ISSN 1392 – 1215 ELECTRONCS AND ELECTRICAL ENGINEERING 2009. No. 3(91)
ELEKTRONIKA IR ELEKTROTECHNIKA

T 115 MEDICINE TECHNOLOGY
MEDICINOS TECHNOLOGIJOS

Investigation of the Possibility of Eye Orbit Tissue Pathology Classification

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Introduction

An echographic investigation is a powerful technique for eye different tissue characterization and diagnosis. Non invasiveness, informativity and user-friendliness are the main features of ultrasound technique.

Simple method for the reliable classification intraocular tumours is presented in [1]. The method is based on search and evaluation of the specific geometrical parameters – size, shape, and microstructure of tumour. Intraocular tumours are visible, therefore it is relatively simple to evaluate these indicators and use it for tumours diagnosis in clinical practice.

Ultrasound spectral technique to improve eye cataract early detection and maturity quantitative evaluation by using ultrasound A-scan radiofrequency mode is presented in [2]. Broadband coherent signal, backscattered from the lens tissue was used for the estimation of ultrasound attenuation coefficient and early detection of cataract and classification the stage of desease in to three classes.

Lot of research is made on application ultrasonic spectrum for tissue evaluation. A 15-year retrospective analysis of investigations in this area is presented in [3]. The main drawback of these techniques is requirements of getting radiofrequency signal. Although radiofrequency ultrasonic signal has more valuable information about tissues microstructure alterations, modern commercial clinical scanners do not have this option.

The problem of parameterization of ultrasonic echographic B images for intraocular tumour differentiation is analyzed in [4]. Authors suggest to use the point spread function and inverse filtering technique for restoration of ultrasonic images. Preliminary results are obtained using ultrasound image texture parameters for tumour differentiation. Investigations are made with single image and plausibility of obtained results is not analysed. Further investigations are needed to show whether the usage of complicated mathematical tools reduces the image noises and gives more useful information.

Determination and classification pathology of orbit tissue is under investigated actual problem. An ultrasound image of orbit tissue in comparison, for example, intraocular tumours, frequently has no clear features alterations that may indicate disease.

The search for characteristic features or variations in ultrasound images of orbit tissue that may associate with pathology is one of the important problems. The brightness of ultrasound image element (pixel) depends on the distribution of acoustic impedance or tissue density. The possibility of ultrasound technique applying for classification of various pathologies is based on the direct relationship between tissue morphology, density distribution and feature to reflect ultrasound waves.

Analysis of publications shows the possibilities of known methods for eye pathology classification are not exhausted. It is desirable to increase the reliability of classification, to search for new specific parameters, based on the information about the mechanism of image element genesis, to determine interrelationships between the image fragments.

The aim of present paper is to differentiate orbit tissue by using information that may be obtained from ultrasound A/B mode image scans.

Method of investigation

All patients have been examined with ultrasonic diagnostic imaging system Mentor Advent, using A/B scan mode.

Block diagram of computerized ultrasound system for eye orbit tissue image acquisition and analysis is shown in Fig. 1. Focused transducer center frequency is 7.5 MHz, radius of transducer – 2.7 mm.

The images are transmitted from video output of ultrasound system to PC by the use of frame grabber. Captured echographic images were analyzed using numerical computation and visualization software MATLAB. Some statistical computations were performed using Microsoft Office Excel.

Image texture parameters

Although no formal definition of texture exists, intuitively this descriptor provides measures of properties such as smoothness, coarseness and regularity. The three principal approaches used in image processing to describe the texture of a region are structural, spectral and statistical [5]. Further we will apply last mentioned method.

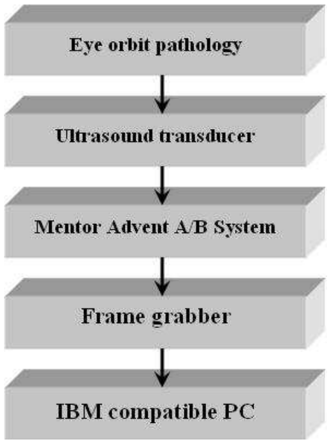


Fig. 1. Block diagram of computerized ultrasound system for image acquisition and analysis

