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AUTOMATED DEVICE FOR GEOMETRICAL PARAMETERS ESTIMATION OF BILE-EXCRETING SYSTEM ON ULTRASOUND IMAGES

There had been presented the automated hard-and-software device for the evaluation of geometric parameters of bile-excreting system on US images, the operation of which is based upon the postprocessing the US images by the specialized filters and segmentators. There had been developed the software allowing to register patient's records.

Key words: *hardware-software system, US-image, filter, segmentator, geometric parameters of the objects, FPGA.*

Introduction

Ultrasonic investigation (USI) is the noninvasive medical visual diagnostics method. Unlike other visual diagnostics methods, for instance radiography, computer-aided tomography and magnetic resonance tomography, USI is less harmful for the human body, and thus can be multiply used for the disease development dynamics observation and the treatment results estimation. Due to this, benefits of USI became widely spread.

USI is one of the most effective research method for the gall bladder diseases diagnostics. Typical US image contains a large number of informative parameters, enabling certain pathologies diagnostics with high degree of accuracy. Main parameters that have diagnostic value are geometric size of objects and distances between them [1]. USI is the irreplaceable diagnostics method for such pathologies as: jaundice, cholestasis, cholecystitis, cholangitis, colitis, calculus, polypus etc.

Main geometric parameters, having the diagnostic value are: gall bladder size, bile duct size, their walls, the small interliver ducts, their walls sizes, presence and sizes of pathological formations (concrements and polyps). The accuracy of the parameters estimation plays a determinative role in the diagnostics and further treatment.

Despite the US diagnostics benefits, there is one important disadvantage that limits the use of this method – low quality of the output US image. Consequently, its value for the gall bladder diseases diagnostics is limited as well. Large error can be made during the distance measuring, due to human vision features, specific speckle noise and low contrast and sharpness level of the image [2].

The research carried out [3] allowed to state that the error in determining the geometric sizes of the US image objects makes up on average from 9% to 36, depending on object size, level of noise and peculiarities of vision system of the operator. Sometimes, as it is shown in [4], the error in determination of object sized by the existing methods of image segmentation may be up to 5 %.

Therefore, objective of the work is to increase the efficiency of gall bladder size estimation by creating an automatic hard-and-soft-ware system, implementing specific image postprocessing methods operating with the gall bladder US images.

Main part

The paper presents the system for automated evaluation of geometric parameters of gall bladder, which includes some blocks. The blocks perform the consecutive operations: speckle noise filtering, image segmentation and the objects geometric size estimation.

Programmable logic devices (PLD) are chosen for the realization of filter and US image segmentation device, since the suggested algorithms are composed of big number of operations and in case of their consecutive execution the time for processing one US image on PC with software may make up more than 5 minutes depending on computer parameters and image size. Considering potentially high performance of the devices on the base of PLD, stipulating for organization of parallel calculations, PLD had been chosen for hardware realization of speckle noise filter and US image segmentation device.

Objects size estimation is more convenient to realize using software. Fig. 1 presents structural and functional diagram of hard-and-software for evaluation of the geometric parameters of objects on US images.

