



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

PhD Student: Salvatore Parlato

Cycle: XXXIX

Training and Research Activities Report

Academic year: 2024-25 - PhD Year: Second

Tutor: prof. Paolo Bifulco

Co-Tutor: prof. Emilio Andreozzi

Date: October 31, 2025

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Author: Salvatore Parlato

1. Information:

- **PhD student:** Salvatore Parlato
- **DR number:** DR997185
- **Date of birth:** 25/08/1994
- **Master Science degree:** Biomedical Engineering
- **University:** University of Naples Federico II
- **Scholarship type:** UNINA
- **Tutor:** Prof. Paolo Bifulco
- **Co-Tutor:** Prof. Emilio Andreozzi
- **Period abroad:**

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Aston University, Birmingham, UK from November 1, 2024 – November 30, 2024.

University of Zaragoza, Spain from October 5, 2025 – October 30, 2025.

2. Study and training activities:

Activity	Type ¹	Hours	Credits	Dates	Organizer	Certificate ²
Shaping robustly control loop: look into stability margins & uncertainties.	Seminar	1	0.2	05.12.2024	Prof. Ciro Visone	Y
Study on measurement techniques to record heartbeat vibrations via smartphone inertial units. Development of an automatic algorithm to localize heartbeats from different kinds of bio-signals.	Research		6	01.11.2024 – 31.12.2024		
Biomedical instrumentation	Tutorship		0.3	01.12.2024 – 31.12.2024		
Design methodologies for digital circuits and systems oriented to FPGA	Course		2.4	18.02.2025 – 27.02.2025	Prof. Gennaro Di Meo	Y
Can we Rely on AI? Reliability Issues in Artificial Neural Networks and Potential	Seminar	1	0.2	16.01.2025	Prof. Edoardo Giusto	Y

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Solutions for Autonomous Vehicles						
The Good, the Bad, and the Ugly in Quantum Computing: Computational Power, Intrinsic Noise, and Transient Faults	Seminar	1	0.2	17.01.2025	Prof. Edoardo Giusto	Y
Bridging Physics to Biomedical Sciences	Seminar	1	0.2	30.01.2025	Dr. Francesco Bajardi	Y
Optimisation-based Control of Flexible Resources in Sustainable Energy Networks	Seminar	1	0.2	05.02.2025	Prof. Luigi Glielmo	Y
Solving distributed delay differential equations (with motivation from pharmacodynamics)	Seminar	1	0.2	06.02.2025	Dr. Francesco Bajardi	Y
Emergent behaviors and collective decisions in cyber-physical human systems	Seminar	1	0.2	13.02.2025	Dr. Alessandro Della Pia	Y
Lunar Laser Retroreflectors for ESA-ASI's Moonlight, Farside & South Pole	Seminar	1	0.2	16.02.2025	Dr. Francesco Bajardi	Y
Study on a novel PVDF sensor to record the mechanical vibrations from various sites of human body.	Research		6	01.01.2025 – 28.02.2025		
Co-supervisor of student Daniele Longobardo's bachelor's thesis entitled “Design and prototype development of an electro-mechanical cardiac monitoring system”.	Tutorship		0.2	01.01.2025 – 28.02.2025		
Support for the organisation of the ‘Porte aperte’ orientation event	Tutorship		0.3	01.01.2025 – 28.02.2025		

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5G & DIGITAL TRANSFORMATION: A VIEW FROM AN UNCONVENTIONAL PERSPECTIVE-SECOND EDITION	Seminar	4	0.8	14.03.2025	Prof. Antonia Tulino	Y
Study on creation of FOSTER, the first dataset of Forcecardiography signals. Development of a single-sensor acquisition system to record mechanical vibrations and sounds generated by blood flow in patients with arteriovenous fistula (AVF). Preliminary study on cardiac resynchronization therapy (CRT) patients.	Research		6	01.03.2025 – 30.04.2025		
Unveiling the faintest side of the Universe: discoveries, structure and open issues on ultra-diffuse galaxies.	Seminar	1	0.2	08.05.2025	Dr. Francesco Bajardi	Y
The Strong Crystalline Field: or how to play with particle beams using tiny crystals!	Seminar	1	0.2	15.05.2025	Dr. Francesco Bajardi	Y
Numerical analysis for the dynamics of delay equations	Seminar	1	0.2	22.05.2025	Dr. Alessandro Della Pia	Y
The initial boundary value problem in General Relativity	Seminar	1	0.2	29.05.2025	Dr. Francesco Bajardi	Y
Superconducting Radio Frequency Cavities for Quantum Computing and Communication	Seminar	1	0.2	24.06.2025	Prof. Edoardo Giusto	Y
Trusted Execution Environments for QPUs	Seminar	1	0.2	27.06.2025	Prof. Edoardo Giusto	Y
In-depth study of mechanical vibrations and sounds generated by the blood flow in patients with	Research		6	01.05.2025 – 30.06.2025		

