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Segmentation of medical images: adaptive contrast enhancement and fuzzy c-meansclustering

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Abstract: ***The efficient segmentation of medical images remains a challenging field of research. Medical images encompass various modalities and originate from different parts of the human body, rendering segmentation methods difficult to apply. Typically, medical images suffer from poor contrast during capture, making the task of segmenting and recognizing objects in these photographs particularly challenging. In this paper, we propose asequential combination of enhancement and segmentation approaches. For contrast improvement, we suggest histogram- based methods. As for segmentation, we propose a three-level thresholding-based Fuzzy C-Means (FCM) segmentation technique for three different types of medical images. We qualitatively assess the performance of contrast enhancement and FCM-based segmentation on MRI brain*** **cancer images, electrocardiography images, and brain scalp images.**

Key Words: **Image Segmentation, Medical images, Contrast Enhancement, FCM, K mean Clustering, Thresholding.**

I. INTRODUCTION

Huge numbers of medical imaging data have been acquired in the last three years. With the advancement of technology over the past two decades, the processing of digital images has become a crucial component of medical science. Differentscanning technologies now capture a wide range of images of human and animal anatomy. X-ray images [1], ultrasound images, computed tomography (CT-scan) images, brain MRI for cancer diagnosis, brain scalp images, and electrocardiographic medical imaging technologies are among the most common.

With the help of these technologies, we can peer inside the body's concealed organs, fully measure, examine, and manipulate them. The process of extracting the different components of incoming medical data, known as medical imaging segmentation [2], is a key aspect of this field.

A. Overview of Segmentation Methods

Segmentation is an essential stage in any medical diagnosis, disease detection, and treatment. Researchers have proposed various segmentation strategies, including pattern recognition [1], histogram-based thresholding [3, 4, 5], segmentations based on local image domains or regions [6], split-and-merge techniques [7], and region-expanding techniques [8]. Just like the three-level thresholding proposed in [9] and [15], there are numerous FCM-based techniques. Image enhancement techniques are described in [11] and [12], while fuzzy-based K-means and C-means clustering methods are discussed in [13] and [14]. Due to the wide range of potential medical imaging objects, achieving responsive segmentation has remained a challenging and complex problem. Participatory fuzzy image segmentation has thus become increasingly popular among researchers in recent years.

In the realm of segmentation, image thresholding techniques are most commonly used. Otsu's adaptive thresholding method has been in use since the 1970s [9 and 15]. However, it is not sufficiently effective for the segmentation of medical images. New strategies are needed to address various medical classification challenges. Thresholding-based approaches have been applied in many areas of medical imaging, such as tissue segmentation, background elimination in MRI, bone extraction in radiation therapy, and skin cancer detection. Thresholding is a common approach for immediate image segmentation, found to be efficient and quick for segmenting well-defined areas. However, due to its sensitivity to noise in medical photos, it can lead to errors in the segmented image. Therefore, the efficiency of this thresholding method must be improved.

Medical images are constantly affected by dominant and erratic color casts as well as various artifacts. Processing medical photos is therefore more challenging than processing regular, aerial, or consumer images [5]. Medical images are crucial for doctors, physicians, medical professionals, and medical facilities to assess patients for evaluation and treatment. Radiologists rely primarily on their visual assessment for the study and examination of these medical images. However, this process often takes a long time, and its efficiency depends on the radiologist's experience. Hence, it is crucial to implement and develop computer-aided systems to overcome these limitations. Digital image processing methods are particularly useful in medical imaging when combined with other algorithms like artificial intelligence, fuzzy logic, pattern recognition, and machine learning [9, 14, and 15].

II. REVIEW OF WORK

Bhargavi et al. [1].research on threshold approaches in picture Segmentation is described in the current paper. One of the fundamental methods used in digital image processing is picture segmentation. Many applications make heavy use of image segmentation. For picture segmentation, a number of general-purpose algorithms and methods have been developed. Applications for segmentation include feature detection, recognition, and measurement.

