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

XXXVII Cycle

Calibration on a Microwave Scanner for Brain Stroke Monitoring

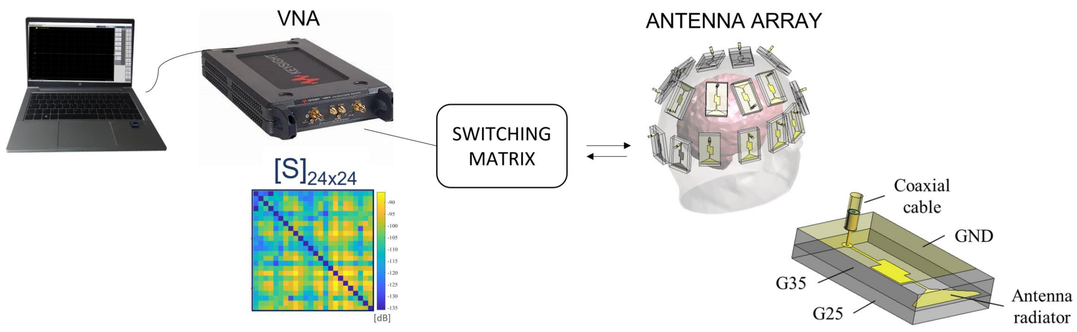
Cristina Origlia

Supervisors: Prof. Francesca Vipiana

Prof. Jorge A. Tobon Vasquez

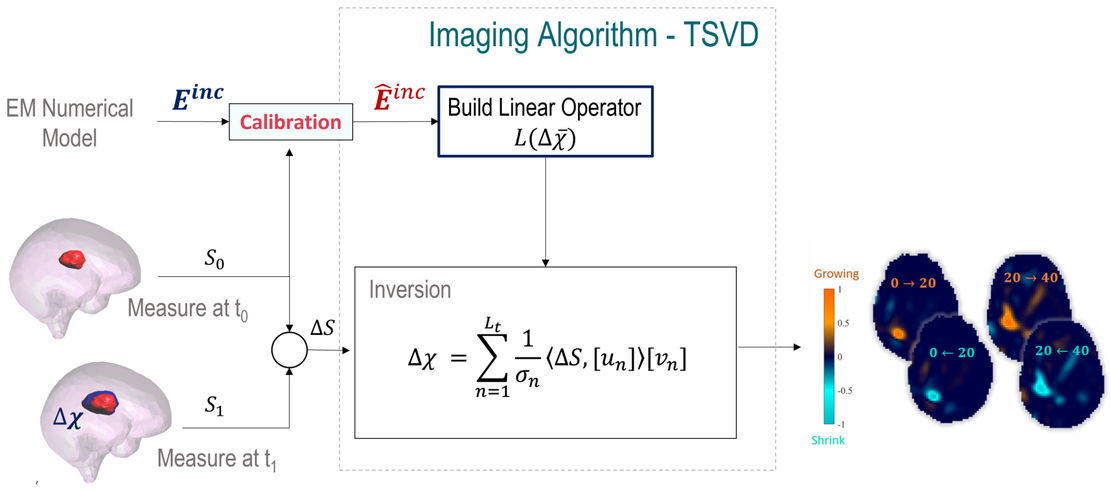
Research context and motivation

- **Brain stroke** is a medical emergency with high incidence, requiring prompt intevention.
- **Microwave medical imaging (MWI)** (working frequencies 0.5-10 GHz)



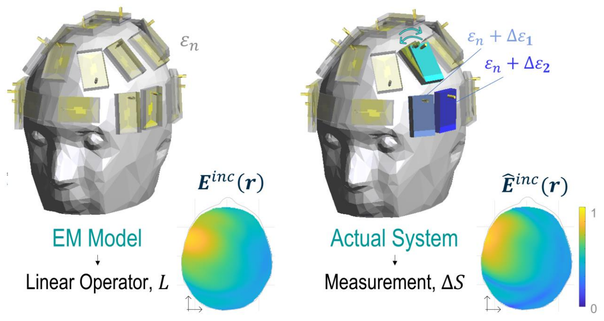
- **MWI algorithms** - non-linear and ill-posed inverse scattering problem

Direct problem: $$\Delta S(\boldsymbol{r}_p, \boldsymbol{r}_q) = \frac{-j\omega\epsilon_b}{2a_p a_q}\int_D E_b(\boldsymbol{r}_p, \boldsymbol{r}) \cdot E_b(\boldsymbol{r}, \boldsymbol{r}_q)\Delta\chi(\boldsymbol{r})dr = L(\Delta\chi)$$



Addressed research questions/problems

- MWI inversion mechanism is based on a-priori numerical estimate of the EM reference scenario. Thus, **modeling errors** due to inaccuracies in the physical system lead to unwanted artifacts in the output image. In medicine, uncertainty also arise from intrinsic variability in patient's anatomy.



