UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II

DOTTORATO DI RICERCA / PHD PROGRAM IN
INFORMATION TECHNOLOGY AND ELECTRICAL ENGINEERING

Activities and Publications Report

PhD Student: Viviana Morlando

Student ID: DR993891

PhD Cycle: XXXV
PhD Cycle Chairman: Prof. Stefano Russo

PhD program student's start date: 01/11/2019
PhD program student's end date: 31/01/2023

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PhD scholarship funding entity:
Università Federico II.

General information

Viviana Morlando received in year 2019 the Master Science degree in Automation Engineering from the University of Napoli Federico II. She attended a curriculum in Control of legged robotic systems within the PhD program in Information Technology and Electrical Engineering. She received a grant from University Federico II for the ITEE PhD program.

Study activities

Attended Courses

Year	Course Title	Type	Credits	Lecturer	Organization
1	Innovation management, entrepreneurship and intellectual property	Ad hoc course	5	Prof. Pierluigi Rippa	Prof. Pierluigi Rippa - StartCup Campani a 202
1	Machine Learning	Ad hoc course	4	Prof. Carlo Sansone	ITEE
1	Field and service robotics	MSc course	6	Prof. Fabio Ruggiero	University Federico II
1	Robotics Lab	MSc course	6	Prof. Vincenzo Lippiello	University Federico II
2	Scientific Programming and Visualization with Python	Ad hoc course	3	Prof. Alessio Botta	University Federico II
2	Statistical data analysis for science and engineering research	Ad hoc course	4	Prof. Roberto Pietrantuono	ITEE

Attended PhD Schools

Year	School title	Location	Credits	Dates	Organization
1st	EECI- International Graduate School on Control 2020- M10 Model Predictive Control	Remote	3	8/06/2020-11/06/2020	European Embedded Control Institute
2nd	SIDRA 2021 PhD Summer School	Bertinoro University Residential Centre	4	12/07/2021-17/07/2021	SIDRA

Attended Seminars

Year	Seminar Title	Credits	Lecturer	Lecturer affiliation	Organization
1st	Numerical methods for	0.2	Dr.	INRIA	ITEE

	modeling, simulation and control for soft robots or robots in interaction with deformable environment		Christian DURIEZ		
1	Computational Biology: Large scale data analysis to understand the molecular bases of human diseases	0.2	Prof. Michele Ceccarelli	University Federico II	ITEE
1	Elettromagnetismo e salute	0.2	Prof. Rita Massa	University Federico II	ITEE
1	How to get published with IEEE	0.4	Eszter Lukacs	IEEE	IEEE Webinar
1	Large Scale Training of Deep Neural Networks	0.4	Prof. Giuseppe Fiameni	NVIDIA	ITEE
1	La programmazione europea e la ricerca. Nuovi scenari della programmazione europea dopo il 2020 - La gestione di un progetto di ricerca.	0.4	Ing. Filippo Ammirati	Innovation Village	DIETI
1	Health 4.0 – La rapidità della medicina e la velocità del cambiamento del nostro mondo organizzato	0.4	Paolo Netti	University Federico II	Paolo Netti
1	Realtà Virtuale e salute reale. Health 4.0 – Dal bit alla mente: spazi virtuali per la salute	0.4	Valentino Magale	Softcare Studios Srls	Valentino Magale
1	Virtual Seminars on 'Sensing'	0.8	J. Wenger, C. Rockstuhl, L. Baldassarre, M. Fleischer	Institute Fresnel, France Karlsruher Institut fur Technologie, Germany University of Roma Sapienza Universitat Tubigen, Germany	Plasmonica Prof. Carlo Forestier e, DIETI
1	Exploring Autonomy in Robotic Flexible Endoscopy	0.4	Prof. Pietro VALDASTRI	University of Leeds	Prof. Fanny Ficuciello
1	"Linear regression in PyTorch" and "Convolutional Neural Networks". Part of the Webinar series on Deep Learning for CINI AIIS Labs.	0.4	Prof. Giuseppe Fiameni	NVIDIA	ITEE

