Algorithm for Image Segmentation Process in Ultrasound Machines

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ABSTRACT: *The function of a Doppler ultrasound machine is to record noise waves that characterize fluids, blood in vessels and exhibit such movements for diagnosis. The images produced in this action inform the blood speed and the ways. We in this work have presented a solution for image segmentation and assess the renal vessels. We suggested the noise reduction of the original image is as first stage of processing for obtaining a clearly contours of the objects. This process will further lead to colour segmentation on the base of k-mean clustering and calculation of some statistical parameters in some health issues. We have tested the algorithm in the MATLAB environment. We have supported our experiments with results and shown that use of this method for a proper diagnosis which will improve health sector.*

Keywords: Doppler Ultrasound Images, Renal vessels, Colour Segmentation, K-mean Clustering

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1. Introduction

The color Doppler ultrasound (US) makes use of a special technology to visualize the blood flowing in arteries and veins. Here the sound waves are converted to color pictures on a screen so that flow can be seen through the blood vessels (color Doppler) or on a graph showing changes in velocity. Both arteries and veins are encoded by this method. The arteries are encoded red, as the flow is coursing toward the probe to the periphery of the kidney. The veins are encoded blue. The Figure 1 presents an anatomy of kidney [1].

Doppler US has the advantages of being noninvasive and inexpensive. However, considerable controversy exists with regard to the role of Doppler US in screening for renal artery stenosis (RAS) or other diseases of the renal vessels [2, 3].

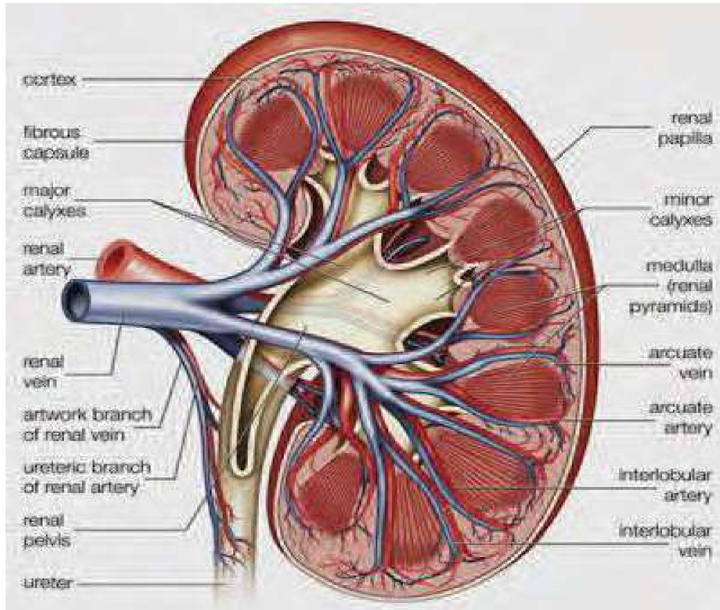

Figure 1. Anatomy of the kidney

Two approaches are used to detect RAS with Doppler US [4]:

- Direct visualization of the renal arteries;

- Analysis of intrarenal Doppler waveforms.

The method of direct visualization is used in this paper, which is preferred to renal vessels evaluation. The entire length of the renal artery (RA) can be seen in this view, although when vessel tortuosity is present, the renal artery may be seen in segments. Sometimes the images are less than optimal. If there is uncertainty, images should not be acquired. However, if the renal artery can be identified coming in from the rest of the noise, then it can be sampled.

We propose to pre-process the original image in regard to noise reduction of speckle noise and segment the processed image on the base of k-mean clustering. The color segmented image can present separately the renal vessels in the obtained cluster images. This approach can be very helpful by obtaining a better evaluation of the statistical parameters of arteries and veins. The results are expressed as numbers of diameters, mean diameter, standard deviation of diameters, min and max diameters, segment length, the ratio diameter/length and tortuosity. This statistic can help the doctor to determine the probability of having RSA [5].

The remainder of this paper is organized as follows: section 2 describes the basic steps in the proposed algorithm; section 3 presents the experimental results to show the effectiveness of the method and; section 4 presents our conclusion and some future works.

