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A Survey on Various Brain MR Image Segmentation Techniques

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ABSTRACT

Prior to medical image analysis, segmentation is an essential step in the preprocessing process. Partitioning an image into distinct regions based on characteristics like texture, color, and intensity is its primary goal. Numerous applications include tumor and coronary border recognition, surgical planning, tumor volume measurement, blood cell classification and heart image extraction from cardiac cine angiograms are all made possible by this technique. Many segmentation methods have been proposed recently for medical images. Thresholding, region-based, edge-based, clustering-based and fuzzy based methods are the most important segmentation processes in medical image analysis. A variety of image segmentation methods have been developed by researchers for efficient analysis. An overview of widely used image segmentation methods, along with their benefits and drawbacks, is provided in this paper.

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1. INTRODUCTION

Using segmentation in medical image processing is an essential part of analyzing or studying an image correctly. Images can be broken down into multiple sections based on factors like texture, colour, and grayscale value during the segmentation process. For the most part, image segmentation is not governed by a set of rules. As a result, various general-purpose ideas are easily segmentable, leading to a variety of medical image segmentation studies. These regions can be easily defined, characterized and exploited as a result of image segmentation. They can be studied in isolation, with no connection to each other. There are five different methods of segmentation, each with their own strengths and weaknesses, as shown in figure1.

A digital image is nothing more than a two-dimensional array made up of a collection of pixels. In gray-scale images, the weight (or numerical value) of each pixel reveals the level of brightness or darkness. There are three main types of digital image classifications: grayscale, binary, and color. Binary images have only two possible pixel weights: 0 and 1, and they are stored in memory as bitmaps, which are packets of arrays of bits. When it comes to digital image processing, binary images are a great fit. Grayscale images use an array of weights ranging from 0 to 255. A value of 0 is black, and a value of 255 is white. Values between 0 and 255 are the different shades of grey. RGB (Red, Green, and Blue) triples are used to describe the colors of images in a way that is easy to read. There is a range of weights, and each weight has a different intensity of the primary color. This ranges from 0 (no color at all) to 255 (all the color) (maximum intensity).

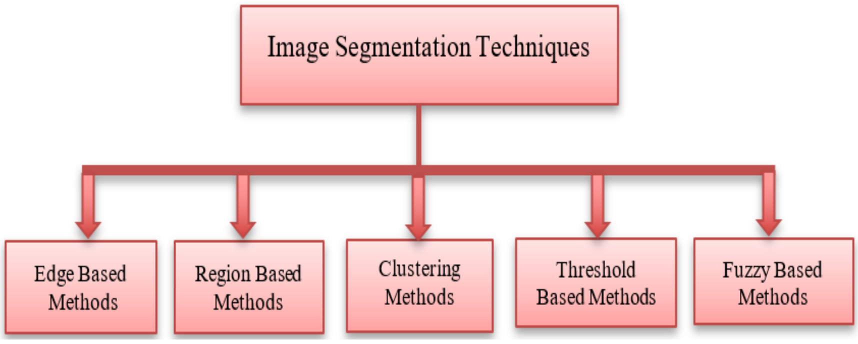


Figure 1. Segmentation Method

Image processing is a method for converting a physical image to a digital format and then extracting as much useful information as possible. The image is regarded as one of the best ways to convey information. An important area of application in digital image technology is the extraction of useful information from an image. During the image processing stage, segmentation of images is carried out. Image segmentation is the process of dividing an image into multiple parts so that it can be expressed and studied more clearly.

2. RELATED WORK

When a digital image is broken down into smaller pieces, it is said to be segmented using segmentation technology Using this system can be dangerous [1]. Image Segmentation techniques include threshold, edge detection, region-based algorithms, histogram, and watershed transformation. Grayscale and color images, for example, are separated into two categories based on the degree of color saturation in the image. As can be seen from content-based retrieval (CBR) [2] [3], color image segmentation differs from grey scale image segmentation. This is determined by the type of image [4]. Edge-based segmentation, which uses an image's edges to determine an image segmentation algorithm’s parameter, relies on pixels' properties and information. The neural network's learning algorithm uses a threshold to separate the background from the image in region-based methods. using a neural network [5] for image segmentation training Different segmentation techniques yield parameters that can be used in further research.

