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Graph Based Image Segmentation Method for Identification of Cancer in Prostate MRI Image

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***Abstract* - Prostate cancer is one of the leading causes of cancer related death for men in the United States. In recent years, multispectral Magnetic Resonance Imaging (MRI) has emerged as an alternative to Ultrasound (US) image modality for clear identification of cancer in Breast, Prostate and Liver etc,. In order to analyze a disease, Physicians consider MR imaging modality is the most efficient one for identification of tumors present in various organs. Therefore, analysis on MR imaging is required for efficient disease diagnosis. The proposed Graph based segmentation technique is a part of image analysis. In this system, segmentation of MR image is carried out with three sequences of steps; Preprocessing using Anisotropic Filtering, Graph Construction using Minimum spanning tree based algorithm, and Segmentation using Pair wise Region Comparison Predicate and Region Mergence methods [1, 2]. This method is developed to improve the automatic detection of tumors in the given image than the manual segmentation. The output of the Graph based method can be compared with the Fuzzy C Means (FCM) algorithm to analyze the variations in the segmented image.**

***Index Terms* - Magnetic Resonance Imaging, Prostate Cancer, Anisotropic Diffusion, Pair Wise Region Comparison Predicate.**

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I. INTRODUCTION

The Prostate cancer is the second leading cause of cancer-related death in the United States among men and is the most commonly diagnosed cancer in American males [3]. Analyzing a medical image manually is a more complex task. To overcome this, image analysis techniques are rapidly growing now days. In research, the segmentation of MRI Prostate image are done widely using Active contour model [4], Compression based method, Histogram method, Watershed, Model based method and Fuzzy C means (FCM) [5], etc. In general, the size of the organ differs for every human being, organ with different size may not be resulted with tumor and organ with same size may be resulted with tumor. For these types of reasons, Graph based image segmentation may be effectively applied [6].

Generally the MR images are affected from a low Signal-to-Noise Ratio (SNR), which is considered to be one of the important problems in medical images [7]. For efficient noise reduction, apply normalization on the median-filtered images of Prostate MRI, and then perform anisotropic diffusion method. This filtering scheme increases the smoothness and contrast between tumor and healthy tissues of MRI images. In Graph based segmentation method, the image is modeled as a weighted, undirected graph. Usually a pixel or a group of pixels are associated with nodes and edges. Weights define the (dis)similarity between the neighborhood pixels. This technique generally represents the problem in terms of a graph G= (V, E) where each node vi belong to V corresponds to a pixel in the image, and the edges in E connect certain pairs of neighboring pixels.

In a constructed graph, each vertex is treated as a sub graph, i.e. there is a boundary between each pair of neighboring pixels in the image. For segmentation, a pair wise region comparison predicate is used to measure the evidence for a boundary between two regions. The region that are found to be similar by comparing those regions based on the defined predicate are to be merged by eliminating the boundary between those regions if that regions are having the pixels with similar intensities. With this region mergence it is easy to identify the tumor regions in the given MRI image by simply merging the regions with same intensities.

The organization of the paper is as follows. Section II describes the proposed methodology, in detail with preprocessing of prostate MRI image using Anisotropic filtering, Minimum Spanning Tree algorithm for Graph construction and Pair wise region comparison and mergence method for Segmentation. Section III shows the results of the proposed experiments using a multispectral prostate MRI dataset. Finally, section IV illustrates the conclusion and the future work of this proposed method.

II. METHODOLOGY

The System Design of the proposed method is shown in Figure 1.