2. Basic Stages in Algorithm for Image Processing

In the paper is proposed an effective algorithm for renal vessels evaluation in US images. It consists of following basic stages:

- Speckle noise reduction

- Segmentation of renal vessels

• Calculation of some statistical parameters of the segmented vessels

• Evaluation of the obtained results

The block diagram of the algorithm is presented in Figure 2.

Image pre-processing is performed in order to reduce the speckle noise, enhance the visual quality and for obtaining a clearly contours of the vessels.

The multiplicative nature of the speckle noise is converted to an additive one through log transformation and the problem of despeckling is thus reduced to the estimation of US image in the presence of additive noise:

$$lnI(x,y) = lng(x, y) + lnn(x, \mathrm{y}) \quad (1)$$

where, I and g are the observed noisy image and noise-free image, respectively, n is the noise variable modeled as a stationary unity means random variable independent of g.

We have used for noise reduction a modified homomorphic filter based on wavelet packet decomposition issued from a given orthogonal wavelets and adaptive threshold of the transformed US image The noise reduction is made in YUV color space for more effectiveness of the filtration. [6].

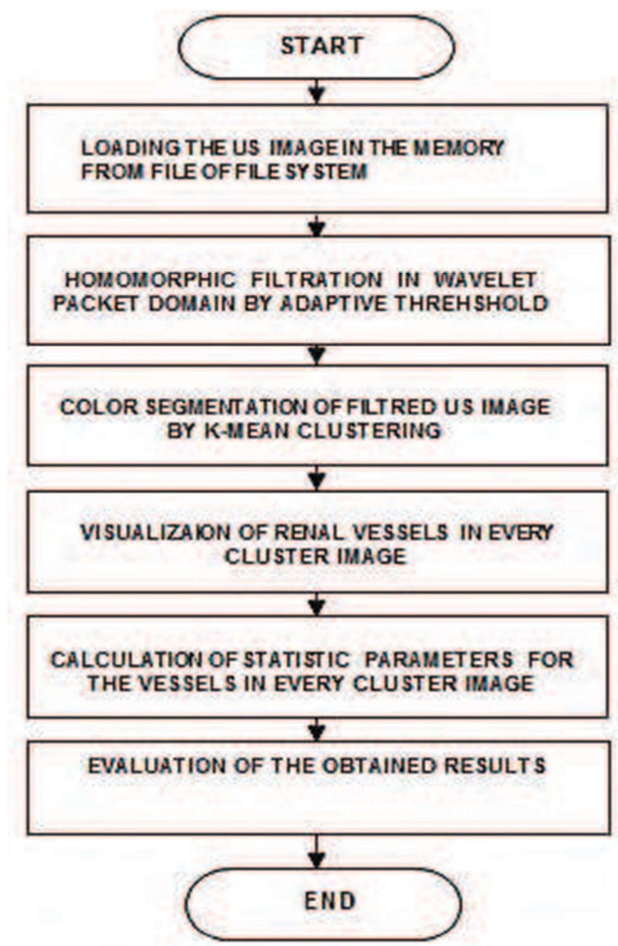

Figure 2. Block diagram of the basic algorithm

The wavelet transform now becomes a linear operation. In this case the application of the WPT to the noisy image *ln I(x, y)* gives:

$$W[\ln I(x, y)] = W[\ln g(x, y)] + W[\ln n(x, y)] \quad (2)$$

where W is the WPT operator. So the Eq. (2) can be rewritten as:

$$Y = X + N \quad (3)$$

where, Y, X, and N are the random variables representing wavelet coefficients, respectively, of the noisy data, noise-free data, and the noise in Equation (1).

The signal components in the detail sub-bands after wavelet decompositions have heavier tails and are sharply peaked at zero. They are described by the zero- mean generalized Gaussian distribution (GGD) [7]. For modelling an image with speckle noise is used the generalized Gaussian distribution and generalized gamma distribution, which is more general to approximate the speckle statistics in the sub-band representation of US images.

