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

PhD Student: Eros Ciccarelli

Cycle: XXXIX

Training and Research Activities Report

Academic year: 2024-25 - PhD Year: Second

Tutor: Prof. Amedeo Capozzoli

Co-Tutor:
Prof. Ana Arboleya Arboleya
Prof. Claudio Curcio
Prof. Angelo Liseno
Prof. Manuel Sierra Castañer

Date: October 31, 2025

1. Information:

- **PhD student: Eros Ciccarelli** **PhD Cycle: XXXIX**
- **DR number: DR997200**
- **Date of birth: 15/06/1999**
- **Master Science degree: Electronic Engineering** **University: Università degli Studi di Napoli Federico II**
- **Scholarship type: PNRR Partenariato Esteso PE14, "RESTART – RESearch and innovation on future Telecommunications systems and networks, to make Italy more smART"**
- **Tutor: Prof. Amedeo Capozzoli**
- **Co-tutor: Prof. Ana Arboleya Arboleya, Prof. Claudio Curcio, Prof. Angelo Liseno, Prof. Manuel Sierra Castañer**
- **Period abroad: Universidad Politécnica de Madrid, from 06/09/2024 to 25/10/2024 and from 01/11/2024 to 30/12/2024.**

2. Study and training activities:

Activity	Type[1]	Hours	Credits	Dates	Organizer	Certificate[2]
Analisi Funzionale	Course	48	6	20/06//2025	Dipartimento di Matematica e Applicazioni "Renato Caccioppoli"	Y
Cooperative and Non Cooperative Localization System	Course	14	3	27/06/2025	Dr. Massimo Rosamilia	Y
Antenna Synthesis	Course	40	3	01/09/2025 – 05/09/2025	Profs. Amedeo Capozzoli, Claudio Curcio, Angelo Liseno European School of Antennas (ESoA)	Y
Robot Autonomy	Seminar	1	0.2	15/04/2025	Prof. Fabio	Y

among Decision-Making Agents					Ruggiero	
Multibeam Antennas	Seminar	2	0.4	15/04/2025	Prof. Claudio Curcio	Y
Safety of Highly Automated Driving Systems	Seminar	1	0.2	23/04/2025	Prof. Marcello Cinque	Y
Multi-Neighborhood Search for Combinatorial Optimization	Seminar	1	0.2	05/05/2025	Profs. Claudio Sterle, Maurizio Boccia, Adriano Masone	Y
How complex is to schedule the Italian Serie A? Problems and methods in sports timetabling	Seminar	2	0.4	15/05/2025	Profs. Claudio Sterle, Maurizio Boccia, Adriano Masone	Y
PhD Survival Strategies	Seminar	1.5	0.3	30/05/2025	Dr. Pietro Liguori	Y
Superconducting Radio Frequency Cavities for Quantum Computing and Communication	Seminar	1	0.2	24/06/2025	Prof. Edoardo Giusto	Y
Trusted Execution Environments for QPUs	Seminar	1	0.2	27/06/2025	Prof. Edoardo Giusto	Y
RESTART Plenary Dissemination Workshop	Seminar	11.5	2.3	30/06/2025 – 02/07/2025	RESTART	Y
Near-Field Meta-Steering: a Low-Profile Method for Complete Steering of the Beam of Any Fixed-Beam Antenna	Seminar	2	0.4	17/09/2025	Prof. Antonio Iodice	Y
Argumentation-Based Reasoning	Seminar	2	0.4	29/09/2025	Profs. Carlo	Y

Frameworks for Public Interest Communication in Healthcare					Sansone, Elio Masciari	
Estimations of Unimodular Signal Waveform and Uncertain Receive Signal Steering Vector for Robust Optimal Receive Beamforming Design	Seminar	1	0.2	02/10/2025	Prof. Massimo Rosamilia	Y
Optimization in Transportation and Logistics	Seminar	1	0.2	16/10/2025	Profs. Claudio Sterle, Maurizio Boccia, Adriano Masone	Y
Local Explainability in Machine Learning: A collective framework	Seminar	1	0.2	16/10/2025	Profs. Claudio Sterle, Maurizio Boccia, Adriano Masone	Y
Radar Cross-Section Estimation and Measurements	Seminar	4	0.8	17/10/2025	Profs. Amedeo Capozzoli, Claudio Curcio, Angelo Liseno	Y
Guardians or Threats? AI at the Frontlines of Cybersecurity	Seminar	4	0.8	17/10/2025	Prof. Antonia Maria Tulino	Y
AI Powered User Interface Design	Seminar	4	0.8	24/10/2025	Prof. Antonia Maria Tulino	Y

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	8	0	8
Bimonth 2	0	0	8	0	8
Bimonth 3	0	0.8	9	0	9.8
Bimonth 4	9	1.3	5	0	15.3
Bimonth 5	0	2.3	9	0	11.3
Bimonth 6	3	3.8	6	0	12.8
Total	12	8.2	45	0	65.2
Expected	30 - 70	10 - 30	80 - 140	0 – 4.8	