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arteriovenous fistula and test of a single-sensor acquisition system.						
Biomedical instrumentation	Tutorship		0.3	01.05.2025 – 30.06.2025		
Strumentazione e Ingegneria Clinica	MSc Course	72	9	01.07.2025	Prof. Paolo Bifulco	Y
Reconfigurable femtosecond-laser-written interferometers for quantum photonics	Seminar	1	0.2	03.07.2025	Prof. Andrea Crespi	Y
Affidabilità dell'AI: è possibile definire dei confini accettabili consapevolmente?	Seminar	2	0.4	08.07.2025	Prof. Leopoldo Angrisani	Y
Study on straightly estimates muscle force via Force myography (FMG). Submission and revision of some scientific papers.	Research		5	01.07.2025 – 31.08.2025		
XLIV Annual School 2025 – Unlocking the Mind and Emotions, Pisa, Italy	PhD School	16	3.2	15.09.2025 – 19.09.2025	Gruppo Nazionale di Bioingegneria (GNB)	Y
2025 Spring School on Transferable Skills	Type C Course	9	2	30.10.2025 – 31.10.2025	Dipartimento di Farmacia Università degli studi di Napoli Federico II	Y
Development of a multi-sensor acquisition system to record the mechanical vibrations and sounds generated by the blood flow in AVF patients. Study on Force cardiography (FCG) and ECG signal processing to optimize cardiac resynchronization therapy (CRT) parameters and blood pressure estimation via	Research		15	01.09.2025 – 31.10.2025		

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pulse transit time (PTT) calculation.						
Biomedical instrumentation	Tutorship		0.3	01.09.2025 – 30.09.2025		

- 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	0.2	6	0.3	6.5
Bimonth 2	2.4	1.4	6	0.5	10.3
Bimonth 3	0	0.8	6	0	6.8
Bimonth 4	0	1.2	6	0.3	7.5
Bimonth 5	9	0.6	5	0	14.6
Bimonth 6	2	3.2	15	0.3	20.5
Total	13.4	7.4	44	1.4	66.2
Expected	10 - 20	5 - 10	30 - 45	0 - 1.6	

3. Research activity:

▪ Innovative devices and methods for cardio-mechanical monitoring

During my second year of PhD course, I carried out research activities in the field of “*Innovative devices and methods for cardio-mechanical monitoring*”. In this year, my research activity mainly focused on the design, development, and testing of a new wearable sensor for Forcecardiography (FCG) measurements. Forcecardiography (FCG) uses force sensors to record the mechanical vibrations induced on the chest wall by cardiac and respiratory activities. FCG is usually performed via piezoelectric lead-zirconate titanate (PZT) sensors, which simultaneously record the very slow respiratory movements of the chest, the slow infrasonic vibrations due to emptying and filling of heart chambers, the faster infrasonic vibrations due to movements of heart valves, which are usually recorded via Seismocardiography (SCG), and the audible vibrations corresponding to heart sounds, commonly recorded via Phonocardiography (PCG). However, PZT sensors are not flexible and do not adapt very well to the deformations of soft tissues on the chest. I proposed a sensor based on a polyvinylidene fluoride (PVDF) piezoelectric transducer attached onto a 3D-printed TPU support and a mechanical coupler was attached to the sensor bottom that ensures good transmission of force from subject’s skin to the sensor active area. This sensor was able to capture the weak mechanical vibrations generated by the cardio-respiratory activity. The sensor requires much less power consumption and allows continuous and prolonged monitoring. I presented the results of this activity in the paper entitled “*A flexible PVDF Sensor for forcecardiography*”. In this study, I compared the PVDF FCG sensor with a well-assessed PZT FCG sensor, as well as with an electro-resistive respiratory band (ERB), an accelerometric SCG sensor, and an electronic stethoscope for PCG. I acquired these signals and an electrocardiographic (ECG) signal simultaneously from a cohort of 35 healthy subjects (16 males and 19 females). Moreover, I assessed the estimation accuracies of PVDF and PZT sensors for

