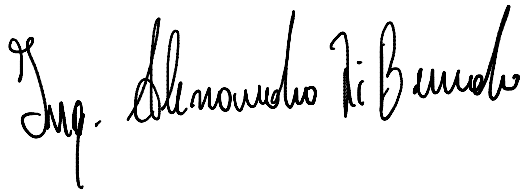
**PhD in Information Technology and Electrical Engineering**
**Università degli Studi di Napoli Federico II**

# PhD Student: Alessandro Di Bernardo

**Cycle: XXXVII**

## Training and Research Activities Report

## Year: First



**Tutor: prof. Leopoldo Angrisani**

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

**Date: October 31, 2022**

# Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

**Cycle:** XXXVII **Author: Alessandro Di Bernardo**

## 1. Information:

- **PhD student:** Alessandro Di Bernardo
- **DR number:** 995867
- **Date of birth:** 03/03/1996
- **Master Science degree:** Biomedical Engineering (bionic and biorobotic field)
  **University:** Università degli Studi di Napoli Federico II
- **Doctoral Cycle:** XXXVII
- **Scholarship type:** no scolarship
- **Tutor: prof.** Leopoldo Angrisani
- **Co-tutor: prof.** Egidio De Benedetto

## 2. Study and training activities:

| Activity | Type[1] | Hours | Credits | Dates | Organizer | Certificate[2] |
|---|---|---|---|---|---|---|
| Designing quantum algorithms | Seminar | 2 | 0.4 | 16/12/2021 | Prof. Michele Amoretti | Y |
| The spatial structure of bi-photon states | Seminar | 1 | 0.2 | 11/01/2022 | Prof. Alessio D'Errico | Y |
| The learning landscape in deep neural networks and its exploitation by learning algorithms | Seminar | 1 | 0.2 | 21/01/2022 | Prof. Michele Ceccarelli | Y |
| Systems biology as a compass to understand tumor-immune interactions in humans | Seminar | 1 | 0.2 | 02/02/2022 | Prof. Michele Ceccarelli | Y |
| Computational analysis of cancer genomes | Seminar | 1.5 | 0.3 | 16/02/2022 | Prof. Michele Ceccarelli | Y |
| Seeqc: the digital quantum computing company | Seminar | 1 | 0.2 | 24/02/2022 | Marco Arzeo | Y |
| 'Project v? C: can a text-to-speech engine generate human sentiments' | Seminar | 1 | 0.2 | 28/02/2022 | Prof. Simon Pietro Romano | N |
| Virtualization technologies and their applications | Course | 20 | 5 | 04/03/2022 | Luigi De Simone | Y |
| Bench to bytes to bedside: converting genomic data into | Seminar | 1 | 0.2 | 04/03/2022 | Prof. Michele Ceccarelli | Y |

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| healthcare tools | | | | | | |
| Dissecting glioblastoma by single cell rna-seq | Seminar | 1 | 0.2 | 11/03/2022 | Prof. Michele Ceccarelli | Y |
| Quantum measurement and control of mechanical motion at room temperature | Seminar | 1 | 0.2 | 29/03/2022 | Filippo Cardano | Y |
| Ethics and politcs of A.I. | Seminar | 1 | 0.2 | 11/04/2022 | Lorenzo De Stefano | N |
| An introduction to deep learning for natural language processing | Seminar | 1 | 0.2 | 13/04/2022 | Francesco Cotugno | Y |
| Explainable natural language inference | Seminar | 1 | 0.2 | 13/04/2022 | Francesco Cotugno | Y |
| Service and companion robots in healthcare | Seminar | 1.5 | 0.3 | 21/04/2022 | Prof. Pasquale Arpaia | Y |
| Towards AI-Driven Cancer Precision Medicine | Seminar | 1 | 0.2 | 22/04/2022 | Prof. Michele Ceccarelli | Y |
| Population and medical genomics applications to human traits and diseases | Seminar | 1 | 0.2 | 29/04/2022 | Prof. Michele Ceccarelli | Y |
| Designing synthetic circuits with sensing with sensing properties and robust expression in mammalian cells | Seminar | 1.5 | 0.3 | 11/05/2022 | Prof. Michele Ceccarelli | Y |
| Reference standards for next generation sequencing assay on cytological samples: A worldwide ring trial study | Seminar | 1.5 | 0.3 | 12/05/2022 | Prof. Pasquale Arpaia | Y |
| Driving precision medicine and drug discovery using systems biology approaches | Seminar | 1.5 | 0.3 | 18/05/2022 | Prof. Michele Ceccarelli | Y |
| Brain Computer Interface: extracting information from EEG signals | Seminar | 1.5 | 0.3 | 18/05/2022 | Prof. Roberto Prevete | Y |
| Statistical data analysis for science and | Course | 12 | 4 | 24/05/2022 | Prof. Roberto | Y |

