Image Segmentation Techniques: A Survey

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***Abstract*—Image segmentation is a mechanism used to divide an image into multiple segments. It will make image smooth and easy to evaluate. Segmentation process also helps to find region of interest in a particular image. The main goal is to make image more simple and meaningful. Existing segmentation techniques can't satisfy all type of images. This survey addressed various image segmentation techniques, evaluates them and presents the issues related to those techniques.**

***Index Terms*—segmentation, image processing, clustering, partial differential equations**

I. Introduction

One of the major goal of image processing is to retrieve required information from the given image in a way that it will not effects the other features of that image. De-noising/enhancement of an image is the most important step required to fulfill this requirement [1]-[2]. After removing noise from an image, you can perform any operation on that image [3].

Image Segmentation is one of the main steps of image processing, in which any image is being subdivided into multiple segments. Each segment will represent some kind of information to user in the form of color, intensity, or texture. Hence, it is important to isolate the boundaries of any image in the form of its segments [4]. This process of segmentation will assign a single value to each pixel of an image in order to make it easy to differentiate between different regions of any image. This differentiation between different segments of image is done on the basis of three properties of image, i.e., color, intensity, and texture of that image. Therefore the selection of any image segmentation technique is done after observing the problem domain [5].

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 Reerival [11]-[12], extracting features and recognizing objects from the given image. [13]-[15]

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, therefore segmentation techniques has been divided into three types, i.e. segmentation techniques based on classical method, AI techniques, and hybrid techniques [16]. Some of the most famous image segmentation methodologies including Edge based segmentation, Fuzzy theory based segmentation, Partial Differential Equation (PDE) based segmentation, Artificial Neural Network (ANN) bases segmentation, threshold based image segmentation, and Region based image segmentation are highlighted in Fig. 1. Fig. 1 contains important and famous image segmentation techniques used for the purpose of image segmentation.

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 shown in Fig. 1. Latest research work on image segmentation techniques highlighted in Fig. 1 is discussed and evaluated below.

A. Threshold Based Image Segmentation

Histogram thresholding is used to segment the given image; there is certain pre-processing and post-processing techniques required for threshold segmentation [17]. Major thresholding techniques proposed by different researchers are Mean method, P-tile method, Histogram dependent technique, Edge Maximization technique, and visual technique. In this section, several new approaches from last five years regarding threshold based image segmentation are being discussed.

Salem Saleh Al-amri [18] has applied Mean technique, Pile technique, HDT, and EMT technique on three satellite images in order to select the best segmented image from all above techniques. Experiments and comparative analysis of techniques have shown that HDT (Histogram Dependent Technique) and EMT (Edge Maximization Technique) are the best thresholding techniques which outperform all other thresholding techniques.

Kaiping WeI [19] have found that current image segmentation techniques are time consuming and require lot of computational cost in order to perform image segmentation. It is a big problem for real time applications. They proposed a new threshold based segmentation method using Particle Swarm Optimization (PSO) and 2-d Otsu algorithm (TOPSO). TOPSO

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algorithm used PSO technique to search an optimal threshold for the segmentation process. They implement the proposed hybrid method on Matlab 7.0. Results shown that TOPSO algorithm takes 25 times less time as compare to traditional Otsu algorithm. It is good for real time applications.