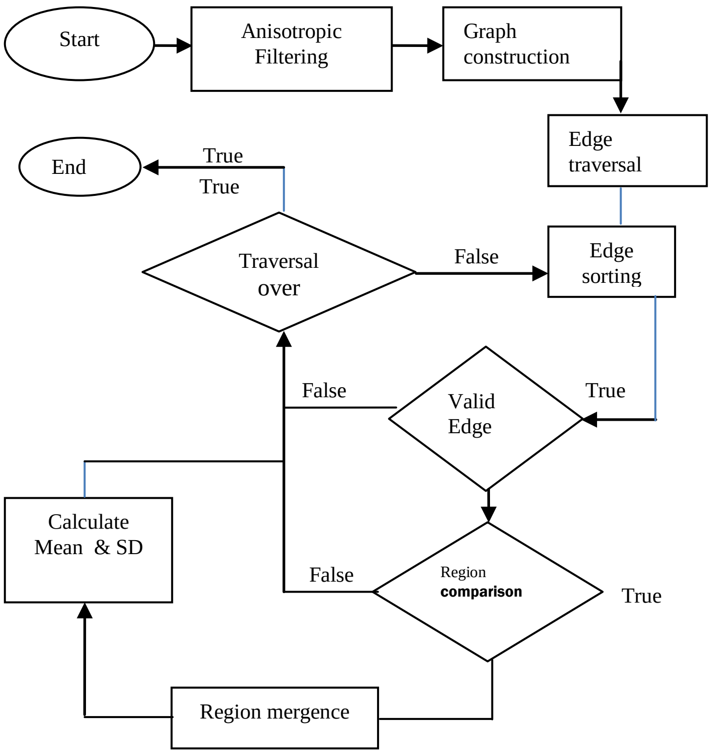

Figure 1. System Design

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A. Data set

Multispectral MRI dataset consists of images that represent the morphological and functional response of prostate gland. Features are directly the pixel intensities of multispectral MR images. Prostate MR Image consists of two regions of interest; Transition Zone (TZ) and Peripheral Zone (PZ), and only PZ region is considered because majority of the prostate cancer occurs in PZ [8, 9].

B. Pre-processing

The preprocessing of MRI prostate image has 3 steps. They are; Median Filtering of Input image, Normalization of Median Filtered image and Anisotropic Filtering of Normalized image.

1. Median Filtering of an Input image

This method is used to remove salt and pepper type of noises. Salt and Pepper noise Equation is given in equation (1). Each pixel in an image has the probability of p/2 (0<p<1) being contaminated by either a white dot (salt) or a black dot (pepper).

$$Y(i, j) = \begin{cases} 255, & \text{probability } (p/2) \\ 0, & \text{probability } (p/2) \\ X(i, j), & \text{probability } (1-p) \end{cases} \qquad (1)$$

X: noise free image, Y: noisy image

This type of noise consists of random pixels being set to black or white (the extremes of the data range). Median filtering is similar to using an averaging filter, in that each output pixel is set to an “average” of the pixel values in the neighborhood of the corresponding input pixel. In median filtering, the value of an output pixel is determined by the median of the neighborhood pixels, rather than the mean. The median is much less sensitive than the mean to extreme values (called outliers). Median filtering is therefore better able to remove these outliers without reducing the sharpness of the image. [11]

2. Normalization of Median Filtered Image

Normalization is a pixel-wise operation that does not change the clarity of the ridge and valley structures. Normalization reduces the variations in gray level values along ridges and valleys, which facilitates the subsequent processing steps. Let I(x, y) denote the grayscale value at pixel (x, y), M and V, the estimated mean and variance of grayscale values in this 64 X 64 window, respectively, and N(x, y), the normalized grayscale value at pixel (x, y). For all the Pixels in the window, the normalized image is defined in Equation (2).

$$N(x,y) = \begin{cases} M_0 + \sqrt{\dfrac{v_0 * (T(x,y) - M^2}{v}}, & \text{if}(x,y)>M \\ M_0 + \sqrt{\dfrac{v_0 * (T(x,y) + M^2}{v}}, & \text{if}(x,y)<M \end{cases} \qquad (2)$$

In Equation (2), M0 and *V*0 are the desired mean and variance Values respectively [12].

3. Anisotropic Filtering of Normalized MRI Input Image

Anisotropic filter allows us to smooth within regions of an image without blurring the edges. For Normalized MRI Prostate image the intensity values and its Standard deviation values are substituted in the diffusion equation.

