Experimental Validation of Medical Microwave Imaging for Breast Cancer Screening

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Abstract

Breast cancer is the second most common type of cancer in Europe and the cancer with most incidence on women [1]. Yet, the detection of breast cancer in an early-stage highly increases the chances of surviving, as well as it decreases the morbidity of tumor treatments, leading to better quality of life of tumor survivors. However, screening breast cancer in mass populations is extremely challenging.

The primary technique used for breast cancer screening is the mammography exam [1]. Despite having very good resolution, it uses ionizing radiation, which is hazardous for health. In fact, there is an established limit for the amount of ionizing radiation a person can be exposed to per year. In case of positive detection of potential carcinomas, the patients are forwarded to further exams, which generally include ultrasound and/or Magnetic Resonance Imaging (MRI). Although these exams offer quite good detection rates, they are time consuming or expensive, thus not appropriate for mass population screening.

Within this framework, new technologies are emerging as alternatives to mammography. One of these is Microwave Imaging (MWI), which is revealing promising results. Unlike X-rays, it uses much lower frequencies (approximately between 1 GHz and 30 GHz) at which there are no known damages in tissues. Nevertheless, as a consequence of using larger wavelengths, microwaves do not achieve the same resolution as X-rays.

MWI involves illuminating the breast with microwave (MW) energy radiated by antennas distributed around the breast. Literature reports sufficient dielectric contrast between

healthy and malignant breast tissues [2], which encourages the use of microwaves. Indeed, the dielectric contrast causes the MW energy to be scattered and picked up by the same antennas. Based on these echoes, it is possible to use strategies to reconstruct the reflectivity map of breast tissues, therefore identifying the tumor. Yet, as any recent technology, MWI involves great investment in research and development, until the concept is experimentally proven and ready for clinical trials, especially in the Medicine field.
At Instituto de Telecomunicações, Lisbon, we are developing and experimentally validating a prototype aiming at the early detection of breast cancer based on MWI. We envisioned the patient would lie on prone posture with the breast inserted in a cavity embedded in the examination bed. This posture reduces the influence of the chest movement due to the respiration and gives easy access to the breast [3]. To this end, we use an anthropomorphic breast model that resembles the examination posture [4]. Moreover, the breast tissues were mimicked by appropriate liquids [5].
The irregular shape of the realistic breast poses a significant challenge in MWI; however most experimental works found in the literature assume regular-shaped breast models. Also, we use a cylindrical antenna configuration around the breast, since it is easily adjustable to any breast size and avoids the use of complex mechanical parts. Lastly, our experimental prototype does not require immersing the breast in any coupling medium, unlike the majority of published works. We reckon this will make the exam more comfortable to the patient without sacrificing the overall imaging performance.
The demonstrator has been assembled and tested in our facilities. The results obtained in our experiments show very good precision, since the tumor was correctly detected. These results show the potential of MWI in breast cancer screening that may serve as an alternative to mammography, thus avoiding the use of hazardous radiation.

Keywords: Antennas for medical imaging, breast cancer screening, experimental validation, microwave imaging.

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