ANALYTICAL FORWARD MODELS FOR BREAST CANCER DETECTION USING ELECTRICAL IMPEDANCE TOMOGRAPHY

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ABSTRACT

Electrical Impedance Tomography (EIT) can be used to determine the admittivity distribution within the breast from measurements made on its surface. It has been reported that the electrical impedance spectra of normal breast tissue is significantly different from that of malignant tissue, making EIT a candidate technology for breast cancer detection. The inhomogeneous structure of breasts, with thin skin layers covering the tissue inside, makes the breast imaging problem difficult. In addition, studies show that the electrical properties of skin vary considerably over frequency. This thesis proposes a layered forward model which incorporates the presence of skin. We study two geometries, namely the x-ray mammography geometry and the ultrasound like hand-held probe geometry. The mammography layered model has three layers, thin top and bottom layers representing skin and a thicker middle layer representing breast tissue. We solve for the forward solution of the layered geometry and compare its behavior to the previously used homogeneous model. Next we develop an iterative method to estimate the skin and breast tissue admittivities from the measured data, and study the robustness and accuracy of the method for various simulated and experimental data. We then look at the reconstruction of a target embedded in a layered body when the homogeneous forward solution is replaced by the layered forward solution. Lastly we demonstrate the improvement that the layered forward model produces over the homogeneous model when working with clinical data.

Next we study the hand-held probe geometry. We develop and study in detail the hand-held probe forward model and reconstruction algorithm for a 8×4 electrode array hand-held probe. We present the Fourier decomposition method, a new approach to obtain the forward solution for the hand-held geometry. We compare the forward solution from the Fourier decomposition method with a method developed earlier which uses the approximate Green's theorem. We then compare the static and difference reconstructions from the two methods for experimental tank data. Next we explore the various methods to obtain better reconstructions using

the hand-held probe. These methods include modifying the reconstruction mesh, using different regularization parameters, varying the electrode array structure and generating optimal current patterns which offer improved distinguishability. This study suggests the use of a 6×6 hand-held probe geometry to obtain better reconstruction results. Next we build a 6×6 hand-held probe, develop its forward model and test its performance for experimental tank data. Lastly we extend the Fourier decomposition approach to introduce the hand-held probe two layered model with a thin skin layer beneath which is the breast tissue layer. We demonstrate the improvement in the reconstruction of a target in a layered medium that the layered model produces over the homogeneous model using simulated data. We apply the layered hand-held probe model to the 6×6 hand-held probe geometry and analyze the layered model using data collected from a human abdomen.