- **Traditional calibration techniques** tailor the collected S-parameters towards the EM model, employing data measured in presence of a 'known' target (always feasible?).
- Goal implementation: **real-time stroke monitoring**. The calibration is embedded in the imaging framework, limiting higher computational functions to offline steps.

Submitted and published works

- Journals

[1] Rodriguez-Duarte, D.O., **Origlia, C.**, Tobon Vasquez, J.A., and Vipiana, F., "*Experimental Assessment of Real-Time Brain Stroke Monitoring via a Microwave Imaging Scanner*", IEEE Open Journal of Antennas and Propagation, vol. III, 2022, pp. 824-835

- Conferences

[2] **Origlia, C.**, Rodriguez-Duarte, D.O., Tobon Vasquez, J.A., and Vipiana, F., "*Hybrid Imaging Kernel Calibration Applied on Microwave Scanner for Brain Stroke Monitoring*", 2022 IEEE Conference on Antenna Measurements and Applications (CAMA), Guangzhou, China, 2022

[3] Savazzi, M., Rodriguez-Duarte, D.O., Karadima, O., **Origlia, C.**, Tobon Vasquez, J.A., Vipiana, F., Kosmas, P., Fernandes, C.A., Felicio, J.M., Conceição, R.C., "*Experimental Assessment of the Effects of Increasing Illumination Angles to Maximise Useful Information in Axillary Microwave Tomography*", 2022 IEEE Conference on Antenna Measurements and Applications (CAMA), Guangzhou, China, 2022

[4] Tobon Vasquez, J.A., Rodriguez-Duarte, D.O., **Origlia, C.**, Turvani, G., Scapaticci, R., Casu, M.R., Crocco, L., Vipiana, F., "*Microwave Imaging Device Prototype for Brain Stroke 3D Monitoring*", 2022 International Workshop on Antenna Technology (iWAT), Dublin, Ireland, 2022

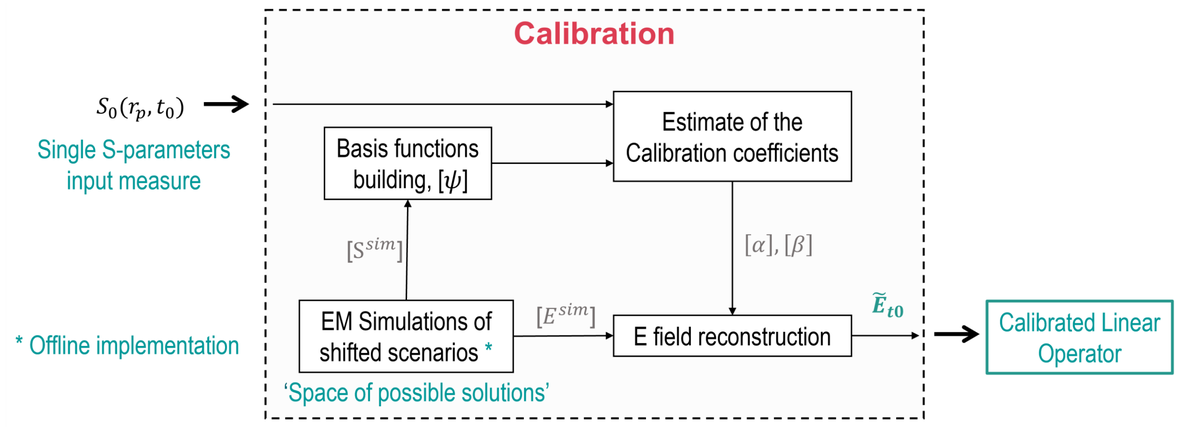
[5] Rodriguez-Duarte, D.O., **Origlia, C.**, Tobon Vasquez, J.A., Scapaticci, R., Crocco, L., and Vipiana, F., "*Wearable microwave imaging system for brain stroke imaging*", 2022 IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting (APS/URSI), Denver, Colorado, USA, 2022

[6] **Origlia, C.**, Rodriguez-Duarte, D.O., Tobon Vasquez, J.A., and Vipiana, F., "*Microwave Antenna Array Calibration via Simulated and Measured S-parameters Matching*", 2022 16th European Conference on Antennas and Propagation (EuCAP), Madrid, Spain, 2022

