Jessica Centracchio

Innovative bioengineering methods for diagnosis and monitoring

Tutor: Prof. Paolo Bifulco

Cycle: XXXV

Year: First

BACKGROUND

EDUCATION

M.Sc. in Biomedical Engineering (University of Naples, Federico II)

Development of a new method for ECoG electrodes localization in CT images

Ph.D. in Information Technology and Electrical Engineering

1st November 2019

MIUR scholarship

Biomedical Group

Healthcare Automation, Biomedical Instrumentation and Telemedicine Laboratory

COLLABORATIONS

Istituto Nazionale di Fisica Nucleare
Sezione di Napoli

Eng. Ph.D. A. Sarno

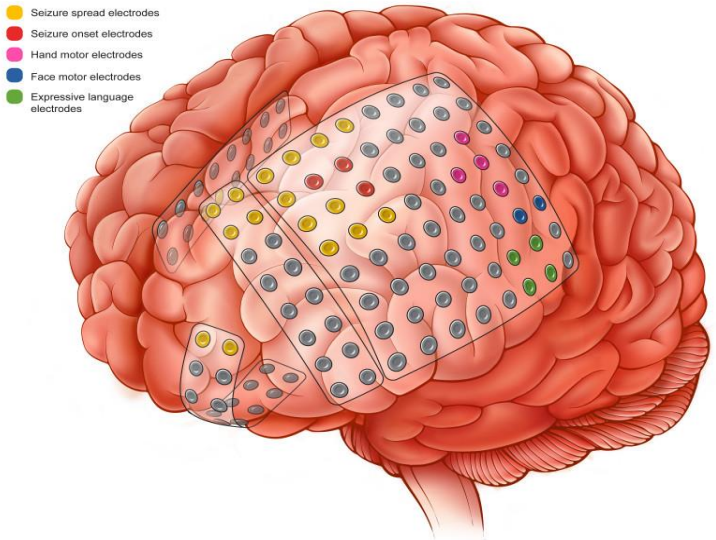
Eng. Ph.D. L. Pavone,
Dr. G. Di Gennaro,
Dr. M. Bartolo,
Prof. Dr. V. Esposito,
Dr. R. Morace,
Dr. S. Casciato

MAIN STUDY ACTIVITIES

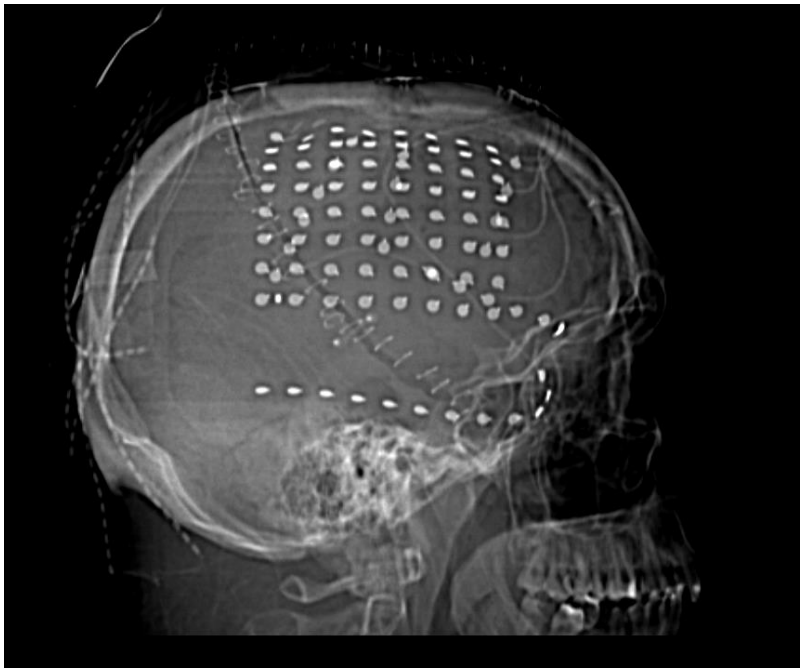
- Study on ECoG electrodes localization in CT images;
- Study on EEG based seizure detection/prediction systems;
- Study on localization of electrodes for Deep Brain Stimulation for patients affected by Parkinson disease;
- Computer Interface for Biological Systems – MSc course;
- BCI & NEUROTECHNOLOGY SPRING SCHOOL 2020;
- Study on non-invasive methods for respiration and heart monitoring;
- Study on biomedical applications of Force Sensitive Resistors.