The diffusion Equation (3) for image *u* is given by

$$\partial u/\partial t = div[c\,(d\,u).\,d\,u] \qquad (3)$$

Where div represents the divergence operator, d *u* is a local image gradient and *c* (d *u*) is the diffusion coefficient, which is a local function of the image gradient. The above mentioned diffusion equation encourages smoothing within a region in preference to smoothing across boundaries. This equation will not cause any inter-regional blurring as often caused by Gaussian smoothing [13].

C. Minimum Spanning Tree Algorithm

A Minimum Spanning Tree (MST) is a minimum - weight; cycle-free subset of a graph's edges such that all nodes are connected [14]. Kruskal’s is a type of algorithm which is used in MST for the construction of graph. The following are the steps for the construction of graph using Minimum Spanning Tree algorithm;

1. Create grids on the Pre-processed MRI input image.
2. Calculate the total number of grids in rows and columns.
3. Calculate the number of pixels present in each grid, from this calculate the total number of pixels present in the image.
4. Assume each pixel in an image as a Vertex V to construct a graph. The distance between the two pixels is called as Edges E of that two pixels.
5. Start traversing all the edges from the initial edge of an image.
6. Consider only the pixels whose values are above the threshold value. Let the threshold value be 0.5.
7. Calculate the Edge weight W_{ij} from the pixels which are above the threshold values.
8. Formula for calculating the Edge weight is given as;
   $$wij = | I(vi) - I(vj) | \qquad (4)$$
9. Sort the calculated edge weights in ascending order and store the sorted edge weight values in an array.
10. With the help of the Pixel locations and its Edge weights the MST graph is constructed using the Kruskal’s algorithm.

D. Pair wise Region Comparison and Mergence Method

Pair wise region comparison predicate defines the boundary between the regions. This is very sensitive to noises, due to this, modified predicate is used. Three definitions are given in [14] for this modified predicate. With the three definitions, arrival of the modified pair wise region comparison predicate determines whether or not a boundary between two components should be preserved.

Region mergence is a method used for merging the regions based on the defined predicate D [14] by eliminating the boundary between those regions only if those regions are having the pixel with similar intensities. With this region mergence method the tumor regions present in different locations can be easily identified in the given MRI image and they are merged based on their similar intensity values.

III. Experimental Results And Discussion

The results obtained from each module are discussed in detail in the following subsections.

A. Pre-processing by Anisotropic Filtering

The work flow diagram for Pre-processing of the proposed method is given in Figure 2.

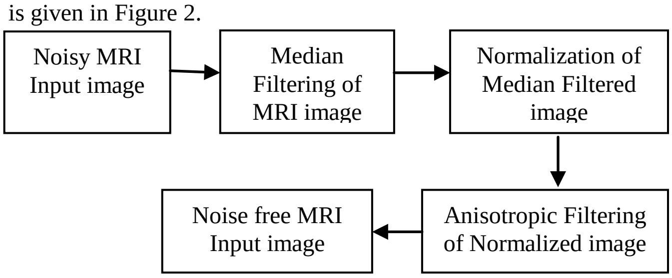

Figure 2. Work flow diagram for Pre-processing of Noisy MRI image

The MRI Prostate image is given in Figure 3.

