

Automatic Boundary Detection and Generation of Region of Interest for Focal Liver Lesion Ultrasound Image Using Texture Analysis

Mihir N.Dalwadi , Prof. D.N.Khandhar, Prof. Kinita H.Wandra,

(C.U.Shah College of Engineering and Technology, Wadhwan), Gujarat, India, Mobile no. 9033416196.

Abstract- The analysis of texture parameters is a useful way of increasing the information obtainable from medical images. It is an on-going field of research, with applications ranging from the segmentation of specific anatomical structures and the detection of lesions, to differentiation between pathological and healthy tissue in different organs. Finding the correct boundary in noisy images is still a difficult task. We have used GVF method for boundary detection for FLL US images. The presence of speckle noise in US images, performing the segmentation methods for the FLL images were very challenging and therefore, deleting and removing the complicated background will speed up and increases the accuracy of the segmentation process.

Therefore, this study proposed an automatic ROI generation for FLL US images. Firstly, some techniques of speckle noise reduction will implemented consist of median, mean, Gaussian low-pass and Wiener filter. Then texture analysis was performed by calculating the local entropy of the image, continued with the threshold selection, morphological operations, object windowing, seed point determination and ROI generation^[1,2,3,4,5].

Index Terms- Gradient vector flow (GVF) model, Boundary extraction, Region of interest (ROI), Focal liver lesions (FLL), Texture analysis, Ultrasound (US), Speckle noise Reduction, Gray Level Co-occurrence Matrix (GLCM).

I. INTRODUCTION

Liver chronic diseases constitute an important public health issue. The evolution of diffuse liver diseases is variable, but it has generally long term. Whatever the nature of the liver aggression, it seems to follow a pattern characterized by the successive stages: inflammation (at the beginning), necrosis, fibrosis, and regeneration (cirrhosis), dysplasia & HCC. Hepatocellular carcinoma (HCC) is one of the most frequent malignant tumors of liver (75% of the liver cancer cases) and others are hepatoblastoma (9%), cholangiocarcinoma (7%) & cystadenocarcinoma (6%)^[6].

We have used GVF model for boundary detection & GLCM method for texture analysis. The snake models have become popular especially in boundary detection where the problem is more challenging due to the poor quality of the images^[4]. The computation of textural features is done through specific texture analysis methods. The 1st order statistics of grey levels, GLCM, Fractal-based methods, Transform-based methods^[1,5].

II. TOOL TO BE USED FOR SIMULATIONS:

MATLAB, The name MATLAB stands for MATRIXLABORATORY. MATLAB was written originally to provide easy access to matrix software developed by the LINPACK (linear system package) & EISPACK (Eigen system package) projects like IP, DSP etc^[21].

III. MATERIALS AND METHODS:

For this study, FLL Ultrasound image images was taken from TOSHIBA AplioMX ultrasound machine with 3.5MHz transducer. MATLAB programming which followed by above algorithm was used to develop the system for generating the Focal Liver Lesion ultrasound region of interest automatically.

The Gradient Vector Flow (GVF) snake model was proposed by Xu and Prince in 1997. The traditional deformable models have problems associated with capture range; it means initialization & poor convergence to boundary concavities. The GVF snake model overcomes the disadvantages of traditional snake model is shown in upcoming sections by comparison of behavior of traditional and GVF snake model. This model used for automatic boundary detection in this paper.

An automatic ROI generation method that facilitates full automation of Liver ultrasound image segmentation. Therefore, we conducted a texture analysis to the Liver images. I have developed an algorithm for automatic ROI generation of ultrasound Focal liver lesion ultrasound image images which consist of speckle noise reduction, texture analysis, threshold selection, morphological operation, objects windowing, seed point determination and lastly ROI generation^[1,2,3].

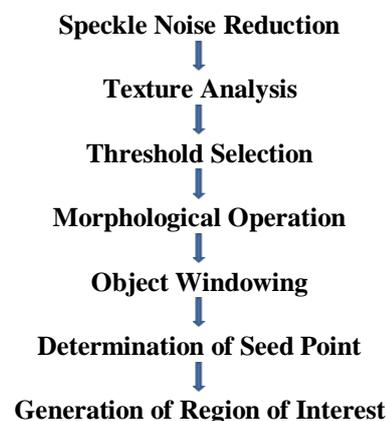


Fig. 1 Algorithm for Automatic Generation of Region of Interest for Focal Liver Lesions.

