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A Survey on Image Segmentation Using Clustering Techniques

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Abstract: ***Image is information which has to be processed effectively. Segmentation, partitions the image into multiple segments. Image segmentation assigns label to every pixel in an image such that pixels with the same label share certain visual characteristic. Several segmentation algorithms are used for this purpose, but all are not suitable for all types of images. In this paper, Threshold method, Region based method, Edge Detection and Artificial Neural Networks (ANN) are discussed. Types of clustering are also studied. Fuzzy clustering is a class of cluster analysis and is powerfully growing approach. Clustering techniques are been widely used for effective automated segmentation.***

Keywords: ***Segmentation, Clustering, Fuzzy C-Means Clustering (FCM), image processing, clustering, Artificial Neural Networks***

I. INTRODUCTION

Image segmentation is the process of partitioning a digital image into multiple segments. Each segment will represent some kind of information to user in the form of color, intensity, or texture. 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. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics. The result of image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image. Each of the pixels in a region are similar with respect to some characteristic or computed property, such as color, intensity, or texture. Adjacent regions are significantly different with respect to the same characteristic(s).

The importance of Image segmentation can't be neglected because it is used in almost every field of science, [i.e., removing noise from an image, medical images [6]-[10], satellite imaging, machine vision, computer vision, biometrics, military, Image Retrieval [11]-[12], extracting features and recognizing objects from the given image. It is observed that there is not a perfect method for image segmentation, since each image has its own different type. It is also a very difficult task to find a segmentation technique for a particular type of image. Since a method applied to one image may not remain successful to other type of images.

II. Image Segmentation Techniques

Many image segmentation techniques have been developed by researchers and scientists, some of the most important and widely used image segmentation techniques are given below:

A. Thresholding

This is the simplest method of image segmentation and is extensively used. Thresholding is used to create binary image based on intensity of the image. This method attempts to find an intensity called threshold. The range function is applied to the intensity values of the image pixels. This technique is to partition an input image into two or more sub-images by comparing with the predefined threshold value T [1]. Let I (i, j) be an image,

$$I(i,j) = \{ 0, p(i, j)<T$$

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{ 1, p(i, j)≥T

Where p (i, j) refers to the pixel value at position (i, j). Thresholding can be either locally or globally. Global thresholding partitions the image into two based on the above equation. In local thresholding image is divided into sub images and thresholding properties are derived from the local properties of its pixels [3]. The disadvantages of this method are difficulty in finding the threshold value, they often lack the sensitivity and specificity needed for accurate classification, thresholding does not take into account the spatial characteristics.

B. Region Growing

Region growing is simple segmentation technique. Regions of an image are connected based on some criteria. These criteria can be intensity information or edges in the image. Region based segmentation is partitioning of an image into similar areas of connected pixels based on some criteria [4]. This technique starts by choosing an arbitrary seed pixel and compare it with neighbouring pixels. Neighbouring pixels that are similar are grouped with the seed points, which increases cluster size. Its main disadvantage is that manual interaction is needed to obtain the seed point. Initial selection of seed point affects the final result. This method can be sensitive to noise and also sensitive if seed lies on edge. Seeded Region Growing (SRG) is one of the simplest region growing algorithms. There are two approaches in region-based methods: Region growing and region splitting.

In the region growing methods, the evaluated sets are very small at the start of the segmentation process. The iterative process of region growing must then be applied in order to recover the surfaces of interest. In the region growing process, the seed region is expanded to include all homogeneous neighbours and the process is repeated. The process ends when there are no more pixels to be classified. Because initial seeds are very small, the processing time can be minimized by minimizing the number of times an images element is used to determine the homogeneity of a region.

In region splitting methods, on the other hand, the evaluation of homogeneity is made on the basis of large sets of image elements. The process starts with the entire image as the seed. If the seed is inhomogeneous, it is split into a predetermined number of sub regions, typically four. The region splitting process is then repeated using each sub region as a seed. The process ends when all sub region are homogeneous. Because the seeds being processed at each step contain many pixels, region spitting methods are less sensitive to noise than the region growing methods. In both approaches, their iterative structure leads to computationally intensive algorithms.

C. Wavelet segmentation

Wavelet technique divides the image into detailed sub signals. A mathematical tool for hierarchically decomposing functions in the frequency domain by preserving the spatial domain is the wavelet [5]. Wavelets represent the image in time-frequency domain. Wavelets are used as basic functions ψk (t) in representing other functions f (t).

Wavelets are functions generated from a single basis function by its operations dilations and translations. The Haar transform is commonly applied tool used in the wavelet transform for the image decomposition and feature extraction. The mathematical analysis of Haar transform is used for image compression and image pixels features extraction using decomposition and reconstruction matrices. This method provides perfect image reconstruction. Haar transform is the simplest compression process of this type. The wavelet transform offers great design flexibility. To enable real time processing capability fast implementation of wavelet transforms using a filter-bank framework is used. Multi-resolution representation is one of the most important features of wavelet transform [6]. Wavelets are used in applications such as computer graphics, image compression and digital image processing and feature detection.