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| engineering research | | | | | Pietrantuono | |
| Orizzonti quantistici per l'industria | Seminar | 6 | 1.2 | 26/05/2022 | Alessandro Zavatta, QTI | Y |
| Towards Sustainable IT | Seminar | 2 | 0.4 | 27/05/2022 | Prof. Antonia Maria Tulino | Y |
| Vine robots: design challenges and unique opportunities | Seminar | 1 | 0.2 | 31/05/2022 | Mario Selvaggio | Y |
| Thermoacoustics for renewable energies | Seminar | 1 | 0.2 | 1/06/2022 | Prof. Pasquale Arpaia | Y |
| Switched differential algebraic equations: jumps and impulses | Seminar | 1.5 | 0.3 | 1/06/2022 | Raffaele Iervolino | Y |
| Variable IO latencies in real life | Seminar | 2 | 0.4 | 9/06/2022 | Prof. Marcello Cinque | Y |
| Wireless collaborative intelligent with goal-oriented communications | Seminar | 2 | 0.4 | 10/06/2022 | Prof. Antonia Maria Tulino | Y |
| Accelerating target identification and drug discovery through the power of high scale human genetics | Seminar | 1.5 | 0.3 | 20/06/2022 | Prof. Michele Ceccarelli | Y |
| Robotic assistance: pros and cons of a new technology | Seminar | 1.5 | 0.3 | 23/06/2022 | Prof. Pasquale Arpaia | Y |
| Lezione 2 corso imprenditorialità accademica | Seminar | 2 | 0.4 | 13/06/2022 | Prof. Pierluigi Rippa | Y |
| Introduction to Intellectual Property management | Seminar | 2 | 0.4 | 19/07/2022 | Prof. Antonia Maria Tulino | Y |
| WHERE DO WE GO FROM HERE? Some useful tips to understand what's around your business idea | Seminar | 2 | 0.4 | 19/07/2022 | Prof. Antonia Maria Tulino | Y |
| Data science for patient records analysis | Course | 10 | 3 | 28/07/2022 | Prof. Marcello | Y |

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| | | | | | Cinque | |
| Neural Network and deep learning | Course | 42 | 6 | 27/10/2022 | Prof. Roberto Prevete | Y |
| Metrology and Machine Learning for Brain Computer Interfaces | Course | 14 | 3 | 19/10/2022 | Prof. Pasquale Arpaia | 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 | 0.4 | 6 | 0 | 6.4 |
| Bimonth 2 | 0 | 1.3 | 7 | 0 | 8.3 |
| Bimonth 3 | 5 | 1.9 | 7 | 0 | 13.9 |
| Bimonth 4 | 4 | 4.9 | 7 | 0 | 15.9 |
| Bimonth 5 | 3 | 1.2 | 4 | 0 | 8.2 |
| Bimonth 6 | 9 | 0 | 4 | 0 | 13 |
| **Total** | 21 | 9.7 | 35 | 0 | 65.7 |
| **Expected** | **20 - 40** | **5 - 10** | **10 - 35** | **0 – 1.6** | |