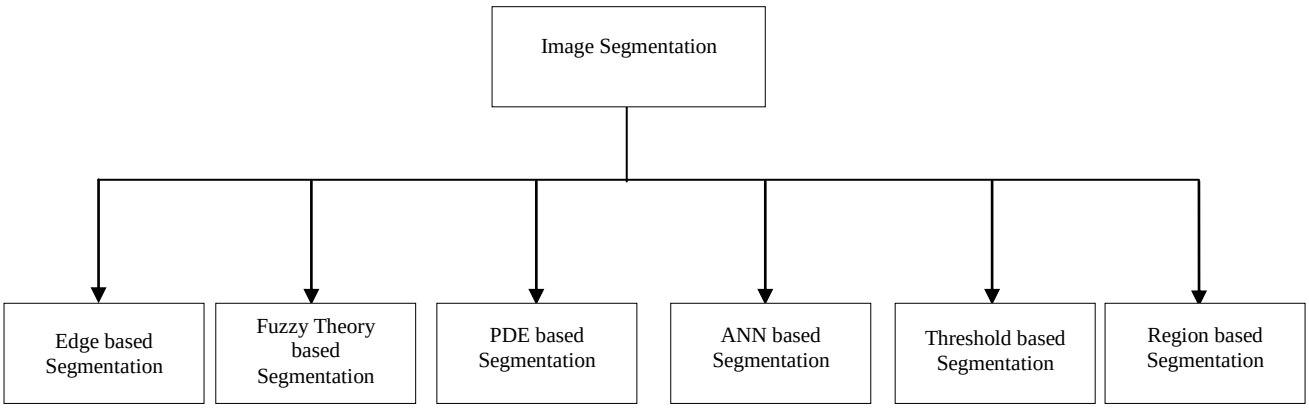

Figure 1. Various image segmentation techniques

B. Region Based Image Segmentation

Region based segmentation is simple as compare to other methods and also noise resilient. It divides an image into different regions based on pre-defined criteria, i.e., color, intensity, or object. Region based segmentation methods are categorized into three main categories, i.e., region growing, region splitting, and region merging [20]. In this section several new approaches regarding Region based image segmentation is discussed from last five years.

Karoui [21] proposed a new unsupervised image segmentation method using level set methods and texture statistics. They claim that their method is different from other methods since it doesn't assume independent variable, and it doesn't restrict to first order grey features. The implementation includes feature selection step to re-adjust the weights of each feature to get the segmentation. In experiment stage, filter response histogram is used to calculate the number of distributions; haar wavelet is used to compute the energy of image wavelet of each band. PDE is used to re-initialize the level sets. Results have shown for a zebra image as correct segmentation.

Yong-mei Zhou [22] has introduced new region-based image segmentation technique with the help of mean-shift clustering algorithm. Firstly, their method extract color, texture, and location features of each pixel of an image, secondly, make the clusters on the basis of those features using mean-shift clustering approach, label the each region, and finally make segments of image on the basis of these labels. They used Matlab 7.0 to implement their algorithm. Experiment shows that their method present better results in term of sped and segmentation.

Civahir Cigla [23] presented a new graph theoretic color image segmentation method, and tries to improve the normalized cut image segmentation method. They used image with weighted un-directed graph, whereas nodes represent the regions, and weights between nodes represent the intensity match of neighboring regions. Their modified normalized cut method has solved the problem of over segmentation in which extra regions are created for image. Experiments are conducted on images of cow, mosaics, and multi-resolution NC image and results compared with NCIS algorithm on the basis of MSE criteria. The results shown that proposed method improve the NCIS algorithm.

C. Edge Based Image Segmentation

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 edge detectors etc [27]. In this section several new approaches regarding Edge detection based image segmentation is discussed from last ten years.

Yu Xiaohan [28] proposed a new image segmentation technique based on region growing and edge detection methods. Their hybrid method helps the segmentation process to avoid from errors when both techniques used in a separate manner. Region growing is used to find the edge pixels in the image, while 2^{nd} order derivative is used for edge detection. Experiments are conducted on 3D MRI image data. Gaussian technique is used for smoothing after edge detection. Results have shown that their technique is better in order to preserve more edge information.

Wesolkowsk [29]-[30] have used the Markov Random Fields for edge and region based hybrid color image segmentation. Firstly, line process is implemented using edge detection algorithm. Vector angle measure is used as a distance measure between pixels in order to detect edges. The main problem with their technique is that it is a pixel neighbor model and has the same drawbacks of region growing method. A parameter estimation technique is used to evaluate the MRF model.

Ying-Tung Hsiao [31] proposed a new image segmentation technique by combining morphological operator with region growing technique. Firstly they used morphological closed operation to enhance the image and then perform edge detection using dilation residue edge detector. After it they deploy growing seeds and perform the region growing process for mage segmentation, after it, region merging and edge detection is performed on the images. They perform experiments on table tennis, girl and MRI image. Snake boundary condition method [32] is used to get better edge detection results. All experiments are conducted in Visual C++.

Amjad Zaim [33] has found that segmentation of prostate boundaries from ultrasound images is a challenging task for surgical procedures. They proposed a new edge based segmentation technique for prostate ultrasound image. Phase symmetry is used to perform the edge detection on the ultrasound images. Median filter is used to reduce the noise. Edge extraction and edge linking is used to produces the final edge based segmentation image. The main advantage is that their method doesn't require any human intervention. Results of contour produced by their method are compared with manually segmented contours, and accuracy of 87% is found.

D. Fuzzy Theory Based Image Segmentation

Fuzzy set theory is used in order to analyze images, and provide accurate information from any image. Fuzzification function can be used to remove noise from image as well [34]. A gray-scale image can be easily transformed into a fuzzy image by using a fuzzification function. Different morphological operations can be combined with fuzzy method to get better results [35]. Fuzzy k-Means and Fuzzy C-means (FCM) are widely used methods in image processing [36]. In this section several new approaches of image segmentation using Fuzzy theory is presented.

