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Image Segmentation Techniques: A Survey

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ABSTRACT

Segmenting an image utilizing diverse strategies is the primary technique of Image Processing. The technique is broadly utilized in clinical image handling, face acknowledgment, walker location, and so on. Various objects in an image can be recognized using image segmentation methods. Researchers have come up with various image segmentation methods for effective analysis. This paper presents a survey and sums up the designs process of essential image segmentation methods broadly utilized with their advantages and weaknesses.

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1. INTRODUCTION

An image with digital in nature is basically collection of pixels which is an array in two dimensions. The weight (numeric value) of each pixel shows its intensity in gray-scale images. The digital images are categorizing into three various categories- grayscale, binary and color. In case of binary image, the possible pixel weight can be only 0 or 1 which is captured in memory space in packet of array of bits as bitmap. The binary images are one the most suitable form for digital processing like segmentation and image thresholding. The weights in grayscale images are in the form of array having the values 0 to 255. The weight 0 represents black color whereas 255 indicates white color and values in between 0-255 shows the various shades of gray. The color images are characterized with an array of RGB (Red, Green and Blue) triples. The weight varies from 0 to 255, where zero reflects no prime color and 255 represents the peak value of main color in the particular pixel.

The image processing is a technique to transform the given image into digital format and extracting best possible crucial data. The image is considered as one of the best approaches to transfer data. In the digital image technology, useful information is extracted from image is the significant area of application. To better understand the process, segmentation of images is done beneath image processing. The process of partitioning an image into many parts in such a manner that it is easy to express and study, is called as image segmentation.

The technology used to convert the digital image in to various sub images or subdivisions or parts or segments is known as segmentation. It is perilous image exploration system [1]. Popular techniques of Image

segmentation are Threshold, Edge Detection, Region based methods, Histogram and Watershed Transformation techniques. As images are classified according to their color like gray scale and color images. Content based retrieval [2] [3] shows that segmenting the color images is different compared to segmenting the gray scale images. Type of image decides the algorithm to be used [4]. Property as well as information of pixels in an image are two parameters for image segmentation algorithm on the basis of edges of an image, edge-based segmentation is used. Background is separated from image using threshold in the region-based methods while learning algorithm is used in neural network. Training in image segmentation is done using neural network [5]. Parameters obtained are used in next level research from the results obtained in different segmentation techniques. Different algorithms are used to diagnosis the diseases like spine, pathology localization, blood vessel and heart [6,7,8,9] in medical science and engineering. Still so much literature is available, but researchers have the challenges to find a robust technique for segmenting the image [10].

The main image segmentation techniques are Edge based, Fuzzy based, partial differential equation based, ANN, threshold based, region based, segmentation based on clustering and segmentation based on CNN [11,12]. Image is represented as meaningful as well as analysable form in image segmentation and it is the first step in analysis of images. Most of the common applications of image segmentations are: Medical Imaging, Automatic traffic control systems, object detection, object recognition, object detection and recognition and surveillance, content-based image recovery etc. [13].

There are two basic types of image segmentation classified as Local Segmentation and Global Segmentation. A number of algorithms are proposed in literature by various authors for segmentation process of images. The latest medical testing and diagnostic equipment (MRI, CT scan, PET scan etc.) produce a very sophisticated images which are quite difficult to study and understand manually. This challenges the researchers to develop the more effective and robust techniques to meet the requirements of medical images [14].

