UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II

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

Activities and Publications Report

PhD Student: Gerardo Saggese

Student ID: DR995145

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

PhD program student's start date: 01/11/2020
PhD program student's end date: 31/10/2023

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Co-supervisor:

e-mail:

PhD scholarship funding entity:
MIUR PRIN2017 "Autonomous In-vivo Brain-Machine-Interface in 28nm-CMOS technology with Ultrasound-based Power-Harvester and Communication-Link (Brain28nm)" (Prot. 20177MEZ7T).

General information

Gerardo Saggese received in year 2020 the Master Science degree in Electronic Engineering from the University of Napoli Federico II. He attended a curriculum in Electronic Engineering within the PhD program in Information Technology and Electrical Engineering. He received a grant from MIUR – PRIN2017.

Study activities

Attended Courses

Year	Course Title	Type	Credits	Lecturer	Organization
1st	Circuiti per DSP	MSc course	9	Prof. Davide De Caro	University of Napoli Federico II
1st	Scientific Programming and Visualization with Python	Ad hoc course	2	Prof. Alessio Botta	ITEE
1st	Statistical data analysis for science and engineering research	Ad hoc course	4	Prof. Roberto Pietroantuono	ITEE
1st	Sistemi Elettronici Programmabili	BSc Course	9	Prof. Ettore Napoli	University of Napoli Federico II
1st	Cambridge FCE	Ad hoc course	6	CLA	University of Napoli Federico II
2nd	Impreditorialità Accademica	Ad hoc Course	4	Prof. P. Rippa	ITEE
2nd	Biosignals measurement and analysis	Ad hoc Course	4	Dr. Emilio Andreozzi	ITEE
2nd	Ultra-low power integrated systems for green growth to the trillion scale	External course	4	Prof. M. Alioto, National University of Singapore	University of Pisa
2nd	FPGA per l'elaborazione dei segnali	MSc course	9	Prof. Nicola Petra	University of Napoli Federico II

Attended PhD Schools

Year	School title	Location	Credits	Dates	Organization
2nd	"Automotive Electronics"	Rende (CS)	4	5/09/22-7/09/22	University of Calabria

Attended Seminars

Year	Seminar Title	Credits	Lecturer	Lecturer affiliation	Organization
1st	Robot Manipulation and	0.5	Prof. Bruno	University of Napoli	Scuola Superiore

	Control		Siciliano	Federico II	Sant'Anna Pisa
1st	Digital Project Management: practices, processes, techniques, tools and scientific approach	0.2	Prof. Dario Carotenuto	Project Management Institute	University of Napoli Federico II
1st	#andràtuttobene: Images, Texts,Emojis and Geodata in a Sentiment Analysis Pipeline	0.3	Prof. Serena Pelosi	University of Salerno	University of Napoli Federico II
1st	Patent Searching Best Practice with IEEE Xplore	0.2	Dr. Eszter Lukacs	IEEE	ITEE
1st	At the Nexus of Big data, Machine Intelligence, and Human Cognition	0.2	Prof.George S.Djorgovski	Caltech Faculty	University of Napoli Federico II
1st	How to Get Published with the IEEE	0.3	Dr. Paul Henriques	IEEE	ITEE
1st	Network Systems, Kuramoto Oscillators and Synchronous Power Flows	0.3	Prof. Francesco Bullo	University of California	Scuola Superiore Meridionale
1st	Exploiting Deep Learning and Probabilistic Modeling for behavior analytics	0.2	Prog. Giuseppe Manco	University of Calabria	University of Napoli Federico II
1st	GDPR basics for computer scientists	0.3	Dr. Rigo Wenning	European Research Consortium for Informatics and Mathematics	Scuola Superiore Meridionale
1st	Measuring the expansion of the universe with Quasars	0.3	Prof. Guido Risaliti	University of Florence	Scuola Superiore Meridionale
1st	Data Driven Transformation in WINDTRE through Managers voice'	0.4	Dr. Marcello Savarese	WINDTRE	University of Napoli Federico II
1st	From Photometric Redshifts Improved Weather Forecast: an interdisciplinary view on machine learning	0.2	Prof. Kai Polsterer	Heidelberg Institute for Theoretical Studies	University of Napoli Federico II
1st	Synchronization: A Universal Concept in Nonlinear Sciences	0.3	Prof. Jurgen Kurths	University of Potsdam	Scuola Superiore Meridionale
1st	Cybercrime and e/evidence: the criminal justice response	0.2	Dr. Matteo Lucchetti	European Council	University of Napoli Federico II
1st	Proibing gravitational field: a fundamental viewpoint	0.3	Prof. Lorenzo Fatibene	University of Torino	Scuola Superiore Meridionale

