



UNIVERSITÀ DEGLI STUDI DI NAPOLI
FEDERICO II

itee^{PhD}
information technology
electrical engineering



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Eliana Cinotti

Innovative sensors and telecommunications for telemedicine

Tutor: Prof. Paolo Bifulco
Co-Tutor: Prof. Emilio Andreozzi

Cycle: XXXIX

Year: Second

BACKGROUND

M.Sc. in Biomedical Engineering (University of Naples, Federico II) - Autoencoder for electromagnetic inverse source

Ph.D. in Information Technology and Electrical Engineering (ITEE) - 1st November 2023

Biomedical Instrumentation Team - Healthcare Automation, Biomedical Instrumentation and Telemedicine Laboratory

PNRR scholarship - Extended Partnership PE14 - **RESTART** - REsearch and innovation on future Telecommunications systems and networks, to make Italy more smART" - CUP: E63C22002040007 - Prof. Daniele Riccio

Period abroad - Aston University (Birmingham, UK) from 2nd October 2024 to 31st November 2024 and to University of Zaragoza (Zaragoza, Spain) from 5th October 2025 to 31st October 2025

RESEARCH FIELD

MONITORING OF VITAL SIGNS VIA PERSONAL DEVICES

Continuous and accurate measurement of physiological parameters is essential for early detection and prevention of health disorders.

The use of personal devices for vital signs monitoring has grown significantly in recent years.

My research activity focused on:

- Monitoring of vital signs via sensors integrated into commercially available personal devices
- Development of novel personal devices based on IoT and Edge-AI

MAIN STUDY ACTIVITIES

- Study on mechanical sensors to monitor cardiac and respiratory function;
- Development of a novel device for monitoring patients with Arteriovenous Fistula (AVF);
- Acquisition and processing of Forcecardiography signals acquired from patients with heart failure;
- Development of an Edge AI-based device for atrial fibrillation detection;
- Attendance at the conference «Telecommunication of the Future – Solution for Telecommunication & Telecommunication as a Solution» by RESTART Foundation ;
- Attendance at the AllC congress 2025 - Associazione Italiana Ingegneri Clinici
- Attendance at the XLIV Annual School GNB “Unlocking the Mind and Emotions”
- Study on cardio-mechanical signals acquired via inertial sensors integrated into smartphones – research activity abroad at Aston University (Birmingham, UK) from 1st November 2024 to 30th November 2024;
- Study on cardiomechanical signals acquired from Cardiac Resynchronization Therapy (CRT) patients and study on non-invasive blood pressure measurements via Forcecardiography – research activity abroad at University of Zaragoza (Zaragoza, Spain) from 5th October 2025 to 31st October 2025.

MONITORING OF VITAL SIGNS VIA PERSONAL DEVICES

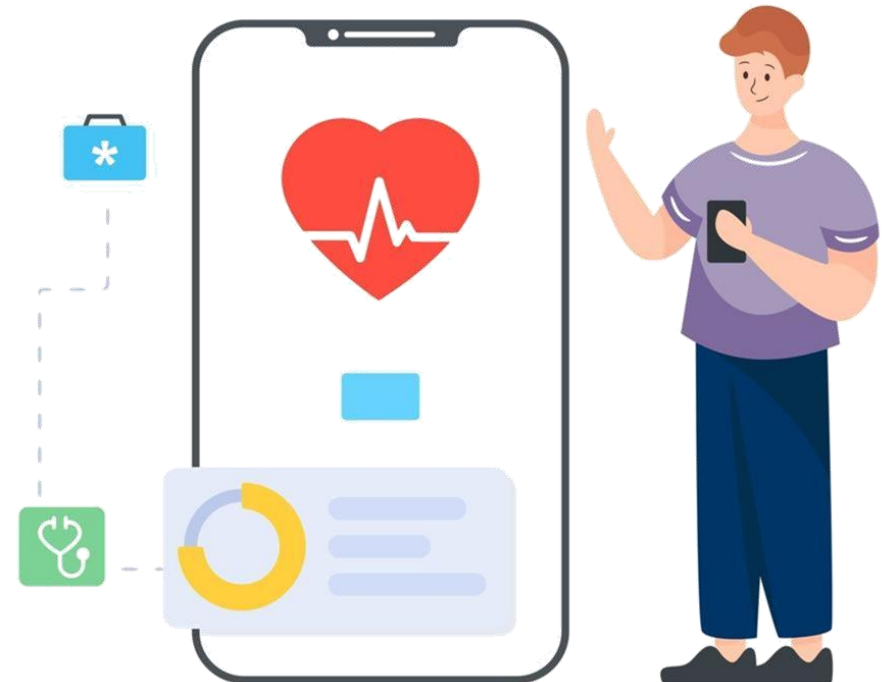
PROBLEM

Cardio-respiratory diseases and their consequences still affect a considerable percentage of the population.