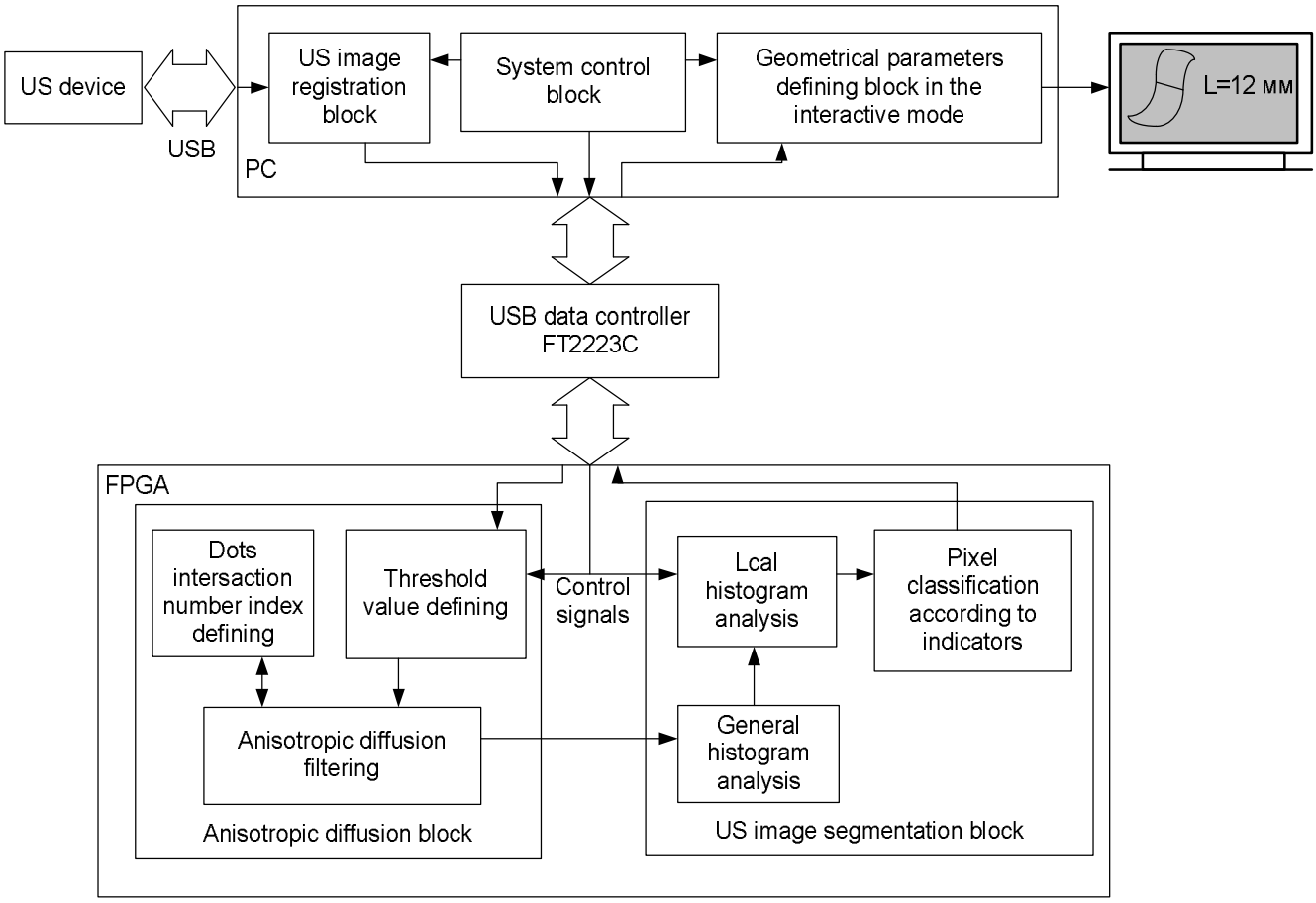


Fig. 1. Structural and functional diagram of the hard-and software device for the evaluation of geometrical parameters of gall bladder on US images

The suggested diagram consists of PC and PLD which include:

1) Input interface for uploading in PLD and converting into the RAW of the US images of gall-bladder in BMP or JPG;

2) Adaptive speckle noise filter, including: filtering on the base of anisotropic diffusion, definition of threshold value of intensity and determination of number of iteration;

3) US images segmentation device, including local histogram analysis, general histogram analysis block and the classification analysis, pixel classifying.

4) Output interface for sending the segmented US image back to the PC and converting processed image into the BMP format;

5) Software for the gall bladder and objects size determination.

The first step in the US image processing is the speckle noise filtering. There had been suggested the adaptive filter based on the anisotropic diffusion function, which considers the general noise level of the input images as well as the intensity drops in at the object boundary areas, which changes its filtering parameters in accordance with this information [4].

The filter structural diagram is presented in Fig. 2. Input data is the pixel intensity level of nonfiltered image, in the grey level gradation from 0 to 255, and the number of rows and columns of the image as well. Output data is the pixel intensity level of the processed image. Adaptive filter supposes the three operations execution: threshold intensity level computing, filtration, and calculation of iterations. The threshold intensity value computing is executed by the computing of the average noise

level and the estimation of the largest intensity function drop at the object edge area over the US image. Intensity threshold coefficient value (K) is used as the input parameter for the filter. Filtration itself is the iteration process of the directed blurring in the direction of the smallest intensity drops values.