1st	AI LEGAL: Artificial Intelligence for notary's sector – a case study	0.2	Dr. Salvatore Palange	Fluel Innovation for Business	University of Napoli Federico II
1st	Quantum Simulators	0.3	Prof. Rosario Fazio	International Centre for Theoretical Physics	Scuola Superiore Meridionale
1st	The era of industry 4.0: new frontiers in business model innovation	0.2	Dr. Marco Balzano	University Ca' Foscari	University of Napoli Federico II
1st	Engineering the firearm ecosystem: research on media coverage and firearm acquisition in the aftermath of a mass shooting	0.3	Prof. Maurizio Porfiri	New York University	Scuola Superiore Meridionale
1st	Machine Learning: casuality lost in translation	0.3	Dr. Edwin A. Valentjin	University of Groningen The Netherlands	Scuola Superiore Meridionale
1st	Measuring the cosmological parameters with SNe/Ia and Gamma/ray Bursts	0.3	Prof. Massimo della Valle	Astronomical Observatory of Capodimonte	Scuola Superiore Meridionale
1st	Approaches to Graph Machine Learning	0.2	Dr. Miroslav Cepek	Oracle Labs	University of Napoli Federico II
1st	Designing a Socially Assitive Robot for adaptive and personalized assistance to patients with dementia	0.2	Dr. Antonio Andriella	Technical University of Catalonia	Scuola Superiore Meridionale
1st	Variation approximations of the Griffith functional	0.2	Prof. Francesco Solombrino	University of Napoli Federico II	Scuola Superiore Meridionale
1st	The SHIP project at CERN	0.2	Prof. Andrey Golutvin	Imperial College London	Scuola Superiore Meridionale
1st	Visual Interaction and Communication in Data Science	0.4	Dr. Marco Quartulli	Vicomtech	University of Napoli Federico II
1st	Astroparticle Physics in the era of multi-messenger Astronomy	0.3	Prof. Gennaro Miele	University of Napoli Federico II	Scuola Superiore Meridionale
1st	Big data and Computational Linguistics	0.4	Dr. Francesco Cotugno	University of Napoli Federico II	University of Napoli Federico II
1st	Hierarchical Seismic Imaging	0.3	Prof. Jean Virieux	Université Grenoble Alpes	University of Napoli Federico II
1st	Sensoria Health	0.2	Dr. Stefano Rossotti	Sensoria Health	University of Napoli Federico II
1st	Additive Manufacturing. A world full of opportunities	0.3	Prof. Ferdinando	University of Pavia	Scuola Superiore Meridionale

