ScuDo
Scuola di Dottorato – Doctoral School
WHAT YOU ARE, TAKES YOU FAR

XXXV Cycle

Microwave Imaging Algorithms for Biomedical Applications

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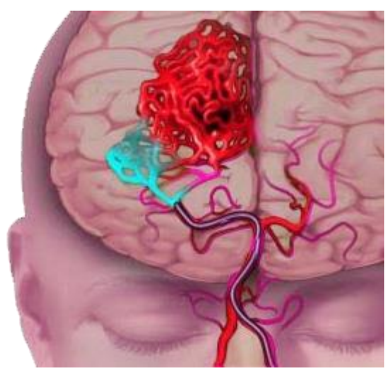
Research context and motivation

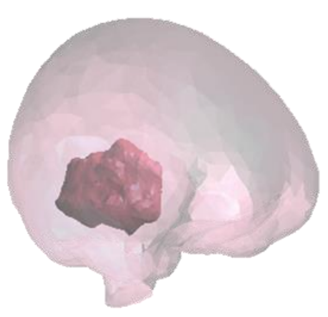


BRAIN STROKE

It is one of the most common cardiovascular diseases. There are two types of stroke: **ISCHEMIC** and **HEMORRAGIC**

THERAPY

- **Tipology** of the stroke
- Intervention **TIME**



BASIC CONCEPT

Considerable **dielectric contrast** between stroke region and healthy brain tissues at **microwave frequencies**

Addressed research questions/problems

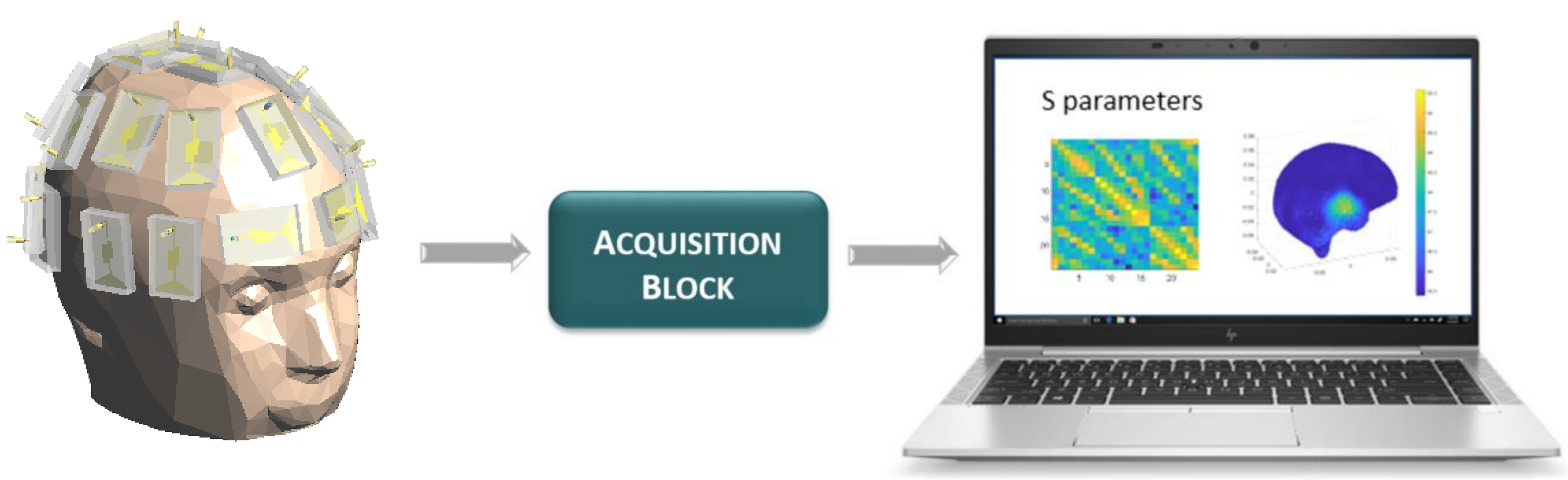
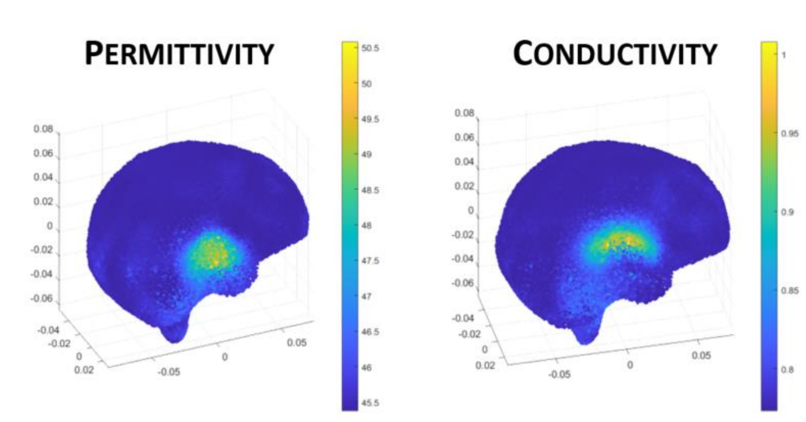


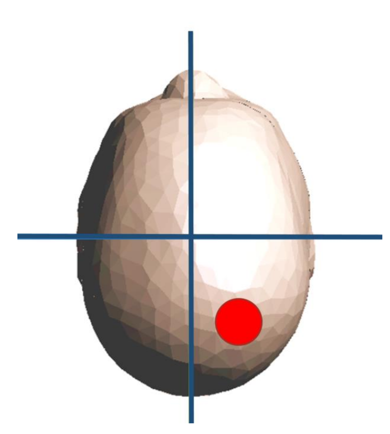
Image Reconstruction Algorithm

The Contrast Source Inversion (**CSI**) method is a non linear iterative algorithm for quantitative reconstructions



Machine Learning Algorithms

ML is used to detect the presence and the tipology of the stroke and the affected head region



- stroke/no stroke
- ischemic/hemo.
- 4 head regions

↓

9 CLASSES

Novel contributions

Image Reconstruction Algorithm

Novel discretization of the CSI method that **simplifies** the algorithm implementation and, at the same time, improve the **accuracy** of the discretized quantities.

