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A Review on Image Segmentation with its Clustering Techniques

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Abstract

Segmentation refers to a technique in which an image in digital form is partitioned into multiple segments (basically groups of pixels, also termed as Super pixels). This paper is a survey on Image Segmentation with its clustering techniques. Image Segmentation is the procedure of apportioning a picture into numerous segments, to change the exemplification of a picture into another which is more useful and easy to segment. A few universally useful calculations and approaches have been developed for picture division. It separates a digital picture into numerous locales to investigate them. It is likewise used to recognize segment items in the picture. A few picture segmentation procedures have been developed by the specialists with a specific end goal to make pictures smooth and simple to access. This paper describes segmentation techniques, advantages and disadvantages of the clustering methods and a comparison of the techniques.

Keywords*: Image segmentation; K-Means algorithm; Fuzzy C-Means algorithm; log – based clustering*

1. Introduction

A digital image is basically an array in two dimensions of square regions known as pixels. In case of a monochrome or gray-scale image, the intensity of every pixel is denoted by a numeric value. It is also depicted as a fixed set of values in digital form of a two-dimensional image called pixel elements or pixels. Digital images can be formed by a number of input devices and techniques: Scanners, Digital cameras, Coordinate measuring machines. Digital images are of various types. They are Binary image, Grayscale image and Color image.

A Binary image is basically a digitalized image which has only two values, 0 and 1, for each pixel. They are also termed as two-level or bi-level. A binary image is generally stored in memory space as a bitmap, a packet of bits array. Binary images often ascend in digital image processing as masks or as the product of certain operations such as segmentation and image thresholding.

Gray-scale images typically have values in the array from 0 and going to 255, where 0 shows the black color, 255 shows white color and the remaining values in between 0 and 255 represents shades of gray.

A color image is denoted in an array in two dimensions of Green, Red and Blue triples. Basically in a triple, each number lies in between 0 to 255, where 0 shows that none of the prime color is there in that pixel and 255 shows a maximum amount of that main color in that pixel.

Image processing is the technique in which a picture is converted into digital form and to perform some processes on it, in order to acquire a superior image or to extract some essential data from it. It is basically a kind of signal exemption in which input is image, such that a photograph or video frame and output can be image or features related with that image. Usually Image Processing system comprises of treating images as signals in two dimensions while applying already usual signal processing methods to them.

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2. Image Segmentation

Image Segmentation is defined as the method in which an image is partitioned into many parts, such that an image is depicted into something that is easy to express and easy to study. Image segmentation is vital for meaningful analysis and interpretation of medical images [1]. Segmentation is the advanced technique in which a digitalized image is partitioned or segmented into numerous segments or parts based on the values of pixel. It is a perilous and important section of image exploration system [2].

The purpose of Image Segmentation is to divide an image into semantically interpretable regions with regard to a particular application and to identify homogeneous regions within the image as discrete and belonging to distinct objects [1].

There are several algorithms and methods that have been established for segmenting image. Modern medical imaging modalities like MRI and CT scans generate large images which cannot be studied manually. This develops the requirement for more effective and robust image determination approaches, tailored to the problems met in medical images [3].

3. Segmentation Technique

There are many methods for segmenting an image that have been recognized by scientists and researchers. Hence, there are several such techniques that are quite popular, important and are regularly used for image segmentation. These are classified as follows:

- Region Based Segmentation
- Edge Based Segmentation
- Threshold Segmentation
- Clustering Based Segmentation

Region Based Segmentation systems try to group pixels together with identical features (such as estimated gray level quality) into regions [5]. This segmentation technique is quite easy and efficient as compared to other techniques and it is also noise resilient. It is a type of segmentation technique in which an image is split into many unlike sections based on criterion *i.e.* object, color or intensity. The segmentation methods based on region are characterized into the following categories *i.e.* region splitting, region growing, and region merging [4].

