SUPPLEMENT ISSUE

IIOAB JOURNAL
ISSN: 0976-3104

ARTICLE

A HYBIRD MIK SEGMENTATION TECHNIQUE FOR DIAGNOSING ASPIRED FOREIGN BODY ON PEDIATRIC RADIOGRAPHY IMAGES

Vasumathy M* and Mythili Thirugnanam

School of Computer Science and Engineering, VIT University, Vellore, Tamil Nadu, INDIA

ABSTRACT

Background: *Radiography plays an important role in medical image processing. At present, different radiographic techniques such as X-ray, Computer Topography (CT), and Magnetic Resonance Imagining (MRI) are commonly used in the field of pediatric health informatics. These techniques are used to analyze the anatomical structures and other regions of the human body. In nature, radiography image contains a lot of noise, irrelevant information, intensity problems and partial volume effect which makes the task of locating and analyzing the suspicious area in such a image is very difficult task.* ***Methods:*** *Existing works does not focus more on segmentation corresponding to the aspired foreign body pediatric radiography images. Therefore, this work analyzed eleven image segmentation techniques are discussed in [Table 3] and proposed a hybrid segmentation technique with the combination of Median filtering, Iterative thresholding and K-means clustering which is named as MIK segmentation technique.* ***Results:*** *The quantitative metrics such as SNR, PSNR, RMSE and MAE are computed for evaluating the performance of segmentation techniques.* ***Conclusions:*** *The performance evaluation results prove that the proposed MIK segmentation technique is the most suitable segmentation technique for foreign body aspired pediatric radiography images.*

KEY WORDS
Medical images, Image Segmentation, Radiography images, Quality Matrices

Published: 2 Oct 2016

*Corresponding Author
Email: vasumsse@gmail.com
Tel.: +91-9003856667

INTRODUCTION

In medical image processing, the accuracy of the segmentation proves way for early diagnosis in most of the clinical studies and recommends a treatment plan for radiotherapy. Radiography techniques such as X-ray, Computer Topography (CT) and Magnetic Resonance Imagining (MRI) are most commonly used in radiology techniques. It is mandatory for a medical imaging technician to use computers to reduce processing time and improve reliability in case of large data. Existing techniques available for image segmentation are specific to the imaging modality. The segmentation techniques are useful to identify the anatomical structures, region of interest, measure tissue volume in order to measure growth of tumor, help in treatment of radiation therapy, in radiation dose calculation and to distinguish one anatomic structure from the other.

RELATED WORKS

In General, segmentation of medical images is one of the most difficult tasks in image processing. Segmentation sub-divides an image into constitute regions or objects. Segmentation techniques involve edge detection, thresholding and clustering for segmenting the region/boundary or detect the edges from an image. Segmentation accuracy determines the success or failure of computerized analysis procedures. The following [Table 1] contains an exhaustive survey on various existing segmentation techniques used in medical field for interested region segmentation.

Table 1: Existing survey on various segmentation techniques used in X-ray images

S.No	Segmentation Technique used	Observation
1	Adaptive thresholding Technique, Morphological Operator-based Algorithm, Connected Component Labeling algorithm(CCL) ,watershed algorithm as edge-based image Segmentation and Region Growing (RG) algorithm.[1]	A hybrid segmentation technique which is capable to segment liver from abdominal CT and detect hepatic lesions automatically. The experimental results show that 93% of good extraction for liver from abdominal CT.
2	Combination of Direct Thresholding and Adaptive Thresholding.[2]	The accuracy of the detection of regions is improved by applying adaptive thresholding.
3	Mean Shift Segmentation Algorithm And Adaptive Region Merging process.[3]	The proposed segmentation algorithm is highly effective. The computational time of the segmentation is very high.
4	Sobel, Prewitt, Roberts, Laplacian And Canny.[4]	Canny is the best of all for accurate edge detection. Fails to detect flesh and bone separately.
5	Morphological operations, Fuzzy C-Means	Fuzzy C-Means clustering was used to