3. Research activity:

The research activity carried out focused on advanced techniques and methodologies for testing high-performance Reconfigurable Intelligent Surfaces (RIS'). In particular, the analysis of each possible RIS configurations needs the repeated execution of measurement processes of the scattered fields and evaluate the meeting of the specifications. This makes the time of each measurement process critical. RIS have recently gained increasing interest thanks to their properties of flexibility which make the parameters suitable in highly dynamic and complex environments where they can be illuminated by a vast range of waveforms with nontrivial temporal and spatial profiles. For this reason, the need to characterize RIS for all possible incident fields, which requires the ability to generate incident fields within anechoic chambers, arises. Flexible systems capable of generating complex waveforms in both spatial and temporal domains becomes mandatory. These can be implemented through antenna arrays combined with advanced measurement systems, such as probe-arrays and positioning systems based on robotic arms. Indeed, such setups allow to reduce the number of the mechanical points wherein the probe is positioned to acquire the electromagnetic field of interest and to optimize the positions of such points.
The second year of the Ph.D. ITEE programme focused on these two possibilities.
Regarding the first possibility, thanks to the collaboration with Universidad Politècnica de Madrid (UPM) and Universidad Rey Juan Carlos (URJC), which have advanced measurement systems based on probe-arrays and a positioning system based on robotic arms, a Singular Value Optimization (SVO) approach has been developed to minimize the number of sampling points in Near-Field measurements (planar scanning and aperture antennas) required to determine the Far-Field Pattern (FFP) of the Antenna Under Test (AUT). Specifically, it allows to improve the efficiency and the effectiveness of the analysis process bringing out a better conditioning of the problem, which has been treated as an inverse problem. The implemented SVO algorithm exploits the Non-Uniform Fast Fourier Transform Non-Equispaced Results (NUFFT – NER Type), an analytical evaluation of the gradient of the objective functional considered and the compensation for probe effects in planar Near-Field measurements. These allow, at the same time, to evaluate an accurate optimum solution for the problem, improve the robustness of the optimization algorithm with respect to ill-conditioning problems and numerical instability, and reduce the computational burden and, so, the time required for the optimization. The approach has been validated for the case of a single probe through an exhaustive numerical analysis accounting for different types of AUTs, linearly o circularly polarized. The FFP predictions from simulated Near-Field data evaluated on the optimized grid were compared with the simulated FFP of the

AUTs, as well as with FFP predictions obtained from standard half-wavelength sampling grids. The simulations were carried out with the commercial electromagnetic software Altair FEKO. A further experimental validation of the algorithm has been carried out with the UPM and the URJC for the case of commercial linearly polarized single-probe and AUT using the robotic arm to move the probe to the sampling points on the Near-Field acquisition plane. The results have been compared with the experimental data obtained with a standard half-wavelength Near-Field measurement and have been considered satisfactory and promising for future use with probe-arrays.
On the other hand, regarding the second possibility, a further improvement has been made to the approach for the synthesis space-time complex waveforms generator. This approach consists of a mixed numerical-analytical methodology for the synthesis of a continuous planar equivalent source, formulated as a scalar problem under a two-dimensional geometry assumption. An experimental validation has been made in the anechoic chamber of the Microwave and Millimeter Waves Laboratory at the Dipartimento di Ingegneria Elettrica e delle Tecnologie dell'Informazione (DIETI), where the equivalent radiator has been implemented in a virtual fashion using an open-ended waveguide as the radiating element. Moreover, a linear chirp modulation has been numerically synthesized on the data collected in the anechoic chamber and an equalization of the frequency response of both the receiving system under test and radiating element has been performed. The experimental results are consistent with their numerical versions implemented in MATLAB and have been considered satisfactory for typical applications of canonical waveform generators for antenna testing.

4. Research products:

Conference Paper:
Title: Vector Spheroidal Harmonics to Modelling Radiation/Scattering from Oblong Objects,
Authors: E. Ciccarelli, F. Bevilacqua, A. Capozzoli, C. Curcio, A. Liseno,
Status: published,
Conference name: 46th Annual Meeting and Symposium of the Antenna Measurement Techniques Association (AMTA), in Cincinnati (Ohio, US), 27/10/2024 – 01/11/2024.

5. Conferences and seminars attended

Participation as speaker at the 46th Annual Meeting and Symposium of the Antenna Measurement Techniques Association (AMTA), in Cincinnati (Ohio, US), 27/10/2024 – 01/11/2024.
Presented work: Vector Spheroidal Harmonics to Modelling Radiation/Scattering from Oblong Objects.

6. Periods abroad and/or in international research institutions

The period abroad ranges from 06/09/2024 to 30/12/2024, at the Universidad Politécnica de Madrid (UPM), in Madrid (Spain), in cooperation with the Universidad Rey Juan Carlos (URJC) in Madrid under the supervision of Professor Manuel Sierra Castañer from UPM and Professor Ana Arboleya Arboleya from URJC.
The research activities consisted of the development, on Graphics Processing Units (GPUs), of SVO approaches for the optimized characterization of large planar radiators/scatterers by using probe arrays and robotic arms. Then in further improvements based on the individuation of a more fitting model for the radiating operator, an analytical evaluation of the radiating operator, the implementation of the compensation of the probe's effects on planar Near-Field measurements, and the usage of a constrained local optimization algorithm.

In the academic year 2023-2024, the first of the ITEE PhD Program, a total of 50 days are spent in the Universidad Politécnica de Madrid: from 06/09/2024 to 25/10/2024.
In the academic year 2024-2025, the second of the ITEE PhD Program, a total of 60 days are spent in the Universidad Politécnica de Madrid: from 01/11/2024 to 30/12/2024.

7. Tutorship

8. Plan for year three

During the third year of the Ph.D. program, we will continue the research activity in collaboration with the UPM and URJC, looking for an experimental validation of the SVO algorithm considering a multi-probe system as acquisition device, and apply an efficient and effective representation of the electromagnetic field based on Vector Prolate Spheroidal Wave Functions (V-PSWFs), which has been carried out during the previous Academic Year, to near-field measurements of the electromagnetic field radiated by an oblong-shaped antenna to further validate the approach.