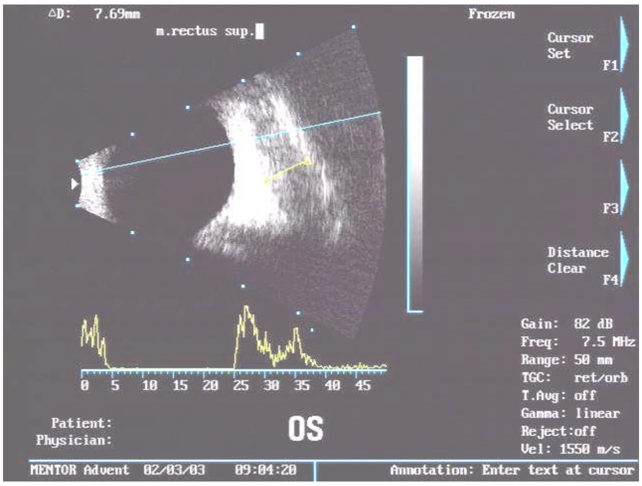


Fig. 2. Typical B and A images, obtained with ultrasound research MENTOR Advent A/B System

One of the simplest approaches is to use statistical moments of gray-level histogram of an image. This technique suffers from limitation that carries no information regarding the relative position of pixels with respect to each other. In the view of ultrasound images may be more informative technique is so called grey-level co-occurrence matrix ***C*** that considers the positions of the pixels with equal or nearly equal intensity values [4].

C is a matrix of relative frequencies $P_d\,(i,j)$, in which two pixels separated by a distance d along direction θ are found in the image, one with gray level i and other with gray level j. For the image with n gray levels co-occurrence matrix ***C*** size is $n \times n$. For one image or image fragment may be found several matrixes.

Usually a following set of parameters characterize the "content" of ***C*** [5]:

- uniformity:

$$U = \sum_i \sum_j P_d^2(i,j); \quad (1)$$

- entropy:

$$E = -\sum_i \sum_j P_d(i,j) \cdot \log P_d(i,j); \quad (2)$$

- contrast or element difference moment of second order:

$$C = \sum_i \sum_j (i-j)^2 \cdot P_d(i,j); \quad (3)$$

- homogeneity or inverse element difference:

$$H = \sum_i \sum_j \frac{P_d(i,j)}{1+|i-j|}. \quad (4)$$

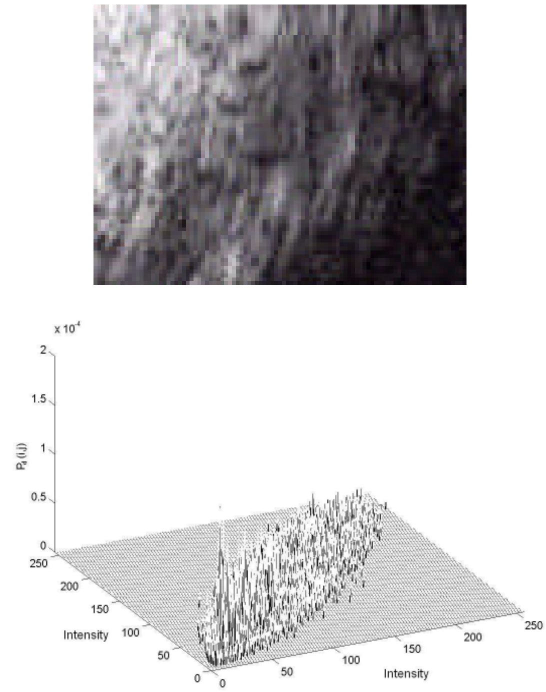


Fig. 3. Ultrasonic image fragment and its co-occurrence matrix

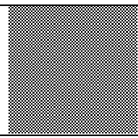
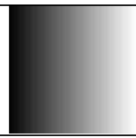
Simulated test images / Texture parameters			
Uniformity U	0,5	0,0125	0,0002
Entropy E	0,3	1,9	3,76
Contrast C	6,5	11,2	1,11
Homogeneity H	0,004	0,26	0,038

Fig. 4. Typical test images and its texture evaluation parameters

Parameters from A-mode signal

The amplitude of echosignal depends on the ratio of acoustic impedances of tissue or on the ratio of densities of tissue in the given point of image. So, echosignal carries valuable information about morphology of tissue – shape, homogenity and structure. Reflectivity of tissue is characterized by reflection coefficient K_A (%), which is calculated as a ratio of mean and maximal amplitudes of echosignal:

$$K_A = \frac{\frac{1}{m}\sum_{i=1}^{m} u_i}{U_{\max}} \times 100\%; \quad (5)$$

where u_i is a i-value of digitized echosignal amplitude, reflected from tissue, U_{max} – maximal amplitude of echosignal, m is a number of discrete points. Physically reflectivity coefficient indicates the continuity of the distribution mean variations of tissue density.