IIOAB JOURNAL
ISSN: 0976-3104

	clustering.[5]	segment the lungs and the morphological operations were used for smoothening the irregular boundary. The algorithm is simple and is effective for lung images only.
6	Hybrid Region Growing Algorithm.[6]	The results observed from proposed hybrid region growing technique are more accurate even when images are blunt. Sometimes the detection results include false region detection along with true regions.
7	Marker Watershed Transform.[7]	The manual intervention and processing time for segmentation process is reduced.
8	Fuzzy C-Means ,k-means, Active contour algorithms and region growing.[8]	Open source software tool "MIASYS" is developed. Image misalignments often occur. The image registrations of local deformations are not handled in the current version of the software.
9	Three generations of segmentation techniques development. [9]	Each generation adds an additional level of algorithmic complexity.
10	K-means clustering algorithm seeded region growing algorithm. [10]	The proposed algorithm performs well in real time though not fully automatic
11	Threshloding, Region Based Segmentation, Mean Shift, k-means Clustering Algorithm, And Fuzzy C-Means.[11]	This paper suggests that using appropriate image segmentation in quality input images give better results in the identifying the region of interest.
12	Threshloding, Region Based Segmentation, Mean Shift, k-means Clustering Algorithm, And Fuzzy C-Means.[12]	This paper suggests that using appropriate image segmentation in quality input images give better results in the identifying the region of interest.
13	FCM, Prior-Information-Guided FCM (PIGFCM) algorithm.[13]	The proposed approach improves the accuracy of segmentation process, but it fails to address the intensity variation.
14	Improved Fuzzy C-Means Clustering.[14]	It is suggested that the parameters used for improving the FCM such as entropy, mean square error, peak signal to noise ratio should be improved for better image segmentation.
15	Segmentation techniques like, Edge detection, Thresholding, Skeletonization, Contour and Watershed Transform.[15]	The analyzed segmentation technique successfully helps in segmenting X-ray images. Selection of correct threshold value determines the efficiency of the edge detection
16	Contrast adjustment ,region growing algorithm.[16]	Contrast adjustment causes false positive metallic regions detection.
17	Fuzzy clustering algorithm, alternative FCM(AFCM).[17]	The results of the proposed AFCM algorithm prove better than the standard FCM. FCM does not address the intensity variation during segmentation process.
18	Snakes contouring techniques, histogram analysis, nonlinear anisotropic diffusion and automatic thresholding.[18]	The proposed technique is applicable only for the image containing homogeneities region.
19	Improved FCM Based On Measure Of Medium Truth Degree.[19]	The proposed algorithm is more suitable for images with less noise. FCM is sensitive to noise.
20	Watershed segmentation and Otsu's Thresholding, Discrete Step Algorithm.[20]	X-ray image is prone to noise. Watershed and Otsu's segmentation technique still needs lot of improvements in identifying the image with noise and low intensity for better segmentation with the desired areas in X-ray images.
21	Region growing algorithm, thresholding.[21]	Region growing algorithm is used for organ segmentation. Both over and under segmentation error occur during experimental test. Does not achieve high precision results.
22	Region Growing, Multi-Region Segmentation Based on a Topological.[22]	The accuracy of the proposed approach depends on the accuracy of the extraction of the prior information of topological graph
23	Wavelets Transform And Morphological Operators.[23]	The efficiency of the algorithm is analyzed only based on the segmentation speed.
24	Automated medical image segmentation algorithm.[24]	The novelty of the algorithm is proved by considering the whole MRI data set as a 3D entity. More computation time is needed to process the data set.
25	Modified Watershed Segmentation Algorithm With De-Noising.[25]	This work proves that combining denoising with segmentation techniques perform well in segmenting medical images rather than applying by individual approach.