Continuous monitoring of **heart and breathing rates** is essential for early detection of cardiorespiratory diseases.

Commercially available personal devices, such as **smartphones**, can be used for health monitoring.

These devices can also be used in **emergence situations** to monitor vital signs.



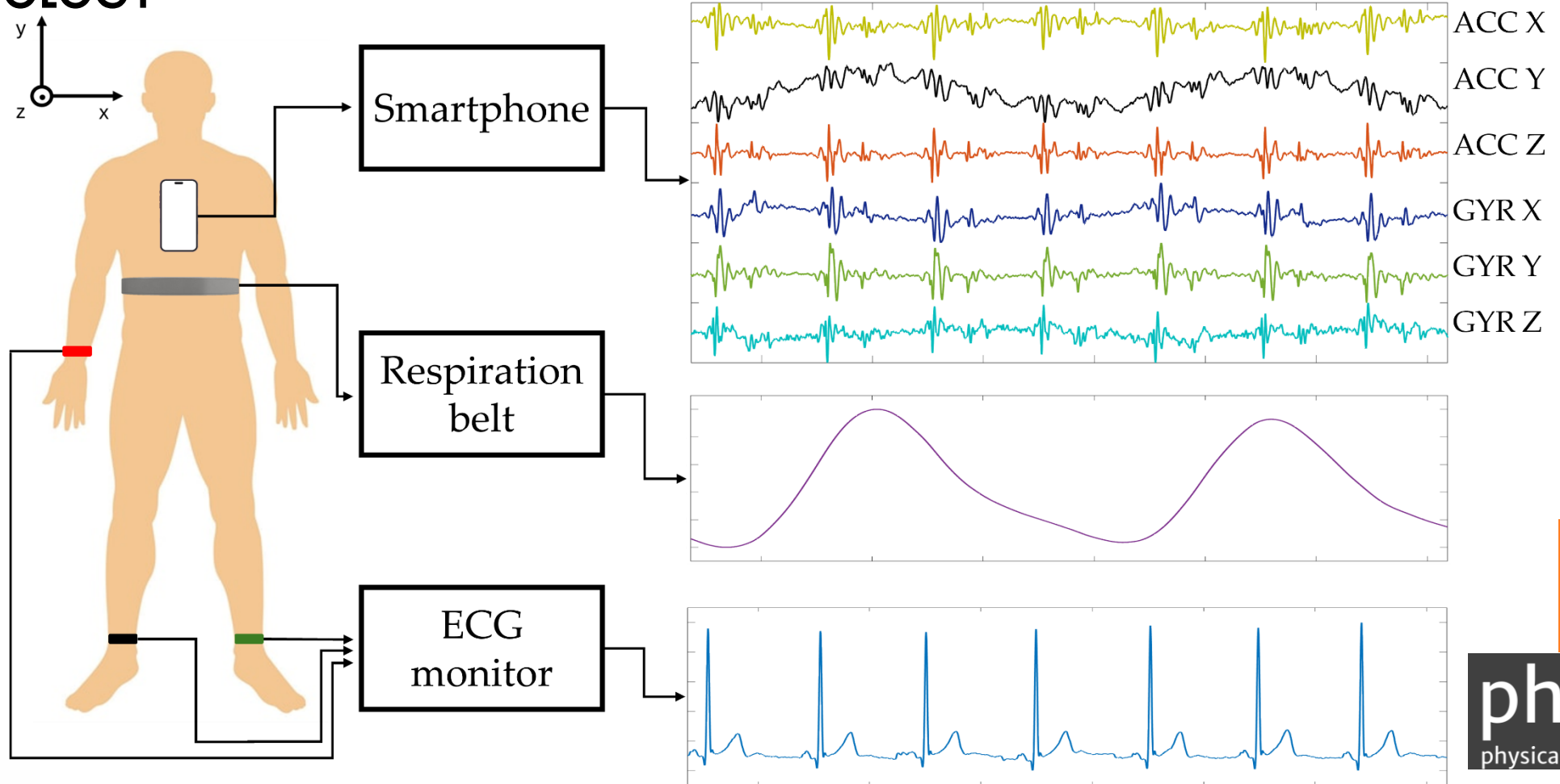
MONITORING OF VITAL SIGNS VIA PERSONAL DEVICES

OBJECTIVE

- Triaxial accelerometers and gyroscope are largely integrated into smartphones.
- **Smartphone inertial sensors** can be used to simultaneously monitor changes in chest inclination due to respiration and cardiac-induced chest wall vibrations known as Seismocardiograms and Gyrocardiograms.
- Accelerometric and gyroscopic signals were acquired by a smartphone to measure instantaneous heart rate and breathing rate.
- The performances of smartphone inertial sensors in estimating inter-beat intervals (**IBIs**) and inter-breath intervals (**IBris**) were assessed against reference techniques.

