Conductivity Estimation of Breast Cancer Using COMSOL® Modeling of Microwave Scattering and Frechet Mean Estimate of Covariance

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Abstract

Breast cancer detection is one of the most important problems in health care as it is second most frequent cancer according to WHO. Breast cancer is among cancers which are most probably curable, only if it is diagnosed at early stages. Therefore, frequent screening is of great importance. It is recommended that women over fifty or even younger in some cases like those with family background do a screening test every two years. Besides clinical breast examination, there are number of imaging methods used for this purpose, such as mammography, ultrasound and MRI. Among them, mammography is the one which is mostly used for screening purpose. It is relatively cheap and widely available. But, it suffers from some disadvantages. First, ionizing radiation is used in this method, so it is not safe to be used frequently. Second, it is not comfortable for women to do this test, thus number of women may avoid the test and loose the chance of an early detection. Finally, there are many reports of false positive and false negative results which may cause unnecessary biopsy and anxiety or on the other hand missing the early diagnosis. To this purpose it has been recently proposed that microwave imaging could be used as a cheaper and safer alternative. From a physical standpoint breast cancer can be modeled as a scatterer with a significantly (tenfold) larger conductivity than a healthy tissue.

In our previous work we proposed a maximum likelihood based method for detection of cancer which estimates the unknown parameters by minimizing the residual error vector assuming that the error can be modeled as a multivariate (multiple antennas) random variable. However we have recently demonstrated that the detection performance can be significantly improved (even in a Gaussian case) if classical sample covariance estimate is replaced by Frechet mean average. Rationale behind this approach is that Frechet means ensures positive definiteness of the covariance matrix thus implicitly implementing constrained optimization. In this paper we develop COMSOL® model of a breast cancer and apply Frechet mean estimation to determine the unknown conductivity of the scatterer (tumor). To illustrate the applicability of our approach we evaluate the mean square error of conductivity estimation using Frechet mean estimate instead of classical estimation. In Figure 1 we illustrate the geometry of the corresponding COMSOL model and in Figure 2 we illustrate the MSEE corresponding to the aforementioned estimation. The simulation result of the electrical field component Ey in the presence of single scatterer is presented in Figure 3.

Figures used in the abstract

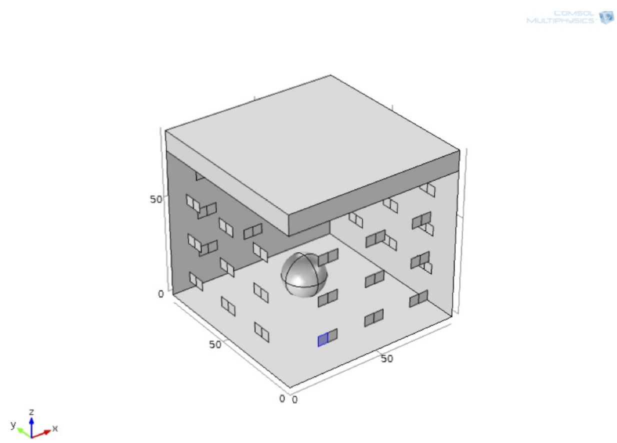

Figure 1: COMSOL geometry.

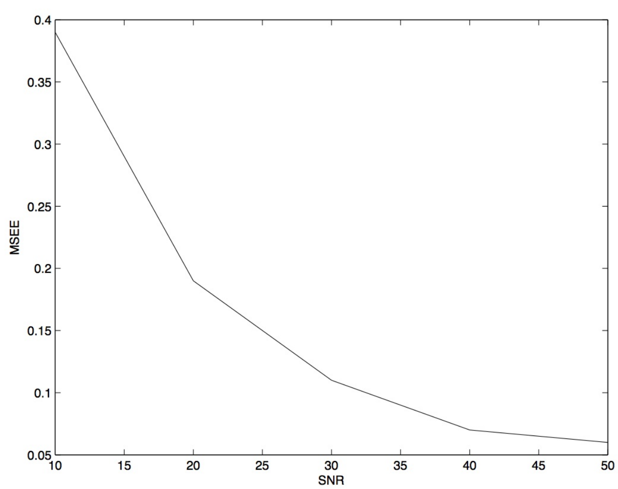

Figure 2: Mean square error of conductivity estimation.

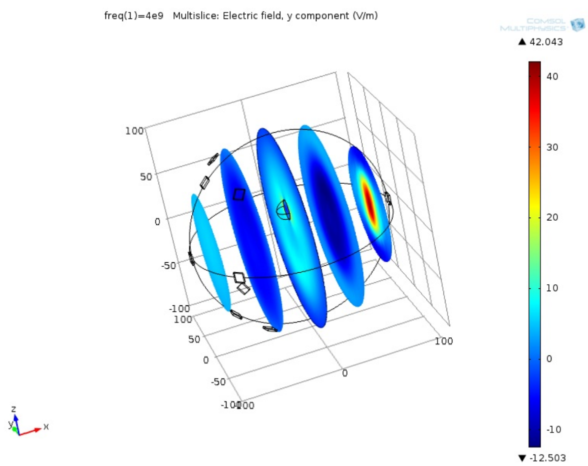

Figure 3: Ey field component in the presence of single scatterer.