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ELECTRICAL IMPEDANCE TOMOGRAPHY BASED IMAGE RECONSTRUCTION OF THE UTERUS USING PHANTOM

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Abstract: The resistivity of different human tissue varies with large difference ranging from cerebrosinal fluid to bone. Images of such varied distributed resistivities inside an closed object can easily be reconstructed using image reconstruction algorithm. Electrical impedance tomography is relatively a new imaging technique which maps the distribution of electric resitivity of the closed object such as our body. The aim here is to reconstruct a conductivity image in the phantom papaya which is a model of a uterus of human using finite element method.

Keywords: electrical impedance tomography, boundary values, opposite method, fem

I. INTRODUCTION

Human body is one of the most well known closed and controlled system. It has always been a challenge to develop non-invasive, user friendly, cost effective sensitive tool that can effectively be used to study and monitor morphological and physiological changes occurring in any physiological system inside the closed human body in real time without interfering with the actual real time dynamics, so that the actual pathological and physiological changes can be documented. Though tools such as sonography, MRI are available but none are suitable for mass health care and for long term monitoring purpose as they require high end technological input. Thus, a need was felt to explore the possibility of Electrical Impedance Tomography (EIT) as a suitable alternative technique for monitoring and functional of human beings. One of the most vital in-accessible dynamic closed system in human being is feto-maternal (uterine) and the challenges it pose in bio-instrumentation development for monitoring pregnant mother as well as growing fetus in uterus. Developing appropriate non invasive functional imaging technology has been eluding biomedical scientists and biomedical engineers for decades. To overcome the limitations of presently available techniques, here electrical impedance tomography based on impedance plethysmograph principle is proposed. As shown in figure 1. This technique helps in mapping of electrical field distribution inside a closed object by applying current and measuring voltages on the surface. The distribution of conductivity inside the body shows good contrast hence conductivity images can be produced of these distributions. The unique solution of conductivity distribution are possible for an isotropic conductor but not for anisotropic. If sufficient data of surface voltages are obtained for different input current patterns [7], then anisotropic tissue becomes isotropic. In order to map conductivity distribution inside the phantom into an image some experiments were conducted using opposite method for data acquisition. [9]

II. DATA COLLECTION

EIT is an imaging technique used to reconstruct the resistivity/conductivity distribution within an object from boundary voltage measurements. Various methods of acquisition of data are available such as neighbor, opposite, cross and adaptive [7]. Sixteen electrodes are placed around the cross-section to be imaged, current is applied to two drive electrodes and measurements made of the resultant potential difference across adjacent pairs of the other electrodes. The drive electrodes are rotated to the next pair and the process is repeated until a full data set is obtained.

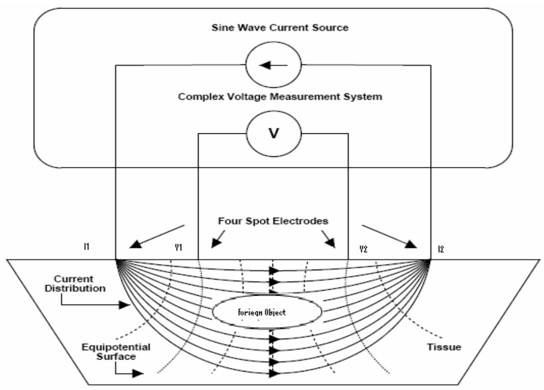

Figure 1 Principle of impedance plethysmograph

A resistivity/conductivity distribution map or image is then produced by means of a suitable reconstruction algorithm. Many linear algorithms for image reconstruction have been proposed including equapotential back projection, regularization methods, and sensitivity matrix method. The inverse problem is to reconstruct the conductivity distribution from the current sources and given voltage boundary conditions. The reconstruction problem in EIT is a typical inverse problem in which the domain of interest is represented by a finite-element model with n pixels. Then by using the procedures of finite element method like finding the stiffness matrix and the assembly we get the set of simultaneous equations. So after solving these equations we get the conductivity distribution inside the body and image is constructed. Figure 2 shows the complete setup. Field distribution inside the object in term of voltage is measured from all other electrodes except from the current electrodes, yielding 13 voltage measurements. For N electrodes, N/2 current patterns are applied and N (N-3)/2 independent measurements are made. When 16 electrodes are used, ,opposite method yields 8×13 = 104 data points.

