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INITIAL DEVELOPMENT ON MAGNETIC INDUCTION TOMOGRAPHY IMAGING

NOR MUZAKKIR NOR AYOB[1*], ZULKARNAY ZAKARIA[2], MOHD HAFIZ FAZALUL RAHIMAN[3], RUZAIRI ABDUL RAHIM[4] & SAZALI YAACOB[5]

Abstract. Non-intrusive imaging systems have always been of much interest for use in many applications such as process, industrial and medical. Electrical techniques, in particular, are proving to be an inexpensive imaging instrument with low but sufficient resolution capability on imaging the internal distributions processes. Magnetic Induction Tomography (MIT) is an electrical tomographic method based on the use of inductance measurement for monitoring the distribution of electrically conductive and magnetically permeable material within the sensing area. This paper details the fundamental investigation of the software development for magnetic induction tomography imaging. Research works are concentrated on generating the sensitivity maps needed to reconstruct tomographic images of the electromagnetic distribution. Initial results on the simulative studies have shown acceptable result for using the generated sensitivity map for imaging electrical conductivities.

Keywords: Magnetic induction tomography; non-intrusive imaging; inductance; sensitivity map

Abstrak. Sistem pengimejan yang tidak intrusif telah banyak menarik perhatian di dalam banyak aplikasi seperti pemprosesan, industri dan perubatan. Teknik elektrikal khususnya, terbukti menjadi instrumen pengimejan berkos rendah dengan kemampuan resolusi rendah tetapi memadai untuk pengimejan pemprosesan. Tomografi Induktansi Magnetik (TIM) adalah kaedah tomografi elektrikal berdasarkan penggunaan bacaan induktansi untuk memantau distribusi bahan konduksi elektrik dan magnetik dalam kawasan pemerhatian. Karya penyelidikan ini adalah berdasarkan pembangunan perisian untuk kegunaan pengimejan tomografi induktansi magnetik. Hasil penyelidikan tertumpu untuk menghasilkan peta sensitiviti yang diperlukan untuk rekonstruksi semula imej tomografi dari taburan elektromagnetik. Keputusan awal mengenai kajian simulatif telah menunjukkan hasil yang positif iaitu peta sensitiviti yang dihasilkan adalah bersesuaian untuk digunakan dalam pengimejan konduktiviti elektrik.

[1&4] Process Tomography Research Group (PROTOM), Control and Instrumentation Engineering Department, Faculty of Electrical Engineering, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia

[2,3&5] Tomography Imaging Research Group, School of Mecatronics Engineering, Universiti Malaysia Perlis, Ulu Pauh Campus, 02600 Arau, Perlis, Malaysia

* Corresponding author: normuzakkir@mail.com

Kata kunci: Tomografi induktansi magnetik; pengimejan tidak-intrusif; induktansi; peta sensitiviti

1.0 INTRODUCTION ON MAGNETIC INDUCTION TOMOGRAPHY

Magnetic Induction Tomography (MIT) has a potential for process tomography applications. As a non-intrusive imaging instrument, MIT have broad range of application that can utilize its advantages, not only for medical use but also for industrials [1, 2].

MIT attempts to infer interior conductivity distribution, and possibly collect the distribution of other electromagnetic parameters. This is made possible by monitoring the mutual inductances measurements between coils exterior to the object [3]. The imaging technique is done by passing an alternating current through the excitation coils. This will produce an alternating magnetic field that will induce a voltage to the sensing coils that is a nonlinear function of the electromagnetic properties [4]. The data from the measurements of the spatially varying electromagnetic properties is a reconstruction problem that if solved is able to image the conductivity distribution.

2.0 MODELING THE MAGNETIC FIELD DISTRIBUTION

There are diverse ways to model the excitation and the sensing coils [5, 6, 7]. In this research, COMSOL, a modeling and engineering simulation software is used to solve the numerical equations and visualize the electromagnetic distributions in the given domain subject to the given boundary conditions in two-dimension.

As shown in Figure 1, a section of a typical fixed arrangement of excitation and sensing coils for the MIT system. In this setup, 8 coils are specifically used as the excitation coils (red circles) and another 8 are used for the sensing coils (blue circles).