Basar et al. [2] solved the segmentation problem of color photographs by addressing it with the classic K-means method in this study, using a unique and adaptive initialization approach to find the number of clusters and initial central points of clusters. The given methodology employs a scanning method of the RGB color-channel histograms to identify the most prominent modes in each histogram. Bezdec et al. [3] have proposed a segmentation algorithm presented in this research that is totally automatic and is based on the geometrical and local properties of color images. With this approach, any general segmentation algorithm whose segmentation sensitivity may be adjusted by parameters will integrate a hierarchical assessment scheme. To generate various segmentation levels in the hierarchy, the parameters are changed.

J. Singhai and P. Rawat [4] have presented various histogram- based enhancement methods for different image types. Silver, B., et al. [5] used a histogram equalization approach which has some drawbacks; hence, in this study, we present an image improvement strategy based on utilizing histogram data obtained from transform domain coefficients. The inherent dynamic range increase of conventional histogram equalization has historically caused various issues. Standard histogram equalization can over-enhance many photographs with data that is strongly grouped around specific intensity values, resulting in artifacts and a general change in the tone of the image. Karthick et al. [6] have used region-based segmentation. Kelkar, D. and Gupta, S. [7] (2008) suggested an improved quad-tree method (IQM) for split-merge, introduced as the neighbor-naming based image segmentation method (NNBISM). It combines top-down and bottom-up approaches of region-based segmentation techniques. The key components of IQM are image splitting, initializing a neighbor list, and combining the splatted regions.

Lin et al. [8], in order to acquire precise and topologically preserved surface structures of anatomical objects of interest, offer a hybrid 3D picture segmentation method that combines region growth and deformable models. The suggested method begins by employing a region-growing algorithm to determine a crude but reliable estimate of the objects. Khandelwal and others [9] stated that medical input data can be examined and extracted in various parts using the segmentation of medical images. To increase the effectiveness of these segmentation algorithms, several strategies have been developed. The primary objective of the suggested approach, based on the three-level threshold methodology, is to quickly and effectively create a three-level FCM clustering algorithm. The newly developed method acquires the threshold more quickly than the conventional way because it uses a pseudo- random number generator that produces initially fuzzy estimates that are normally distributed.

Menon, Neeraja [10], initially proposed an FCM-based segmentation approach and adopted Bee colony optimization for segmentation. Dwivedi et al. [11] research compare two widely used enhancement techniques and conclude that each technique creates two independent image sets from the initial low- contrast image. Fuzzy-based clustering techniques can effectively be used with these sets to segment objects. Enhancement using the global contrast adjustment approach and contrast-limiting adaptive-based histogram equalization (CLAHE) is presented in the paper. Gupta et al. [12] proposed a hybrid segmentation algorithm for ILD images that included superpixel and K-means clustering techniques. Superpixel images that have been segmented effectively adapt an uneven local and geographic neighborhood, which helps enhance the effectiveness of K- means clustering-based ILD image segmentation.

Hnin Mar Lar Win et al [13] study describe a strategy to perform image segmentation and edge detection tasks that combine k-means and watersheds segmentation techniques. In order to acquire the primary segment image into several intensity regions, we first used k-means algorithms to inspect each pixel in the picture and assign it to one of the clusters based on the minimum distance. According to Dwivedi and colleagues [14], underwater image segmentation is a tough subject to examine due to limited lighting. As a result, this study addresses a number of issues and concerns based on recent studies in the field of underwater segmentation. Since underwater photographs have numerous applications in everyday life, including marine engineering, study and observation of underwater organisms and vegetation, and oil well monitoring. As a result, the segmentation of underwater objects is a hazy challenge. The fuzzy clustering approaches for image segmentation are therefore reviewed in their study.

III. CHALLENGES

The following challenges may be derived from the review of the literature:

- The segmentation output of the present FCM-based clustering algorithms is a monochrome or binary image. To create a color-segmented image, it is necessary.
- Clustering is less successful when a large number of diagnostic photos are used, especially when the level of brightness is not uniform, as in pictures of the body. Thresholding might be utilized to boost the effectiveness of FCM-based techniques.
- Using contrast enhancement could make FCM-based segmentation algorithms more effective.
- Achieving completely adaptable and automatic segmentation of images is an ambiguous challenge and a

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difficult area for medical image segmentation.