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inter-beat intervals (IBIs) and inter-breath intervals (IBrIs) against reference ECG and ERB measurements. The results of statistical analyses confirmed that the PVDF sensor provides FCG signals with very high similarity to those acquired via PZT sensors (median cross-correlation index of 0.96 across all subjects) as well as with SCG and PCG signals (median cross-correlation indices of 0.85 and 0.80, respectively). Moreover, the PVDF sensor provides very accurate estimates of IBIs, with $R2 > 0.99$ and Bland–Altman limits of agreement (LoA) of $[-5.30; 5.00]$ ms, and of IBrIs, with $R2 > 0.96$ and LoA of $[-0.510; 0.513]$ s. The flexibility of the PVDF sensor makes it more comfortable and ideal for wearable applications. Unlike PZT, PVDF is lead-free, which increases safety and biocompatibility for prolonged skin contact. The flexible PVDF sensor provides several advantages over the PZT sensor, such as higher robustness and conformability to the human body, as well as improved stability to thermal drift. All these features make the flexible PVDF sensor more suitable for integration into wearable devices for continuous, long-term cardiorespiratory monitoring of subjects.

▪ A fully automated method to localize heartbeats from cardio-mechanical signals

During my second year of PhD, I also developed a fully automated method to localize heartbeats from cardiomechanical signals of both healthy and pathological subjects, and I show the results in the paper: “*A fully automated template matching method for ECG-free heartbeat detection in cardiomechanical signals*”. This study presented a fully automated template matching method for ECG-free heartbeat detection in cardiomechanical signals. The proposed method is an advancement of an earlier method, whose main limitation was the need to manually select the heartbeat template to search within the signal. The automatic template selection algorithm proposed in this study overcomes this limitation, thus making the overall method fully automated, reproducible, and operator-independent. This study represents an important step toward the effective implementation of continuous, long-term, ECG-free patient monitoring via wearable cardiomechanical sensors. The performance validation carried out in this study showed that, beyond the very high performance achieved on healthy subjects, the proposed method also ensured high performance on pathological subjects, thus demonstrating its effectiveness in monitoring actual patients, even with irregular and non-repetitive heartbeat morphologies. I validated this automatic method on 256 Seismocardiography (SCG), Gyrocardiography (GCG), and Forcecardiography (FCG) signals, from 150 healthy and pathological subjects. I carried out a comparison with all existing methods for ECG-free heartbeat detection. The method scored sensitivity and positive predictive value (PPV) of 97.8% and 98.6% for SCG, 96.3% and 94.5% for GCG, 99.2% and 99.3% for FCG, on healthy subjects, and of 85% and 95% for both SCG and GCG on pathological subjects. Statistical analyses on inter-beat intervals reported almost unit slopes ($R2 > 0.998$) and limits of agreement within ± 6 ms for healthy subjects and ± 13 ms for pathological subjects. The proposed automated method surpasses all previous ECG-free approaches in heartbeat localization accuracy and was validated on the largest cohort of pathological subjects and the highest number of heartbeats. The method proposed in this study represents the current state of the art for ECG free monitoring of cardiac activity via cardiomechanical signals, ensuring accurate, reproducible, operator-independent heartbeats localization. I also released a MATLAB® code as an off-the-shelf tool to support a more widespread and practical use of cardio-mechanical monitoring in both clinical and non-clinical settings.