Medical science and engineering use many different algorithms to figure out what's wrong with people's bodies. These algorithms are used for things like the spine, pathology localization, blood vessels and the heart. Still, there is a lot of information out there, but researchers are having a hard time finding a good way to separate the image [9]. Edge-based, Fuzzy-based, partial differential equation-based, ANN, threshold-based, region-based, threshold-based, clustering-based, and CNN-based image segmentation are some of the most common ways to break up an image. In image segmentation, the image is shown in a form that is both meaningful and can be used to analyses it. The first phase in image analysis. Image segmentation is commonly employed in medical imaging, traffic control, object detection, object recognition, object detection and surveillance, and content-based image recovery [10].

Images can be divided into two main categories: Local and Global Segmentation. Several algorithms have been proposed in the literature for the segmentation of images by various authors. MRI, CT scan, and PET scan are just a few of the high-tech medical imaging tools now available, and they all produce incredibly complex images that are nearly impossible to decipher by hand. Scientists are challenged to come up with new and improved methods to suit the demands of medical imaging [11].

3. DIFFERENT METHODS OF BRAIN MR IMAGE SEGMENTATION

Various methods for segmenting images have been discussed in the literature. [44,45,46]. For image segmentation, there are a number of viable options available. However, the most basic and widely used approaches are those based on edge and location. From these two fundamental approaches, all other ways may be derived [12, 13] There are three categories for all procedures.

1) Strategies for basic segmentation: These are the methods that use information about the structure of the part of the image that you want to look at.

2) Stochastic Methods for Segmentation: These are the methods that only look at individual pixels in an image, not the whole thing at once.
3) Hybrid Techniques- These methods integrate structural and stochastic segmentation notions, i.e., additional data and discrete pixel values. The most common image segmentation methods include edge, fuzzy, threshold, region, and clustering. A comparison of picture segmentation methods is shown in Figure 1.

3.1. Brain Image Modalities

Today, MRI is one of the most often used medical imaging processes for detecting tumours in the brain. It is possible to create a range of tissue contrast pictures that can be used to segment and diagnose tumours and their subregions using various MRI modalities by altering the period of excitation during image acquisition.

In figure 3, you can see a representation of a brain tumour, as well as the three MR image layouts used to diagnose tumours, namely T1 and T2-weighted MRI and FLAIR. Longer TE (Time to Echo) and TR (Repetition Time) are used to create T2-weighted pictures than shorter ones for T1-weighted images. T1 and T2 characteristics of tissue are also used to determine picture brightness and contrast. Using FLAIR images, which are similar to T2-weighted images, doctors may see whether or not the patient's CSF fluid is normal or abnormal.

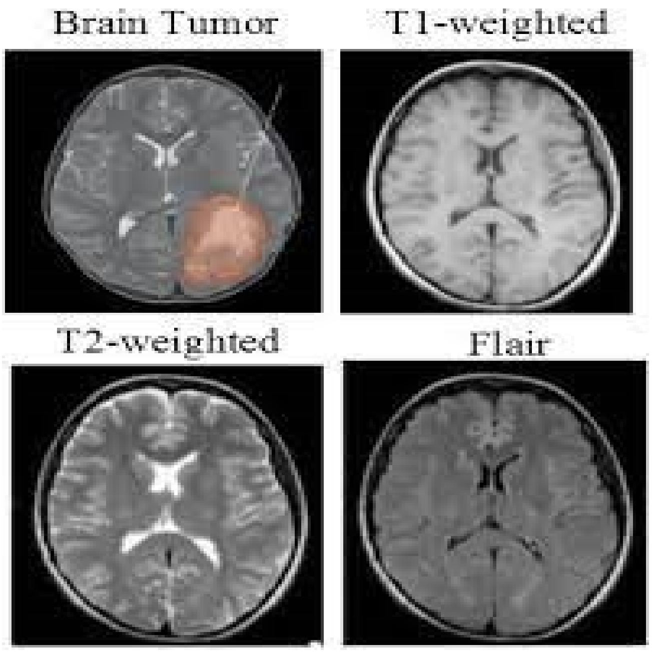


Figure 2.Three categories of Brain MR Images

3.2. Threshold Based Image Segmentations

In this method, images of varying intensities can be used since they can be partitioned into many separate sections. In terms of picture segmentation, threshold-based image segmentation is the most frequent and commonly used [14] parallel segmentation technique. A comprehensive overview of threshold-based segmentation has been provided by Pare et al. [15]. Medical images can be segmented using the novel method proposed by Anping XU [16]. For segmentation purposes, the de-noising filter result is passed to the Fast-Marching Method utilizing a threshold-based approach. Low-contrast images can be difficult to segment using thresholding, which relies on the selection of an optimal threshold. [18] In order to pick threshold values based on image intensity, histogram analysis is utilized. Local and global thresholding methods are the two main types of thresholding.

