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Review of Image Segmentation Techniques Including Pre & Post Processing Operations

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Abstract*— Image Segmentation has been an area for a long time which is providing opportunities to do research work. Image segmentation is most of judging or analyzing function in image processing and analysis. Image segmentation is a process of partitioning an image into meaningful regions that are homogenous or similar and inhomogeneous in some characteristics. Image segmentation results have an effect on image analysis and it following higher order tasks. Image analysis includes object description and representation, feature measurement. Higher order task follows classification of object.. Hence characterization, visualization of region of interest in any image, delineation plays an important role in image segmentation .These image segmentation techniques need comparative analysis for further development and modifications for continuous and consistent improvement. Hence, in this paper an overview of image segmentation and its present techniques is presented which demands a lot of research work.

***Index Terms*— Image, Image Segmentation, Segmentation Techniques..**

I. INTRODUCTION

Images are considered as one of the most important medium of conveying information, in the field of computer vision, by understanding images the information extracted from them can be used for other tasks [9].

An image is a word derived from Latin word '*imago*', which is a representation of visual perception in a two-dimension or three-dimension picture that has a similar appearance to some subject.

A digital image is a numeric representation of a two-dimensional image. A digital image is composed of a finite number of elements, each of which has a particular location and value, are called picture elements, image elements, pels and pixels [1]. Pixels are the smallest individual element in an image, holding finite, discrete, quantized values that represent the brightness, intensity or gray level at any specific point.

There are generally two types of image- raster type and vector type. *Raster images* are images having a finite set of digital values which are represented in a fixed number of rows and columns of pixels where these pixels are stored in memory as a two-dimensional array. Digital images are usually referred as raster images. *Vector images* are images generated from mathematical geometry known as vector which have points having both magnitude and direction. The paper is organized as follows: the current section gives an overview of image and its types; the next section describes image segmentation and its processes; the third section gives a description of the different image segmentation techniques and their different respective methods used; the fourth section compares the different segmentation techniques and their methods on the basis of their advantages and disadvantages; and the last section gives a brief conclusion of the whole.

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II. IMAGE SEGMENTATION

Image segmentation is the foundation of object recognition and computer vision [2]. Image segmentation is the process of subdividing a digital image into multiple regions or objects consisting of sets of pixels sharing same properties or characteristics which are assigned different labels for representing different regions or objects. 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 [2]. Image segmentation is used to locate objects and boundaries in images. Segmentation is done on basis of similarity and discontinuity of the pixel values.

There are two types of segmentations – soft segmentations and hard segmentations. Segmentations that allow regions or classes to overlap are called *soft segmentations* whereas a *hard segmentation* forces a decision of whether a pixel is inside or outside the object [3].

Image segmentation is practically implemented in many applications such as medical imaging, content based image retrieval, object detection, feature recognition (such as face recognition, fingerprint recognition, iris recognition, object recognition, etc) and real-time object tracking in video.

The following computational steps have to applied for image segmentation process on the image taken as input to get the required segmented data [4], [5], [6]:-

1) Preprocessing: The main aim of the preprocessing step is to determine the area of focus in the image [4]. As the input image may have a certain amount of noise in the images, it is necessary to reduce or remove the noise.

2) Image Segmentation: In this step, the preprocessed image is segmented in its constituent sub-regions.

3) Post Processing: To improve the segmented image, further processing may be required which is performed in post processing step.