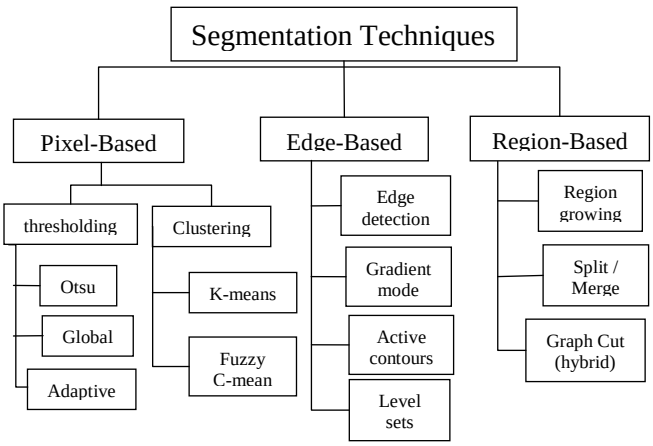

Figure 1. Image Segmentation Technique

Edge based segmentation technique is one of the most basic step used in image segmenting process. In edge detection technique, the image is split by spotting the difference in pixels of the digital image or intensity [4]. Edge detection technique is determining the value of pixels on the boundaries of region. The image segmentation is done by edge detection method by noticing pixels or edges in between diverse sections that basically have quick change in intensity are removed [2] and coupled to create closed margins of object. The outcome is an image in binary form [6]. Gray histogram and Gradient are two primary techniques which are used for segmenting image via edge detection [4].

Thresholding technique is the primary method used for image segmentation. It is a method used for discriminating background from foreground. The gray scale image can be converted into binary image by choosing an acceptable threshold value T. The image which is in binary form must have all the vital knowledge of the shape and position of the interested objects (foreground)[7]. The algorithms based on thresholding can be obtained physically by having some priori knowledge or repeatedly by formation of image [8].

4. Clustering Algorithm

Clustering in image processing is basically defined as the technique in which groups of identical image primitive are identified [1].Clustering is a method in which objects are unified into groups based on their characteristics. A cluster is basically an assembly of objects which are similar between them and are not similar to the objects fitting to additional clusters. An image can be segmented based on its keyword (metadata) or its content (description)[9].

Data clustering algorithms are built over the whole image and these algorithms studies data distance. The pixels of a cluster are not surely connective in data clustering. The algorithms based on clustering are further categorized into two techniques *i.e.* Hierarchical and Partitional. Hierarchical clustering is a successive split process, which fallouts in a cluster structure which is hierarically nested, and partitional clustering is an iterative partitioning process [10]. The clustering algorithms are as follows :

4.1. K-Means Clustering

K-Means algorithm is a quite known clustering algorithm that categorizes the input points of data into many groups produced on their inherent distance from one another [10].

The K-means algorithm [2], is one of the most common iterative algorithm which is basically used for its simplicity of implementation and convergence speed. K-means also produces moderately high quality clusters seeing the low level of computation and calculations required. The K-means technique focuses to diminish the total of squared distances in between all points of pixel and the center of the cluster. K-means algorithm is statistical clustering algorithm.

In this algorithm, the number of partitions are basically predefined. The cluster centers are arbitrarily initialized for already defined clusters. Each data point is then allocated to one of the nearest cluster. The cluster centers are then basically re-estimated which and new centroid is computed. Until there is no significant change in the cluster centre, this method is repeated [11].

K-means algorithm is particularly based over the index of resemblance or difference between sets of components of data. K-means algorithm is nondeterministic, iterative, numerical and a method which is not supervised [4]. K-means performs good with many data sets, but its decent presentation is limited mainly to compact groups.

The popular K-means algorithm [11] is an error minimization algorithm where the function to minimize is the sum of squared error:

$$e^2(K) = \sum_{k=1}^{K} \sum_{i \in C_k} (x_i - c_k)^2 \quad (1)$$

Where $c_k$is the centroid of cluster C_k and K the number of clusters (known a priori). Two factors have made the k-Means popular: it has linear time complexity and its easy implementation.