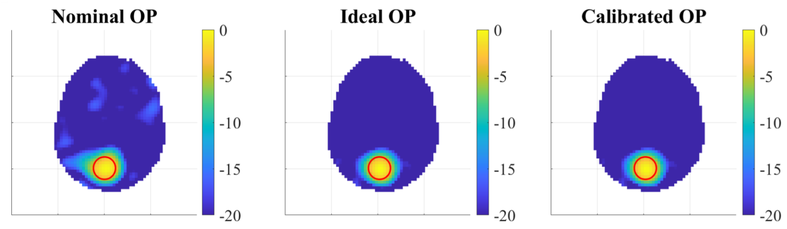
[7] Rodriguez-Duarte, D.O., **Origlia, C.**, Tobon Vasquez, J.A., and Vipiana, F., "*Hybrid Resolvent Kernel Calibration Technique for Microwave Imaging Systems*", 2021 IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting (APS/URSI), Marina Bay Sands, Singapore, 2021

Novel contributions

- **Calibration basic principles**

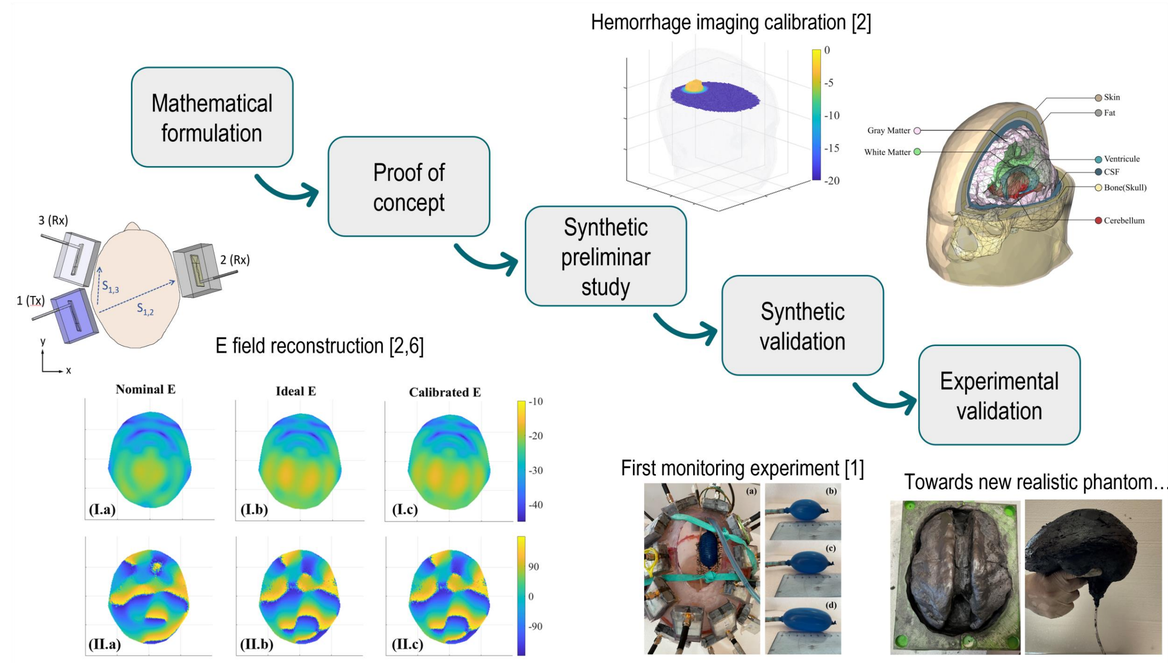


- This technique can compensate for **several variables** of different natures, from physical inaccuracies in the probes to the external electronics phase shifts. Moreover, it can be used in other MWI system and embedded in **different imaging algorithm**.
- Preliminary studies [2]: the calibration removes **image artifacts** and correctly recover **dielectric contrast value**



Adopted methodologies

- Calibration scheme validation



Future work

- Test the MWI scanner with new **antropomorphic phantom**.
- Apply the calibration on the actual measurements. To achieve this step, the calibration parametric model should be integrated accounting for **additional variables** which affect the physical system.
- Optimizing the implementation of the calibration algorithm to achieve faster computational times and embedded it in the **real-time** imaging process.

Acknowledgments

This work was supported by the Italian Ministry of University and Research under the PRIN project "MiBraScan", and by the European Union's Horizon 2020 Research and Innovation Program under the EMERALD project, Marie Sklodowska-Curie grant agreement No. 764479.

List of attended classes

- 01DPJRV – Lens antennas: Fundamentals and present applications. (didattica di eccellenza) (7/12/2021, 2)
- 01SFVRV – Metamaterials: Theory and multiphysics applications (8/4/2022, 4)
- 01UIZRV – Microwave sensing and imaging for innovative applications in health and food industry (22/3/2022, 4)
- 01RGBRV – Optimization methods for engineering problems (7/6/2022, 6)
- European School of Antennas (ESoA) course 2022 - Diagnostic and therapeutic applications of electromagnetics (17/6/2022, 30h) (External training activities)

Politecnico di Torino 1859

Wavision Research Group
Politecnico di Torino

PhD program in
Electrical, Electronics and Communications Engineering