ANALYSIS AND COMPARISON OF IMAGE SEGMENTATION ALGORITHMS

Vasundhara Lokhande*

Prof. N. A. Charaniya*

Abstract- The image segmentation is a key process of the image analysis. The goal of segmentation is to simplify /and or change the representation of an image into something i.e. more meaningful and easier to analyze. The main aim of this paper is to compare the performance of image segmentation algorithms on real images. Comparison is based on time taken and Mean Square Error.

We present the methods for segmentation are Prewitt, Canny Edge, Edge Maximization, Region growing, Region Splitting and merging, Marker controlled watershed Transform, k-means and Fuzzy c-means. They are compared with one another so as to choose the best technique for segmented image.

The problem of segmentation is well studied one in literature and there are wide varieties of approaches that are used. The quality of output of a particular algorithm is difficult to measure quantitatively due to the fact that there may be many "correct" segmentation for a single image.

Keywords: Image Segmentation, Segmentation algorithm, Edge based segmentation, Region based segmentation, Cluster based segmentation.

* Master of engg. Babasaheb Naik College Of Engg. Pusad, Associate Professor of Babasaheb Naik College of Engg. Pusad

1. Introduction

Segmentation is the process of partitioning a digital image into multiple segments. The level to which this subdivision is carried depends on the problem being viewed. Some time need to segment the object from the background to read the image correctly and identify the content of the image. For this reason there are two techniques of segmentation.

i. Discontinuity detection techniques

ii. Similarity detection techniques

In first technique the approach is to partion an image based on abrupt changes in intensity, such as edges. In second technique the approach is based on partitioning an image into regions that are similar according to a set of predefined criteria. Thresholding, region growing, region splitting and merging are the methods used in this category. [4]

The Prewitt edge detector is an appropriate way to estimate the magnitude and orientation of an edge. Canny technique is very important method to find edges by isolating noise from the image before find edges of image, without affecting the features of the edges in the image and then applying the tendency to find the edges and the critical value for threshold.[7] Region growing method is based on seed point selection criterion.[3] In split and merge method we split the image into smaller and smaller region until all the coherent regions are coherent then recursively merging these to produce larger coherent regions.[1] Watershed segmentation is based on gray scale mathematical morphology, to the case of color or generally speaking multicomponent images.[10] k-means clustering algorithm classifies the input data points into multiple classes based on their inherent distance from each other. Fuzzy c-means algorithm assigns pixels to fuzzy clusters without labels.[2]

The objective of this work is to compare the segmentation algorithms and to find the good segmentation algorithm which gives the good segmented result.

2. Related Work

There has been large number of literature on image segmentation evaluation. Most of previous works are focused on developing better ways to measure the accuracy error of the segmentation.

This paper presents the comparison of image segmentation algorithms. The methods we used for comparison are Prewitt, Canny edge, edge Maximization, Region Growing, Region Splitting and merging, Marker controlled Watershed Transform, k-means and Fuzzy c-means.

Edge detection refers to the process of identifying and locating sharp discontinuities in an image. This process detects outline of an object and boundaries between objects and the background of the image. So, edge detection is a vital step in image analysis.

Region based segmentation is a procedure to subdivide an image into its constituent parts or objects called regions, using image attributes such as pixel intensity, spectral values and/ or textural properties. Clustering is the task of grouping a set of objects in such a way that objects in the same group are more similar to each other than to those in other groups.

3. Methodology

We present three segmentation methods for comparison. These segmentation methods have been compared on the basis of the time it takes each to segment a given image and Mean square error to check the accurate result.

3.1 Edge based Method

Edge detection is the fundamental tool in image processing application. This process detects outline of an object and boundaries between object and background of the image. An edge in an image is significant local change in image intensity usually associated with a discontinuity in either the image intensity or the first derivative of the image intensity. We are discussing here three edge detection algorithms.

3.1.1 Prewitt Detection

It is an appropriate way to estimate the magnitude and orientation of an edge. This gradient based edge detector is estimated in the 3x3 neighborhood for eight directions. Following convolution mask is selected, for edge detection.

