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# A hybrid tomography for assessing the moisture level of walls and building condition

***Abstract***. *The article presents an innovative solution for assessing the moisture level of walls and building condition. The use of modern tomographic techniques allows for a non-destructive and very precise spatial assessment of the humidity level. Prepared constructions contain special electrodes for measuring humidity in a brick wall. The proposed application solves the inverse problem in electrical tomography. A level set method was used to reconstruct the images.*

***Streszczenie.*** *W artykule przedstawiono innowacyjne rozwiązanie do oceny poziomu wilgotności ścian i stanu budynku. Zastosowanie nowoczesnych technik tomograficznych pozwala na nieniszczącą i bardzo precyzyjną ocenę przestrzenną poziomu wilgotności. Przygotowane konstrukcje zawierają specjalne elektrody do pomiaru wilgotności w ścianie z cegły. Proponowane zastosowanie rozwiązuje problem odwrotny w tomografii elektrycznej. Do rekonstrukcji obrazów użyto metody zbiorów poziomicowych (**Tomografia hybrydowa do oceny poziomu wilgotności ścian i stanu budynku**).*

**Keywords:** Electrical Impedance Tomography; Inverse Problem; Sensors
**Słowa kluczowe:** elektryczna tomografia impedancyjna; zagadnienie odwrotne; sensory

## Introduction

The non-destructive method [4,20,26,27,34] of brick wall insulation is tested using electrical impedance tomography (EIT). The aim of the presented method is to obtain image reconstruction using the proposed solution. The set was used to determine the humidity of the test wall on specially constructed models. The presented algorithms have been successfully used in the reconstruction of model wall measurement data. These approaches were based on the sensitivity analysis. An effective algorithm for solving forward and inverse problems would also improve many numerical results of the proposed methods. In modeling the problem in electrical tomography, it is required to identify unknown conductivities from near-limit potential measurements [17-19,21]. The discussed technique can be used to solve inverse problems in electrical impedance tomography.

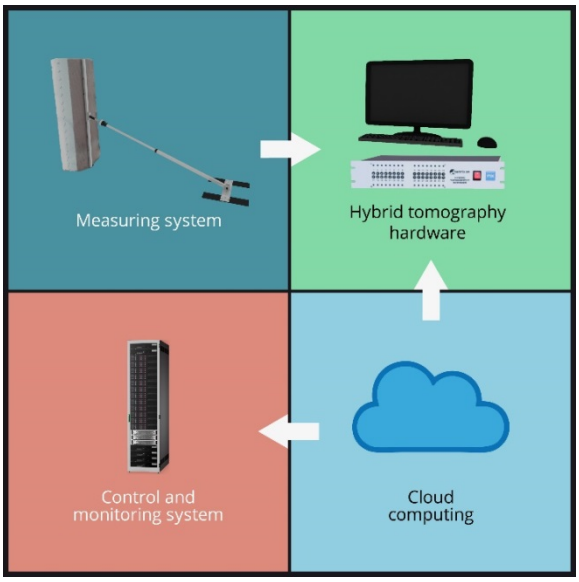


Fig. 1. Hybrid tomography system.

Electrical tomography consists in restoring the conductivity of the interior of the tested object with the knowledge of currents and tensions imposed on its surface. Most of the available research methods allow only a point evaluation of moisture, thanks to which it is possible to achieve only the discrete distribution itself. Permeation of moisture in the walls of old buildings, which are in direct contact with the soil, leads to migration of soluble salts in relation to many wall problems. Building porous materials (eg bricks or concrete), both natural and made, has pores (like a sponge). The data collection system collects the measured voltage from the electrode and then processes the data [1-3,5-11,13-15,28-33]. Figure 1 presents the model of a hybrid tomography system.

## Measurement system

The electrical tomography is a technique of imaging the distribution of conductivity or permittivity inside the tested object from measurements of the distribution of potentials on the object surface. Many different techniques can be used for the optimization process [10,12,16,24,25].

Fig. 2. Surface electrodes on the damp brick wall.

Figure 2 shows surface electrodes, while the wall with measurement system is presented in Fig. 3. The prepared objects contain special electrodes for measuring damp brick wall on one side and two-sided. The way in which we can define state of wall depends on the fact that every material has the unique conductance. There were used necessary electrodes and the hybrid tomograph device (Fig. 4).

Fig. 3. The measurement system – wall I and II.