D. Edge Detection

Edge detection techniques have been used as the base of segmentation technique. Edge detection is a basic step for image segmentation process [24]. It divides an image into object and its background. Edge detection divides the image by observing the change in intensity or pixels of an image. Gray histogram and Gradient are two main methods for edge detection for image segmentation [25]. Several operators are used by edge detection method, i.e., Classical edge detectors, zero crossing, Laplacian of Guassian(LoG)[26], and color

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edge detectors etc. The edges identified by edge detection are often disconnected. To segment an object from an image however, one needs closed region boundaries. The desired edges are the boundaries between such objects.

E. *ANN Based Image Segmentation*

In Artificial Neural Network, every neuron is corresponding to the pixel of an image. Image is mapped to the neural network. Image in the form of neural network is trained using training samples, and then connection between neurons, i.e., pixels is found. Then the new images are segmented from the trained image [40]. Some of the mostly used neural networks for image segmentation are Hopfield, BPNN, FFNN, MLFF, MLP, SOM, and PCNN. Segmentation of image using neural network is perform in two steps, i.e., pixel classification and edge detection [41]. In this section several new approaches of ANN used for image segmentation is discussed from last five years.

III. Clustering Type

A. Hard Clustering

Hard clustering assumes sharp boundaries between clusters [2]; a pixel belongs to one and only one cluster. A popular and well known hard clustering algorithm is K-means clustering algorithm. K-means algorithm is a clustering technique to partition n pixels into k clusters, where $k < n$. K-means algorithm Developed by Mac Queen in 1965 and then refined by Hartigan and Wong in 1979. K-means algorithm is a clustering technique, which classify pixels in an image into K number of clusters, where K is a positive integer, according to some similarity feature like grey level intensity of pixels and distance of pixel intensities, from centroid pixel intensity. The main advantages of this algorithm are its simplicity and low computational cost, which allow it to run efficiently on large data sets. The main drawback is that: K the number of clusters must be determined, it does not yield the same result each time the algorithm is executed and the resulting clusters depend on the initial assignments of centroids. They assume a Euclidean space, and they also assume the number of clusters, k, is known in advance. It is, however, possible to deduce k by trial and error.

The process is as follow:

(i) Randomly choose number of clusters K.
(ii) Randomly chooses K pixels of different intensities as Centroids.
(iii) Centroids are calculated out by finding mean of the region and place Centroids as much far away from each other as possible.
(iv) Now, compare a pixel to every centroid and assign pixel to closest centroid to form a cluster.
(v) Re-estimate the mean of the cluster as new centroid.
(vi) Repeat step 5 & 6, until Centroids no longer move.
(vii) Image is now separated into K clusters.

The complexity of the k-means algorithm is O (n*K*I*d) where, n is number of points; K is cluster number: I is number of iterations; d is number of attributes.

B. Soft Clustering

In real time applications, one of the most difficult task in image analysis & computer vision is to classify the pixel in an image correctly [8], when there is no crisp boundaries between objects in an image thus in order to address this difficulty , fuzzy clustering techniques are used.

Soft or Fuzzy clustering technique classify pixel values with great extent of accuracy & it is basically suitable for decision oriented applications like tissue classification & tumor detection etc. Fuzzy clustering divides the input pixels into clusters or groups on the basis of some similarity criterion, such that similar pixels belong to same cluster. Similarity criterion used can be distance, connectivity, intensity. The resulting partition improves the understanding of human beings & helps in a more informed decision making. The advantage of fuzzy system is that they are easy to understand, as the membership function partition the data-space properly [8]. Fuzzy clustering algorithms include FCM (fuzzy C means) algorithm, GK (Gustafson-Kessel), GMD (Gaussian mixture decomposition), FCV (Fuzzy C varieties), AFC (Adaptive Fuzzy Clustering) algorithm and etc. The FCM is the most accepted method since it can preserve much more information than other approaches.Fuzzy c-means algorithm (FCM) is most popular objective function based fuzzy clustering algorithm.

FCM algorithm the procedure is as follows:

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(i) Initially the number of clusters c ($2 \leq c < n$), m, U are specified by user.
(ii) All the user-defined parameters are defined, run the algorithm.
(iii) The validity index measures the compactness of the output cluster is measured.
Validity index measures like Partition Coefficient, Partition Entropy, etc ate used to measure the fitness of the outcome.
(iv) If the calculated index is satisfactory, then it moves to next step or the parameters are changed and process is repeated.
(v) Least Square Estimation (LSE) is calculated. This error should be minimum.

(vi) Finally the outputs obtained for various inputs are compared and plotted.