-1	+1	+1
-1	-2	+1
-1	+1	+1

0°

+1	+1	+1
-1	-2	+1
-1	-1	+1

45°

Figure 1: Prewitt mask

3.1.2 Canny Edge Detection

This technique is used to find the edges by isolating noise from the image before find edges of image, without affecting the features of the edges in the image and then applying the tendency to find the edges and the critical value for threshold.

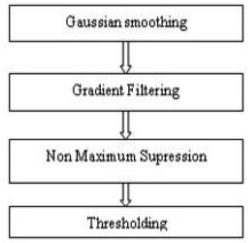


Figure 2: Workflow of Canny edge detection

Algorithm

i. Convolve image f(x,y) with a Gaussian function to get smooth image $f_s(x,y)$.

$$f_s(x,y) = f(x,y)*G(x,y)$$

ii. Apply first difference gradient operator to compute edge strength then edge magnitude and direction.

iii. Apply non-maximal or critical suppression to the gradient magnitude.

iv. Apply threshold to the non-maximal suppression image.

3.1.3 Edge Maximization Technique

In image when there is more than one homogenous region (e.g. an image many objects with different gray levels) or where there is a change on illumination between the objects and its background. In this case portion of the background may be merged with the background or portion of the background may be appear as the object.

From the above fact any of the automatic threshold selection techniques performance becomes much better in images with large homogenous separated regions.

This improves technique works on edge enhanced image.

3.2 Region based Method

The region based segmentation is partitioning of an image into similar/homogenous areas of connected pixels through the application of homogeneity/similarity criteria among the candidates sets of the pixels. [11]

3.2.1 Region Growing Method

The first step in region growing is to select a set of seed points. Seed point selection is based on some user criterion. The initial regions begin as the exact locations of these seeds. The regions are then grown from these seed points to adjacent points depending on a region membership criterion. The criterion should be e.g. pixel intensity, gray level texture or color.

Algorithm

i. Select the first element of the region i.e. seed point.

ii. Look for the neighbors.

iii. If a neighbor point does not belong to any region and it has not been added to the queue yet, it will be queued.

iv. Select the following element in the queue and verify whether it belongs to the region or not using a predefined criterion.

v. Repeat the process until the queue is empty.

3.2.2 Split and Merge Method

In this method split the image recursively into smaller and smaller regions until all the individual regions are coherent then recursively merging this to produce larger coherent regions.

The splitting phase basically builds a quad tree. Each of the regions so produced is now coherent. However several adjacent squares of varying sizes have similar characteristics. Merge these squares into larger regions from the bottom up, much as merged regions earlier since we are starting with regions.

Algorithm

i. Split any region R_i into four square regions where $P(R_i)$=FALSE

ii. Merge any adjacent regions R_j and R_k for which $P(R_j \cup R_k)$=TRUE.

iii. Stop when no further merging or splitting is possible. Otherwise repeat steps (i) and (ii).

3.2.3 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 “catchments basins” and “watershed ridge lines” in an image by treating it as a surface where light pixels are high and dark pixels are low. All the catchment basins that have not been marked are filled by the morphological reconstruction. Segmentation using the watershed transforms works well if you can identify, or “mark,” foreground objects and background locations.

Algorithm

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

ii. Compute the foreground markers. These are connected blobs of pixels within each of the objects.
iii. Compute background markers. These are pixels that are not part of any object.
iv. Modify the segmentation function so that it only has minima at the foreground and background marker locations.
v. Compute the watershed transform of the modified function.

3.3 Cluster Segmentation

Cluster analysis or clustering is the task of grouping a set of objects in such a way that objects in the same group (called a cluster) are more similar (in some sense or another) to each other than to those in other groups (clusters). Clustering is a process whereby a data set is replaced by clusters that belongs together.

3.3.1 k-means clustering

It is an algorithm to classify or to group your objects based on attributes/features into K number of group. K is positive integer number. The grouping is done by minimizing the sum of squares of distances between data and the corresponding cluster centroid. Thus, the purpose of K-mean clustering is to classify the data. This algorithm aims at minimizing the objective function, in this case a squared error function.

