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Spine Image Segmentation using Fuzzy C-Mean

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Abstract:

Recent research has placed a premium on medical image processing. Medical image processing is a discipline that has evolved from an active and fast expanding field. Medical image segmentation is an important step in medical studies for diagnosis (X-ray, CT, MRI, PET), controlling, and surgical planning. Physically segmenting medical images is a time consuming and labor-intensive process. As a result, high-accuracy automated segmentation algorithms are appealing. A segmentation algorithm's performance is determined by a number of critical factors like accuracy of the results, the segmentation technique's application area and so on.[1]Fuzzy C means clustering, as one type of image segmentation technique, is an effective and compact segmentation approach. Fuzzy c-means (FCM) clustering is the most precise method for image segmentation in unsupervised methods, and it can be smooth and produce intended outcomes. This paper discusses medical picture modalities and mathematically explains the processes of the FCM clustering algorithm with output. It partitions the disc which is present in between the vertebral on magnetic resonance imaging (MRI) of the spine, using the FCM segmentation method; we were able to achieve a decent result of up to 70.41 percent average accuracy on total 80 MRI spine images.
Keywords: *Spine MRI image, Medical Image Modality, Segmentation, Fuzzy C-means clustering (FCM), Morphological filtering.*

I. INTRODUCTION:

With the increased use of imaging modalities (such as CT and MR images) for clinical purposes, powerful computers are required to assist radiological experts in diagnosis and treatment planning. Furthermore, manual segmentation is a time-consuming and error-prone task due to the numerous image scans for each patient and the similar intensity of the nearby organs. As a result, trustworthy automated algorithms must be used.[2] Due to the complexity of medical imaging, which usually have a perfectly linear property, automatic segmentation of medical images is a tough challenge. RI and CT images have some advantages and disadvantages. Segmentation is the process of separating an image into sections with similar attributes such as gray scale level, colors, pattern, sharpness, and intensity. The goals of computer-aided diagnosis (CAD) are to facilitate speedy and standard documentation, the method must be so that a large number of instances can be handled with the same precision, i.e. the results are not altered by stress, input overburden, or absent human steps. results and to facilitate faster communication, whereby patient care can be advanced to remote areas through the use of information technology[2].Here by using the Fuzzy C-mean segmentation we have checked the result for MRI image and which gives better result.

II. LITURARY S: URVEY-

A. Different Modalities for Medical Imaging:

In medical imaging, MRI, CT, audio, Positron Emission Tomography (PET), and other techniques are often used. In this review, we will concentrate solely on the segmentation of MRI. In the field of radio imaging, the most common technique is magnetic resonance imaging (MR imaging). Differential image contrast is achieved by altering pulse sequences and imaging parameters such as diagonal relaxation time (T1) and diagonal settling time (T2), as well as a camera positioned on T1 and T2 weighted pictures that correspond to various tissue features. The capable of enhancing settings have an impact on the MR dynamic range. The much more common pulse durations are T1-weighted and T2-weighted spin-echo durations[2].In conclusion, the fuzzy clustering-based segmentation methodology presented in this paper holds promise for advancing the field of spinal image analysis. By addressing challenges associated with variability in T1-weighted MR images, it contributes to the refinement of clinical decision-making processes and lays the groundwork for future advancements in spinal imaging research. [4].The use of FCM clustering in a new image segmentation procedure is crucial for obtaining all desired features and creating clusters to extract their patterns. Additionally, the outcomes of each phase are crucial for manually identifying the areas that can be strengthened and changed. To understand the difference between them, finalvalues are compared to initial values. After validation, it is discovered that the FCM approach produces better segmentation results than its competitors. The methods' time complexity is also shown [3].Since 90% of disk herniation occur in the lumbar region, discs in the lumbosacral region are the focus of the procedure. Evaluation of the disc herniation is based on the axial slice outline. Extension or protrusion is the grading of ruptured discs [5]. Disc herniation, deterioration, and spinal stenosis are classified semi automatically [6]. The thresholding is extended by the area growing techniques by integrating connectivity with intensity similarity. These techniques start with a seed location and then use a connected neighborhood to spread the intensity column across neighboring areas. They are, however, extremely sensitive to noise and the early seeds. FCM algorithm uses a classification-based segmentation technique [7]. In this work, presented a novel segmentation method to extract the five vertebrae of the lumbar spine (L1, L2, L3, L4 and L5) from MRI. The suggested methodology, known as VBSeg (Vertebral BodySegmentation), uses super pixel segmentation as a pre- segmentation step to make it easier to identify the shape ofeach vertebra. To effectively extract the vertebrae contours,

