A REGION GROWING SEGMENTATION ALGORITHM BASED ON CLAHE AND WAVELET TRANSFORMATION FOR ULTRASOUND IMAGES

Veska M. Georgieva

Faculty of Telecommunications, Technical University of Sofia, Bulgaria
1000 Sofia, "Kl. Ohridsky" str. 8
T. (+359 2) 965-3293; E-mail: vesg@tu-sofia.bg

Abstract

Segmentation of medical images using region growing technique is a popular method because of its ability to involve high-level knowledge of anatomical structures in seed selection process. Due to its non-invasive nature and easily portable devices, ultrasound imaging is nowadays used for the diagnostic and clinical studies of many diseases. The quality of ultrasound (US) images is very important by detection of some pathological modifications in a body structures and tissues. This paper presents an approach for US image segmentation of internal organs. As element of stage for pre-processing is used enhancement, based on contrast limited adaptive histogram equalization (CLAHE), following by noise reduction, based on the Wavelet Packet Decomposition (WPD).

Implementation results are given to demonstrate the visual quality in the perspective of clinical diagnosis.

1. INTRODUCTION

Among all other imaging techniques like Computer Tomography (CT), Magnetic Resonance imaging (MRI), US imaging is cheap, non-invasive and does not emit any radiation. But CT and MRI images are taken in well defined planes and the organs in the images are more homogeneous and so are much easy to segment as compared to US image. US images contain speckle noise, attenuation artifacts and organs don't appear homogeneous so it is difficult to be segmented. Many challenging methods have been adopted for proper segmentation of US images [1],[2].

In the paper is presented one approach based on CLAHE for contrast enhancement and noise reduction on the base of wavelet packet decomposition as stages of preprocessing.

To improve the diagnostic quality of the medical objects some parameters of the wavelet transforms are optimized such as: determination of best shrinkage decomposition, threshold of the wavelet coefficients and value of the penalized parameter of the threshold. This can be made adaptively for which image on the base of calculation and estimation of some objective parameters. For US image segmentation is used a region growing technique because of its ability to involve high-level knowledge of anatomical structures in seed selection process.

2. CLAHE FOR CONTRAST ENHANCEMENT

Contrast limited adaptive histogram is a technique utilized for improving the local contrast of images. CLAHE does not operate on the whole image works like ordinary Histogram Equalization (HE), but it works on small areas in images, named tiles. Each tile's contrast is enhanced, so that the histogram of the output area roughly matches the histogram determined by the 'Distribution' parameter. This parameter can be selected depending on the type of the input image. The adjacent tiles are then combined using bilinear interpolation to eliminate artificially induced boundaries. The contrast, particularly in homogeneous regions, can be limited to avoid amplifying any unwanted information like noise which could be existed in images. The algorithm CLAHE limits the slope associated with the gray level assignment scheme to prevent saturation. The CLAHE method can be divided into steps to achieve as following [3]:

- The US image is divided into contextual regions which are continuous and non-overlapping. Each contextual region size is M×N pixels;
- The histograms of each contextual regions are calculated;
- The histograms of each contextual region are clipped.

For limiting the maximum slope is to use a clip limit β to clip all histograms. This clip limit can be related to what is referred to as clip factor, α in percent, as follows (1), [4]:

$$\beta = \frac{MN}{L}\left[1+\frac{\alpha}{100}\left(S_{\max}-1\right)\right] \quad (1)$$

where α is a clip factor, M×N are numbers of pixels of each region and L are the number of grayscales;

Finally, cumulative distribution functions (CDF) of the resultant contrast limited histograms are determined for grayscale mapping. The result mapping at any pixel is interpolated from the sample mappings at the four surrounding sample grid pixels. The procedure of CLAHE can be applied to Y component of the selected image that is processing in YUV system as more effectiveness.

3. NOISE REDUCTION

3.1. Noise model in US images

In an US image contained additive Gaussian white noise the basic model for each pixel is as follows (2) [5]:

$$s(x,y) = f(x,y) + n(x,y) \quad (2)$$

where $f(x,y)$ is the desired image, without noise, $n(x,y)$ is N(0,1) noise.

As speckle noise is proportional to the desired signal it is generally modeled as multiplicative noise (3):

$$s(x,y) = f(x,y).n(x,y) \quad (3)$$

where $f(x,y)$ is the desired image, without noise, $n(x,y)$ is the noise.

Logarithmic transformation of a US image converts the multiplicative noise model to an additive noise model (4):

$$\log(s) = \log(f) + \log(n) \quad (4)$$

Our goal is to extract f and reduce the noise n.