	and challenges		Auricchio		
1st	Why do we cooperate? Understanding and Modelling Societies using Reinforcement Learning	0.3	Prof. Mirco Musolesi	University College London	Scuola Superiore Meridionale
1st	Rheo-Engineeering Microfuids. How to exploit rheological properties of fluids to design microfluidic applications	0.3	Prof. Luca Maffettone	University of Napoli Federico II	Scuola Superiore Meridionale
1st	Classical Cepheids as distance indicatoris from the Milky Way to the hubble constant	0.3	Dr. Marcella Marconi	Astronomical Observatory of Capodimonte	University of Napoli Federico II
1st	Webinar “IEEE Authorship and Open Access Symposium Best Practices to Get Published to Increse the Exposure and Impact of Your Research	0.3	Dr. Joseph M. Guerrero, Eszter Lukàcs and Dr. Paul Canning	IEEE	University of Napoli Federico II
1st	Microgravity, science and Technology an overview	0.3	Dr. Fabio Peluso	Leonardo S.p.A	Scuola Superiore Meridionale
1st	The coming revolution of Data driven Discovery	0.3	Prof. Giuseppe Longo	University of Napoli Federico II	University of Napoli Federico II
1st	DoveAndiamoDomani - Deep Tech	0.3	Dr. Francesco Matteucci	University of Napoli Federico II	University of Napoli Federico II
1st	Distributional Semantics Methods: How Linguistic features can improve the semantic representation	0.3	Dr. Alessandro Maisto	University of Napoli Federico II	University of Napoli Federico II
1st	Putting More PHYS into PHSA: Advancing Seismic Hazard Analysis with Physics-Based Modelling	0.3	Prof. Thomas H. Jordan	University of South California Dornsife	Scuola Superiore Meridionale
1st	Modelling the Complexity of Multiagent Activity for Human AI/Interaction using Dynamical Primitives	0.3	Prof. Micheal Richardson	Macquarie University	Scuola Superiore Meridionale
1st	Dark Energy and Cosmic Acceleration	0.3	Prof. Jalison Alcaniz	Observatorio Nacional Astronomia &	Scuola Superiore Meridionale

				Astrofisica	
1st	Introduction to FPGAs and the Intel Quartus Prime Software	0.8	Dr. Larry Landis	Intel	Intel
1st	Artificial Intelligence and 5G combined with holographic technology: a new perspective for remote health monitoring	0.4	Dr. Pietro Ferraro, Dr. Pasquale Memmolo	University of Napoli Federico II	University of Napoli Federico II
1st	Introduction to Simulation and Debug of FPGAs" Intel FPGA Workshop	0.8	Dr. Larry Landis	Intel	Intel
1st	Distributional Semantics Methods: How Linguistic features can improve the semantic representation	0.4	Dr. Alessandro Maisto, Prof. Flora Amato	University of Napoli Federico II	University of Napoli Federico II
2nd	Vehicular Hacking in Akka Tecnologies	0.3	Dr. L.Guido	Akka Technology	University of Napoli Federico II
2nd	Cyber security in Akka Tecnologies	0.4	Dr. L Villa	Akka Technology	University of Napoli Federico II
2nd	Exploring the early Universe through the cosmic microwave background	0.3	Prof. P. Notoli	Università di Ferrara	Scuola Superiore Meridionale
2nd	Evolution by curvature of networks in the plane	0.2	Prof. C. Montegozza	Scuola Superiore Meridionale	Scuola Superiore Meridionale
2nd	Turbolent Dynamics in viscous fluids: a complex phenomenon ubiquitous in nature	0.3	Prof. V. Carbone	University of Calabria	Scuola Superiore Meridionale
2nd	Graphons: a tool for the analysis of the systems on large networks	0.2	Dr. P. Frasca	GIPSA-lab, Grenoble	Scuola Superiore Meridionale
2nd	Connecting the dots: Investigating an APT compaign using Splunk"	0.4	Dr. A. Forzieri	Splunk Inc.	University of Napoli Federico II
2nd	Threat Hunting Essentials	0.4	Group-IB	Group-IB	University of Napoli Federico II
2nd	Threat Hunting Use-Cases	0.4	Group-IB	Group-IB	University of Napoli Federico II
2nd	GDPR basics for computer scientists	0.4	Dr. R. Wenning	European Research Consortium for Informatics and Mathematics	Scuola Superiore Meridionale
2nd	Design Quantum	0.4	Prof. M.	University of Parma	University of Napoli