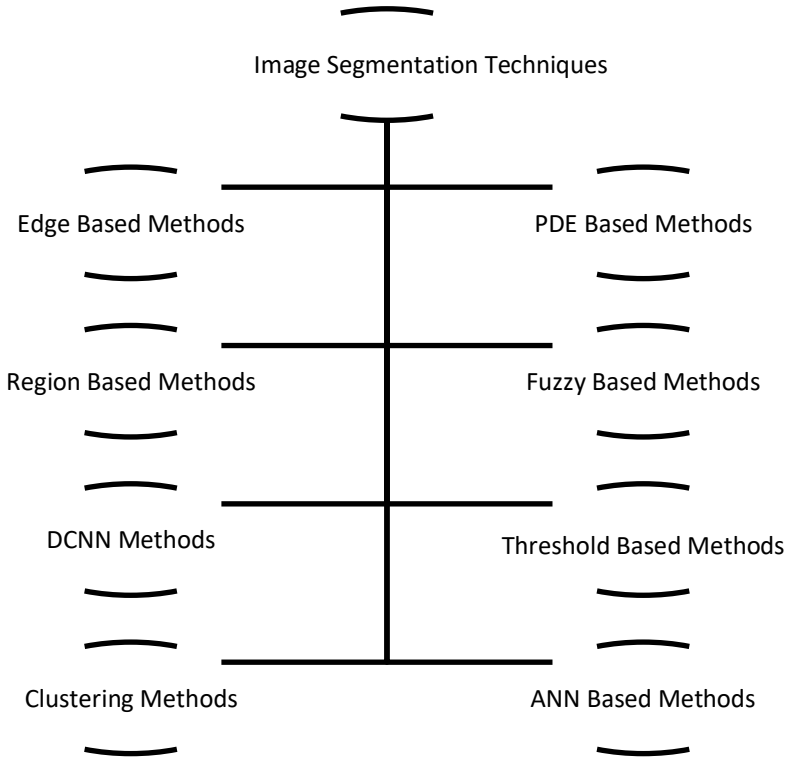

Figure 1. Image Segmentation Techniques

2. CLASSIFICATION OF IMAGE SEGMENTATION TECHNIQUES

Many different techniques of image segmentation have been described in the literature. [60,61,62]. It is worth to state that all the accessible methods utilized for image segmentation have their own significance however the edge-based and locale-based methodologies are the most fundamental and well-known

methodologies. All the methods can be drawn nearer from these two fundamental methodologies. All the procedures are ordered into three classes [15, 16].

1) Basic Segmentation strategies- These are the method which depends upon the data of the structure of required segment of the image.
2) Stochastic Segmentation Techniques- These are the methods which deal with discrete pixel estimations of image as opposed to auxiliary data together.

3) Hybrid Techniques-These sorts of strategies utilize the ideas of both Structural Segmentation procedures and Stochastic Segmentation methods i.e. auxiliary data and discrete pixel esteems together the most popular techniques used for image segmentation are Edge-based, Fuzzy-based, PDE-based, ANN-based, Threshold-based, Region-based, Clustering-based and NN based supervised learning. Fig. 1 shows the different Image segmentation techniques which are discussed below.

2.1 Edge Based Image Segmentation

The local features of the image which are discontinuous in nature are known as the edge of the object. The various properties change into local brightness in this process like- the mutation of gray value, color mutation, change in the texture etc. Finally, by detecting the edge based on the discontinuities, the image segmentation is realized.

Edge and information based on region using morphological algorithm as well as spectral method is being proposed by F Monteiro [17] in the segmentation technique for image processing. In the first step, bilateral filter is used to reduce the noise as a pre-processing step, while in the second step, preliminary segmentation is done by merging the regions. In the next step region similarity is performed and lastly graph based using Multiclass Normalized Cut method (MCNCM) [18] is done. Data sets used are Berkley segmentation dataset. The technique is compared with multi-scale graph-based segmentation, mean shift, and JSEG. The results obtained outperformed other methods. Estimation of number of clusters with the help of edge detection method by R V Patil [19] was another method for segmenting the image. They proposed that K-means segmentation provides good results when clusters are estimated in correct manner. After that these edges are used to find clusters. Clusters are made by using threshold and Euclidean distance. Finally, K-means is used for segmenting the image. The new method was introduced by Anna Fabijańska [20] in which by using the variance filter, edge position was found for the edge detection in image segmentation.

