
UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II

**DOTTORATO DI RICERCA / PhD PROGRAM IN
INFORMATION TECHNOLOGY AND ELECTRICAL ENGINEERING**

Activities and Publications Report

PhD Student: Simone D'Angelo

Student DR number: DR995858

PhD Cycle: XXXVII

PhD Cycle Chairman: Prof. Stefano Russo

PhD program student's start date: 01/11/2021

PhD program student's end date: 31/10/2024

Supervisor: Prof. Bruno Siciliano

e-mail: bruno.siciliano@unina.it

Co-supervisor: Fabio Ruggiero

e-mail: fabio.ruggiero@unina.it

PhD scholarship funding entity: Università Federico II

General information

Simone D'Angelo received in year 2021 the Master Science degree in Automation Engineering from the University of Napoli Federico II. He attended a curriculum in aerial robotics within the PhD program in Information Technology and Electrical Engineering. He received a grant from Università Federico II.

Study activities

Attended Courses

Year	Course Title	Type	Credits	Lecturer	Organization
1 st	Matrix Analysis for Signal Processing with MATLAB examples	Ad hoc course	2	Prof. Carotenuto (UNINA)	ITEE
1 st	Statistical data analysis for science and engineering research	Ad hoc course	4	Prof. Pietrantuono (UNINA)	ITEE
1 st	Imprenditorialità accademica	Ad hoc course	4	Pierluigi Rippa	ITEE
1 st	Methods for Artificial Intelligence	MSc course	0	Prof. Silvia Rossi (UNINA)	University of Naples Federico II
1 st	Control of Complex Systems and Networks	MSc course	6	Prof. De Lellis (UNINA)	University of Naples Federico II
1 st	Operational Research: Mathematical Modelling, Methods and Software Tools for Optimization Problems	Ad hoc course	4	Adriano Masone (UNINA)	ITEE
2 nd	Using Deep Learning properly	Ad hoc course	0	Andrea Apicella	ITEE
2 nd	Model Predictive Control	MSc course	4	Prof. Bemporad (Scuola IMT Alti Studi Lucca)	Scuola IMT Alti Studi Lucca
2 nd	Semantic artifacts and Multimedia knowledge graphs for biodata integration	Ad Hoc course	2	Cristiano Russo	ITEE
2 nd	Formazione sulla progettazione europea offerta dalla Direzione Generale della Ricerca del Ministero dell'Università e della Ricerca nell'ambito	Ad hoc course	3.4	Università Federico II	Università Federico II

Attended PhD Schools

Year	School title	Location	Credits	Dates	Organization
1 st	IEEE RAS Summer School on Multi Robot Systems in Prague	Prague, Czech Republic	2	1-5/8/2022	Czech Technical University in Prague
2 nd	2023 Spring School in Transferable Skills	Napoli, Italia	2	24-25/5/23	University of Napoli Federico II

Attended Seminars

Year	Seminar Title	Credits	Lecturer	Lecturer affiliation	Organization
1 st	The era of Human-Robot Collaboration: Deep Sea Exploration	0.4	Prof. Siciliano & Prof. Khatib	University of Napoli Federico II	ITEE
1 st	ICAR 2021 Workshop on Design, Learning and Control for Sage Human-Robot Collaboration	1.2	Mario Selvaggio, Gennaro Notomista, Valeria Villani and Kelly Merckaert	University of Napoli Federico II	ICAR
1 st	Strumenti Digitali e Robotici per l'Inclusione	0.4	Prof. Siciliano	University of Napoli Federico II	ITEE
1 st	Intelligenza artificiale e sistemi d'arma autonomi	0.4	Diego Latella, Guglielmo Tamburrini, Giuliano Colombetti and Fosca Giannotti	University of Napoli Federico II	ITEE
1 st	Evento Enel	0.2	Prof. Cotroneo	University of Napoli Federico II	ITEE
1 st	An Introduction to Deep Learning for Natural Language Processing	0.2	Prof. Cutugno	University of Napoli Federico II	ITEE
1 st	Explainable Natural Language Inference	0.3	Prof. Cutugno	University of Napoli Federico II	ITEE
1 st	Global and Cluster Synchronization in Complex networks and beyond	0.2	Dr. Coraggio	SSM	SSM
1 st	IEEE Authorship and Open Access Symposium: Tips and Best Practices to get published from IEEE Editors	0.3	Rachel Berrington Director	IEEE	IEEE
1 st	On using simple optimization techniques for tuning UAVs	0.4	Prof. Ruggiero	University of Napoli Federico II	ITEE
1 st	Vine robots: design and unique opportunities	0.2	Prof. Selvaggio	University of Napoli Federico II	ITEE
1 st	ICRA Workshop 2022: Shared Autonomy in Physical Human Robot	1.6	Mario Selvaggio, Jessie	University of Napoli Federico II	ICRA

