A Hybrid Image Reconstruction for Medical Magnetic Induction Tomography: an experimental evaluation

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Abstract: Magnetic induction tomography is a tomographic technique with potential medical applications. However, the realization of this technique remains a challenging topic both in hardware and in image reconstruction. This paper presents a hybrid image reconstruction algorithm for the image reconstruction using experimental data.

1 Introduction

Magnetic induction tomography (MIT) is capable of imaging electrical properties of the materials under testing [1]. Due to its contactless and non-invasive nature, it has great potential to be employed in medical applications, such as brain imaging. As MIT is a low-resolution technique, one of the major issues lies in the image reconstruction. The main objective of this study is to improve the quality of reconstructed images by using a hybrid regularization algorithm resulting in some enhancements in reconstructed images.

2 Methods

In the forward problem of MIT, a reduced magnetic vector potential is used [2]. The general equation in quasi-static electromagnetic field can be written as.

$$\nabla\times\left(\frac{1}{\mu}\nabla\times A_r\right)+j\omega\sigma A_r = \nabla\times H_s - j\omega\sigma A_s - \nabla\times\frac{1}{\mu}\mu_0 H_s \quad (1)$$

where A_r is the reduced magnetic vector potential in the eddy current region, ω is the angular frequency, σ is the electrical conductivity, H_s is the magnetic field due to the the excitation coil, which can be directly computed according to the Biot-savart law. A_s is the impressed magnetic vector potential as a result of source current density J_s, μ_0 is the permeability of the free space, and μ is the permeability of the medium. In equation 1), the only unknown is A_r, which can be computed by soving the system linear equation [3].

$$SA_r = b \quad (2)$$

where S is a system matrix, and b is the right hand side current density. The inverse problem of MIT can be solved by using a hybrid image reconstruction algorithm [4].

$$\Delta\sigma = (J^T J + \alpha R_1 + \beta R_2)^{-1} J^T(\Delta v) \quad (3)$$

where Δv is the changes in the induced voltage measurements, J is the sensitivity map computed from the forward model, R_1, R_2 are the regularization matrices, and α and β are the regularisation factors for R_1 and R_2 respectively. A combination of NOSER and identity matrix was used as hybrid regularization scheme. Combined regularization produces images with more accurate location and shape of the inclusion(s).

3 Imaging system

The Bath medical MIT system is shown in Figure 1. It is a 16 channel National Instrument based system working at 13 MHz excitation modes. The detailed system design has been reported in [5]. Imaging different level of salinity solutions inside various salinity solutions background carries out the experiments. Both individual and multiple bottles are used. A large number of experimental data are collected to verify the proposed method. Figure 1 gives an example of reconstructed images using non- conductive bottles inside 0.9% saline solution in different locations.

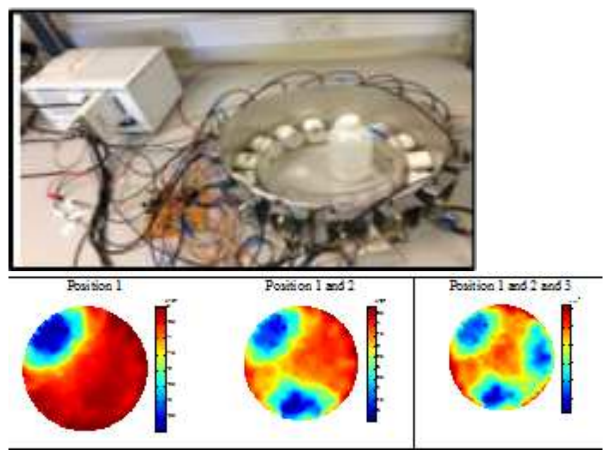

Figure 1: Bath 16-channel medical MIT system, reconstruction of 1, 2 and 3 bottles in saline background with 0.9% saline.

4 Conclusions

A hybrid image reconstruction algorithm is presented in this study in an attempt to improve the quality of reconstructed images. Both forward and inverse problems are studies, and the results are validated using large number of experimental data. The proposed hybrid regularization provides better quality reconstruction compared to each of these regularization methods.

References

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