A. Speckle Noise Reduction

Ultrasound image suffers from speckle noise, caused by the interference between coherent waves that is backscattered by the natural surfaces and it is depends on bandwidth, frequency, as well as the position of the transducer. Due to this speckle noise, further image processing such as image segmentation & edge detection has become much more complicated. Therefore, speckle noise reduction techniques can be applied to US image to reduce the noise & improve the image quality by enhancing the contrast of the image. We use Mean, Median, Wiener and Gaussian Law pass filter for Speckle noise reduction^[9,10].

1. Median Filter:

Median filter, one of the nonlinear filter types is created by replacing the median of the gray values of pixels into its original gray level of a pixel in a specific neighborhood. Fig. 2 shows an example to calculate median pixel value. Median filter can help in reducing speckle noise as well as salt and pepper noise. The noise-reducing effect of the median filter depends on the neighborhoods' spatial extent and the number of pixels involved in the median calculation. Fig. 2 Example for calculating the median value of a pixel neighborhood^[10,13,21]

140	135	124	130	135
128	115	119	123	127
130	124	126	127	140
138	120	150	125	128
125	125	122	135	132

Fig. 2 Ex. for calculating the median value of a pixel neighborhood. Neighborhood values 115,119,123,124,127,120,150, 125, Median values: 126

2. Wiener Filter:

Wiener filter inverts the blurring and removes the additive noise simultaneously by performing an optimal trade-off between inverse filtering and noise smoothing. Besides, Wiener filtering is optimal in terms of the mean square error, where it minimizes the overall mean square error in the process of inverse filtering and noise smoothing. Wiener filtering is also a linear estimation of the original image. The Wiener filter in the frequency domain is as in equation (1):

$$W(f_1, f_2) = [H^*(f_1, f_2) S_{xx}(f_1, f_2)] / [|H(f_1, f_2)|^2 S_{xx}(f_1, f_2) + S_{nn}(f_1, f_2)] \dots\dots (1)$$

Where $S_{xx}(f_1, f_2)$, $S_{nn}(f_1, f_2)$ are respectively power spectra of the original image & the additive noise & $H(f_1, f_2)$ is the blurring filter^[10,13,21].

3. Gaussian Low Pass Filter:

Gaussian Low-pass filtering has been used in previous researches for removing the speckle noise in US images. Gaussian filter has similar function as median filter but it uses different kernel, which has the bell-shaped distribution as shown in Fig. 3.

The equation for Gaussian filter is:

$$g(x) = \frac{1}{\sqrt{2\pi}\sigma} \cdot e^{-x^2/2\sigma^2} \dots\dots\dots (2)$$

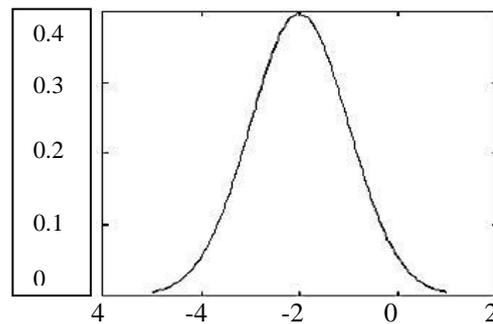


Fig. 3 The bell-shaped of Gaussian distribution.

In the eq. (2) sigma is the standard deviation of the distribution, and also the degree of smoothing. The larger the value of sigma, the filtered image is smoother. In order to be accurate, if larger value of sigma is used, larger convolution kernel need to be used. Besides, low-pass filter based on Gaussian function is also common in frequency domain filtering, since both the forward & the inverse Fourier transforms of a Gaussian are the real Gaussian functions^[10,21].

B. Texture Analysis:

Texture analysis is important in characterizing regions in an image by their texture content & it is helpful when objects in an image are more characterized by their texture than by intensity and traditional thresholding techniques cannot be used effectively. When certain values either range, standard deviation or entropy of the image are calculated, they will provide information about the local variability of the intensity values of pixels in the image, thus the texture can be characterized^[5].