Machine Learning Algorithm

An alternative method, based on the Born approximation and the **linearization** of the scattering operator, which **minimizes** the **time** to generate a **large data set** needed to train the machine learning algorithms.

Adopted methodologies

Comparison between the original and the proposed discretization, starting from simple geometry to more complex ones.

↓

These tests reveal the **better resolution** of variables with the new discretization.

Generation of a dataset composed by 10000 samples through a **linearized integral operator** and tests with 3 different ML algorithms:

$$\Delta S \cong \mathcal{S}\{\Delta\chi(\underline{r})\}$$

↓ **Differential Scattering Parameters**

↓ **Dielectric contrast**

13 hours << 3.5 years with full–wave simulations!

Future work

- **Optimization** of the 3D code
- Tests with **experimental data**
- Generation of more **head models** for the training set phase
- Testing with **experimental data**

List of attended classes

- 01QAAAA – Data mining for the analysis of clinical studies (18/3/2021, 33.33)
- 01UJIRO – Lens antennas: Fundamentals and present applications (6/12/2021, 16.67)
- 01QUWRV – Mathematical-physical aspects of electromagnetism (25/10/2020, 20.00)
- 01UIZRV – Microwave sensing and imaging for innovative applications in health and food industry (8/10/2020, 33.33)
- 01SFURV – Programmazione scientifica avanzata in matlab (26/4/2020, 37.33)
- 01MMRRV – Tecniche numeriche avanzate per l'analisi ed il progetto di antenne (8/6/2021, 33.33)
- Principi, materiali ed applicazioni della robotica nella biomedicina (5/3/2020, 25.05)
- Computing@Polito Workshop (16/1/2020, 5.32)
- COMPRESSIVE SENSING IN ELECTROMAGNETICS (3/2/2021, 46.76)
- Microwave Imaging and Diagnostics: Theory, Techniques, and Applications (24/10/2021, 35.91)
- Getting Started with AI in MATLAB (15/3/2021, 2)
- 02LWHRV – Communication (27/11/2019, 6.67)
- 01DMJRV – Design Thinking, Processes and Methods (3/5/2022, 2.67)
- 01SHMRV – Entrepreneurial Finance (3/5/2022, 6.67)
- 01UNVRV – Navigating the hiring process: CV, tests, interview (20/7/2020, 2.67)
- 01UNYRV – Personal branding (2/11/2020, 1.33)
- 08IXTRV – Project management (9/4/2020, 6.67)
- 01RISRV – Public speaking (11/12/2020, 6.67)
- 01SYBRV – Research integrity (29/2/2020, 6.67)
- 01SWQRV – Responsible research and innovation, the impact on social challenges (7/4/2020, 6.67)
- 02RHORV – The new Internet Society: entering the black-box of digital innovations (18/3/2020, 8)
- 01UNXRV – Thinking out of the box (13/11/2020, 1.33)
- 01SWPRV – Time management (2/12/2019, 2.67)

Submitted and published works

- Mariano, V. , Tobon, J.A., Scapaticci, R., Crocco, L., Kosmas, P., and Vipiana, F., "*Comparison of Reconstruction Algorithms for Brain Stroke Microwave Imaging*", IEEE IMBioC, Toulouse, 2020, pp. 1-3
- Mariano, V. , Tobon, J.A., and Vipiana, F.,"*Discretization Error Analysis in the Contrast Source Inversion Algorithm*", EuCAP, Dusseldorf, 2021, pp. 1-4
- Mariano, V. , Tobon, J.A., Casu, R.M., and Vipiana, F., "*Model-Based Data Generation for Support Vector Machine Stroke Classification*", APS/URSI, 2021, pp. 1685-1686
- Mariano, V. , Tobon, J.A., Scapaticci, R., Crocco, L., and Vipiana, F., "*An efficient implementation of CS-FEM Inversion Schemes for Microwave Imaging Applications*", URSI, Rome, 2021
- Mariano, V., Casu, R.M., and Vipiana, F., "*Simulation-based Machine Learning Training for Brain Anomalies Localization at Microwaves*", EuCAP, Madrid, pp. 1-3
- Mariano, V. , Tobon, J.A., Casu, R.M., and Vipiana, F., "*Efficient Data Generation for Stroke Classification via Multilayer Perceptron*", APS/URSI, Denver
- Mariano, V. , Tobon, J.A., Casu, R.M., and Vipiana, F., "*Brain Stroke Classification via Machine Learning Algorithms Trained with a Linearized Scattering Operator*", submitted to IEEE Transactions on Antennas Propagation
- Mariano, V. , Tobon, J.A., and Vipiana, F., "*A Novel Discretization Procedure in the CSI-FEM Algorithm for Brain Stroke Microwave Imaging*", submitted to MDPI Sensors

POLITECNICO DI TORINO

PhD program in
Electrical, Electronics and Communications Engineering