UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II

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

Activities and Publications Report

PhD Student: Salvatore Giugliano

Student ID: DR994201

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

PhD program student's start date: 1/11/2019
PhD program student's end date: 31/10/2022

Supervisor: Roberto Prevete

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PhD scholarship funding entity:
No scholarship.

General information

Salvatore Giugliano received in the year 2019 a Master of Science degree in Computer Science from the University of Napoli Federico II. He attended a curriculum within the Information Technology and Electrical Engineering PhD program. He enrolled on the ITEE PhD program without a grant.

Study activities

Attended Courses

Year	Course Title	Type	Credits	Lecturer	Organization
1	Accelerated Computing With Cuda C/C++	Ad hoc course	0.4	Luigi Troiano	ITEE
1	Intelligenza Artificiale ed Etica	Ad hoc course	1.5	Roberto Prevete, Guglielmo Tamburrini	ITEE
1	Deep Learning for Computer Vision	Ad hoc course	0.4	Luigi Troiano	ITEE
1	Scientific Programming and Visualization with Python	Ad hoc course	2	Alessio Botta	ITEE
1	Matlab Fundamentals	Ad hoc course	2	Agostino De Marco	ITEE
1	Virtualization technologies and their applications	Ad hoc course	4	Luigi De Simone	ITEE
1	Innovation management, entrepreneurship, and intellectual property	Ad hoc course	5	Pierluigi Rippa	ITEE
1	Design and Implementation of Augmented Reality Software Systems	Ad hoc course	4	Domenico Amalfitano, Anna Rita Fasolino, Domenico Irilli	ITEE
1	Machine Learning	Ad hoc course	4	Marco Aiello, Anna Corazza, Diego Gragnaniello, Francesco Isgrò, Roberto Prevete, Francesco Raimondi, Carlo Sansone	ITEE
2	Data science for patient records analysis	Ad hoc course	2.5	Marcello Cinque	ITEE
2	Matrix Analysis for Signal Processing with MATLAB Examples	Ad hoc course	2	Augusto Aubry, Vincenzo Carotenuto, Antonio De Maio	ITEE
2	Real-Time Embedded Systems for I4.0 and IIoT	Ad hoc course	2	Marcello Cinque, Alessandro Cilardo	ITEE

Attended Seminars

Year	Seminar Title	Credits	Lecturer	Lecturer affiliation	Organization
1	Marked Point Processes for Object Detection and Tracking in High Resolution Images: Application to Remote Sensing Data	0.2	Josiane Zerubia		ITEE
1	Computational Biology: Large scale data analysis to understand the molecular bases of human diseases	0.2	Michele Ceccarelli		ITEE
1	Elettromagnetismo e Salute	0.2	Rita Massa		ITEE
1	How to get published with the IEEE?	0.4	Eszter Lukacs		IEEE Client Services Team
1	Large Scale Training of Deep Neural Networks	0.4	Giuseppe Fiameni		ITEE
1	Design e Nuove tecnologie. Possibili scenari per fronteggiare	0.2	Amleto Picerno Ceraso		Medaarch (innovation village)
1	La programmazione europea e la ricerca. Nuovi scenari della programmazione europea dopo il 2020	0.4	Filippo Ammirati		ITEE
1	SAS Analytics	0.4	Cinzia Gianfiori		ITEE
1	Planning 5G under EMF constraints: challenges and opportunities	0.4	Luca Chiaraviglio		ITEE
1	L'Associazione Professori Emeriti Federiciani invita la S.V. al primo APEF Webinar	0.2	Carlo Lauro, Giuseppe Cantillo, Luigi Nicolais, Roberto Vona		ITEE
1	Joint Design of Optics and Post-Processing Algorithms Based on Deep Learning for Generating Advanced Imaging Features	0.4	Raja Giyres		ITEE
1	Sensing	0.8	Marina Giordano		Plasmonica & Nano-OtticaWorking group
1	Bias from the wild	0.4	Nello Cristianini		ITEE
1	Adversarial attacks on image classifiers	0.4	Andrea Cavallaro		ITEE
1	Noninvasive Mapping of Electrical Properties using MRI	0.3	Riccardo Lattanzi		ITEE