1	"Efficient Data Loading with DALI" and "Mixed Precision Training using Apex".	0.2	Prof. Giuseppe Fiameni	NVIDIA	ITEE
1	"Multi-GPU Training using Horovod" , "Deploying Models with TensorRT" and "Profiling with NVTX". Part of the Webinar series on Deep Learning for CINI AIIS Labs.	0.4	Prof. Giuseppe Fiameni	NVIDIA	ITEE
2	Robot Manipulation and Control	0.5	Prof. Bruno Siciliano	University Federico II	University of Pisa
2	Antonio Picariello Lectures on DataScience, "Digital Project Management: Practices, processes, techniques, tools and scientific Approach"	0.2	Prof. Dario Caroten uto	University Federico II	University Federico II
2	L'esperienza del progetto di teleriabilitazione NEUROREAB	0.6	Ing. D. Furno e Ing. L. Romanelli	University Federico II	University Federico II
2	Antonio Picariello Lectures on DataScience, "#andràtuttobene: Images, Texts, Emojis & Geo-data in aSentiment Analysis Pipeline"	0.3	Prof. Serena Pelosi	University of Salerno	University Federico II
2	IEEE Webinar "Patent Searching best practices with IEEE Xplore"	0.2			IEEE
	Antonio Picariello Lectures on Data Science, "At the Nexus of Big Data, Machine Intelligence, and Human Cognition"	0.2	Prof. George S. Djorgov ski	CALTECH	University Federico II
	Scientific Colloquia at SSM, Network Systems, Kuramoto	0.3	Prof. Francesco Bullo	UC Santa Barbara	Scuola Superiore Meridionale

	Oscillators, and Synchronous Power Flow				
	Antonio Picariello Lectures on Data Science, "Exploiting Deep Learning and Probabilistic Modeling for Behavior Analytics"	0.2	Prof. Giuseppe Manco	ICAR-CNR	University Federico II
	Antonio Picariello Lectures on Data Science, "Data driven transformation in WINDTRE through Managers voice"	0.4	Marcello Savarese	WINDTRE	University Federico II
	Antonio Picariello Lectures on DataScience, "From Photometric Redshifts to Improved Weather Forecasts, an interdisciplinary view on machine learning	0.2	Prof. Kai Polsterer	University of Haideberg	University Federico II
	Antonio Picariello Lectures on DataScience, "Cybercrime and evidence: the criminal justice response"	0.4	Matteo Lucchetti	C-PROC	University Federico II
	Antonio Picariello Lectures on Data Science, "AI: Artificial Intelligence for notary's sector - a case study"	0.2	Salvatore Palange	Fuel Innovation for Business	University Federico II
	"Advances in Machine Learning for Modelling and Understanding in Earth Sciences"	0.2	Prof. Gustau Camps-Valls	Universitat de València	University Federico II
	"IFRR Colloquium on Quadruped	0.4	Marco Hutter,	ETH Zurich, MIT, IIT	International

	Robotics", http://ifrr.org/quadruped-robotics		Sangbae Kim, Claudio Semini		Foundation of Robotics Research
	Antonio Picariello Lectures on Data Science, "Machine Learning: causality lost in translation"	0.3	Prof. Edwin E Valentjin	University of Groningen	University Federico II
	Antonio Picariello Lectures on Data Science, "Approaches to Graph Machine Learning"	0.2	Miroslav Cepek	Oracle Labs	University Federico II
	Antonio Picariello Lectures on DataScience, "Visual Interaction and Communication in Data Science"	0.4	Marco Quartulli	Vicomtech	University Federico II
	Robo Ludens: A game design taxonomy for human robot interaction	0.2	Prof. Silvia Rossi	University Federico II	University Federico II
	Antonio Picariello Lectures on DataScience, "Big Data and Computational Linguistics"	0.4	Francesco Cotugno	University Federico II	University Federico II
	Artificial Intelligence and 5G combined with holographic technology: a new perspective for remote health monitoring	0.4	Dr, Pietro Ferraro, Dr. Pasquale Mammolo	Telco	University Federico II
	Introduction to Underwater Robotics	0.4	Prof. Gianluca Antonelli	University of Cassino	University Federico II
	Introduction to legged robots and examples of IIT's Dynamic Legged Systems Lab	0.4	Claudio Semini	IIT	University Federico II