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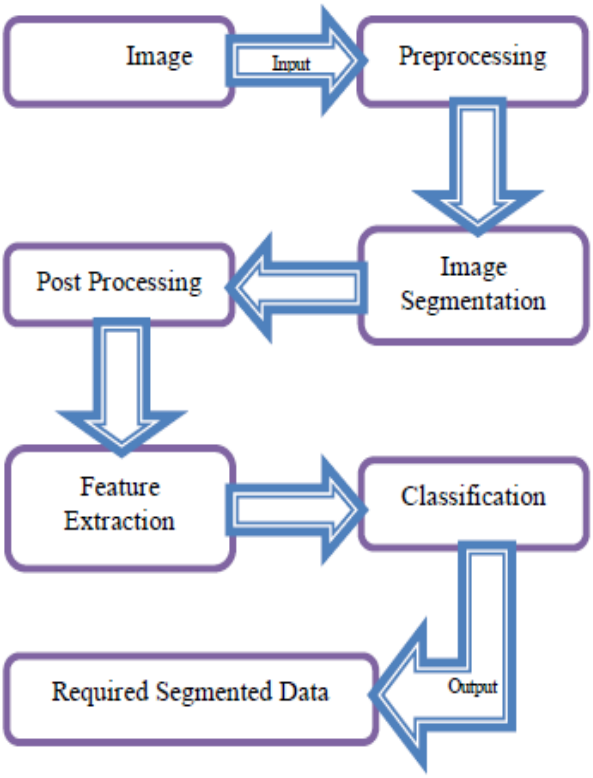

Fig. 1: Computational steps for Image Segmentation.

4) Feature Extraction: Feature extraction is the method in which unique features of an image are extracted. This method helps in reducing the complexity in classification problems and the classification can be made more efficient [6]. Different kind of features present in an image can be intensity-based, textural, fractal, topological, morphological, etc.

5) Classification: The aim of the classification step is to classify the segmented image by making use of extracted features. This step uses statistical analysis of the features and machine learning algorithms to reach a decision [4].

III. LITERATURE SURVEY

Mei Yeen Choong [7], proposed segmentation on synthetic images and natural images are covered to study the performance and effect of different image complexity towards segmentation process. This study gives some research findings for effective image segmentation using graph partitioning method with computation cost reduced. Because of its cost expensive and it becomes unfavourable in performing image segmentation on high resolution image especially in online image retrieval systems. Thus, a graph-based image segmentation method done in multistage approach is introduced here.

Ivana Despotovi [9] present a new FCM-based method for spatially coherent and noise-robust image segmentation. The contribution is twofold: 1) the spatial information of local image features is integrated into both the similarity measure and the membership function to compensate for the effect of noise; and 2) an anisotropic neighborhood, based on phase congruency features, is introduced to allow more accurate segmentation without image smoothing. The segmentation results, for both synthetic and real images, demonstrate that our method efficiently preserves the homogeneity of the regions and is more robust to noise than related FCM-based methods.

Johannes Ulén [18] introduce a multiregion model for simultaneous segmentation of medical images. In contrast to many othermodels, geometric constraints such as inclusion and exclusion between the regions are enforced, which makes it possible to correctly segment different regions even if the intensity distributions are identical. than current state of the art. As the method is based on global optimization techniques, the resulting segmentations are independent of initialization.

Changyang Li [19] propose a novel joint probabilistic model that correlates a new probabilistic shape model with the corresponding global intensity distribution to segment multiple abdominal organs simultaneously. The probabilistic shape model estimates the probability of an individual voxel belonging to the estimated shape of the object. The probability density of the estimated shape is derived from a combination of the shape variations of target class and the observed shape information. To better capture the shape variations, we used probabilistic principle component analysis optimized by expectation maximization to capture the shape variations and reduce computational complexity. The maximum *a posteriori* estimation was optimized by the iterated conditional mode-expectation maximization. Human intestinal parasites constitute a problem in most tropical countries, causing death or physical and mental disorders. Their diagnosis usually relies on the visual analysis of microscopy images, with error rates that may range from moderate to high.

Truong Quang Vinh [12] present an embedded design for dental intraoral system which supports dental image capturing and image tooth segmentation. This device assists dentists in diagnosis by using dental images, which is captured from dental camera. Moreover, we propose advanced features for the dental intraoral system including touch screen with Vietnamese graphic user interface (GUI), dental image processing, patient records, and dentist's diagnosis note. Especially, the segmentation of teeth is important for examining and extracting teeth features from dental images. A teeth segmentation method based on active contour without edge algorithm has been proposed in this paper. Consequently, our system is portable, economic and ready to be applied at dental clinics. The system can help dentists examine at patient's home and voyages, not only in clinics.