ISSN: 0976-3104

From the literature survey, it is found that the image segmentation plays a vital role in medical Imaging. This will lead to proper extraction of the interested region for detection and identification. Therefore, identifying the suitable segmentation technique for different modality images such as X-ray, CT and MRI are required. Hence, assessing the performance of various segmentation techniques need to be carried out to identify the suitable segmentation technique for medical images. The detailed survey helps us to identify widely used segmentation technique in the medical field. [Fig. 1] demonstrates the steps involved for identifying suitable segmentation techniques in pediatric foreign body aspired X-ray images.

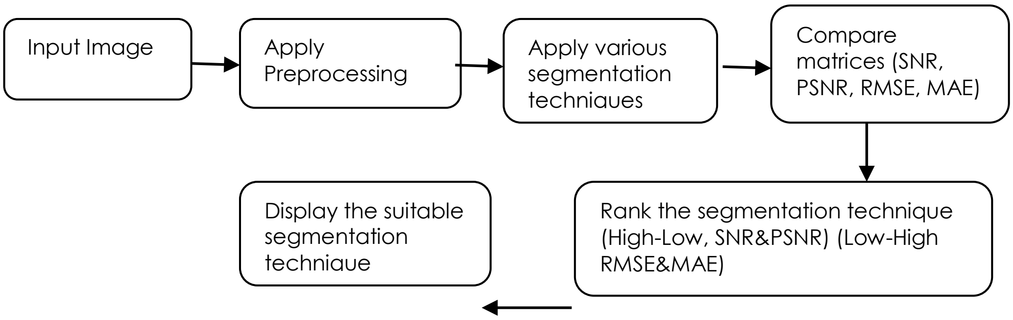


Fig.1: Steps involved for identifying suitable segmentation techniques

METHODS

This section provides an overview of the various segmentation techniques for segmentation of pediatric foreign body aspired images.

Thresholding based Segmentation Technique

Thresholding is one of the simplest methods of image segmentation. Image thresholding techniques partition an image into a foreground and background. It isolates the objects by converting grayscale image into binary images. Some of the existing thresholding techniques such as Otsu, Huang, Percentile and Adaptive performance are assessed to identify the suitable thresholding technique for pediatric foreign body aspired X-ray images. Otsu's method separates an image into background and foreground by two classes of pixels and calculates the optimum threshold with combined spread [25]. Huang thresholding utilizes the measure of fuzziness to evaluate the fuzziness of an image to determine the optimal threshold value. It is used as an evaluation criterion to identify the uniformity and measures boundary of an image [12].The percentile thresholding strategy uses data-driven method for selecting the optimum threshold value. It also improves the recovery performance [10]. Adaptive thresholding calculates the mean of pixels as an initial threshold value and compares with all the pixels of the image. If the pixel value is below the threshold it is set to the background value, otherwise it assumes the foreground value [25].

Edge based Segmentation Technique

Edge based segmentation is performed based on information about edges in the image. Edge is a boundary between two homogeneous regions. Edge detection refers to the process of identifying and locating sharp discontinuities in an image. Detected edges are used to identify the objects present in an image. Some of the existing edge detection techniques such as Canny, Sobel, and Robertcross [20, 21, 7, 5] are assessed to identify the suitable edge detection technique for pediatric foreign body aspired X-ray images. The Sobel operator calculates gradient of the image based on each pixel position in the image. Roberts cross operator calculates the gradient of an image through discrete differentiation which is achieved by computing the sum of the squares of the differences between diagonally adjacent pixels. Canny edge detection technique detects as many edges as possible in the image with low error rate. It uses different steps such as Gaussian filter, intensity gradients, non-maximum suppression, double threshold and hysteresis to detect edges.

Region based Segmentation Technique

Region based segmentation techniques aim to differentiate the regions of interest (objects) from the background. Some of the existing Region based Segmentation Techniques such as K-means, FCM, watershed and single seed region growing are assessed to identify the region based segmentation technique for pediatric foreign body aspired X-ray images. K-means is an unsupervised learning algorithm that partitions a group of data points into a small number of clusters in an image. Fuzzy c-means (FCM) clustering algorithm allows one piece of data to belong to two or more clusters. The watershed segmentation is based on mathematical morphology that segments the image regions into catchment basins as rain flood. Single seed region growing technique takes a single seed point starting in the middle of an object and then growing outward until it meets the object boundaries.