ECoG ELECTRODES RECOGNITION IN CT IMAGES

Purpose: development of a new, automated method for ECoG electrodes recognition in CT images of patients with drug-refractory focal epilepsy.



ECoG electrodes onto the cerebral cortex



Head CT image

ECoG ELECTRODES RECOGNITION IN CT IMAGES

Electrodes are usually recognized by manual operation or by simple image thresholding.

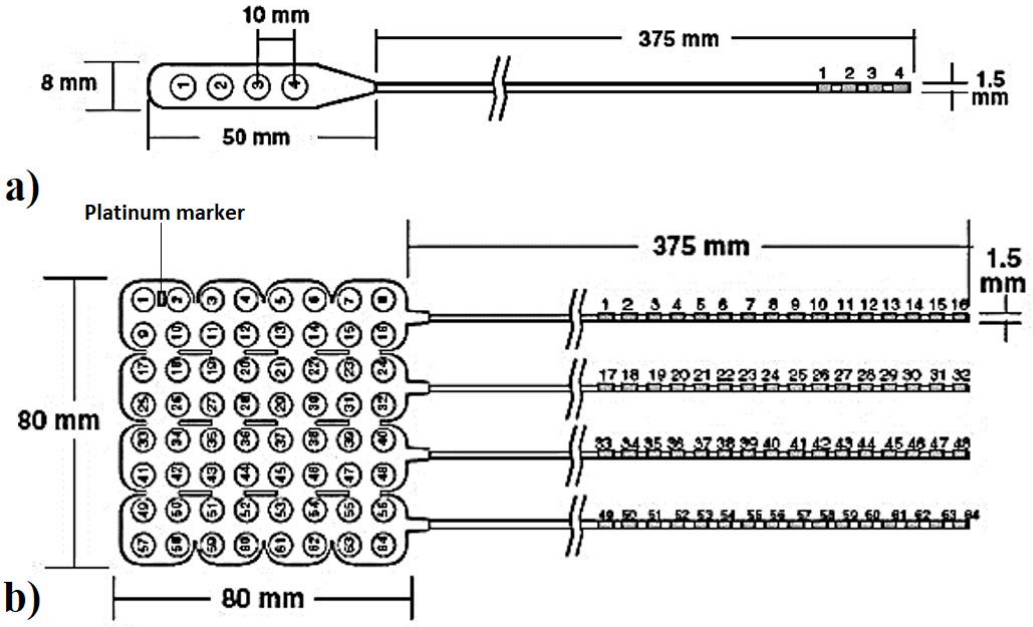
- Manual methods are extremely time consuming and prone to inaccuracy.

- The thresholding is not able to exclude other metal objects, such as wires, stitches, screws, tooth fillings etc.

The proposed method is based on shape analysis and provides completely automatic electrodes recognition, being also very time-saving.

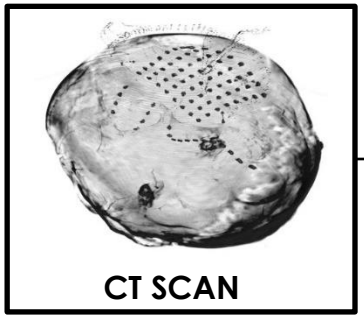
ECoG ELECTRODES RECOGNITION IN CT IMAGES

- Each electrode consists of a **round** platinum-iridium **disc** with a **4 mm diameter** and a **thickness** of about **0.5 mm**.
- The electrodes are arranged in **strips** or **grids** within a flexible sheet, placed at **10 mm inter-distances**.



a) strip 4x1, b) grid 8x8 (Ad-Tech Medical Instrumentation)