The toolbox in MATLAB includes three texture analysis functions that filter an image using standard statistical measures, such as range, standard deviation, and entropy. Rangefilt is used to calculate the local range of the image. If the image has smooth texture, it will have small value, whereas if the image's texture is rough, the value will be larger. Stdfilt is used to calculate the local standard deviation of an image while entropyfilt is used to calculate the local entropy of a grayscale image which also represents a statistical measure of randomness^[13,21].

C. Morphological Operation:

After image binarization morphological operations were performed to remove the unwanted regions. Morphological filters are based on two main operations, which are dilation and erosion. The dilation of A by B is defined by:

$$A \oplus B = \cup_{b \in B} A_b \dots\dots\dots (1)$$

The erosion of A by B is also given by the expression:

$$A \ominus B = \cup_{b \in B} A(-b) \dots\dots\dots (2)^{[11]}$$

D. Determine seed Point:

The left regions will undergo another selection steps to determine which is the correct seed point. The algorithm for seed point selection is as in Fig. 4 For seed point detection,

firstly, the number of connected components (region), n needs to be determined so that we can know how many regions left in the image. If there is only one region left, it is automatically considered as the seed point. If not, the region areas (pixel), A also needs to be determined. We set the threshold pixel areas as $6k$. If the area, A is less than $6k$, that region is selected as the seed point. If not, the other region will be selected.

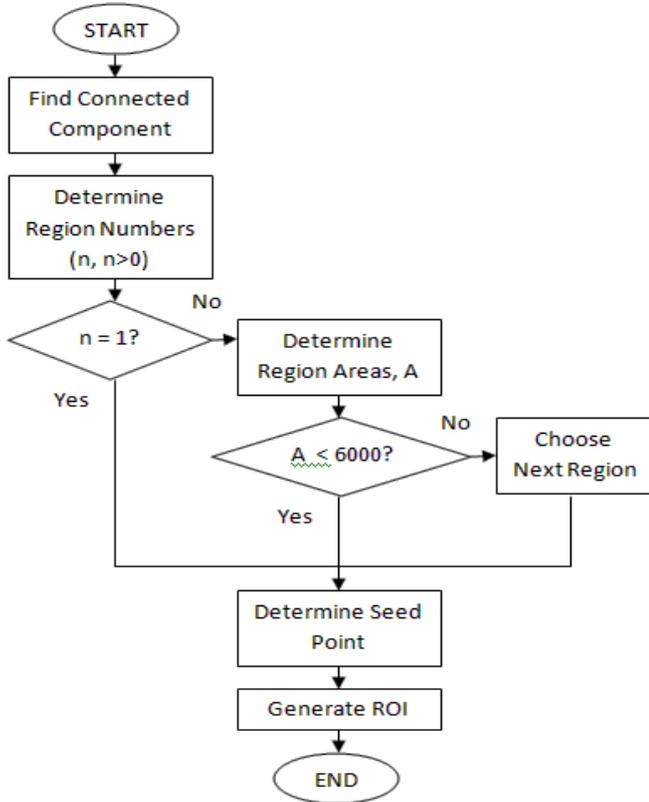


Fig. 4 Algorithm for seed point detection.

IV. RESULTS AND ANALYSIS:

1. Comparison of different speckle noise reduction filter:

Here I use four different filters for speckle noise reduction which are median filter, mean filter, wiener filter, Gaussian low pass filter^[10,13,21].

