FULL-WAVE ASSESSMENT OF FEASIBILITY GUIDELINES FOR 3-D MICROWAVE IMAGING OF BRAIN STROKES

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Microwave imaging (MWI) can provide truly non-invasive and affordable tools to perform biomedical monitoring for diagnostic purposes, as it exploits non-ionizing - therefore harmless - radiations and relatively cheap and portable devices. In this respect, besides breast cancer imaging, which is still the mostly addressed topic by researchers worldwide, there are several emerging applications relevant to the so-called *aging society* scenario, such as early diagnosis of bones degradation [*P. M. Meaney, T. Zhou, D. Goodwin, A. Golnabi, E. A. Attardo and K. D. Paulsen, "Bone Dielectric Property Variation as a Function of Mineralization at Microwave Frequencies," Int. Journal of Biom. Imag. 2012*] and monitoring of brain injuries due to strokes. In these applications, the capabilities of a microwave technology can be helpful to cooperate with existing diagnostic technologies, in order to improve the overall reliability and timeliness of the diagnosis.

As far as brain stroke imaging is concerned, MWI is potentially useful to continuously monitor the patient during the critical or post-critical stages of the injury event, possibly at the patient's bed. This task cannot be accomplished with the main clinical imaging tools used to diagnose brain strokes, that is computerized tomography (CT) and magnetic resonance imaging (MRI), as they are not cost effective, their operation is time consuming and the involved instrumentations are not portable.

Taking these circumstances into account, it is interesting to investigate the potentialities offered by microwave imaging devices designed to monitor the evolution of a brain stroke event. In this respect, one important issue is to outline the most favorable operating conditions required to successfully perform the imaging task. To this end, it is for instance necessary to maximize the coupling of the probing wave with the head's interior, taking into account the fact that the head is a complex structure from an electromagnetic point of view (both for its high inhomogeneity and the dispersive behavior of involved tissues). In turn, this requires to determine the electromagnetic properties of a convenient coupling medium and to choose a suitable working frequency range.

Such a question has been addressed in a recent study [*R. Scapaticci, L. Di Donato, I. Catapano, and L. Crocco, "A feasibility study on microwave imaging for brain stroke monitoring," Progress In Electromagnetics Research B, Vol. 40, 305-324, 2011*] wherein, by exploiting a simple schematization of the head as a multiple layer medium, it has been shown that in microwave imaging of brain a "forbidden band" exists from 1GHz to 3.5GHz, regardless of the adopted coupling medium, for which the incoming power is almost completely reflected. As a consequence, not all frequencies are viable to perform the imaging. In addition, due to the dispersive nature of brain tissue a decreasing wave penetration depth is observed for increasing working frequencies. It follows that frequencies higher than 3GHz are actually not useful (unless the anomaly is located in the head's exterior layers) and thus the imaging systems has to rely on frequencies lower than 1GHz. This circumstance has an immediate consequence in terms of a degradation of the achievable spatial resolution, which has to be counteracted by properly choosing an electromagnetically dense coupling medium.

Since the overall analysis in [*R. Scapaticci, L. Di Donato, I. Catapano, and L. Crocco, "A feasibility study on microwave imaging for brain stroke monitoring," Progress In Electromagnetics Research B, Vol. 40, 305-324, 2011*] has been carried out in free space and for a two-dimensional configuration, this communication reports on the results of an extensive campaign carried out using a full-wave electromagnetic solver capable of simulating the wave's propagation in more realistic conditions, that is for the 3-D full-wave case and for an imaging system embedded into an enclosure. At the conference, the results of the simulation campaign will be discussed and analyzed to provide the guidelines for the design of an actual brain stroke imaging apparatus. The effectiveness of these guidelines will be also tested by carrying out simulated imaging experiments concerned with time-lapse monitoring of brain strokes.