

Hybrid Approach for Vertebrae Segmentation of Spine MRI Images

Reena S. Sahane¹, J V. Shinde²

P.G. Student, Department of Computer Engineering, Late G.N Sapkal College Of Engineering, Nashik, India¹

Assistant Professor, Department of Computer Engineering, Late G.N Sapkal College Of Engineering, Nashik, India²

ABSTRACT: Medical field contains a monotonous task of image segmentation. Segmentation forms a very important phase for image processing which should be applied properly on MRI images. Segmentation when applied on MRI images is able to detect various disorders and defect present in human vertebra. In existing system superpixels were used for segmenting MRI images which was followed by Otsu thresholding to generate the vertebra of the human body. The existing system had disadvantage of accuracy and efficiency. So in this work we have proposed a novel approach which has overcome the problem of existing system. The proposed system uses the superpixels generated using Simple Linear Iterative Clustering (SLIC) as an object for Fuzzy C-Means followed by region growing for final segmentation. The result provides better accuracy and efficiency as compared to existing.

KEYWORDS: Superpixels, Segmentation, Clustering, Otsu, MRI Images.

I. INTRODUCTION

Image segmentation is processes where the image can be divided into various segments which make the image easier to understand. Through segmentation many things can be done with image like face detection, object detection, video surveillance etc. In medical field the segmentation is very important to perform on MRI images which are able to extract the proper parts from the image. If proper segmentation is done on the MRI images it helps to detect the various disorders present in human body clearly. To perform segmentation on medical image is a tedious task for radiologists as it takes a lot of time to segment the image. This system is a semi-automatic system which can help the radiologists to perform the segmentation without taking much of their time. The system basically deals with MRI (Magnetic Resonance Image) medical images. If radiologist manually segment this MRI images it is a time taking process so this system will semi-automatically segment the image providing a good amount of processing speed and better results. In human body there are total 33 vertebra present among which there are 5 lumbar vertebra. The lumbar vertebra is part of the human spine on which system is working which are labelled as L1, L2, L3, L4, L5. The lumbar vertebrae form the complex structure among all the spine structure. In medical field it is very essential to study the all the characteristics of the spine to detect all deformities present in spine.

In this work we have proposed a semi-automatic system which will help and assist the medical specialist for segmenting the vertebral bodies of spine images. The proposed system uses the concept of Superpixels which reduces the image complexity and makes easy detection of the vertebral body contour. Superpixels are the group of pixels which clustered under some similarity basis. Whenever MRI image is used it is required that at prior stage it should be pre-processed so that it can be properly served for segmentation. The process of pre-processing contains steps like denoising, skull-stripping, intensity, normalization etc which helps to improve image contrast and remove noise. Applying segmentation on MRI images recognizes the vertebral fractures, spondylolisthesis and scoliosis of the human body. For segmentation various approach are available but Superpixels forms the best technique here to apply

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segmentation. Superpixel has various characteristics like reads complete spatial information of the image, reduces the processing time, reduces complexity of the image etc.

Using superpixel is not enough as it lacks to detect the boundary pixels of the image. In existing system they worked on Otsu method of thresholding through which the boundary image pixels can be obtained. But problem with Otsu was its fails when the point comes for global distribution so to overcome this proposed system has applied Fuzzy C-Means on superpixels to generate accurate and efficient vertebra of the human body

The work in this paper firstly describes all the related work of the system followed by the system architecture which shows the system flow with required parameters. The system takes the input as MRI image it selects the perfect slice from the series of image. After this the user have to select five seed points of vertebra and then the selected slice is pre-processed. Then SLIC is applied and after that Fuzzy is applied on superpixels. The final result is generated after region growing and we get efficient vertebra of human body. The experimental results shows the comparison between the existing and proposed method, where it shows the proposed method has better results than existing. The last part concludes the work.

II. RELATED WORK

In this section, an overview of existing methods for dealing with superpixels is provided.