3.0 SENSITIVITY MAP FOR MAGNETIC INDUCTION TOMOGRAPHY

A matrix of the virtual magnetic field from an excited coil with the corresponding sensing coils is called the sensitivity map. Each pixel in the sensitivity maps (Figure

2.1 until Figure 2.8) represents the sensitivity area of the electromagnetic propagation based on the assumption that there is no other surrounding electromagnetic noise

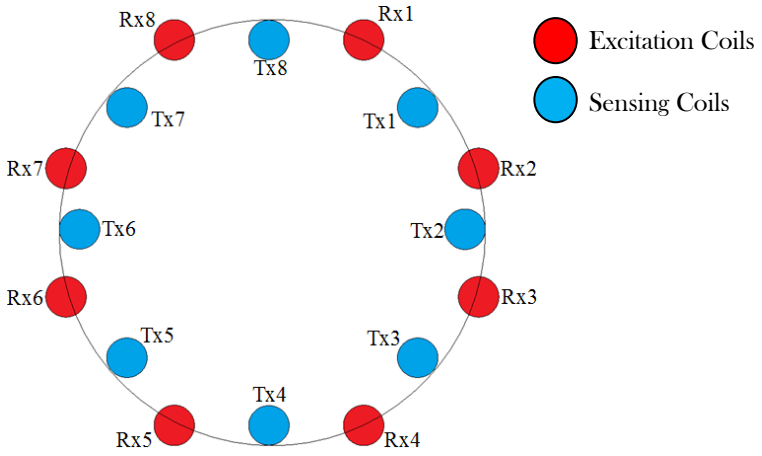

Figure 1 MIT sensor arrangement

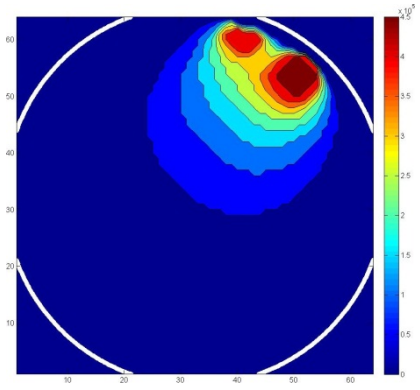

Figure 2.1 Sensitivity map for excitation coil 1 and sensing coil 1

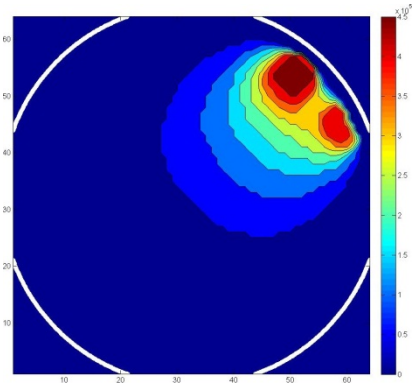

Figure 2.2 Sensitivity map for excitation coil 1 and sensing coil 2

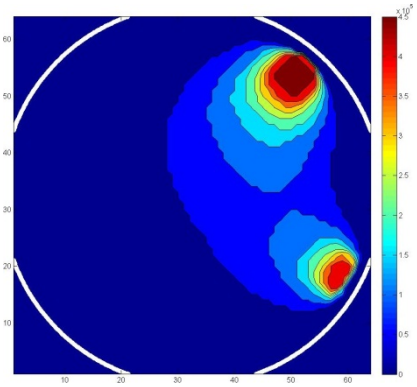

Figure 2.3 Sensitivity map for excitation coil 1 and sensing coil 3

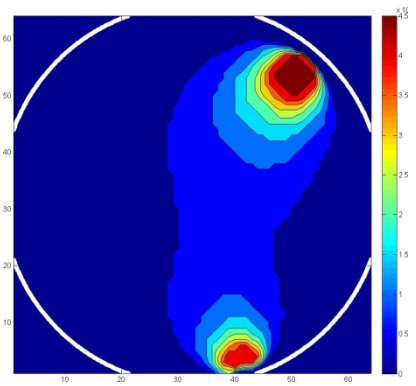

Figure 2.4 Sensitivity map for excitation coil 1 and sensing coil 4

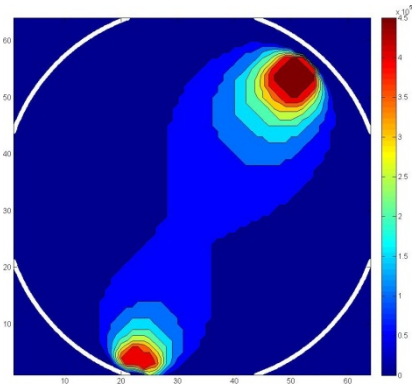

Figure 2.5 Sensitivity map for excitation coil 1 and sensing coil 5

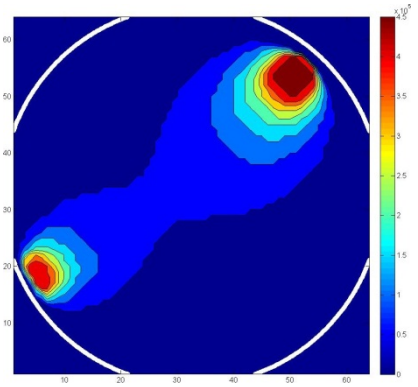

Figure 2.6 Sensitivity map for excitation coil 1 and sensing coil 6

