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A Review on Various Approaches Utilized for image segmentation

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Abstract: Image segmentation is the process of partitioning a digital image into multiple segments to simplify the representation of an image into something that is more meaningful and easier to analyze. In this paper, various techniques of image segmentation are discussed and compared with the basic parameters. Medical images are generally characterized by multiple regions, and weak edges. When regions in medical images are made up of homogeneous group of intensities, it becomes more difficult to analyze because different organs or anatomical structures may have similar gray level or intensity representation. Practically Multi Thresholding, Correlation Matching, FCM, KFCM and PFCM have been evaluated and the results obtained shows that Multi Thresholding is the most efficient

as it is less prone to errors.

Keywords- **Hybrid Multi level Segmentation, Multi Thresholding, Medical Images, Correlation matching, FCM, KFCM, PFCM.**

Introduction

Image Segmentation

Image segmentation is the process of partitioning a digital image into multiple segments (sets of pixels, also known as super pixels). The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. All the more accurately, picture division is the methodology of doling out a name to each pixel in a picture such that pixels with the same mark impart certain qualities. The consequence of picture division is a collection of fragments that altogether cover the whole picture, or a set of forms extricated from the picture. Each of the pixels in an area is comparative regarding some trademark or registered property, for example, color, power, or surface. Neighboring locales are essentially diverse as for the same characteristic [14]. Picture division is the division of a picture into locales or classes, which relate to distinctive questions or parts of articles. A decent division is commonly one in which pixels in the same class have comparable gray scale of multivariate values and structure a joined area, neighboring pixels which are in distinctive classifications have different qualities.

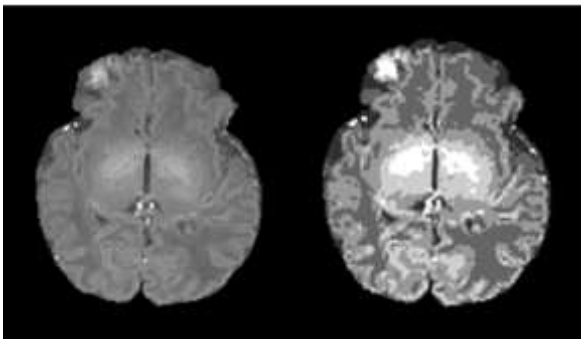


Fig 1: MRI brain segmentation is more complex and challenging task.

Medical images here refers to images of any part of the human anatomy taken with the aid of medical imaging devices/machines like magnetic resonance, computed tomography, X-ray, magnetic resonance angiography, et cetera, and taken in accordance with stipulated procedure[14]. One of the main characteristics of medical images that distinguished it from other type of images is its weak edges [1], meaning there is a continuous flow of image information from one region to the adjacent one. This characteristic makes it more difficult to segment medical images into distinct regions for proper examination and accurate analysis in addition to the fact that no single segmentation technique is perfect in all respect [2].

The hybrid and multilevel segmentation aims at producing accurate and fast segmentation of medical images or any other image with many regions of indistinguishable boundaries. The rest of the paper is organized as follows. In Section I we first revisit the various segmentation techniques. In Section II related work is discussed. Section III contains result of the practically performed jobs on

MATLAB. Section IV explains the conclusion and sections V lists all the references.

SECTION I

Techniques Used

1. Hybrid Segmentation

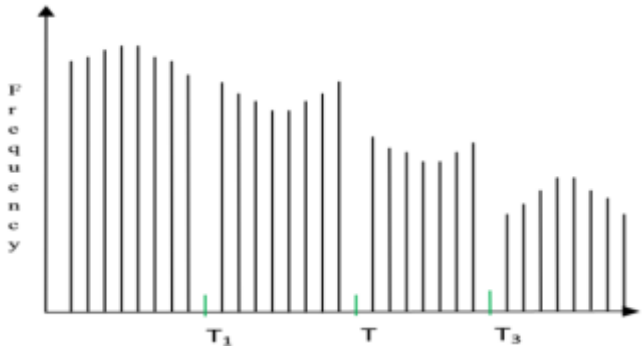
Hybrid Segmentation involves more than one technique to segment an image. Here, this term includes threshold and correlation matching. Multiple threshold values are selected on the basis of visual information and the boundaries which cannot be differentiated are passed for correlation matching to handle.