R. Achanta, A. Shaji, K. Smith, and A. Lucchi [1] has proposed a new superpixel algorithm SLIC(Simple Linear Iterative Clustering) which works well as compared to state-of-art methods. Here they compared many state-of art methods of superpixels like NC05, GS04, SL08, GCa10 and GCb10, MS02. Normalized cut [2] algorithm partitions the graph of pixels repeatedly using contour and texture of the image. GS04 generates superpixels using clustering of pixels where pixel are considered nodes on a graph, where superpixel generated fit well in boundaries of the image. SL08 algorithm divides the image into horizontal and vertical regions which generate superpixels by finding best path formed by the grid.

In next paper the author has described various superpixel methods such as turbopixel [1], quick shift [1, 2] SLIC superpixel [1, 2]. Turbo pixel algorithm selects manually certain seed points and forms a curve such as it collects all the seed points. Its speed is very much high as compared to other methods, even is has control over generation of superpixels. SLIC algorithm uses spatial information and color similarity of pixels to generate superpixels. Superpixels generated by SLIC are compact with similar size. In this algorithm superpixels are generated using clustering depending on the intensity values and proximity in the image. It is somewhat similar to Means. Quick shift algorithm selects the data points and brings them into the feature space with the help of Parzen density ascendant direction. QS Captures the boundary pixels of the image in good proportion.

A. Suzani, A. Rasoulilian, S. Fels, R. N. Rohling, and P. Abolmaesumi,[12] proposed semi-automatic method for segmenting vertebral bodies in multi-slice MR images is described in this paper. To achieve a fast and reliable segmentation, the method takes advantage of the correlation between shape and pose of die rent vertebrae in the same patient by using a statistical multi-vertebrae anatomical shape+pose model.

N. Otsu [9] has proposed automatic threshold selection for image segmentation. For automatic selection they have used unsupervised and nonparametric methods. They have made use of selecting optimal threshold so as to maximize the separability of the resultant classes. This method is very basic which refers all the objectives of the unsupervised decision procedure. This process uses Zeros and first order cumulative measures of the gray-level histogram. In [10] they have proposed an Otsu thresholding method for segmentation. In Otsu the image is divided into subparts and then thresholding is applied. For better results CIE L*a*b color space is used in thresholding, where thresholding is applied on each component i.e. L, a, b separately.

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DongjuLiu, JianYu [11], here they have described the equality between the K-means and the Otsu method. They want to through this paper that the methodology used by both is somewhat same and which matches a lot. Otsu uses global optimal threshold whereas k-means uses local optimal threshold for searching. Otsu before running require computing of gray level histogram while k-means do not require to do this. Means can be very easily extended to multilevel thresholding method as compared to Otsu method. In this approach they have satisfied with the result that k-means method keeps the centroid order with respect to one-dimensional dataset.

III. SYSTEM ARCHITECTURE

The proposed system is firstly given input as the dataset containing the images of human spine. The dataset contains T1 weighted MRI image of vertebral body of the human spine. The T1-weighted images of the sagittal plane showcase the vertebrae L1, L2, L3, L4 and L5 i.e. lumbar vertebral body where actually processing is going to take place. On the MRI image firstly the seed points of the vertebra are selected and then segmentation is performed on it. The segmentation is done by using the Superpixels technique. Superpixels gather together pixels on the basis of feature similarity of the pixels. They reduce the complexity of image processing task and provide the complete spatial information. To address segmentation a superpixels algorithm SLIC (Simple Linear Iterative Clustering) is applied. This algorithm is based on Means which is simple and effective to use. The SLIC algorithm works in CIELab color space and generates superpixels of uniform shape which are compact in nature.

