2]
AERO-TRAIN PhD Data Management Plan webinar - part 1	Seminar	1	0.2	20.12.2021	Jitlka Stilund Hansen, , DTU, Denmark	Y
Preliminary Research with State-of-the-art and beginning of making the simulation of the setup.	Research		9.8	1.11.2021 – 31.12.2021		N
AERO-TRAIN PhD Data Management Plan webinar - part 2	Seminar	1	0.2	21.01.2022	Jitlka Stilund Hansen & Signe Gudegaard, , DTU, Denmark	Y
Continue State-of-the-Art and Simulation Setup	Research		9.8	1.01.2022 – 28.02.2022		N
First Training School of AERO-TRAIN project	Course	56	2	07.03.2022 – 11.03.2022	José Àngel Acosta, PI (USE), General Chair	Y
IEEE Authorship and Open Access Symposium: Tips and	Seminar	1.5	0.3	30.03.2022	Rachel Berrington Director	Y

Best Practices to Get Published from IEEE Editors,						
Using Delays for Control (part 1)	Seminar	1	0.2	21.04.2022	Prof. Emilia Fridman	Y
Using Delays for Control (part 2)	Seminar	1	0.2	28.04.2022	Prof. Emilia Fridman	Y
On using simple optimization techniques for tuning of UAVs	Seminar	2	0.4	27.04.2022	Prof. Dariusz Horla	Y
AERO-TRAIN 1st Exploitation Workshop: Intellectual Property Management	Seminar	2	0.4	26.04.2022	Luca Maini, Eurecat, Spain	Y
Service and Companion Robots in Healthcare	Seminar	1.5	0.3	21.04.2022	Andrea Ruggiero	Y
Potential and Challenges of Next Generation Railway Signaling Systems: Moving Block and Virtual Coupling	Seminar	1	0.2	06.04.2022	Eng. Joelle Aoun	Y
Introduction to Deep Learning for Natural Language Processing & Explainable Natural Language Inference	Seminar	2.5	0.5	13.04.2022	Dr. Marco Valentino	Y
Study on simulation application for multi-agent system, and laboratory activities	Research		5.5			N
Field and Service Robotics (FSR)	Course	168	6	06.03.2022 – 07.06.2022	Fabio Ruggiero	Y
Robotics Lab	Course	168	6	06.03.2022 – 07.06.2022	Jonathan Cacace	Y
5G Networks in Action – The Private Mobile Era	Seminar	1.5	0.3	11.05.2022	Marco Centenaro	Y
Vine robots: design	Seminar	1	0.2	31.05.202	PhD.	Y

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challenges and unique opportunities				2	Nicholas Naclerio	
Workshop: Shared Autonomy in Physical Human-Robot Interaction: Adaptability and Trust	Seminar	8	1.6	23.05.2022	X. Jessie Yang	Y
Neural Network for State Estimation and laboratory activities	Research		1.9			N
IEEE RAS Summer School on Multi-Robot Systems 2022	Doctoral School	56	2	31.07.2022 - 06.08.2022	Martin Saska	Y
AERO-TRAIN Training School 2: Training School on Autonomous systems working in uncertain environments	Course	80	2	12.06.2022 - 18.06.2022	Matteo Fumagalli	Y
Neural Network for State Estimation and preparation for Experiments with laboratory activities	Research		6			N
Neural Networks and Deep Learning	Course	224	8	11.01.2022 – 20.10.2022	Prof. Giorgio Buttazzo	Y
Improvement of Neural Network for State Estimation and beginning of Experiments	Research		2			N

1) Courses, Seminar, Doctoral School, Research, Tutorship
2) Choose: Y or N

2.1. Study and training activities - credits earned

	Courses	Seminars	Research	Tutorship	Total
Bimonth 1	0	0.2	9.8	0	10
Bimonth 2	0	0.2	9.8	0	10
Bimonth 3	2	2.5	5.5	0	10
Bimonth 4	12	2.1	1.9	0	16
Bimonth 5	4	0	6	0	10
Bimonth 6	8	0	2	0	10

Total	26	5	35	0	66
Expected	30 - 70	10 - 30	80 - 140	0 – 4.8	

3. Research activity:

General:

This research project aims to develop a ground control framework for a single operator piloting a team of aerial manipulators with haptic feedback. Multiple drones allow the lift of larger payloads than a unique aerial manipulator, but at the same time, this increases control complexity. Therefore, it is first a matter of proposing to reduce the dimensionality of the pilot inputs required to control the semi-autonomous system. The research explores strategies to perform these manipulations. The final result would be a multimodal framework to let a single operator control multiple aerial robots for telemanipulation. It is also expected to understand to what extent haptic feedback for aerial manipulation influences the operator on his task.

