Bayesian Estimation of Tumors in Breasts Using Microwave Imaging

Aleksandar Jeremic[1], Elham Khosrowshahli[1]

[1]McMaster University, Hamilton, ON, Canada

Abstract

According to Canadian Cancer Society, breast cancer is the most frequently diagnosed cancer in women with over 23,400 new cases expected in 2011 [1]. Due to the progressive nature of the disease early detection is extremely important and can significantly improve survival rates. Currently all of the clinical procedures are based on mammography which is routinely prescribed for older women who tend to be more susceptible to the disease [1]. Although mammography is extremely important diagnostic technique, it suffers from some limitations such as false negative and positive results, using ionizing radiation and patient's discomfort [2], [3]. The number of false positives is rather significant in the case of so called dense breasts in which healthy tissue may be mistaken for malignant and as a consequence unnecessary biopsies are prescribed. Furthermore, complicating the matter is the fact that mammography is a two-dimensional technique in which three-dimensional images are obtained through image reconstruction from 2D projections which can also lead to false positives. Microwave imaging has been recently proposed as an additional medical imaging technique which can potentially overcome some of the shortcomings of the mammography. Essentially the technique is based on illuminating breast with electromagnetic-wave(s) in microwave range. From the physical point of view this can be represented as wave propagation in medium (breast) that contains scatterers (both healthy and malignant tissue). Due to the fact that malignant tissue has larger conductivity the measurements obtained by receiving array of antennas will be different if the scatterers are present. Therefore once the wave propagates through the breast the received signal is analyzed in order to obtain permittivity map using appropriately selected image reconstruction technique [4]. Most of the image reconstruction techniques minimize a particular cost function (e.g. mean-square error). In most cases the number of unknowns (e.g. number of pixels in the map) is much larger than the number of available measurements which requires an additional constraint. In this paper we propose a simplified parametric inverse 3D model which enables us detection of tumor presence and estimation of its size and/or position. Most of the existing solutions [3] employ non-parametric image reconstruction techniques. We believe that accuracy can potentially be improved by considering parametric models. In general, parametric models can increase modeling noise. However, we believe that appropriately defined parametric model can be useful as long as an appropriate clinical decision can be made based on reduced number of parameters. To this purpose we first use COMSOL Multiphysics to develop a three-dimensional finite element model of electromagnetic wave propagation through the breast tissue. We define our model with respect to tumor size and location and assume that the permittivity of tumor can be modeled by Gaussian probability density function (pdf). We then derive probability density function of the measured data (power received by receiving antennas) obtained using COMSOL's RF

module and the corresponding likelihood function. We then maximize the likelihood with respect to the unknown parameters.

Reference

1. Gemignani, M. L., "Breast Cancer Screening: Why, When, and How Many?," Clinical Obstetrics and Gynecology, Vol. 54, No. 1, 125–132 (2011)

2. Tice, J., and Kerlikowske,~K, "Screening and Prevention of Breast Cancer in Primary Care, " Primary Care: Clinics in Office Practice, Vol. 36, No. 3, 533–558 (2009)

3. Pastorino, M., Stochastic Optimization Methods Applied to Microwave Imaging: A Review, IEEE Transactions on Antennas and Propagation, Vol. 55, No. 3, 538-548, (2007)

Figures used in the abstract

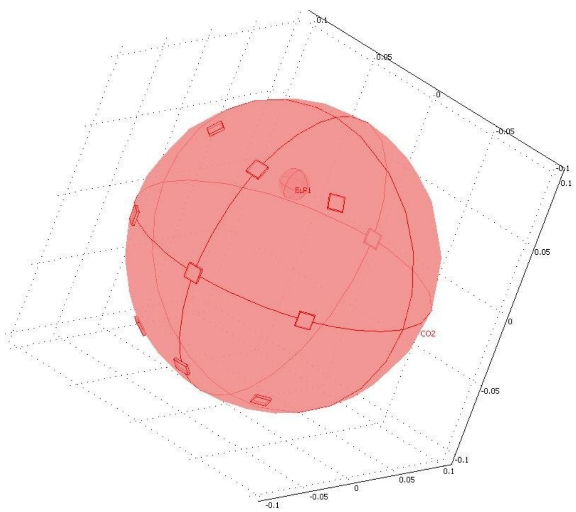

Figure 1: Model geometry.

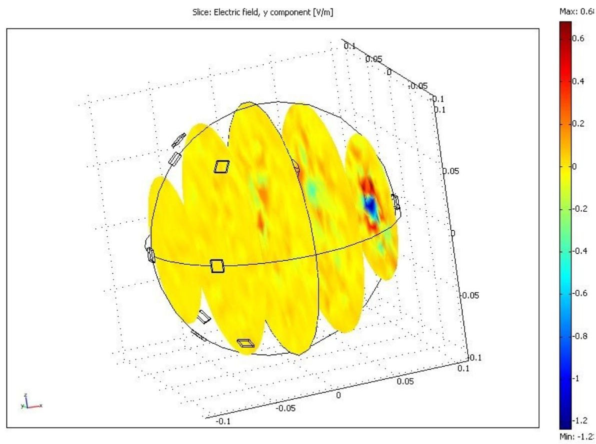

Figure 2: Example of microwave propagation for 2GHz wave.