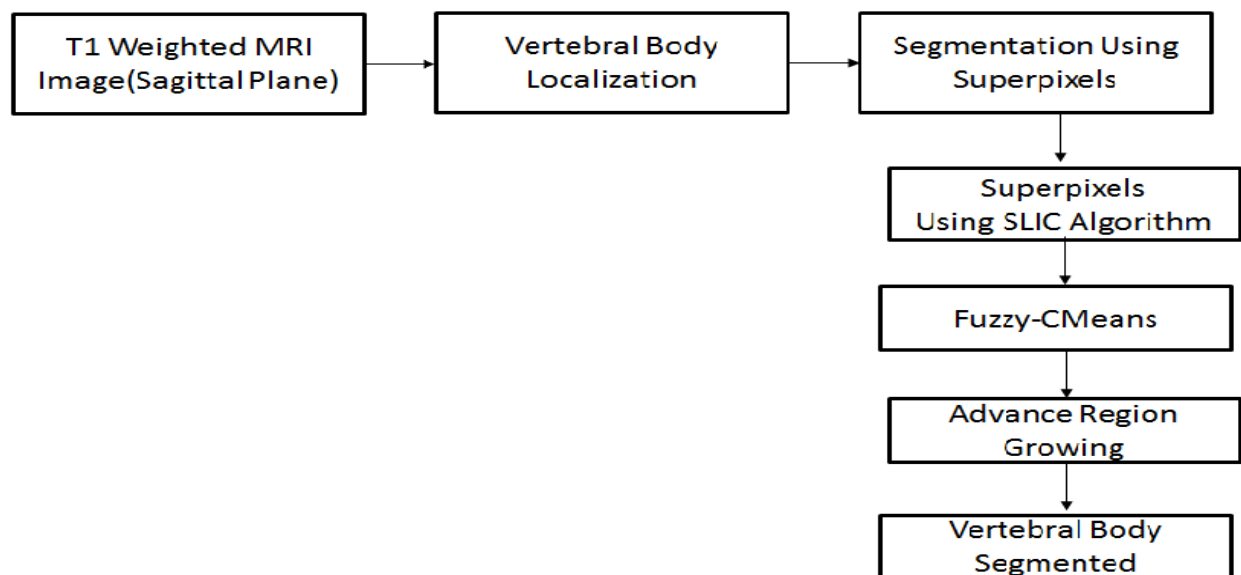


Fig :1 Proposed System Architecture Diagram

Advantage of using superpixels is it strengthens the space information and effectively process the inhomogeneity problem. Only applying SLIC for segmentation is not enough as this superpixels do not cover complete object of the image i.e. they may miss the boundary pixels of the compact structure. To overcome this the system performs post-processing segmentation on the superpixels. The existing system used Otsu method for thresholding. Otsu method divides the superpixels into smaller regions and find out the threshold value T such that it minimizes the intra-region variance. The existing system use Otsu method which is applied on each superpixel and the disconnected region which

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is found is termed as new superpixels. The Otsu method works well on superpixels and performance is pretty good. But the problem with Otsu is it fails when global distribution of the target and the background vary extensively. Otsu is suitable when there are two classes in the image. This method divides image into two groups and could not be applied in variable illumination conditions. As the system works for medical field and takes input as MRI images the result generated cannot be compromised in any case so to overcome the Otsu problem the proposed system is going to use new thresholding method named as Fuzzy C-Means .Fuzzy C-means was introduced to solve the bias field estimation and segmentation. FCM has various benefits like simple realization, fast processing speed. The FCM algorithm is used to cluster the superpixels rather than pixels, and the membership is used to determine the classification for these superpixels. At the last region growing is applied on the process for better performance. In region growing only the seed points which were initially selected is considered i.e. five lumbar points of the spine. The seed superpixels are compared with its neighbours, if there is difference between their values i.e. if the value is lower than threshold value in such case the neighbour superpixels will be assigned to the vertebra. In this way the process will repeat until all superpixels are processed. At final step we will get the segmented vertebra of the spine from MRI image.

IV. EXPERIMENTAL RESULTS

The proposed system is basically related to the image segmentation based on Magnetic Resonance Imaging (MRI).As compared to Computed Tomography (CT), MRI is not exposed to any harmful radiation and that is why it can obtain good information of the subject. The T1 weighted images in sagittal plane are used by the system which are provided by the clinical hospital (Samarth Diagnosis Centre). Each image contains the lumbar L1, L2, L3, L4 and L5 of the human vertebral body on which the processing is conducted. The MRI images are actually the series of slices containing in the stack so the user has to select the perfect slice which is to be segmented.