Activities and Publications – Final Report

UNINA PhD in Information Technology and Electrical Engineering – XXXVII Cycle

PhD candidate: Simone D'Angelo

	Interaction Adaptability and Trust		Yang, Luka Peternel, Laurel Riek, Elizabeth K Phillips		
2 nd	Game Theory for Information Engineering	0.6	Prof. Caleffi	University of Napoli Federico II	ITEE
2 nd	From Cyber Situational Awareness to Adaptive Cyber Defense: Leveling the Cyber Playing Field	0.4	Prof. Sperli	University of Napoli Federico II	ITEE
2 nd	Cybercrime and Information Warfare: National and International Actors	0.4	Prof Romano	University of Napoli Federico II	ITEE
2 nd	Industry 4.0 Fundamentals in Bosch Applications	2	Eng. Martino Bruni, Prof. Ing. Mariagrazia Dotoli, Ph.D.	University of Napoli Federico II	ITEE
2 nd	Is control a solved problem for aerial robotics research?	0.2	Prof. Franchi & Prof. Ruggiero	University of Napoli Federico II	ITEE
2 nd	NDT in contest aeronautico	0.2	Prof. Carlo Forestiere, Ing. Giovanni Gravina	University of Napoli Federico II	ITEE
2 nd	Multi robot control of heterogeneous herds	0.2	Prof. Montijano	University of Napoli Federico II	ITEE
2 nd	From Romeo & Juliet to OceanOne Deep-Sea Robotic Exploration	0.2	Prof. Siciliano & Prof. Khatib	University of Napoli Federico II	ITEE
2 nd	Ai, Robots and society: challenges and opportunities for social innovation	0.2	Prof. Siciliano & Dr. Pandey	University of Napoli Federico II	ITEE
2 nd	Robotic Spacecraft Rendezvous with a	0.2	Prof. Siciliano &	University of Napoli Federico II	ITEE

	Tumbling Target for Capture Robust Methods for Planning and Control		Dr. Lampariello		
2 nd	Exploring Advanced Aerial Robotics: A journey into cutting-edge projects and neural control	0.2	Prof. Ruggiero & Dr. Cuniato	University of Napoli Federico II	ITEE
2 nd	IEEE Authorship and Open Access Symposium: Tips and Best Practices to Get Published from IEEE Editors	0.3	ieeexplore	IEEE	IEEE
3 rd	Multi-agent autonomous flight at Leonardo Labs	0.2	Prof. Lippiello & F. Schiano	University of Napoli Federico II	ITEE
3 rd	Optimization-based planned and control for multi-limbed walking robots	0.4	Prof. Bellicoso & prof. Siciliano	University of Napoli Federico II	ITEE
3 rd	Simultaneous Perception and Manipulation	0.2	Dr. Zito & prof. Siciliano	University of Napoli Federico II	ITEE
3 rd	Analytic center selection of optimization-based controllers for robot ecology	0.2	Prof. Notomista & Prof. Siciliano	University of Napoli Federico II	ITEE
3 rd	Lessons learned from superhuman autonomous drone racing	0.2	Dr. Loquercio & Prof. Siciliano	University of Napoli Federico II	ITEE