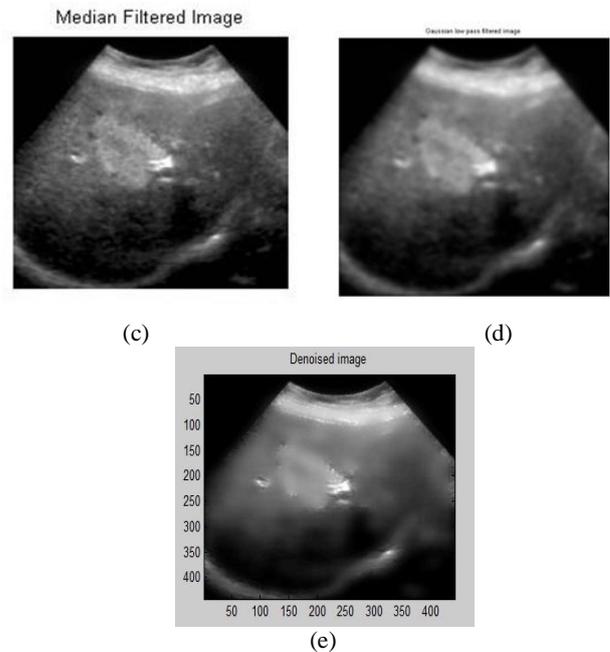
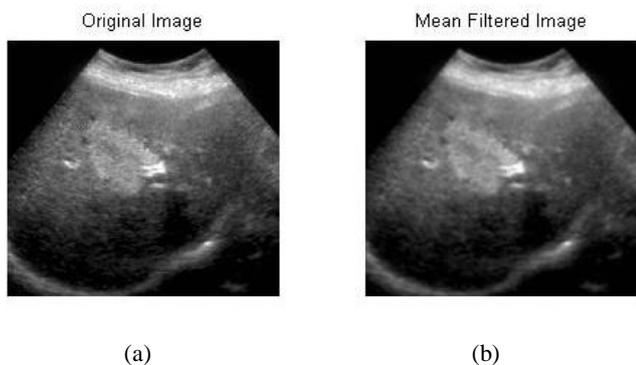


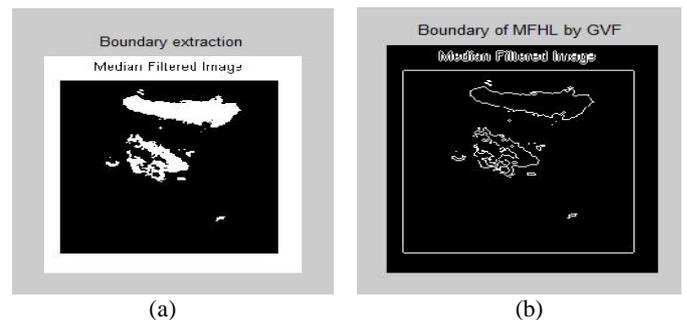
Fig. 5 (a) Original image, (b) Mean filter image, (c) Median filter image, (d) GLP filter image, (e) Wiener filter image.

Filter	MSE	RMSE	SNR	PSNR[dB]
Median	47.7273	6.9085	74.5810	31.3089
Wiener	57.0200	7.5511	73.8084	30.5364
GLP	93.3280	9.6606	71.6542	28.3965
Mean	68.6847	8.2876	73.0001	29.7280

Table.1 Comparison of different parameter of speckle noise reduction filter

Fig. 5 shows the result of the images after applying speckle noise reduction techniques. We can see that the image was blurred compared to the original image. All these output images were used for ROI generation to compare which filter gives the best output. Fig. 6 shows the result of boundary extraction and detection using GVF^[2,3,10].

2. Automatic Boundary Extraction & Detection using GVF:



[Fig.6 (a) Boundary extraction by Gradient vector flow, (b) Boundary of median filter image by Gradient vector flow model]

3. Texture Analysis Result:

Texture analysis is implemented and the result is changed to binary by setting the threshold value at 0.7. Fig. 7 show the results of three texture filters which are range filter, standard deviation filter and GLCM feature Extraction together with their binary images at threshold 0.7^[15,16].

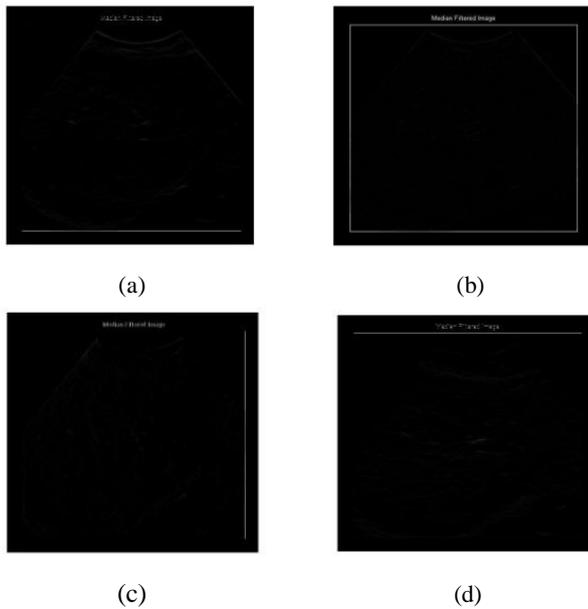


Fig. 7 (a) Range filters result (b) Range filter with threshold 0.7 (c) Standard deviation filter (d) SD filter with threshold 0.7

