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

PhD Student: Vincenzo Scognamiglio

Cycle: XXXVII

Training and Research Activities Report

Academic year: 2021-22 – PhD Year: First

Tutor: prof. Vincenzo Lippiello _____

Co-Tutor: Eng. Alessandro Massa

Date: 23/10/2023

1. Information:

➢ **PhD student: Vincenzo Scognamiglio**
➢ **DR number: DR995995**
➢ **Date of birth: 30/11/1996**
➢ **Master Science degree: Automation Engineering   University: Federico II of Naples**
➢ **Doctoral Cycle: XXXVII**
➢ **Scholarship type: Leonardo S.p.A.**
➢ **Tutor: Prof. Vincenzo Lippiello**
➢ **Co-tutor: Eng. Alessandro Massa (Leonardo S.p.A.)**

2. Study and training activities:

Activity	Type[1]	Hours	Credits	Dates	Organizer	Certificate[2]
- Implementation of a Two Stage Kalman Filter on ROS for estimation of actuator faults **- Working on a localization framework for indoor autonomous navigation in industrial environment for pipe inspection tasks** **- Setting up of Intel Realsense D435i camera for SLAM application** **- Studying of ROS2 and Docker systems**	**Research**		8,3	**From 01/11/2022 to 31/12/2022**		
IROS Workshop: Human-Multi-Robot Systems: Challenges for Real World Application	**Seminar**	7,5	1,5	27/10/22	**Prof. Gennaro Notomista – IROS Conference 2022 Kyoto**	**Y**
Complex Network Systems: Introduction and Open challenges	**Seminar**	1	0,2	17/11/22	**Scuola Superiore Meridionale – SSM**	**Y**

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- Testing of a Two Stage Kalman Filter on ROS for estimation of actuator faults **- Implementation of SLAM and navigation algorithms on robots using Docker Containers** **- Study of the state of art on Multi-Robot SLAM and navigation** **- Experiments with UAV in contact using onboard state estimation** **- Submission of a Conference Paper to ICUAS**	**Research**		**7,8**	**From 01/01/2023 to 28/02/2023**		
Is control a solved problem for aerial robotics research?	**Seminar**	**1**	**0,2**	**12/01/2023**	**Prof. Fabio Ruggiero (DIETI)**	**Y**
Industry 4.0 Fundamentals In Bosch Applications	**Seminar**	**10**	**2,0**	**23-24-25-26/01/23**	**Prof. Eng. Mariagraz ia Dotoli (Politecnic o di Bari)**	**Y**
- Submission of the paper: "Motor Fault Detection and Isolation for Multi-Rotor UAVs Based on External Wrench Estimation and Recurrent Deep Neural Network" to Journal of Intelligent and Robotic Systems **- Leonardo Drone Contest: simulation of a cooperative multi-robot system composed by a UGV and a UAV** **- Study of the problem of the map maintenance in semi-**	**Research**		**10**	**From 01/03/2023 to 30/04/2023**		

static environment						
Exploring Advanced Aerial Robotics: A Journey into CuttingEdge Projects and Neural Control	**Seminar**	**1**	**0,2**	**29/06/2023**	**Eng. Julien Mellet (ITEE PhD)**	**Y**
AI, Robots and Society: Challenges and Opportunities for Soicial Innovation	**Seminar**	**1**	**0,2**	**25/05/23**	**Prof. Bruno Siciliano**	**Y**
- Tests for the Leonardo Drone Contest with a Multi-Robot Heterogenous system **- Implementation of mapping algorithm in semi-static environment** **- Research of a robust state estimation system for a UAV in GPS-denied environment, applying several sensors**	**Research**		**9,6**	**From 01/05/2023 to 30/06/2023**		
- Tests in Torino for the Leonardo Drone Contest with a Multi-Robot Heterogenous system **- Developing of a multi-robot mapping method using different kind of sensors**	**Research**		**4**	**From 01/06/2023 to 31/08/2023**		
Robotics Lab	**Courses**	**60**	**6**	**25/07/23**	**Prof. Jonathan Cacace – MSc Degree in Automazione e Robotica**	**Y**
Tutorship for the course of Mobile Robots of Master Degree in Autonomous Vehicle	**Tutorship**	**10**	**1,6**	**20/06/23**		