III. IMAGE RECONSTRUCTION ALGORITHM

Electrical impedance tomography is a non-invasive and relatively new technique for the production of images of the conductivity distribution inside the closed object when low current at very high frequency is injected into it by the electrodes attached on the surface [5].

Figure 2. Experiment setup for measurement of boundary voltages

The transfer impedance in term of voltages is measured on the outer surface of the object using impedance plethysmogrpahy [9]. The measurement may be related to the internal impedance of the object. It is an established technique for measurement of various biomedical parameters [2]. Figure 5 shows pictorial representation of current distribution and equi-potential lines on the surface of the object. The high frequency low current is applied between any two electrodes which get uniformly distributed and the resulting voltage hence impedance is measured between remaining electrodes. It is based on a principle of conducting and non conducting mediums distributed inside the closed object under applied electric field [3]. Suppose a conducting foreign object is inserted in the conducting cell, the current line have tendency to pass through the conducting object and therefore get curved. The resulting equi-potential measured is smaller than the previous case hence the high equivalent conductivity. In contrast, when an insulating object is inserted in place of conducting, the current try to avoid the insulating material with the result equi-potential lines get distorted and leave the insulating object. In this case the voltage measured is high, indicating low conductivity [1]. The current –voltage relationship distribution of the applied current (0.8 - 1 mA AC at 20-100 KHz) and resulting voltage in a closed object is determined by Poisson's (Ә2V/ Әx2 + Ә2 V/ Әy2 =f) or Laplace's equation (Ә2 V / Әx2 + Ә2 V/ Әy2 =0) with given boundary conditions measured at the surface[8]. When such a high frequency constant ac current is applied to the closed object like biomedical, the high frequency sources inside are missing therefor the Possion's equation ($\frac{\partial^2 V}{\partial x^2}+\frac{\partial^2 V}{\partial y^2}=f$) becomes the Laplace equation ($\frac{\partial^2 V}{\partial x^2}+\frac{\partial^2 V}{\partial y^2}=0$). The Laplace equation in the EIT technique is modifiy in voltage current and condutivity term as ∇ρ -1 ∇v = i and ∇ρ -1 ∇v = 0. The calculas equation can be converted into linear algeabric equation in the form Gv=i. To solve the allebriac equation the object underconsideration is first converted into mesh of finite nodes and elements using Delaunay triangular algorithm [4]. The nodes represent the pixels of the condutivity image. All nodes are numbered in the mesh and represent the resoloution of the image. For the given bounday conditions the linear equations are form for the mesh area. In the equation the conductance matrix G is NxN matrix, v is the node voltage maxtix and i is the node current matrix where N is the toatl number of nodes of the mesh which is to be solved to find the node intensity [9]. The reconstruct EIT images represent an impedance change inside the phantom in which pixels intensity are proportional to resistivity.

IV. IMPLEMENTATION AND RESULT

Most of the organ systems or tissues have non-homogenous as well as anisotropic properties such as it may have a ectoderm or epithelial layers and muscle layer and vessels. Each tissue has different independent characteristic which will be illustrated with this instrument system where by the image reconstruction of each tissue layer will be presented. Each homogenous tissue undergoes different kinds of differential during disease with alerted conductivity. The phantom papaya here taken is assumed to be of different layers of tissues. When the algorithm is implemented and simulated on the data, different pictures of papaya have been obtained as shown in Figure 6-7.