Advantages:

1) This algorithm is quite easy to understand, robust and fast.
2) It is relatively well organized or systematic algorithm: O (tknd), where n is the number of objects, k is the number of clusters, d is the dimension of each object, and t is the iterations. Basically k, t, d << n.
3) When the data set is discrete, this algorithm offers the best result.

4.2. Fuzzy C-Means Clustering

The Fuzzy C-Means algorithm (normally abbreviated as FCM) is basically an iterative algorithm[1] that helps to find clusters in data and in which the idea of fuzzy membership is used. As an alternative of giving a pixel to a single cluster, each pixel can have distinctive membership values on each cluster[12].Fuzzy C-means(FCM) is a system of clustering which lets one piece of data to belong to two or extra clusters. This approach (developed by Dunn in 1973 and elevated via Bezdek in 1981) is most often used in recognition of pattern.

This algorithm is an unverified clustering algorithm that is functional to quite many issues which involves classifier and clustering design, feature analysis. This algorithm has a number of applications like astronomy, geology, image analysis, chemistry, shape analysis, medical diagnosis, and recognizing of the target. The Fuzzy C-Means [2] tries to catch clusters of pixel in the data by reducing the objective function as shown in the equation below:

$$K = \sum_{p=1}^{N} \sum_{q=1}^{C} \mu_{pq}^{m} \left| x_p - c_q \right|^2 \quad (2)$$

Here K is the objective function. After one iteration of the algorithm, the value of K becomes small. It shows that the algorithm is coming closer to a fair separation of pixels into clusters. In the image, N represents the number of pixels in the algorithm, C represents the clusters number, here fuzziness factor is denoted by m (a value always greater than 1), the p^{th} pixel in N is denoted by x_p, the q^{th} cluster in C is denoted by c_q and $\left| x_p - c_q \right|$ is the Euclidean distance between x_p and c_q[12].

Many feature spaces can represent an image, and the FCM algorithm categorizes the image by making groups of identical data points in the feature space into clusters. This algorithm is obtained by iteratively reducing a cost function which is reliant on the displacement of the pixels to the centre of the clusters. The pixels on an image in the immediate neighborhood own the same feature data *i.e.* the pixels on image are correlated. Therefore, the association of neighboring pixels is an essential property that is of huge importance in image segmentation.

Advantages:

1) For the partly cover set of data, this algorithm gives good results and it is quite efficient than k-means algorithm.
2) The data point completely belong to single centre of cluster, where as in FCM the data point is given membership to each centre of cluster, because of which data point belongs to more than one centre of cluster.

4.3. Log-Based Clustering

The logs which are maintained by information retrieval process (like web servers access logs) can be used to achieve image segmentation using clustering. But log–based clustering can result in incomplete information. This is because log–based clusters are created on those forms which are accessed by some of the users. To solve this issue, a log –based vector is kept for each session vector which is built on log–based documents [13]. A given document in a hybrid matrix form is usually represented by one vector. And for those documents that are in a log based document is created in a hybrid matrix form. Also the unaccessed document generates their own vector. The documents which are a cluster of content based clustering algorithm is basically represented by a hybrid matrix. The log–based clustering algorithm is fairly precise in comparison to previous algorithm but this algorithm is not very proficient to use.

An image can be clustered by the recovery systems which are managed by the information reclamation procedure. The session keys are retrieved and shaped for retrieval process. By this process the session clusters are made. Each session cluster creates documents based on log and resemblance of image couple is recovered. For each session vector a log-based vector is formed which depends on the documents based on log. Further, this vector is swapped by the session vector. The unaccessed document generates its own vector. A hybrid matrix is created with a single distinct document vector and one log-based clustered vector. Finally the hybrid matrix is clustered. This method is quite tough to achieve in the case of multidimensional images. To solve this problem, hierarchical clustering is approved.