However, superpixel segmentation alone is insufficient. Therefore, used Otsu's technique to split each superpixel into smaller superpixels[8]. They have provided a straightforward, precise, and effective HOG-based algorithm for localising vertebrae in lumbar MRI scans of the spine [9]. They suggest a kernel-based unsupervised FCM method for segmenting images that have been tainted by noise and intensity non - homogeneity. The findings of this study demonstrate that using the kernel measure to build a reliable image clustering algorithm is a successful strategy [10].There are dozens of image artifacts in each modality techniques and due to some artifacts like Gradient, Motion, Wrap Around and Gibbs Ringing etc. in MRI as a result, image artifacts can cause false negatives and false positives.

Advantages and Disadvantages of MRI and CT imaging:

The following are the primary advantages of using an MR imaging system: 1) It has a significant amount of soft tissue imaging capability.2) It has an extremely good signal-to-noise ratio. 3) It has a very high resolution of 1mm cubic voxels. 4) Using different pulse sequences, multi-channel images with variable contrast can be acquired, which can then be used for segmenting and classifying complex shape and structures. The following are the primary advantages of a CT imaging system: 1) High spatial resolution is achieved using modern multi-slice scanners. 2) Low cost and more availability. 3) Quick scan time. 4) Greater sensitivity for subarachnoid hemorrhage than MRI. 5) Improved ability to detect intracerebral calcifications. The disadvantages of MR imaging are as follows: 1) MR acquisition takes significantly longer than CT, and 2) MR picture quality is more difficult to achieve uniformly.

The disadvantages of CT imaging systems are as follows:1) Inadequate soft tissue contrast compared to MRI because it is based on X-rays. 2) Risk of cancer. Even with their drawbacks, CT scans are widely used in the radiographic examination of the nervous system, kidneys, and thoracic spine.

B. Segmentation:

The process of segmenting a picture into parts with comparable qualities including tone, pattern, grey tone, sharpness, and intensity is known as segmentation. Because medical images are complicated and rarely contain any sequential features, segmenting them is a difficult task. The result of the segmentation algorithm is influenced by image artifacts. There is different segmentation based on the gray level features, edge based and region based. Here we are focusing of Fuzzy C-mean clustering algorithm with their output.

Fuzzy C-Mean clustering:

To acquire every needed feature and make clusters to extract their patterns, a new image segmentation procedure using FCM clustering is critical. Furthermore, the outcomes of Every step is critical when manually searching for information. What are the flaws that can be changed and improved? The final values are compared to the beginning values in order to recognize the distinction between them Although the FCM clustering approach automates this process, altering parameters is a crucial criterion for obtaining the most accurate segmented images.[B. A. Mohammed et al., 2020]

Cluster analysis is a statistical categorization technique for determining whether subgroups belong to various classes based on numerical assessments of their characteristics. It splits incoming data into clusters based on some similarity criterion, so that comparable data objects are grouped together. Distance, connectedness, and intensity are examples of measures that can be employed in clustering. The resulting split contributes to a better knowledge of people and more intelligent decision. The benefit of utilizing a similarity metric is that it allows you to manage the creation of clusters. Two types of clustering methodologies are typically employed to explore cluster formation: Clustering can be divided into two types: strict clustering and smooth clustering. Strict clustering separates information into many groups, with each data item corresponding to one group only, whereas fuzzy set assigns affiliations to collected data, which are subsequently used to allocate these between one or more groups or classes in the image data set. In smooth filtering, data items might belong to many clusters with various degrees of membership. Fuzzy cluster analysis of data, segmentation techniques, and other uses of fuzzy cluster analysis.