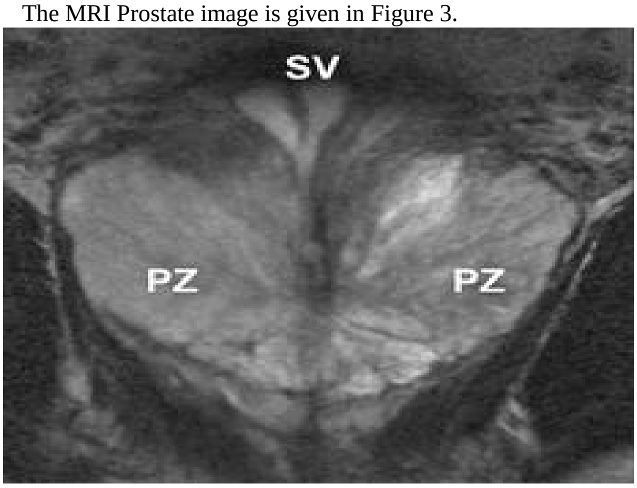

Figure 3. MRI Prostate image

MRI Prostate image with Salt and Pepper noise is given in Figure 4

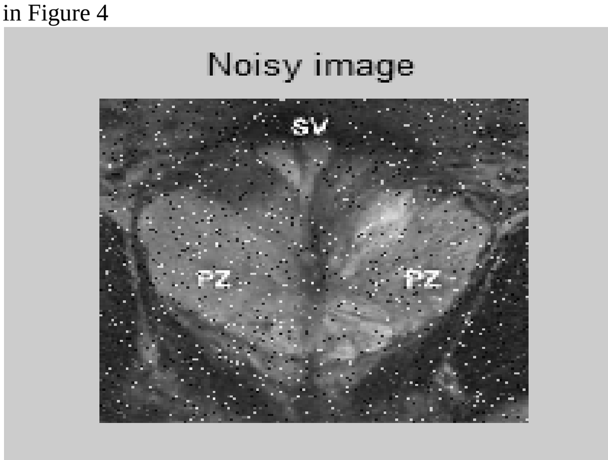

Figure 4. MRI Prostate image with noise

The results of the Median Filtered MRI Prostate image is given in Figure 5

Figure 5. Median Filtered MRI Prostate image

The results of Normalized MRI Prostate image is given in Figure 6. This is the second step in pre-processing.

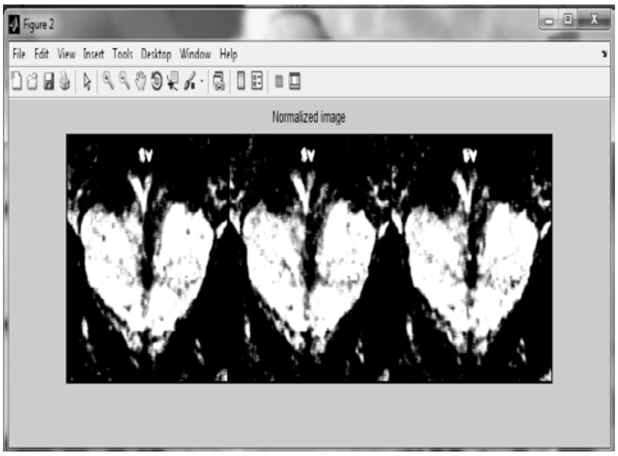

Figure 6 Normalized MRI Prostate

The results of Anisotropic Filtered MRI Prostate image is shown in Figure 7.

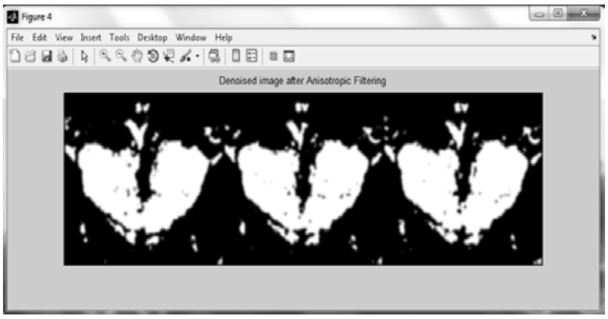

Figure 7 Anisotropic Filtered MRI Prostate

B. Graph Construction using Minimum Spanning Tree Algorithm

The work flow diagram for the Construction of Graph using Minimum Spanning Tree algorithm is given in Figure 8.

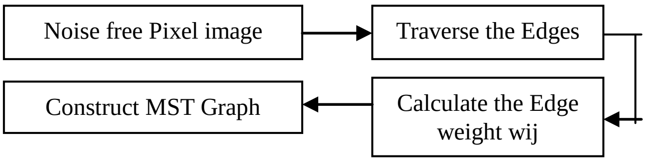

Figure 8. Work flow Diagram for Graph Construction

The Pre-processed MRI Prostate image with Grids for construction of MST graph is given in Figure 9.