5. Literature Survey

SyojiKobashi (2013) *et al.* present that in order to properly study the medical images, the study of image segmentation is essentially required. Though there are numerous literatures that studied automated image segmentation, it is then also quite tough to section regions of interest in any form of picture. In this paper two methodologies of interactive image segmentation method based on Fuzzy Connectedness Image Segmentation (FCIS) are introduced in order to shorten the process time and to reduce the effort of users. The first technique enhances object affinity of FCIS in line with user's additional seed voxels. The second method samples the outline of the object affinity by making use of the radial-basis function network (RBFN). These suggested techniques enhances segmentation outcomes for the other miss classified voxels and for the primary seed voxels. The second technique however produced better outcomes than the first according to experimental outcomes [14].

Jay C. Acharya (2013) *et al*. present that the phenomena like atmosphere, water, temperature and pressure have a direct impact on the properties of submerged images. This tells the significance of Image segmentation, in which a digitalized image is segmented into numerous segments or regions based on the value of pixels. Image Segmentation is the most advanced technique among all essentially computerized image recognition systems. There exists many such segmentation techniques that are used for segmenting submerged images. The presentation of an algorithm performing Image Segmentation is based on the interpretation of image. Algorithms based on Image segmentation namely adaptive image thresholding, Fuzzy C means with thresholding, K-means segmentation, edge based image segmentation are applied for submerged images and these techniques are also compared on the parameters like Relative Entropy, Redundancy and Discrete Entropy. Fuzzy c means with thresholding (FCMT) performs far better than other methods is shown by the experimental results is shown in the paper[15].

AC Bharath (2014) *et al*. present that with a huge number of images, User assisted segmentation of lungs parenchyma pathology bearing regions becomes more tough. In this paper, a technique using Bayesian network model based (BNMB) Image Segmentation is proposed which is a graphical model for segmenting lung tissues from the CT images of chest. The aim of this technique is to partition of lung parenchyma from the rest of chest CT image. This is done with the use of a probabilistic graph construction to show the coordination between edge segments and super pixel regions. By using an iterative method which depends on the probability model, the regions are identified and then finally regions are merged together. In this paper, experimental results demonstrates high precision and productivity in segmenting CT image of lungs [16].

Xuemei Cui (2014) *et al*. present that on weak edges the watershed transform shows good performance but in process of image segmentation not able to get useful partition in an image. In this work an enhanced watershed algorithm present for image segmentation. By the use of watershed algorithms get the marks on the forefront and background objects obtain better partition. With properties of gradient image and morphological open close function reconstruction operations the watershed transform algorithm applying to obtain the structure tag. Then, obtained tag using morphological minimum calibration technology forces as an original local minimum value of the gradient image, and shields the original all local minimum value in the gradient image. At the end, watershed which is enhanced by the gradient images will have a image segmentation, in such aspects as outline eliminate over segmentation and regional positioning have a very good segmentation effect [17].

Yongjing Wan (2015) *et al*. present that Image edge detection is sensitive to noise which is contained by natural images so that it affects the quality of the picture partition. In order to remove noise and improve edge detection accuracy, then improving the quality of picture segmentation, a novel image segmentation algorithm via neighborhood the main section analysis and Laplace operator is proposed. The feature vectors of each pixel are extracted through the main section analysis to get the main component, which effectively suppresses noise. Then the Laplace operator is used to detect the edge to realize the image segmentation. Compared to the traditional image segmentation of Sobel operator and LOG operator, the algorithm is proposed estimate the parameter values by principal component analysis instead of depending on experience. It can effectively decrease the noise on the image interference and simplify the computational complexity. Experimental results demonstrates that the algorithm can effectively improve the segmentation of the picture with a strong advantage in the accuracy and robustness [19].

Junpeng Wu (2015) *et al*. present that Markov Random Field (MRF) model along with Image Segmentation is anticipated to attain the sonar image segmentation. In this firstly, the assets of the field and the label field of sonar image is recognized by the MRF model. After this, the remaining image segmentation is handled by region growing centered on the primary image segmentation and finally this minimizes the segmentation signs which are a result of MRF method. In this paper, the experimental results demonstrates that the discussed technique obtains image segmentation well.