Progress towards expected results:

Because no open-source solution exists for multi-drone manipulation with force feedback, we first need to investigate the three topics separately: **drone manipulation**, **multi-robot control**, and **haptic feedback**. Thanks to a deep literature study, the state-of-the-art of each topic has been reached.

The preliminary study achieved to make two aerial robot grasp and transportation within a simulation. It is considered state-of-the-art for multi-aerial manipulation. Then, because of the lack of accuracy of current haptic joysticks from the lab, the study initially proposed for the first year has been delayed for the secondment that begins in November at ETH Zurich.

The study of aerial manipulators highlighted some lack of standard platforms, which makes them quite challenging to be used in the field. Standard aerial manipulators can be stated as flat-quadrotor with a cable-suspended load. Then, the initial study slightly deviated to try to improve one platform. The main idea is to perform state estimation of the tethered load using only drone proprioception. It has therefore been proposed to train a neural network through a simulated environment to make the payload state estimation. This tool should further be used to make prediction on a study of time-delay. During this research, a new platform has been designed. It is low-cost manufactured and has the advantage of scalability for further studies with multi-robot systems.

On the other hand, participation in machine learning courses enabled to get the necessary knowledge to perform an accurate study with artificial neural networks. Courses in the robotics field allowed to understand theoretical models and the tools used to control machines. Moreover, the participation in the _IEEE RAS Summer School on Multi-Robot System_ has been a great opportunity to exchange about multi-robots with international experts.

Currently, no issue had been noticed to reach the proposed research.

4. Research products:

a. _Simulation Setup (prototype):_ Implementation of a virtual 3D environment with an accurate physics engine so called ODE (Open Dynamics Engine) inside Gazebo simulator. The robotic platform has been designed as a state-of-the-art aerial manipulator, a quadrotor with a cable suspended end-effector. The simulator embeds a commercial autopilot SITL (Software In The Loop) that allows piloting the platform with standard commands. A manipulator has been added, allowing to grasp objects to perform aerial manipulation. This simulation wants to replicate the real aerial lifting platform and its control behaviour with multi-agents.

b. _Control Framework (prototype):_ From the operator side, a framework has been proposed. It uses the standard MAVLink protocol to communicate with one or several platforms. Different control modalities have been explored, and multi-drone transportation has been realized virtually. A limitation of standard joystick controller highlighted that it does not easily map the number of control inputs with the number of degree-of-freedom allowed by the multi-robot system.

c. _Aerial Lifting Platform (prototype):_ Because the gap between simulation and the real world is always crucial in robotics, a real platform has been developed. It is entirely manufacturable for a low cost inside the lab. It has been generatively designed to be robust, lightweight, and 3D printable. Thus, the vehicle is relatively easy to repair and to replicate for multi-robot application. Contrary to standard quadrotors, it embeds performant motors, allowing a power-to-lift ratio close to 1,4. It means that the platform can lift more than its weight, so it is highly adapted to aerial manipulation.

d. _Neural Payload State Estimation (prototype):_ To reduce number of embedded sensors for aerial platform, a neural estimator using the drone proprioception has been proposed. From the simulation, using a blind standard platform, it allows to get payload state estimation.

5. Conferences and seminars attended

No conference attended

6. Activity abroad:

- **_TS1: Training school on unmanned aerial systems for inspection and maintenance, University of Sevilla, Spain:_** For period of one week, inside the ITN AERO-TRAIN project is has been a matter to discover the thory behind drones. Courses on design, control and inspection has been taught by the supervisors of the european project for the ESRs (Early Stage Researchers).
- **_TS2: Training school Autonomous systems working in uncertain environments, DTU: Technical Universiy of Denmark, Denmark:_** For a period of one week, inside the ITN AERO-TRAIN project is has been a matter to discover the thory behind drones. Courses on entrepreunership, automation and maintenance has been taught by the supervisors of the european project for the ESRs (Early Stage Researchers).
- **_IEEE RAS Summer School on Multi-Robot Systems 2022, Czech Technical University, Czech Republic:_** For a period of one week, within an IEEE Summer School courses had been about Multi-Robot Systems. Courses about swarming and multi-aerial systems ahs been taught by international experts for PhD students and other researchers. A final experimentation with real multi-drone has also been developed as application of the theory.

A total of three weeks (0,75 month) has been spending abroad this year.

7. Tutorship

No Tutorship