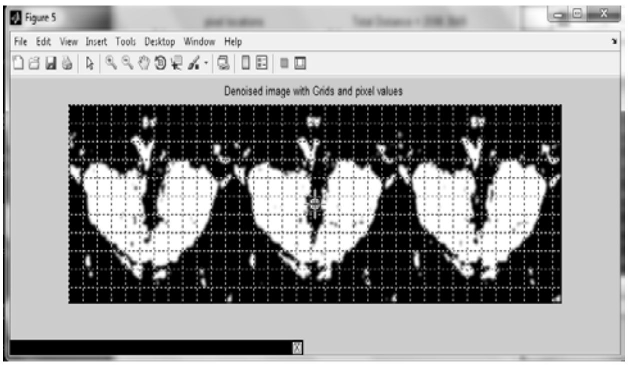

Figure 9. Denoised MRI Prostate image with Grids

The edge weight and its corresponding locations are shown in Figure 10.

Variable Editor - rm

rm <18692x5 double>

	1	2	3	4	5	6
1	2	175	2	174	1	
2	2	177	2	178	1	
3	3	67	3	68	1	
4	3	177	3	178	1	
5	4	95	3	95	1	
6	4	95	4	94	1	
7	4	95	4	96	1	
8	5	59	4	59	1	
9	5	59	5	58	1	
10	5	59	5	60	1	
11	6	59	5	59	1	
12	5	93	5	94	1	
13	5	95	5	96	1	
14	6	72	6	73	1	
15	6	85	5	85	1	
16	6	85	6	84	1	
17	6	94	5	94	1	

Figure 10. Edge weight and its corresponding location values of MRI Prostate image

In the mentioned Figure 10 the Edge weight values in non-decreasing order of MRI Prostate Image are stored in column 5 and its corresponding location values are stored from column 1 to column 4.

C. Region Comparison and Region Merging

The number of regions formed for the given MRI input image is shown in Figure 11.

```
ProstateMSTwithcancer2.m × | ProstateMSTwithcancer1.m × | ProstateMSTwithoutcance... × | Pros
Command Window
   46   176    45   176   105
   50   183    49   183   105
   66    80    66    81   105
  109   160   109   161   105
  154    77   153    77   105
   33    86    33    87   106
  150   112   150   113   106
   32    87    32    88   107
  101    95   101    94   107
   34    87    34    88   108
   37    67    36    67   109
  108   161   108   162   109
   37    65    36    65   110
  102    96   102    95   111
  149   111   148   111   111
  149   111   149   112   113
   39    65    38    65   114
   38    64    37    64   119
   39    63    38    63   121
   38    66    37    66   123

Total No. of Components found : 28
```

Figure 11. Region formation for given MRI Prostate image

The region mergence for the given MRI image is shown in Figure 12

```
ProstateMSTwithcancer2.m × | ProstateMSTwithcancer1.m × | ProstateMSTwi
Command Window
  150   112   150   113   106
   32    87    32    88   107
  101    95   101    94   107
   34    87    34    88   108
   37    67    36    67   109
  108   161   108   162   109
   37    65    36    65   110
  102    96   102    95   111
  149   111   148   111   111
  149   111   149   112   113
   39    65    38    65   114
   38    64    37    64   119
   39    63    38    63   121
   38    66    37    66   123

Total No. of Components found : 28
Total No. of Components after merging: 2
>>
```

Figure 12 Region Mergence for the given MRI Prostate image.

