A 2D and 3D Electrical Impedance Tomography Imaging Using Experimental Data

Shulga Dmitry

Abstract - **In this paper model, method and results of 2D and 3D conductivity distribution imaging using experimental data are described. The 16-electrodes prototype of computer tomography system, special Matlab and Java software were used to perform imaging procedure. The developed system can be used for experimental conductivity distribution imaging and further research work.**

Keywords - **Electrical Impedance Tomography, Finite Element Method, inverse problem, regularization.**

I. INTRODUCTION

Electrical Impedance Tomography (EIT) is an imaging technique where an image of conductivity distribution inside the object is obtained using surface electrical measurements. The finite element model of object is used to predict electrical potential distribution inside and on the surface of the object. In measurement procedure small alternating current applied to probe electrodes and resulting electrical voltages are measured at other electrodes. These voltages are compared with predicted and then are transformed to conductivity distribution by means of sensitivity matrix, which is obtained from finite element model of object. Mathematically, the EIT problem is a non-linear inverse problem and is severely ill-posed. Thus regularization techniques are used to get a sufficient solution.

II. MODEL, METHOD AND RESULTS

The following physical model links conductivity distribution σ and electrical potential ϕ inside the object:

$$\nabla \cdot (\sigma \nabla \phi) = 0 \tag{1}$$

EIT equation is complemented with Complete Electrode Model [1] to describe electrode models, set current flow and initial potential distribution. For D collections of measurements for all current patterns observation vector of measured voltages $\vec{V} = \left(V_1^1, \ldots, V_M^1, \ldots, V_m^d, \ldots V_1^D, \ldots V_M^D\right)^T$ is formed. The finite element method (FEM) is used to get system of D linear equations from continuous EIT equation form (Eq. (1)). Mathematical model

$$\vec{V} = h(\vec{\sigma}) \tag{2}$$

links unknown conductivity $\vec{\sigma} = (\sigma_1, \ldots, \sigma_k, \ldots, \sigma_K)^T$ and observations $\vec{V}$, which is in practice are corrupted by noise.

Iteration Gauss-Newton algorithm is used to get conductivity distribution (Eq. (3)).

Shulga Dmitry - Scientific and Technical Center of Radio-Electronic Medical Equipment and Technologies XAI-MEDICA National Aerospace University KhAI, Chkalova str.17, Kharkov 61070, UKRAINE,
E-mail:shulgadim@gmail.com

$$\vec{\sigma}_{j+1} = \vec{\sigma}_j + \left(J_j^T J_J\right)^{-1} J_j^T \left(\vec{V} - \vec{U}_j\right) \tag{3}$$

The sensitivity matrix J is ill-conditioned, thus the regularization techniques such as Tikhonov and truncated singular value decomposition (TSVD) [2] are used to get sufficient solution.

The 16-electrodes prototype tomography computer system has been designed. Based on finite element model of object with applying iterative Gauss-Newton algorithms, TSVD and Tikhonov regularizations, Matlab and Java software had been written. A 2D and 3D conductivity distribution images using experimental data showed on Fig.1 and Fig.2 respectively.

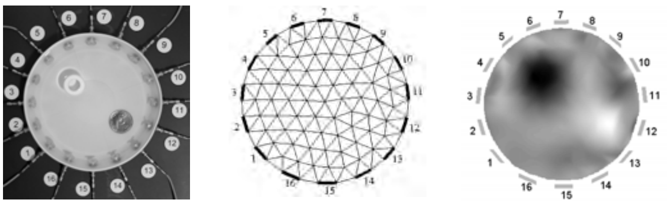

Fig.1 Experimental phantom, FEM model and obtained conductivity distribution for 2D case

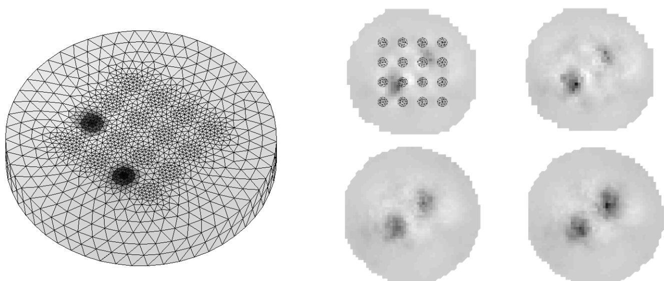

Fig.2 FEM model and obtained depth slices of conductivity distribution for 3D case

III. CONCLUSION

Developed EIT hardware and software system can get 2D and 3D conductivity imaging. Relative resolution for inhomogeneity detection depends on physical dimension of electrodes and container and in our case was about 1 cm.

REFERENCES

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