ECoG ELECTRODES RECOGNITION IN CT IMAGES



CT SCAN

PRE-PROCESSING

METAL ARTIFACTS SUPPRESSION

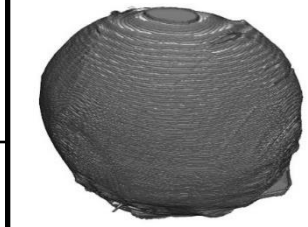
Metal Deletion Technique

RE-SAMPLING

Cubic Interpolation

THRESHOLDING

>2400 HU



HEAD MASK

ELECTRODES and NON-ELECTRODES inside the head

SHAPE ANALYSIS

FEATURES EXTRACTION

LDA CLASSIFIER

10-fold cross validation

ELECTRODE

NON-ELECTRODE

ECoG ELECTRODES RECOGNITION IN CT IMAGES

After thresholding, for each cluster of voxels six geometric features were computed:

1. Volume;
2. Primary axis length;
3. Secondary axis length;
4. Tertiary axis length;
5. Circularity;
6. Cylinder-similarity.

- **The electrodes have the shape of a flattened cylinder. They should have circularity and cylinder-similarity both equal to 1, because of their symmetry.**
- **Segments of wires or stitches have an elongated and potentially curved shape.**

ECoG ELECTRODES RECOGNITION IN CT IMAGES

Descriptive statistics of the geometric features of the electrodes

Electrode Features	Mean	Std. Dev.	Min	25th perc.	Median	75th perc.	Max
Volume [mm^3]	20.27	5.16	5.88	16.13	18.88	24.25	42.75
Primary axis length [mm]	4.54	0.35	3.60	4.28	4.50	4.75	6.25
Secondary axis length [mm]	3.81	0.25	2.75	3.64	3.80	3.99	4.66
Tertiary axis length [mm]	1.86	0.26	0.80	1.69	1.84	2.01	2.86
Circularity [adim]	1.19	0.11	1.00	1.11	1.18	1.25	2.06
Cylinder-similarity [adim]	1.28	0.08	1.16	1.22	1.26	1.31	1.77

Descriptive statistics of the geometric features of the non-electrode objects

Non-Electrode Features	Mean	Std. Dev.	Min	25th perc.	Median	75th perc.	Max
Volume [mm^3]	4.15	22.70	0.13	0.25	0.38	1.13	534
Primary axis length [mm]	2.29	2.88	0.58	1.15	1.15	2.31	30.91
Secondary axis length [mm]	1.22	1.39	0.58	0.58	0.58	1.15	18.70
Tertiary axis length [mm]	0.82	0.58	0.58	0.58	0.58	0.81	8.03
Circularity [adim]	1.92	0.89	1.00	1.41	2.00	2.00	11.84
Cylinder-similarity [adim]	1.61	0.80	1.19	1.36	1.36	1.61	11.15

ECoG ELECTRODES RECOGNITION IN CT IMAGES

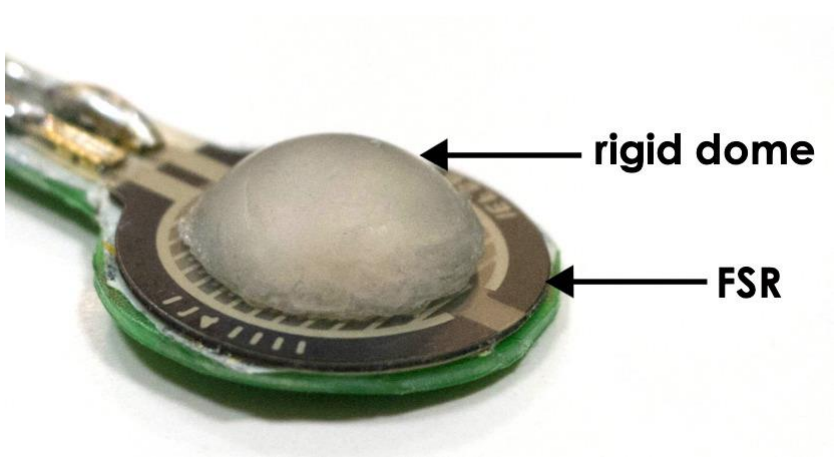
Finally, a Linear Discriminant Analysis (LDA) algorithm was used for model training and data classification. Classification accuracies were assessed by applying the 10-fold cross validation providing:

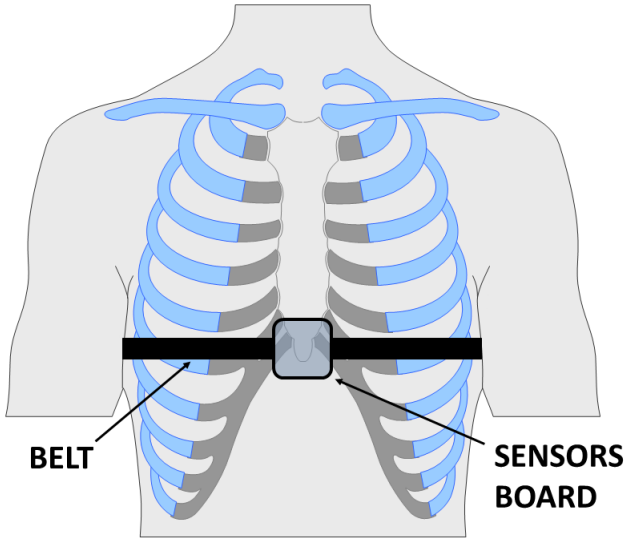
- a 98.08% mean classification accuracy across all patients;
- a 95.47% classification accuracy on the combined database;
- a high percentage of true positives and true negatives;
- a very low percentage of false positives and false negatives.

1758 recognized electrodes on 1765 total

ANALYSIS AND MONITORING OF HEART MECHANICAL ACTIVITY VIA FORCE SENSORS

Purpose: Investigation on a novel, non-invasive technique to monitor the mechanical activity of the heart via force sensors, referred to as Forcecardiography (FCG).

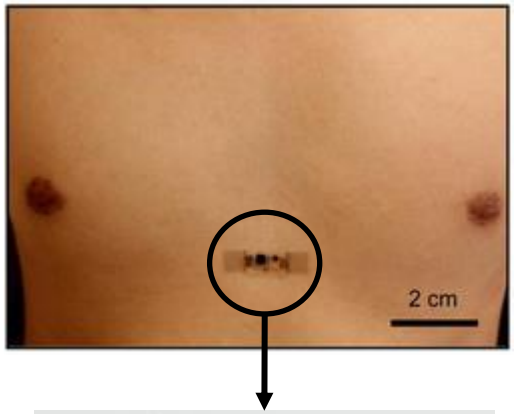


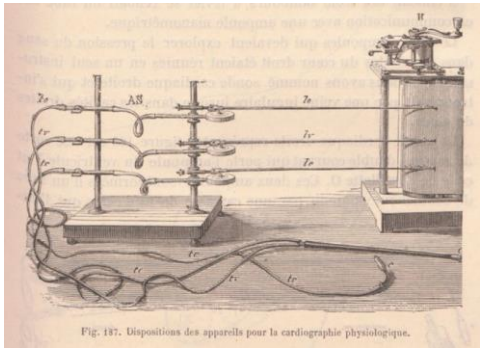


ANALYSIS AND MONITORING OF HEART MECHANICAL ACTIVITY VIA FORCE SENSORS

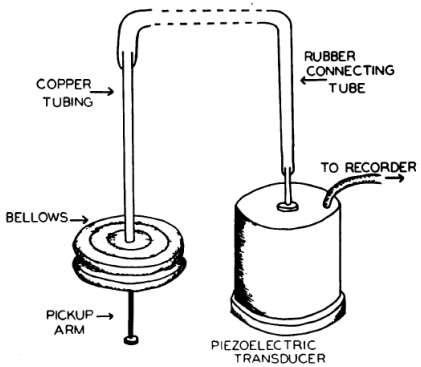
Since the 19th century, many techniques and instruments have been proposed to record the mechanical vibrations induced onto the chest wall by the beating heart.

