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Implementation Image Analysis and Optimization Techniques in e-Medicus System

***Abstract**. Article presents methods to identify the properties and reconstruction of the images. A special e-Medicus system to analysis and compare data or pictures was prepared. The solution shows the architecture of the system collecting and analysing data. The internal conductivity distribution is recovered from the measured boundary voltage data. New results of a reconstruction of a numerically simulated phantom are presented. The reconstruction task is a nonlinear and ill-posed inverse problem, whose solution calls for special regularized algorithms. New methods have also been implemented to identify arbitrary number of phases for the segmentation problem. With the use of modern algorithms, it can obtain a quicker diagnosis and automatically marking areas of the interest region in medical images.*

Streszczenie.** Artykuł przedstawia metody do identyfikacji właściwości i rekonstrukcji obrazów. Przygotowano specjalny system e-Medicus do analizy i porównywania danych oraz obrazów. Rozwiązanie przedstawia architekturę systemu zbierającego i analizującego dane. Rozkład wewnętrznego przewodnictwa jest uzyskiwany z mierzonych danych dotyczących granicy napięć. Przedstawiono nowe wyniki rekonstrukcji symulowanego numerycznie fantomu. Problem rekonstrukcji jest nieliniowy i źle postawiony (zagadnienie odwrotne), którego rozwiązanie wymaga regularyzacji. Zaimplementowano również nowe metody do zidentyfikowania dowolnej liczby faz dla problemu segmentacji. Dzięki zastosowaniu nowoczesnych algorytmów uzyskuje się szybszą diagnozę i automatycznie oznacza interesujące obszary w obrazach medycznych. (Implementacja analizy obrazu i technik optymalizacyjnych w systemie e-Medicus**).

Keywords: Image Analysis, Gradient Methods, Level Set Method
Słowa kluczowe: analiza obrazów, metody gradientowe, metoda zbiorów poziomicowych

Introduction

In this paper. gradient reconstruction algorithms, medical and stereoscopic images in e-Medicus system were implemented. The reconstruction problem is a nonlinear and ill-posed, whose solution calls for special regularized algorithms [6-8]. In many cases the linear systems arising in practice consist of real number coefficients and data. The image reconstruction is very sensitive to the ubiquitous modelling errors which are caused by inaccurately known auxiliary variables of the measurement model [21-25]. Figure 1 presents the model of the imaging system.

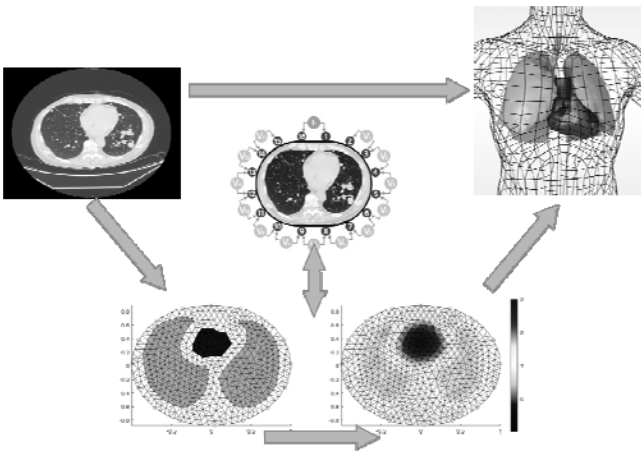


Fig. 1. The model of the imaging system

The image data is of immense practical importance in medical informatics. Medical images, such as Computed Axial Tomography (CAT), Magnetic Resonance Imaging (MRI), Ultrasound, and X-Ray, in standard DICOM formats are often stored in Picture Archiving and Communication Systems (PACS) and linked with other clinical information in EHR clinical management systems. Research efforts have been devoted to processing and analysing medical images to extract meaningful information such as volume, shape, motion of organs, to detect abnormalities, and to quantify changes in follow-up studies. Recent advances in a wide range of medical imaging technologies have revolutionized how we view functional and pathological events in the body and define anatomical structures in which these events take place. X-ray, CAT, MRI, Ultrasound, nuclear medicine, among other medical imaging technologies, enable 2D or tomographic 3D images to capture in-vivo structural and functional information inside the body for diagnosis, prognosis, treatment planning and other purposes.