▪ FOSTER: the first dataset of Forcecardiography signals

During the second year of my PhD, I carried out simultaneous acquisitions of forcecardiography (FCG), seismocardiography (SCG), phonocardiography (PCG), respiratory and electrocardiographic (ECG) signals, with the aim of creating a unique, publicly accessible database, as well as promoting and facilitating research into non-invasive cardio-respiratory monitoring using mechanical sensors. To achieve this, I collected data from 40 healthy subjects (20 males and 20 females) using force sensors, an accelerometer, an electro-resistive band (ERB), an electronic stethoscope, and an ECG monitor. All signals were acquired simultaneously to ensure precise temporal alignment for accurate analysis. Each recording lasts about 7 minutes and includes both long phases of quiet breathing and short phases of inspiratory and expiratory apneas. The study was carried out in accordance with the Declaration of Helsinki and approved by the Ethical Committee "Università Federico II - AORN A. Cardarelli" (prot. nr. 0015104, date: 28 March 2023). Informed consent was obtained from all subjects involved in the study. These acquisitions led to the creation of FOSTER, the first forcecardiography database, with simultaneous acquisition of SCG, PCG, ECG and respiratory signals. The open accessibility of the FOSTER dataset aims to facilitate advancements in unobtrusive cardio-respiratory patient monitoring, support the development of novel diagnostic tools and algorithms to detect specific events of the cardiac and respiratory cycles, and help researchers to explore the potential of combined electrical and mechanical cardiac monitoring. I performed the technical validation of the dataset by first assessing the quality of the data via the estimation of signal-to-noise ratio (SNR) and by evaluating the error associated with the estimation of key vital signs, such as the instantaneous heart rate and respiratory rate. This analysis provides evidence of signals quality and consistency with respect to the reference signals. I published the FOSTER dataset on *Scientific Data* journal (<https://doi.org/10.1038/s41597-025-05694-2>).

▪ Development of innovative devices to record the mechanical vibrations and sounds generated by blood flow in patients with arterio-venous fistulas

The arteriovenous fistula (AVF) generates easy vascular access for hemodialysis in end-stage kidney disease patients. AVF management is essential for a successful dialysis treatment and can influence long-term patient survival. Physical examination is the first step to diagnose and treat a malfunctioning AVF and includes palpation of AVF pulse and thrill, and auscultation of bruit sounds. Guidelines recommend frequent visits during AVF maturation and throughout the dialysis period, with large deployment of financial and human resources. A tele-monitoring system can enable more frequent monitoring and earlier recognition of stenoses.

During the second part of the year, I collaborated with other colleagues in a PRIN project based on the development and testing of a new system to record the vibrations and sounds induced by blood flow in patients with arteriovenous fistulas. The system is based on a small, lightweight, non-invasive piezoelectric force sensor that records infrasonic and audible vibrations from the skin over the anastomosed vein of a patient's forearm. An ad hoc signal processing allows accurate separation of the sphygmic pulse from the thrill and bruit sounds. We tested proposed system on 18 patients. Recordings were acquired on measurement sites along the anastomosed vein to verify the progressive amplitude reduction of thrill and bruit sounds from the anastomosis. Additional recordings were acquired during the vein occlusion test, to verify the brisk amplitude reduction of thrill and bruit sounds observed in routine examinations. One-tailed Wilcoxon rank sum tests confirmed the expected amplitude reductions in both tests ($p < 0.0001$). This study proposed, for the first time in literature, a solution that allows quantitative analysis of infrasonic

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thrill vibrations, in addition to bruit sounds, and sphygmic pulses. We showed the results in the paper entitled: “*A novel system to record pulses, thrills, and bruit sounds generated by arteriovenous fistulas*”. This paper is currently under review and will be published shortly. About this field, I also developed a 4-force sensor acquisition system to record the vibrations and sounds induced by blood flow in patients with arteriovenous fistulas to capture vascular signals at multiple sites at the same time, from the anastomosis to the brachial artery and provide a complete and detailed view of AVF hemodynamics. This multimodal, multi-location approach allows researchers to study flow patterns and detect potential abnormalities along the entire length of access.