Performance Evaluation of Existing Segmentation Techniques

Performance evaluation carried out gives the impact on the significance of identifying appropriate segmentation techniques for pediatric foreign body aspired images. There are various quantitative analysis metrics for examining image quality, such as signal-to-noise ratio (SNR), Peak signal-to-noise ratio (PSNR), Mean square error (MSE), Root mean square error (RMSE). The evaluation process assesses the SNR, PSNR, RMSE, and MAE of images according to the definitions of Gonzalez [26] as given below

1. Signal-to-Noise Ratio (SNR)is defined as the ratio of the power of meaningful information and the power of background noise. The better segmentation indicates the higher value of SNR.[26]

$$\mathrm{SNR} = 10.log_{10}\left[\frac{\sum_{0}^{n_x-1}\sum_{0}^{n_y-1}[r(x,y)]^2}{\sum_{0}^{n_x-1}\sum_{0}^{n_y-1}[r(x,y)-t(x,y)]^2}\right]$$ r (x, y) is original image, t (x, y) is target image

2. Peak Signal-to-Noise Ratio (PSNR) represents region homogeneity of the final segmentation. The better segmentation indicates the higher value of PSNR [26].

$$\mathrm{PSNR} = 10.log_{10}\left[\frac{\max(r(x,y))^2}{\frac{1}{n_x-n_y}.\sum_{0}^{n_x-1}\sum_{0}^{n_y-1}[r(x,y)-t(x,y)]^2}\right]$$ r (x, y) is original image, t (x, y) is target image

3. Root Mean Square Error (RMSE) is a measure of each pixel by adding up the squared difference of all the pixels and dividing by the total pixel count. The better segmentation indicates the lowest value of RMSE [26].

$$\mathrm{RMSE} = \sqrt{\frac{1}{n_x-n_y}.\sum_{0}^{n_x-1}\sum_{0}^{n_y-1}[r(x,y)-t(x,y)]^2}$$, r (x, y) is original image, t (x, y) is target image

4. Mean Absolute Error (MAE) of the image is calculated by subtracting the original image from the target image for all the pixels. The better segmentation indicates the lowest value of MAE [26].

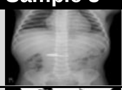
$$\mathrm{MAE} = \frac{1}{n_x-n_y}.\sum_{0}^{n_x-1}\sum_{0}^{n_y-1}[r(x,y)-t(x,y)]$$ r (x, y) is original image, t (x, y) is target image

These metrics are computed based on the fundamental benchmark of the quantitative analysis metrics. The results of quantitative metrics SNR, PSNR, RMSE, and MAE analysis are as given in [Table 3].

RESULTS

The performance estimation of various segmentation techniques such as Otsu thresholding, Haung thresholding , Percentile thresholding , Iterative thresholding, Canny edge detection, Sobel edge detection , Robert cross edge detection K-means Clustering , FCM Clustering , Watershed segmentation , Single Seed Region growing. The results of various segmentation techniques are shown in [Table 2]. Based on the observation and with the results obtained, it is concluded that the clustering based segmentation techniques perform better in pediatric foreign body aspired images.