3.2. Noise reduction based on WPD

The next stage of the algorithm is noise reduction. It is based on the wavelet packet transform [6]. Based on the organization of the wavelet packet library, it can be determinate the decomposition issued from a given orthogonal wavelets. The classical entropy-based criterion is a common concept for finding on optimal decomposition. It's looking for minimum of the criterion from three different entropy criteria: the energy of the transformed in wavelet domain image, entropy by Shannon and the logarithm of the entropy by Shannon. By looking for best shrinkage decomposition to noise reduction two important conditions must be realized together. They are the conditions (4) and (5):

$$E_K(S) = \min, \quad for\, K = 1,2,3...n \quad (4)$$

where E_K is the entropy in the level K for the best tree decomposition of the image S

$$s_{ij} \geq T \quad (5)$$

where s_{ij} are the wavelet coefficients of S in an orthonormal basis, T is the threshold of the coefficients.

By determination of the threshold it is used the strategy of Birge-Massart. This strategy is flexibility and used spatial adapted threshold that allows to determinate the threshold in three directions: horizontal, vertical and diagonally. Choosing the threshold too high may lead to visible loss of image structures, but if the threshold is too low the effect of noise reduction may be insufficient. The procedure for noise reduction can be determined on the base of some calculated estimation parameters [6].

4. SEGMENTATION

Region growing is one of the simplest approaches to image segmentation; neighboring pixels of similar amplitude are grouped together to form a segmented region. However, in practice, constraints, some of which are reasonably complex, must be placed on the growth pattern to achieve acceptable results [7].

5. EXPERIMENTAL PART

The formulated stages of processing are realized by computer simulation in MATLAB 7.12 environment by using IMAGE PROCESSING TOOLBOX and WAVELET TOOLBOX. In analysis are used 20 grayscale US images from abdominal organs with size 640x480 pixels. Some results from simulation, which illustrate the working of proposed algorithm, are presented in the next figures below. In Fig. 1 is shown the original US image of size 640x480 pixels with stone of GB Neck. In Fig. 2 is presented the result of CLAHE preprocessing. In Fig. 3 is shown the US image after CLAHE and nose reduction based on WPT. In Fig. 4 is illustrated the result of segmentation by proposed approach. It presented better the located stone of GB Neck and its boundaries.

Figure 1. Original US image

Figure 2. US image after CLAHE

Figure 3. US image after CLAHE and noise reduction

Figure 4. US image after segmentation

6. CONCLUSION

In the paper is presented a new approach to US image segmentation on the base of wavelet packet decomposition. The proposed approach combines CLAHE with noise reduction to achieve better results for segmentation of different objects in the ultrasound images. The implemented studying and obtained results by using of real images attempt to make diagnostic more precise.

The proposed approach can be demonstrated by studying of medical image processing in engineering and medical education.

Acknowledgments

This paper was supported by the Joint Research Project Bulgaria-Romania (2010-2012): "Electronic Health Records for the Next Generation Medical Decision Support in Romanian and Bulgarian National Healthcare Systems", DNTS 02/19.

References

[1] A. Khana, M. Sood, S. Devi, "US Segmentation based on Expection Maximalization and Gabor Filter", *International Journal of Modeling and Optimization*, Vol.2, №3, 2012, pp.230-233.

[2] J.A. Noble, "US Image Segmentation: A. Survey", *IEEE Transactions on Medical Imaging*, Vol.25, №8, 2006, pp.175-180.

[3] Z. Xu, X. Lin, X. Chen, "For removal from video sequences using contrast limited histogram equalization", Proceedings of the International Conference on Computational Intelligence and Software Engineering, IEEE Xplore Press, Wuhan, 2009, pp.1-4.

[4] Ali M. Reza, "Realization of CLAHE for Real-time Image Enhancement", *Journal of VLSI Signal Processing,* Vol. 38, Kluwer, 2004, pp.35-44,

[5] V. Georgieva, "Edge Detection in US Medical Images using Wavelet Decomposition", Proceedings of CEMA'10, Athen, Greece, 2010, pp.108-111.

[6] V.Georgieva, R. Kountchev, "An influence of the wavelet packet decomposition on noise reduction in ultrasound images", Proceedings of ICEST'06, Sofia, Bulgaria, 2006, pp.185-188.

[7] Sheng-Chih-Yang, Chuin-Mu Wang, Yi-Nung Chung, Giu-Cheng Hsu, San-Kan Lee, Pau-Choo Chung and Chein-1 Chang "A Computer Aided System for Mass Detection and Classification in Digitized Mammograms", Biomedical Engineering-Applications, Basis and Communications, 2005, vol. 17, No.5, pp. 215-228.