- **Analysis and monitoring vital signs via smartphone inertial units**

Seismocardiography (SCG) and Gyrocardiography (GCG) use lightweight, miniaturized accelerometers and gyroscopes to record, respectively, cardiac-induced linear accelerations and angular velocities of the chest wall. These inertial sensors are also sensitive to thoracic movements with respiration, which cause baseline wanderings in SCG and GCG signals. Nowadays, accelerometers and gyroscopes are widely integrated into smartphones, thus increasing the potential of SCG and GCG as cardiorespiratory monitoring tools. During my period abroad in Birmingham, UK from 1st November 2024 to 30th November 2024, I collaborated with other colleagues in a study aimed at continuous, long-term monitoring of heart and breathing rates via smartphone inertial units. We showed the results in a paper entitled “*Accuracy of the Instantaneous Breathing and Heart Rates Estimated by Smartphone Inertial Units*”. This study investigates the accuracy of smartphone inertial sensors in simultaneously measuring instantaneous heart rates and breathing rates. Smartphone-derived SCG and GCG signals were acquired from 10 healthy subjects at rest. The performances of heartbeats and respiratory acts detection, as well as of inter-beat intervals (IBIs) and inter-breath intervals (IBrIs) estimation, were evaluated for both SCG and GCG via the comparison with simultaneous electrocardiography and respiration belt signals. Moreover, IBIs measurements reported strong linear relationships ($R^2 > 0.999$), non-significant biases, and Bland–Altman limits of agreement (LoA) of ± 7.33 ms for SCG and ± 5.22 ms for GCG. On the other hand, respiratory acts detection scored a sensitivity and PPV of 95.6% and 94.7% for SCG and of 95.7% and 92.0% for GCG. Furthermore, high R^2 values (0.976 and 0.968, respectively), non-significant biases, and LoA of ± 0.558 s for SCG and ± 0.749 s for GCG were achieved for IBrIs estimates. The results of this study confirm that smartphone inertial sensors can provide accurate measurements of both instantaneous heart rate and breathing rate without the need for additional devices.

- **Monitoring of respiration and cardiorespiratory interactions**

In the last part of the year, I collaborated with other colleagues in a study entitled “*Monitoring of respiration and cardiorespiratory interactions from multichannel seismocardiography*”. This study investigated the influence of accelerometer placement on the monitoring accuracy of respiration and cardiorespiratory interactions from SCG signals. Simultaneous recordings acquired by 16 accelerometers and a respiration belt placed onto 9 subjects’ chests were analyzed. Respiratory signals were estimated considering: (a) chest inclination, (b) amplitude modulation (AM) and (c) morphological changes of SCG signals for each sensor location. For the first time in literature, a continuous description of respiratory-induced changes in SCG morphology was obtained via a morphological similarity index (MSi). The

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performance of respiratory acts detection and inter-breath intervals (IBIs) estimation was evaluated against the concurrent reference respiration signal. High accuracy was achieved in all three kinds of respiratory signals, with average sensitivity and positive predictive value of 95.8% and 95.5% for chest inclination, 85.9% and 84.4% for AM, 94.3% and 95.7% for MSi. Moreover, IBIs measurements showed non-significant biases and limits of agreement of about ± 0.8 s for chest inclination and MSi, and ± 1 s for AM. Performance achieved by chest inclination and MSi appeared not much influenced by sensor location, while AM showed higher variations. Information on breathing and cardiorespiratory interactions can be accurately obtained via SCG on multiple sites on the chest. Some differences were found for amplitude modulation of SCG signals acquired at different sensors locations, but no general conclusions could be drawn because of the limited number of subjects involved. Analyses of SCG signals from a larger cohort of subjects, including elderly people and patients with cardio-pulmonary diseases, are envisioned in the future, also considering different body postures and movements, as well as wider ranges of respiratory rates and depths.

▪ Other research activities

I contributed to various other studies. The first one aimed to evaluate the performance of ForceMyography (FMG) compared to surface Electromyography (EMG) in estimating instantaneous muscle force during isometric contractions. This study involved simultaneously recording FMG, EMG, and torque signals during gradual and rapid isometric biceps brachial contractions in ten healthy subjects. Sigmoidal regression models were used to estimate the actual developed force recorded at the wrist using a load cell.