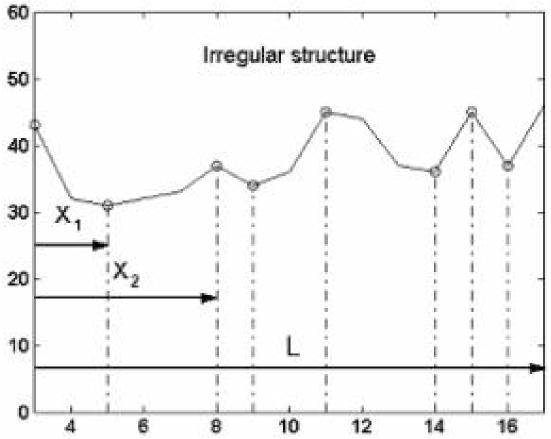


Fig. 5. The example of A-scan echosignal from the orbit tissue with the irregular structure, L – the length of the examined tissue sample, X_1, X_2 – the distance between the peaks of signal amplitudes

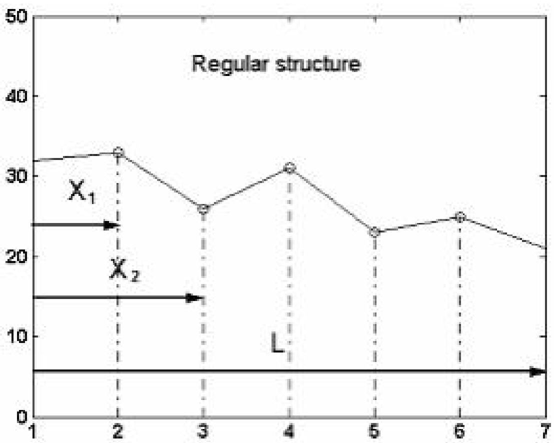


Fig. 6. The example of A-scan echosignal from the orbit tissue with the regular structure, L – the length of the examined tissue sample, X_1, X_2 – the distance between the peaks of signal amplitudes

In Fig. 5, 6 units of abscissa and argument (axial) axes are relative number of discrete points, obtained from A-scan image (Fig. 2) analysis.

The regularity of tissue characterized by irregularity coefficient:

$$K_R = \frac{\sqrt{\sum_{i=1}^{m}(x_i - \Delta x \cdot i)^2}}{L}; \quad (6)$$

where x_i is a position (mm) of i-peak value of echosignal in A image, L is a length (mm), m is a total number of peak values in echosignal, $\Delta x = L / m$ – the step of regular tissue structure. Irregularity coefficient shows the continuity of distribution of maximal variation of tissue densities.

Experimental investigations

Experimental investigations were performed with computerized ultrasound system (Fig.1). Typical orbit tissue ultrasound image is shown in Fig.2. A statistical approach and parameters of **A**-mode were used for image texture analysis. Two type's of diseases were investigated: orbit tissue tumours and Graves ophthalmopathy.

The 73 ultrasonic **B** images with normal and orbit tissue tumours were used for the first investigation. The database consists of 270 image fragments and the size of each fragment - 20×20 pixels.

For each fragment co-occurrence matrix was calculated and 16 texture parameters derived: uniformity, entropy, contrast and homogeneity, when analysis distance was d=1 and direction - θ = 0°, 45°, 90° ir 135°. Orbit tissue image fragment and 3D co-occurrence matrix are shown in Fig. 3 (d=1, θ = 45°).

Typical test images with substantially different texture were simulated and analyzed (Fig. 4). To a certain degree these images look like as ultrasound images. Texture evaluation parameters differ significantly and this allow better understanding the dependence among the features of images and parameters of co-occurrence matrix.

The program See 5.0/C5.0 was used for the detection of orbit tissue pathology. Initial data with known conclusions (diagnosis) are used for the classifiers constructing. There were used four classifiers: the decisions tree, classification rules, corporal decision tree and corporate classification rules. After this the classification is performed using new cases with unknown diagnosis. Data attributes with continuous and/or digitized values can be used.

Random picked 60% of cases in databases were used for training of selected classifier, 20% - for evaluation of classifier reliability and other 20% - for verifying of classifier reliability.

The 84 ultrasound **B/A** images of Graves ophthalmopathy were used for the other investigation.. Texture parameters were combined with parameters, derived from A-mode signal. Typical examples of regular and irregular tissue structure are shown in Fig. 5,6. Regular tissue physically means that profile tissue densities have constant space frequency or period.

The random picked 70% of cases in databases were used for training of selected classifier, 30% - for evaluation of classifier reliability.