1	Exploring Autonomy in Robotic Flexible Endoscopy	0.4	Pietro Valdastri		ITEE
1	"Linear regression in PyTorch" and "Convolutional Neural Networks". Part of the Webinar series on Deep Learning for CINI AIIS Labs	0.4	Christian Hundt		ITEE
1	"Efficient Data Loading using DALI" and "Mixed Precision Training using Apex". Part of the Webinar series on Deep Learning for CINI AIIS Labs.	0.2	Giuseppe Fiameni, Paul Graham		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	Gunter Roeth, Niki Loppi, Giuseppe Fiameni		ITEE
1	Wearable Brain-Computer Interface for Augmented Reality-based Inspection in Industry 4.0	0.2	Pasquale Arpaia		ITEE
2	Robot Manipulation and Control	0.5	Bruno Siciliano		ITEE
2	Data Driven Transformation in WINDTRE through Managers voice VII Antonio Picariello Lectures on Data Science Flora Amato	0.4	Flora Amato		ITEE
2	Cybercrime and e-evidence: the criminal justice response	0.4	Matteo Lucchetti		ITEE
2	The era of Industry 4.0: new frontiers in business model innovation	0.2	Marco Balzano		ITEE
2	Machine learning: Causality lost in translation	0.3	Edwin A. Valentijn		ITEE
2	Approaches to Graph Machine Learning	0.2	Miroslav Cepek		ITEE
2	Visual Interaction and Communication in Data Science	0.4	Marco Quartulli		ITEE
2	Robo Ludens: A game design taxonomy for human-robot interaction	0.2	John Edison Muñoz Cardona		ITEE
2	Ethics of quantification	0.2	Andrea Saltelli		ITEE
2	L'esposizione ai campi elettromagnetici generati dal sistema 5G	0.8	Sara Adda, Daniele Franci, Settimio Pavoncello		ITEE
2	SAE 2021 - Big4small, Data Science Methodology Transfer: Big to Small.	0.4	Edwin Valentjin		ITEE

3	Intelligenza artificiale e sistemi d'arma autonomi	0.4	Giuliano Colombetti, Antonello Provenzale, Fosca Giannotti, Guglielmo Tamburrini		Gruppo Interdisciplinare su Scienza, Tecnologia e Società (GI-STS) dell'Area della Ricerca di Pisa del CNR
3	Project Vac: Can a Text-to-Speech Engine Generate Human Sentiments? Antonio Picariello Lectures on Data Science- II Cycle	0.2	V.K. Gubani, Simon Pietro Romano		ITEE
3	Picariello Lectures on Data Science – II Cycle A day in the life of a Chief Data Officer	0.4	Roberto Maranca		ITEE

Research activities

Salvatore Giugliano participated in the research on the analysis and interpretation of EEG signals with Machine Learning techniques. This research was conducted with the long-term goal of taking advantage of eXplainable Artificial Intelligence (XAI) methods to improve the performances of EEG signal classifiers based on Machine Learning (ML) approaches. For this reason, the candidate followed two main research lines: 1) Developing new ML classifiers of EEG signals and 2) developing new XAI methods.

Concerning the first point, Salvatore Giugliano analysed the state of the art of EEG signal classifiers based on ML techniques. Starting from this analysis, he applied advanced ML techniques such as convolutional neural networks and domain adaptation methods on well-known EEG datasets. These approaches were carefully tested in experimental scenarios. In particular, the candidate contributed in significant ways to two problems of EEG signals: engagement classification from EEG data for the AVATEA project and SSVEP detection from EEG data.

Regarding the second research line, a central issue addressed by the rapidly growing research area of XAI is to provide methods to give explanations for the behaviours of ML non-interpretable models after the training. These methods could be exploited to locate/transform the most relevant EEG features to mitigate the domain shift problem typically occurring for these signals. To this end, the candidate collaborated actively to develop and test new XAI methods, which can give multiple explanations in terms of middle-level input features based on auto-econder approaches.

Credits summary

PhD Year	Courses	Seminars	Research	Tutoring / Supplementary Teaching
1st	23.3	6.9	40.5	
2nd	7	4.2	48	
3rd		1	60	

Research periods in institutions abroad and/or in companies

PhD Year	Institution / Company	Hosting tutor	Period	Activities
2nd	Istituto Superior Tecnico	Pedro Silva Girão	3 months	Analysis and interpretation of EEG signals using Machine Learning techniques. In-depth study of signal processing strategies applied to electroencephalographic (EEG) signals for the recognition of psychophysiological conditions relevant to Industry 4.0 (stress, distraction, engagement). Design and experimental validation of feature extraction systems and EEG signal classification.

PhD Thesis

In the PhD Thesis, Salvatore Giugliano addresses the problem of developing trusty classification systems for EEG signals by Machine Learning (ML) approaches in the context of Brain-Computer Interface (BCI) applications.

