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

**PhD Student: Maria Cacciapuoti**

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**Cycle: XL**

**Training and Research Activities Report**

**Year: First**

*Maria Cacciapuoti*

**Tutor: prof. Leopoldo Angrisani**

**Co-Tutor: prof. Egidio De Benedetto**

**Date: October 20, 2025**

# Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

Cycle: 40

Author: Maria Cacciapuoti

## 1. Information:

- **PhD student:** Maria Cacciapuoti
- **DR number:** DR999873
- **Date of birth:** 03/06/1999
- **Master Science degree:** Biomedical Engineering  
**University:** University of Naples Federico II
- **Doctoral Cycle:** XL
- **Scholarship type:** UNINA
- **Tutor:** prof. Leopoldo Angrisani
- **Co-tutor:** prof. Egidio De Benedetto

## 2. Study and training activities:

Activity	Type <sup>1</sup>	Hours	Credits	Dates	Organizer	Certificate <sup>2</sup>
How to boost your PhD	Course	18	5	8-15-22- 29/01/202 5 5- 12/02/202 5	Antigone Marino	Y
Using Deep Learning properly	Course	12	4	3-6-10- 14-17- 19/02/202 5	Andrea Apicella	Y
Round Table “Imprenditorialità e proprietà intellettuale”,	Seminar	2	0.4	06/02/202 5	Flavio Farroni, Lorenzo Rossi, Fabrizio Dughiero, Sonia Leva	Y
Optimization-Based Control of Flexible Resources in Sustainable Energy Networks	Seminar	1	0.2	05/02/202 5	Alessandra Parisio	Y
Can we Rely on AI? Reliability Issues in Artificial Neural Networks and Potential Solutions for Autonomous Vehicles	Seminar	1	0.2	16/01/202 5	Paolo Rech	Y
Methodologies and Tools for Conducting	Course	12	3	28- 29/04/202	Domenico	Y

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SLRs and SMSs				5 - 05-06-09-12-14/05/2025	Amalfitano.	
BCI & NEUROTECHNOLOGY SPRING SCHOOL 2025, "CUTTING EDGE BCI APPLICATIONS", "INVASIVE AND NON-INVASIVE BCI APPLICATIONS"	Seminar	25	5	01-02/05/2025	g.tec medical engineering	Y
Introduction to Python	Course	12	2.4	14-16-21-23-28-30/01/2025	Scuola Superiore Meridionale, Marco Coraggio e Davide Salzano	Y
Horizons Exploring 5G-6G Innovations	Seminar	3	0.6	30/04/2025	Sameh Yamany, Ali Khayrallah, Anwer Al-Dulaimi	Y
Authorship and Open Access Symposium Tips and Best Practices to Get Published from IEEE Editors	Seminar	1h and 30 min	0.3	30/04/2025	Giovanni Ghione, Eszter Lukács, Judy Brady	Y
The complexity paradigm: design principles of the digital twin in healthcare	Course	8	2	From 01/07/2025 To 09/07/2025	Annarita Tedesco	Y
IX National Forum on Measurement	Seminar	15	3	10-12/09/2025	National Congress on Electrical and	Y

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					Electronic Measurement	
Practical Network Intrusion Detection with Machine Learning and Generative AI	Course	11	4	1-2-7-8-9/10/2025	Giampaolo Bovenzi	Y
Basic LabVIEW with cDAQ HandsOn and Fundamentals of Data Acquisition and Synchronisation	Course	9	2	09/2025	Measure_it - Jacopo Giorgi	Y
IEEE International Conference MetroXRAINE  (about to start at the time of this 1 <sup>st</sup> year report)	Seminar	25	3	22-24/10/2025	Pasquale Arpaia	Y
Regolamento sull'intelligenza artificiale e protezione del lavoratore	Course	12	4	1) 30/09/2024 03-10-28/10/2024	Giuseppe Gentile Lucia D'Arcangelo Marco Biasi Marco Peruzzi	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			5		5
Bimonth 2	9	0.8	5		14.8
Bimonth 3	3	5	5		13
Bimonth 4	2.4	0.9	5		8.3
Bimonth 5	2		6		8
Bimonth 6	10	3	6		19
<b>Total</b>	<b>26,4</b>	<b>9,7</b>	<b>32</b>		<b>68,1</b>
<b>Expected</b>	<b>30 - 70</b>	<b>10 - 30</b>	<b>80 - 140</b>	<b>0 - 4.8</b>	

### 3. Research activity:

During the first year of my PhD, my research activity has been mainly focused on two interconnected lines:

- **EEG and Early Alzheimer's Detection**

This main research line focuses on the early diagnosis of Alzheimer's disease, with particular attention to Mild Cognitive Impairment (MCI), a critical intermediate stage in cognitive decline. The goal is to identify robust and interpretable EEG-based biomarkers by integrating: advanced EEG signal preprocessing, nonlinear and complexity analyses, and metrological validation to ensure traceability and reproducibility.