Nupur J. Gandhi (2014) *et al*. present that Image segmentation is an important and interesting matter in an image study. In an image, segmenting object is quite tough and costly. A region based Image Segmentation technique that is mean shift clustering approach is studied in this paper. In Image Segmentation, the most essential phase is pre-processed image by a typical mean shift based segmentation that conserves needed gaps which are there in the image and guarantees over

segmentation in the picture. This mean shift segmentation process which partitions the regions decreases the noise sensitivity and therefore increase the presentation of segmentation [21].

Table 1. Monochrome Image Segmentation Techniques [22]

Segmentation Technique	Method Description	Advantages	Disadvantages
Histogram Thresholding	This segmentation process mainly needs that the histogram of the picture has numerous peaks, where each relates to a specific region.	It normally doesn't require a previous information of the image. And it includes fewer calculational complexity.	1) Basically for an image without some noticeable peaks or the image with wide and even valleys, this technique does not works fine. 2) This technique does not reflect the facts, so it is not able to assure that partitioned regions are contiguous.
Region-Based Approaches	Group Pixels into homogeneous regions. Includes region merging, region splitting, region growing or their combinations	It works best when the region homogeneity standard is quite simple to describe. This technique first removes noise and then detects the edges.	1) The biggest drawback is that this technique is quite costly both in memory management and time used in computations; 2)This technique has a characteristic dependency on the variety of seed region and the way in which regions and pixels are studied;

Edge Detection Approach	Based on the recognition of discontinuity, basically efforts to locate points with more or less abrupt changes in gray level.	Edge detection technique is the method in which human notices things and works well for images having fine difference between regions.	1)It does not work fine with images in which the edges are not properly-defined or there are many edges; 2) It is not a insignificant job to crop a closed curve or boundary; 3) Less resistant to noise than other techniques.
Fuzzy Approaches	Apply fuzzy operators, mathematics, Properties and inference rules, provide a way to handle the uncertainty inherent in a diversity of problems due to ambiguity rather than randomness.	Fuzzy membership function can be used to represent the degree of some properties or linguistic phrase, and fuzzy IF-THAN rules can be used to perform approximate inference.	1)The determination of fuzzy membership is not a small job; 2) The computation involved in fuzzy approaches could be intensive.
Neural Network Approaches	Using neural networks to perform classification or clustering	No need to write complicated programs. Can fully utilize the parallel nature of neural networks.	1) Training time is long; 2)Initialization may effect the result; 3)Overtraining should be avoided.

Table 2. Image Segmentation Methods: A Comparative Study [23]

Parameter	Threshold Based Segmentation	Edge Based Segmentation	Region Based Segmentation
Nature of the Output Image	Black-White	Black-White	Black-White
Spatial Information	Neglected	Neglected	Considered
Region-Continuity	Moderate	Moderate	High
Computation Complexity	Less	Moderate	High
Speed	Fast	Moderate	Slow
Noise Immunity	Noise Immunity	Noise Immunity	Less
Detection of Multiple objects	Poor	Poor	Moderate
Automaticity	Interactive (Semi Automatic)	Interactive	Interactive (Semi Automatic)
Accuracy	Moderate	Moderate	Good

6. Conclusion

In mainframe vision, image segmentation is defined as the process in which an image is partitioned into many sections. The aim of segmentation is to solve and/or vary the depiction of an image into something that is more essential and easy to examine. Image segmentation is basically used to see objects and background in images. More exactly, the process in which a label is assigned to every pixel in an image so that pixels with exactly same label share certain visual properties is called Image Segmentation. Image segmentation is an essential signal handling tool that is widely used in many applications including object base coding, object detection, object tracking, image retrieval, and clinical organ or tissue identification. Image segmentation is very important in many medical imaging applications. Here presenting some survey and review of the current technologies and approaches for the segmentation of images. In this paper some important issues in image segmentation have been discussed. Reviews related with image segmentation and problem identification about those papers have been covered.

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