MONITORING OF VITAL SIGNS VIA PERSONAL DEVICES

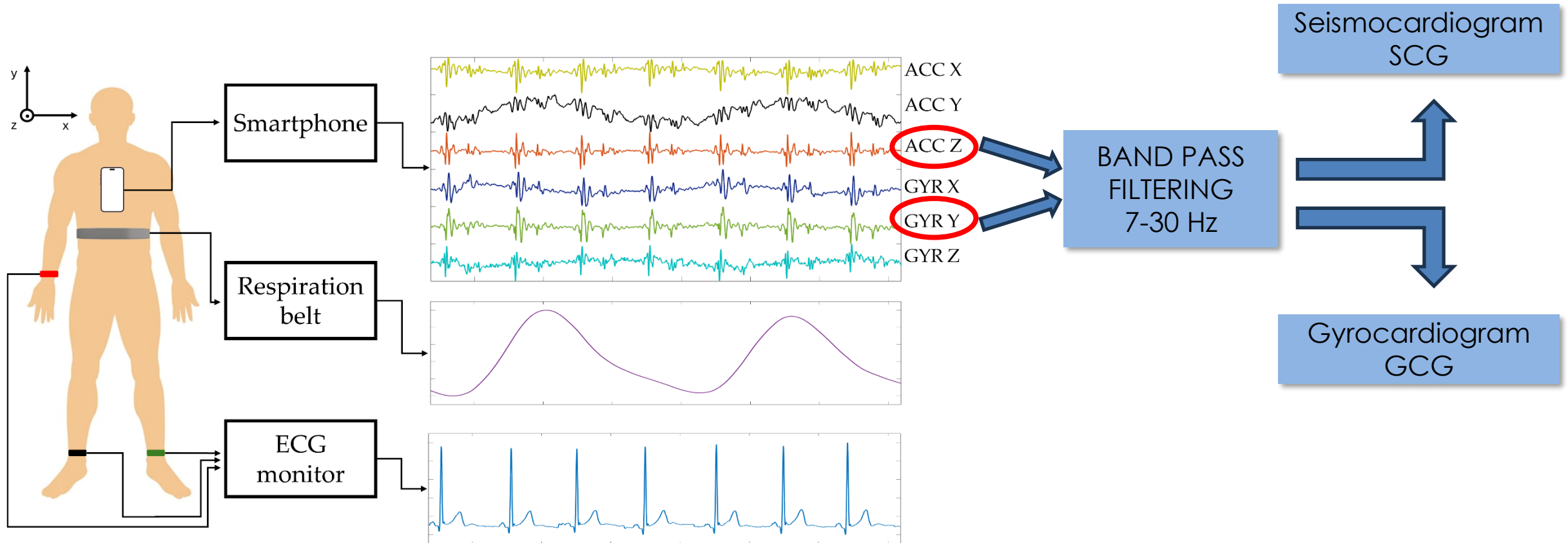
METHODOLOGY



Eliana Cinotti

MONITORING OF VITAL SIGNS VIA PERSONAL DEVICES

CARDIAC ACTIVITY

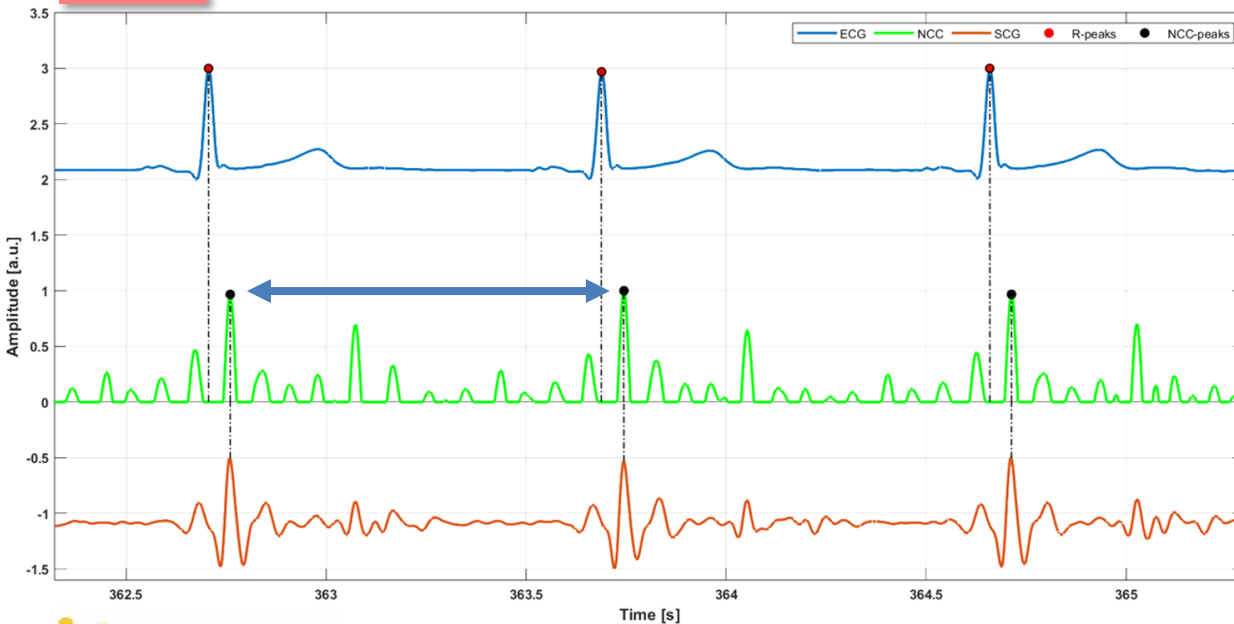


MONITORING OF VITAL SIGNS VIA PERSONAL DEVICES