Gour Chandra Karmakar [37] introduced a new fuzzy rule based image segmentation technique which can integrate the spatial relationship of the pixels. Three types of membership functions are used, i.e., Membership function for Region pixel distribution, to measure the closeness of the region, and to find the spatial relationship among pixels. There is no need to define parameters in their technique, like FCM algorithm. Fuzzy rules uses above three membership functions and fuzzy IF-THEN rule structure to perform segmentation of an image. FCM and proposed technique is implemented on Matlab 5.3.1 on X-ray image and human vocal tract image. Results have shown that GFRIS outperform FCM and isolate the object from background accurately.

Amol S. Pednekar [38] proposed a new image segmentation technique based on fuzzy connectedness using dynamic weights. Author has found that traditional segmentation schemes can't solve the problems of fuzzy medical images. They introduce DyW algorithm which dynamically adjusts the linear weights in fuzzy connectedness. The seed DyW algorithm is applied successfully to the images of different modalities, whereas multiple seed is applied to infrared face segmentation. It is found that DyW image segmentation algorithm gives 99% more accuracy as compare to other techniques.

Liu Yaju [39] has proposed a new fuzzy color image segmentation algorithm based on feature divergence and fuzzy dis-similarity. Their algorithm claims to improve segmentation quality. Their algorithm extracts sub-images feature eagen-vector using watershed technique. Firstly, color image is transform into gray level image, histogram is created in second step, cluster are created in next step, FCM is applied to each cluster, then they applied erosion, dilation, and region growing on resultant image. After it, the segmented region image is produced at the end. Image is taken with complex background, i.e., photographic images. Results have shown that fuzzy approaches generate better results.

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.

Xuejie Zhang [42] proposed a new Fast learning Artificial Neural Network (FLANN) based color image segmentation approach for R-G-B-S-V (i.e., RGB and HSV) cluster space. In first step, noise is removed using 3*3 averaging filter to reduce the disparity in color distribution. In second step, pixels are converted to RGBSV space using HSV conversions. FLANN clustering is performed to produce a cluster result of image. Next, pixels with same color are being separated. Segment number is assigned to each segment of image. Effect of tolerance and neighborhood size is observed. Results have shown that proposed algorithm produced perfect segments for colors in the image.

Farhad Mohamad Kazemi [43] proposed a fast C-means based training of Fuzzy Hopfield Neural network [44] in order to apply it into image segmentation. Objective function is used based on 2-f Fuzzy HNN. This objective function found the average distance between image pixels and cluster's centroids. According to author, Fuzzy HNN provides better segmentation as compare to other methods. Firstly, they make clusters from given data, then perform normalization, i.e. grey level images, calculate centroids, then compute distances, find new centroids, and computer new membership function value using fuzzy C-means [45]. The results have shown that FHNN provides a faster speed as compare to other techniques of ANN.

F. PDE Based Image Segmentation

PDE (Partial Differential Equations) equations or PDE models are used widely in image processing, and specifically in image segmentation. They uses active contour model for segmentation purpose. Active Contour model or Snakes transform the segmentation problem into PDE. Some famous methods of PDE used for image segmentation are Snakes, Level-Set, and Mumford shah method [46]. In this section, several new approaches for image segmentation based on PDE are discussed.

Gloria Bueno [47] presents a new method of segmentation of anatomical structure in medical images. Adaptive PDE models, i.e., fuzzy PDE Contour model, and PDE geometrical Contour model with Fuzzy C-Means classification is used for segmentation of images. Adaptive PDE models helped to find the region of interest. 3D brain MRI Image is used as a dataset. Fuzzy PDE model has segment the MRI brain image using Fuzzy Clustering approach. The model has outperformed 'Snakes' model and reduce some of drawbacks of Snakes model.

Feature extraction schemes in [48]-[49] are capable to handling geometrical complexity, rate of change, and orientation of image. New PDE based segmentation scheme is also presented that increase contrast criteria of texture information. PDEs are used for modeling the segmentation scheme. Watershed method [50] is extended by using PDE models. They compare their proposed scheme with watershed segmentation method, and it is found that coupling of textural information, and modeling using PDEs leads the image segmentation to high quality process and outperforms the watershed segmentation algorithm.

III. Conclusion

In this article, various techniques of image segmentation has been discussed, an overview of all related image segmentation techniques has been presented in this paper. Recent research in image segmentation techniques is presented in this paper. After the analysis of different techniques of image segmentation, it is observed that a hybrid solution for image segmentation consists of two or more techniques is being the best approach to solve the problem of image segmentation.

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