Furthermore, I contributed to a preliminary study on forcecardiography (FCG) capability to predict echocardiography parameters in patients undergoing cardiac resynchronization therapy (CRT). We showed the preliminary results in a paper entitled “A PRELIMINARY STUDY ON FORCECARDIOGRAPHY CAPABILITY TO PREDICT ECHOCARDIOGRAPHY PARAMETERS IN PATIENTS UNDERGOING CARDIAC RESYNCHRONIZATION THERAPY” presented at Heart Rhythm Conference 2025 in San Diego, CA. This study aimed to assess the correlation between FCG-derived features and ECG/ECHO parameters, exploring additional tools for diagnosis and treatment planning, across intrinsic rhythm and pacing modalities. FCG and ECG signals were collected from 11 HFrEF patients (ischemic and non-ischemic etiologies) with CRT-D devices under intrinsic rhythm, biventricular pacing (BiV), and right ventricular pacing (RV). FCG features, including energy, skewness, and kurtosis, were extracted and compared with ECG-derived metrics (e.g., QRS duration) and ECHO parameters (stroke volume (SV), global longitudinal strain (GLS), LVOT velocity-time integral (VTI), and global work index (GWI)). Regression models evaluated relationships between FCG features and ECG/ECHO parameters, with performance assessed using R^2 and root mean squared error (RMSE). Significant correlations were observed between FCG-derived features and ECG/ECHO parameters (coefficients: -0.53 to 0.85). Regression models showed high predictability for GWI ($R^2=0.93$, $RMSE=174.44$ mmHg%), LVOT VTI ($R^2=0.90$, $RMSE=3.51$ cm), and SV ($R^2=0.91$, $RMSE=12.09$ mL). FCG proved to be a promising non-invasive method for estimating ECHO metrics such as GWI, LVOT VTI, and SV. FCG-derived features, particularly kurtosis, showed strong predictive value across intrinsic rhythm and pacing modalities. Larger studies are needed to validate these findings and establish broader clinical use.

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In addition, I contributed to a paper entitled: “*Spectral Analysis of AVF Signals for Early Dysfunction Detection: Towards AI-Based Home Monitoring*”.

This work presents a signal processing pipeline based on spectral analysis for early detection of AVF dysfunction, using acoustic signals recorded via a portable, wearable acquisition system. The custom-designed sensor platform captures mechanical vibrations from the AVF site, enabling the collection of real-world vascular signals in both stenotic and non-stenotic conditions. The signals are analyzed using deterministic techniques, including Fast Fourier Transform (FFT), Short-Time Fourier Transform (STFT), and Mel spectrograms, from which twelve frequency domain features are extracted and evaluated. Results indicate that features such as Area Under the Curve (AUC), f_{95} , and skewness show strong discriminatory power between pathological and healthy cases. These findings demonstrate the feasibility of lightweight, embedded-compatible algorithms for future integration into AI-based, real-time monitoring platforms. The proposed approach lays the groundwork for continuous, at-home AVF monitoring through wearable biomedical technologies. This paper has been accepted, and it will be presented at 2025 International Workshop on Biomedical Applications, Technologies and Sensors (BATS).

At the end of the year, I contributed with other colleagues in a study aimed to verify the possibility of using neural network algorithms directly on a micro-controller connected to sensors for the recognition of atrial fibrillation. Sequences of 25, 50, and 100 RR were extracted from a public database of electrocardiographic signals with annotated episodes of atrial fibrillation. The sequences were used to train and test a custom 1D-CNN model. A progressive enhancement in model performance was observed as the RR window length increased, with accuracy rising from 0.951 (25RR) to 0.965 (50RR) and 0.978 (100RR). This improvement suggests that longer RR sequences provide richer temporal information, enabling the CNN to more effectively learn rhythm irregularities characteristics of atrial fibrillation. A prototype sensor consisting of a low-power ECG analog front-end, an ARM Cortex M7 micro-controller, and an IoT transmitting module was utilized for realistic tests. Inferencing time, peak RAM usage, flash usage and current absorption were measured. The results obtained show the possibility of using neural network algorithms directly on micro-controllers for real-time recognition of atrial fibrillation with very low power consumption. The prototype is also capable of sending the suspicious ECG trace to the cloud for final validation by a physician. The proposed methodology can be used for personal screening not only with ECG signals but with any other signal that reproduces the sequence of heartbeats (e.g., photoplethysmographic, pulse oximetric, pressure, accelerometric, etc.). We showed the results in a paper entitled “*An Edge-AI approach for low-power, real-time atrial fibrillation detection on wearable devices based on heartbeat intervals*”. This paper is currently being submitted.

4. Research products:

a. scientific papers:

Title: Accuracy of the Instantaneous Breathing and Heart Rates Estimated by Smartphone Inertial Units.