A. Summary of Segmentation Techniques

When segmenting an image, thresholds are utilized for creating uniform sections within the image based on a set of minimum parameters. T. Assume that we possess a photograph like the one in Figure 1 that is made up of dark items that have various grey levels on a light backdrop with varying grey levels Figure 1.

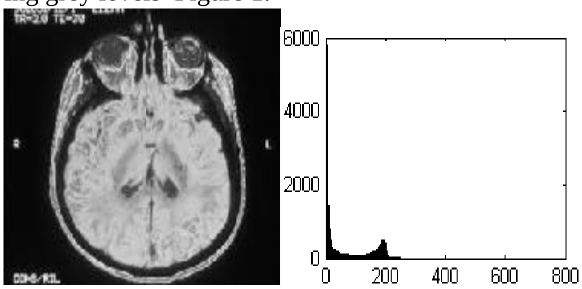

Fig.1.Histogram and medical magnetic resonance imaging (MRI) of a brain cancer

Choosing a threshold T which spans the two zones is an apparent technique to distinguish the items from the backdrop. A point (x,y) is then referred to as an object point if f(x,y)T, and a background point if f(x,y)>T.

$$T= T[x, y, A(x, y), f(x, y)] \quad . \quad (1)$$

Where A(x,y) stands for some local attribute of this image in the vicinity of this image and thef(x,y) is the grey degree data of the image value. The definition of a threshold image is given by

If f(x,y)>T at 0 if f(x,y)T,
then g(x,y)=(1 if f(x,y)>T@0) (2)

Because of this, pixels labeled 1 (or every other practical grey level) represent objects, while pixels labeled 0 (or some other practical grey level not allocated to objects) relate to background.

IV. PROPOSED SEGMENTATION USING FCM

This research proposes an effective image segmentation approach that makes use of the benefits of dynamic three level thresholds for categorizing the medical items utilizing the fuzzy C means arranging of medical images in order to increase the effectiveness in the segmentation of medical images. Figure.2 displays the block architecture of the suggested segmentation approach.

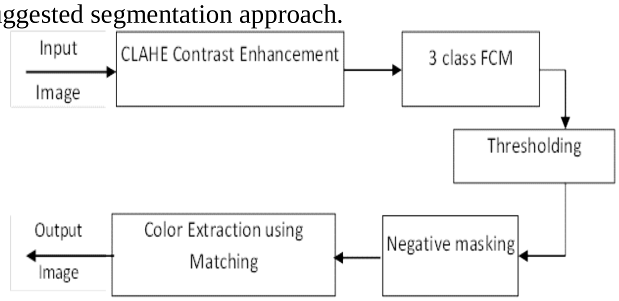

Fig.2. Block diagram of the suggested segmentation approach

It is recommended to use CLAHE-based expansion at the front end to boost image contrast before to segment in order to enhance segmentation quality. For the majority of the photos, classification based on CLAHE functions is effective. The FCM and thresholding are combined to increase segmentation efficiency. The suggested method also uses the matching matrix's logical segment output from the usual three-class threshold method to provide cultured segmented outputs.

Due to its simplicity, fuzzy c-means (FCM) grouping is regarded as a desirable clustering approach for picture segmentation. The suggested segmentation method uses FCM with the three class thresholds idea [10] to organize the pixel data. By average the greatest value in the group with the largest center and the lowest in our group with the middle center, the proposed method's threshold is determined [10]. These are often situated where the first and third peaks of the histogram's demarcation line meet. One way to think about this is as a trade-off between local and global traits. It is not possible for edge information recorded in uses sufficient past knowledge to direct course of the curve. Furthermore, because it is derived from the range, it is highly noise-sensitive.