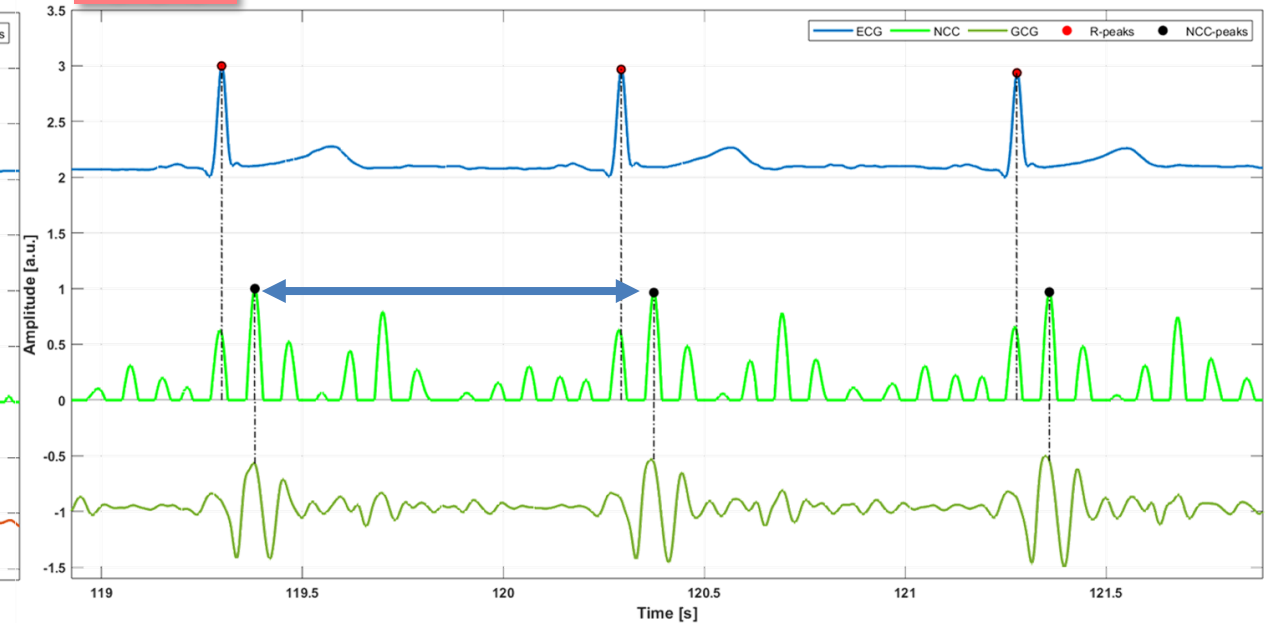
CARDIAC ACTIVITY

Heartbeats were located via template matching as the local maxima of Normalized Cross Correlation function. **Inter beats intervals** (IBIs) were calculated from the signals as time differences between their consecutive heartbeat fiducial points.

