SURVEY ON VARIOUS IMAGE SEGMENTATION TECHNIQUES

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Abstract: ***The computer vision, image segmentation is the process of partitioning a digital image into multiple sections. That is more important and easier to examine. It is used to identify objects and background in images. It is the process of assigning a label to every pixel. Those pixels with the same label share certain visual properties. It is a signal processing tool. This is widely employed in many applications including object-based coding, object tracking, object detection, image retrieval, and clinical organ or tissue identification. That is, critically analyzed various segmentation techniques. Such as Thresholding, Edge based segmentation, Color based segmentation, and Region based segmentation and also covered image segmentation. This study is helpful for an appropriate use of existing evaluation methods. Then improving their performance as well as for systematically designing new evaluation methods.***

Index Terms— Image processing, Segmentation, Partial Differential Equations

1. INTRODUCTION

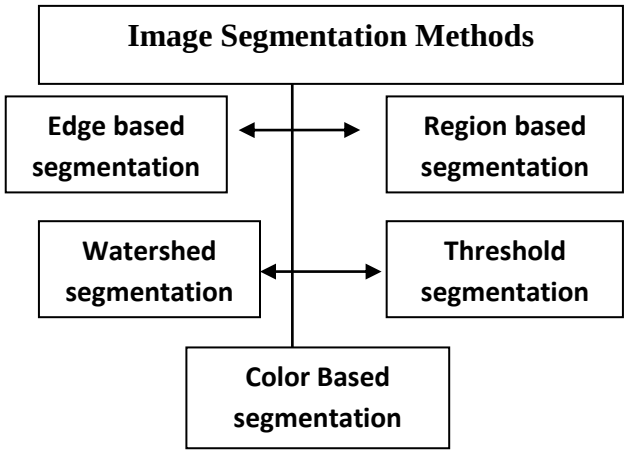
One of the major goals of image processing is to retrieve required information. The given image in a way will not affect another feature of that image. De-noising/enhancement of an image is the most important step necessary to fulfill this requirement [7] after removing noise from an image. Image Segmentation is one of the main steps of image processing. Any image is being subdivided into multiple segments. Each segment will represent the kind of information to the user in the form of color, intensity, or texture. It is important to isolate the boundaries of any image in the form of its segments [4]. This process of segmentation will be assigned a single value. Each pixel of an image in order segmentation technique is done after observing the problem domain [5].

Segmentation algorithms are based on two basic properties of color, gray values, or texture. It is discontinuity and similarity. The First category is to partition an image based on abrupt changes in intensity as edges in an image. The Second category is based on partitioning an image into regions. That is similar, according to predefined criteria. Histogram thresholding approach falls under this category. Image segmentation is an initial and vital step to a series of processes aimed at overall image understanding.

A method applied to one image may not remain successful to another type of images. The segmentation techniques have been divided into three types. Segmentation techniques based on classical method, AI techniques, and hybrid techniques. The most famous image segmentation methodologies including Edge based segmentation, color based segmentation, Partial Differential Equation-based segmentation, Artificial Neural Network based segmentation, threshold based image segmentation, and Region based segmentation.

Partitions are different objects in the image. Which include the equal texture or color? The result of image segmentation is a set of the region that collectively covers the entire image. A set of contour extracted from the image. All of the pixels in a region are similar with respect to several characteristics or computed property. Such as color, intensity, or texture. The next regions are significantly different with respect to the same characteristics. The Edge detection is one of the most frequently used techniques in digital image processing. The limitations of the object surface in a scene often lead to knowledge localized changes in an intensity of an image, called edges. Famous techniques of the image segmentation which are still being used by the researchers are Edge Detection, Threshold Region-based methods, and Watershed Transformation.

2. TYPES OF IMAGE SEGMENTATION



2.1 Edge-Based Segmentation

Segmentation can also be done by using edge detection techniques. In this technique, the boundary is identified to the segment. It is detected to identify the discontinuities in the image. Edges of the region are traced by identifying the pixel value and it is compared with the neighboring pixels. The edge-based segmentation there is no need for the detected edges to be closed. These methods have problems with images that are:

- Edge-less
- Very noisy
- Boundary that is very smooth
- Texture boundary

The four steps of Edge Detection

Smoothing: The contain as much noise as possible, without destroying the true edges.
Enhancement: Apply a filter to enhance the quality of edges in the image.
Detection: Determine which edge pixels should be discarded as noise. This should be retained.
Localization: Find out the exact location of an edge. Edge thinning and linking are usually required in this step.