V. FINDINGS AND CONCLUSION

This section describes few of experimental findings for development of suggested segmenting of medical images. Figure 3 depicts data underlying input actual medical pictures.

a) brain-cancer-MRI weather b) MRI of the brain
Fig.3.Enter a database of medical images

electoral chartography_2
Fig.4. Database of medical images

VI. THE IMPACT OF CONTRAST ENHANCEMENT

A contrast of the several CLAHE distributes is provided in this section. Although it is evident from Figure.4 that the

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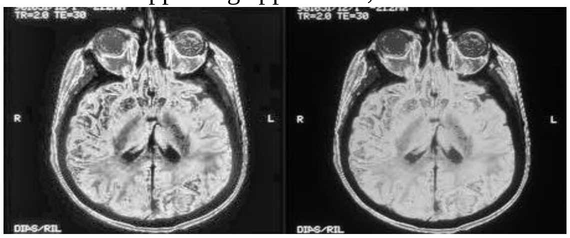
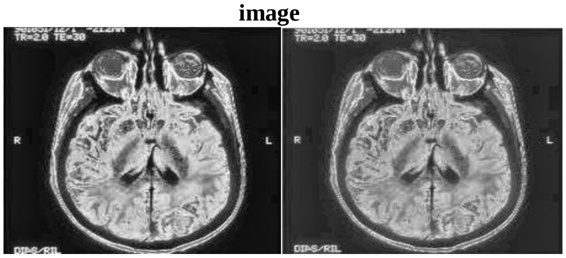
distribution of Rayleigh angles offers medical photos a more natural and appealing appearance,



a) Original see plant image b) Uniform distribution image

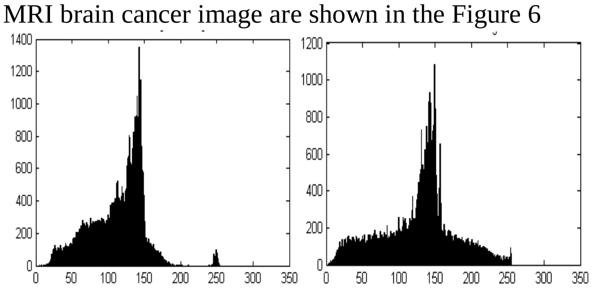


c) Exponential distribution d) Rayleigh distribution image

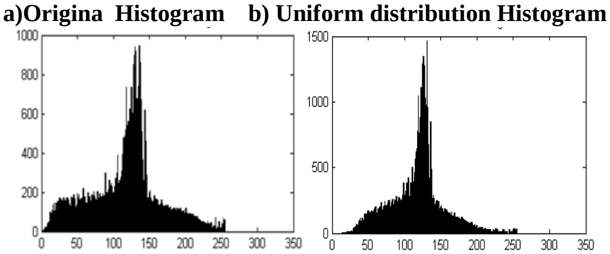
Fig.5. Comparison of CLAHE Results

The reaction of the equalized histogram to the consistent distribution is significantly flat. Therefore, it is suggested that a standard distribution be used in this study. Medical image segmentation using the CHALE approach is compared in Figure 5.

The results are comapred for the three histogram distributions using the CHAHE enhancement resoectvlly uniform, rehaigh and exponential distirbution of contrast. For segmentation uniform distribution is prefered for the unifirm brigthness pattern.. The respective Histogram comparison of CLAHE based econtrast ehnamcnet results for MRI brain cancer image are shown in the Figure 6



a)Origina Histogram b) Uniform distribution Histogram



c) Exponential distribution d) Rayleigh distribution Histogram

Fig.6. Histogram comparison of the CLAHE based enhancment for MRI cancer iamge

VII. RESULTS OF THE SUGGESTED SEGMENTATION

This section highlights a few of our experimental findings related to the development of the suggested strategy for segmenting medical images. For input medical photos, some findings of FCM employing three class thresholding based segmentation are shown in this section.