Research activities

Viviana Morlando's research has been mainly focused on the problem of the robust locomotion of limbed robots. Her research can be divided in three activities:

First activity: involved the development of a whole-body controller based on the decoupling of the centroidal's dynamics (the dynamics of the center of mass) from the legs' ones. This research brought to the development of two different observers. The first one is a momentum-based observer that takes into account also the disturbances acting on legs that are still swinging, so that the robot is able to work under challenging conditions such as in difficult atmosphere situations or in narrow spaces where it is easy to have a collision between a leg that is still moving and the environment. The second observer is a new hybrid observer dealing with disturbances acting both on the center of mass and on the legs. The resulting control architecture is thus different from existing approaches, which can guarantee either the CoM's tracking or the drift's rejection only.

Second activity: focused on the nonprehensile transportation with a legged manipulator. Regarding this aspect, the research has been focused on developing an optimization-based whole-body control architecture for a legged robot transporting an object on a tray in a nonprehensile configuration. The proposed controller takes into account both nonprehensile manipulation and locomotion constraints in a unified and principled way.

Third activity: involved the development of a model predictive controller for a cable-driven parallel robot, with the main goal to attenuate vibrations and oscillatory movements given by the flexibility of the cables. The controller has been tested and validated on the "Floating base robot" in the Robotic System Lab of ETH Zurich.

Tutoring and supplementary teaching activities

Viviana Morlando tutored 3 BSc students of Automation Engineering and 2 MSc students of Automation and Robotics Engineering for their Thesis

Credits summary

PhD Year	Courses	Seminars	Research	Tutoring / Supplementary Teaching
1st	24	4.8	34.2	63
2nd	11	7	44	62
3rd	0	0	60	60

Research periods in institutions abroad and/or in companies

PhD Year	Institution / Company	Hosting tutor	Period	Activities
3	Italian institute of technology	Claudio Semini, Head of the Dynamic Legged System Lab	15/11/2021-31/01/2022	Research on a disturbance observer for a legged manipulator
3	ETH Zurich	Prof. Marco Hutter, Robotic System Lab	01/04/2022-30/09/2022	Realization of a model predictive controller for cable-driven parallel robots

PhD Thesis

Title: Disturbance rejection in optimal control for limbed parallel robots

Despite the great recent developments in robust control and disturbance rejection with the goal of integrating robots in real-life situations and unstructured environments, robots are still mostly confined in industrial or research scenarios.

Some simple mobile robots, usually wheeled ones, are starting to be introduced as commercial products to act in human environments, such as robotics vacuum. Nevertheless, other kinds of robots are still struggling to find their space in real life given their intrinsic instability and since there are still a lot of challenges for obtaining stable and safe control.

For this reason, the thesis is framed in the field of robust control and disturbance rejection. With the main objective of realising control architectures that improve the stability and the safeness of robotic systems, the work of the thesis focuses on the robust control of the limbed parallel robots. The thesis can be divided into two main sections:

- **Quadruped robots**: the legged robots are highly unstable, and, in some cases, even a little external disturbance, such as hitting the ground, can cause their fall. For this reason, different solutions have been realized, like disturbance observers and model predictive controllers. This thesis focuses of disturbance observer-based control. It will be first presented a novel momentum-based observer that can deal with disturbances applied both to swing and stance legs, differently from existing approaches that usually consider only disturbances acting on the CoM. Then, an extension is developed, realizing a novel hybrid observer that integrates the previous estimation on the legs with a double observer on the CoM. In this way, all kinds of disturbances acting on the robot are taken into account and compensated. Robust control and a disturbance rejection allow the robots to start making their way into the real-life environment and tasks, especially for the safety of the humans working in the same environment. For this reason, the natural evolution of this work has been an application in real life for a human-robot interaction task, useful in the field of care assistance.
- **Cable-driven parallel robots (CDPR)**: Substituting cables for rigid links introduces inevitable challenges for the control of CDPRs, because of their flexibility, which causes a lot of vibrations during the motion. Usually, a desired wrench is computed and

commanded for the robot's movement. However, minimum and maximum cable tension limits play a crucial role since the cables must not become slack. Nevertheless, the proposed control strategies are often not able to handle these constraints within the motion controller. These constraints are usually handled in a cable tension distribution algorithm, which acts only after the desired wrench is computed by the controller. Consequently, if the computed desired wrench is unfeasible with the cable tension limits, the controller will not be able to realize the movement. To overcome this problem, model predictive control started to be used. However, only MPC able to work with fully and redundantly constrained CDPRs have been proposed. In this thesis, an MPC for underconstrained CDPR is presented. The use of this controller, taking into consideration the tension limits, allows the robot to approach the equilibrium point in a smooth and safe way, attenuating the
oscillatory movements caused by the cables' flexibility. The results are compared with the use of other optimization controllers that, not taking into account the cable tension, causes a lot of vibrations.

Publications

Research results appear in *1* paper published in international journals and 1 paper submitted, *2* contributions to international conferences and 2 contribution currently under review, *1* contribution to national conferences.

List of scientific publications

International journal papers

Viviana Morlando, Ainoor Teimoorzadeh, Fabio Ruggiero
"Whole-body control with disturbance rejection through a momentum-based observer for quadruped robots",
Mechanism and Machine Theory,
vol. 164 , pp. 104412, 2021, DOI: https://doi.org/10.1016/j.mechmachtheory.2021.104412

International conference papers

Viviana Morlando, Mario Selvaggio, Fabio Ruggiero
"Nonprehensile Object Transportation with a Legged Manipulator",
2022 International Conference on Robotics and Automation (ICRA),
Philadelphia, Pennsylvania, May 2022, pp. 6628-6634, IEEE, DOI: 10.1109/ICRA46639.2022.9811810

Viviana Morlando, Fabio Ruggiero
"Disturbance rejection for legged robots through a hybrid observer",
2022 30th Mediterranean Conference on Control and Automation (MED)
Athens, Greece, June 2022, pp. 743-748, IEEE, DOI: 10.1109/MED54222.2022.9837169

National conference papers

Viviana Morlando , Mario Selvaggio, Fabio Ruggiero
"Robotic Non-prehensile Object Transportation",
Conferenza I-RIM 3D 2022, 4 Conferenza Italiana di Robotica e Macchine Intelligenti
Roma, Italia, Oct. 2022

Papers under review

Viviana Morlando, Fabio Ruggiero

"Tethering a Human with a Quadruped Robot: A Guide Dog to Help Visually Impaired People",

Submitted to 2023 IEEE International Conference on Robotics and Automation,

 London, United Kingdom, 2023

Viviana Morlando, Gianluca Neglia, Fabio Ruggiero,

"Drilling task with a quadruped robot for silage face measurements,"

Submitted to the 2023 IEEE International Workshop on Measurements and Applications in Veterinary and Animal Sciences, Naples, Italy, 2023

Viviana Morlando, Till Karbacher, Salman Faraji, Marco Hutter

"An MPC framework for an underconstrained floating cable-driven robot"

Submitted to "Robotics and Automation Letters"

Date 15/01/2023 _____

PhD student signature _____

Supervisor signature _____