(i) Multiple thresholding

Thresholding converts a simple input image(I) to a binary image(B) but multiple thresholding involves conversion of an image(I) into regions of pixels with gray levels from set A and otherwise background B.

$$B(x,y) = \begin{cases} 1 \; for \; I(x,y) \geq T(foreground) \\ 0 \; for \; I(x,y) < T(background) \end{cases} \ldots\ldots(i)$$

T is threshold, B(x, y) is output pixel, and I(x, y) input pixel intensity value.



(ii) Correlation Matching

It is a mathematical operation of information from signals and images. This technique works with the help of an image template. This technique works with the help of an image template. This image template is passed through a filter and where it matches the most, those are the points of high correlation. Lesser the distance between image and filter higher will be the correlation. It has 2 main approaches:

- *Feature Based Approach:* If the template image has strong features, a feature-based approach may be considered; the approach may prove further useful if the match in the search image might be transformed in some fashion. Since this approach does not consider the entirety of the template image, it can be more computationally efficient when working with source images of larger resolution, as the alternative approach, template-based, may require searching potentially large amounts of points in order to determine the best matching location.[5]
- *Template-based approach:* For templates without strong features, or for when the bulk of the template image constitutes the matching image, a template-based approach may be effective. As aforementioned, since template-based template matching may potentially require sampling of a large number of points, it is possible to reduce the number of sampling points by reducing the resolution of the search and template images by the same factor and performing the operation on the resultant downsized images (multi resolution, or Pyramid (image processing)), providing a search window of data points within the search image so that the template does not have to search every viable data point, or a combination of both.

2. FCM algorithm

Fuzzy c-means (FCM) is a method of clustering which allows one piece of data to belong to two or more clusters. This method (developed by Dunn in 1973 and improved by Bezdek in 1981) is frequently used in pattern recognition. It is based on minimization of the following objective function:

$$J_m = \sum_{i=1}^{N} \sum_{j=1}^{C} u_{ij}^{m} \left\| x_i - c_j \right\|^2$$

where m is any real number greater than 1, u_{ij} is the degree of membership of x_i in the cluster j, x_i is the I th of d-dimensional measured data, c_j is the d-dimension center of the cluster, and ||*|| is any norm expressing the similarity between any measured data and the center. Fuzzy partitioning is carried out through an iterative optimization of the objective function shown above, with the update of membership u_{ij} and the cluster centers c_j by:

$$J_m = \sum_{i=1}^{N} \sum_{j=1}^{C} u_{ij}^{m} \left\| x_i - c_j \right\|^2$$

Where is a termination criterion between 0 and 1, whereas k is the iteration steps? This procedure converges to a local minimum or a saddle point of J_m. The algorithm is composed of the following steps:

1. *Initialize* $U=[u_{ij}]$ *matrix,* $U^{(0)}$

2. *At k-step: calculate the centers vectors* $C^{(k)}=[c_j]$ *with* $U^{(k)}$

$$J_m = \sum_{i=1}^{N}\sum_{j=1}^{C} u_{ij}^{m} \left\| x_i - c_j \right\|^2$$

3. *Update* $U^{(k)}$, $U^{(k+1)}$

$$J_m = \sum_{i=1}^{N}\sum_{j=1}^{C} u_{ij}^{m} \left\| x_i - c_j \right\|^2$$

4. *If* $|| U^{(k+1)} - U^{(k)}||<$
5. *Then STOP; otherwise return to step 2*

In medical field minute details of image are also matter a lot that's why it is very difficult to process. They need to be divided in such a manner so that their minute details can be easily examined. To divide the image into parts is called segmentation. In this work image segmentation is used to find the region of interest (ROI). The segmentation will be accomplished using fuzzy C mean technique.

3. K-FCM ALGORITHM

In this approach the kernel based fuzzy C mean approach is used for the segmentation of the image. In this kernel based segmentation approach used for segmentation process this approach can be implemented to manipulate the input data into higher dimensions of feature vectors by using the nonlinear map. This feature space division of the image is known to be the small regions of the image that have been separated for the implementation of FCM to each single region by providing kernel values. In this approach the image is firstly de-noised by using nonlinear spatial filter to enhance the quality of the image. In this approach one advantage is that it automatically defines the number of clusters that have to develop using KFCM. This approach firstly utilizes kernel values and then computes the fuzzy membership functions for the image regions using the computation equations. It finds the centric for each sub feature space of the image and this process goes till to the best cluster centers has been found for each region of the image. This approach is more robust to noise and original clustered forms and outliers of the image. This approach includes class of robust non-Euclidean at distance measures for original data spaces. This approach simple retains computation simplicity. In KFCM approach Euclidean distance between neighbor pixels has been computed on the basis of that distance various parts of the image. This approach provides better performance for the non-spherical and complex dataset that has not been provided by FCM.