Engineering						
Field and Service Robotics	**Course**	**60**	**6**	**19/10/23**	**Prof. Fabio Ruggiero – MSc Degree in Automazione e Robotica**	**Y**
- Tests in flight arena to prepare for the Leonardo Drone Contest that will take place on 7-9 November - Working on map refinement for multi robot systems with sensor heterogeneity.	**Research**		**2,4**	**23/10/23**		

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**	**1,7**	**8,3**	**0**	**10**
Bimonth 2	**0**	**2,2**	**7,8**	**0**	**10**
Bimonth 3	**0**	**0**	**10**	**0**	**10**
Bimonth 4	**0**	**0,4**	**9,6**	**0**	**10**
Bimonth 5	**6**	**0**	**4**	**0**	**10**
Bimonth 6	**6**	**0**	**2,4**	**1,6**	**10**
Total	**12**	**4,3**	**42,1**	**1,6**	**60**
Expected	**30 - 70**	**10 - 30**	**80 - 140**	**0 – 4.8**	

3.   Research activity:

To give continuity to the work begun in the previous year, we implemented a complete framework for pipe inspection tasks using an aerial robot able to localize the pipe, plan its motion to approach the pipe and inspect it with onboard sensing and computing. During the experiments, the drone can map and localize itself to provide stable feedback to the flight controller and to remain stable in flight. We noticed that bad localization occurs when the aerial robot must explore large and unknown environments, due to vibrations during the motion and light conditions changing, camera sensors became noisy and unstable.

To solve this problem, we investigate the possibility of adding redundancy and heterogeneity in sensors to achieve better performances and avoid faults during navigation. From this perspective, we investigate also different algorithms for visual navigation and other sensor suites that can strengthen the localization ability. As involved in the "Leonardo Drone Contest", we need to develop a Multi-Robot system composed of a UAV and a UGV capable of exploring a semi-unknown environment looking for intruders. As a research activity, we investigated the opportunity of sharing spatial knowledge between the two agents. They use different kinds of maps and localization systems: the ground robot needs a 2-D map while the aerial robot requires a 3-D map. In general, due to their different dynamics and different kinds of sensors, the rover can build a more accurate map, this difference can be exploited to refine a global map that can be useful for both agents. This system can be also employed to explore efficiently an unknown environment: the two robots can recognize places that cannot be reached due to their physical constraint and can communicate to the ground control station, which manages the task planner, that the other agent can try to reach that place.

During this year, we also had the opportunity to keep working on the Fault Detection and Isolation of an actuator in an aerial robot. We devised a data-driven estimator, and we compared this technique with other model-based. For this work, after the study of the state-of-the-art works, we implemented in ROS a model-based technique and we simulated its dynamical behavior through multiple runs of the Gazebo simulator comparing detection and isolation results with our approach.

4. Research products:

Conference paper: *S. Roos-Hoefgeest, J. Cacace, V. Scognamiglio, I. Álvarez, R. C. González, F. Ruggiero, V. Lippiello, "A Vision-based Approach for Unmanned Aerial Vehicles to Track Industrial Pipes for Inspection Tasks," 2023 International Conference on Unmanned Aircraft Systems (ICUAS), Warsaw, Poland, 2023, pp. 1183-1190, doi: 10.1109/ICUAS57906.2023.10156565.*

Journal paper: *J. Cacace , V. Scognamiglio, F. Ruggiero , V. Lippiello, "Motor Fault Detection and Isolation for Multi-Rotor UAVs Based on External Wrench Estimation and Recurrent Deep Neural Network", Journal of Intelligent & Robotic Systems, Currently under review*

5. Conferences and seminars attended

6. Activity abroad:

7. Tutorship

Lecturer assistant: *Mobile Robots Course for prof. Fabio Ruggiero and prof. Jonathan Cacace – May 2023*

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