"ANALYSIS AND COMPARISION OF IMAGE SEGMENTATION ALGORITHMS"

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Abstract—The image segmentation is a key process of the image analysis. The goal of image segmentation is to partition an image into a set of disjoint regions with uniform and homogeneous attributes such as intensity, color, tone or texture etc.There are various methods for segmentation. The main aim of this project is to compare the performance of image segmentation algorithms on real images .The influence of the variation in background, the object characteristics diversity and the noise is taken into consideration while comparing the methods.

Index Terms— Segmentation, segmentation methodssegmentation algorithms.

I. Introduction

Segmentation is the process of partitioning a digital image into multiple segments(set of pixels,also known as superpixels). The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful easier to analyze. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual 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(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 of intensity values: discontinuity and similarity.In the first category the approach is to partition an image based on abrupt changes in intensity,such as edges in an images.In the second category are based on partitioning an image into regions that are similar according to a set of predefine criteria.Thresholding,region growing, and region splitin and merging are example of method of this category.Image segmentation can be broadly classified into four different classes as follows [1-3]:-

i) Edge detection methods. ii) Thresholding and Histogram based methods. iii) Region based methods .iv) Cluster based methods.

2) Edge detection methods

An edge is the discontinuity in an image. An edge is the boundary between an object and the background, and indicates the boundary between overlapping objects. There are various algorithms for edge detection,few are discussed here.Sobel operator: For Better approximations of the gradients a Sobel operator is used. It looks for edges in both horizontal and vertical directions, and then combines the information into a single metric. The matrix coefficients are 0, 1,-1, 2 and -2.The Marr-Hildrethmethod:It is a gradient based operator which uses the Laplacian to take the second derivative of an image. The idea is that if there is a step difference in the intensity of the image, it will be represented in the second derivative by a zero crossing [5]: Canny Edge Detector:The Canny edge detector was released after Marr-Hildreth edge detector. Canny saw the edge detection problem as a signal processing optimization problem, so he developed an objective function to be optimized [4-6]. Fig1 shows segmentation by using sobel,Marr,canny edge detector.

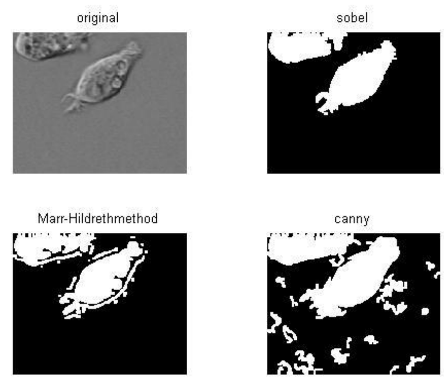


Fig1 .Edge based segmentation

3Thresholding and Histogram based methods

Histogram-based image segmentation techniques use the histogram to select the gray levels for grouping pixels into regions. In a simple image there are two entities: the background and the object. The background is generally one gray level and occupies most of the image. Therefore, its gray level is a large peak in the histogram. The object or subject of the image is another gray level, and its gray level is another, smaller peak in the histogram.

A thresholded image g(x, y) is defined as

$$g(x, y) = \begin{cases} 1, & f(x, y) > T \\ 0, & f(x, y) < T \end{cases}$$

Where 1 is object and 0 is background

When T = T [f(x, y)], threshold is global

When T = T [p(x, y), f(x, y)], threshold is local

When T = T [x, y, p(x, y), f(x, y)], threshold is dynamic or adaptive

3.1 Fixed (or global) Thresholding algorithm:

The threshold value is constant throughout the image.

Step1. Select an initial estimate **T** to separate object from background.

Step2. Segment the image using **T**. This will producetwo groups of pixels. $\mathbf{G_1}$ consisting of all pixels withgray level values **>=T** and $\mathbf{G_2}$ consisting of pixels with values **<T.**

Step3. Compute the average gray level values mean1 and mean2 for the pixels in regions $\mathbf{G_1}$ and $\mathbf{G_2}$**.**

Step4. Compute a new threshold value i.e. T = (1/2) (mean1 + mean2).

