



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

PhD Student: Eliana Cinotti

Cycle: XXXIX

Training and Research Activities Report

Academic year: 2023-24 - PhD Year: First

Tutor: prof. Paolo Bifulco

Date: October 31, 2024

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1. Information:

- **PhD student:** Eliana Cinotti **PhD Cycle:** XXXIX
- **DR number:** DR997207
- **Date of birth:** 18/04/1998
- **Master Science degree:** Biomedical Engineering **University:** Università degli Studi di Napoli Federico II
- **Scholarship type:** PNRR-Partenariato Esteso PE14-"RESTART - RESearch and innovation on future Telecommunications systems and networks, to make Italy more smART"
- **Tutor:** Prof. Paolo Bifulco
- **Period abroad:** Period and research activity abroad spent from 2nd October 2024 to 31st October 2024, at Department of Mechanical, Biomedical and Design Engineering, Aston University, Birmingham B47 7ET, UK, under the supervision of Prof. Antonio Fratini.

2. Study and training activities:

Activity	Type ¹	Hours	Credits	Dates	Organizer	Certificate ²
Programmazione LabVIEW BASE	Other courses	20	2	From 28/11/2023 to 01/12/2023	Nicola Bavarone	Y
Energy-Efficient Data Science	Smeniar	1	0.2	13/12/2023	Prof. Elio Masciari	Y
Multi-agent autonomous flight at Leonardo Labs	Seminar	1	0.2	21/12/2023	Prof. Vincenzo Lippiello	Y
Study on Telemedicine, wearable devices, communication and teamwork in healthcare	Research		2	01/11/2023 - 31/12/2023		
Laboratory activity to design an electronic system for detection of bio-signals in application of telemedicine	Research		3	01/11/2023 - 31/12/2023		
Costituzione e sovranismo digitale	Seminar	3	0.6	30/01/2024	Prof. Luca Di Majo, Prof Andrea Patroni Griffi	Y
AI @ The Deep Edge	Other Courses	21	3	From 31/01/2024 to 02/02/2024	STMicroelectronics	Y

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Study on photoplethysmography signal processing and acquisition	Research		2	01/01/2024 – 29/02/2024		
Laboratory activities on wearable devices and cloud data transmission	Research		2	01/01/2024 – 29/02/2024		
Analytic center selection of optimization-based controllers for robot ecology	Seminar	1	0.2	09/04/2024	Prof. Bruno Siciliano	Y
Exploring the Frontiers of Modern Cryptography	Seminar	1.5	0.3	12/04/2024	Prof. Simon Pietro Romano	Y
Study of electrocardiographic signals of patients with atrial fibrillation	Research		6	01/03/2024 – 30/04/2024		
Using Deep Learning properly	Course	12	4	23-25-30/01/2024 01-06-08/02/2024	UniNa-DIETI- Prof. Andrea Apicella	Y
An overview of polytopal approximations of partial differential equations	Seminar	1	0.2	02/05/2024	SSM	Y
IEEE Authorship and Open Access Symposium: Tips and Best Practices to Get Published from IEEE Editors,	Seminar	2	0.4	07/05/2024	IEEE	Y
Rewire the brain: the potential of neuroplasticity	Seminar	2	0.4	09/05/2024	5G Academy	Y
Explaining and controlling turbulent flows through deep learning	Seminar	1	0.2	09/05/2024	SSM	Y
5G & digital transformation: a view from an unconventional perspective	Seminar	4	0.8	10/05/2024	5G Academy	Y
Regolazione in tema di intelligenza artificiale alla luce dell'AI ACT	Seminar	5	1	13/05/2024	5G Academy	Y
Riabilitazione Robot-assistita sul modello SLA	Seminar	1.5	0.3	14/05/2024	Prof.ssa Fanny Ficuciello	Y

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Waves where physics meet biology: collective states of motile cilia	Seminar	1	0.2	23/05/2024	SSM	Y
Machine Deception	Seminar	1	0.2	23/05/2024	Prof. Alessandra Rossi	Y
Generative AI for software engineering: strategies, impacts, and practical applications,	Seminar	5	1	29/05/2024	5G Academy	Y
Preparation and revision of the paper “A narrowband IoT personal sensor for long-term heart rate monitoring and atrial fibrillation detection”	Research		8	01/05/2024 – 30/06/2024		
Computer interface for biological system	Other Course-MSc course	48	6	From 04/03/2024 to 05/06/2024	UniNa-DIETI-Prof. Paolo Bifulco	Y
Biomedical Imaging	Other Course-MSc course	48	6	From 06/03/2024 to 06/06/2024	UninNa-DIETI-Prof. Emilio Andreozzi	Y
Study on atrial fibrillation detection device integrating artificial intelligence.	Research		2	01/07/2024 – 31/08/2024		
Publication of the papers: “Narrowband IoT Personal Sensor for Long-Term Heart Rate Monitoring and Atrial Fibrillation Detection” and “A Learned-SVD Approach to the Electromagnetic Inverse Source Problem”.	Research		3	01/07/2024 – 31/08/2024		
Study on wearable devices for cardiac monitoring, focusing on atrial fibrillation detection, including the use of artificial intelligence.	Research		2	01/09/2024 – 31/09/2024		

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Period and research activities aboard on the development of wearable sensors for monitoring cardiac activity.	Research		2	02/10/2024 – 31/10/2024		
Analysis of signals for monitoring cardiac activity and respiration, along with the preparation of a paper on this topic.	Research		3	01/09/2024 – 31/10/2024		

