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Automatic Image Segmentation Using Wavelet Transform Based On Normalized Graph Cut

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Abstract: *Model-Based image segmentation plays an important role in image analysis and image retrieval. To analyze the features of the image, model based segmentation algorithm will be more efficient. This paper, proposed Automatic Image Segmentation using Wavelets (AISWT) based on normalized graph cut method to make segmentation simpler. Discrete Wavelet Transform is considered for segmentation which contains significant information of the input for the approximation band of image. The Histogram based algorithm is used to obtain the number of regions and the initial parameters like mean, variance and mixing factor.*

Keywords: *Discrete Wavelets, Image Segmentation, Histogram, Generalized Gaussian Distribution, EM Algorithm, ML Estimation.*

I. INTRODUCTION

In image processing the input is an image and the output is either an image or parameters related to the image is used to solve identification problems, such as forensic medicine or creating weather maps from satellite pictures. Image segmentation is a process of extracting and representing information from an image in order to group pixels together into regions of similarity. Image segmentation is classified into three categories viz.

i) Manual i.e., supervised or interactive in which the pixels belonging to the same intensity range pointed out manually and segmented, the disadvantage is that it consumes more time if the image is large.

ii) Automatic i.e., unsupervised which is more complex and algorithms need some priori information such as probability of the objects having a special distribution to carry out the segmentation.

iii) Semi-automatic is the combination of manual and automatic segmentation [1]. The pixel intensity based image segmentation is obtained using Histogram-Based method, Edge-Based method, Region-Based method and Model-Based method. Model-Based segmentation algorithms are more efficient compared to other methods as they are dependent on suitable probability distribution attributed to the pixel intensities in the entire image[2]. To achieve close approximation to the realistic situations, the pixel intensities in each region follow Generalized Gaussian Distribution (GGD). Some of the practical applications of image segmentation are Medical Imaging to locate tumors and other pathologies, locate objects in satellite images viz., roads, forests, etc., automated-recognition system to inspect the electronic assemblies, biometrics, automatic traffic controlling systems, machine vision, separate and track regions appearing in consequent frames of an image sequence and real time mobile robot applications employing vision systems [3][4].

Image segmentation plays an important role in biometrics as it is the first step in image processing and pattern recognition. Model based algorithms are used for efficient segmentation of images where intensity is the prime feature. The problem of random initialization is overcome by using Histogram based estimation [2]. The Wavelet transform solves the problem of resolution which can indicate the signal without information loss and reduces the complexity. The segmentation is faster since approximation band coefficients of DWT are considered [1].

This paper, introduced Wavelet based on normalized graph cut method concept for image segmentation which may easy way by considering approximation band of an image which is small in dimensions and contains significant information of original image. The initial parameters and final parameters are obtained by applying Histogram based algorithm and Expectation and Maximization algorithm respectively [5]. GGD model is constructed and segmented by Maximum Likelihood estimation of each approximation coefficient.

II. WAVELET TRANSFORM

In this section the paper discussed definitions and AISWT model

A. Definitions:

i. Mean: The average intensity of a region is defined as the mean of the pixel intensities within that region. The mean μz of the intensities over M pixels within a region K is given by Equation (1)

$$\mu_z = \frac{1}{M}\sum_{i=1}^{M} x_i \qquad (1)$$

Alternatively, we can use formulation based on then normalized intensity histogram p(zi) where i=0,1,2,…,L-1 and L is the number of possible intensity values as given by Equation (2)

$$\mu = \sum_{i=1}^{L} z_i \, p(z_i) \qquad (2)$$

ii. Variance: The variance of the intensities within a region K with M pixels is given by Equation (3).

$$\sigma_z^2 = \frac{1}{M}\sum_{i=1}^{M}(x_i - \mu_z)^2 \qquad (3)$$

Using histogram formulation the variance is given by Equation (4)

$$\sigma^2 = \sum_{i=0}^{L}(z_i - \mu)^2 \, p(z_i) \qquad (4)$$

iii. Probability Distribution Function (PDF) of the intensities: The PDF P(z), is the probability that an intensity chosen from the region is less than or equal to a given intensity value z. As z increases from -∞ to +∞, P (z) increases from 0 to 1. P(z) is monotonic, non-decreasing in z and thus $dP/dz \geq 0$.

iv. Shaping parameter P: Shaping parameter defines the Preakness of the distribution which varies from 1 to ∞. The GGD becomes Laplacian Distribution if P = 1, Gaussian distribution if P=2 and Uniform Distribution if P→ +∞.

v. Computational Time: Time required for the Execution of the algorithm.

