Inverse Problem Method for Microwave Intrabody Medical Imaging

Authors : J. Chamorro-Servent, S. Tassani, M. A. Gonzalez-Ballester, L. J. Roca, J. Romeu, O. Camara

Abstract : Electromagnetic and microwave imaging (MWI) have been used in medical imaging in the last years, being the most common applications of breast cancer and stroke detection or monitoring. In those applications, the subject or zone to observe is surrounded by a number of antennas, and the Nyquist criterium can be satisfied. Additionally, the space between the antennas (transmitting and receiving the electromagnetic fields) and the zone to study can be prepared in a homogeneous scenario. However, this may differ in other cases as could be intracardiac catheters, stomach monitoring devices, pelvic organ systems, liver ablation monitoring devices, or uterine fibroids' ablation systems. In this work, we analyzed different MWI algorithms to find the most suitable method for dealing with an intrabody scenario. Due to the space limitations usually confronted on those applications, the device would have a cylindrical configuration of a maximum of eight transmitters and eight receiver antennas. This together with the positioning of the supposed device inside a body tract impose additional constraints in order to choose a reconstruction method; for instance, it inhabitants the use of well-known algorithms such as filtered backpropagation for diffraction tomography (due to the unusual configuration with probes enclosed by the imaging region). Finally, the difficulty of simulating a realistic non-homogeneous background inside the body (due to the incomplete knowledge of the dielectric properties of other tissues between the antennas' position and the zone to observe), also prevents the use of Born and Rytov algorithms due to their limitations with a heterogeneous background. Instead, we decided to use a time-reversed algorithm (mostly used in geophysics) due to its characteristics of ignoring heterogeneities in the background medium, and of focusing its generated field onto the scatters. Therefore, a 2D time-reversed finite difference time domain was developed based on the time-reversed approach for microwave breast cancer detection. Simultaneously an in-silico testbed was also developed to compare ground-truth dielectric properties with corresponding microwave imaging reconstruction. Forward and inverse problems were computed varying: the frequency used related to a small zone to observe (7, 7.5 and 8 GHz); a small polyp diameter (5, 7 and 10 mm); two polyp positions with respect to the closest antenna (aligned or disaligned); and the (transmitters-to-receivers) antenna combination used for the reconstruction (1-1, 8-1, 8-8 or 8-3). Results indicate that when using the existent time-reversed method for breast cancer here for the different combinations of transmitters and receivers, we found false positives due to the high degrees of freedom and unusual configuration (and the possible violation of Nyquist criterium). Those false positives founded in 8-1 and 8-8 combinations, highly reduced with the 1-1 and 8-3 combination, being the 8-3 configuration de most suitable (three neighboring receivers at each time). The 8-3 configuration creates a region-of-interest reduced problem, decreasing the ill-posedness of the inverse problem. To conclude, the proposed algorithm solves the main limitations of the described intrabody application, successfully detecting the angular position of targets inside the body tract.

Keywords : FDTD, time-reversed, medical imaging, microwave imaging
Conference Title : ICMIEIP 2020 : International Conference on Microwave Imaging and Electromagnetic Inverse Problems
Conference Location : Lisbon, Portugal
Conference Dates : April 16-17, 2020

Open Science Index, Electrical and Computer Engineering Vol:14, No:04, 2020 publications.waset.org/abstracts/121449.pdf