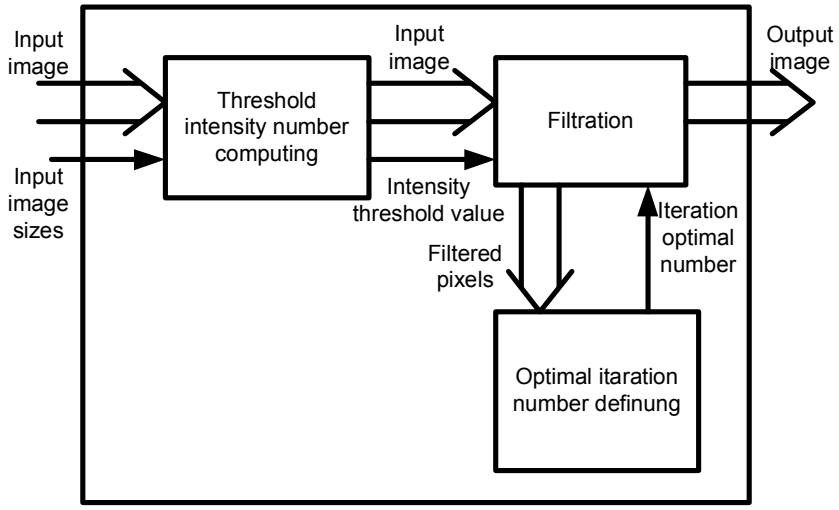


Fig. 2. The functional scheme of the adaptive filter of speckle noise on the US image

Intermediate filtered images of the i-th iteration and two previous iterations are used for the calculation of iteration process stop function. The necessary condition for the filtering process stop is the correctness of the inequality: $N_{i-2} > N_{i-1} < N_i$, where N_{i-2}, N_{i-1}, N_i - the factors of the cross points number. The filtered image of the current iteration at the stop time point is considered as the output filtered image.

The next image processing step is the gall bladder US image segmentation which classifies of each pixel of the under processing image according to the set of classifying parameters. The local statistics parameters of the neighbors of the current processed pixel are used for the classifying of that processed pixel [5].

The segmentation device scheme is presented in Fig. 3.

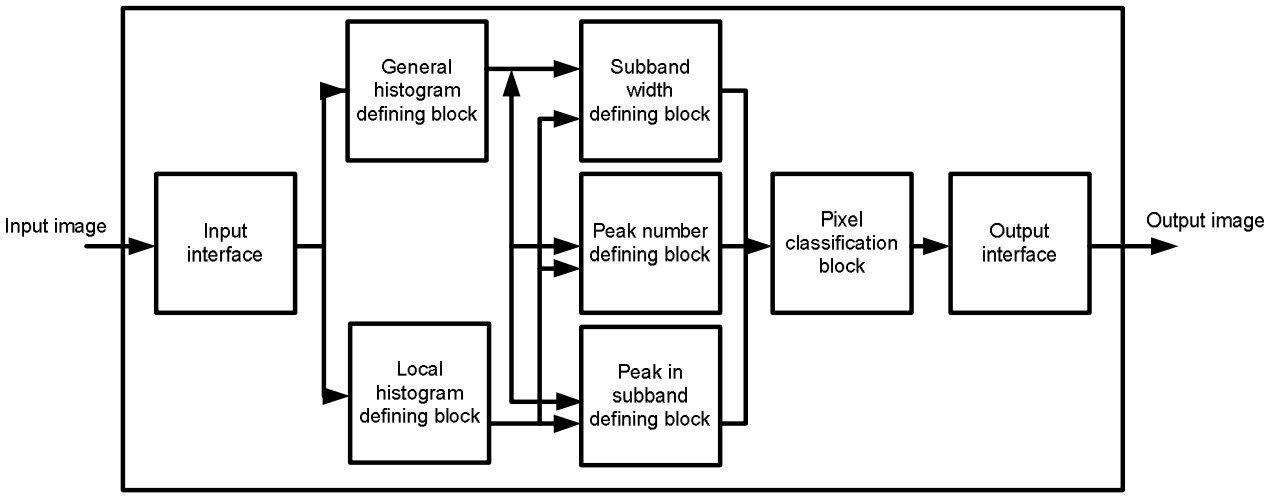


Fig. 3. The functional scheme of the US image segmentator

The input data for the segmentation device is the filtered image pixel intensities and the size of the image itself: the number of columns and the number of rows.

The subrange border determination is executed on the base of local statistics of the US image histograms. Maximum and minimum are determined in the processed histogram. Those histogram mi-

nimums shall be used as subrange borders for further classification. Local histograms are taken using the processing window, sliding over the image and getting local statistics in each particular position. Subrange width, peaks in subrange and the number of subrange peaks are analyzed in each window position. After all parameters of the histogram are taken, the window slides to the right and then down with the step of 1 pixel.

