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Image Segmentation Based on Thresholding, Cluster Based and RoI Method

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Abstract:
Image processing plays a one of the important vital role in developing real world application is an Image Segmentation, which is used widely in Computer vision for the purpose of object tracking and to identify image boundaries. It aims at extracting meaningful objects lying in the image. Generally there is no unique method or approach for image segmentation The different algorithms used in Image segmentation are Clustering-based, Region-based and Edge based. Image segmentation is the division or separation of an image into multiple segments i.e. set of pixels, pixels in a region are similar according to some criterion such as color, intensity or texture. This paper gives the view about the methods in image segmentation such as thresholding, k-means clustering, grab-cut method and graph -cut method. Every method is discussed along with its advantage and disadvantages which helps us in deciding which the best and efficient method of image segmentation is. The main aim of the paper is to come out with the more efficient method in image segmentation which can be used for real world application development.

1.1 Introduction

In computer vision, image segmentation is the process of partitioning a digital image into multiple segments. The goal of segmentation is to simplify and change the representation of an image into something that makes easy to extract more meaningful and easier to analyze. Image segmentation is used to locate objects and boundaries (lines, curves, etc.) in images. Image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain 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 (see edge detection). 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 characteristics

The division of an image into meaningful structures, image segmentation, is often an essential step in image analysis, object representation, visualization, and many other image processing tasks. A great variety of segmentation methods has been proposed in the past decades, and some categorization is necessary to present the methods properly here. A disjunct categorization does not seem to be possible though, because even two very different segmentation approaches may share properties that defy singular categorization. The categorization presented in this chapter is therefore rather a categorization regarding the emphasis of an approach than a strict division.

The following categories are used:

• **Threshold based segmentation**. Histogram thresholding and slicing techniques are used to segment the image. They may be applied directly to an image, but can also be combined with pre- and post-processing techniques.

• **Edge based segmentation**. With this technique, detected edges in an image are assumed to represent object boundaries, and used to identify these objects.

• **Region based segmentation**. Where an edge based technique may attempt to find the object boundaries and then locate the object itself by filling them in, a region based technique takes the opposite approach, by (e.g.) starting in the middle of an object and then "growing" outward until it meets the object boundaries.

• **Clustering techniques**. Although clustering is sometimes used as a synonym for (agglomerative) segmentation techniques, it is used to denote techniques that are primarily used in exploratory data analysis of high-dimensional measurement patterns. In this context, clustering methods attempt to group together patterns that are similar in some sense. This goal is very similar to segmenting an image, and indeed some clustering techniques can readily be applied for image segmentation.

• **Matching**. When an object to be identified is known(approximately), it can be matched with the image to identify. This approach to segmentation is called matching.

1.2 Thresholding

The simplest method of image segmentation is called the thresholding method. The thresholding methods replace each pixel in an image with a black pixel if the image intensity $\mathbf{I_{i,j}}$ is less than some fixed constant **T** (that is**,** $\mathbf{I_{i,j} < T}$), or a white pixel if the image intensity is greater than that constant. In the example Figure 1 & 2 shown below, this results in the dark tree becoming completely black, and the white snow becoming completely white. This method is based on a clip-level (or a threshold value) to turn a gray-scale image into a binary image. The key of this method is to select the threshold value (or values when multiple-levels are selected). Several popular methods are used in industry including the maximum entropy method, balanced histogram thresholding, hybrid thresholding and Otsu's method (maximum variance). Recently, methods have been developed for thresholding computed tomography (CT) images.

Figure 1. Original image

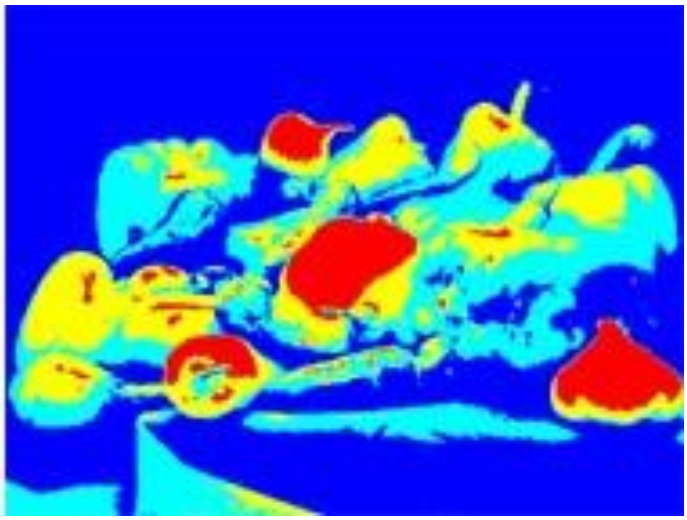

Figure 2. Threshold effect used on an image.