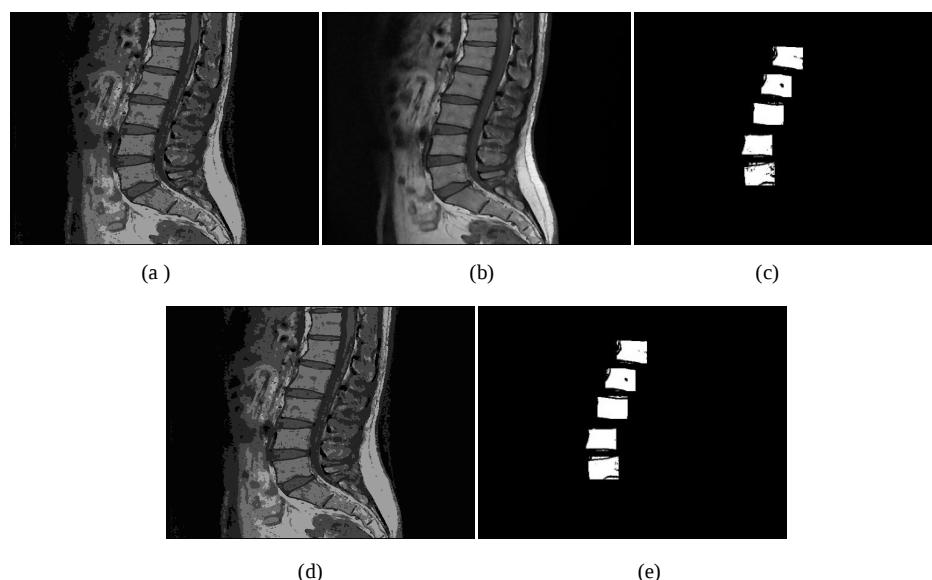


Fig. 2 Vertebral Body Segmentation (a) Original image (b) Pre-processed Image (c) Image after applying SLIC and Otsu (d) Image Applying FCM Algorithm (e) Image after FCM gives accurate and efficient result of segmented vertebra as compared to fig c.

We have processed many MRI real time images and found that the accuracy after applying FCM on superpixels is better as compared to applying it on Otsu. We have used many metrics of image segmentation for finding the result of MRI image. The metrics used are Precision, Recall, Dice and Jaccard. The following table will display the values of each image tested.

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Image	Dice Coefficient		Jaccard Coefficient		Recall		Precision	
	OTSU	Hybrid Approach	OTSU	Hybrid Approach	OTSU	Hybrid Approach	OTSU	Hybrid Approach
T1_sag_P1	0.695	0.703	0.533	0.542	53.31	54.27	69.488	70.77
T1_sag_P 2	0.517	0.537	0.348	0.367	34.89	36.78	41.21	41.83
T1_sag_P 3	0.582	0.614	0.410	0.443	41.09	44.38	43.84	44.09
T1_sag_P 4	0.856	0.864	0.748	0.761	74.85	76.13	96.25	97.97
T1_sag_P 5	0.632	0.647	0.462	0.479	46.22	47.90	57.98	58.13
T1_sag_P 6	0.580	0.598	0.408	0.427	40.88	42.73	53.37	53.53
T1_sag_P 7	0.842	0.852	0.683	0.742	72.83	74.23	96.47	97.62
T1_sag_P 8	0.602	0.620	0.431	0.449	43.11	44.98	44.56	44.58
T1_sag_P 9	0.811	0.851	0.642	0.763	74.60	76.30	95.51	97.62
T1_sag_P 10	0.689	0.745	0.482	0.518	45.622	47.84	59.37	60.01
T1_sag_P 11	0.716	0.734	0.558	0.579	55.80	57.99	69.80	70.31
T1_sag_P 12	0.689	0.698	0.525	0.533	52.59	53.37	50.16	50.92
T1_sag_P 13	0.761	0.790	0.614	0.653	61.44	65.39	73.49	74.78
T1_sag_P 14	0.520	0.532	0.351	0.362	35.18	36.24	58.93	59.59

Table 1: Showing the comparative results of the images after applying OTSU and Hybrid Approach

V. CONCLUSION

We have implemented a segmentation system which is able to properly segment human lumbar vertebra from MRI images. Our algorithm considers the superpixels as an object which segments the image properly and gives better vertebra of human body. We have applied our algorithm on many real time MRI images and found that it successfully segment the vertebra from the images with better accuracy and efficiency.

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