The global thresholding method is the best option for segmentation if there is a high homogenous contrast or intensity between the object and background. The Gaussian distribution approach is a useful tool for determining the appropriate threshold value. It is necessary to use these methods when a single threshold value or the entire image histogram cannot deliver good segmentation results when determining a threshold value. Figure 3 shows how many separate regions can be segregated in gray-level images using the thresholding method, which is commonly used in the first stage of segmentation in most applications.

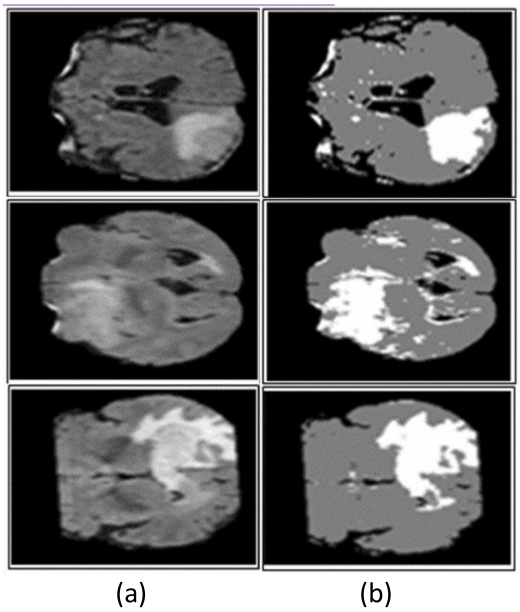


Figure 3. Otsu thresholding a original images, b Otsu thresholding [48]

3.3. Edge Based Image Segmentation

In brain MR images edges can be detected using several edge detection operators, which are then used to segment the image. These edges are used to identify points in an image where the grey levels, color, texture, etc. are different. The grey level may alter as we walk from one area to another. In other words, the edge can be found if we can detect a break in the pattern. A number of edge detection operators are provided, but the generated image should not be mistaken with the final segmented image. For the image to be segmented, more processing must be applied. An additional step involves integrating edges segments obtained into a single segment rather than small borders that may impede region filling, thus reducing the number of segments. This is done in order to have a smooth object boundary. In order to achieve the final segmented image, we must first perform edge segmentation, which is an intermediate step in the process [18].