Algorithm:

1. Select initial threshold value, typically the mean 8-bit value of the original image.
2. Divide the original image into two portions;
    1. Pixel values that are less than or equal to the threshold; background
    2. Pixel values greater than the threshold; foreground
3. Find the average mean values of the two new images
4. Calculate the new threshold by averaging the two means.
5. If the difference between the previous threshold value and the new threshold value are below a specified limit, its finished. Otherwise apply the new threshold to the original image keep trying.

Advantages of Thresholding

- Does not require prior information of the image.
- Computationally inexpensive.
- Fast and simple for implementation.
- Can be used in real time applicatins.

Disadvantages of Thresholding

- For an image with broad and flat valleys or without any peak, it doesn't works well.
- Neglects spatial information of an image, cannot guarantee that the segmented regions are contiguous.
- Highly noise sensitive.
- Selection of threshold is crucial, wrong choice may result into over or under segmentation.

1.3 Clustering based method

Clustering of an image is one of the good techniques, which is used for segmentation of images. After extraction of features, these features are put together into well-separated clusters based on each class of an image. The clustering algorithm aim is to develop the partitioning decisions based on initial set of clusters that is updated after each iteration. Currently the clustering method often used for segmenting large-scale images. Clustering is one of the unsupervised learning method in which a set of essentials is separated into uniform groups. There are different types of clustering: hierarchical clustering, Fuzzy C-means clustering, K-means clustering. The K means method is one of the most generally used clustering techniques for various applications

K-means clustering

K-means clustering is a partition-based cluster analysis method. The K-means clustering technique is a widely used approach that has been applied to solve low-level image segmentation tasks. The choosing of initial cluster centers is very important since this prevents the clustering algorithm to producing incorrect decisions. The most common initialization procedure chooses the initial cluster centres randomly from input data. The procedure is shown in the below Figure 3 and Figure 4 is the original image to which k-means algorithm is applied .The result of the algorithm on image is shown in Figure 5.