Research activities

Simone D'Angelo during the three years of the PhD participated in the research on aerial robotics within PrismaLab research group with a particular emphasis on the semi-autonomous control of robotics platforms in interaction with the environment: the main goal was the development of solutions for completing non-destructive testing (NDT) in industrial environments. The work involved extensive research on tilting unmanned aerial vehicles (UAVs) and unmanned aerial manipulators (UAMs), focusing on developing flight and interaction control techniques. Different techniques are investigated, such as direct, indirect, and hybrid force control approaches integrating data from multiple onboard sensors to ensure precise task execution. Tests were conducted in both simulation and real-world scenarios. Furthermore, the research contributed to the mechatronic design, development, and testing of aerial platforms, ensuring their suitability for industrial inspection tasks. An additional goal is reached by exploring optimal control techniques, such as Model Predictive Control (MPC), considering explicitly friction constraints with contact

surfaces. This approach allowed for better prediction and handling of forces, improving overall system performance in challenging industrial inspection scenarios. This work represents a significant advancement in aerial robotics for complex NDT applications.

Tutoring and supplementary teaching activities

Tutorship activity for the course “Field and Service Robotics” for Prof. Fabio Ruggiero, Second Semester 2023 (06/03/2023- 9/06/2023)

Credits summary

PhD Year	Courses	Seminars	Research	Tutoring / Supplementary Teaching
1 st	22	5.8	32.2	0
2 nd	11.4	5.1	41.9	1.6
3 rd	0	1.2	58.8	0

Research periods in institutions abroad and/or in companies

PhD Year	Institution / Company	Hosting tutor	Period	Activities
3 rd	Toronto Metropolitan University (TMU), Toronto (On), Canada	Prof. Reza Faieghi, Assistant Professor	13-01-2024 / 11-03-2024	Research on optimization techniques for trajectory planning and real-time obstacle avoidance of aerial platforms
3 rd	Technical University of Denmark (DTU), Copenhagen (Denmark)	Prof. Matteo Fumagalli, Associate Professor	29-04-2024 / 09-08-2024	Research on a novel aerial platform capable of shifting the center of mass during the flight. We focus on the mechatronics and the control algorithm development.

PhD Thesis

In the PhD Thesis, Simone D’Angelo focuses on the development and implementation of advanced control methods for aerial manipulators equipped with tilting motors, intended for performing non-destructive tests (NDT) in contact with the environment. The main objective is to guarantee a safe, stable, and precise interaction between the tool mounted on board the manipulator and the inspected surface, even in the presence of external perturbations and variations in environmental conditions.

The thesis focuses on the use of two main aerial platforms, equipped with force and position-measuring sensors. Both have motor tilting capabilities giving them greater dexterity and the

ability to decouple attitude and position control. Initial tests are conducted in the simulated environment on advanced mathematical models including drone-surface interaction dynamics. In the real environment, on the other hand, tests are carried out on metal and composite surfaces to validate the techniques developed and verify their robustness.

In this work, various force control strategies are proposed and analysed. Among these, indirect, direct, and hybrid control approaches are presented and distinguished. Indirect control exploits system dynamics models to adjust the drone's position and ensure the correct application of force. On the other hand, direct control relies on direct measurements of the interaction force to adjust the motors' thrust in real-time. Hybrid approaches combine the advantages of both, optimizing performance in terms of precision and dynamic response. The control techniques to be presented will exploit the fusion of feedback information on the external environment captured by a complex system of onboard sensors.

A key aspect of the research concerns the management of interaction forces, particularly those generated by static and dynamic friction during contact. In addition, the tilting capability of drones provides additional degrees of freedom, proving essential for operations on uneven or hard-to-reach surfaces.

Research products

Research results appear in **1** paper published and **4** others still under review in international journals and **4** contributions and **1** other still under review to international conferences.