SCG

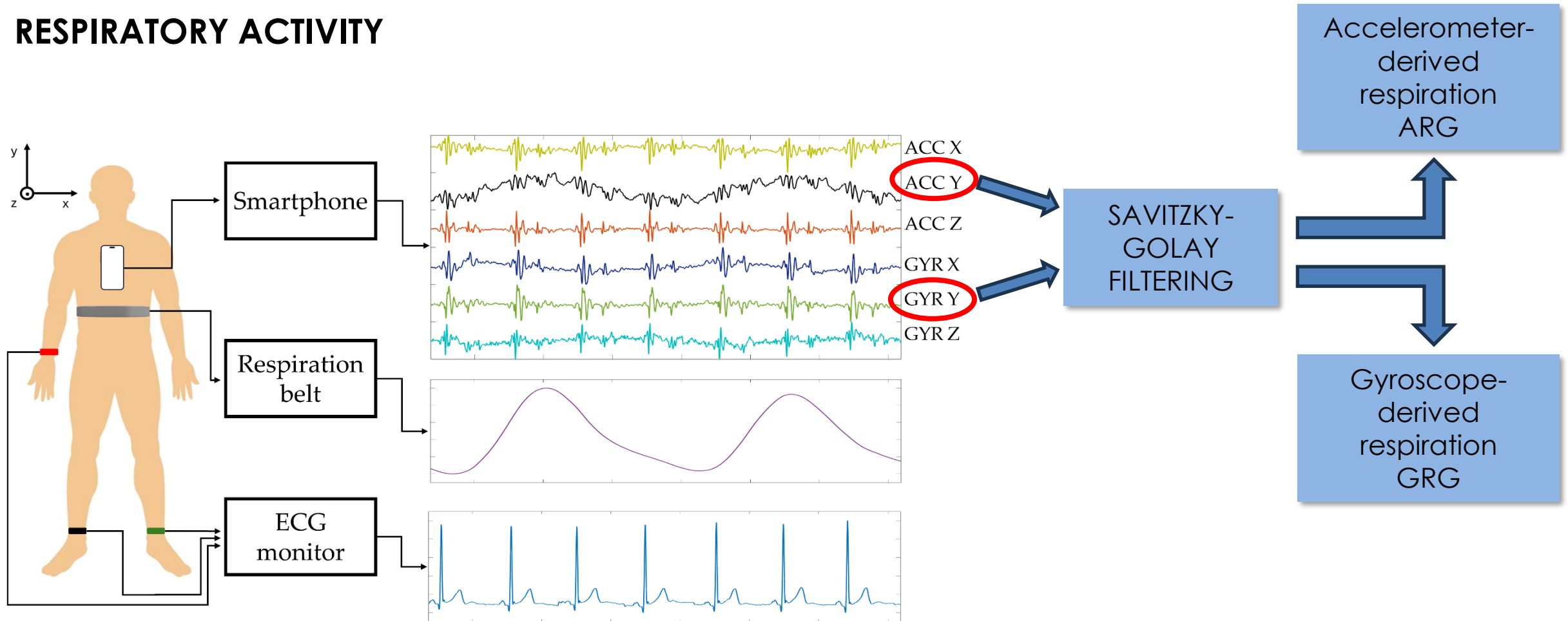


GCG



MONITORING OF VITAL SIGNS VIA PERSONAL DEVICES

RESPIRATORY ACTIVITY

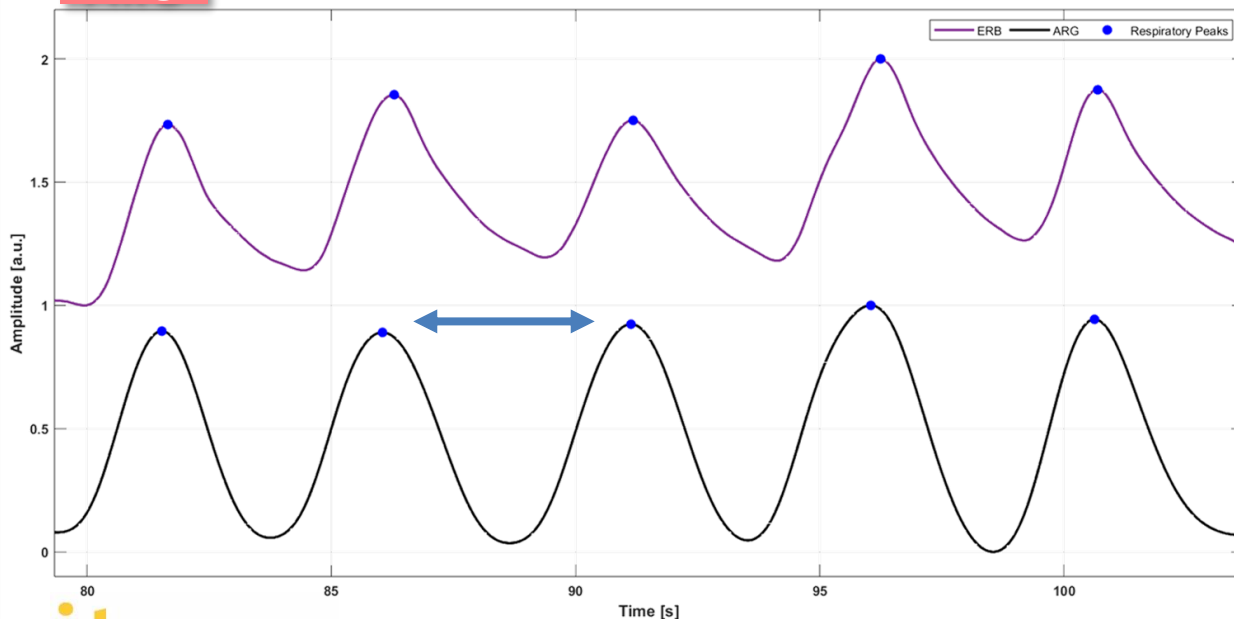


MONITORING OF VITAL SIGNS VIA PERSONAL DEVICES

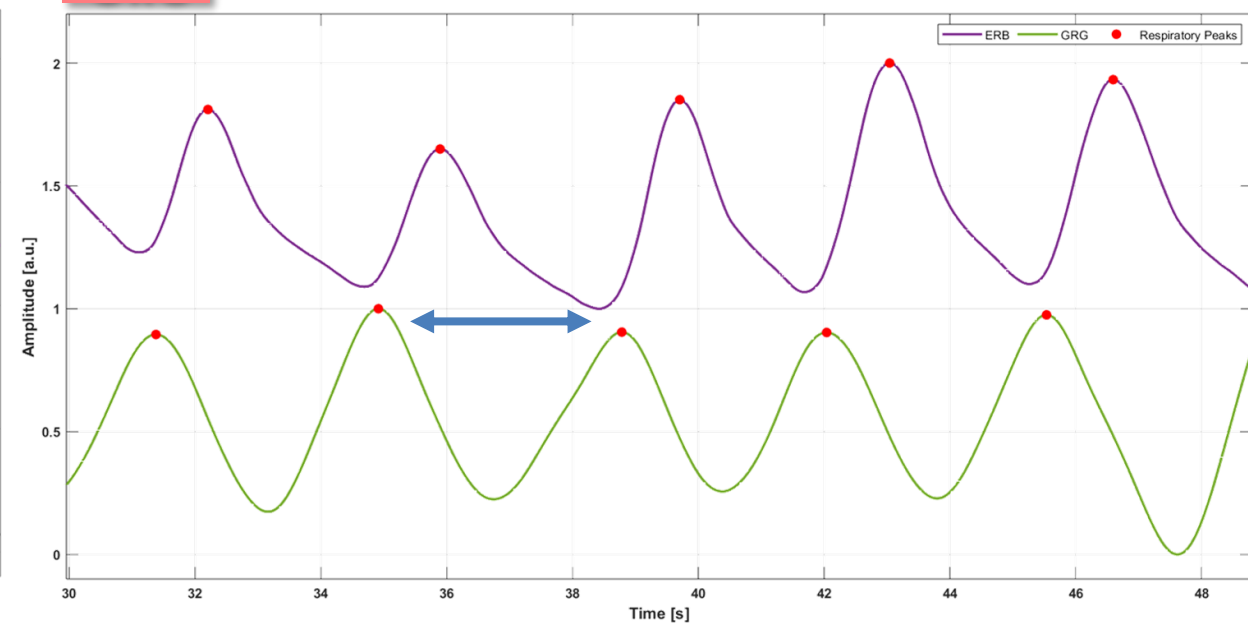
RESPIRATORY ACTIVITY

Purely **respiration signals** were obtained capturing the baseline wanderings of ARG and GRG due to respiratory-induced thoracic movements. **Inter breaths intervals** (IBrIs) were obtained by computing the time differences between consecutive respiratory acts.

ARG



GRG



MONITORING OF VITAL SIGNS VIA PERSONAL DEVICES

RESULTS

For both analysis, cardiac and respiration activity, linear regression, correlation and Bland-Altman analyses were carried out to compare IBIs and IBIs obtained from signals acquired with smartphone and their own reference signals.

		SCG	GCG
Performance of heartbeats detection	Sensitivity (%)	89.3	97.3
	PPV (%)	93.3	97.9
Regression analysis	Slope	1.00	1.00
	Intercept (ms)	0.041	-0.648
	R2	0.9996	0.9998
Correlation analysis	r	0.9998	0.9999
Bland-Altman analysis	Bias (ms)	0.075	0.032
	LoA(ms)	7.33	5.22

		ARG	GRG
Performance of respiratory acts detection	Sensitivity (%)	95.6	95.7
	PPV (%)	94.7	92.0
Regression analysis	Slope	1.00	0.986
	Intercept (s)	0.002	0.065
	R2	0.976	0.968
Correlation analysis	r	0.988	0.984
Bland-Altman analysis	Bias (s)	0.007	0.008
	LoA(s)	0.558	0.749