Nowadays, the most widespread technique to acquire such mechanical signals is Seismocardiography (SCG), which is usually based on MEMS accelerometers.

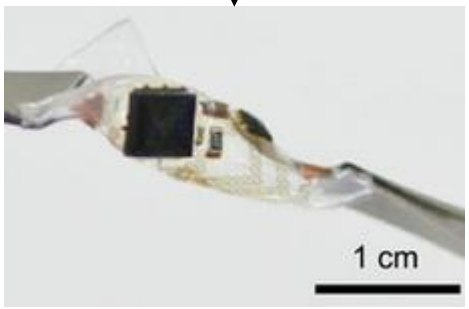




Marey, 1878



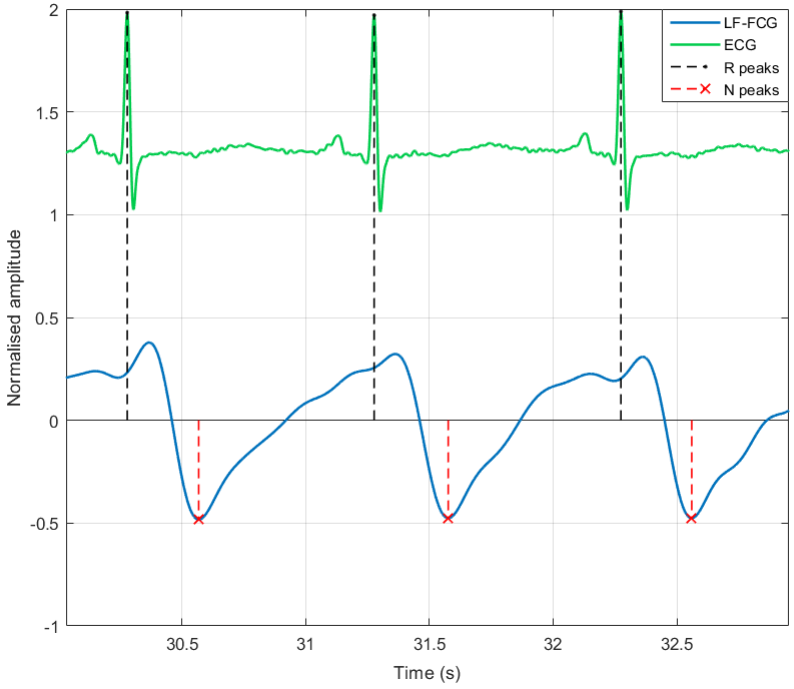
Eddleman et al., 1953



Liu et al., 2016

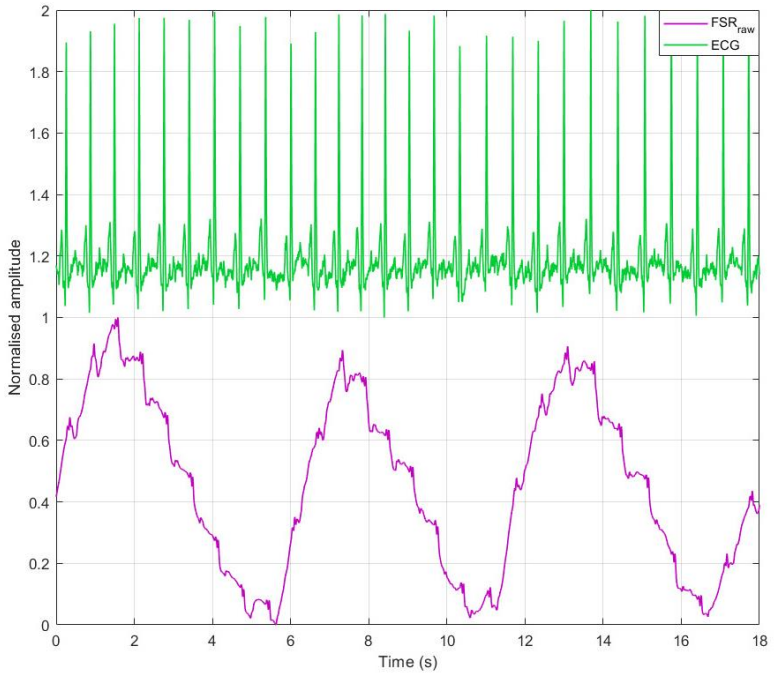
ANALYSIS AND MONITORING OF HEART MECHANICAL ACTIVITY VIA FORCE SENSORS

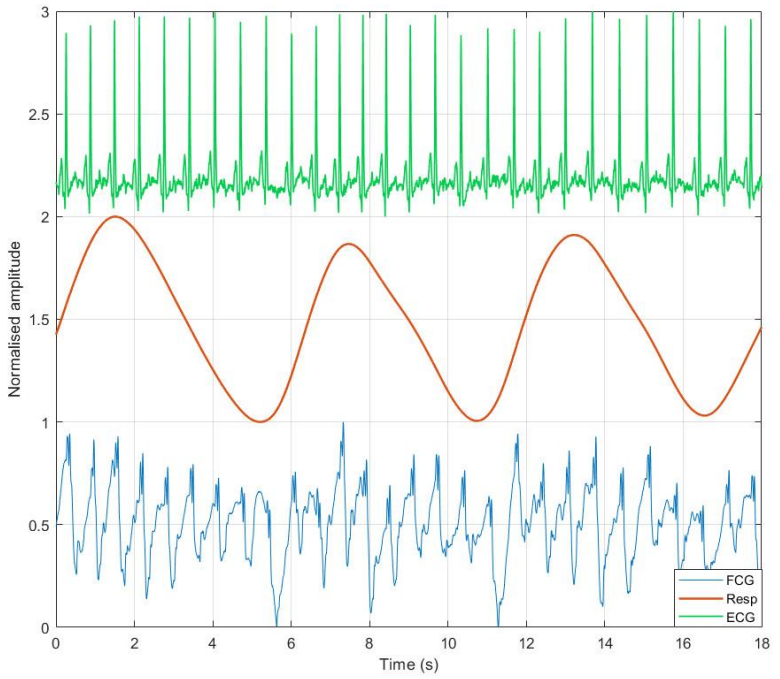
- **Forcecardiography** is a novel non-invasive technique that allows recording mechanical vibrations from the chest wall.
- The acquired forcecardiograms consistently show a low-frequency component that seems to be related to the filling and empyting of the heart.
- This suggests its potential use in enabling a long-term monitoring of stroke volume variations.



ANALYSIS AND MONITORING OF HEART MECHANICAL ACTIVITY VIA FORCE SENSORS

Preliminary results of the experimental activities I joined in my first year show that the FCG sensors are able to monitor, at the same time, both respiratory and cardiac activity with high accuracy, thus proving as valid, cheap and lightweight devices for long-term patient monitoring.





