ISSN 2320-6802
ICIRET-2014

INTERNATIONAL JOURNAL FOR ADVANCE RESEARCH IN ENGINEERING AND TECHNOLOGY

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A Comparative Survey on Image Segmentation Algorithms

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Abstract-*Image segmentation is the field of image processing that deals with partitioning a digital image into multiple segments. The goal of image segmentation is to change the representation of an image into more meaningful and easier to analyze. This paper deals with two image segmentation algorithms namely normalized cut algorithm and wavelet based segmentation. Normalized cut algorithm segments an image by considering the given image as a graph. Wavelet based algorithm segments an image with the help of thresholding and skeletonizing and it is an emerging technique for image segmentation. The results shown in this paper compares the efficiency of each algorithm.*

Keywords-*Image segmentation, Image processing, Normalized cut algorithm, Wavelet based segmentation, Thresholding, Skeletonizing.*

1. INTRODUCTION

Image processing is a method to convert an image into digital form and perform the operations like Acquisition, Enhancement, Segmentation, Restoration, and Compression, in order to get an enhanced image or to extract some useful information from it. It is a type of signal dispensing in which input is image, like video frame or photograph and output may be image or characteristics associated with that image. Usually image processing system includes treating images as two dimensional signals while applying already set signal processing methods to them. It is among rapidly growing technologies today, with its applications in various aspects like medical imaging, satellite imaging, pattern recognition, etc. Image processing forms core research area within engineering including computer science disciplines.

The Figure 1 explains various steps involved in image processing. In many fields of image processing from satellite imaging to medical imaging, the problem persists in extracting the specific region of interest from the image. Thus image segmentation is necessary to extract region of interest from the image in wide variety of applications [1].It plays a vital role in pedestrian detection, face recognition, finger print recognition, traffic control systems and video surveillance. Other applications include content-based image retrieval, machine vision and medical imaging. The previous image segmentation algorithms were based on thresholding and edge detection. Two algorithms were proposed in this paper, which is used for various applications.

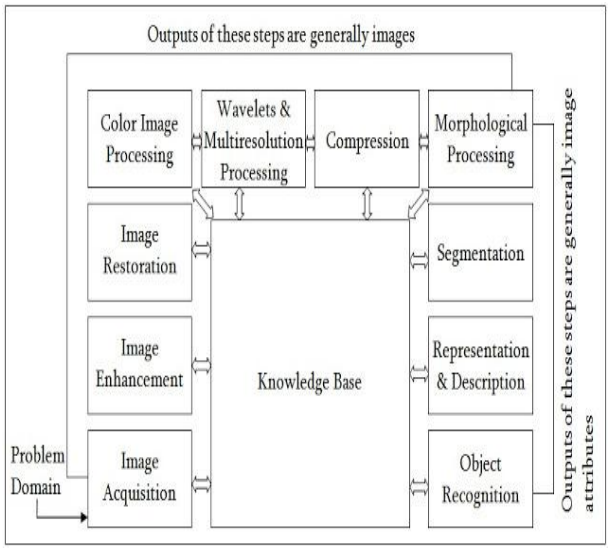


Figure1: Steps in image processing

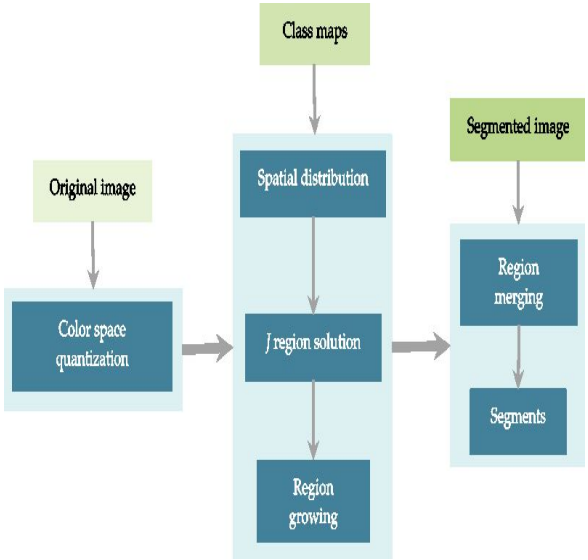


Figure 2: Steps in image segmentation

The Figure 2 explains various steps that are involved in image segmentation. Chapter 2 deals with mathematical formulations in image segmentation. Chapter 3 deals with normalized cut algorithm. Chapter 4 deals with wavelet based image segmentation. In chapter 5 the result for the image segmentation algorithms is presented in the form of images and in chapter 5 the conclusion is made by analyzing the two algorithms.

2. MATHEMATICAL FORMULATIONS

According to [2], segmentation is the process of partitioning an image into non-intersecting regions, such that each region is homogenous and the union of no two adjacent regions is homogenous. Let R represents the entire spatial region occupied by an image. Image segmentation partitions R into n sub-regions $R_1, R_2, \ldots, Rn$, such that,

a) $\bigcup_{i=1}^{n} Ri = R$ (1)

Segmentation must be complete and every pixel must be in a region.

b) Ri is a connected set, $i=1,2,3,\ldots,n$ (2)

Points in a region are connected in a pre defined sense.

c) $Ri \cap Rj = \emptyset$, for all i and j, $i \neq j$ (3)

Regions Ri and Rj must be dis-joint.

d) $Q(Ri) = True$ for $i=1,2,3,\ldots,n$ (4)

e) $Q(Ri \cup Rj) = False$ (5)

Thus two adjacent regions must be different.