Fig.1) shows the FCM (fuzzy C-mean) implementation procedures for spinal cord segmentation. To obtain image correction, first read the MRI image, preprocess the input image, and apply the segmentation algorithm to the image. To acquire a crisp segmentation by reducing noise, use morphological processes like erosion and dilation. Then, to ensure correct picture segmentation accuracy, compare the segmented output image to the ground truth image.

We used the 2018b version of MATLAB software in an i5 CPU for this experiment. We tested this experiment on 80 MRI images of the spinal cord and confirmed the accuracy with a local doctor; the results reveal that we get a ok result when compared to the actual result of the doctor's analysis, with an average accuracy of 70.41 percent.

Algorithm 1. Fuzzy C-Means

Input : X, w, max number of iterations (T), threshold (ε)

Output : r_{nk}, μ_k

1. set $t = 0$
2. initialize μ_k
3. update $t = t + 1$
4. calculate $r_{nk} = \left[\sum_{j=1}^{K}\left(\frac{\|x_n - v_k\|_2}{\|x_n - v_j\|_2}\right)^{2/w-1}\right]^{-1}, \forall n, k$
5. calculate $\mu_k = \frac{\sum_{n=1}^{N}((r_{nk})^w x_n)}{\sum_{n=1}^{N}(r_{nk})^w}, \forall k$
6. if a stopping, i.e., $t > T$ or $\|R^t - R^{t-1}\|_F < \varepsilon$, is fulfilled then stop, else go back to step 3

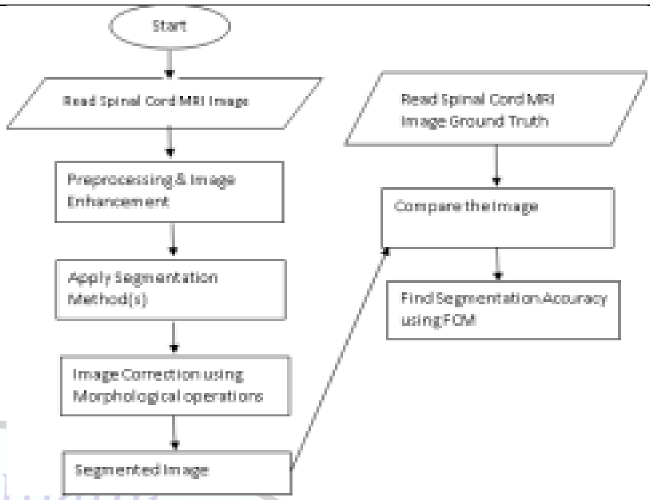


Fig. 1) FCM implementation flowchart with code implementation step 1 to step 12.

Detailed steps of code implementation, which type of output get at each step with flowchart as shown in Fig.1)

Step1: Read Input Image

Step2: Convert to Binary by applying Otsu's threshold

Step3: Fill the holes

Step4: Apply morphological operations

Step5: Fill the holes to generate ROI Mask

Step6: Apply Mask to original image to remove unwanted background

Step7: Apply FCM (Fuzzy C-mean)

Step8: Find disk segments

Step9: Smoothen edges using erode

Step10: Remove unwanted noisy pixels

Step11: Compare the disk segment with ground truth

Step12: Calculate accuracy of segmentation

Fig. 2b) shows the segmented result of the image of Fig. 2a)