The problem has been addressed by Celso T. N.Suzuki [17] via computational image analysis, but only for a few species and images free of fecal impurities. In routine, fecal impurities are a real challenge for automatic image analysis. We have circumvented this problem by a method that can segment and classify, frombright fieldmicroscopy images with fecal impurities, the 15 most common species of protozoan cysts, helminth eggs, and larvae in Brazil. Our approach exploits ellipse matching and image foresting transform for image segmentation, multiple object descriptors and their optimum combination by genetic programming for object representation, and the optimum-path forest classifier for object recognition. The results indicate that method is a promising approach toward the fully automation of the enteroparasitosis diagnosis.

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Maoguo Gong [21] present an improved fuzzy C-means (FCM) algorithm for image segmentation by introducing a tradeoff weighted fuzzy factor and a kernel metric. The tradeoff weighted fuzzy factor depends on the space distance of all neighboring pixels and their gray-level difference simultaneously. By using this factor, the new algorithm can accurately estimate the damping extent of neighboring pixels. In order to further enhance its robustness to noise and outliers, we introducea kernel distance measure to its objective function. The new algorithm adaptively determines the kernel parameter by using a fast bandwidth selection rule based on the distance variance of all data points in the collection. Furthermore, the tradeoff weighted fuzzy factor and the kernel distance measure are both parameter free. Experimental results on synthetic and real images show that the new algorithm is effective and efficient, and is relatively independent of this type of noise.

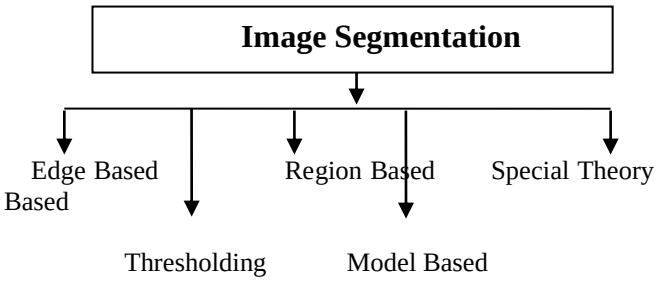
Peng Zhang, Ming Li [22] propose a hierarchical TMF (HTMF) model for unsupervised synthetic aperture radar (SAR) image segmentation. In virtue of the Bayesian inference on the quadtree, the HTMF model captures the global and local image characteristics more precisely in the bottom–up and top–down probability computations. In this way, the underlying spatial structure information is effectively propagated. To model the SAR data related to radar backscattering sources, generalized Gamma distribution is utilized. The effectiveness of the proposed HTMF model is demonstrated by application to simulated data and real SAR image segmentation.

Haili Zhang [23] presents a variational model for simultaneous multiphase segmentation and intensity bias estimation for images corrupted by strong noise and intensity inhomogeneity.Since the pixel intensities are not reliable samples for region statistics due to the presence of noise and intensity bias,the authors use local information based on the joint density within image patches to perform image partition. Hence, the pixel intensity has a multiplicative distribution structure. Then, the aximuma-posteriori (MAP) principle with those pixel density functions generates the model. To tackle the computational problem of the resultant nonsmooth nonconvex minimization, we relax theconstraint on the characteristic functions of partition regions, and apply primal-dual alternating gradient projections to construct a very efficient numerical algorithm. They show that all the variables have closed-form solutions in each iteration, and the computation complexity is very low. In particular, the algorithm involves only regular convolutions and pointwise projections onto the unit ball and canonical simplex. Numerical tests on a variety of images demonstrate that the proposed algorithm is robust, stable, and attains significant improvements on accuracy and efficiency over the state-of-the-arts..

IV. CLASSIFICATION OF SEGMENTATION TECHNIQUES

Image segmentation can be broadly classified into two types:
1. Local segmentation
2. Global segmentation

Global segmentation is concerned with segmenting a whole image. Global segmentation deals mostly with segments consisting of relatively large number of pixels[7]-[8].This makes estimated parameter values for global segments most robust. Image segmentation can be approach from three different philosophical perspectives. They are as region approach, Thresholding, edge approach, Model Based and Special Theory Based as illustrated in figure2.