The basic problem in segmentation is to partition an image into regions that satisfy the above conditions a) to e).Most of the segmentation algorithms are based on one of the two basic properties of intensity values, i.e., discontinuity and similarity[2].In discontinuity, partition is based on abrupt changes in the intensity values. In similarity, image is partitioned into regions that are similar according to a set of pre-defined criteria. The techniques used are thresholding

Threshold techniques make decisions based on local pixel information and are effective when the intensity levels of the objects are different from the background. Because, when spatial information is ignored, the blurred regions can create problems.

In Edge-based methods and in contour detection, the weakness is in connecting together the broken contour lines to make them continuous boundaries.

Region-based method usually partitions an image into connected regions by grouping neighboring pixels of similar intensity levels. Adjacent regions are then merged under some criterion.

3. NORMALIZED CUT ALGORITHM FOR IMAGE SEGMENTATION

In [3], a graph theoretical framework is considered by modeling image segmentation as a graph partitioning and optimization problem using the normalized cut criterion. The problem with the cut criterion is that it does not consider association within a cluster. In order to overcome this problem, the cut cost as a fraction of the total edge connections to all the nodes in the graph is considered. Thus, normalized cut is explained in (6),where Cut(A,B) represents the summation of weights of edges going across A and B and assoc(A,V) is given in (7).

$$Ncut(A,B) = \frac{cut(A,B)}{assoc(A,V)} \quad (6)$$

$$assoc(A,V) = \sum_{u \in A, v \in V} w(u,v) \quad (7)$$

From (7), node A travels to all nodes in the graph. When looking at the clusters with high group similarity, normalized cut association is given as,

$$Nassoc(A,B) = \frac{assoc(A,A)}{assoc(A,V)} + \frac{assoc(B,B)}{assoc(B,V)} \quad (8)$$

assoc(A,A) and assoc(B,B) are the total weights of edges connecting nodes within A and B respectively. Thus by (8),the nodes are strongly connected in a network. A very important property that can be derived here is that Ncut and Nassocare naturally related as in (9).

$$Ncut(A,B) = 2 - Nassoc(A,B) \quad (9)$$

Thus, the two partition criteria are, minimizing the disassociation between the groups and maximizing the association within the groups can be satisfied simultaneously. Thus, the Ncut criterion takes care of both inter-set dissimilarity (by the minimization of Ncut) as well as intra-set similarity (by the simultaneous maximization of Nassoc).By setting a threshold on the normalized cut value, the number of groups segmented can also be controlled. But the major block here is that Normalized cut algorithm is NP-complete [4].

4. WAVELET BASED IMAGE SEGMENTATION

In [5], texture segmentation is done by energy and size from discrete wavelet transform. For an original NxN image, the

sub-image Ci,j is considered. Thus the original image is decomposed by taking 4x4 sub-images from the top left corner. New features are formed based on (10) and (11).

$$\text{Energy} = \sum_{i,j=1}^{N} C^2_{i,j} \quad (10)$$

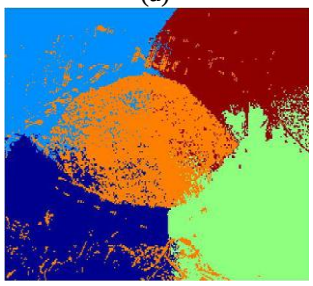
$$\text{Contrast} = \sum_{i,j=1}^{N} (i-j)^2 \quad (11)$$

A new matrix is obtained, by evaluating the difference between value by value of features in both horizontal and vertical direction. Across the texture boundaries, segmentation is formed. Noises are formed in the regions of high difference of features, which are removed by applying circular averaging filter. The processed image is subjected to global thresholding, which removes isolated pixels (individual 1's surrounded by 0's). Skeletonizing removes pixels on the boundaries of the objects without breaking it. The left-out pixels form the image skeleton. Though there is the problem of selecting optimal value for thresholding and skeletonizing, spurious artifacts and noises were removed. This technique can be effectively used in MRI images and in computer graphics.

5. RESULT

This part shows the original input image and the segmented output image for both normalized cut algorithm and the wavelet based segmentation.

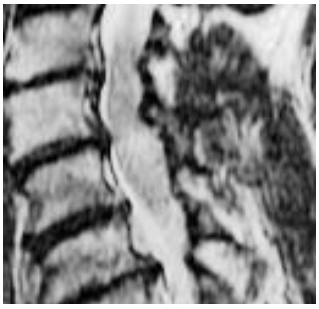
(a)



(b)

Figure3: Normalized cut algorithm based segmentation

Figure 3 explains the Normalized cut algorithm based segmentation in which the fig a. shows the original image and the fig b. explains the segmented image.



(a)

(b)

Figure 4: Wavelet based segmentation

Figure 4 represents the wavelet based segmentation in which the fig (a) shows the original image and the fig (b) explains the segmented image.

6. CONCLUSION

By comparing normalized cut algorithm and wavelet based segmentation, it is concluded that ,normalized cut algorithm gives quite good results for image segmentation even though the NP-complete problem persists and in wavelet based segmentation, though there is the problem of selecting optimal threshold value for thresholding and skeletonizing, wavelet based segmentation makes the image more robust against noises from various sources, than compared with other techniques and wavelet transform is one of the emerging tool for segmentation in various fields.

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