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Electrical Impedance Tomography through an ambient fluid as a solution for electrode contact problem

Abstract. *In this paper we introduce a new approach to impedance tomography where contact electrodes uncertainties is eliminated by immersing unknown object in the known fluid. Optical methods are used to determine the external shape of the object. These shape and known conductivity of the ambient fluid build a priori knowledge which is incorporated into the inverse algorithm method.*

Streszczenie. *W tym artykule został przedstawiony nowy rodzaj tomografi impedancyjnej, w której niepewność pomiaru związaną z kontaktem elektrod wyeliminowano poprzez zanurzenie badanego obieku w płynie o znanych parametrach. Zewnętrzny kształt obiektu został rozpoznany przy pomocy metod optycznych. Kształt obiektu oraz znana konduktywność płynu stanowią wiedzę 'a priori', która została zastosowana w algorytmie rekonstrukcji struktury wewnętrznej obieku. (Tomografia impedancyjna poprzez warstwę przejrzystego płynu o znanych parametrach).*

Keywords: EIT, optical tomography, contact electrodes
Słowa kluczowe: tomografia impedancyjna, tomografia optyczna, elektrody pomiarowe

Introduction

Since its introduction in 1978 [1] Electrical Impedance Tomography (EIT) appeared to be a promising modality for imaging of the human body. It is potentially inexpensive, fast and safe for patients. However, its practical deployment has been hindered by many technical and algorithmic challenges. One of them is a problem of skin-electrode contact [2]. It is difficult to ensure reliable and stable contact between electrode and the skin. Moreover precise location of the electrode could be also an issue.

In this paper we propose a extension to the classical EIT method, where investigated object is immersed in the electrode tank filled with ambient medium. We assume that such fluid should be transparent for the light so optical, visibility algorithms could be deployed to determine shape of the structure. We will show that the numerical accuracy of the method is comparable to more established techniques, while the electrode contact problem is completely resolved.

Combined Tomography

The basic idea of the proposed solution is presented in Fig. 1. On the wall of the circular shaped tank measurement sensors are located: electrodes for the impedance tomography and optical sensors for the visibility algorithms. The main reconstruction of the object is done by impedance method. Moving electrodes out of the area of reconstruction should deteriorate quality of the result. To avoid this problem we extended the method by incorporating knowledge of shape of the object and parameters of the fluid.

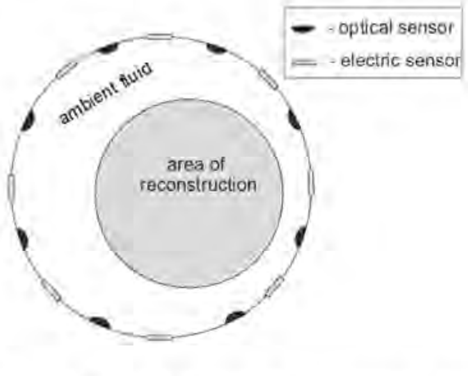

Fig. 1. Idea of EIT through an ambient fluid. Area of reconstruction is limited by the use of the optical visibility methods.

Presented method could be understood as dual-modality tomography, where optical methods are combined with impedance reconstruction. Complete algorithm has several essential steps:

1. determine visibility matrix for given set of sensors,
2. use visibility matrix to find external shape of the object by the help of the graph cut theory [3],
3. define unknowns for the inverse problem by meshing the object,
4. solve the inverse non-linear problem using Gaus-Newton algorithm with regularization [4].

An accurate identification of the external shape of the object allows for better imaging in EIT. The visibility matrix calculation assumes modelling of propagation of highly collimated light in non-scattering and transparent medium. Investigated object shape is obtained by inverse transformation of the visibility matrix.

The paper is based on simulated data. Both optical and electrical measurements were taken from preceding simulations. Authors are aware of risks related with such unrealistic setup. Special attention has been paid to avoid 'inverse crime' pitfall [4] by introducing noise into the signal.

In the full version of this paper we will present details of the algorithms, its prototype implementation, as well as preliminary results and validation. Works will be shown on the basis of two dimensional models, but it could be easily extended into full 3D space.

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