Table 2: Implementation results of various segmentation techniques

Segmentation Techniques	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Original Image					
Otsu thresholding					
Haung thresholding					

IIOAB JOURNAL
ISSN: 0976-3104

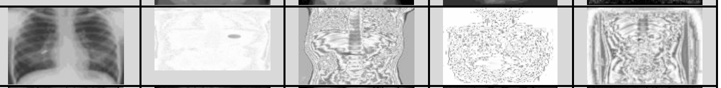
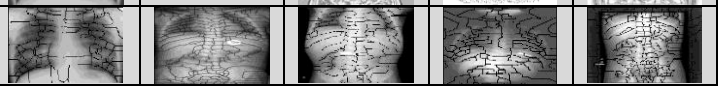
Percentile thresholding	
Iterative thresholding	
Canny edge detection	
Sobel edge detection	
Robert cross edge detection	
K-means Clustering	
FCM Clustering	
Watershed segmentation	
Single Seed Region growing	
MIK Segmentation	

Table 3: Performance evaluation by quality metrics (SNR,PSNR,RMSE,MAE)

Seg.Tech/ Metrics	Samples	ST1	ST2	ST3	ST4	ST5	ST6	ST7	ST8	ST9	ST10	ST11
SNR	Sample1	19.21	19.41	19.38	19.20	0.01	0.83	0.24	21.57	28.91	11.62	28.34
	Sample2	15.69	15.42	14.97	15.69	0.22	1.78	0.87	20.80	20.25	11.17	17.25
	Sample3	21.42	13.68	17.50	21.69	0.02	0.91	0.27	25.41	5.68	10.78	5.68
	Sample4	12.18	11.95	11.76	12.18	0.42	1.82	0.55	24.06	30.78	8.70	26.87
	Sample5	22.99	17.16	16.69	16.56	0.01	1.46	0.45	23.83	12.74	8.81	12.74
PSNR	Sample1	22.90	23.14	22.98	22.85	3.97	4.79	4.02	25.48	32.87	15.64	32.29
	Sample2	21.19	21.33	21.03	21.19	8.20	10.20	9.30	28.09	25.09	18.99	5.01
	Sample3	23.81	35.44	21.43	24.06	5.61	6.50	5.86	30.93	30.13	16.16	0.10
	Sample4	21.82	19.25	17.02	21.82	8.17	10.41	9.14	32.65	40.10	17.34	36.19
	Sample5	26.05	20.00	19.71	19.62	7.37	8.82	7.81	28.70	25.98	14.42	5.91
RMSE	Sample1	18.26	17.77	18.09	18.37	34.09	22.08	31.05	11.00	4.83	35.19	5.17
	Sample2	22.23	21.89	21.88	22.23	84.01	66.72	74.08	7.53	12.00	22.70	12.05
	Sample3	16.45	14.31	21.64	15.99	119.56	107.94	16.19	6.41	18.00	34.23	18.01
	Sample4	20.69	27.80	35.04	20.69	64.77	50.06	57.93	3.87	2.81	22.67	2.81
	Sample5	12.71	25.28	26.37	26.63	109.16	92.40	103.77	6.99	12.06	48.29	12.59
MAE	Sample1	11.63	21.56	21.61	21.64	121.56	106.89	117.08	8.92	3.72	9.22	3.84
	Sample2	12.32	12.25	22.23	32.32	59.02	4.72	51.47	4.72	11.01	14.68	8.06
	Sample3	13.18	13.08	2.19	21.25	93.41	82.01	90.15	4.31	6.00	7.87	8.30
	Sample4	2.01	3.58	5.60	2.01	49.01	38.17	44.91	2.56	0.88	6.91	1.45
	Sample5	21.08	32.95	23.02	8.28	93.53	77.06	88.19	6.33	11.00	15.16	11.00

ST1=Otsu thresholding,ST2=Haung thresholding,ST3=Percentile thresholding,ST4=Iterative thresholding, ST5=Canny edge detection,ST6= Sobel edge detection,ST7=Robert cross edge detection,ST8= K-means Clustering,ST9= FCM Clustering,ST10= Watershed segmentation,ST11=Single Seed Region growing

DISCUSSION

As per the results obtained, clustering techniques such as K-means and FCM show higher values than the other segmentation techniques for the quality metrics SNR and PSNR. The clustering techniques K-means and FCM clustering show lower values than the other segmentation techniques for RMSE and MAE. The overall performance results show that the clustering techniques gives better results compared to other techniques. The SNR, PSNR values obtained with the clustering techniques are high for most of the images and smaller values in RMSE and MAE. Hence, it can be concluded that the clustering techniques such as K-means and FCM are best suitable segmentation technique for foreign body aspired pediatric X-ray images. As per the evaluation the K-means segmentation techniques suits better for most of the sample images of pediatric foreign body aspired radiographic images. The overall performance evaluation with the suitable segmentation technique for each sample is given in [Table 4].