## 3. Research activity:

The research activity was focused on *Quantum Technology (QT)* and, in particular, on how this technology can be applied to Measurement.
Quantum technology is a technology which results from the concepts of quantum mechanics based on the quantum of light. This technologies thanks to two quantum properties, such as superposition and entanglement. The field comprises four domains: quantum communication, where individual or entangled photons are used to transmit data in a provably secure way; quantum simulation, where well-controlled quantum systems are used to reproduce the behavior of other, less accessible quantum systems; quantum computation, which employs quantum effects to dramatically speed up certain calculations, such as number factoring; and quantum sensing and metrology, where the high sensitivity of coherent quantum systems to external perturbations is exploited to enhance the performance of measurements of physical quantities. [1]
So the first step of the research was an in-depth study of the literature related to QT. Research in the field of QT is steadily advancing with applications that extend to several different fields, such as:
- quantum computing
- quantum sensing
- quantum machine learning (QML)
- quantum metrology
- quantum communication
- quantum cryptography

In spite of the growing interest toward QT, research in this field can be considered a frontier research.

The focus of my research was to analyse the concept of QTs and how these can be applied to (or benefit from) the Measurement field. Particularly interesting is the metrological implementation of QT in Cyber Physical Measurement System (CPMS). CPMSs are a new concept of the 4.0 Era and they represent a 4.0-driven evolution of measurement systems. Similarly to the well-established concept of a CPS, CPMS include a representation of the digital twin of a real system, therefore a digital representation that contains all the details of the real system and can be integrated in order to carry out analysis, simulations of new states as a result of changes and also measurement evaluations that is why we talk about CPMS.
The literature review has pointed out that the adoption of artificial intelligence (AI) techniques is particularly relevant for CPMSs. Based on these considerations, the research activity continued with the study of the state of the art of QML. The question has been raised as to whether QML can lead to a further improvement of the classic machine learning.
From this set of considerations, the research work is continuing towards the implementation of quantum technology in a real system (such as a structure, a vehicle, a biological system, a person).
Specifically, this real system is subjected to classical measurements by means of sensors that from a hardware point of view could adopt quantum systems, the measurements obtained are pre-processed before being input to a QML algorithm that report to decision support system to take a choice. This approach allows the use of quantum technologies in two ways, the first from a hardware point of view in the internal mechanisms of the sensors used, the second with the use of QML that guarantees better performance respects the traditional approaches of machine learning today.
As an environment to simulate the use of a quantum computer to apply a QML algorithm is that made available by IBM a few qubits, IBM Lab. They are called a series of specific libraries, at the moment you are trying to define a Quantum Support Vector Machine, specifically it is necessary to identify the hyperplane that is able to distinguish the classes compared. As with the Support Vector Machine for classic systems. Another factor to consider for this possible application is the pre-processing of the EEG signals dataset considered. In fact, the dataset consists of a series of sampled EEG signals that are captured with electrodes placed on the scalp following a visual stimulation. The pre-processing to date is a fundamental aspect for machine applications and deep learning as optimizing the data available can improve the performance of the algorithm that is applied, based on the results, of course, the neural network itself is improved by calibrating it.
As next steps, we will move on to this proposal from theory to practice and gradually the application will be perfected. The potential of this system should be highlighted because it can be adapted to different CPMSs and, at the same time, could emphasize a further improvement of artificial intelligence thanks to quantum technology.

[1] Acín, A., Bloch, I., Buhrman, H., Calarco, T., Eichler, C., Eisert, J., ... & Wilhelm, F. K. (2018). The quantum technologies roadmap: a European community view. New Journal of Physics, 20(8), 080201.

## 4. Research products:

*SCIENTIFIC PAPERS:*

- Pasquale Arpaia, Umberto Bracale, Francesco Corcione, Egidio De Benedetto, Alessandro Di Bernardo, Vincenzo Di Capua, Luigi Duraccio, Roberto Peltrini, Roberto Prevete.
  *"Assessment of blood perfusion quality in laparoscopic colorectal surgery by means of Machine Learning."*

Nature – Scientific Reports
Published 2022

*PROTOTYPES:*

- Implementation of a dataset of EEG signals with an artificial intelligence system based on quantum technology. Specifically, the goal is to implement a Quantum Support Vector Machine (QSVM) that is able to perform a classification of EEG signals. (The design is in progress)

## 5. Conferences and seminars attended

- Orizzonti quantistici per l'industria, 26/05/2022 Villa Galileo (Firenze, Italy)

## 6. Activity abroad:

None. 0 months spent abroad.

## 7. Tutorship

None.