Figur2: Classification of Image Segmentation Methods [2], [3], [5]

Several general-purpose algorithms and techniques have been developed for image segmentation. These techniques must typically be combined with a domain's specific knowledge in order to effectively solve the domain's segmentation problems. There exists many different types of segmentation techniques in literature but there is no particular method which can be applied on different types of images which would generate same result. Algorithm development for one class of images may not always be applied to other class of images [2]. Hence, there are many challenging issues like development of a unified approach to image segmentation which can be applied to all type of images, even the selection of an appropriate technique for a specific type of image is a difficult problem [2], [8], [9].

A. Thresholding

This is the simplest method used for image segmentation. In this method, a certain value is taken for measurement known as threshold. If the value of the pixel in an image is greater than or equal to the threshold value, then it is an object pixel or otherwise it is a background pixel [1]. Thresholding technique can be applied in three ways: local thresholding, global thresholding and adaptive or dynamic thresholding. *Local thresholding* technique is the one in which the threshold parameters is consider over small region. Intensity distribution of object and background pixel are sufficiently distinct, then it is possible to use a *global* (single) *thresholding* on the entire image. If threshold value depends on the spatial co-ordinates (a, b) themselves then thresholding is referred as *dynamic or adaptive thresholding* [1], [12].Thresholding methods can be categorized into the following six groups based on the information the different Thresholding algorithm manipulates [16]:

1) Histogram shape-based methods: In this method, the analysis of smoothed histogram is done on the basis of peaks, valleys and curvatures.

2) Clustering-based methods: In this method, the gray-level samples are clustered in two parts i.e. background object and foreground object, or alternately are modeled as a mixture of two Gaussians.

3) Entropy-based methods: In this method, the entropy of the foreground and background regions is used.

4) Object Attribute-based methods: In this method, the measure of similarity is searched between the gray-level or intensity and the binary images provided.

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5) Spatial methods: In this method, the higher-order probability distribution and/or correlation between pixels are used.
6) Local methods: In this method, the procedures that adapt the threshold value on each pixel to the local image characteristics are used.

B. Edge Based Segmentation

Edge detection is one of the fundamental methods for image segmentation and analysis. Edges are the boundaries between regions in an image, which helps with segmentation and object detection and recognition [8]. Edge pixel is a term in image processing and computer vision, which refers to those pixels at which there is an abrupt change or discontinuity in image brightness or intensity. Edge detection methods require a balance between detecting accuracy and noise immunity in practice. Thus, edge detection algorithms are suitable for images that are simple and noise-free as well often produce missing edges or extra edges on complex and noisy images [9].There are many ways to perform edge detection, however, the majority of different methods may be grouped into two categories:

1) Gray Histogram Technique**:** In this technique, segmentation is done on the basis of a threshold value. The threshold values used can be global threshold i.e. single valued threshold being applied on the whole image, multiple threshold i.e. arbitrary number of threshold is applied on the whole image and variable threshold i.e. different values of threshold is applied on different properties of the image. This method is very efficient as compared to other segmentation methods. Firstly depending upon the color or intensity a histogram is calculated from the entire pixel in the image, and then edges are located on the basis of contours and valleys in image are located [11], [12].

2) Gradient Based Method**:** Gradient can be defined as change in magnitude in the image while traversing from one end to another. This method involves convolving gradient operators with the image. If the gradient magnitude is high, then there is a possibility of rapid transition from one region to another. Then these are pixels which form edges and linking of these edges is done to form closed boundaries to result regions. Common edge detection operators used in gradient based method are Sobel, Prewitt, Roberts, or Canny method [1]. Canny method results are good compared to others, but take more time [12].