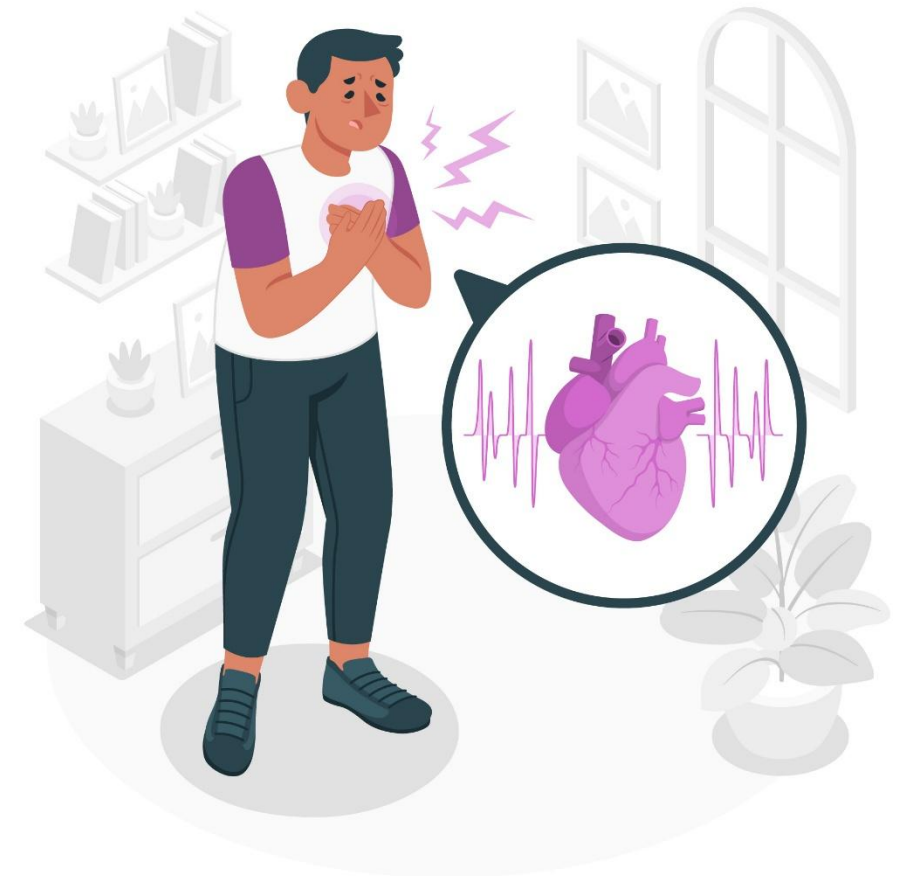
NOVEL HEALTH MONITORING DEVICES BASED ON EDGE-AI

PROBLEMS

Atrial fibrillation (AF) is the most widespread heart rhythm disorder which is mainly characterized by an irregular heart rhythm.

AF episodes detection is challenging because of their very brief duration.

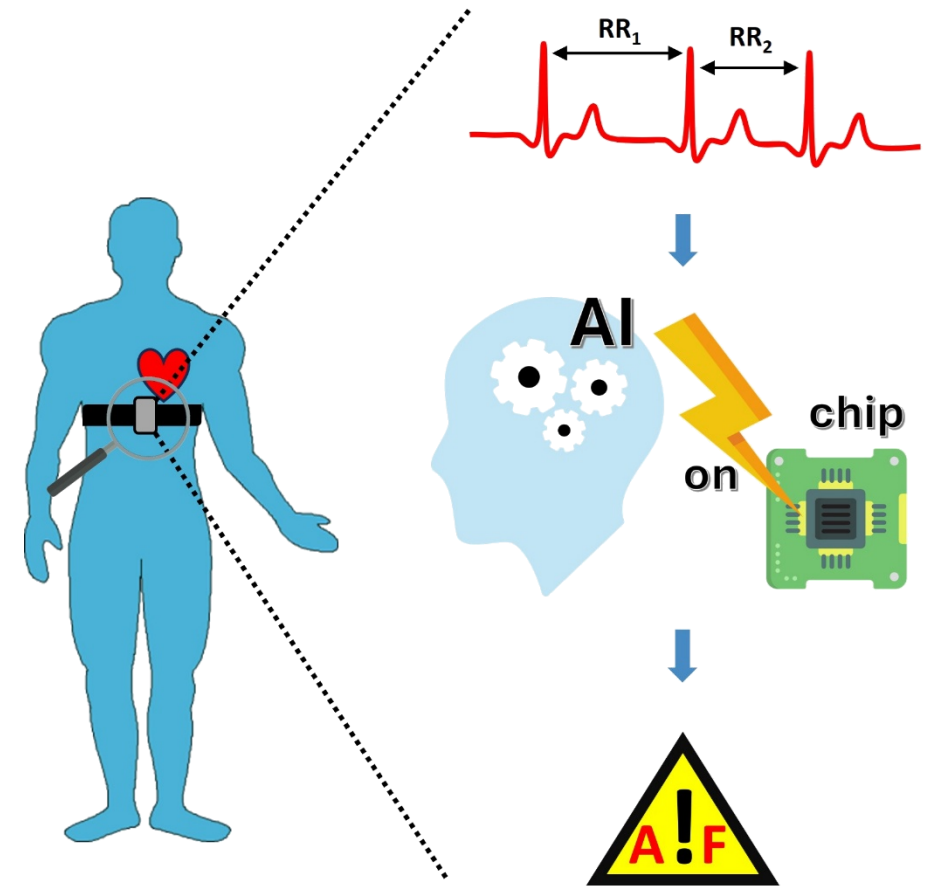
A **continuous, long-term monitoring** of heart rhythm is essential for early detection of AF and timely intervention.