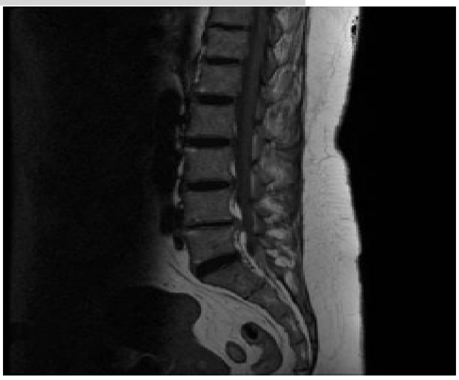


Fig. 2b) shows the segmented result of the image of Fig. 2a) using the Fuzzy C-mean approach with 84.41 percent segmentation accuracy, with red color successfully segmented and blue color incorrectly segmented

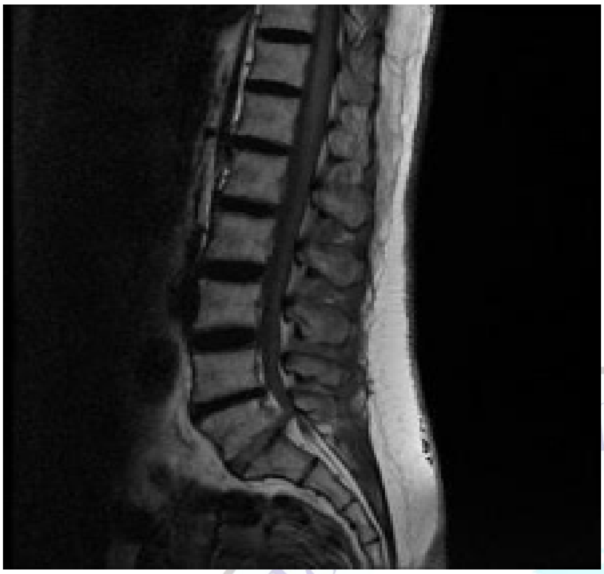
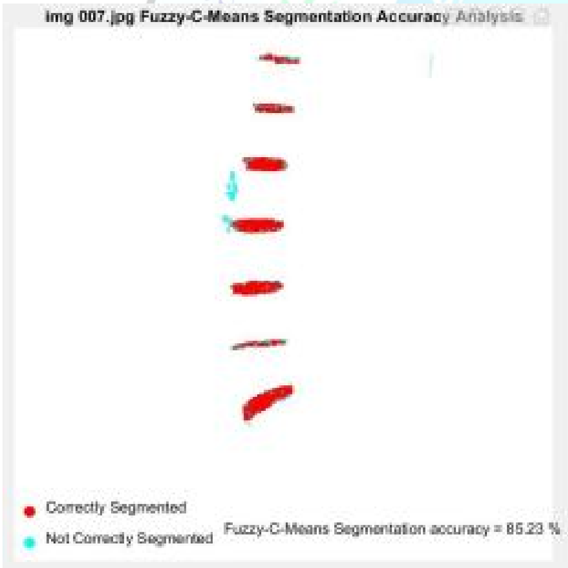
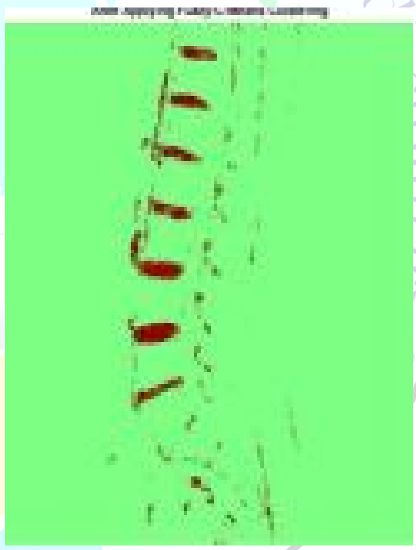


Fig. 3a) spinal cord input MRI image

Fig. 2a) spinal cord input MRI image



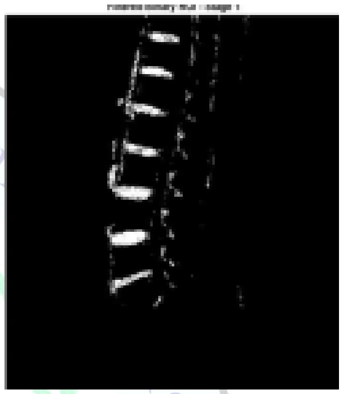


FCM Result's shown in the following figures Fig.5 (with 10 subfigures of FCM steps) as followed steps in Fig.1 with mentioned step 1 to step 12.