Authors: Cinotti, E.; Centracchio, J.; Parlato, S.; Esposito, D.; Fratini, A.; Bifulco, P.; Andreozzi, E.

Journal: Sensors – indexed in Scopus and ISI Web of Science

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Current status: Published (<https://doi.org/10.3390/s25041094>).

Title: A Flexible PVDF Sensor for Forcecardiography.

Authors: Parlato, S.; Centracchio, J.; Cinotti, E.; Gargiulo, G.D.; Esposito, D.; Bifulco, P.; Andreozzi, E.

Journal: Sensors – indexed in Scopus and ISI Web of Science

Year: 2025

Current status: Published (<https://doi.org/10.3390/s25051608>).

Title: Fully automated template matching method for ECG-free heartbeat detection in cardiomechanical signals of healthy and pathological subjects.

Authors: Parlato, S., Centracchio, J., Esposito, D., Bifulco, P., Andreozzi, E.

Journal: Physical and Engineering Sciences in Medicine – indexed in Scopus and ISI Web of Science

Year: 2025

Current status: Published (<https://doi.org/10.1007/s13246-025-01531-3>).

Title: A Forcecardiography dataset with simultaneous SCG, Heart Sounds, ECG, and Respiratory signals.

Authors: Parlato, S., Centracchio, J., Cinotti, E., Manzi, M.V., Canciello, G., Prastaro, M., Lembo, M., Brandwood, B.M., Gargiulo, G.D., Bifulco, P., Esposito, G., Izzo, R., Andreozzi, E.

Journal: Scientific Data (Nature) – indexed in Scopus and ISI Web of Science

Year: 2025

Current status: Published (<https://doi.org/10.1038/s41597-025-05694-2>).

Title: Monitoring of respiration and cardiorespiratory interactions from multichannel seismocardiography signals.

Authors: Centracchio, J., Parlato, S., Schmidt, S.E., Bifulco, P., Esposito, D., Andreozzi, E.

Journal: Physical and Engineering Sciences in Medicine (Springer) – indexed in Scopus and ISI Web of Science

Year: 2025

Current status: Published (<https://doi.org/10.1007/s13246-025-01657-4>).

Title: A novel system to record pulses, thrills, and bruit sounds generated by arteriovenous fistulas.

Authors: Centracchio, J., Cinotti, E., Parlato, S., Bifulco, P., Zamboli, P., Liguori, R., Longo, G., Punzi, M., Liccardo, A., Buonavolontà, F., Capolongo, G., Andreozzi, E.

Journal: Sensors International – indexed in Scopus and ISI Web of Science

Year: 2025

Current status: Accepted.

Title: An Edge-AI approach for low-power, real-time atrial fibrillation detection on wearable devices based on heartbeat intervals.

Authors: Cinotti, E., Gragnaniello, M., Parlato, S., Centracchio, J., Andreozzi, E., Bifulco, P., Riccio, M., Esposito, D.

Journal: Sensors – indexed in Scopus and ISI Web of Science

Year: 2025

Current status: Submitted.

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b. conference papers:

Title: PO-07-024 A PRELIMINARY STUDY ON FORCECARDIOGRAPHY CAPABILITY TO PREDICT ECHOCARDIOGRAPHY PARAMETERS IN PATIENTS UNDERGOING CARDIAC RESYNCHRONIZATION THERAPY.

Authors: Salucci, A., Simonetti, A., Piccirillo, S., Centracchio, J., Andreozzi, E., Parlato, S., Pergola, V., Ammirati, G., Cocchiara, L., Visconti, P., Volpe, A., Faccenda, D., Parlato, E., Santoro, C., Strisciuglio, T., Rapacciuolo, A.

Conference: Heart Rhythm - indexed in Scopus and ISI Web of Science

Year: 2025

Current status: Published (<https://doi.org/10.1016/j.hrthm.2025.03.1784>)

Title: Spectral Analysis of AVF Signals for Early Dysfunction Detection: Towards AI-Based Home Monitoring.

Authors: Liguori, R., Longo, G., Di Benedetto, L., Licciardo, G.D., Centracchio, J., Parlato, S., Cinotti, E., Andreozzi, E., Buonavolontà, F., Liccardo, A., Zamboli, P., Punzi, M., Capolongo, G.