Results and conclusions

Investigations show that there exists strong relationship among the texture parameters in ultrasound tissue images. For example, correlation between texture parameters: uniformity/entropy U/E=0.94, uniformity/homogeneity U/H=0.9, entropy/homogeneity E/H=0.98.

The first type orbit tissue pathology (tumour) investigation shows that normal tissues in most cases (85 %) were identified correctly, but approximately 50 % of tumours were identified as normal tissues.

The second type orbit tissue pathology (Graves ophthalmopathy) investigation shows that there exists average level of correlation between texture and A-mode signal parameters. The following correlations among these parameters are obtained:

reflectivity/uniformity $K_A/U=0.4$, reflectivity/contrast $K_A/C=0.45$, irregularity/entropy $K_R/E=-0.47$.

In this case the plausibility of classification orbit tissue into two classes - normal and pathology significantly increase up to 70 %.

The investigation shows, that there exists the indirect relation between image texture parameters and morphological pathology changes of tissue structure.

The proposed statistical texture analysis technique by using only ultrasound **B** images for orbit tissue classification into two classes – normal and pathology (tumour) show, that normal tissues in most cases were identified correctly, but plausibility of tumours detection is not enough.

The classification method in which ultrasound **B** statistical texture parameters and **A**-mode signal parameters – reflectivity and regularity were combined, plausibility of classification orbit tissue into two classes - normal and Graves ophthalmopathy significantly raises up to 70 %.

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Received 2009 01 20

A. Kopustinskas, M. Žakauskas, D. Imbrasienė. Investigation of the Possibility of Eye Orbit Tissue Pathology Classification // Electronics and Electrical Engineering. – Kaunas: Technologija, 2009. – Nr. 3(91). – P. 57–60.

The important problem in ultrasonic ophthalmology is the increase of diagnostics reliability. The feature of investigations is variation of morphological tissue structure cause the small changes in ultrasound image. The purpose of this work is investigation of possibility to use the texture statistical and A-mode scan parameters for eye orbit tumors and Graves ophthalmopathy differentiation. The proposed technique by using only ultrasound **B** images for orbit tissue classification into two classes, – normal and pathology (tumour), show that normal tissues in most cases were identified correctly. If ultrasound **B** and **A**-mode parameters – reflectivity and regularity were combined, plausibility of classification orbit tissue into two classes - normal and Graves ophthalmopathy significantly raises up to 70 %. Ill. 6, bibl. 5 (in English; summaries in English, Russian, Lithuanian).

А. Копустинскас, М. Жакаускас, Д. Имбрасиене. Исследование возможности классификации патологий орбитальных тканей глаза // Электроника и электротехника. – Каунас: Технология, 2009. – № 3(91). – С. 57–60.

Одной из важнейших целей медицинской диагностики является создание методов для оценки структуры ткани и морфологии. Чаще всего используется ультразвуковая визуализация. Морфологические изменения в ткани дают очень малые изменения в ультразвуковом изображении. Цэль этой работы – выяснить возможность использования текстурных параметров ультразвукового изображения для классификации глазных опухолей и других патологий. При исследовании использовалась матрица втречаемости и её параметры: равномерность, энтропия, контраст и гомогенность. Результаты исследования показали косвенную связь между ультразвуковыми текстурными параметрами и морфологическими изменениями в ткани. Ил. 6, библ. 5 (на английском языке; рефераты на английском, русском и литовском яз.).

A. Kopustinskas, M. Žakauskas, D. Imbrasienė. Orbitinių akies audinių patologijos klasifikavimo galimybių tyrimas // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2009. – Nr. 3(91). – P. 57–60.

Aktualus medicinos diagnostikos uždavinys – padidinti ultragarsinių echoskopinių tyrimų diagnostinį patikimumą. Ultragarsiniams tyrimams būdinga tai, kad audinių morfologijos pokyčiai turi nedaug įtakos ultragarso bangų atspindžio koeficientui, o kartu ir vaizdų fragmentų pokyčiams. Darbo tikslas buvo ištirti galimybę detektuoti ir klasifikuoti orbitinių audinių patologiją, naudojant B vaizdų tekstūros ir A skenavimo parametrus. Pasiūlyta B vaizdų tekstūros įvertinimo metodika parodė, kad normalūs audiniai daugeliu atvejų diagnozuojami teisingai. Jei kartu naudojami tiek B, tiek A skenavimo parametrai, tai Greifso oftalmopatijos diagnostikos patikimumas padidėja iki 70 %. Il. 6, bibl. 5 (anglų kalba; santraukos anglų, rusų ir lietuvių k.).