Fig. 3b) shows the segmented result of the image of Fig. 3a) using the Fuzzy C-mean approach with 85.23 percent segmentation accuracy, with red color successfully segmented and blue color incorrectly segmented.

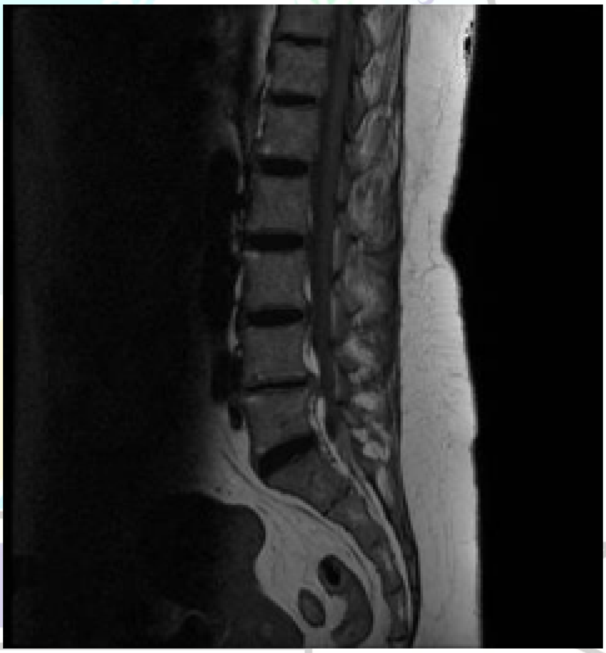
Fig. 4) shows the average segmented accuracy by Fuzzy C mean methos which is 70.41 percent on total 80 MRI spinal cord image. Image size is 512x512.

Fig. 1 depicts the Fuzzy C-mean implementation steps in detail, Fig. 2a depicts the input MRI spine images, and Fig. 2b depicts the fuzzy C-mean output of the input MRI image of Fig. 2a. Similarly, Fig. 3a depicts the second input image of a MRI spine image, with output in Fig. 3b, and Fig. 4 depicts the average segmentation accuracy of total 80 MRI spine images using the Fuzzy C-mean.



RESULT:

We've included some of the results here, along with their individual accuracy.



Here the all the above10 figures shows the FCM output result Of each step as shown in Fig. 5 consist total 10 output of each step according to the steps mentioned in the in-Fig.1 with steps. Using the Fuzzy C-mean approach with 84% percent Average segmentation accuracy, with red color successfully segmented and blue color incorrectly segmented.

IV. DISCUSSION:

We learned from this experiment that using the Fuzzy C-mean does not produce the best results, thus in the future we will use the next area region growing, k-mean, and any other best segmentation method to produce the best output result on spine images.

To identify the major slip disc region of the spine, we analyzed 80 MRI spine images obtained from a local orthopedic doctor. According to a local orthopedic doctor, there are a variety of causes for disc protrusion and spinal cord compression, including the following reasons like Extra weight or overweight, bad lifting techniques, nutritional behaviors such as daytime sleepiness, weak calcium intake, or tobacco, ageing, and bad posture are just these few great factors that can boost the chance of having a spinal condition. Here I've displayed some of the 80 MRI spine images from a local orthopedic doctor that have been analyzed.

Fig.6, Fig.7, Fig.8, and Fig.9 illustrate the doctor's examination of an MRI image to determine the location of disc protrusion and spinal cord compression. The disc protrusion in Fig.6 is seen without cord compression. The disc protrusion at Lumber L4-L5 with cord compression is shown in Fig. 7, Fig.7 also depicts a disc prolapse at L3-L4 without cord compression. Fig. 8 shows a disc prolapse with cord compression at the L4- L5 level. The picture of a normal spine is shown in Fig.9.

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