Stereoscopic images

Stereoscopic imaging techniques allow for 3D images. Simultaneous recording of two images allows for the mutual dependence of the spatial object, the distance from the observer and the depth of the scene. In order to obtain stereoscopic images a pair of two-dimensional images representing a subject or scene from two points of view are made. Stereo image compositions are very similar, but they vary slightly in the way they look at objects and in the details of each object's crossing in the scene. It is these tiny differences that carry information about the third dimension. The stereoscopic skin lesion acquisition and analysis system consists of a dedicated recording device and a computer aided image analysis program e-Medicus. The unit consists of two camera modules, a multiadapter camera, a microprocessor controller, a lighting unit and a power supply. The stereoscopic image is obtained by recording the image on one and the other camera. Cameras are set at a fixed distance (D = 35 [mm]) from each other. This distance is determined between the main optical axes of the camera lenses. Illumination of skin lesions during shooting is accomplished through a set of LED spots. Illuminated dots are digitally controlled eight-digit RGB LEDs. Each point can have individually set parameters such as the intensity and colour of the emitted light wave. The microprocessor controller controls the multiadapter camera for proper operation of the acquisition and illumination system. The connection of the cameras to the adapter is made using a flexible (flexible) tape consisting of fifteen communication wires. Figure 2 presents the device for stereoscopic images of skin lesions. Test reconstructions of stereoscopic photographs was shown in Fig. 3.

Fig. 2. Device for stereoscopic images of skin lesions

The microprocessor controller is also responsible for communication between the recording device and a computer equipped with dedicated e-Medicus software, implemented in Ethernet. Control of the device for image acquisition and lighting is done by dedicated e-Medicus computer program. At the same time, the application allows for the qualitative analysis of stereoscopic 3D images of skin lesions, including cancerous ones.

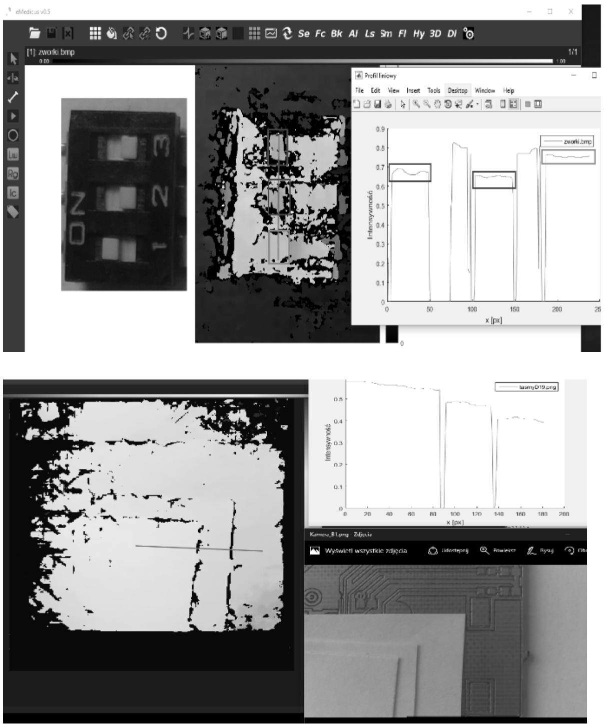


Fig. 3. Test reconstructions of stereoscopic photographs

Processing and analysis of medical images

Processing and analysis of medical images using computer comprises the following: image formation and reconstruction, image restoration, image enhancement, image compression and storage, image-based visualization, feature identification, image segmentation, shape recognition, image matching/registration, and measurement of anatomical and physiological parameters [4,5,10-13,19,20,26]. Using an algorithm level set method and the determination of the relevant parameters [4,16,16-18,27], there was achieved the following results (Fig. 4).

After setting the appropriate parameters, the algorithm is able to obtain satisfactory results for us. Mark not only interesting object but also the outline of the whole picture. The next algorithm that we were tested was generic networks (Fig. 5).