To obtain a precisely detection of renal vessels and to analyze separately the arteries and veins in filtrated image a color classification based on k-mean clustering is used. This method aims to partition n observations into k clusters in which each observation belongs to the cluster with the nearest mean. Color-based Segmentation using k-mean clustering segments colors in an automated fashion using the L*a*b* color space and k-means clustering method. K-means clustering treats each object as having a location in space. It finds partitions such that objects within each cluster are as close to each other as possible. K-means requires that the number of clusters to be partitioned should be specified and also a distance metric to quantify how close two objects are to each other [8].

Let the feature vectors derived from l clustered data be $X = x_i,\ i = 1, 2\ldots, l\}$. The generalized algorithm initiates k cluster centroids $C = \{c_j, j=1,2,\ldots.k\}$ by randomly selecting k feature vectors are grouped into k clusters using a selected distance measure such as Euclidean distance so that

$$d = \|x_i - c_i\| \quad (4)$$

The next step is to precompute the cluster centroids based on their group members and then regroup the feature vector according to the new cluster centroids. The clustering procedure stops only when all cluster centroids tend to converge. This approach can be very helpful by obtaining a better evaluation of the statistical parameters of arteries and veins. The results are expressed as numbers of diameters, which corresponds to number of renal vessels, mean diameter, standard deviation of diameters, min and max diameters, segment length, the ratio diameter/length and tortuosity.

The measurement of the RA diameter was performed in the proximal segment of the renal artery at a distance of 1 to 1.5 cm from the ostium, where the renal artery reaches a uniform width [9]. The widest caliber was measured perpendicular to its long axis. If the kidney has single renal artery, this artery is accepted as a main renal artery (mRA) [5]. If the kidney has multiple arteries, the largest one is accepted as an mRA. On the base of the measured diameters the statistic parameters are calculated.

3. Experimental Results

The experiments are made in MATLAB 7.14 environment by using IMAGE PROCESSING TOOLBOX and WAVELET TOOLBOX. For the investigations are used 20 color Doppler US images with size 640x480 pixels of the kidney. Some of the obtained results are shown in the next figures below. In Figure 3 is presented the original image and in Figure 4 is shown its enhancement modification after homomorphic filtration based on wavelet packet decomposition by using of adaptive threshold.

The obtained modifications after color segmentation based on k-mean clustering are shown in Figure 5 and Figure 6. The cluster images present the separated renal vessels in arteries and veins.

The results from automatic calculated numbers of diameters, which corresponds to number of renal vessels, mean diameter,