Equation:

Let f(x, y) denote the input image and G(x, y) denote the Gaussian function:
Find the gradient strength and direction with:

$$G = \sqrt{G_x^2 + G_y^2}$$

$$\theta = \arctan\left(\frac{G_y}{G_x}\right)$$

Algorithm

Step1: Smooth the input image with a Gaussian filter.
Step2: Compute the gradient and angle images.
Step3: Apply maximum suppression to the gradient magnitude image.
Step4: Use double thresholding and connectivity analysis to detect and link edges.

Advantage:

- The approach related to how humans segment images.
- Works well in images with good contrast between object and background.

Disadvantage:

- Does not work well on images with smooth transitions and low contrast
- Sensitive to noise
- Robust edge linking is not trivial

2.2 Region-Based Segmentation

Region growing is a simple region-based image segmentation method. It is also classified as the pixel-based image segmentation method. The main objective of segmentation is to the separation of the image into regions. Several segmentation methods such as "Thresholding" achieve this goal by looking at for the boundaries between regions based on discontinuities in gray levels or color properties.

Equation:

Using intensity differences as a measure of similarity, our predicate applied at each location (x, y) is,
Q= {TRUE
if the absolute difference of the intensities between the seed pixel at (x, y) is $\leq T$.
Otherwise FALSE.

Region growing Algorithm:

Step1: Starts with a set of seeds (starting pixels)

- Predefined seeds
- All pixels as seeds
- Randomly chosen seeds

Step2: Region growing intensity steps (bottom-up method)

- Find starting points
- Include nearest pixels with similar features (Gray level, texture, color).
- A similarity measure must be selected.

Two variants:

1. Select seed from the entire range of gray levels in the image.
2. Select seed only from objects of interest.

Advantage:

- Region growing methods can correctly separate the regions.
- Region growing methods can provide the original images.
- We can choose the multiple criteria at the same time.

Disadvantage:

- The computation is strong, Rejection matter the time or power.
- Noise or difference of intensity may result in over segmentation.
- This method may not distinguish the shading of the real.

2.3 Watershed Segmentation

The introduced the watershed transformation as a means to separating overlapping objects. A watershed is formed by 'flooding' an image from its local minima and forming 'dams' where waterfronts meet. When simulating this process for image segmentation, two approaches are used. One finds basin then watersheds by taking a set of complement. One computes a complete partition of the image into basins and consequently refined the watersheds by boundary detection. To be more explicit use the expression `watershed transform' to denote a labeling of the image. All points of a given catchment basin have the same unique label. A special label, distinct from all the labels of the catchment basins, is assigned to all points of the watersheds.

Equation:

Let T[n] represent the set of coordinates (s, t) for which g(s, t) <n. That is,

T[n] = {(s, t)|g(s, t) <n}

Solving for watershed lag time.

$$t_L = L^{0.8}\frac{(S+1)^{0.7}}{1900 w_s^{0.5}}$$

Watershed algorithm

Step1: Let g(x, y) be the input image (often a gradient image).

Step2: Let M1…MR be the coordinates of the regional minima.

Step3: Let C (Mi) be a set consisting of the coordinates of all points belonging to the catchment basin associated with the regional minimum Mi.

Step4: Let T[n] be the set of coordinates (s,t) where g(s ,t)<t $T[n] = \{(s, t) \mid g(s, t) < n\}$

Advantage:

- The resulting boundaries form closed and connected regions.
- The boundaries of the resulting regions always correspond to contours.
- The union of all the regions forms the entire image region.

Disadvantage:

- Most natural images it produces excessive over segmentation

2.4 Threshold Based Segmentation

Thresholding is one of the simplest approaches for image segmentation based on intensity levels. The Threshold-based technique works on the statement that the pixels falling within the certain range of intensity values. Represents one class and remaining pixels in the image represents the another class. Thresholding can be implemented either locally or globally. For global thresholding brightness threshold value is to be selected. To segment the image into the object and the background.

It generates a binary image from given input image. The pixels fulfilling threshold test are considered as object pixels with binary value '1' and another pixels are treated as background pixels with binary value '0'. Where T is a predefined threshold.

Steps for multilevel Thresholding are:

- Divide image into subparts.
- Select local threshold for each subpart of an image.
- Compare the pixels for individual subpart and segment the region.
- Do again the process for each subpart and stop. when all subparts are segmented.