List of scientific publications

International journal papers

1. S. D'Angelo, A. Corrado, F. Ruggiero, J. Cacace, V. Lippiello

Stabilization and Control on a Pipe-Rack of a Wheeled Mobile Manipulator with a Snake-like Arm, *International Journal of Robotics and Autonomous Systems – (RAS)*, Volume 171, 2024, 104554, ISSN 0921-8890, <https://doi.org/10.1016/j.robot.2023.104554>

International journal papers (still under review)

1. T. Hui, S. Rucareanu, E. Zamora, S. D'Angelo, H. Liu, M. Fumagalli

Dynamic Center-of-Mass Displacement in Aerial Manipulation: An Innovative Aerial Vehicle Design
International Journal of Robotics and Autonomous Systems – (RAS)

2. T. Hui, E. Zamora, S. D'Angelo, S. Rucareanu, M. Fumagalli

AEROBULL: A Center-of-Mass Displacing Aerial Vehicle Enabling Efficient High-Force Interaction
IEEE ASME Transaction on Mechatronics – (T-MECH)

3. S. D'Angelo, M. Selvaggio, V. Lippiello, F. Ruggiero

Semi-autonomous Unmanned Aerial Manipulator Teleoperation for Push-and-Slide Inspection using Parallel Force/Vision Control
Robotics and Autonomous Systems – (RAS)

4. S. D'Angelo, S. Marcellini, A. De Crescenzo, M. Marolla, V. Lippiello and Bruno Siciliano

A Semi-Autonomous Aerial Platform Enhancing Non-Destructive Tests

Journal: International Journal of Robotics Research - (IJRR)

International conference papers

1. S. D'Angelo, F. Pagano, F. Ruggiero and V. Lippiello

Development of a Control Framework to Autonomously Install Clip Bird Diverters on High-Voltage Lines
2023 International Conference on Unmanned Aircraft Systems (ICUAS), Warsaw, Poland, 2023, pp. 377-382, doi: 10.1109/ICUAS57906.2023.10156403.

2. S. D'Angelo, F. Pagano, F. Longobardi, F. Ruggiero and V. Lippiello

Efficient Development of Model-Based Controllers in PX4 Firmware: A Template-Based Customization Approach

2024 International Conference on Unmanned Aircraft Systems (ICUAS), Chania - Crete, Greece, 2024, pp. 1155-1162, doi: 10.1109/ICUAS60882.2024.10556938.

3. H. Ullah, **S. D'Angelo**, F. Ruggiero, V. Lippiello and S. M. Orozco Soto

Horizontal Sustained Force Delivery with an Aerial Manipulator Using Hybrid Force/Position Control
2024 25th International Carpathian Control Conference (ICCC), Krynica Zdrój, Poland, 2024, pp. 1-5, doi: 10.1109/ICCC62069.2024.10569948.

4. Marcellini, S., **D'Angelo, S.**, De Crescenzo, A., Marolla, M., Lippiello, V., Siciliano, B.

Development of a Semi-autonomous Framework for NDT Inspection with a Tilting Aerial Platform.

In: Ang Jr, M.H., Khatib, O. (eds) *Experimental Robotics*. ISER 2023. Springer Proceedings in Advanced Robotics, vol 30. Springer, Cham. https://doi.org/10.1007/978-3-031-63596-0_31

International conference papers (still under review)

1. R. Campaci, V. Lippiello, **S. D'Angelo**, T. Borzone, L. Madia, M. Favaretto, A. Vignali

Drone-Based Solutions for Asset Integrity: Development of NDT Drone and 3D FPV Payload for Asset Remote Testing and Inspection

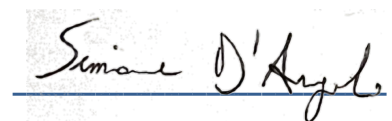
Conference: International Petroleum Technology Conference - (IPTC)

Patents and/or spin offs

Awards and Prizes

Date 14/10/2024

PhD student signature



Supervisor signature