Table 4: Identification of suitable segmentation technique by Ranking the Quality metrics evaluation

Sample	Suitable segmentation Technique	SNR	PSNR	RMSE	MAE
Sample 1	FCM	28.91	32.87	4.83	3.72
Sample 2	K-means	20.08	28.09	7.53	4.72
Sample 3	K-means	25.41	30.93	6.41	4.31
Sample 4	FCM	30.78	40.10	2.81	0.88
Sample 5	K-means	23.83	28.70	6.99	6.33

A comparative analysis of each quality metrics such as SNR, PSNR, RMSE and MAE are given in [Fig. 2].

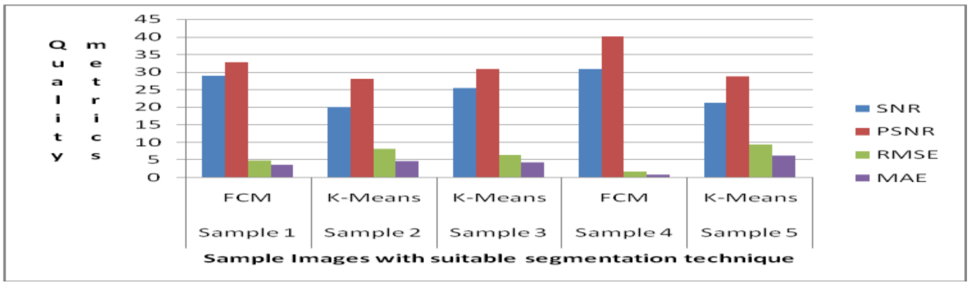


Fig. 2: Performance evaluation with existing segmentation techniques.

MIK Segmentation Technique

A hybrid segmentation technique with the combination of Median filtering, Iterative thresholding and K-means clustering (MIK) is proposed to segment the interested regions in foreign body aspired pediatric radiography images. The proposed work uses the best suitable segmentation technique as per the performance evaluation of the existing segmentation techniques. The performance evaluation of the proposed hybrid MIK segmentation technique is done by the quality metrics as same as the existing segmentation techniques such as SNR, PSNR, RMSE and MAE.

Table 5: MIK segmentation technique (Median filtering + Iterative thresholding + K-means clustering)

Sample	Suitable Segmentation Technique	SNR	PSNR	RMSE	MAE
Sample 1	MIK segmentation	39.710	43.62	1.39	0.82
Sample 2	MIK segmentation	27.33	35.23	3.53	1.99
Sample 3	MIK segmentation	36.11	41.55	1.87	1.02
Sample 4	MIK segmentation	30.69	39.01	1.80	0.82
Sample 5	MIK segmentation	24.72	32.09	6.33	3.13

IIOAB JOURNAL ISSN: 0976-3104

Performance Evaluation of MIK segmentation technique

The proposed MIK segmentation obtains higher values for SNR, PSNR and lowest value of RMSE and MAE when compared to existing segmentation techniques. The performance evaluation of the proposed hybrid MIK segmentation technique is shown in [Table 5] and [Fig. 3].