Equation:

where the membrane potential is governed by a differential equation:

$$C\frac{dV}{dt} = F(V) + I$$

Empirical threshold measures used *in vivo* can be analyzed in the same technique. The voltage threshold measured by the first derivative method is the value $\theta_e$such that DV/Dt=k_{th}. The solution of $F(\theta_e) = Ck_{th} - I$. The empirical threshold can be approximately related to V_T with the following formula $\theta_e \approx V_T + \Delta_T \log \frac{V_T - (E_L + RI - \tau k_{th})}{\Delta_T}$

Algorithm:
Step1: Select an initial estimate for the global threshold, T.
Step2: Segment the image using T.
Step3: This will produce two groups of pixels. The G1 consisting of all pixels with intensity values >T. The G2 consisting of pixels with values ≤T.
Step4: Compute the average (mean) intensity values m1, m2 for the pixels in G1 and G2, respectively.
Step5: Compute a new threshold value: T=1/2(m1+m2).

Advantage:
- Do not require previous information of the image.
- The computationally expensive.
- The Fast and simple for implementation.
- Can be used in real time Applications.

Disadvantage:
- Neglects spatial information of an image.
- Highly noise sensitive.
- Selection of threshold is crucial, the wrong choice may result into over or under segmentation.
- Gives the better result in comparison with other segmentation methods.
- Provides flexibility to choose an interactive and automatic technique for image segmentation.

2.5 Clustering Based color Image Segmentation

In cluster based segmentation, data is combined into groups. The data with similar features will fall into one group. The data clusters are being different from each other. The *k*-means algorithm is commonly used for determining the organization of the data. This unsupervised clustering approach has a strong affinity to get trapped into local minima. Generating an optimal solution. It makes clustering wholly dependent on the primary cluster centers distribution. Study to identify correct input parameters for getting optimal or suboptimal clustering results.

K-means Algorithm

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

Data clustering algorithms are built over the total image and these algorithms study data distance. The pixels of a cluster are not surely connected in a data clustering. The algorithms based on clustering are extra categorized into two techniques *i.e.* Hierarchical and Partitioned. Hierarchical clustering is a successive split process of fallouts in a cluster structure. Which is hierarchically nested, and partitioned clustering is an iterative partitioning process

Algorithm
Step1: Choose the number k of clusters, either randomly or based on several heuristics.
Step2: Generate k clusters and determine the cluster center.
Step3: allocate each pixel in the image to the clusters. That minimizes the distance between the pixel and the cluster center.
Step4: Re-compute cluster center by averaging all of the pixels in the cluster.
Step5: Repeat steps 2 and 3 until the meeting is attained.

Advantage:
- When k is small, K-means is computationally faster.
- It may produce clenched clusters than hierarchical clustering.
- The clusters are globular.

Disadvantage:
- Difficult to predict k with fixed number of clusters.
- Does not work well with a non-globular cluster.

Comparison of Segmentation Techniques

Segmentation Techniques	Method Description	Advantage	Disadvantage
Edge-Based Method	Based on discontinuity detection.	Works well in images with good contrast between object and background.	The Sensitive to noise Robust edge linking is not trivial.
Region Based Method	Based on partitioning an image into homogeneous regions.	Flow from inner point to outer region generates clear object boundaries.	Sequential by nature and quite expensive in both computation time and memory.
Clustering Method	Based on a division into cluster regions.	For small values of *k*, *k* means is computationally faster. Eliminates noisy spots.	Difficult to predict k with fixed number of clusters. Computationally expensive.
Watershed Method	Based on a topological interpretation.	The resulting boundaries form closed and connected regions.	Most natural images it produces excessive over segmentation.
PDE Based-Method	Based on the working of differential equations.	Works well for images having good contrast between regions.	Size of operator and computational complexity are Proportional to each other.
ANN Based Method	Based on the simulation of a learning process for decision-making system.	No need to write complicated the programs.	Training time is long. Overtraining should be avoided.

3. CONCLUSION

This paper summarizes various segmentation techniques, the advantages, and disadvantages. Segmentation can be applied to any type of images. Comparing to other methods thresholding is the simplest and computationally fast. Depending on the application the technique varies. Various techniques of image segmentation have been discussed. All related image segmentation techniques have been 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. The result of image segmentation depends on many factors, i.e., pixel color, texture, intensity, a similarity of images, image content, and problem domain. It is not possible to consider a single method for all type of images. All methods can perform well for a particular type of image.

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