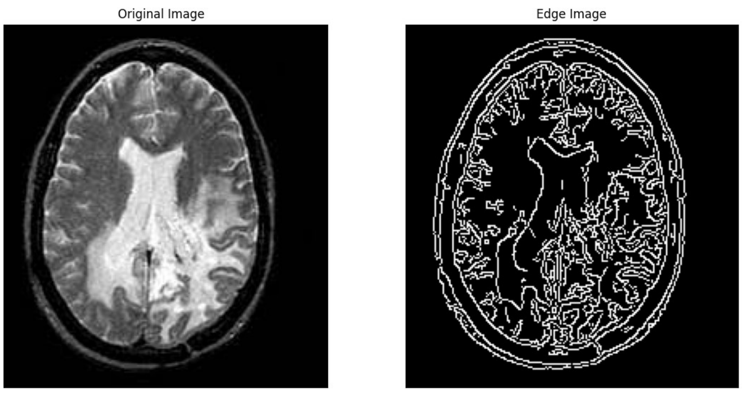


Figure 4. Edge detection method of brain MR images

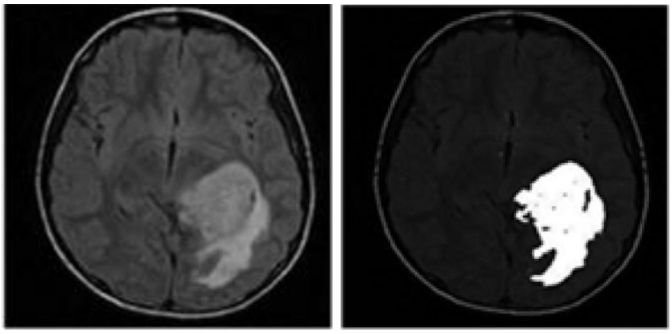
The results were better than those that could have been achieved using other methods. R V Patil [19] came up with a different way to break up a picture. He suggested figuring out how many clusters there are by using the edge detection method. They thought that when clusters are calculated correctly, K-means segmentation works well. Then, clusters are discovered using these edges. The threshold and Euclidean distance are used to create clusters. Finally, segmentation of the image is accomplished using K-means. Anna Fabijaska [20] pioneered a new method in which the edge position for edge detection in image segmentation was determined using the variance filter. Mohammed J. Islam [21] discovered that pharmaceutical businesses utilize picture segmentation algorithms for real-time capsule assessment via computer vision. [22] claims that edge-based image segmentation algorithms, likewise employed in facial recognition, are responsible for this success. The noise-suppression feature of the Sobel Edge Detector makes it possible to detect edges. Lastly, the Otsu Thresholding method was used to identify background and foreground pixels in an image. The testing results are superior to neural network-based segmentation methods since the difference in processing time is only 10 milliseconds. Segmenting ultrasound medical images using a hybrid edge-based approach was disclosed by Gupta et al. [23].

3.4. Region Based Image Segmentations

Region-growing segmentation was developed by Baziyad and coworkers [24] as a precise strategy for creating segments that are as homogeneous as possible in order to enhance hiding capacity and stego quality. The Gabor filter is used to extract grey values and edges from an image. [25] There is also the usage of Guass-Laplace filters [26]. Finally, ANN approaches are employed to extract the area of interest. Regions with comparable features can readily be separated by regional growth, which helps with border information and segmentation results. As a result of the homogeneity behaviors of a image, a background segmentation in region-based mode is created, and the image pixels are checked for accuracy. As a result, the neighbouring pixels produced by the separate regions were combined in accordance with similarities in preset phenomena (Ilunga et al. 2017) [27] in order to perform the estimation process. Watershed segmentation and region expanding segmentation are the two types of region-based segmentation that can be found.

3.4.1. Region growing

Most widely utilised in region-based segmentation was region-growing. This method used a bonded region identical to an actual image pixel [28] and only one seed was required. To estimate related regions, the neighboring pixels were amplified into the region-based homogeneity criteria. This seed was selected manually or automatically [29]. Tissues and lesions segmentation in MRI images is easily done by region growing. The architecture of multispectral image registration contains prior knowledge, fuzzy features, and changes in the fuzzy region increasing. Using FLAIR, T1 and T2 MRI, probabilistic intensity segmentation of tumours is possible.



(a) (b)

Figure 5. Region based segmentation (a) Original Image (b) Region growing

3.5. Clustering Based Image Segmentation

This clustering approach is widely used for image segmentation; however, it suffers from poor performance due to the random selection of initial centers [30, 31]. Further complicating matters, no advance prediction can be made as to the number of clusters that will be formed from unknown data using this method of analysis. If the gap approach is employed, the K-means method can be used to discover the optimal number of clusters in picture segmentation. Pixels in an image are divided into groups based on the distribution of their global properties in this technique. Image segmentation techniques known as "collection of comparable elements" are based on a combination of ideas and procedures. Feature space clustering algorithms are used to segment the image's pixels. In this aggregation, the feature space is split, and the mapping is done by returning to the original picture space. K-means is the most commonly used algorithm for clustering. Samples are gathered into different clusters, and the distance between the clusters is calculated. The K-means implementation is as follows:

- ➢ Initially, k centres are chosen at random.
- ➢ The distance between every sample and every cluster centre is determined.
- ➢ The centre of newly formed clusters is used to calculate the mean of all samples.
- ➢ Repeat the second and third steps until the centroid has completed the specified number of iterations.

This K-mean clustering approach is not only simple but also extremely quick. This algorithm's high efficiency is another key benefit. Distant partitioning is another feature of this technique [32,33]. agglomerative top-down technique [34] is another image segmentation algorithm, and it can lower the number of clusters by merging comparable clusters [35], but it has the significant flaw of not being able to discover an optimal number of clusters up to which clusters can be combined. With the help of clustering techniques, several methods for picture segmentation have been developed [36].