4. PENALIZED FCM ALGORITHM

PFCM approach is an extension of FCM approach. In FCM approach spatial information about image is not taken into consideration it only depends on the different gray level information about the image. FCM is very sensitive to noise so Penalization of FCM is purposed. General Principal of this approach is only to interoperate neighbor pixel information. In order to incorporate the spatial context into FCM objective function is penalized by regularized term. This is inspired by NEM algorithm. Objective function given by

$$J_{PFCM}=\sum_{i=1}^{k}\sum_{i=1}^{c}(U_{ik})q \quad d^2(x_k, v_i) + \gamma \sum_{i=0}^{n}\sum_{i=0}^{n}\sum_{i=0}^{n} U_{ik(1-U_{iq})^q w_{kj}} \quad (1)$$

This approach used for the image segmentation utilized regularization term for the removal of noise sensitive in the FCM. A function ɣ (<=0) controls the effect of penalty term used in the PFCM. Value of the penalty term should be minimum for the better execution of FCM algorithm in the process of image segmentation [9].

SECTION II

Related Work

Duraisam[1] Author introduced an effective CNN based segmentation method with lung and brain MRI images. It included two important steps: 1)Pre-processing of the brain and lung images, 2) Segmentation using cellular neural network in the pre-processing step, image de-noising was done using the linear smoothing filters, such as Gaussian Filter. Then, the pre-processed image was segmented according to CNN-based image segmentation. Finally, the different MRI images (brain and lung) were given to the proposed approach to evaluate the performance of the proposed approach in segmentation process. The Comparative analysis is carried out using Fuzzy C-means (FCM) and K-means classification.

Balafar [2]: The author explained new method for image segmentation based on dominant grey level of image and fuzzy C-mean (FCM). In this the color image is converted to grey level image and stationary wavelet was applied to decrease noise and the image was clustered using ordinary FCM, afterwards, clusters with error more than a threshold were divided to two sub clusters. This process continued until there remain no such, erroneous, clusters. The dominant connected component of each cluster was obtained - if existed. In obtained dominant connected components, the 'N' biggest connected components were selected. 'N' is specified based upon considered number of clusters. Averages of grey levels of 'n' selected components, in grey level image, were considered as dominant grey levels. Dominant grey levels were used as cluster centers. Eventually, the image was clustered using specified cluster centers.

Harini [3]: the author has explained the formation of kernel for the medical images by performing the deviation of mapped image data within the scope of each region from the piecewise constant model and based on the regularization term based on the function of indices value of the region. The functional objective minimization was carried out by two steps minimization in image segmentation using graph cut methods, and minimization with respect to region parameters using constant point computation. Nearest neighbor classifiers were introduced to the benchmarked image data segmented portions. Among the different methods in supervised statistical pattern recognition, the nearest neighbor rule resulted in achieving high performance.

Nawaz&Adnanet al [6]: The author exhibit a segmentation method that is based on combined color with temporal features like motion vectors. Earlier segmentation methods for region of interest (ROI) coding were only based on one feature such as motion color or luminance. But the method explained by the authors is based on two features there by combining the strengths of each separate segmentation technique.

Magana &Januchs et al [9]. The authors have explained PFCM with e.g. of Salamanca city. Salamanca has been considered among the most polluted cities in México. There is an Automatic Environmental Monitoring Network (AEMN) which measures air pollutants (Sculpture Dioxide (SO_2), Particular Matter (PM_10), Ozone (O_3), etc.), as well as environmental variables (wind speed, wind direction, temperature, and relative humidity), and it takes a sample of the variables every minute. In this work, PFCM is used (Possibility Fuzzy c Means) as clustering algorithm to get a combined measure, from the three stations, looking to provide a tool for better management of contingencies in the city, such that local or general action can be taken in the city according to the pollution level given by each station and the combined measure. Besides, an analysis is performed of correlation between pollution and environmental variables. So, the combined measure and the correlations can be used for the establishment of general contingency thresholds.

Hameed &Aboaba [14]: The authors have explained the segmentation of medical images using hybrid multi- level segmentation technique. Hybrid technique include Multiple thresholding and correlation matching techniques for the extraction of region of interest and then edge detection is done at multiple levels to generate the object of interest.