The objective function is

$$V = \sum_{i=1}^{k} \sum_{x_j \in s_i} (x_j - \mu_i)^2$$

Where there are k clusters, μ_i is the centroid and i=1,2,……,k.

New centroid for each of the cluster

$$\mu_i = \frac{\sum_{i=1}^{n}\{C(i)=j\}x^{()}}{\sum_{i=1}^{n}\{C(i)=j\}}$$

where 'i' iterates over all the intensities, j iterates over all the centroids.

Algorithm

i. Choose a number of desired clusters, k.
ii. Choose k starting points to be used as initial estimates of the cluster centroids. These are the initial starting values.

iii. Examine each point in the data set and assign it to the cluster whose centroid is nearest to it.
iv. When each point is assigned to a cluster, recalculate the new k centroids.
v. Repeat steps (iii) and (iv) until a maximum number of passes through the data set is performed.

3.3.2 Fuzzy c means clustering

Fuzzy c-means is a method of clustering which allows one piece of data to belong to two or more clusters. Thus points on the edge of a cluster may be in the cluster to a lesser degree than points in the centre of cluster. Fuzzy c-means has been very important tool for image processing in clustering objects in an image.

The standard function is

$$\mu_{k(x)} = \frac{1}{\sum_j \left(\frac{d(center\ k,x)}{d(center\ j,x)}\right)^{\frac{2}{m-1}}}$$

Where μ_{ij} is the membership value and m determine the level of cluster fuzziness.

Algorithm

i. Read the image into the Matlab environment
ii. Get the size of the image.
iii. Calculate the distance possible size using repeating structure.
iv. Concatenate the given dimension for the image size
v. Repeat the matrix to generate large data items in carrying out possibly distance calculation.
vi. Begin Iterations.
vii. Stop Iteration when possible identification elapses.

4. Result

The segmentation algorithms are implemented in MATLAB 7.7.0. The following are the benchmarks used to compare the result.

i. **Time of Computation (TOC)**- This defines the time required to segment the complete the algorithm. It is measure in second(s). TOC should be less for best segmentation algorithm.
ii. **Mean square error (MSE)-** This is a cumulative squared error between segmented image and original image.

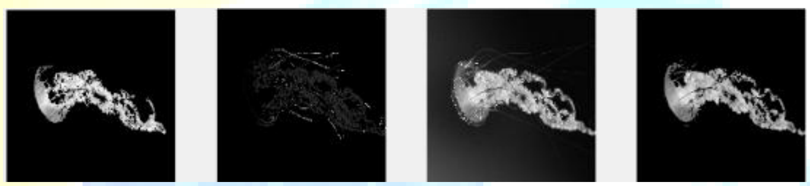
$$MSE = \frac{1}{MN}\sum_{y=1}^{M}\sum_{x=1}^{N}[I(x,y) - S(x,y)]^2$$

Where I (x,y) is the original image, S (x,y) is the segmented image and M, N are the dimensions of the images.

A lower value for MSE means lesser error.

The result of segmented image is shown below.

a) b) c) d) e)

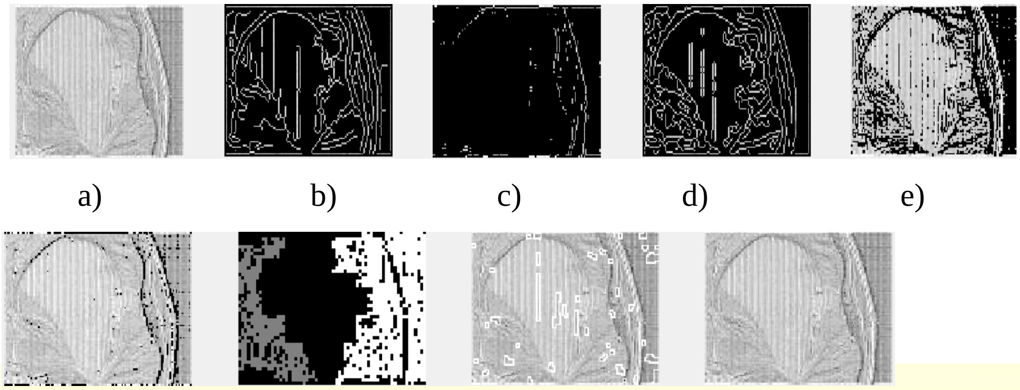


f) g) h) i)