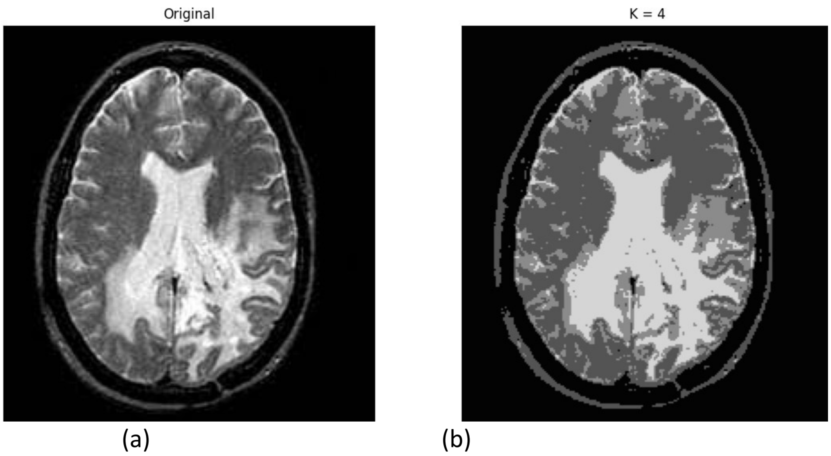


Figure 6. Clustering based image segmentation

3.6. Fuzzy Theory Based Image Segmentation

Sostak et al. [37] introduced a novel approach termed "fuzzy morphological" that is based on the fusion image segmentation technique. The approach applies smoothing and gradient operations to the final image, similar to the Morphological opening and closing operations described in detail in [38]. As proven by a comparison between the watershed algorithm and Prewitt techniques, a fusion strategy can address the over-segmentation problem more quickly. Fuzzy object models and scale-based fuzzy segmentation were utilized by Srinivasan et al. [39] to identify the brain parenchyma. Initially, the foreground region is segregated, followed by an MRI intensity adjustment for inhomogeneity, and finally a scale-based Fuzzy Object Model [40]. Edge detection in digital images can be improved by using a generalized transfer learning scheme in paper [38]. To achieve the best edge detection and noise reduction, the spatial statistical features of the image are examined and described in fuzzy form as a training data set. Furthermore, Muhammad Rizwan Khokher [41] proposed a method for segmenting images using Fuzzy Rules and Graph Cuts. These images are first segmented into their component parts using graph cuts in grayscale, color, and texture, respectively Images are then weighted using fuzzy rules for various features. Algorithms based on fuzzy rules first use images to extract features before calculating constants like weighted average constants and normalized graph cut methods to arrive at a similarity matrix and segmented images, respectively [42,43]. The Berkley database was used to test the algorithm. To carry out the experiments, MATLAB and a programming language are used to simulate the real world.

4. ANALYSIS AND COMPARISON

The Davies Bouldin Index (DB), Dunn's Index, and other approaches can be used to assess segmentation quality. It is clear from the foregoing explanation that speed is important in real-time applications, but quality is also important. In offline or one-time segmentation settings, fuzzy and ANN-based algorithms are computationally demanding. Table 1 compares different image segmentation approaches. It discusses the pros and cons of each strategy.

Table 1. Comparison of various image segmentation methods.

Method of Segmentation	Description of Method	Pros	Cons
Edge Based	Dependency on discontinuity detection	This method works best with images that have small changes across the various regions.	It has a lower noise resistance and is mostly dependent on peaks.
Region Based	As they're processed, images are being divided up into portions that are all the same color. Other techniques include dividing and combining regions and increasing the size of regions.	The impact of noise is greater.	In terms of memory and time, it is expensive.
Clustering	It is based on the division of the population into homogeneous groups.	Real-time problem-solving apps benefit greatly from this capability.	Trying to figure out what the membership function is in the method is tough.
Thresholding	It is possible to find threshold values that are dependent on the histogram peaks.	A straightforward procedure that does not necessitate any prior knowledge.	Peaks are based on the situation.
Fuzzy based Fuzzy	This method makes use of mathematical concepts and operators.	When describing the degree of similarity between two linguistic expressions, the fuzzy membership function is used.	This method necessitates a significant amount of computing.

5. CONCLUSIONS

There are numerous methods for segmenting images that can be used in image analysis. Because of the wide range of approaches available, it can be difficult to select the best approach to use in any given situation. Combining different techniques for image segmentation is clearly desirable in context of the advantages and disadvantages of these image segmentation methods. It is also possible to improve the segmentation by using machine learning methods. In the future we use the CNN model to recover the region of interest, and then classic segmentation methods are used to further enhance the segmentation outcomes.

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