SECTION III

RESULTS

(i) Parametric Values

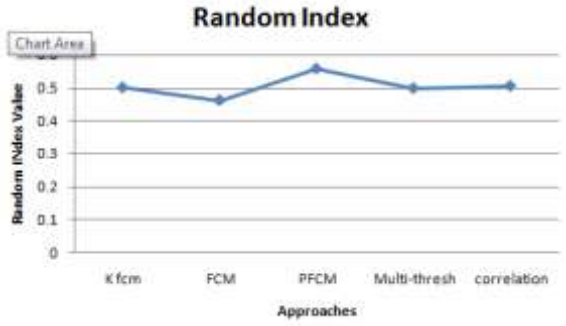
This section contains various comparison between different approaches of image segmentation.

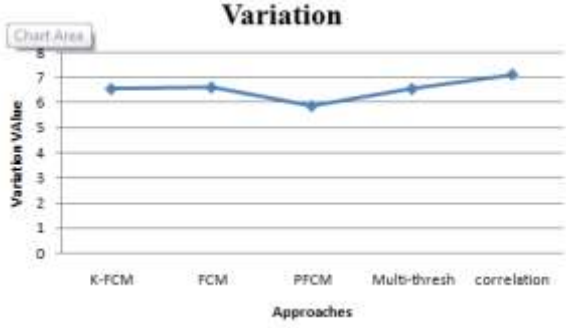
Approaches	Random Index	GCE	Variation
K-fcm	0.50015	0.1	6.55
FCM	0.4612	0.3	6.61
PFCM	0.5569	0.05	5.87
Multithreshold	0.4977	0.010	6.55
Correlation	0.5048	0.12	7.12

- Random Index: The **Rand index** or **Rand measure** (named after William M. Rand) in statistics, and in particular in data clustering, is a measure of the similarity between two data clustering. From a mathematical standpoint, Rand index is related to the accuracy. The Rand index has a value between 0 and 1, with 0 indicating that the two data clusters do not agree on any pair of points and 1 indicating that the data clusters are exactly the same.

- Global Consistency Error: D. Martin proposed several error measures to quantify the consistency between image segmentations of differing granularity. This error measure is not symmetric and encodes a measure of refinement in one direction only. Global Consistency Error (GCE) forces all local refinements to be in the same direction.
-
- Variation: Work in computes a measure of information content in each of the segmentations. The proposed measure, termed the Variation of Information (VI), is a metric and is related to the conditional entropies between the class label distributions of the segmentations. The measure has several promising properties but its potential for evaluating results on natural images where there is more than one ground-truth clustering is unclear.

(ii) Graphs





(iii) Images

- Input Image

Image Courtesy: Google Images

- Multi Threshold

- Correlation

- FCM

- KFCM

- PFCM

SECTION IV

CONCLUSION

From the above discussion it is concluded that Multiple Thresholding is the best technique as it is less prone to errors and is efficient. The most critical task in this technique is to obtain the multiple threshold values. Various advantages and disadvantages of the discussed techniques have been listed below:

Approach Used	Advantages	Disadvantages
Multi Thresholding	Several threshold values segment the image more specifically. The region of interest extracted has very clear boundaries.	It is difficult to select multiple threshold values.
Correlation Matching	It is essential for extraction of boundary of region that has to be segmented.	It is totally based on threshold values and no other features due to which important regions of the image are sometimes neglected.
FCM	This approach is beneficial for the simple and spherical datasets or images. This	This approach does not provide better performance for non-spherical and complex

	approach identifies similar cluster using the centroids from each cluster and find neighborhood pixel values[1]	data values. This approach is very noise sensitive[2]
P-FCM	Penalized fuzzy c mean approach has advantage of a term penalty for the removal of noise variation in the FCM algorithm. This approach regularizes the penalty tem which increase the segmentation performance of the algorithm[9]	This approach is mainly based on the penalty value used for the regularization of the penalty term. Is the value of particular term is higher than the centerfolds values of the clusters get disrupted and degrade the performance[10]
K-FCM	This can be efficient for the non-spherical and complex databases, robust to noise available in the image and number of clusters has been defined automatically in this approach [3]	The KFCM has main disadvantage of multiple use of kernel values for variant feature space computation used in the algorithm. These feature spaces sometimes get correlate with other feature space but the kernel value process each segment in different way[13]

Table 4.1 Comparison table for different approaches

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