NOVEL HEALTH MONITORING DEVICES BASED ON EDGE-AI

METHODOLOGY

- The prototype consists of:
 - an ECG analog front-end
 - a microcontroller with embedded artificial intelligence (EDGE-AI)
 - An IoT-based communication unit
- **A one-dimensional convolutional neural network (1D-CNN)** was implemented on the microcontroller for AF detection.
- The 1D-CNN receives as input sequences of inter-beat intervals (RR) of fixed length and provides as output the results of classification.



NOVEL HEALTH MONITORING DEVICES BASED ON EDGE-AI

RESULTS

The 1D-CNN has an inferencing time of 2 ms and allows AF detection **in real-time**. It can be applied on a **wide range of sensors** that monitors the heart rhythm and can be easily implemented on microcontrollers commonly used in wearable devices.

The prototype is characterized by very **low power consumption**, thus enabling continuous, long-term monitoring of heart rhythm.

Dataset	Training Samples	Validation Samples	Accuracy
25 RR	27824	6956	0.983
50 RR	13905	3477	0.988
100 RR	6945	1737	0.991

Dataset	Test Samples	Accuracy
25 RR	5812	0.951
50 RR	2906	0.965
100 RR	1452	0.978

SECOND YEAR PRODUCTION

JOURNAL PAPERS

- **Cinotti, E.**; Centracchio, J.; Parlato, S.; Esposito, D.; Fratini, A.; Bifulco, P.; Andreozzi, E. Accuracy of the Instantaneous Breathing and Heart Rates Estimated by Smartphone Inertial Units. *Sensors* 2025, 25, 1094;
- Parlato, S.; Centracchio, J.; **Cinotti, E.**; Gargiulo, G.D.; Esposito, D.; Bifulco, P.; Andreozzi, E. A Flexible PVDF Sensor for Forcecardiography. *Sensors* 2025, 25, 1608;
- Parlato, S., Centracchio, J., **Cinotti, E.** et al. A Forcecardiography dataset with simultaneous SCG, Heart Sounds, ECG, and Respiratory signals. *Sci Data* 12, 1370 (2025);
- Centracchio, J., **Cinotti, E.**, Parlato, S., Bifulco, P., Zamboli, P., Liguori, R., Longo, G., Punzi, M., Liccardo, A., Buonavolontà, F., Capolongo, G., Andreozzi, E. A novel system to record pulses, thrills, and bruit sounds generated by arteriovenous fistulas, *Sensors International*, accepted;
- **Cinotti, E.**, Gragnaniello, M., Parlato, S., Centracchio, J., Andreozzi, E., Bifulco, P., Riccio, M., Esposito, D. An Edge-AI approach for low-power, real-time atrial fibrillation detection on wearable devices based on heartbeat intervals, *Sensors*, submitted;
- 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. Spectral Analysis of AVF Signals for Early Dysfunction Detection: Towards AI-Based Home Monitoring, *IEEE BATS 2025*, accepted conference paper;

TUTORSHIP

- Co-supervisor for the Thesis entitled: “Progetto e sviluppo di un sistema prototipale per il monitoraggio non invasivo dell'attività cardiaca elettro-meccanica” by the candidate Daniele Longobardo;
- Staff member for: “Open Day: Porte Aperte Ingegneria 2025 - UNINA”;
- Speaker/Tutor for PCTO program - “Percorsi per la Competenze Trasversali e l'Orientamento”;
- Staff member for: “Career Day” UNINA;
- Co-Supervision of a MSc Thesis entitled: “Applicazione del Paradigma IoT 5.0 al Rilevamento in Tempo Reale della Fibrillazione Atriale mediante Dispositivo Wearable Embedded” by the candidate Sara Balletta.

Student: Eliana Cinotti PhD Cycle: XXXIX
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Credits year 2								
		1	2	3	4	5	6	
	Estimated	Bimonth	Bimonth	Bimonth	Bimonth	Bimonth	Bimonth	Summary
Courses	Min 10 – Max 20	0	2.4	0	0	9	2	13.4
Seminars	Min 5 – Max 10	0.2	0.8	0.8	1	0.6	3	6.4
Research	Min 10 – Max 45	7	10	8	7	5	8	45
	60	7.2	13.2	8.8	8	14.6	13	64.8
Tutorship		0	0.5	0.3	0	0.2	0.3	1.3

NEXT YEAR

OBJECTIVES FOR NEXT YEAR

- Novel methods for detecting Atrial Fibrillation and other arrhythmias
- Developing new wearable, IoT devices for health monitoring and disease detection
- Extraction of relevant clinical information from Forcecardiography signals
- Investigating new applications of Forcecardiography sensors



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THANK YOU
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