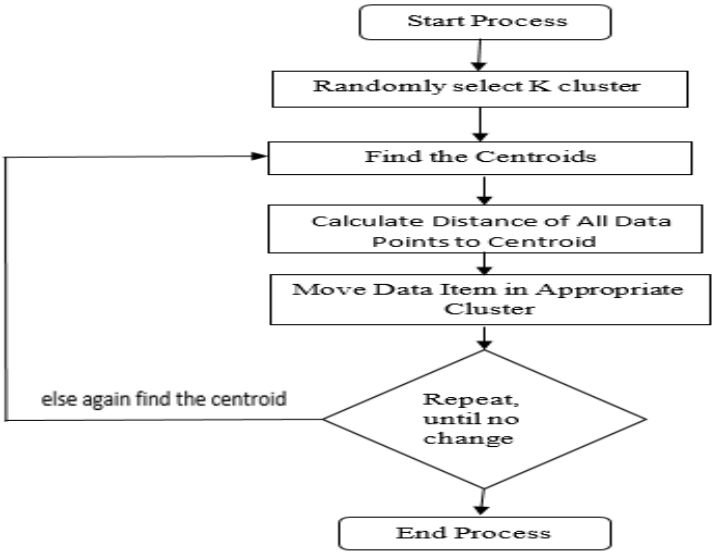

Figure 3. K-means algorithm

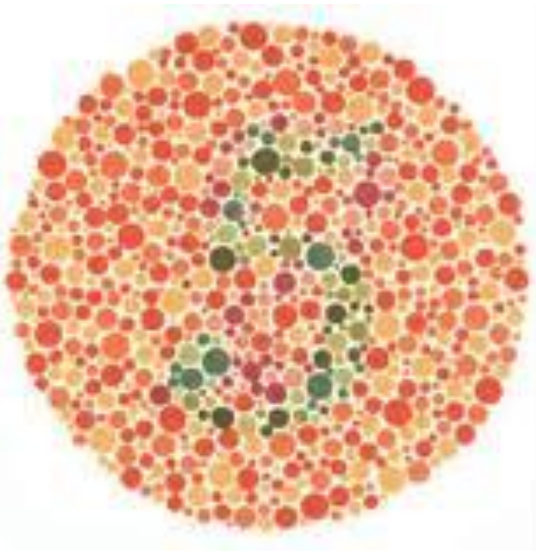

Figure. 4 Original image

Figure 5. Image after running k-means with k = 16

Advantages of Clustering based segmentation

- For small values of k,k-means is computationally faster.
- Eliminates noisy spots
- Reduces false blobs
- More homogeneous regions are obtained.

Disadvantages of Clustering based segmentation

- Difficult to predict k with fixed number of clusters.
- Sensitive to initialization condition of cluster number and centre.
- Computationally expensive.
- Doesn't works well with non globular clusters.

1.3 Grab Cut algorithm

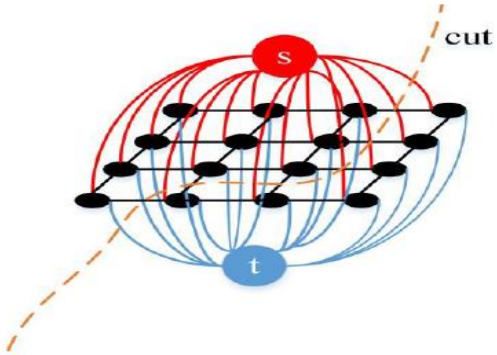

Figure 6. Graph with s-t network

The algorithm determines whether each pixel belongs to the background or foreground, so that it can meet the energy minimization. Based on the Mincut/Maxflow algorithm, the pixels of image are built as a s – t map, as shown in the Figure 6, s and t are respectively the vertex of foreground and background. At the beginning, s and t are related to all pixels (called edge). When the segmentation is completed, it will be foreground which is connected with s, others will be background.

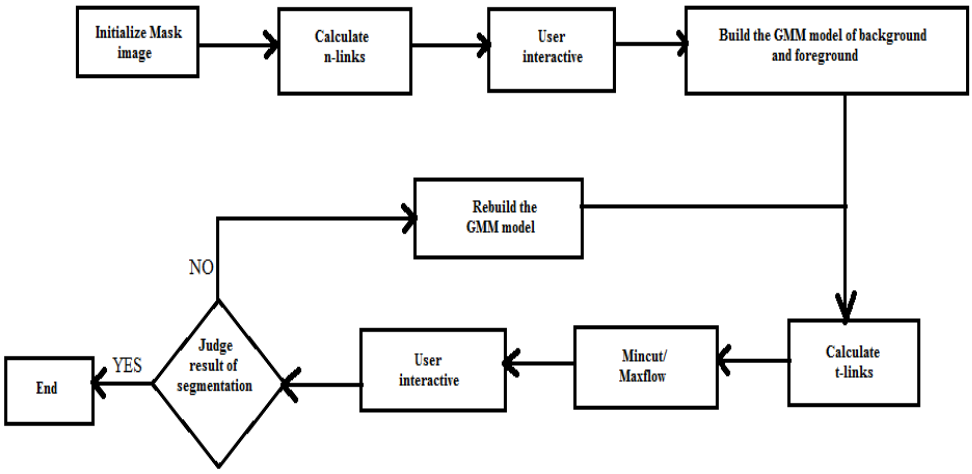

Figure 8. Grab Cut algorithm

According to the above analysis, the GrabCut algorithm's process shown in Figure 8 is as follows:

1) Input an image, drag a rectangle to select a ROI;
2) Drag a rectangle around the object in ROI;
3) Classify all pixels to three categories: the initial background pixels, the initial foreground pixels and abandoned pixels;
4) Initialize each gaussian component of two GMMs according to the RGB values of the initial background pixels and the initial foreground pixels;
5) Calculate probabilities of each pixel inside the rectangle two belongs to each gaussian component of the GMMs, then the pixel belongs to the gaussian component that has the largest probability;
6) Study and optimize GMM parameters;
7) Estimate the segmentation;
8) Repeat the above three steps until convergence;

9) Adopt border matting to smooth the boundary of the segmentation.