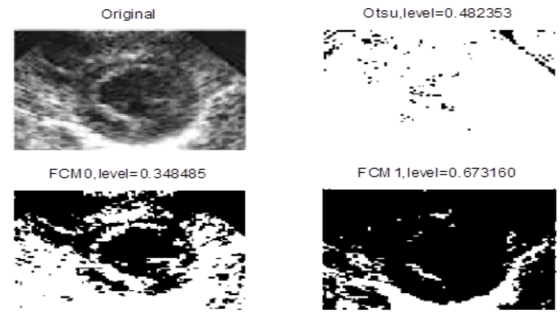
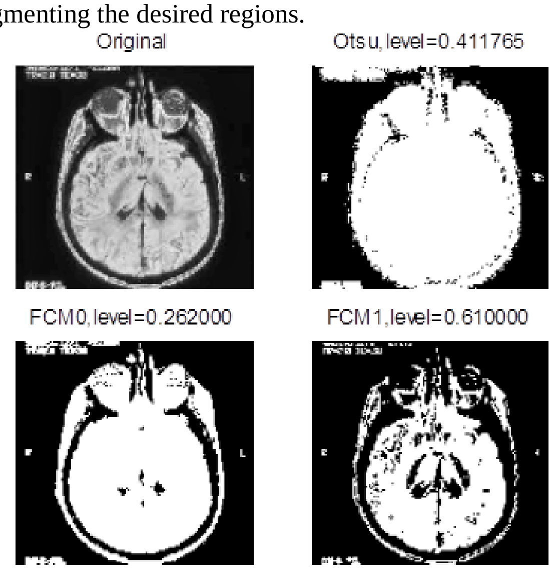


Fig.7.The outcome of the proposed three-class thresholding FGM with CLAHE enhancement (electorcordiograghy_2)

The outcome of the proposed three-class thresholding FGM with CLAHE enhancement for electrocardiography images is shown in the Figure 7.

It can be seen that the desired region may belongs to any of the two segmented class and the otsu's adaptive threshold is unable to segment the desired region individually. Thus proposed approach out perform on otsu method of thresholding. The outcome of the proposed three-class thresholding FCM with enhancement for MRI cancer image is shown in the Figure 8. And the outcome of the segmentation for the Brain image for proposed method is shown in the Figure 9 respectively. The qualitative evaluation of the result makes it clear that proposed combination of processing for is capable of biter segmenting the desired regions.



.Fig.8.Outcome of proposed three-class thresholding FGM with CLAHE enhancement (weather_cancer_MRI_brain)

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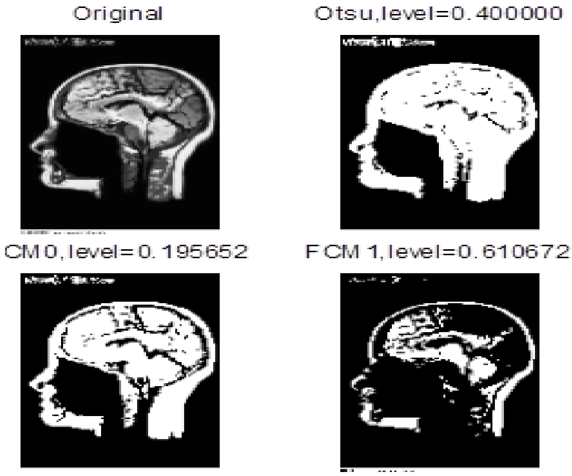

Fig.9. Result of proposed 3 class thresholding FGM with CLAHE enhancement (MRI_Brain_Scan)

VIII. CONCLUSION AND FUTURE SCOPE

This paper sought to determine whether suitable image processing techniques can be used to process medical images, allowing the detection of objects within these images for use with further scientific analysis applications. In this project, a novel enhancement method is proposed which can yield the optimal equalization in the sense of entropy maximization, under the constraint of the contrast improvement, called Contrast Limited Adaptive Histogram Equalization (CLAHE). Experimental results show that CLAHE can enhance the image quite well when preserving the mean brightness and improves the contrast with flat histogram distribution.

The comparison of the segmentation result for original and CLAHE enhanced image are presented. It is clear that CLAHE gives better result for same threshold T. The results are also analyzed for the different threshold segmentation.

The time and wavelength analysis can also be included in it. The depth analysis can be done in the future. Use of the adaptive thresholding may improve the performance of the segmentation method. Various adaptive threshold methods can be analyzed in future.

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