ScuDo

Scuola di Dottorato ~ Doctoral School

WHAT YOU ARE,TAKES YOU FAR

XXXIV Cycle

EM DEVICE FOR CEREBROVASCULAR DISEASES IMAGING

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Research context and motivation

STROKES occurs when blood flow to the brain is Interrupted. Without Oxygen-rich blood, brain Cells die.

Someone has a stroke every **2 SECONDS**

#2

Stroke is the No.2 cause of death behind heart disease.

MICROWAVE tomography decrease **COST**, **SIZE** of the equipment and is **NON-IONIZING***.

Stroke

World incidence

1 IN 6 PEOPLE will have a stroke In their lifetime

Traditional imaging diagnosis techniques as MRI or CT can result **EXPENSIVE**, **BULKY** and **HARMFUL***.

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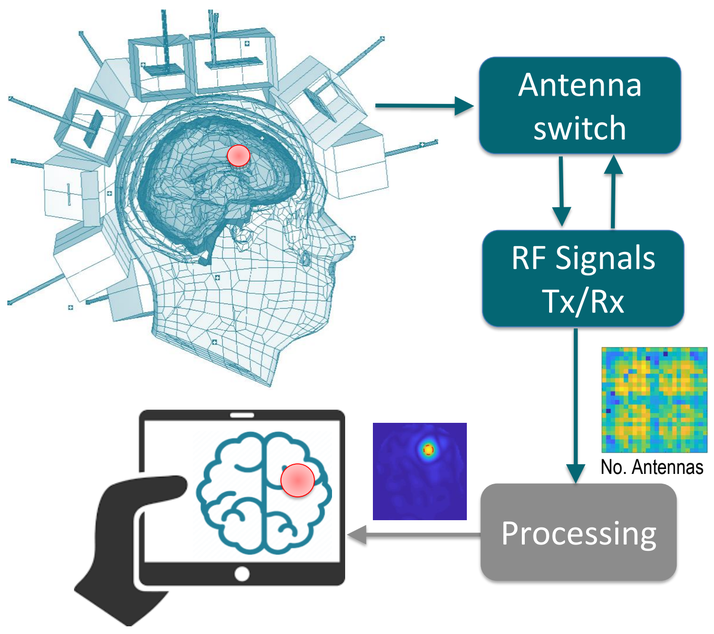
MILLION PEOPLE WORLDWIDE had a stroke in 2010. Slightly more than half (16.9 million) were first strokes.

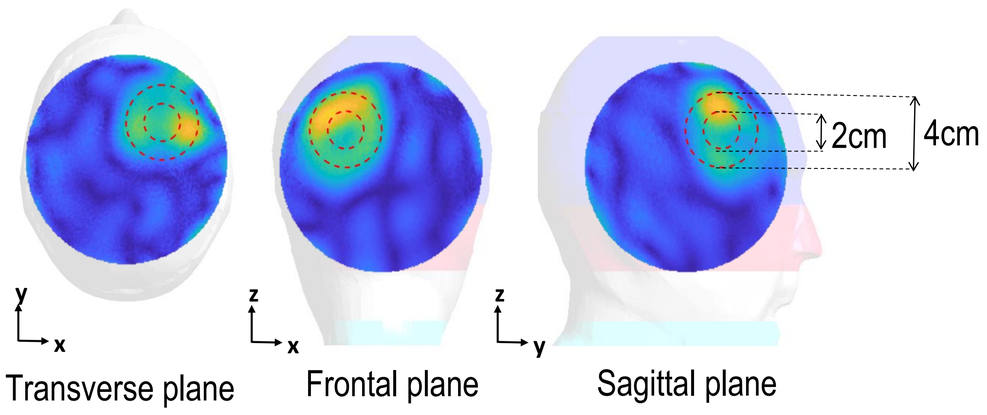
*R. Scapaticci, M. Bjelogrlic, J. T. Vasquez, F. Vipiana, M. Mattes, L. Crocco, Emerging Electromagnetic Technologies for Brain Diseases Diagnostics, Monitoring and Therapy. Springer int. pub., 2018, Ch. 2 Microwave Technology for Brain Imaging and Monitoring: Physical Foundations, Potential and Limitations, pp. 7–35.

** Statistics from the American heart/ American stroke association. Update: http://strokeassociation.org

Addressed research questions/problems

- Antenna selection
- Matching medium
- Operation frequency
- Human tissues
- Imaging algorithms