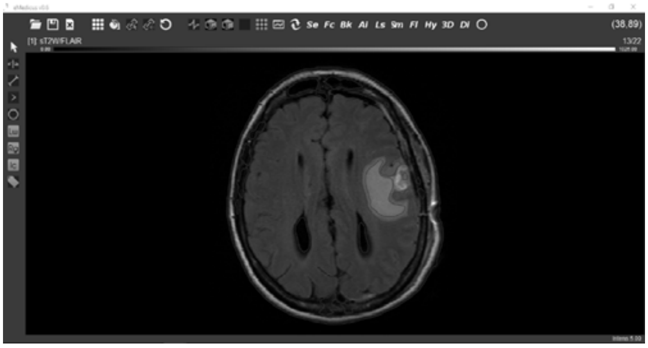


Fig. 4 Segmentation by Level Set Method

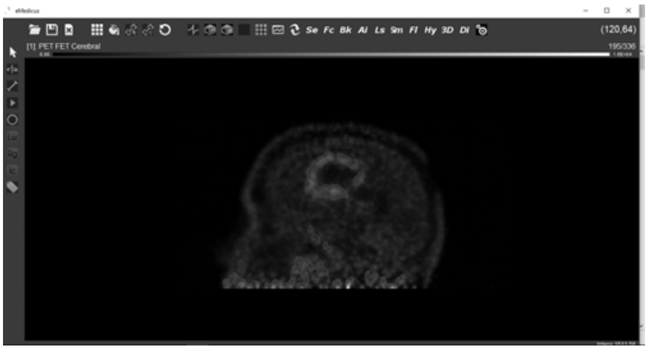


Fig. 5 Generic networks

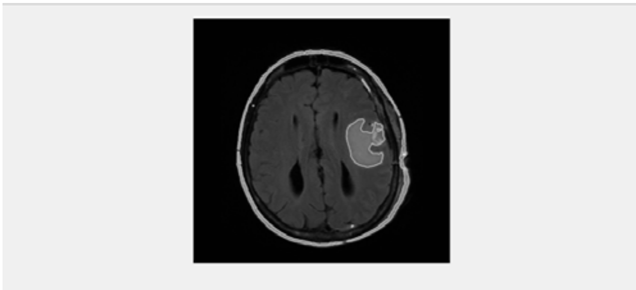


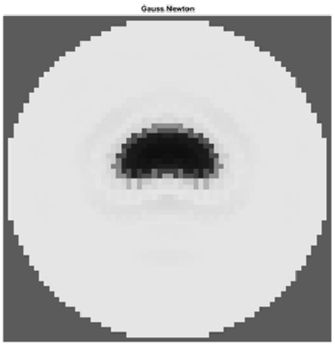
Fig. 6. Fuzzy sets

Generic networks work similarly to the level set method above, but you can see that it is coping with the area of interest. The change is better illustrated and will also translate into faster diagnostics. The best algorithm that has highlighted exactly the area of interest is the Fuzzy sets (Fig. 6). As you can see in the pictures above, by indexing the medical image, the algorithm detects the appropriate scale of grays and on this basis correctly marks the object of interest, in this case changed in the brain.

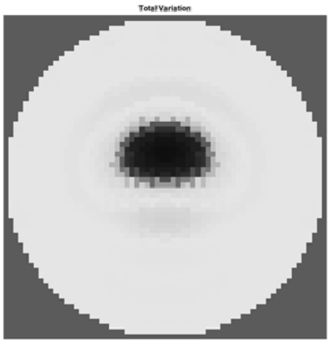
Gradient methods

Electrical tomography is an extremely ill-posed inverse problem and high-resolution imaging would require unpractically accurate current injection, voltage measurement, low noise levels, and large number of electrodes attached to the boundary of the object [1,2,9,15]. Gradient methods were compared as following: Gauss-Newton, Total Variation, Back Projection, Kalman, Conjugate Gradient in Fig 7 and Fig. 8. Reconstructions were studied by experimental data by the test model from a laboratory setup. The results suggest that the non-linear approach could be used to improve the accuracy and specificity of EIT in applications. The Gauss-Newton method gives the best results.

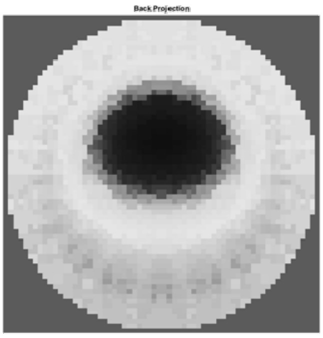
a)



b)



c)



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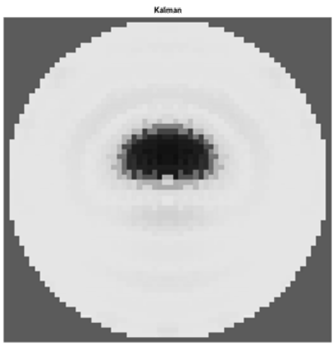


e)

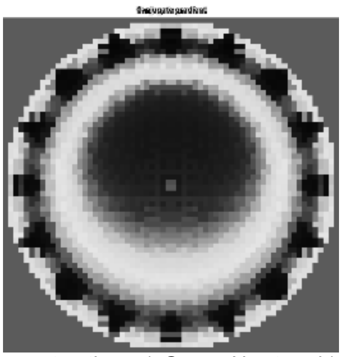


Fig. 7. Image reconstruction: a) Gauss-Newton, b) Total Variation, c) Back Projection, d) Kalman, e) Conjugate Gradient