FIRST YEAR PRODUCTION

JOURNAL PAPERS

1. J. Centracchio, A. Sarno, D. Esposito, E. Andreozzi, L. Pavone, G. Di Gennaro, M. Bartolo, V. Esposito, R. Morace, S. Casciato, P. Bifulco; **Efficient Automated Localization of ECoG Electrodes in CT Images Via Shape Analysis.** Submitted to International Journal of Computer Assisted Radiology and Surgery (INTJCARS)

NEXT YEAR

- Analysis of EEG/intracranial EEG signals for epileptic seizure prediction;
- Assessment of stroke volume variations during controlled experiments involving physical exercises.

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Cycle: XXXV

	Credits year 1							
		1	**2**	**3**	**4**	**5**	**6**	
	Estimated	**Bimonth**	**Bimonth**	**Bimonth**	**Bimonth**	**Bimonth**	**Bimonth**	**Summary**
Courses	Min 20 – Max 40	1.2	0	2	5	4	9.6	21.8
Seminars	Min 5 – Max 10	0.2	0	6.4	0.7	0	0	7.3
Research	Min 10 – Max 35	1.5	7	7	7	5.5	5	33
	60	2.9	7	15.4	12.7	9.5	14.6	**62.1**

THANK YOU
FOR YOUR KIND ATTENTION