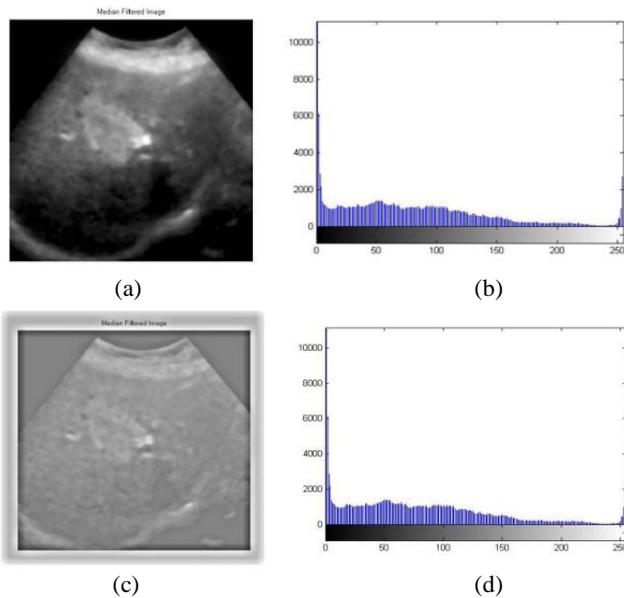


Fig. 8 (a) Median filters Image or original image (b) Histogram of original image. (c) GLCM feature extraction of Median filter with threshold 0.7. (d) Histogram of GLCM features extraction.

	Median	Mean	GLP	Wiener
Energy	3.7088e+10	2.4219e+09	1.9912e+09	4.0905e+09
Entropy	-2.343e+06	-5.316e+05	-4.773e+05	-7.072e+05
Homogeneity	9.6292e+04	2.46065e+04	2.2311e+04	3.1978e+04
Correlation	1.3284e+14	2.7068e+12	1.9426e+12	5.7678e+12
GLDH	2.041e+05	5.577e+05	4.997e+04	7.170e+04

Table 2 Comparison of Parameters of GLCM feature extraction of different filters.

Based on the result in Fig. 7 and 8, it shows that the output for range filter and standard deviation filter detect less texture

compared to the output of GLCM texture extraction. Besides, after being converted into binary image with the threshold value at 0.7 for all filters, almost nothing were appeared in range filter and standard deviation filter output images. However, for GLCM feature extraction output image, there were some regions detected. Therefore, we choose GLCM Feature Extraction to be implemented for the rest of the Focal Liver Lesion Ultrasound images for generating the ROI^[13,15,16].