The selection of initial cluster center is directly related to the performance of the algorithm. If cluster center is close to actual center, then the algorithm converges quickly. This also reduces the processing time.

Disadvantage of FCM is that for noisy images it does not take into account spatial information, which makes it sensitive to noise & other image artifacts. To overcome these drawbacks of FCM, several other algorithms are introduced as modified FCM, GSFCM (Generalized spatial FCM), mean shift based FCM, FLICM (fuzzy logic information C-means clustering algorithm), NFCM (novel FCM), and ISFCM (improved spatial FCM).

IV. CONCLUSION

In this survey, an overview of different segmentation methods and clustering are studied, an overview of all related image segmentation techniques has been presented in this paper. Though many techniques are developed, not all types are useful for all types of images. Segmentation segments the image and clusters according to some similarity. In this, Fuzzy is powerful unsupervised clustering method which is widely used for robust segmentation of real time images. This review provides a platform for the development of the novel techniques in this area as future work.

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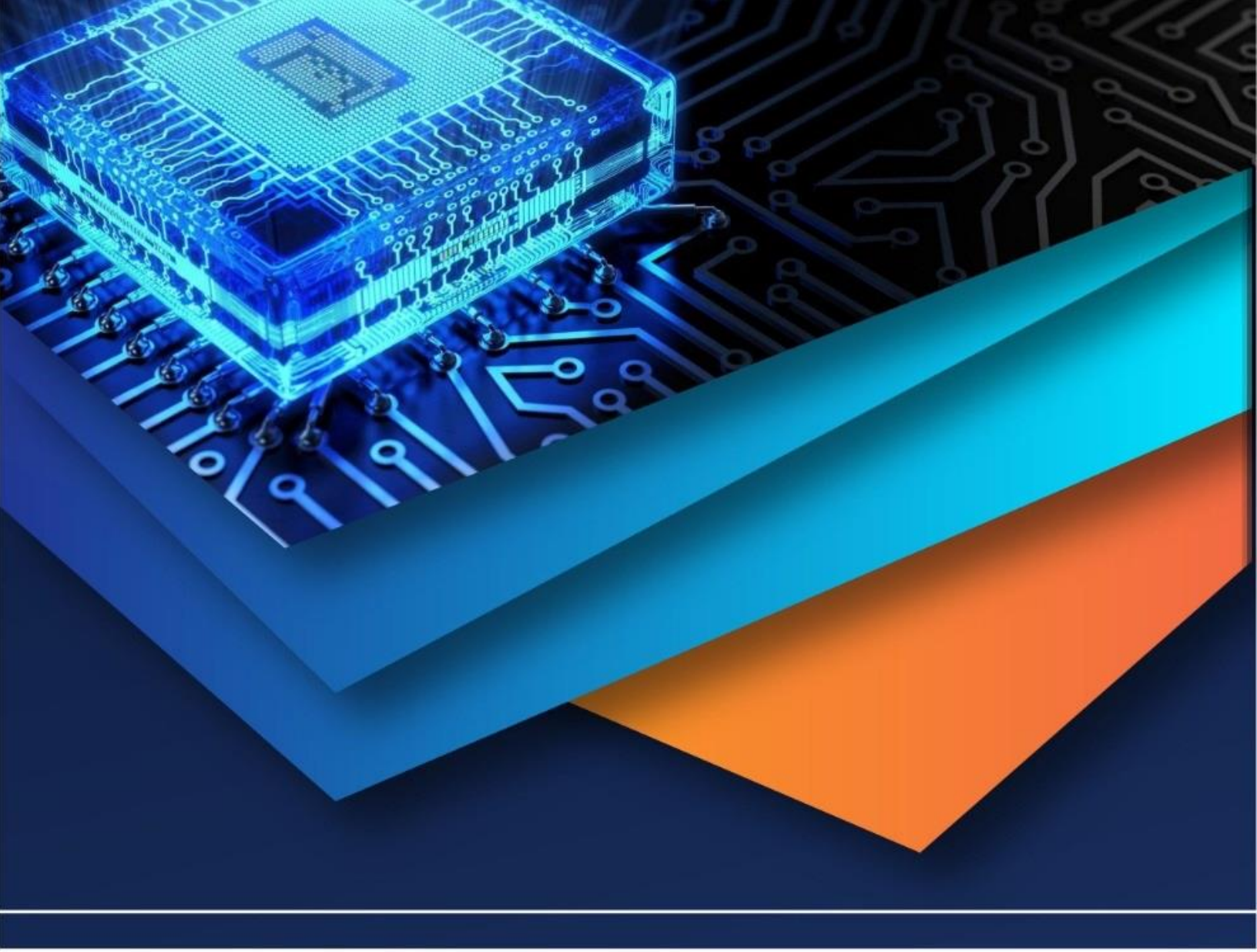

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