The use of ML techniques for EEG signal classification is gaining increasing attention in BCI applications thanks to promising performances reported by many ML systems, from one side, and the non-invasiveness and high time resolution of the EEG acquisitions from the other one. However, several EEG-based BCI applications suffer the main drawbacks of the EEG signals, such as their non-stationarity, which makes the employing systems particularly sensitive to changes in users or time acquisitions. Despite several efforts, performance with different acquisition times or subjects remains low in several applications. Therefore, such systems can be unreliable, particularly when used in safety-critical domains.

From the ML point of view, the non-stationarity of EEG signals can be viewed as a significant instance of the well-known Dataset Shift problem where, differently from the ML standard hypothesis, training and test data can belong to different probability distributions, leading ML systems toward poor generalisation performances.

The research work of this PhD thesis was conducted with the long-term goal of exploiting the knowledge from eXplainable Artificial Intelligence (XAI) domain to develop EEG-based classification systems which overcome the performance returned by the current ones. XAI methods try to explain the behaviour of AI systems, such as ML ones, by providing explanations about the response of an AI system, given a specific input, in terms of relevant input features.

More specifically, the contribution of this PhD thesis is threefold: firstly, a study on BCI systems that relied on EEG signals is made, leading to two different proposals for two different tasks: EEG-based emotion recognition and SSVEP classification. These proposals explore advanced ML techniques such as convolutional neural networks and domain adaptation methods on well-known EEG datasets. Secondly, a study on modern XAI methods is made, converging toward a new

method to build explanations in an ML-based image classification task. Finally, on the basis of the results obtained in the previous investigations, an experimental analysis of explanations produced by several XAI methods on an ML system trained on EEG data for emotion recognition is made. Preliminary results suggest the plausibility to develop BCI methods able to leverage on XAI methods to generalise across different subjects and different times without further efforts.

Publications

Research results appear in *3* papers published in international journals, *0* papers published in national journals, *1* contribution to international conferences, *3* contributions to national conferences, *0* patents.

List of scientific publications

International journal papers

Apicella A., Giugliano S., Isgrò F., & Prevete R.,
Exploiting auto-encoders and segmentation methods for middle-level explanations of image classification systems,
Knowledge-Based Systems,
vol. 255 (109725), 2022, DOI: 10.1016/j.knosys.2022.109725

Apicella A., Arpaia P., Giugliano S., Mastrati G., & Moccaldi N,
High-wearable EEG-based transducer for engagement detection in pediatric rehabilitation,
Brain-Computer Interfaces,
vol. 9 (3), pp. 129-139, 2022, DOI: 10.1080/2326263X.2021.2015149

Apicella A., Arpaia P., De Benedetto E., Donato N., Duraccio L., Giugliano S., & Prevete R.,
Enhancement of SSVEPs classification in BCI-based wearable instrumentation through machine Learning Techniques,
IEEE Sensors Journal,
vol. 22 (9), pp. 9087-9094, 2022, DOI: 10.1109/JSEN.2022.3161743

International conference papers

Angrisani L., Apicella A., Arpaia P., De Benedetto E., Donato N., Duraccio L., Giugliano S, & Prevete R.,
A ML-based Approach to Enhance Metrological Performance of Wearable Brain-Computer Interfaces,
IEEE International Instrumentation and Measurement Technology Conference (I2MTC)
Ottawa, Canada, May. 2022, pp. 1-5, IEEE, DOI: 10.1109/I2MTC48687.2022.9806518

National conference papers

Apicella A., Arpaia P., Cataldo A., De Benedetto E., Donato N., Duraccio L., Giugliano S, & Prevete, R.,
Adoption of Machine Learning Techniques to Enhance Classification Performance in Reactive Brain-Computer Interfaces,
IEEE International Symposium on Medical Measurements and Applications (MeMeA),
Messina, Italy, Jun. 2022, pp. 1-5, IEEE, DOI: 10.1109/MeMeA54994.2022.9856441

Apicella A., Giugliano S., Isgrò F., & Prevete R.,
Explanations in terms of Hierarchically organised Middle Level Features,
Italian Workshop on Explainable Artificial Intelligence,
Milano, Italy, Dec. 2021, vol. 3014 (4), CEUR Workshop, URL: http://ceur-ws.org/Vol-3014/paper4.pdf

Apicella A., Giugliano S., Isgrò F., & Prevete R.,
A general approach to compute the relevance of middle-level input features,
International Conference on Pattern Recognition - International Workshops and Challenges,
Virtual-Milano, Italy, Jan. 2021, pp. 189-20, Springer, DOI: 10.1007/978-3-030-68796-0_14

Date 19/10/2022

PhD student signature _____

Supervisor signature _____