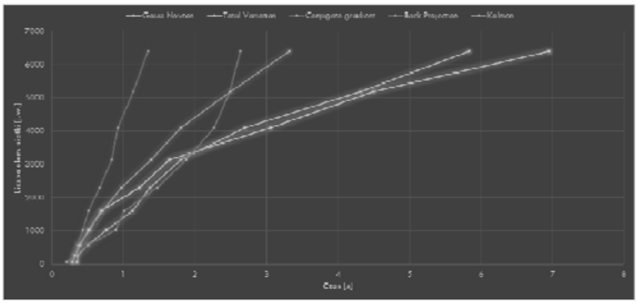
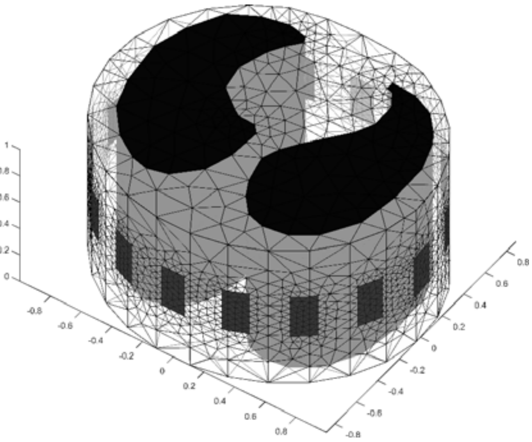


Fig. 8. Comparison of algorithms for reconstruction

Image reconstruction

a)



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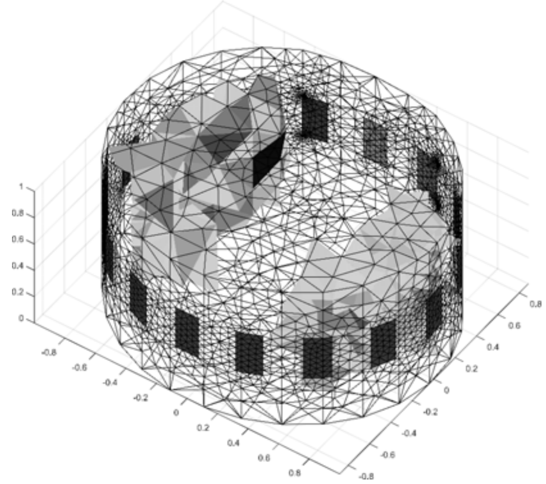
b)



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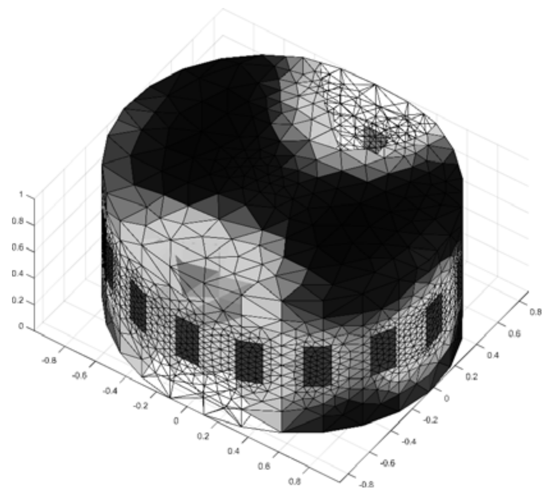

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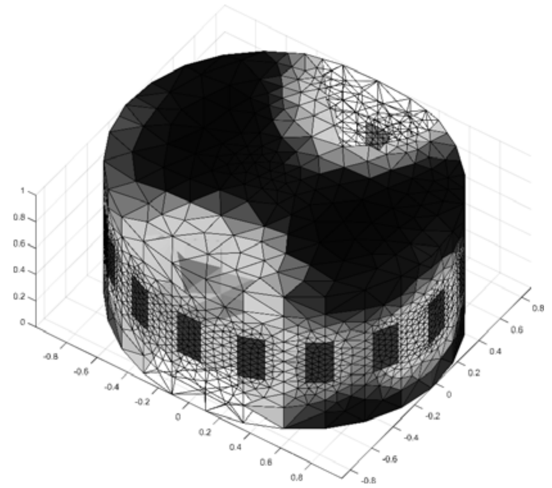

Fig. 9. 3D image reconstruction: a) model, b) Gauss-Newton with Tikhonov regularization, c) Gauss-Newton with Laplace regularization, d) Total Variation

Monitoring the lungs of unconscious intensive care patients, data acquisition on the entire boundary of the body is impractical. The boundary area available for electrical tomography measurements is restricted. Physiological processes that produce changes in the electrical conductivity of the body can be monitored by hybrid algorithms. The proposed approach was based on solving the non-linear inverse problem. there was proposed an approach to EIT image reconstruction in cases where the Gauss-Newton and Total Variation were implemented. Figure 9 presents the 3D image reconstruction of the pulmonary model.

Summary

This paper presents the architecture of the system based to image analysis. The proposed algorithms have been used to real pictures with promising results in the medical images. With the use of modern algorithms, the physician is able to obtain a quicker diagnosis. By automatically marking areas of interest you will notice all the changes in medical images. This will allow artificial intelligence to automatically diagnose changes and to tell the radiologist what type of disease is present in the medical image. In this work, there were developed and effective algorithms and the e-Medicus system to machine learning, analysis and compare medical images.

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