From the above mentioned Figure 12 it is observed that the regions are merged only if the given MRI image is having cancer and if the image is not having any cancer then there won't be any regions mergence. The total number of regions merged is equal to the number of cancer regions present in the given MRI images. The MRI Prostate Image in X,Y and Z axis as input for MST construction and the identified cancer regions in that corresponding images are shown in Figures 13 and 14

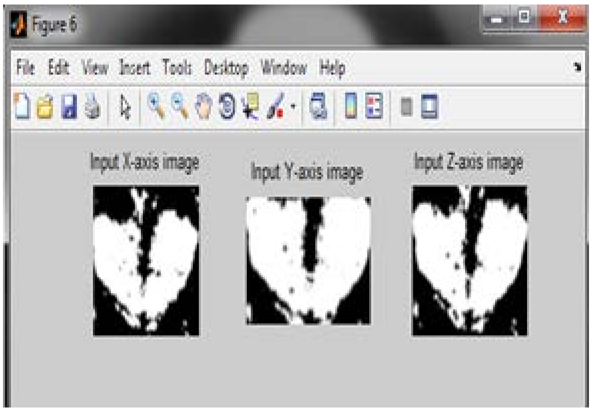

Figure 13. MRI Prostate Image in X, Y and Z axis as input for MST construction

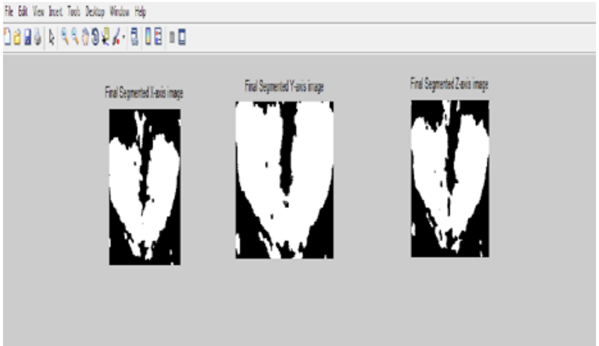

Figure 14. MRI Prostate Image in X, Y and Z axis with identified cancer regions

D. Fuzzy C Means Method

For Fuzzy C Means method the pre-processed MRI Prostate image using Anisotropic Filtering method is given as an input. The output of this method is the identification of cancer regions present in the given MRI image using Fuzzy C Means algorithm based on the minimization of the objective function. The screen shot for identification of cancer regions through FCM implementation is shown in the Figure 15.

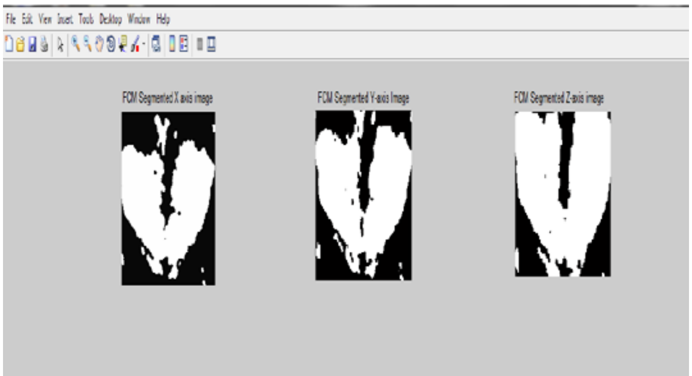

Figure 15. FCM Segmented MRI Prostate Image in X, Y and Z axis

Figure 15 shows the final FCM segmented MRI Prostate image in X, Y and Z axis. The number of clusters formed is clearly shown.

E. Performance Analysis

The performance analysis of the proposed Graph based segmentation and FCM method are shown in Table 1

Table 1. Analysis on cancer regions by Graph Based and FCM Segmentation Methods

GRAPH BASED METHOD						FCM METHOD		
X		Y		Z		X	Y	Z
Total Region	Region merged	Total Region	Region merged	Total Region	Region merged	No of Clusters	No of Clusters	No of Clusters
28	2	25	3	21	4	2	3	3

Table 1 shows the performance evaluation for the given Input image in both Graph based segmentation and FCM method. From this Table 1, it is clearly shown that smaller lesions are more effectively identified in Graph based segmentation method when compared to FCM method.