Step5. Repeat steps 2 through 4 until difference in **T** in successive iterations is smaller than a predefined parameter $\mathbf{T_0}$.[26]

3.2 Optimal thresholding using Otsu's method: The criterion for Otsu is the minimization of the within-group variance of the two groups of pixels separated by the threshold. The between class variance is obtained by subtracting the within-class variance from the total variance of the combined distribution:

$$\sigma^2_{Between}(T) = \sigma^2 - \sigma^2_{within}(T)$$

Fig 2 shows comparison of histogram based and Otsu's method

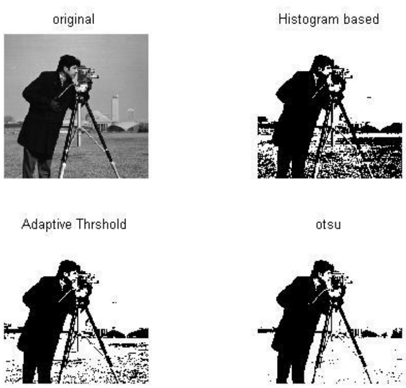


Fig2 Threshold based segmentation

4 Region based methods

Region-based approaches that aim to detect regions satisfying a certain predefined homogeneity criterion.

4.1 Seeded region growing method[11]:The first region growing method was the seeded region growing method. Seed is a basic uniform region that belongs together.The seeds mark each of the objects to be segmented. The regions are iteratively grown by comparing all unallocated neighboring pixels to the regions. The algorithm is as follows

Step1. Find initial set of candidate pixels, calculate their fitness and put them into the priority queue.

Step2. While Queue is not empty –2a) Get candidate pixel with best fitness from queue. 2b) If (Candidate has more than one neighboring regions.) Then mark pixel as border region. Else Mark pixel with label of its neighboring region.

Step3. Identify new candidates among the neighbors of the pixel just processed, calculate their fitness and put them into the queue [11].

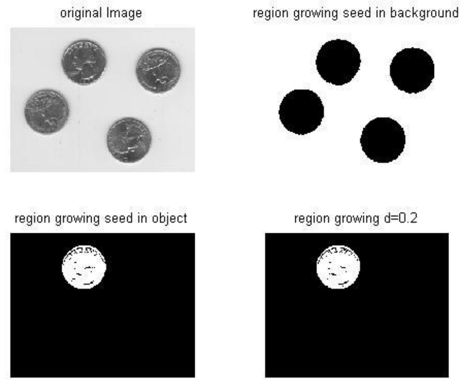


Fig3 Seeded region growing

Fig3 shows results of seeded segmentation,the effect of selecting the seed pixel on background and object is shown .

4.2 Split and Merge method:

Segments image by recursively dividing it into four equal blocks if the variability in its pixels is greater than a certain amount. It merges the blocks depending on the similarity.

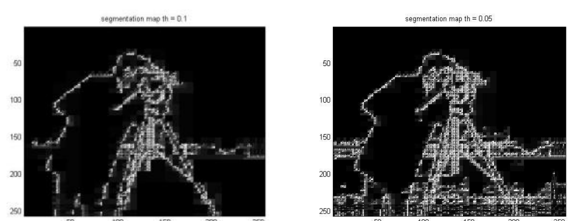
The algorithm is given below,

Step1**.** Split the given image into four disjoint quadrants any region R_i for which $P(R_i) = \text{False}$

Step2**.**When no further splitting is possible, merge any adjacent regions $R_j$and R_k for which

$P(R_j \cup R_k) = \text{True}$

Step3. Stop when no further merging is possible[28].Figure 4 shows effect of segmentation and the size of minimum block.Fig 4a has higher size of the minimum block as compared to figure 4b



4.3 Marker-Controlled Watershed Segmentation:

Separating touching objects in an image is one of the more difficult image processing operations. The watershed transform is often applied to this problem. The watershed transform finds "catchment basins" and "watershed ridge lines" in an image by treating it as a surface where light pixels are high and dark pixels are low.The algorithm is

Step1**.** Compute a segmentation function. This is an image whose dark regions are the objects you are trying to segment.