	algorithms		Amoretti		Federico II
2nd	Social network dynamics leading to community formation and residential segregation	0.3	Prof. M. Franceschetti	University of California	Scuola Superiore Meridionale
2nd	Structure, processes and dynamics of networks with higher order interactions	0.3	Dr. S. Boccaletti	Institute of Complex Systems of the Italian CNR	Scuola Superiore Meridionale
2nd	The needle in the haystack: the search for rare processes and the fundamental laws of Nature	0.3	Prof. F. Ambrosino	University of Calabria	Scuola Superiore Meridionale
2nd	An overview of the transient sky at high energies	0.3	Dr. Anrea Sanna	University of Cagliari	Scuola Superiore Meridionale
2nd	Global and cluster synchronization in complex networks and beyond	0.3	Prof. M. Frasca	University of Catania	Scuola Superiore Meridionale
2nd	High Energy X-ray Astrophysics from Space revealing the backbones of the Universe	0.3	Prof. M. Paolillo	University of Napoli Federico II	Scuola Superiore Meridionale
2nd	From basic principles in spintronics to some recent developments toward spinorbitronics	0.3	Dr. V. Cros	University of Rome La Sapienza	Scuola Superiore Meridionale
2nd	Capillary Surfaces and a Model of Nanowire Growth	0.3	Prof. M. Morini	University of Parma	Scuola Superiore Meridionale
2nd	An informal discussion around stochastic and freeboundary problems	0.3	Dr. L. Buoninfante	University of Torino	Scuola Superiore Meridionale
2nd	Are 2 derivative enough to describe nature at a fundamental level	0.3	Prof. T. de Angelis	Nordita (Sweden)	Scuola Superiore Meridionale
2nd	Comprehensive Digital IC Implementation & Sign-Off	7	Europractice	Europractice	Europractice
3rd	Verification for Digital Designs	3.3	Europractice	Europractice	Europractice
3rd	Advanced Digital IC Design and	4.4	Europractice	Europractice	Europractice

	Implementation				

Research activities

Gerardo Saggese participated in the research of the design and implementation of spike detectors for on-implant multichannel brain machine interface (BMI) system algorithm and the design of approximated arithmetic circuits. More specifically, he contributed to the research of the following topics: (i) analysis and comparison of the most popular techniques employed within the realm of spike detectors, (ii) design novel noise estimates to efficiently extract the main information from the noisy neural signal, (iii) VLSI low-power implementation methodologies, (iv) approximated multipliers and (v) the synergy of approximate computing techniques in BMI application. During his period abroad, Gerardo Saggese has been a visiting Ph.D. student at the Fulda University of Applied Sciences, Germany (Hessen), where he studied the design and the optimization of approximate recursive multipliers block for FPGA synthesis. Gerardo Saggese has presented 3 contributions at international conference (PRIME) and 2 poster contribution at the 53rd and 54th annuals meeting of SIE (Società Italiana di Elettronica).

Tutoring and supplementary teaching activities

- Co-supervision of MSc thesis (Turboli Orazio) titled *"Architettura hardware per un Sistema di individuazione di impulsi neuronali per un sensore multi transistor da 1024 pixel".*
- Co-supervision of MSc thesis (Fornaro Claudio) titled *"Implementazione a ridotta dissipazione di potenza in tecnologia 28nm di un microsistema impiantabile per l'individuazione di impulsi neuronali".*
- Co-supervision of MSc thesis (Parretta Nicola) titled *"Realizzazione hardware di un rivelatore di spike multi-canale in tecnologia CMOS 28nm".*
- Co-supervision of BSc thesis (Esposito Carmine) titled "*Progettazione e realizzazione Hardware di un rilevatore di complessi QRS basato sull'operatore non lineare MOBD".*
- Co-supervision of BSc thesis (Tavassi Ciro) titled *"Progettazione e realizzazione hardware di un rivelatore di complessi QRS basato sull'operatore non-lineare ASO".*
- Co-supervision of BSc thesis (Vaccaro Michele) titled *"Studio di un sensore IoT basato su misure optofluidiche".*
- Co-supervision of BSc thesis (Iacovelli Marcello) titled *"Realizzazione board didaticca per esperienza laboratoriali".*
- Co-Supervision MSc thesis (De Felice Silvia) titled *"Progettazione, realizzazione e test di un circuito di codifica/decodifica Manchester per applicazioni ferroviare".*