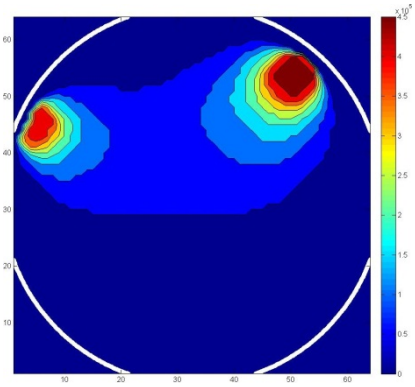

Figure 2.7 Sensitivity map for excitation coil 1 and sensing coil 7

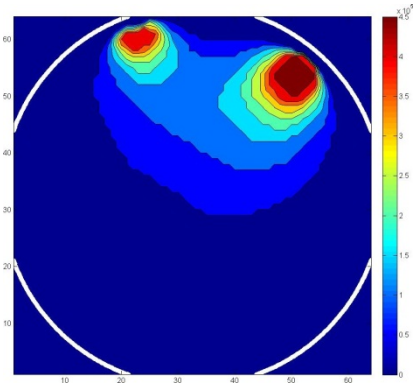

Figure 2.8 Sensitivity map for excitation coil 1 and sensing coil 8

It can be noted that in the simulated MIT system, the magnetic field perturbations to be detected are very small when compared to the excitation field which can be significantly noticed on the high concentration at the center of each excitation coils (dark red).

4.0 INITIAL IMAGE RECONSTRUCTION RESULTS

For the image reconstruction in MIT, one needs to solve the forward problem by using the sensitivity maps. Simulation on the forward model is initially done to ensure that correct fundamentals of process tomography technique have been implemented specifically in image reconstruction.

Phantoms are used to test the results of the reconstruction images based on the use of the sensitivity maps in solving the forward problem. The image on the left of Figure 3.1 to Figure 3.5 shows the phantom distribution while the image on right of these figures shows the reconstructed images.