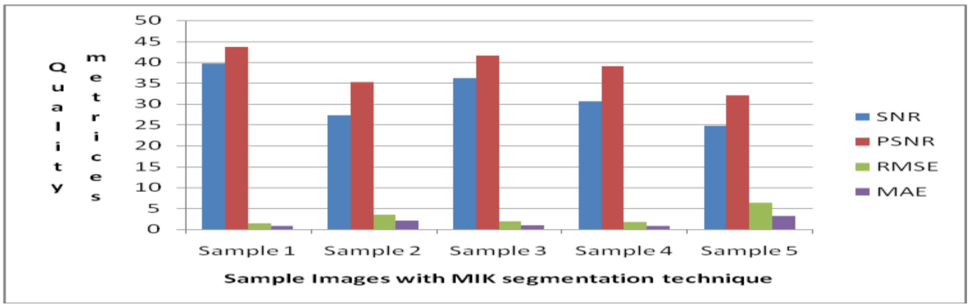


Fig. 3: Performance evaluation with MIK segmentation technique.

CONCLUSION AND FUTUREWORK

This work focuses to identify suitable segmentation techniques in order to segment aspired foreign body in pediatric X-ray images. A detailed survey has been made to list various segmentation techniques used in medical imaging. Widely used segmentation techniques on foreign body aspired pediatric radiographic images are implemented. The quantitative metrics such as SNR, PSNR, RMSE and MAE are computed for evaluating the performance of segmentation techniques. As per the evaluation results, K-means and FCM segmentations techniques are most suitable segmentation technique for foreign body aspired pediatric radiographic images. By the experimental results the proposed hybrid MIK segmentation technique comparatively gives better results than the existing segmentation techniques. As further improvement, this work will be extended to develop a framework for automatic identification of intrude objects in pediatric radiographic images.

CONFLICT OF INTEREST

The authors declare no conflict of interest

ACKNOWLEDGEMENTS

None

FINANCIAL DISCLOSURE

None

REFERENCES

[1] Ahmed M. Anter, Ahmad Taher Azar, Aboul Ella Hassanien , Nashwa El-Bendary, Mohamed Abu ElSoud. [2013] Automatic computer aided segmentation for liver and hepatic lesions using hybrid segmentations techniques. Proceedings of the 2013 Federated Conference on Computer Science and Information Systems: 193–198.

[2] Abhra Dasgupta, Aditya Nigam, Muktinath Viswakarma and Phalguni Gupta. [2013] Foreign body detection in ear. Sixth international conference on sensing technology: 18-21.

[3] Cristina Stolojescu-Crisan and Stefan Holban. [2014] An Interactive X-Ray Image Segmentation Technique for Bone Extraction. Proceedings IWBBIO: 7-9.

[4] Cristina Stolojescu-Crisan. [2012] Edge detection techniques for X-ray image segmentation. Proceedings of the 13th Symposium of Mathematics and its Applications: 1-3,

[5] C. Karthikeyan, B. Ramadoss and S. Baskar.[2012] Segmentation Algorithm for CT Images using Morphological Operation and Artificial Neural Network', International Journal of Signal Processing, Image Processing and Pattern Recognition, 5(2):115-122.

[6] D. Muhammad Noorul Mubarak, M. Mohamed Sathik, S.Zulaikha Beevi and K.Revathy. [2012] A hybrid region growing algorithm for medical image segmentation. International Journal of Computer Science & Information Technology (IJCSIT), 4(3):61-70.

[7] Dibyendu Goshal, Pinaki Pratim Acharjya.[2012] MRI Image Segmentation Using Watershed Transform. International Journal of Emerging Technology and Advanced Engineering, 2(4): 373-376.

[8] D Yang, J Zheng, A Nofala, JO Deasya, IM El Naqa. [2009] Techniques and software tool for 3D multimodality medical image segmentation. Journal of Radiation Oncology Informatics, 1[1]:1-21.

