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

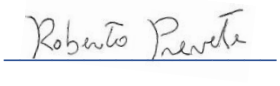
PhD Student: Salvatore Giugliano

Cycle: XXXV

Training and Research Activities Report

Year: First

Tutor: Roberto Prevete



Co-Tutor: Francesco Isgrò

Date: October 21, 2020

Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

Cycle: XXXV **Author: Salvatore Giugliano**

1. Information:

- **PhD student:** Salvatore Giugliano
- **DR number:** DR994201
- **Date of birth:** 20/08/1986
- **Master Science degree:** Computer Science (cum laude)
- **University:** Università degli Studi di Napoli "Federico II"
- **Doctoral Cycle:** XXXV
- **Scholarship type:** no scholarship
- **Tutor:** Roberto Prevete
- **Co-tutor:** Francesco Isgrò

2. Study and training activities:

Activity	Type[1]	Hours	Credits	Dates	Organizer	Certificate[2]
Accelerated Computing With Cuda C/C++	Course	8	0.4	25/11/2019	Luigi Troiano	Y
Intelligenza Artificiale ed Etica	Course	8	1.5	6/12/2019	Roberto Prevete, Guglielmo Tamburrini	Y
Deep Learning for Computer Vision	Course	8	0.4	16/12/2019	Luigi Troiano	Y
Marked Point Processes for Object Detection and Tracking in High Resolution Images: Application to Remote Sensing Data	Seminar	1	0.2	2/12/2019	Giuseppe Scarpa	Y
Scientific Programming and Visualization with Python	Course	16	2	6/3/2020	Alessio Botta	Y
Matlab Fundamentals	Course	20	2	27/3/2020	Agostino De Marco	Y
Computational Biology: Large scale data analysis to understand the molecular bases of human diseases	Seminar	1	0.2	9/4/2020	Michele Ceccarelli	Y

Elettromagnetismo e Salute	Seminar	2	0.2	9/4/2020	Rita Massa	N
How to get published with the IEEE?	Seminar	2	0.4	20/4/2020	Eszter Lukacs	Y
Virtualization technologies and their applications	Course	35	4	15/5/2020	Luigi De Simone	Y
Innovation management, entrepreneurship, and intellectual property	Course	30	5	19/6/2020	Pierluigi Rippa	Y
Design and Implementation of Augmented Reality Software Systems	Course	20	4	25/6/2020	Domenico Amalfitano, Anna Rita Fasolino, Domenico Irilli	Y
Large Scale Training of Deep Neural Networks	Seminar	2	0.4	6/5/2020	Giuseppe Fiameni	N
Design e Nuove tecnologie. Possibili scenari per fronteggiare	Seminar	1	0.2	11/5/2020	Amleto Picerno Ceraso	Y
La programmazione europea e la ricerca. Nuovi scenari della programmazione europea dopo il 2020	Seminar	2	0.4	13/5/2020	Filippo Ammirati	N
SAS Analytics	Seminar	2	0.4	14/5/2020	Cinzia Gianfiori	N
Planning 5G under EMF constraints: challenges and opportunities	Seminar	2	0.4	18/5/2020	Luca Chiaraviglio	N
L'Associazione Professori Emeriti Federiciani invita la S.V. al primo APEF Webinar	Seminar	1	0.2	19/5/2020	Carlo Lauro, Giuseppe Cantillo, Luigi Nicolais, Roberto Vona	N
Joint Design of Optics and Post-Processing Algorithms Based on Deep Learning for Generating Advanced Imaging Features	Seminar	2	0.4	19/5/2020	Raja Giyres	N

Sensing	Seminar	4	0.8	20/5/2020	Marina Giordano	Y
Bias from the wild	Seminar	2	0.4	26/5/2020	Nello Cristianini	N
Adversarial attacks on image classifiers	Seminar	2	0.4	10/6/2020	Andrea Cavallaro	N
Noninvasive Mapping of Electrical Properties using MRI	Seminar	1.5	0.3	11/6/2020	Riccardo Lattanzi	N
Exploring Autonomy in Robotic Flexible Endoscopy	Seminar	2	0.4	12/6/2020	Fanny Ficuciello	Y
"Linear regression in PyTorch" and "Convolutional Neural Networks". Part of the Webinar series on Deep Learning for CINI AIIS Labs	Seminar	2	0.4	29/6/2020	Christian Hundt	N
Machine Learning	Course	20	4	17/7/2020	Marco Aiello, Anna Corazza, Diego Gragnaniello, Francesco Isgrò, Roberto Prevete, Francesco Raimondi, Carlo Sansone	Y
"Efficient Data Loading using DALI" and "Mixed Precision Training using Apex". Part of the Webinar series on Deep Learning for CINI AIIS Labs.	Seminar	1	0.2	1/7/2020	Giuseppe Fiameni, Paul Graham	N
"Multi-GPU Training using Horovod", "Deploying Models with TensorRT" and "Profiling with NVTX". Part of the Webinar series on	Seminar	2	0.4	2/7/2020	Gunter Roeth, Niki Loppi, Giuseppe Fiameni	N

Deep Learning for CINI AIIS Labs.						
Wearable Brain-Computer Interface for Augmented Reality-based Inspection in Industry 4.0	Seminar	1	0.2	29/7/2020	Pasquale Arpaia	N

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	**2.3**	**0.2**	**7.5**		**10**
Bimonth 2			**8**		**8**
Bimonth 3	**4**	**0.8**	**6**		**10.8**
Bimonth 4	**13**	**5.1**	**7**		**25.1**
Bimonth 5	**4**	**0.8**	**4**		**8.8**
Bimonth 6			**8**		**8**
Total	**23.3**	**6.9**	**40.5**		**70.7**
Expected	**20**	**5**	**35**	**0**	**60**

3. Research activity:

The research topic is “Applications of Graph Convolutional Neural Networks”. During this first year of PhD, I analyzed the state of the art of Graph Convolutional Neural Networks (GCNN). I started working on two applications of GCNN: parking prediction using the San Francisco park dataset and engagement classification from EEG data for the AVATEA project. Another research activity that I have studied and worked on is eXplainable Artificial Intelligence (XAI).