C. Region Based Segmentation

Region based segmentation is another image segmentation method in which the image is divided into its constituent sub-divisions which has similar properties known as regions [17]. This segmentation can be categorized into various techniques:

1) Region Growing**:** It is an approach of image segmentation in which pixel groups or sub-regions are grouped into larger regions based on predefined criteria of growth [1]. One seed pixel and threshold value is selected in this process and check is conducted for every pixel for the given threshold value. If threshold is greater than pixel value then put into one region otherwise put into another region. A small numbers of seed points are needed to represent the property of region we require. This process will be continued until
all the pixels are resulting into the region.

2) Region splitting and merging: It is an approach of image segmentation in which an image is subdivided into a set of arbitrary disjoint regions and then these disjoint regions are merged to satisfy the condition of segmentation [1]. A top-down approach used for splitting or dividing an image which results to a quad tree where an image is successively subdivided into smaller quadrant.

3) Graph Based Technique**:** It is based on pair wise region comparison. In Graph based approach for segmentation, there is a graph G having vertices V and edges E such that G=(V,E) where each edge is connecting two vertices and have a weight w(vi,vj) which is a measure of dissimilarity between two neighboring elements vi and vj [13].

D. Special Theory Based Segmentation

Many different fields have contributed in development of better image segmentation such as clustering based technique, neural network-based technique, genetic algorithm-based technique, wavelet-based technique, and so on [12].

1) Genetic Algorithm Based Segmentation**:** A genetic algorithm is a heuristic search method that imitates the process of natural selection and evolution for optimization of search problems. Genetic algorithm is a part of evolutionary algorithms (EA), which uses techniques like selection, crossover, mutation and inheritance. Solutions are represented by a population of individual chromosomes, each made of genes having their own property [18]. Crossover is done to combine two chromosomes to generate a new individual. Mutation is applied on a small set of individuals to alter their chromosomes which may generate optimal individuals thus, resulting optimal result. The genetic algorithms used for image segmentation can be classified into two major classes [19]:

i. Parameter selection based image segmentation
ii. Pixel-level labeling based image segmentation

2) Neural Network Based Segmentation: An artificial neural network is an imitation of a real nervous system. Neural networks are systems of interconnected "neurons" which communicate with each other and compute values from inputs by forward feeding or back propagate information through the network. Each neuron represents a pixel. The mostly used neural networks are Kohonen and Hopfield ANNs [20]. Neural network based segmentation approach has three basic characteristics [2]:

i. High parallel computing and fast computing capability.
ii. Unrestricted nonlinear and high interaction among processing units i.e. neurons.
iii. Satisfactory robustness making it insensitive to noise.

3) Clustering Based Segmentation**:** Clustering is a process of grouping of pixels into various classes without any prior information such that pixels belonging to the same class should be similar to each other. This technique can be classified into two types: Hierarchical clustering and Partition clustering [10]. In the *hierarchical clustering*, the distance between each pattern is calculated. In the *partition clustering*, centroid of cluster is calculated. Several clustering based image segmentation algorithm exists such as Fuzzy c means clustering algorithm and K-Means clustering algorithm [2].

4) Wavelet Based Segmentation: This technique uses wavelet transform for features extraction associated with individual image pixels [21]. Wavelet transform has been used as a good image representation and analysis tool mainly due to its multi-resolution analysis, data reparability, compaction and sparsity features in addition to statistical properties [22].

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Wavelets provide the inpainting feature for images. Inpainting is the art of modifying an image in a form such that it is not easily detectable by an ordinary observer [23].

E. Model Based Segmentation

Model Based Segmentation is useful when there is a need to segment object which have a repetitive structure or form of geometry i.e. the shape of the object to be segmented is known beforehand [17]. Hence, is widely used in medical imaging.

V. CONCLUSION

This paper presents discussion on image segmentation and its different techniques that are used in various fields such as biomedical field, computer vision and image processing. The review is aimed at providing an overview of current image segmentation techniques; therefore, analysis and comprehensive assessment of these image segmentation techniques are done. Based on this, we now come to the conclusion that image segmentation has a promising future and a lot of research work is required for developing a common and consistent segmentation technique which can be applied universally.

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