III. BLOCK DIAGRAM OF AISWT

The Figure 1 gives the block diagram of AISWT

1. Input image:

The input images are of different formats, sizes and types. The image pixel intensity in the entire image is a Random Variable and follows a GGD.

2. DWT:

The Wavelet Transform is created by repeatedly filtering the image coefficients on a row by row and column by column basis. A two-dimensional DWT decomposition of image contains various band information such as low-low frequency approximation band, high-low frequency vertical detail band, low-high frequency horizontal detail band and high-high frequency diagonal detail band. We assume each coefficient of approximation band is a Random Variable z and also follow GGD. The approximation band is used for the segmentation purpose, which is quarter the size and has significant information of the original image. Hence the computation time required reduces.

3. Initial parameters Estimation:

Initial parameters like mean μ, variance σ and mixing parameter α are determined using Histogram based initial estimation which is a clustering algorithm. The initial parameters are calculated in two steps:

i) Histogram is constructed by dividing approximation band coefficients into intervals and counting the number of elements in each subspace, which is called as bin. The K highest density bins are selected and the average of the observed elements belonging to the bins is calculated to derive a Centroid. If K centroids are not obtained because of narrow intervals, the Histogram is rebuilt using wider intervals and the centroids are recalculated.

ii) The minimum distance clustering is used to label all the observed elements by calculating the distance D between each centroid and all the elements of the histogram as given in Equation (5)

$$D_j = \min\|C_i - Y_j\| \quad (5)$$

Where
Ci is ith centroid for i = 1 to K
Dj is minimum distance between Ci and jth element Yj for j= 1 to N.

The Histogram based initial estimation do not use random selection for initial parameters, thus the method is stable and useful for unsupervised image segmentation applications. The obtained mean, variance and mixing parameter for the k regions are considered as the initial parameters for EM algorithm.

IV. Shaping parameter P:

The Shaping parameter defines the peakness of the distribution. In GGD, the three parameters mean, variance and shaping parameter determines the PDF. The optimal shaping parameter [22, 23] is determined using initial parameters and the absolute mean value E [$|z|$] . The absolute mean is given by Equation (6)

$$E\left[|z|\right] = \frac{1}{N}\sum_{i=1}^{N}\sum_{j=1}^{k}\left|z_i - \mu_j\right| \quad (6)$$

P is estimated using Equation (7)

$$P = M^{-1}(\rho) \quad (7)$$

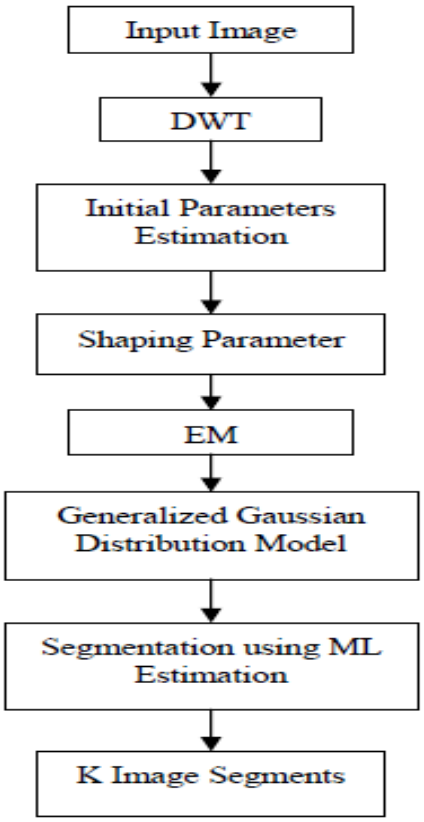
Where ρ is given by

$$\rho = \frac{E^2\left[|z|\right]}{\sigma^2}$$

M is the Generalized Gaussian ratio function given by Equation (8)

$$M(\rho) = \frac{\Gamma^2}{\Gamma}$$

IV. BLOCK DIAGRAM OF AISWT



V. RESULTS

Here we have used model based segmentation algorithm to increase the efficiency of the segmentation process. Automatic Image Segmentation using Wavelet Transform (AISWT) based on normalized graph cut method is applied on image having significant information of the input image & observed that larger images can be easily segmented. Original image, preprocessed image with partitioned image is as shown below

Originals image with its preprocessed image.

Segmented parts

VI. CONCLUSION

This paper gives easy segmentation algorithm AISWT using normalized graph cut method. The approximation band of an image DWT is considered. The initial parameters are estimated using Histogram based method. Through EM algorithm, the final parameters are obtained. The segmentation is done by ML estimation. The AISWT algorithm is computationally efficient for segmentation of large images and performs much superior to the earlier image.

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