4. Result of Morphological operation:

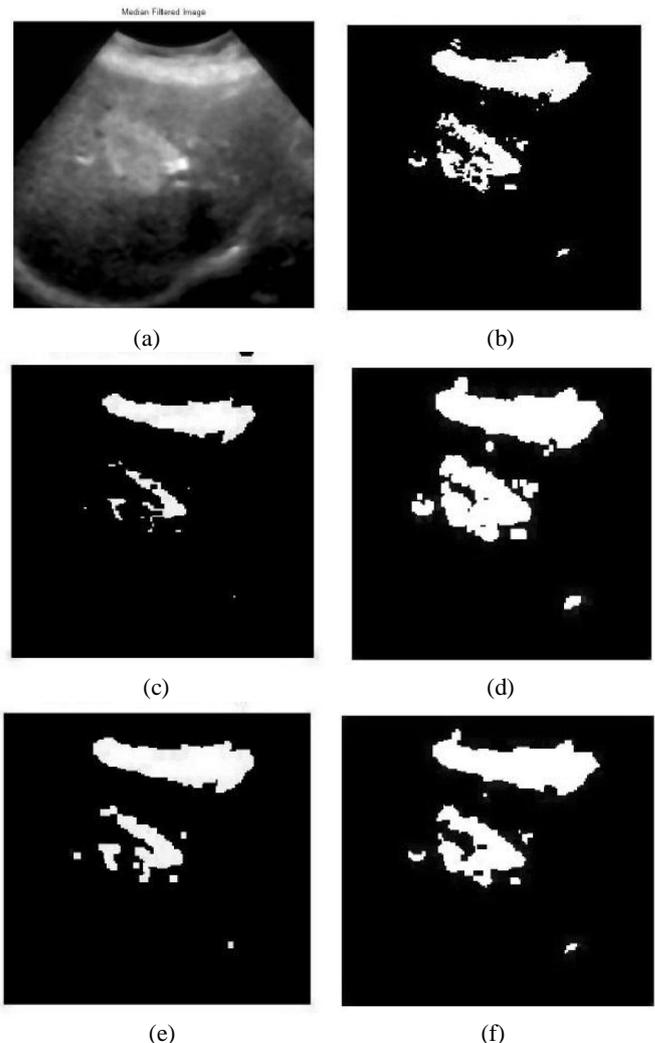


Fig. 9 (a) Original image, (b) Binary image with threshold 0.7, (c) Erosion, (d) Dilation, (e) Opening, (f) Closing operation.

Morphological operation is performed consist of filling the holes and removing small regions by using dilation and erosion theories. There are several operators in MATLAB Image Processing Toolbox such as bwareaopen, imopen, imclose, and imfill. bwareaopen is morphologically open a binary image and remove small object and it is usually used to remove background. imopen is function to erodes an image then it will dilate the eroded image using the same SE (Structuring Element)^[11,21].

5. Seed Point Result:

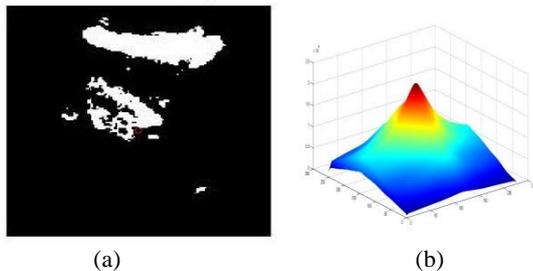


Fig.10 (a) Seed point detection, (b) peak point of image a.

While `imclose` is used to dilate an image and then erodes the dilated image using the same SE. `imfill` is used to fill any holes in the image. For binary image, it changes any connected background pixels to the foreground pixels. Then, the result is windowed by using a centre window with 80x80 height and width, assuming that the Focal liver lesion is located almost at the centre of the image. Figure 8 shows seed point detection and Fig. 11 Shows region of interest and its texture analysis^[13].

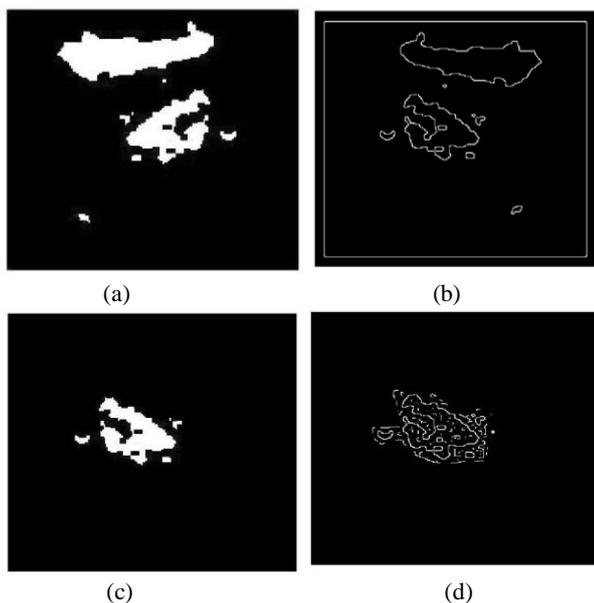


Fig. 11 FLL ultrasound image, (a) after morphological operation, (b) boundary of image a (c) Region of Interest, (d) Texture of ROI.

V. CONCLUSIONS

We have designed a technique for boundary detection using GVF snakes model for focal liver lesion ultrasound images which is very useful in medical image analysis. The results of detecting the object boundaries in noisy images show that the technique is much better than the other models.

From the results PSNR of Gaussian Low Pass filter is low in all images which I have used for Automatic boundary detection and generation of region of interest for focal liver lesion. Gaussian Low Pass filter image gives better result for boundary detection and generation of region of interest.