The methodology systematically evaluates how preprocessing techniques influence the stability and comparability of EEG complexity measures, introduces new metrics that integrate temporal, spatial, and frequency dynamics, and verifies their reproducibility across datasets and acquisition conditions. The results obtained so far demonstrate that amplitude normalization and proper preprocessing significantly enhance the reliability and consistency of EEG-derived biomarkers, supporting the vision of developing a digital twin of the brain for early cognitive assessment.

- **Metrology and Artificial Intelligence.**

This emerging research line explores the integration of metrological principles into Artificial Intelligence systems, aiming to make AI a trustworthy, measurable, and reproducible scientific tool. The objective is to establish rigorous metrology-based methodologies to assess the reliability, traceability, and uncertainty of AI models, particularly in biomedical and human-centered applications.

This activity has been recently strengthened through the IEEE Instrumentation and Measurement Society Graduate Fellowship Award, which supports the development of this line and its future experimental advancements.

### 4. Research products:

The research activity carried out during the first year resulted in several scientific outputs:

#### Journal papers

1. Arpaia, P., **Cacciapuoti, M.**, Cataldo, A., Criscuolo, S., De Benedetto, E., Masciullo, A., ... & Schiavoni, R. (2024). Improving Multiscale Fuzzy Entropy Robustness in EEG-Based Alzheimer's Disease Detection via Amplitude Transformation. *Sensors*, 24(23), 7794.
2. Arpaia, P., **Cacciapuoti, M.**, Cataldo, A., Criscuolo, S., De Benedetto, E., Masciullo, A., ... & Schiavoni, R. (2025). Assessing the Role of EEG Biosignal Preprocessing to Enhance Multiscale Fuzzy Entropy in Alzheimer's Disease Detection. *Biosensors*, 15(6), 374.
3. Arpaia, P., **Cacciapuoti, M.**, Cataldo, A., Criscuolo, S., De Benedetto, E., Masciullo, A., ... & Tedesco, A. (2025). A Novel Entropy Metric for Unified Analysis of Temporal, Spatial, and Spectral EEG Properties. *IEEE Transactions on Biomedical Engineering*.

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## Conference papers

1. Arpaia, P., **Cacciapuoti, M.**, Cataldo, A., Criscuolo, S., De Benedetto, E., Masciullo, A., ... & Schiavoni, R. (2024, October). Comparison of EEG Preprocessing Techniques for Complexity Measures in Alzheimer's Disease Detection. In 2024 IEEE International Conference on Metrology for eXtended Reality, Artificial Intelligence and Neural Engineering (MetroXRINE) (pp. 1183-1188). IEEE.
2. Arpaia, P., **Cacciapuoti, M.**, Criscuolo, O., Criscuolo, S., De Benedetto, E., Masciullo, A., Pesola, M., Schiavoni, R., & Tedesco, A. (2025, October). A Preliminary Study on Band-Specific Multivariate Multiscale Fuzzy Entropy of EEG in Mild Cognitive Impairment. In 2025 IEEE International Conference on Metrology for eXtended Reality, Artificial Intelligence and Neural Engineering (MetroXRINE) — *accepted for presentation*.
3. Arpaia, P., **Cacciapuoti, M.**, Cataldo, A., Criscuolo, O., Criscuolo, S., Masciullo, A., Pesola, M., Schiavoni, R., & Tedesco, A. (2025, October). EEG Complexity Measures and Their Applications in Alzheimer's Disease Detection. In 2025 IEEE International Conference on Metrology for eXtended Reality, Artificial Intelligence and Neural Engineering (MetroXRINE) — *accepted for presentation*.

## 5. Conferences and seminars attended

- **IEEE International Conference on Metrology for eXtended Reality, Artificial Intelligence and Neural Engineering (MetroXRINE 2025)**, Ancona, Italy, 22–24 October 2025.  
Speaker – Presented the paper “A Preliminary Study on Band-Specific Multivariate Multiscale Fuzzy Entropy of EEG in Mild Cognitive Impairment.”
- **IX National Forum on Measurement, which included the 42nd National Congress on Electrical and Electronic Measurement and the 33rd National Congress on Mechanical and Thermal Measurement**, University of Naples Federico II – School of Engineering and Basic Sciences, Naples, Italy, 10–12 September 2025.  
Participant – Attended technical sessions related to metrology, AI applications, and biomedical measurement.
- **IEEE International Instrumentation and Measurement Technology Conference (I2MTC 2025)**, Chemnitz, Germany, 19–22 May 2025.  
Participant – Attended the conference to receive the IEEE Instrumentation and Measurement Society Graduate Fellowship Award.