Mohammed J. Islam [21] found that image segmentation techniques are also used in pharmaceutical companies for real time inspection of capsules using computer vision. This is done to develop a robust system for good quality inspection with the help of edge-based image segmentation techniques which is also used for facial recognition as discussed in [22]. This is done with Sobel Edge Detector is to detect the edges by means of noise-suppression property. Finally, for localization of background and foreground pixels, Otsu Thresholding technique was used in image segmentation. Experimental results when compared with neural network-based segmentation techniques are better as accuracy seems better because of only 10ms processing time difference. Gupta et al. [23] presented a hybrid edge-based segmentation method for ultrasound medical images. The proposed method is based on the kernel fuzzy clustering and active contour model using distance regularized level set function. The proposed method helps to remove the need of manual intervention and also increase the averaged computational time.

2.2 Fuzzy Theory Based Image Segmentation

The new Algorithm named fuzzy morphological based on fusion image segmentation algorithm was proposed by Sostak et al [24]. Operations like Morphological opening and closing operations which are discussed in detail in [25] are applied on final image using the algorithm to smoothen as well as to perform the gradient operation. Comparison of watershed algorithm with Prewitt methods shows that problem of over-segmentation can be solved by fusion approach with improved speed. Srinivasan et al [26] used fuzzy object model and also scale based fuzzy segmentation to find cerebral parenchyma region by segmenting the brain image of newly born baby. Foreground region parted as a first step followed by MRI intensity correction in- homogeneity as a second step and finally Fuzzy Object Model which is scale based as a third step is applied to obtained the resultant image [27].

The technique discussed in paper [28] introduces a generalized transfer learning scheme using rule based fuzzy logic for edge detection in digital images. The spatial domain statistical properties of the image are explored as training data set and expressed in fuzzy format to obtain a decision function for optimal edge detection along with reduction of impulse noise. Muhammad Rizwan Khokher [29] also proposed image segmentation technique using Fuzzy Rule and Graph Cuts based system. In the first step gray scale, color as well as texture images using graph cuts are segmented. Secondly, weights are assigned using fuzzy rules to

the features of image. In the proposed algorithm, they firstly extract the features of images and then calculate the constants with the help of fuzzy rules followed by calculations of weighted average constants to find similarity matrix and lastly partition the graph [30] to get the segmented image using normalized graph cut method. The data set used was Berkley database to evaluate the algorithm. Experiments are performed by simulation using tool MATLAB and programming language.

2.3 Partial Differential Equation (PDE) Based Image Segmentation method

Fast segmenting methods use Partial Differential equations (PDE) method which is being used in image segmentation techniques. Non-linear isotropic diffusion filter and convex non quadratic variation restoration are the two basic PDE methods. Second order PDE methods can be used to detect the edges and boundaries while fourth order PDE method is used to minimize the noise in the image. Non-linear discontinue partial differential equation (PDE) model proposed by Guo et al. [31]. The curve representation method in plane differential geometry is expounded, with the SegNet-v2 segmentation model analyzed and tested in medical image segmentation. The test results show that the partial differential equation image segmentation algorithm can achieve more accurate segmentation, especially in medical image segmentation, which can achieve good results, and it is worth in practice to further promote. Fengchun Zhang [32] proposed variation model with the help of fourth order Partial Differential Equation for the vein of finger to find image de-noising. Noise is reduced by 4th order PDE and boundaries are approximated with 2nd order PDE effectively. 2dB Power to signal (P/S) ratio increases in the experimental results. Results attained in the proposed method are more accurate when comparing with threshold-based segmentation technique or algorithm for the real finger vein image. For the color images, C Yuan [33] segmentation model was based on Geodesic Active Contour (GAC) model having limitation that it is limited to the images having gray-scale only.