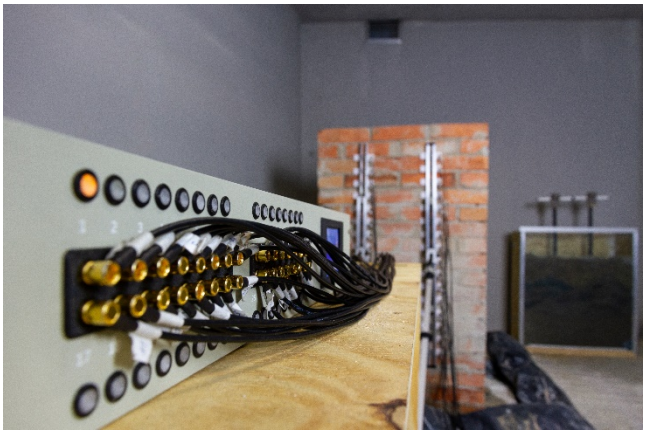

Fig. 4. Hybrid tomograph.

## Results

The following experiments show reconstructions as imaging the conductivity map. On the outside of the wall, voltage drops are measured.

In order to obtain a moisture distribution, the inverse problem is solved. Figures 5 and 6 show the geometrical model 3D with the image reconstruction by level set function [22,23].

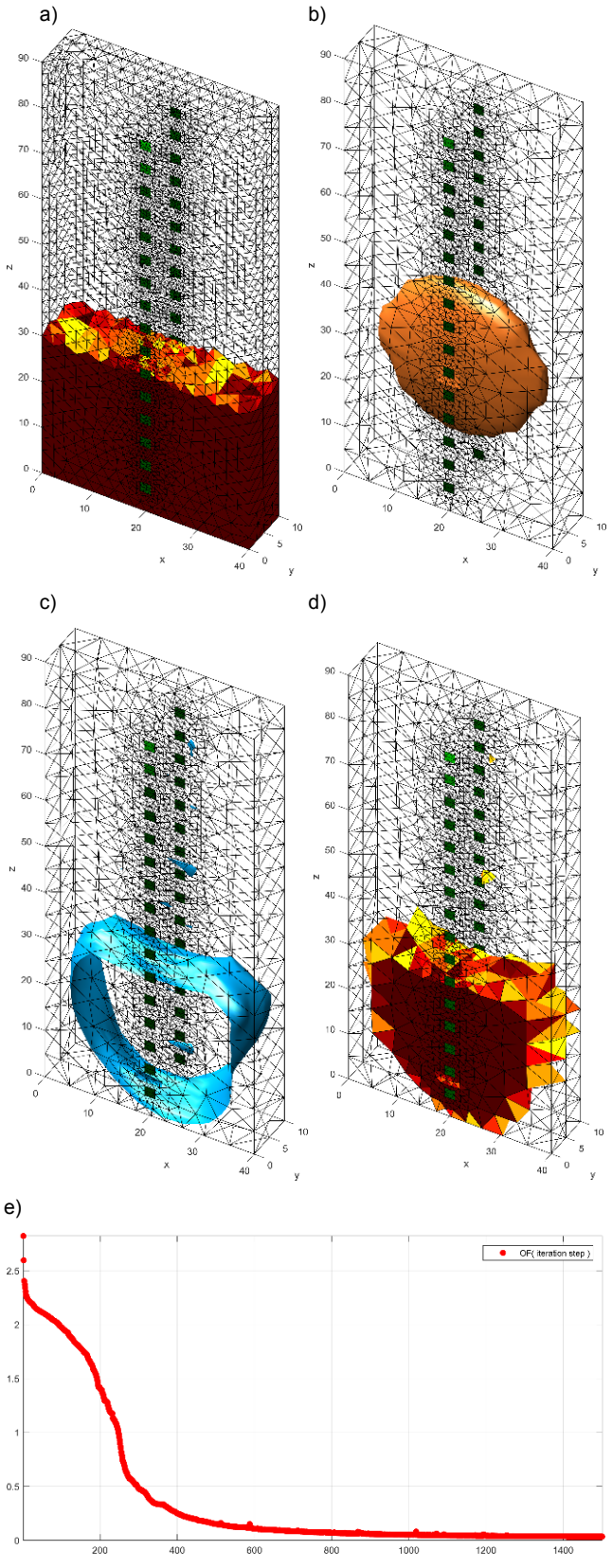


Fig. 5. The geometrical model 3D with 2 x 16 electrodes – the image reconstruction with simulation measurements: (a) model, (b) zero level set function, (c) final reconstruction by LSM, (d) final distribution of conductivity, (e) the objective function.

