MAGNETIC RESONANCE CONDUCTIVITY IMAGING

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Abstract— A new imaging modality combining electrical impedance tomography (EIT) and magnetic resonance imaging (MRI), by utilizing both the voltage measurements from EIT and magnetic field measurements from MRI, is proposed and tested using simulated data. It has been shown that, high resolution and absolute conductivity images can be obtained.

Index words— electrical impedance tomography, current density imaging, magnetic resonance imaging

I. INTRODUCTION

In 2D EIT, surface measurements are used to reconstruct the conductivity distribution in the object [1], but surface measurements are not sensitive to inner conductivity perturbations. Also, since the number of measurements is limited, the reconstructed images have low resolution. It has been shown that magnetic field generated by injected currents can be measured using MRI [2] and this information can be used to reconstruct conductivity distribution [3]. Although this method yields high resolution images, absolute conductivity values can not be obtained. In this study, a new imaging modality combining EIT and MRI, for high resolution absolute conductivity imaging, is proposed and simulated.

II. METHODS

A 16 electrode, opposite drive EIT measurement strategy is adopted [1]. The proposed method uses the voltage measurements of EIT and magnetic field obtained from MRI.

EIT measurements are simulated by using a 2D finite element method and magnetic field data is obtained by using Biot-Savart law.

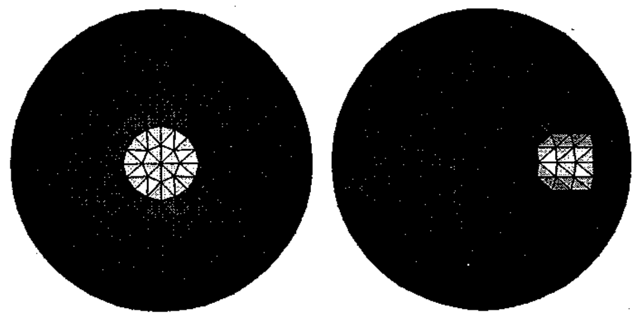
The conductivity distribution, σ, for a given set of voltage measurements (ϕ_s) and magnetic field measurements (B) is calculated using a three stage iterative algorithm. First, an initial σ is assumed and the potential, ϕ, is solved throughout the imaging region (forward problem, FP). The FP involves the solution of mixed boundary value problem where ϕ_s values are applied as Dirichlet boundary conditions. The current density distribution can be obtained as $-\sigma\nabla\phi$. Secondly, the current density is calculated using the magnetic field measurements by evaluating $\nabla \times \vec{B}$ and dividing by μ_o. If the initially assumed conductivity distribution were correct, the current density calculated using these two methods would be the same. Finally, the conductivity distribution which minimizes the difference between the current density values of each method is calculated as:

$$\sigma_j = \frac{1}{\mu_o} \frac{\sum_X \int_{S_j} \nabla\phi \cdot \left(\nabla \times \vec{B}\right) dS}{\sum_X \int_{S_j} \nabla\phi \cdot \nabla\phi \, dS} \qquad (1)$$

where σ_j and S_j are the conductivity and area of the j^{th} element respectively, X is the number of excitations. σ calculated using (1) is assumed to be the initial σ in next iteration and above procedure is reapplied.

III. RESULTS

In Fig. 1, two images reconstructed from simulated data using the proposed algorithm are presented. In both images background and object conductivity values are 0.002S/cm and 0.02S/cm respectively. The initial conductivity is taken as 0.001S/cm and 6 iterations are made for both cases. The reconstructed objects coincide exactly with the actual objects in the corresponding simulations.



(a) (b)

Fig. 1 Reconstructed conductivity images. (a) concentric inhomogeneity (b) eccentric inhomogeneity

IV. DISCUSSION

The results of this preliminary study show that the proposed method can be used to obtain high resolution absolute conductivity images. The convergence properties of the iterative algorithm need to be investigated. Furthermore, optimization of the applied current pattern will probably improve the reconstruction. Future studies will involve the practical implementation of the method and its extension to 3D.

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