2.4 Artificial Neural Network (ANN) Image Segmentation techniques

Extracting the features followed by segmentation using neural network are the two basic steps in ANN. Artificial Neural Network (ANN) is mostly used in medical science extensively. Inputs to system for segmentation are extracted features of the images. Targeted images are separated from background proposed by Wencang Zhao [34] is an image segmentation technique or algorithm depends totally on textural features [35] as well as neural network [36]. The Dataset used are CT images and in the pre-processing step noise is removed from the image using De-noising filter. Feature extraction as a second step followed by Back Propagation Neural Network is created to modify the weight number in the network. The speed and accuracy of proposed algorithms outperforms thresholding method and region growing method of segmentation.

Mohan and Raj [37] classified the rice grains based on non-contact image processing technique in which features extracted are examined for the quality of grain using Neural Networks (NN) and Support Vector Machine (SVM) classifier. Ahmed in [38] proposed the technique as image texture classification technique in which image is captured to have pre-processing as a first step followed by feature extraction [39] and ANN classifier [40] for texture classification.

2.5 Threshold Based Image Segmentations

Images with different intensities are effectively used in this approach because image with different intensity values is partitioned into many different regions. Threshold based image segmentation is the simplest method of image segmentation and also one of the most common and widely used [41] parallel segmentation methods. Pare et. al. [42] have given a detailed review on threshold-based segmentation. Anping XU [43] proposed the new method in which both thresholds based and Fast Marching Method segmentation technique is included for medical images [44]. Filter result (de- noising) passes to Fast Marching Method using threshold-based technique for segmentation purpose.VC++ and ITK is used to find the results which are clearer, accurate and more perfect segmentation. Frank Jiang [45] proposed a multilevel segmentation technique based on threshold using PSO and Wavelet mutation. The method is compared with HCOCLPSO, and it is found to produces optimal threshold and the algorithm is suitable for real time applications.

2.6 Region Based Image Segmentations

Magnitude gradient as a pre-processing step with noise filter is used as a first step. Pre- segmentation as a second step followed by region similarity graph and lastly segmentation is done with the help of Multi Class Normalized Cut. Results of proposed technique are far better as compared to Spectral Clustering method. It is difficult to find fast extraction of object information from a given image in real time image processing. Baziyad et. al [47] proposed a precise segmentation process using the region-growing

segmentation method is applied to maximize the homogeneity level between pixels in a segment, and thus, maximizing the hiding capacity while achieving improved stego quality. Image is taken as an input to extract gray values as well as edges by means of Gabor filter [48]. In this case, Guass-Laplace filters [49] is also used. Lastly ANN methods are used to extract the region of interest. The boundary information and segmentation results are well achieved with help of regional growth which easily distinguish the connected regions with similar characteristics. The information on common development is humble and needs a couple bit focuses to finish.