Step2. Compute foreground markers. These are connected blobs of pixels within each of the objects.
Step3. Compute background markers. These are pixels that are not part of any object.
Step4. Modify the segmentation function so that it only has minima at the foreground and background marker locations.
Step5. Compute the watershed transform of the modified segmentation function.
Figure 5 shows the result of application of watershed algorithm ,

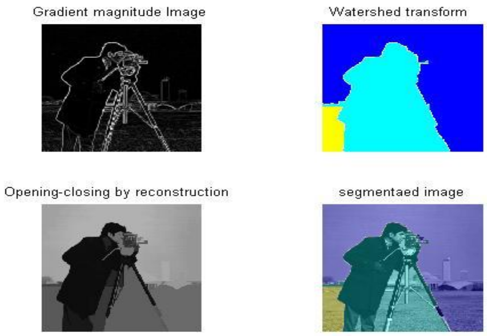


Fig5 Watershed Segmentation

5 Cluster based methods

Clustering is the problem of grouping similar objects together. Clustering is a process whereby a data set is replaced by **clusters** that "belong together".

5.1 K-means clustering:

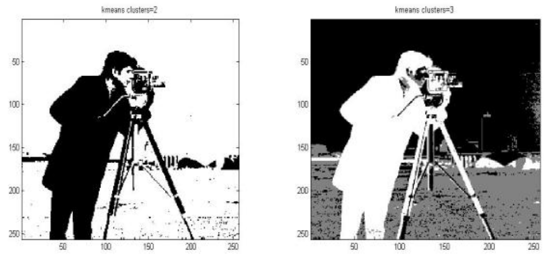
It is an iterative Technique that is used to partition an image into *K* clusters**.**This algorithm aims at minimizing an *objective function*, in this case a squared error function. The objective function

$$J = \sum_{j=1}^{k} \sum_{i=1}^{n} \left\| x_i^{(j)} - c_j \right\|^2$$

where $\left\| x_i^{(j)} - c_j \right\|^2$ is a chosen distance measure between a data point $x_i^{(j)}$ and the cluster centre c_j, is an indicator of the distance of the *n* data points from their respective cluster centers.The algorithm is as follows

Step1.Choose the number K of clusters either manually, randomly or based on some heuristic.
Step2.Generate K clusters and determine the cluster's center.
Step3**.** Assign each pixel in the image to the cluster that minimizes the variance between the pixel and the cluster center
Step4**.**Re-compute cluster centers by averaging all of the pixels in the cluster.
Step5**.**Repeat steps 3 and 4 until some convergence criterion is met

Figure6 shows segmentation in 2 and 3 clusters using this method



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ws one piece of data to belong to two or more clusters. It is based on minimization of the following objective function:

$$J_m = \sum_{i=1}^{N} \sum_{j=1}^{C} u_{ij}^m \left\| x_i - c_j \right\|^2 , \quad 1 \le m < \infty$$

The algorithm is as given below.

Step1. Choose a number of clusters in a given image.
Step2. Assign randomly to each point coefficients for being in a cluster.
Step3. Repeat until convergence criterion is met.
Step4. Compute the center of each cluster.
Step5. For each point, compute its coefficients of being in the cluster[17].
Fig7 shows the image segmented by c means algorithm

Fig7 C means

6. Conclusion

The paper compares various image segmentation algorithms .The algorithms are developed in MATLAM for analysis and comparison. Table 1 shows comparison of time required for segmentation for all these methods. Otsu's method is the least complex method. Watershed algorithm is the most complex algorithm but has advantages in segmenting images having occlusions

Method	**Time**
Global threh using otsu's	0.055485 sec
Marr-hildreth method	0.250379 sec
Canny edge detection	0.301408 sec
Sobel edge detection	0.427063 sec
Fuzzy c-means clustering	0.487124 sec
Split and merge method	1.286568 sec
K-means clustering	1.680861 sec
Watershed method	4.816477 sec
Seeded region growing	31.182382 sec

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