[9] D.J. Withey and Z.J. Koles.[2007] Three Generations of Medical Image Segmentation, Methods and

IIOAB JOURNAL ISSN: 0976-3104

Available Software. International Journal of Bioelectromagnetism, 9(2): 67-68.
[10] Faleh H. Mahmood, Wafaa A. Abbas, S. M. Ali. [2014] Estimating the Lung Tumor size in CT images using Image Segmentation Techniques. International Journal of Emerging Technology and Advanced Engineering, 4(7): 509-517.
[11] Jay Patel and Kaushal Doshi. [2014] A Study of Segmentation Methods for Detection of Tumor in Brain MRI, Advance in Electronic and Electric Engineering, 4(3): 279-284.
[12] Moumen T El-Melegy and Hashim M Mokhtar, El-Melegy and Mokhta.[2014] Tumor segmentation in brain MRI using a fuzzy approach with class center priors. EURASIP Journal on Image and Video Processing, 2(1): 1-14.
[13] M. Murugeswari, M.Gayathri.[2014] Tumor detection in MRI brain image segmentation using phase congruency modified Fuzzy C-Means algorithm. International Journal of Innovative Science, Engineering & Technology, 1(2): 190-194.
[14] Manoj R. Tarambale and Nitin S. Lingayat. [2013] Computer Based Performance Evaluation of Segmentation, Methods for Chest X-Ray Image, International Journal of Bioscience, Biochemistry and Bioinformatics, 3(6): 545-551.
[15] Murat CEYLAN, Y¨uksel ¨OZBAY, O. Nuri UC¸AN, Erkan YILDIRIM. [2010] A novel method for lung segmentation on chest CT images: complex-valued artificial neural network with complex wavelet transform, Turkish Journal of Electronics Engineering & Computer Science, 18(4): 613-623.
[16] Martin Prang, Hermann Hellwagner, Christian Spielvogel, Horst Bischof and Tibor Szkaliczkic. [2006] Realtime automatic metal extraction of medical x-ray images for contrast improvement, Proceedings of the SPIE, medical imaging, 61(44): 1929-1936.
[17] Miin-Shen Yanga, Yu-Jen Hu, Karen Chia-Ren Lin, Charles Chia-Lee Lin. [2002] Segmentation techniques for tissue differentiation in MRI of Ophthalmology using fuzzy clustering algorithms. Magnetic Resonance Imaging, 20(4): 173–179.
[18] M. Stella Atkins and Blair T. Mackiewich.[1998] Fully Automatic Segmentation of the Brain in MRI. IEEE Transaction on medical imaging, 17(1): 98-107.
[19] Ningning Zhou, Tingting Yang, and Shaobai ZHuang.[2014] An Improved FCM Medical Image Segmentation Algorithm,Based on MMTD. Computational and Mathematical Methods in Medicine, 2(2): 8-13.
[20] Nidaa aldeek, Raja S.Alomari, M B Al-Zoubi,Hazem hiary. [2014] Liver segmentation from abdomen CT images with Bayesian model. Journal of Theoretical and Applied Information Technology, 60(3):483-490.
[21] Paola Campadelli, Elena Casiraghi, Stella Pratissoli. [2009] Automatic Abdominal Organ Segmentation from CT images. Electronic Letters on Computer Vision and Image Analysis, 8(1):1-14.
[22] Saif Dawood Salman Al-Shaikhli, Michael Ying Yang, and Bodo Rosenhahn. [2014] Medical Image Segmentation Using Multi-level Set Partitioning with Topological Graph Prior. PSIVT 2013 Workshops: 57–168.
[23] S.K.Mahendran and S.Santhosh Baboo. [2011] Enhanced Automatic X-Ray Bone Image Segmentation using Wavelets and Morphological Operators. 2011 International Conference on Information and Electronics Engineering IPCSIT, 37(3): 30-36.
[24] Suhuai Luo.[2006] Automated Medical Image Segmentation Using a New Deformable Surface Model', IJCSNS International Journal of Computer Science and Network Security, 6(5): 109-115.
[25] Usha Mittal, Sanyam Anand. [2013] Modified Watershed Segmentation with Denoising of Medical Images. International Journal of Innovative Research in Science, Engineering and Technology, 2(4): 982-987.
[26] Rafael Gonzalez and Richard E.Woods. [2006] Digital Image processing (3rd edition) ISBN: 013168728X. Prentice-Hall, Inc. Upper saddleriver,USA.