Submitted and published works

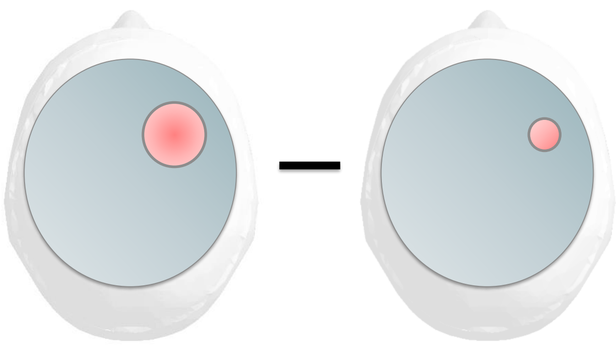
- Rodriguez-Duarte, D. O.; Mansoori, M. A.; Tobon Vasquez, J. A.; Turvani, G.; Casu, M. R.; Vipiana, F., "*Development of an EM Device for Cerebrovascular Diseases Imaging and Hardware Acceleration for Imaging Algorithms within the EMERALD Network*", 13th European Conference on Antennas and Propagation (EuCAP 2019)
- Tobon Vasquez J. A. ; Rodriguez-Duarte, D.O; Scapaticci R.; Turvani G.; Bellizzi G.; Joachimowicz N.; Duchêne B.; Casu M.; Crocco L. and Vipiana F. , "*Experimental testing and calibration issues in the realization of a microwave imaging device for brain stroke monitoring*", Progress In Electromagnetics Research Symposium Abstracts, Xiamen, China, December 17– 20, 2019
- Rodriguez-Duarte, D.O; Tobon Vasquez J. A. ; Scapaticci R. Kolundzija B.; Crocco L. and Vipiana F. , "*High fidelity modelling of a microwave imaging device for brain stroke monitoring*", Progress In Electromagnetics Research Symposium Abstracts, Xiamen, China, December 17– 20, 2019
- Rodriguez-Duarte, D. O.; Tobon Vasquez, J. A.; Scapaticci R.; Turvani, G.; Casu, M. R.; Crocco L. and Vipiana, F., "*Development of an EM Device for Cerebrovascular Diseases Imaging and Hardware Acceleration for Imaging Algorithms within the EMERALD Network*", in preparation for 14th European Conference on Antennas and Propagation (EuCAP 2020)

Novel contributions

- Software and hardware validation of a complete microwave imaging system for **DETECTION** and **FOLLOW-UP** of cerebrovascular diseases.

First approach

Differential imaging



Scenario time = T1 — Scenario time = T0

Linear model: TSVD algorithm*
(Distorted Born approximation)

Background field in the reference scenario

TX/RX antennas

$$\Delta S(\boldsymbol{r}_p, \boldsymbol{r}_q) = \frac{-j\omega\epsilon_b}{4}\int_D \boldsymbol{E}_b(\boldsymbol{r}_p, \boldsymbol{r}) \cdot \boldsymbol{E}_b(\boldsymbol{r}, \boldsymbol{r}_q)\Delta\chi(\boldsymbol{r})d\boldsymbol{r}$$

Domain of interest — Variation contrast

$$\Delta S(\boldsymbol{r}_p, \boldsymbol{r}_q) = L(\Delta\chi) \qquad [u_n, \sigma_n, v_n] = SVD(L)$$

$$\Delta\chi = \sum_{n=1}^{T} \frac{1}{\sigma_n} < \Delta S, u_n > v_n$$

*R. Scapaticci, M. Bjelogrlic, J. T. Vasquez, F. Vipiana, M. Mattes, L. Crocco, Emerging Electromagnetic Technologies for Brain Diseases Diagnostics, Monitoring and Therapy. Springer int. pub., 2018, Ch. 2 Microwave Technology for Brain Imaging and Monitoring: Physical Foundations, Potential and Limitations, pp. 7–35.

Adopted methodologies

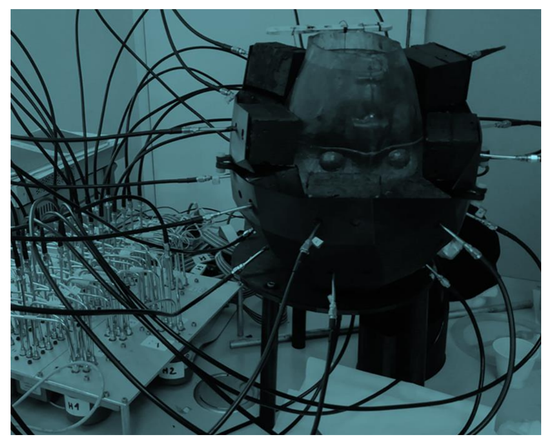
- Because the implementation of a imaging microwave system considers software and hardware components, the methodologies follow different approaches. The software takes into account the EM modeling of human-antennas system and the imaging algorithms. The hardware relies on antenna measurements, calibrations, switching matrix and realistic phantoms.

Microwave imaging system for cerebrovascular diseases

- Ad-hoc problem-based design procedure
- Reliable & effective forward solver
- Model-based imaging technique
- Specialized hardware

Future work

- Testing and assessment of the imaging algorithms for medical diagnosis devices using the EM imaging device developed in the first year.
- Integration in the realized EM device of the ad-hoc radiofrequency front-end system, customized for the proposed imaging technique.
- Extensively testing with the anthropomorphic phantoms in various experiments mimicking different conditions.



List of attended classes

- 01MMRRV Tecniche numeriche avanzate per l'analisi ed il progetto di antenne (14/03/2019,4)
- 01SFURV Programmazione scientifica avanzata in matlab (15/05/2019, 4)
- 01QRNRV Electromagnetic dosimetry in MRI: computational and experimental met (07/05/2019, 4)

External training activities

- Compressive sensing electromagnetics (European School of Antennas-ESoA-, 22/03/2019)
- WIPL-D 3D EM full wave computational tool for modelling of medical microwave imaging scenarios(09/05/2019)
- Diagnostic and therapeutic electromagnetic applications(ESoA, 09/09/19)
- Antenna imaging technologies (ESoA, 16/09/19)

POLITECNICO DI TORINO

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EMERALD ElectroMagnetic imaging for a novel genERation of medicAL Devices

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