

Design, Realization and Experimental Testing of a Microwave Brain Scanner for Cerebrovascular Diseases Monitoring

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Abstract—This work describes the realization, characterization and first experimental validation of a novel portable device for brain stroke monitoring via microwave imaging. A low-complexity approach is the base for the cited device. The 24 antennas are distributed on a surface conformal to the human head, as a helmet. The initial validation of the system is performed through a set of experiments on a 3-D anatomically realistic phantom.

Index terms—microwave imaging; stroke monitoring; antennas; switching matrix

I. INTRODUCTION

In recent years, microwave tomography (MWT) has attracted an increasing interest as an alternative diagnostic tool for medical imaging. The use of microwaves permits a low cost, reduced size of the equipment and guarantees low intensity and non-ionizing radiations. This technique could be thought as complementary and, in some cases, as alternative to standard diagnostic tools for brain stroke, such as magnetic resonance imaging (MRI) and x-ray computerized tomography (CT), which are indeed much more expensive, bulky and harmful for operators.

In this paper, we present the design, realization and experimental testing of a novel device able to monitor cerebrovascular diseases, whose realization is based on microwave imaging technology.

II. MICROWAVE IMAGING SYSTEM

The system (Fig. 1) consists of a set of 24 antennas, placed around the considered phantom, with the antennas immersed in a coupling medium. Each antenna acts as transmitter and receiver (RX/TX) thanks to a custom 24x2 switching matrix connected to a vector network analyzer (VNA). The signals collected by the VNA are the used by the imaging algorithm. The switching matrix is built of electromechanical coaxial switches and semi-rigid coaxial cables to minimize losses and maximize path isolation.

The antennas are wideband monopoles printed on a standard FR4 substrate, deployed conformal to the head. The optimal layout of the 3-D array is obtained following a precise procedure as in [1], considering the available information on the region of interest, the spatial resolution, the reconstruction capabilities and the actual dynamics and signal to noise ratio of the measurement system. The antennas are immersed in a coupling medium obtained of urethane rubber and graphite powder [2]. The use of a solid (also if flexible) material permits each antenna and its coupling material to be considered as a block in the mounting and designs stages of the helmet. Figure 2 shows the helmet around the head phantom.



Figure 1. Overview of the realized microwave brain scanner.

The other key points of the design, i.e. frequency bandwidth and dielectric characteristics of the coupling medium, are designed according to [3, 4], in order to maximize the transmission coefficients through the different head tissues. The working frequency is set to around 1 GHz and the coupling medium dielectric constant is around 20, obtained with the previously mentioned mixture.

The implemented reconstruction algorithm is the Truncated Singular Value Decomposition (TSVD). The initial testing of the algorithm had been performed on simulations [1]. The nature of the algorithm permits also an easy hardware acceleration [5].

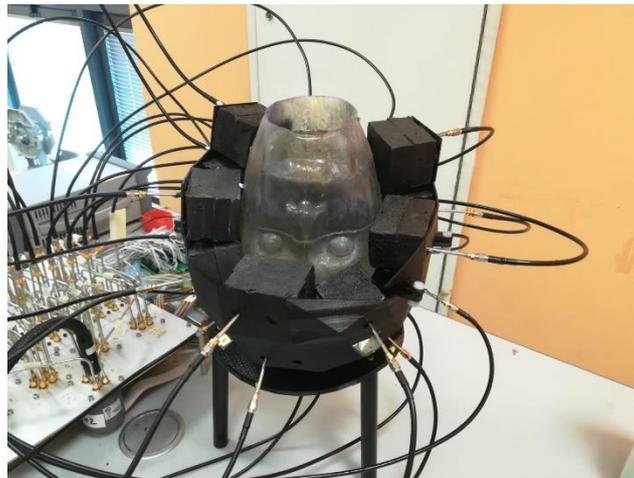


Figure 2. Phantom and Designed Helmet

III. EXPERIMENTAL VALIDATION

The experimental validation reported herein has been led with the 3-D scanner helmet on a 3-D phantom obtained from real human head information [6] as seen in Fig. 2. The phantom is filled with a Triton X-100 and water mix that mimics the average brain dielectric properties. Differential measurements are performed on the phantom with and without target inside, that is a plastic target of 1.25 cm of radius. The reference scenario, used to generate the discretized Green's function in the TSVD algorithm, is the homogenous average head. Figure 3 shows a reconstructed image where the yellow spot shows the size and position of the target.

IV. CONCLUSION AND PERSPECTIVES

In this work we have described the design and realization of a microwave brain scanner for cerebrovascular diseases monitoring. Experimental validations have shown promising capabilities. The next step of the project is to test another realistic targets and more complex head phantoms.

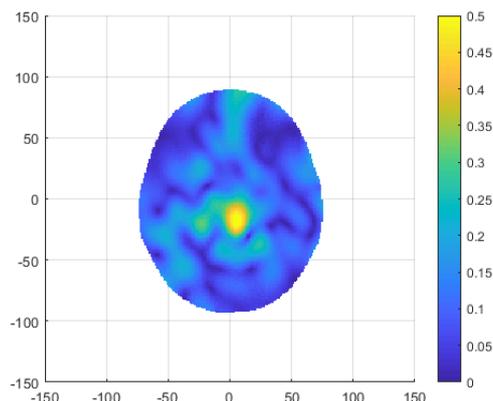


Figure 3. Image of target inside head phantom

ACKNOWLEDGMENTS

This work was supported by the Italian Ministry of University and Research (MIUR) under the PRIN project “MiBraScan - Microwave Brain Scanner for Cerebrovascular Diseases Monitoring”.

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