Conference: 2025 International Workshop on Biomedical Applications, Technologies and Sensors (BATS)- indexed in Scopus and ISI Web of Science

Year: 2025

Current status: Accepted.

5. Conferences and seminars attended

During my second year of PhD, I attended at the AIIC conference (14-17 June 2025, Naples, Italy): Tecnologie, sostenibilità, ambiente. Il contributo dell'innovazione alla sanità del futuro, where three research idea were showed as posters. Details are below:

- Bracciale sensorizzato per il monitoraggio continuo del ritmo cardiaco: un'alternativa allo smartwatch;
- Dispositivo indossabile per il riconoscimento di aritmie con tecniche di EDGE-AI;
- Sistema di telemonitoraggio per la fistola arterovenosa.

Furthermore, in the last part of the year, I attended at XLIV Annual School 2025 – Unlocking the Mind and Emotions, Pisa, from September 15, 2025, to September 19, 2025. The school offered a high-level multidisciplinary program, with presentations by Italian and international experts on engineering for mental health, computational neuroscience, emotion modelling, and technologies for psycho-physiological assessment and intervention.

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6. Periods abroad and/or in international research institutions

During my second year of PhD, I carried out study and research activities abroad, from 1st November 2024 to 30th November 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. In particular, I analyzed accelerometer and gyroscope data recorded via a smartphone in order to estimate instantaneous heart and breathing rates. I also helped in the development of a sensorized garment for cardio-respiratory monitoring using pressure sensors.

At the end of my second year of PhD, I carried out study and research activity abroad, from 5th October 2025 to 31st October 2025, at Departamento de Ingeniería Electrónica y Comunicaciones, University of Zaragoza, Spain, under the supervision of Prof. Pablo Laguna. During this period, I focused on the study of Cardiac Resynchronization Therapy (CRT) patients monitoring and blood pressure estimation via the calculation of the pulse transit time (PPT).

Details of the expected periods abroad are outlined below:

Expected period abroad: October 2, 2024 - November 30, 2024

City: Birmingham B47 7ET, UK

Host University: Aston University

Supervisor: Prof. Antonio Fratini

Activities carried out abroad: Development of wearable devices based on pressure sensors for monitoring vital signs.

Months spent abroad in the current year: 1 (30 days).

Expected period abroad: October 5, 2025 - November 30, 2025

City: Zaragoza, Spain

Host University: University of Zaragoza

Supervisor: Prof. Pablo Laguna

Activities carried out abroad: Use of force sensors to monitor blood pressure via the calculation of pulse transit time (PTT) and signal processing to optimize Cardiac Resynchronization Therapy (CRT) parameters.

Months spent abroad in the current year: ~1 (27 days).

6. Tutorship

During my second year of PhD, I was involved in several tutorship and academic support activities. Specifically, I conducted classroom tutorials within the courses CIBS and Biomedical Instrumentation. I also assisted my supervisor and co-supervisor during the written examinations for the courses Biomedical Instrumentation, Computer Interface for Biological Systems, and Biomedical Imaging. Additionally, I provided support during the student orientation event “Porte Aperte”.

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Finally, I acted as a co-supervisor for a bachelor's thesis within the Fundamentals of Bioengineering course. Details are below:

Student: Daniele Longobardo

Title: Design and prototype development of an electro-mechanical cardiac monitoring system.

Course: Fundamentals of bioengineering

Supervisor: Prof. Emilio Andreozzi

7. Plan for year three

Next year, I will mainly focus on Innovative devices and methods for cardio-mechanical monitoring which will be the topic of my PhD thesis. First, I will focus on creating a new database of mechanical signals caused by arteriovenous fistulas (AVF). I will also work on non-invasive blood pressure estimation by calculating pulse transit time (PTT) and optimizing Cardiac Resynchronization Therapy (CRT) parameters, which are the topics I worked on during my time abroad.

Another research plan is to study Forcecardiography (FCG) in depth, in particular working on non-invasive estimation of cardiac output by observing variations in stroke volume on FCG signals.

Finally, I would like to devote myself to the study and design of a new system capable of detecting vibrations on the human body without using force and pressure sensors.