Credits summary

PhD Year	Courses	Seminars	Research	Tutoring / Supplementary Teaching
1st	30	13.7	26.5	-
2nd	25	14.1	36.5	-
3rd	-	7.7	60	-

Research periods in institutions abroad and/or in companies

PhD Year	Institution / Company	Hosting tutor	Period	Activities
3rd	Fulda University of Applied Sciences, Germany (Hessen)	Dr. Ing. Martin Kumm, Professor of "Embedded Systems"	01.01.2023 14.04.2023	Research on approximate recursive multiplier for FPGA.

PhD Thesis

In the PhD Thesis, Gerardo Saggese investigates spike detector algorithms and approximate arithmetic circuits. Brain-Machine Interface (BMI) systems have gained attention for direct communication between brain and outside environment. The spike detection algorithm is crucial for extracting neural information from recorded signals. Integrating spike detection algorithms with proximity calculations improves the efficiency of BMI systems and enables real-time processing for responsive device control. This reduction in computational intensity and power consumption promotes low power, energy-efficient BMI hardware. The main objective of this research activity is to overcome the challenges faced by conventional spike detection algorithms, especially in terms of computational intensity and power consumption, when applied to implantable BMI systems with many channels. To this end, spike detection algorithms tailored to BMI applications have been researched and developed, and their performance evaluated using metrics such as accuracy, computational effort, and resource requirements. Another research topic that builds on this foundation is the approximate computation paradigm. Multipliers are

essential building blocks in many signal processing tasks, including spike detection algorithms. Therefore, I have been working on developing approximate multipliers to reduce the complexity and computational cost of multiplication operations while maintaining an acceptable level of accuracy, resulting in improved computational efficiency and reduced power consumption. The use of approximate multipliers in spike detection algorithms can improve the overall efficiency and performance of the spike detector and thus the BMI system. Overall, his work aims to advance the field of BMI by addressing the computational challenges associated with spike detection algorithms and exploring the benefits of approximate computational techniques. The results of this research have the potential to provide valuable insights into optimising computational resources, power efficiency and real-time processing capabilities, paving the way for more efficient and practical BMI systems.

Publications

Research results appear in *11* papers published in international journals and 4 contributions to international conferences.

List of scientific publications

International journal papers

M. Tambaro, E. A. Vallicelli, G. Saggese, A. G. M Strollo, A. Baschirotto, and S. Vassanelli,
Evaluation of In Vivo Spike Detection Algorithms for Implantable
MTA Brain—Silicon Interfaces,
Low Power Electronics and Applications,
vol. 10, no. 3, p. 26, Sep. 2020, DOI: 10.3390/jlpea10030026.

G. Saggese, M. Tambaro, E. A. Vallicelli, A. G. M. Strollo, S. Vassanelli, A.Baschirotto, and M. D. Matteis,
Comparison of Sneo-Based Neural Spike Detection Algorithms for Implantable Multi-Transistor Array Biosensors,
Electronics,
vol. 10, no. 4, p. 410, Feb. 2021, DOI: 10.3390/electronics10040410.

G. Saggese, and A. G. M. Strollo,
A Low Power 1024-Channels Spike Detector Using Latch-Based RAM for Real-Time Brain Silicon Interfaces,
Electronics,
vol. 10, no. 24, p. 3068, Dec. 2021, DOI: 10.3390/electronics10243068.

G. Di Meo, D. De Caro, G. Saggese, E. Napoli, N. Petra, and A. G. M. Strollo,
A Novel Module-Sign Low-Power Implementation for the DLMS Adaptive Filter With Low Steady-State Error,
IEEE Transactions on Circuits and Systems I: Regular Papers,
vol. 69, no. 1, pp. 297–308, Jan. 2022., DOI: 10.1109/TCSI.2021.3088913.