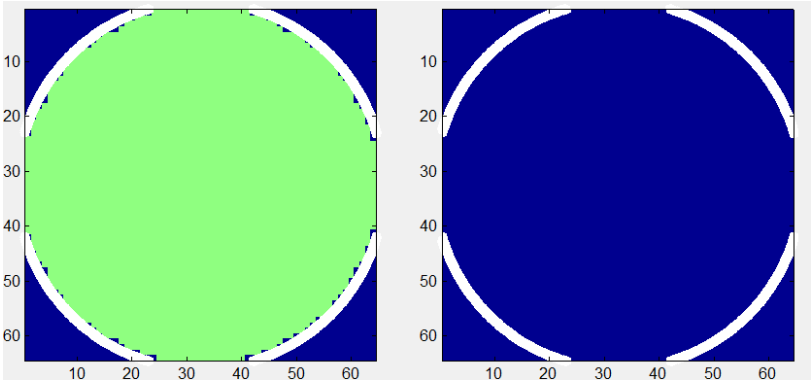

Figure 3.1 Reconstructed image without inclusion

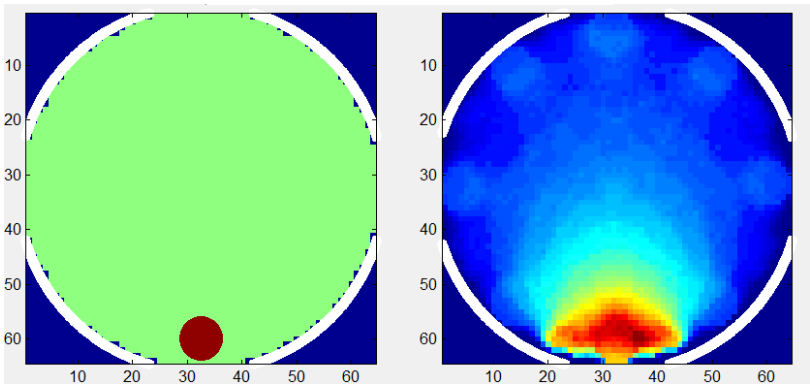

Figure 3.2 Small inclusion at the bottom of the sensing area

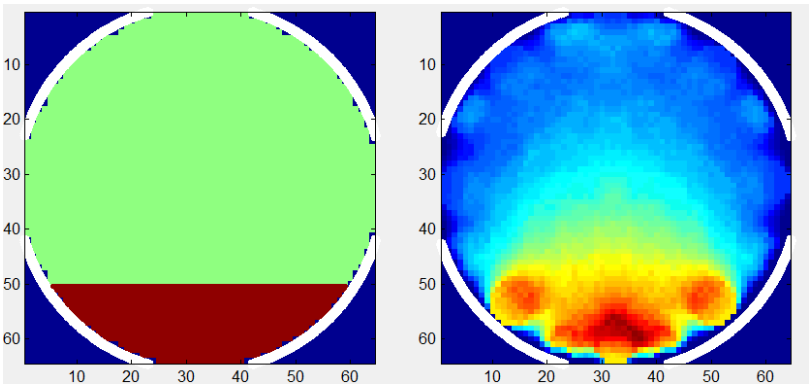

Figure 3.3 Quarter inclusion

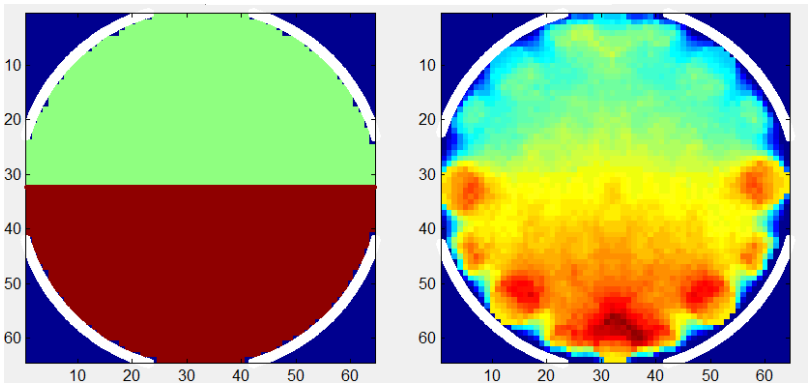

Figure 3.4 Half inclusion

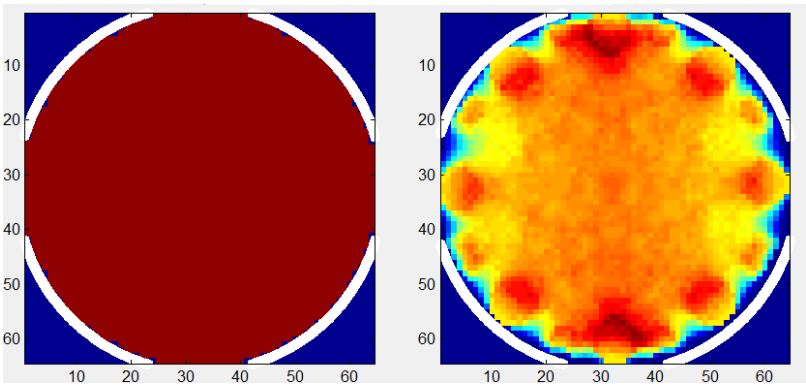

Figure 3.5 Full inclusion

5.0 CONCLUSION

In the simulation study (Figure 3.1 until Figure 3.5), it is shown that the image reconstructions results in feasible detection on the electromagnetics activity inside the sensing area. The image reconstruction problem is to find the distribution of electrical conductivity within the region of interest (sensing area) using a knowledge of all 64 measurements of the simulated induced voltage.

Among other imaging modalities in Process Tomography techniques, MIT can be regarded as a fascinating area to be explored. The technical challenges in acquiring good quality MIT data are considerable and have wide opportunities.

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