Experimental Testing and Calibration Issues in the Realization of a Microwave Imaging Device for Brain Stroke Monitoring

Experimental Testing and Calibration Issues in the Realization of a Microwave Imaging Device for Brain Stroke Monitoring

Jorge A. Tobon[1], **David Rodriguez-Duarte**[1], **Rosa Scapaticci**[2], **Giovanna Turvani**[1], **Gennaro Bellizzi**[3], **Nadine Joachimowicz**[4], **Bernard Duchêne**[5], **Mario R. Casu**[1], **Lorenzo Crocco**[2], **and Francesca Vipiana**[1]

[1]Dept. Electronics and Telecommunications, Politecnico di Torino, DET-POLITO, Torino, Italy
[2]Institute for Electromagnetic Sensing of the Environment
National Research Council of Italy, IREA-CNR, Napoli, Italy
[3]Dept. of Electric Eng. and Information Technologies, University of Naples Federico II, Napoli, Italy
[4]Group of Electrical Engineering, Paris (GeePs), CNRS, CentraleSupélec
Univ. Paris-Sud, Gif-sur-Yvette, France
[5]Laboratoire des Signaux et Systèmes (L2S), CNRS, CentraleSupélec
Univ. Paris-Sud, Gif-sur-Yvette, France

Abstract— Electromagnetic imaging at microwave frequencies is a complementary modality to current clinical imaging techniques that have been gaining relevance in recent years due to its advantages over the traditional and well-proven technologies, such as X-Ray imaging and magnetic resonance imaging. This technology works with low power of non-ionizing waves, whereby it is entirely harmless, economically sustainable due to the progress in the mobile industry and microwave devices and presents favourable penetration depths of human in comparison to optical ones.

In this paper, we present the realization, testing and calibration of a novel portable low-complexity microwave imaging device for brain stroke monitoring.

The system consists of a set of 24 printed wide-band monopoles antennas that act as transmitter and receiver (RX/TX) thanks to a custom 24×2 switching matrix connected to a vector network analyzer (VNA). The 3-D antenna layout follows the procedure as in [1, 2]. Each antenna is immersed individually in a block of coupling medium and is placed around a human-head phantom [3]. The coupling blocks are filled with a mixture of urethane rubber and graphite powder [4], while the phantom with a Triton X-100 and water mix that mimics the average brain dielectric properties. The implemented reconstruction algorithm is the Truncated Singular Value Decomposition (TSVD), applied the signals collected by the VNA. The preliminary testing of the algorithm had been performed on simulations [1]. The nature of the algorithm also permits smooth hardware acceleration [5].

In this work, differential measurements are performed on the phantom with and without a blood target inside. The measured data pass to the reconstruction algorithm, calibrated using the techniques of time gating and de-embedding.

ACKNOWLEDGMENT

This work was supported by the Italian Ministry of University and Research under PRIN project "MiBraScan" — Microwave Brain Scanner for Cerebrovascular Diseases Monitoring.

REFERENCES

1. Scapaticci, R., J. Tobon, G. Bellizzi, F. Vipiana, and L. Crocco, "Design and numerical characterization of a low-complexity microwave device for brain stroke monitoring," *IEEE Trans. on Ant. & Prop.*, Vol. 66, No. 12, 7328–7338, Dec. 2018.
2. Bucci, O. M., L. Crocco, R. Scapaticci, and G. Bellizzi, "On the design of phased arrays for medical applications," *Proc. IEEE*, Vol. 104, No. 3, 633–648, Mar. 2016.
3. Joachimowicz, N., B. Duchêne, C. Conessa, and O. Meyer, "Anthropomorphic breast and head phantoms for microwave imaging," *Diagnostics*, Vol. 8, No. 4, 85, Dec. 2018.
4. Garrett, J. and E. Fear, "A new breast phantom with a durable skin layer for microwave breast imaging," *IEEE Transactions on Antennas and Propagation*, Vol. 63, No. 4, 1693–1700, Apr. 2015.
5. Sarwar, I., G. Turvani, M. R. Casu, J. A. Tobon, F. Vipiana, R. Scapaticci, and L. Crocco, "Low-cost low-power acceleration of a microwave imaging algorithm for brain stroke monitoring," *Journal of Low Power Electronics and Applications MDPI*, Vol. 43, No. 8, Nov. 2018.