- 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	0.4	5	0	7.4
Bimonth 2	3	0.6	4	0	7.6
Bimonth 3	0	0.5	6	0	6.5
Bimonth 4	4	4.7	8	0	16.7
Bimonth 5	12	0	5	0	17
Bimonth 6	0	0	7	0	7
Total	21	6.2	35	0	62.2
Expected	20 - 40	5 - 10	10 - 35	0 – 1.6	

3. Research activity:

The goal of the work carried out during the first year, was focused on the study of wearable devices based on integrated circuits. The possibility of connecting these devices to the cloud was presented, allowing not only for user data storage but also for the online analysis of acquired data instead of on the board. The project is based on designing and testing a narrowband personal IoT sensor for long-term heart rate monitoring and atrial fibrillation (AF) detection, mainly dealing with the software part. This study proposes an Internet of Things (IoT) sensor that can provide a very long period of continuous monitoring. The sensor consists of an ECG-integrated Analog Front End (MAX30003), a microcontroller (STM32F401RE), and an IoT narrowband module (STEVAl-STMODLTE). The instantaneous heart rate is extracted from the ECG recording in real time. At intervals of two minutes, the sequence of inter-beat intervals is transmitted to an IoT cloud platform (ThingSpeak). The software for recognising atrial fibrillation events runs on the cloud and generates alerts when it recognises such an arrhythmia. Performances of the proposed sensor were evaluated by generating analog ECG signals from a public dataset of ECG signals with atrial fibrillation episodes, the MIT-BIH Atrial Fibrillation Database, each recording lasting approximately 10h. Software implementing the Lorentz algorithm, one of the best detectors of atrial fibrillation, was implemented on the cloud platform. The accuracy, sensitivity, and specificity in recognizing atrial fibrillation episodes of the proposed system was calculated by comparison with a cardiologist's reference data. Across all patients, the proposed method achieved an accuracy of 0.88, a sensitivity 0.71, and a specificity 0.99. The results obtained suggest that

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the developed system can continuously record and transmit heart rhythms effectively and efficiently and, in addition, offers considerable performance in recognizing atrial fibrillation episodes in real time. This study has some limitations. The prototype device was tested only on ECG data reproduced by the patient simulator, and not on actual patients. The transmitting device was tested only in a laboratory environment, and not during trips; hence, potential issues due to network coverage could not be assessed. The AF detection performance was tested on ECG data from the MIT-BIH Atrial Fibrillation Database which were not heavily corrupted by noise. Moreover, the ECG data analyzed in this study comprised only AF episodes, so the specificity of AF detection was not assessed in the presence of additional cardiac arrhythmias. In a real-world scenario, motion artifacts, electromagnetic interferences, and muscle electrical activity may significantly degrade ECG signal quality and hinder the performance of the MAX30003 in heartbeat detection and inter-beat interval estimation. Future trends will certainly include the development of new device features. Once a rhythm abnormality is recognized, the morphology of the ECG tracing needs to be further analyzed to confirm the absence of coordinated atrial activity represented by P waves and/or to exclude recording artifacts. At present, the ECG signal is erased from time to time, retaining only the rhythm data. In the future, at each AF detection, the corresponding ECG trace will be automatically stored and transmitted to the cloud, so as to provide physicians with incontrovertible evidence of the discovery of transient AF episodes. In addition, it is planned to activate a messaging service aimed at both the patient and the physician to convey information to stakeholders in a timely manner and to trigger the acquisition of further information about the circumstances surrounding recognized episodes of AF. In the last part of the year the topic of integrated circuits for biomedical applications was explored, incorporating artificial intelligence (AI) into the circuit to perform data pre-processing and provide users with greater accuracy regarding the acquired data.

4. Research products:

Scientific Papers:

- Cinotti, E.; Centracchio, J.; Parlato, S.; Andreozzi, E.; Esposito, D.; Muto, V.; Bifulco, P.; Riccio, M. A Narrowband IoT Personal Sensor for Long-Term Heart Rate Monitoring and Atrial Fibrillation Detection. *Sensors* 2024, 24, 4432. <https://doi.org/10.3390/s24144432>
- Capozzoli, A.; Catapano, I.; Cinotti, E.; Curcio, C.; Esposito, G.; Gennarelli, G.; Liseno, A.; Ludeno, G.; Soldovieri, F. A Learned-SVD Approach to the Electromagnetic Inverse Source Problem. *Sensors* 2024, 24, 4496. <https://doi.org/10.3390/s24144496>

5. Conferences and seminars attended

During the first year I did not attend any conferences or seminars.

6. Activity abroad:

In the current year I spent a period and research activity abroad from 2nd October 2024 to 31st October 2024, at Department of Mechanical, Biomedical and Design Engineering, Aston University, Birmingham B47 7ET, UK, under the supervision of Prof. Antonio Fratini. During this period, I focused on the study of heart activity monitoring sensors for wearable devices and on the analysis of signals for

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monitoring cardiac activity and respiration. Heart rate and breathing rate are acquired and calculated using Phyphox, an open-source Android application. This app relies on signals from seismocardiography (SCG) and gyrocardiography (GCG), gathered by the smartphone's internal components, such as the accelerometer and gyroscope. By accurately analyzing the various signal components, detailed information about the user's heart rate and respiration can be obtained. The acquisitions were carried out with the subjects in a supine position. During the study, the ECG signal was recorded using a cardiac monitor, while the respiratory signal was captured with an electro-resistive respiratory band (ERB).

7. Tutorship

During this first year, I did not carry out any tutorship activities.