VI. Conclusion and Future Work

The proposed Graph based Image segmentation method is carried out in three sequences of steps. They are: Pre-processing of Noisy input image using Anisotropic Filtering, Graph construction using Kruskal's Algorithm and Region comparison followed by Region Mergence using Predicate method. The segmented image resulted from Graph based method is compared with Fuzzy C -Means clustering technique. The analysis shows that the proposed method out performs than the FCM method.

The proposed system can be extended for some other modality of images for different organs. This proposed system finds its application in the Medical field and other research areas.

References

[1] C. T. Zahn, (1971) 'Graph-theoretical methods for detecting and describing gestalt clusters,' IEEE Transactions. Computers.

[2] Jianbo Shi and Jitendra Malik, (2000) 'Normalized cuts and Image Segmentation', IEEE Transactions vol. 22, NO. 8,

[3] Olga Miljkovi, 'Image pre-processing Tool', College of Computer Science, Megatrend University of Belgrade, 11000 Novi Beograd, Serbia.

[4] Preethi Pathak, (2010) 'Image Compression Algorithms for Fingerprint System', IJCSI International Journal of Computer Science Issues, vol. 7, Issue 3, No 9.

[5] P. F. Felzenszwalb, D. P. Huttenlocher, (2004) 'Efficient Graph-based Image Segmentation', International Journal. Computer Vision.

[6] Q. H. Huang, Y. P. Zheng, M. H. Lu, T. F. Wang, S. P. Chen, (2009) 'A New Adaptive Interpolation Algorithm for 3D Ultrasound Imaging with Speckle Reduction and Edge Preservation', Computerized Medical Imaging and Graphics, vol. 33, no. 2, pp. 100-110.

[7] Q. H. Huang, M. H. Lu, Y. P. Zheng, Z. R. Chi, (2009) 'Speckle Suppression and Contrast Enhancement in Reconstruction of Free-hand 3D Ultrasound Images using an Adaptive Distance-Weighted Method', Applied Acoustics, vol. 70, no. 1, pp. 21-30.

[8] Suying Lee, Qinghua Huang, Lianwen Jin, Minhua Lu, Tianfu Wang, (2010) 'A Graph-based Segmentation Method for Breast Tumors in Ultrasound Image', Bioinformatics and Biomedical Engineering (iCBBE), 4th International Conference IEEE Transactions.

[9] X. Liu, IS. Yetik, M. Wernick,(2009) 'Prostate Cancer Segmentation with Simultaneous Estimation of the MRF Parameters and the Class', IEEE Transactions on Medical Imaging, vol. 28, No. 6, pp. 906-915.

[10] Yusuf Artan, Masoom A. Haider, Deanne L. Langer, Imam Samil Yetik, (2010) 'Semi Supervised Prostate Cancer Segmentation with Multiple MRI Images', Biomedical Imaging: From Nano to Macro, IEEE International Symposium , IEEE Transactions.

[11] Y. Artan, I. S. Yetik, et al. (2009) 'Prostate Cancer Segmentation with multispectral MRI using cost sensitive Conditional Random fields', ISBI.

[12] www.ehm.yildiz.edu.tr/dersweb/vedat/vedatnot.htm

[13] www.csee.wvu.edu/~xinl/courses /ee465/image_denoising.ppt

[14] http://emedicine.medscape.com /article/379996-overview#a21

[15] http://www.prostatecancer.org/pcricms/node/126

[16] www.ajronline.org/cgi/content/full/185/5/1214

Biography

I am **N.Gopinath** received my B.Tech degree from Anna University in Information Technology in 2005, M.E degree from Anna University in Computer Science and Engineering in 2011. Currently I begin my career as Lecturer in Computer Science and Engineering Department in S.K.P Institute of Technology, Thiruvannamalai, TamilNadu, India from July 2011. I presented a Technical paper in the area of Image Processing in Velammal College of Engineering in 2011, Chennai. I would like to do my Ph.d in Image Processing field in Anna University. My area of interest includes Image Processing, Software Engineering and Data Structures.