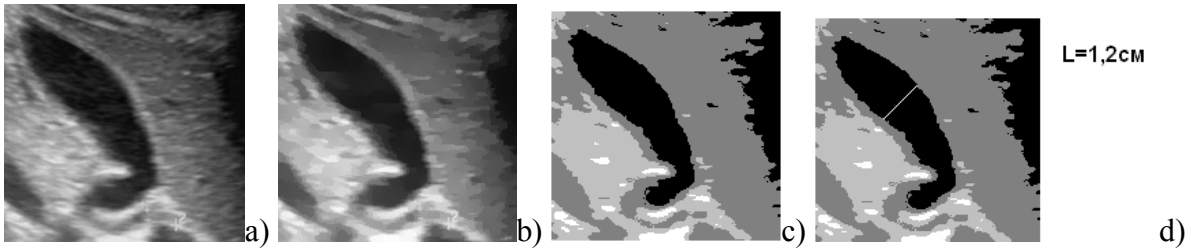
Following the set rules, the received factors of local statistics are used for the determination of control pixel classification in the window to the specific object group. Pixel may be a part of hyper- or hypo- echohenic area, cocrement or a cavity with liquid.

So each pixel of the input US image is classified as a part of some object type. Pixels, which belong to the same object type receive the same intensity level.

The determination of geometric size of segmented gall bladder objects is the last image processing operation. The parameterization is done in the interactive mode. The user sets two points on the object edges and the distance between these two points is the diagnostics parameter. The input image is the segmented US image and the output image is the segmented image with the computed sizes of objects.

Four processing stages and the resulting images after each step are presented in Fig. 4.

The general problem of the automatic parameterization includes some particular smaller problems: speckle noise filtering, US image segmentation, geometric size of segmented objects defining.



a) b) c) d)

Fig. 4. Stages of evaluation of the gall-bladder USI image geometric parameters evaluation; a) input image, b) filtered image c) segmented image, d) segmented image with the marked sizes

Designed software «GB-diagnostics» makes the FPGA devices and PC operations synchronization and enables the user to create the patients data base with the research results. Main window of the «GB-diagnostics» software is presented in the fig 5.

Software contains interface elements:

- tab containing the patient research records;
- tab containing the information about the patient;
- tab containing the instruments for the US image processing and diagnostics parameters determination;
- tab for the doctor's comments.

There is also a possibility of the automatic research report formation in the html format.

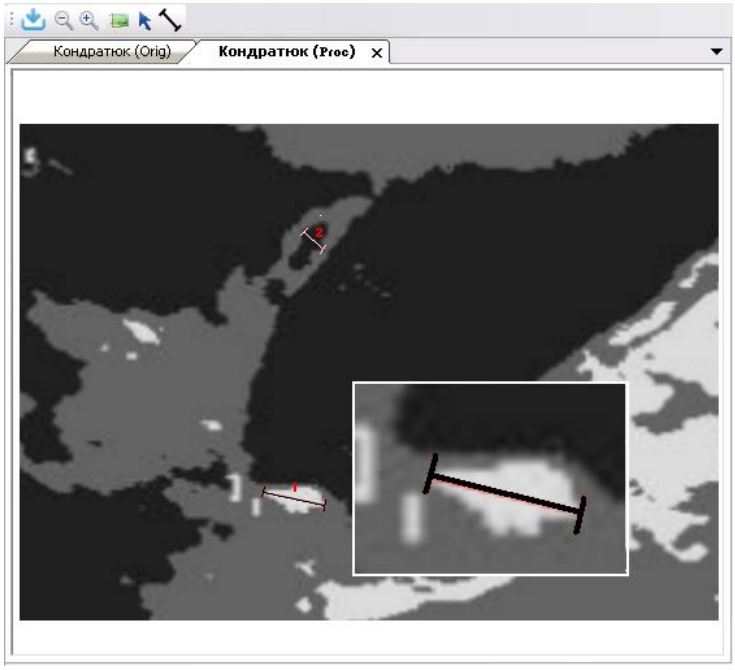


Fig. 5. «GB-diagnostics» software interface

The report contains the information about the patient and the research results.

Conclusion

The conducted researches [2, 3] state that the solution of the problem of gall-bladder diagnostics on the US images will further be aimed at development of automated systems of diagnostics. The paper presents the soft- and hardware device for the evaluation of diagnostics parameters of bile-excreting system which allows to determine the geometric parameters of objects of bile-excreting system and to keep the electronic data base of individual patients' registration process.

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