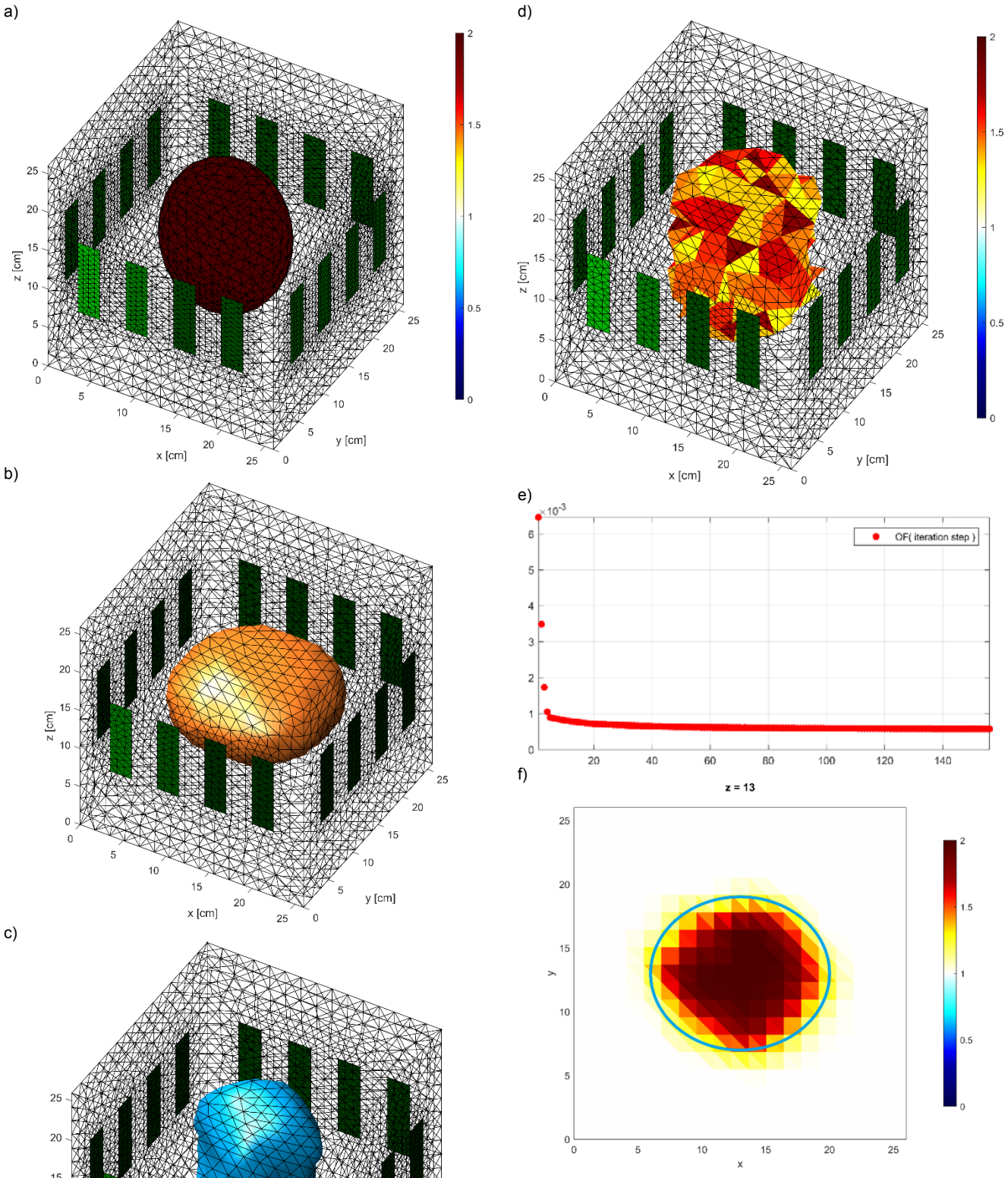


Fig. 6. The geometrical model 3D with 16 electrodes – the image reconstruction with simulation measurements: (a) model, (b) zero level set function, (c) final reconstruction by LSM, (d) final distribution of conductivity, (e) the objective function in the subsequent iterative steps, (f) conductivity on the cross-section - plane {z - 13.0 = 0}.

## Conclusion

The article presents an innovative solution for data processing, visualization, registration and analysis. A new, non-destructive method of checking walls in the model of the historic buildings system has been introduced. The device parameters were in line with expectations. The proposed application solves the inverse problem in electrical

tomography. According to the assumptions, it is possible to effectively build a small system of electrical tomography. Prepared constructions contain special electrodes for measuring humidity in a brick wall. A level set method was used to reconstruct the images. Electric tomography is a good technique to display the distribution of electrical conductivity and permeability in walls and historical buildings.

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