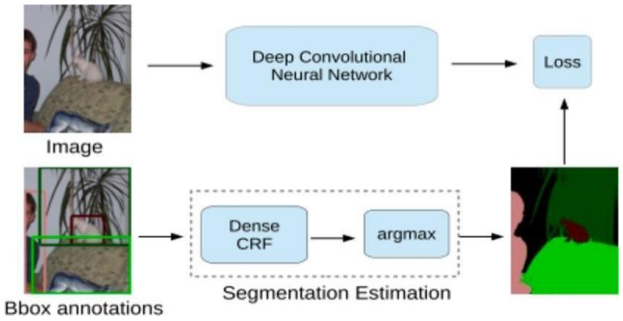

Figure 2. Deep Lab model training using image-level labels

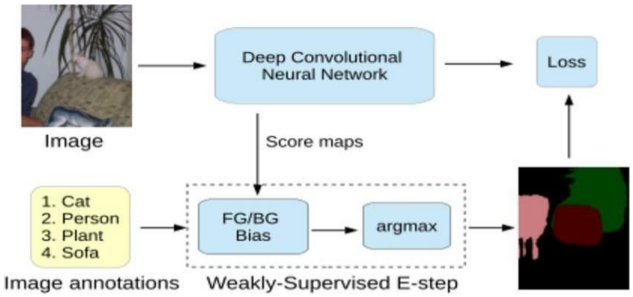

Figure 3. Deep-Lab model training from bounding boxes

2.7 Clustering Based Image Segmentation

One of the most popular image segmentation technique is K-means based clustering algorithm but its performance is marred by its random election of initial centers which greatly affect its performance [50, 51]. Another problem of this method is that it can't decide about the number of clusters in advance for the unknown data [52]. K-means method can find out optimum number of clusters in image segmentation if used with gap method. This is a strategy in which pixels of image are isolated into various groups as indicated by according to global features distribution. Some specific theories and methods are combined in image segmentation techniques known as collection of similar elements. Clustering methods using feature space are used to segment the pixels in the image. Feature space in this aggregation is segmented and mapping is done by back the original image space to achieve the segmented results. The most common algorithm used for clustering is K-means. The idea behind is collection of samples into dissimilar clusters rendering to distance. The execution for K-means be:

- K initially centers are selected randomly.
- Distance of each sample to each cluster center is calculated.
- The center of new clusters is taken as mean of all samples.
- Repetition 2nd& 3rd step till the cluster center reaches the required set nos. of iterations.

This K-mean clustering algorithm is not only simple but fast also. Highly efficient is also one of the main advantages of this algorithm. Also, this algorithm is a distance-based partitioning method [53]. Another algorithm of image segmentation is agglomerative top-down method [54] which then similar clusters can be merged to reduce number of clusters [55] but its major problem is that it cannot find optimum number of clusters up to which clusters can be merged. Various schemes have been evolved for image segmentation using clustering techniques [64, 65, 66].

3. COMPARISON AND ANALYSIS

There are several methods of finding the quality or validity of segmentation such as Davies Bouldin Index (DB) [56, 57], Dunn's Index [58] and many other Validity Measures based on similarity and dissimilarity concept [59]. Based on the above discussion, it can be clearly deduced that for real time application clustering method and thresholding methods are good for their speed but these should be watched out for their quality. There are sophisticated methods such as fuzzy based and ANN based but these are computationally intensive and can be used only in offline segmentation or one time segmentation scenarios. Comparison between various Image Segmentation techniques is shown in Table 1. It shows the description of various methods with their limitations.

Table 1. Different Segmentation techniques comparison

Segmentation techniques	Method description	Advantages	Limitations
Edge Based	Discontinuity detection dependency	It is better for images with fine difference between regions.	It is less resistance to noise, mostly depends on peaks.
Fuzzy based	Fuzzy mathematics and operators are applied in this method.	Degree of linguistic phrase is represented by using fuzzy membership function.	Intense computation is involved in this method.
PDE	Differential equations dependent.	One of the fastest techniques.	Complex computation.
ANN	Based on simulation of learning process for decision making.	Complex programs can be avoided.	Delay in training is large.
Thresholding	Threshold values are found which depends on the histogram peaks.	One of the easiest methods which do not required any previous information.	Peaks dependent.
Region Based	Images are partitioning into homogeneous regions. It also uses region splitting, merging and growing.	Effect of noise is more.	Costly in reference to memory and time.
Clustering	It is based on Segmentation into homogeneous clusters.	Useful in real-time problem applications.	Difficult to determine the membership function in the method.
DCNN Method	FCN and CRF is used to get the better	Results are very good.	Complexity is high.

4. CONCLUSION

The paper describes various image segmentation procedures that can be utilized in image analysis. Considering the diversity of these techniques it is hard to decide about the procedure to be implemented for a particular application. presented. In view of the advantages and limitations of these image segmentation method, it is inferred that hybrid arrangements having different techniques are better for image segmentation. Also, machine learning algorithms are used for parameter selection to improve the segmentation. Finally, the region of interest is retrieved with the help if CNN model and then in the next stage it is segmented by using traditional segmentation method to enhance the segmentation results.

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