A. G. M. Strollo, E. Napoli, D. De Caro, N. Petra, G. Saggese, and G. Di Meo,
Approximate Multipliers Using Static Segmentation: Error Analysis and Improvements,
EEE Transactions on Circuits and Systems I: Regular Papers,
vol. 69, no. 6, pp. 2449–2462, Jun. 2022, DOI: 10.1109/TCSI.2022.3152921.

E. Zacharelos, I. Nunziata, G. Saggese, A. G. M. Strollo, and E. Napoli,
Approximate Recursive Multipliers Using Low Power Building Blocks,
IEEE Transactions on Emerging Topics in Computing,
vol. 10, no. 3, pp. 1315–1330, Jul. 2022, DOI: 10.1109/TETC.2022.3186240.

G. Di Meo, G. Saggese, A. G. M. Strollo, D. De Caro, and N. Petra,
Approximate Floating-Point Multiplier based on Static Segmentation,
Electronics,
vol. 11, no. 19, p. 3005, Sep. 2022, DOI: 10.3390/electronics11193005.

G. Saggese and A. G. M. Strollo,
Low-Power Energy-Based Spike Detector ASIC for Implantable Multichannel BMIs,
Journal of Electronics,
vol. 11, no. 18, p. 2943, Sep. 2022, DOI: 10.3390/electronics11182943.

G. Di Meo, G. Saggese, A. G. M. Strollo, and D. De Caro,
Design of Generalized Enhanced Static Segment Multiplier with Minimum Mean Square Error for Uniform and Nonuniform Input Distributions,
Electronics,
vol. 12, no. 2, p. 446, Jan. 2023, DOI: 10.3390/electronics12020446.

E. Zacharelos, I. Nunziata, G. Saggese, A. G. M. Strollo, and E. Napoli,
Approximate squaring circuits exploiting recursive architectures,
Integration,
vol. 91, pp. 35–42, Jul. 2023, DOI: 10.1016/j.vlsi.2023.02.007.

G. Di Meo, G. Saggese, A. G. M. Strollo, and D. De Caro,
Approximate MAC unit using Static Segmentation,
EEE Transactions on Emerging Topics in Computing,
vol., no. 01, p. 1-12, Sep. 2023, DOI: 10.1109/TETC.2023.3315301.

International conference papers

M. Tambaro, E. A. Vallicelli, G. Saggese, A. La Gala, M. Maschietto, A. Leparulo, A. Strollo, M. D. Matteis, A. Baschirotto, and S. Vassanelli,
A scalable spike detection method for implantable high-density multielectrode array,
International Conference on SMACD and 16th Conference on PRIME,
online, 2021, pp. 1-4., Publisher VDE.

G. Saggese, E. Zacharelos, and A. G. M. Strollo,
Low Power Spike Detector for Brain-Silicon Interface using Differential Amplitude Slope Operator,
International Conference on Ph.D Research in Microelectronics and Electronics (PRIME),
Jun. 2022, pp. 301-304, Publisher IEEE, DOI: 10.1109/PRIME55000.2022.9816758.

I. Nunziata, E. Zacharelos, G. Saggese, A. M. G. Strollo, and E. Napoli,
Approximate Recursive Multipliers Using Carry Truncation and Error Compensation,
International Conference on Ph.D Research in Microelectronics and Electronics (PRIME),
Jun. 2022, pp. 137-140, Publisher IEEE, DOI: 10.1109/PRIME55000.2022.9816787.

G. Saggese, E. Napoli, and A. G. M. Strollo,
CFPM: Run-time Configurable Floating-Point Multiplier,
International Conference on Ph.D Research in Microelectronics and Electronics (PRIME),
Jun. 2023, Publisher IEEE, DOI: 10.1109/PRIME58259.2023.10161866

Awards and Prizes

In 2022, Gerardo Saggese was awarded the "GOLD LEAF" for being in the top 10% papers at the International Conference on Ph.D Research in Microelectronics and Electronics (PRIME).

Date 09/10/2023

PhD student signature Gerardo Saggese

Supervisor signature