- **Applications of GCNN**
  The data in many deep learning tasks are represented in the Euclidean space. In an increasing number of applications, the data are generated in a non-Euclidean space and are represented by graphs. The graph is the input of the neural network. Most graph neural network architectures present in literature redefine the concept of convolution, where it is applied here on a graph. These approaches are called graph convolutional neural networks (GCNN). There are spectral-based and space-based methods. These methods perform the convolution in the domain of the graph by aggregating the information of the neighbouring nodes.
  - **Parking prediction**
    An application domain of the GCNN is the parking prediction. The road network is modelled as a graph, with nodes, for example, being parking locations and edges transferring parking demand among nodes. Then, a graph is generated that has a non-Euclidean structure. By modeling the data on a graph, an important component is

preserved which is the spatial relationship between the roads. A GCNN model that takes the road network graph as input can be used to extract not only the temporal features but also the spatial relationships between the road sectors. The combination of temporal and spatial features allows for a more effective parking prediction.

- **Engagement classification**
  The term engagement means the level of involvement of an individual under three main aspects: cognitive, emotional, and behavioural. Through the EEG waves, it is possible to quantify the level of engagement of a person. These waves are collected through a helmet equipped with a variable number of non-invasive electrodes placed on the surface of the head. It is possible to model the position of the electrodes on a graph. In this way, the spatial relationship between the electrodes that signal the eeg waves on the surface of the head is preserved. A GCNN model can be used to extract both temporal and spatial features to have a better engagement classification.

Both problems, therefore, due to their non-Euclidean nature, have in common the possibility of modeling data in a graph. The graph keeps intact the spatial component between the streets, in the problem of forecasting parking spaces, and between the electrodes, in the problem of engagement classification.
In this first year the data was analyzed in depth on both applications. An experimental baseline was built with traditional machine learning and deep learning techniques. Trials are currently underway on GCNN models. The results of this experimentation will be reported in future papers as reported in the next section.

- **XAI**
  XAI refers to the principle of making the operation of artificial intelligence and its results understandable to the user. Mainly, in literature, two types of XAI methods can be distinguished: agnostic (or black-box) methods which are independent of the machine learning model to be explained and white-box methods which instead have access to the structure of the model to be interpreted. Another possible distinction between XAI methods is the level (low or middle) of the features to be explained. Low-level feature approaches allow for an explanation of a model's output in terms of low-level features such as pixels in an image classification problem. A popular method based on this approach is Layer-wise Relevance Propagation (LRP), which maps a relevance value to each pixel of the image as an explanation of the model's output. Relevance values are shown on a heatmap. This method is also a typical example of a white-box approach. For approaches on middle-level features, an explanation is provided on parts of the image (superpixels). This set of superpixels is an explanation of the model's response. These types of approaches are usually black-box methods.
  In this first year of PhD, I analyzed the state of the art of the most famous XAI techniques. I have worked on new methods and some of the work has already been submitted. Indeed, I collaborated in the realization of the paper "**A general approach to compute the relevance of middle-level input features**". The proposed method is a variant and a generalization of the LRP method. Instead of returning a relevance value for each pixel input, it returns relevance values for a set of middle-level features. The proposed method uses two different definitions of middle-level features: a segmentation-based approach, and a dictionary learning approach. It is a general framework insofar as it can be applied on several different computational representations of middle-level features. The input of a machine learning model can be encoded and decoded on the

basis of middle-level features and LRP can be applied on both the model and the decoder. The results of the experiments are encouraging, both from a qualitative point of view, giving explanations that can be easily interpreted by the human being, and from a quantitative point of view, giving performances comparable to other methods present in the current literature.

4. Research products:

Conference paper submitted

- "**A general approach to compute the relevance of middle-level input features**", Andrea Apicella, Salvatore Giugliano, Francesco Isgrò and Roberto Prevete, Workshop on Explainable Deep Learning-AI**,** EDL-AI 2020**.**

Papers in preparation

- "**Engagement classification in a pediatric rehabilitation environment**", Andrea Apicella, Pasquale Arpaia, Mirco Frosolone, Salvatore Giugliano, Francesco Isgrò, Giovanna Mastrati, Nicola Moccaldi and Roberto Prevete.

- "**Measurement of engagement in a pedagogical teaching environment**", Andrea Apicella, Pasquale Arpaia, Mirco Frosolone, Salvatore Giugliano, Francesco Isgrò, Giovanna Mastrati, Nicola Moccaldi and Roberto Prevete.

5. Conferences and seminars attended

During my first PhD year I did not participate to any conference.

6. Activity abroad:

During my first PhD year I did not spend any time abroad.

7. Tutorship

During my first PhD year I did not make any tutorship activity.