From the results, it is concluded that for FLL US images, texture analysis by using GLCM feature extraction method is better compared to range and standard deviation filter. Based on the comparison between speckle noise reduction techniques, Median filter gave the highest TRUE ROIs which were 100% after being tested using threshold value 0.7. The generation of true ROI can be used as the pre-processing methods for any

other segmentation techniques. This ROI generation can make the next image processing methods is faster.

REFERENCES

1. Krit, Nipon and Sansanee A., "Boundary Detection in Medical Images Using Edge Following Algorithm Based on Intensity Gradient and Texture Gradient Features" IEEE TRANSACTIONS ON BIOMEDICAL ENGINEERING, VOL. 58, NO. 3, MARCH 2011.
2. C. Xu, J. L. Prince, "Snakes, shapes, and gradient vector flow," IEEE Trans. On Image Processing, vol. 7, March 1998, pp. 359-369.
3. Xu Chenyang, Prince J. L., "Gradient Vector Flow: A New External Force for Snakes," Proceedings of the 1997 Conference on Computer Vision & Pattern Recognition, 1997, pp.66-71.
4. Nikos, olivier and visvanathan ramesh "Gradient Vector Flow Fast Geometric Active Contours" IEEE transactions on pattern analysis & machine intelligence, vol. 26, no. 3, march 2004.
5. Castellano, Bonilha, L.M. Li, Cendes "Texture analysis of medical images" Neuro-image Laboratory, Faculty of Medical Sciences, State University of Campinas, Brazil Clinical Radiology-04, 59, 1061-1069.
6. Technical University of Cluj-Napoca. Computer Science Department, "Detection of Focal Liver Diseases from US Images"
7. Xie, J., Jiang, Y., Tsui, H., "Segmentation of Kidney from Ultrasound Images Based on Texture and Shape Priors", IEEE Trans on Medical Imaging, Vol. 24, No. 1, 2005.
8. Shrimali, Anand, R. S., Kumar, V., "Comparing the performance of ultrasonic liver image enhancement techniques: a preference study", IETE Journal of Research, Vol 56, Issue 1, 2010.
9. Yu, Y., Acton, S. T., "Speckle reducing anisotropic diffusion". IEEE Trans on Image Process, Vol 11, pp 1260-1270, 2002.
10. Ramachandrans, Nair, M.G., "Ultrasound Speckle Reduction Using Nonlinear Gaussian Filters in Laplacian Pyramid Domain". IEEE 3rd International Congress on Image & Signal Processing 2010.
11. Maragus, P.A "A representation theory for morphological image & signal processing" IEEE Transact & Pattern Analys Mach Intellig-89
12. Hong Ding, Wen-Ping Wang, Bei-Jian Huang, Rui-Xue Wei, Nian-An He, Qing Qi, Chao-Lun Li" Imaging of FLL".
13. Yap, M.H., Ewe, H.T., "Region of interest (ROI) detection in ultrasound breast images". In: Proceedings of MMU International Symposium on Information & Comm. Technologies. 2005: 5–8.
14. R. C. Gonzalez & R. E. Woods, "Digital Image Processing". Addison-Wesley, 1992.
15. Mitrea, Nedevschi, Cenan, Lupsor, Badea, "Exploring Texture-Based Parameters, Noninvasive Characterization and Modelling of Diffuse Liver Diseases and Liver Cancer from Ultrasound Images", WSEAS Transactions on Computers, vol. 6, no.2, Feb 07, pp. 283-291
16. Mitrea, Nedevschi, Mitrea, Lupsor, Badea, Coman, "Exploring texture-based parameters for the automatic recognition of the hepatocellular carcinoma (HCC) ultrasound images", poster presented at the CEEX Conference, Sibiu, Romania, Oct 25-26, 2007.
17. Gonzalez and Woods, "Digital Image Processing", 3rd edition, Prentice Hall, 2009.
18. Jiri Jan, "Medical Image Processing, reconstruction, and restoration concepts and methods", Taylor & Francis Group, 2006.
19. Gonzalez and Woods, Eddins, "Digital Image Processing using MATLAB," 2nd Edition, Tata McGraw Hill, 2010.
20. Issac N. Bankman, Ph.D. "Handbook of medical imaging processing and analysis" Jhohns Hopkins University, Maryland.
21. Rudrapratap, "Getting started with MATLAB, A quick introduction for Scientists and Engineers" Indian Edition, Oxford University Press.