Figure 3: Comparison of image segmentation algorithm for image1 a)Original image b)Canny Edge Detection c)Prewitt Detection d)Edge Maximization e)FCM Segmentation f)Region Growing Method g)Split and Merge Method h)Watershed Segmentation i)k-means Clustering

Table1: Comparison of Segmentation results on image 1

Algorithms	**TOC**	**MSE**
Canny Edge Detection	0.40s	0.9462db
Prewitt Method	0.14s	0.97102dB
Edge Maximization	0.27s	0.97517dB
Region Growing	0.72s	0.019dB
Split and Merge	1.14s	0.86dB
Marker Controlled Watershed	0.96s	0.00001dB
k-means Clustering	0.44s	0.8721dB
Fuzzy c-means clustering	5.33s	0.87292dB



a) b) c) d) e)

f) g) h) i)

Figure 4: Comparison of image segmentation algorithm for image 2 a)Original image b)Canny Edge Detection c)Prewitt Detection d)Edge Maximization e)FCM Segmentation f)Region Growing Method g)Split and Merge Method h)Watershed Segmentation i)k-means Clustering

Table2: Comparison of Segmentation results on image 2

Algorithms	TOC	MSE
Canny Edge Detection	0.30s	0.79191dB
Prewitt Method	0.10s	0.96304 dB
Edge Maximization	0.14s	0.84548 dB
Region Growing	3.23s	0.02538 dB
Split and Merge	0.67s	0.66893 dB
Marker Controlled Watershed	0.35s	0.00003 dB
k-means Clustering	0.13s	1.0000 dB
Fuzzy c-means clustering	1.95s	0.37867 dB

5. Conclusion

Segmentation algorithm tells us that how correctly the image is segmented depending upon the certain parameters e.g. accuracy, error, time taken to segment the image.

In terms of Time taken to segment the image, Prewitt Method takes less time to segment the image. As we consider MSE, Marker controlled Watershed algorithm has very less MSE. Marker controlled Method has high accuracy than any other method.

Also due to the importance of image segmentation a number of algorithms have been proposed but based on the image that is inputted the algorithm should be chosen to get the best result.

References

[1] A.B.M. Faruquzzaman, Nafize Rabbani Paiker, Jahidul Arafat, M Ameer Ali and Md. Ziaul Karim “Literature on Image Segmentation Based On Split and Merge Technique”.

[2] Ajala Funmilola A, Oke O.A., Adedegi T. O., Alade O.M., Adewusi E.A. “Fuzzi k-c means Clustering Algorithm for Medical Image Segmentation” JIEA vol2 No6, 2012.

[3] Brayn S. Morse “Segmentation (Region Based)” Brigherm Young University, 1998-2000.

[4] Gonzalez - Woods: “Digital Image Processing”, 2nd Edition, Pearson Education, 2002.

[5] http://en.wikipedia.org/wiki/segmentation(image processing)

[6] Hai Gao, Weisi lin, Ping Xue, Wan-Chi Siu “Marker Based Image Segmentation Realying On Disjoint Set Union” 2005 published by Elsevier B.V.

[7] Mr. Salem Saleh Al-amri, Dr. N. V. Kalyankar and Dr. Khamitkar S.D. “Image Segmentation by using Edge Detection” IJCSE Vol. 02 No 03 ,2010.

[8] N. Senthilkumaran and R. Rajesh “Edge Detection techniques for Image segmentation- A Survey of Soft computing Approaches” IJRTE vol 1 No2, May 2009.

[9] Oscar E. Ramos, Babak Rezaei “Scene Segmentation and Interpretation Image Segmentation using Region Growing”.

[10] R. Gaetane, G. Masi, G. Scarpa, Poggi “A Marker Controlled watershed Segmentation: Edge,Mark and Fill” IEEE 2012.

[11] S. Lakshmi, Dr. V. Sankaranarayanan “A Study of Edge Detection Techniques for Segmentation Computing Approaches” IJCA CASCT 2010.