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Visualization of Surface Conductivity Distributions of Tomography Cross-Section Using Conductivity Zones Method

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Abstract—Conductivity zones method is suggested that allows reconstructing the image of electrical impedance tomography with essentially lower computation expenses. Results of reconstruction performed by regularizing the matrix of contour-edge voltage derivatives with respect to zones' surface conductivities.

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Visualization of surface conductivity distributions of EIT cross-section (Electrical Impedance Tomography) finds wide application in solving a number of medical and technical diagnostic problems supplementing existing methods of non-destructive research [1–5]. The procedure of obtaining the conductivity distribution image in a cross-section of the studied object expects measuring voltages on the external edge of the cross-section or phantom followed by calculation of internal conductivity distribution using these measurements.

The problem of measuring parameters of a physical object or making calculating based on external-contour voltages is called a direct problem (analysis), while the one that expects finding surface conductivity distribution in a tomography cross-section is called a reverse problem (synthesis).

We should note that current of independent source flows not only in the tomography cross-section's plane in contrast to X-rays, but above and below the considered cross-section as well. This is similar to the effects in pendulum ultrasound tomography due to wide radiation angle and increasing the sector's height upon moving away from the source [2, 6]. Spatial flow of currents causes distortions since "shadows" of these currents and corresponding voltages get projected onto the phantom's surface, but their influence may be eliminated by additional restoration procedures [7].

The most complete model of the EIT measurement and calculation is described by the Maxwell equations. Nevertheless solving these equations analytically typically is connected with essential difficulties. Hence in practice various approximate methods are used to solve the EIT problems.

The finite elements methods obtained wide spreading due to sufficient precision and relatively simple implementation on PCs [9]. When using this method given the current source frequencies up to 1 MHz the model of the target may be represented by a set of equivalent electrical circuits in the form of impedance (admittance) triangles with common nodes that correspond to vertices of triangular, quadrangular and other finite elements.

In contrast to X-ray, emission, magnetic resonance and ultrasound tomography [2], information signal trajectories or equal-voltage curves in EIT are not linear even in the case of uniform phantom (Fig. 1). Thus, based on carrier-signal trajectory EIT should be considered "non-linear".

The image made of equal-voltage curves becomes even more complex if the phantom includes heterogeneities with lower (Fig. 2) and greater (Fig. 3) conductivity compared to the background.

As follows from distributions of equal-voltage curves in Figs. 2, 3, the use of reverse projection method, which is common in linear tomography, in EIT is unreasonable expect for rare special cases of diagnosing in presence of prior information on impedance distribution onside the phantom [10].

Solution of the direct problem expects building a system of node voltage $\overline{U}$ equations using phantom's equivalent electrical circuit based on equivalent circuits of finite elements and solving the obtained system of equations [2, 3, 11]. Since every finite elements represents a pixel in the image, the number of such elements should be increased in order to improve calculations precision and reconstructed image perception.