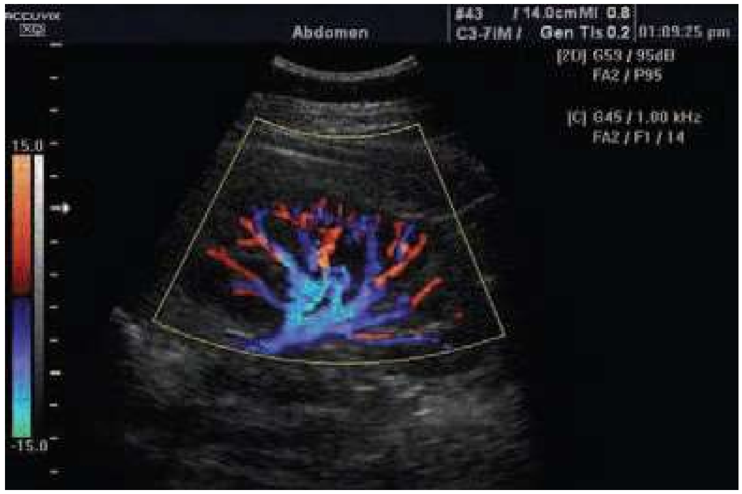

Figure 3. Original US image

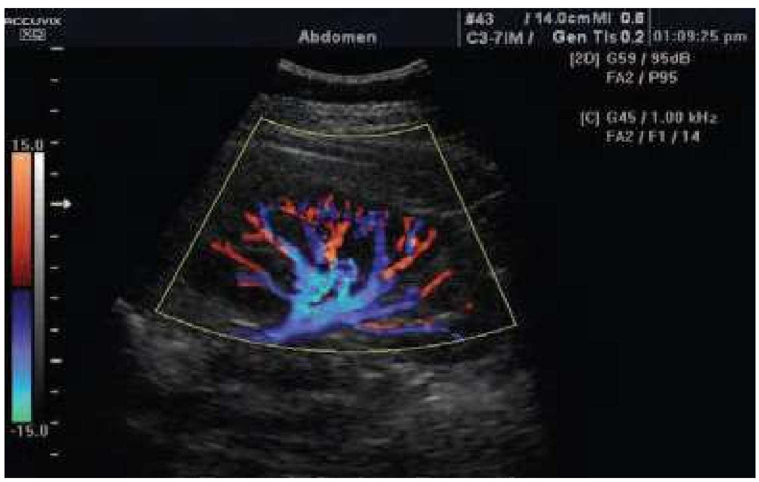

Figure 4. US image after homomorphic filtration

Figure 5. US cluster image with renal artery

Figure 6. US cluster image with renal veins

standard deviation of diameters, min and max diameters, segment length, the ratio diameter/length and tortuosity, which are obtained by analysis in every cluster image are presented in Table 1.

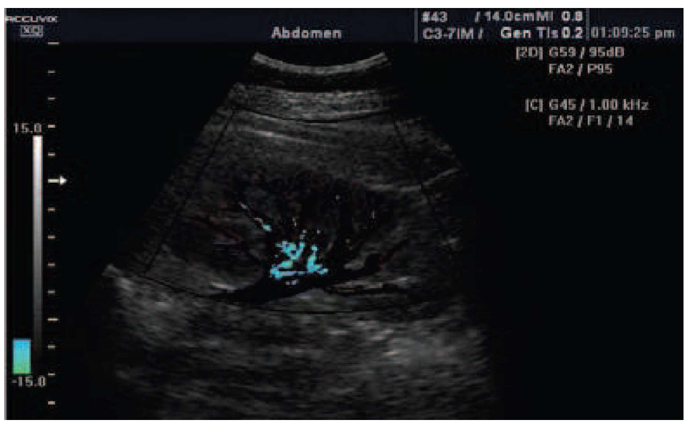

Figure 7. US cluster image with renal vein anomaly

The obtained third cluster image by the segmentation gives some information about the anomaly in blood vector flow in the renal vein. It is sown in Figure 7.

Cluster image	diam.	Mean diam.	Stand. deviation	Min diam.	Max diam.	Segm. lenght	Diam. /lenght
Renal artery	30	9.31	1.19	7.28	10.1	28.2	0.32
Renal vein	6	3.41	0.38	3.13	4.04	11.8	0.28
Anomaly renal vein	5	3.46	0.32	3.13	3.94	4.22	0.82

Table 1. Experimental Results for Statistic Parameters

Images	Accuracy	Sensitivity	Specificity
CT	97	54	87
US	95.45	53.35	84.24

Table 2. Experimental Results for Measures Accuracy, Sensitivity and Specificity in %

The presented measured values of the parameters are in pixels. It can be calibrated in *cm* or *mm*. The tortuosity for the segments in all clusters is 1px.

The results are evaluated by calculating the measures accuracy, sensitivity and specificity. The values were calculated for each image and, then, averaged over all images.

These results are compared to results obtained by evaluation of renal vessels in CT images [5]. The obtained results are given in Table 2.

4. Conclusion

In this paper is proposed an effective approach for automatic renal vessels evaluation in color Doppler US images. It consists noise reduction by homomorphic filter on the base of wavelet packet decomposition. Then an automatic color segmentation on the base of k-mean clustering is applied. It is very helpful by obtaining a better evaluation of the statistical parameters of arteries and veins. Experimental results showed that the proposed approach can evaluate the renal vessels such as arteria and vein accurately with average accuracy, sensitivity and specificity of 95.45%, 53.35% and 84.24%, respectively, which is satisfactory. It shows that Doppler US can be a very effective method in screening for renal artery stenosis (RAS) or other diseases of the renal vessels. From other side color Doppler US has the advantages of being noninvasive and inexpensive.

Our future works will be focused in applying of other methods of segmentation for more effectiveness of automatic detection of different diseases in the renal vessels.

Acknowledgement

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