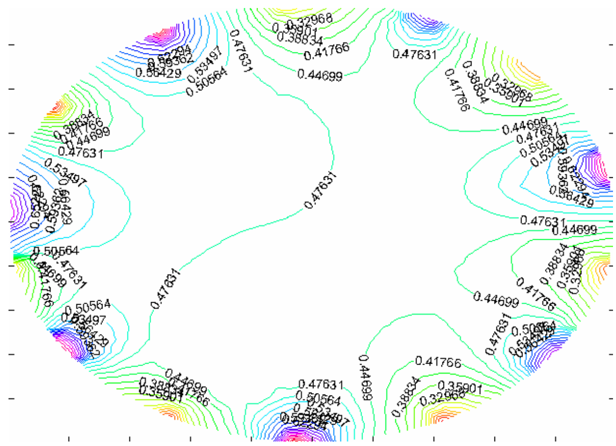

Figure 6, The 2-D image of an empty papaya

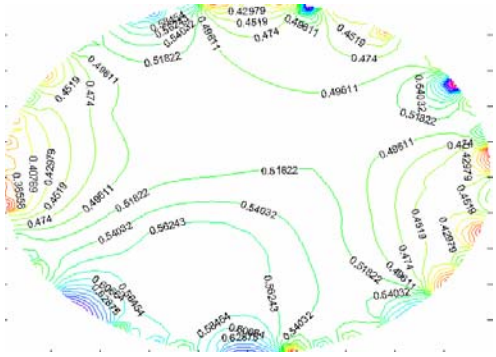

Figure 7. The 2-D image of the phantom papaya with objects inside

V. CONCLUSION

The software design here is user friendly and generates meshes, nodes and equations automatically for any length of boundary voltages. The software also has a capability to solve these equations which represent the pixel intensity in term of conductivity distribution inside the closed object. The algorithm has very wide application in biomedical area especially in the field of electrical impedance tomography. Also same algorithm can be applied to non-medical such as in industrial processes. Although eelectrical impedance tomography (EIT) is an immature, new medical imaging technique which has low spatial and high temporal resolution, isotropic conducting imaging makes this technique a research area. The same instrument can be used for various ranges of applications such as biomedical and non-biomedical applications. The main objective here is to use the same software in reconstruction of images of a phantom.

VI. REFERENCES

[1] Woo, E. J., Hua, P., Webster, J. G., Tompkins, W.J, “Finite –element method in electrical impedance tomography, Medical physics and imaging, pp 530-35, 1994.

[2] Kim, B. S., Boverman, G.., Newell, J. C., Saulnier, G. J. and Isaacson, D., “The complete electrode model for EIT in a mammography Geometry, Physiol Meas., pp 57–69, 2007.

[3] Halter, R.J., Hartov, A., Heaney, J.A. , Paulsen, K..D., Schned A.R., “Electrical Impedance Spectroscopy of the Human Prostate”, IEEE Transactions on Biomedical Engineering, pp 1321-1327.

[4] Sakamoto, M. M., Cardoso, J. R. , Machado, J. M. and Salles, M., “A 2-D Delaunay Refinement Algorithm Using an Initial Prerefinement From the Boundary Mesh,” IEEE Transactions on Magnetics, pp 1418-2,12008.

[5] Smith, R. W. M. I., Freeston, L., and Brown, B. H., “A Real-Time Electrical Impedance Tomography System for Clinical Use-Design and Preliminary Results”, IEEE Transactions on Biomedical Engineering, pp 133-140, 1995.

[6] Cheney, M. D., Isaacson, J., Newell, C., , “Electrical Impedance Tomography” ,SIAM Review, pp 85-101,1999.

[7] Tidswell, T., Gibson, A.G., Baybard, R.H. and Holder, D.S., “ Three Dimensional Electrical Impedance Tomography of Human Brain Activity,” NeuroImage,pp 283-94 ,2001.

[8] Zienkiewicz, O.C., The Finite Element Method, Third Edition, TMH, New Delhi, pp 1-33, Chap. 1,2006.

[9] Nowakowski ,A., Palko, T., and Wtorek, J., “Advances in electrical impedance methods in medical diagnostics”, Bulletin of the Polish Academy of Sciences Technical Sciences , pp 231-243,2005.