The user operation steps are as shown in fig. 5. The user selects a ROI (rectangle with the dashed line), and then drags a rectangle (rectangle with solid line) outside the object in ROI. After the segmentation, the user can improve segmentation result through user interaction.

Figure 9 . Effect of Grab-Cut algorithm

1.4 Graph Cut Segmentation

Graph cut segmentation, as a preprocessing step, image segmentation, which can do partition of an image into different regions, plays an important role in computer vision, objects recognition, tracking and image analysis. Graph cut based method is efficient and accepted world-wide since it can achieve globally optimal result for the energy function. It is not only promising to specific image with known information but also effective to the natural image without any pre-known information. For the segmentation of N-dimensional image, graph cut based methods are also applicable. Due to the advantages of graph cut, various methods have been proposed. In this methods are classified into three categories. They are speed up-based graph cut, interactive-based graph cut and shape prior-based graph cut.

1. Speed-up based graph cut

In order to speed up the computation of graph cut algorithm, implementation based on GPU with CUDA code. This kind of method is to fulfill the speed up by the parallel computing which have good performance compared with sequentially computing. However, the most used method for reducing the computational time for the graph cut related algorithms is based on the reduction of the graph nodes during the reconstruction of graph. Conventionally each pixel in the image will be viewed as one node in the graph. Thus, with the increase of image resolution, the graph will be very big and make the computation of graph cut slowly. Since most of the case, the object just occupy a small region in the whole image, the object can be segmented by only considering a relative smaller part which cover the target. In this case, the graph size is reduced since the image size is decreased to some extent. The smaller area can be selected by user's input or by some matching algorithm.

2.Interactive-based graph cut

To most of the images, it is difficult for the application of pure automatic segmentation. Especially for the natural images and images which the accuracy requirements of target segmentation are very high, interactive segmentation is inevitable. Interactive based graph cut varies from easily choosing the interest object region or simple seed points to iteratively seed point selection. They use the bounding box to select the interested object area. The center area in the bounding box is taken as object and the histogram of the object can be derived from these pixels while the area outside of the bounding box is viewed as background and the background histogram can also be obtained by them.

They need to choose both object seeds and background seeds at one time so as to establish the graph with more reasonable weight. The iteratively interactive graph cut is applied. Thus, every time when the result is not perfect, more seeds will be added and the segmentation result can be revised until got the satisfying interest object. Iteratively interactive graph cut is also robust to the object with week boundary since it can ideal choose the object and background seeds along the week edge. All of the interactive graph cut will make the seed points being perfectly segmented to the object or background. Conventionally, the weight for the graph in the interactive graph cut segmentation can be given as following table when the graph is denoted as **G=< V, E >** where **V=P∪{S,T}**.

3.Shape prior-based graph cut

Due to noise, diffuse edge or occluded objects, conventional graph cut which only incorporate regional and edge information cannot get ideal segmented object. Even though the interactive-based graph cut can reduce these problems to some extent, many rounds of interaction will be needed and this will affect the segmentation efficiency. Thus, the shape prior-based graph cut algorithms are widely researched which will incorporate the shape information of the object into the energy function so as to improve the segmentation result. Especially for the images with known prior information, shape prior-based graph cut can work well when the shape is described appropriately. To some shape prior-based graph cut method, they use the same energy function . They first segment the object within a selected area, then, they use an ellipse shape to fit the obtained object and segment the area around the fitted ellipse boundary.

Conclusion

This paper deals with different types of algorithm used in the segmentation of the image processing. Different techniques developed for image segmentation are composed. Graph Cut methods gives better result in comparison with other segmentation methods**.** Segmentation based on graph cuts works very well for most of the images, for some issues it becomes more laborious. This means, base of the segmentation on the gradient of an image requires more detailed user seeds if the boundaries of the object don't differ clearly enough from the edges in the background. Due to a lot of graph cut-based segmentation method which will confuse the research direction, these methods are classified into three categories. They are speed up-based graph cut, interactive-based graph cut and shape prior-based graph cut. After this classification, researcher can put weight to different aspect as their requirement. However, it is not necessary for the three kinds of graph cut methods to be executed independently. Most of the time, they can be combined so as to improve the segmentation result. Many algorithms for image segmentations such as K-mean clustering algorithms, edge based algorithms grab-cut and graph cut algorithms are used. And finally concluding that graph cut method is widely used for image segmentation.

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