

A Comparative Study on Image Segmentation Techniques

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Abstract— Image segmentation is the first step from image processing to image analysis. Image segmentation is the partition of image into multiple segments to have clear distinction between object and background of image. In existing method, in order to obtain threshold accurately, discrete wavelet transform (DWT) method is used which decompose the image into four sub-bands via high and low pass filters. To determine threshold value, Otsu’s method is applied on low pass filter and on high pass filter edge enhancement is implemented. The overall objective of this paper is to review the image segmentation techniques and find their limitations.

Keywords—Image Segmentation, gray stretch, fuzzy c- means

I. INTRODUCTION

Image segmentation is the first step in image analysis. Image segmentation is the division of a digital image into multiple segments i.e. in set of pixels on the basis of some criteria such as color, shape, texture, intensity values so as to locate objects and boundaries in image. The main aim of segmentation is to have clear distinction between [1] object and its background. Segmentation techniques mainly convert the complex image into a simple image.

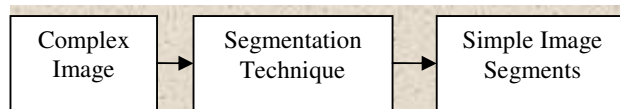


Fig. 1 Segmentation Technique [1]

The choice of a segmentation technique over another and the level of segmentation are decided by the particular type of image and characteristics of the problem being considered.

II. IMAGE SEGMENTATION TECHNIQUES

Different approaches of image segmentation are broadly classified based on [2] two properties of image.

a) *Detecting Discontinuities*: - It includes division of image on the basis of discontinuous intensity values of pixels like in edge detection algorithm of image segmentation.

b) *Detecting Similarities*: - It includes partition an image on the basis of some already stated similarity criteria into set of homogeneous regions using image segmentation algorithms such as thresholding and region splitting and merging. There are many approaches to segment an image.

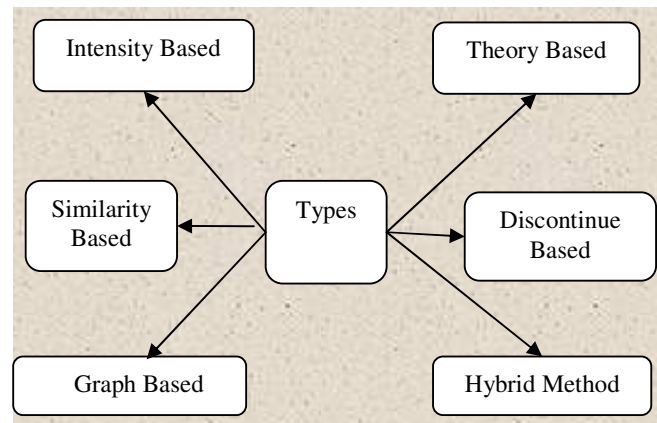


Fig. 2 Types of Image segmentation

Some of these are described in the following section.

A. Intensity Based Approach: -

This is the simplest method of image segmentation and also called as THRESHOLD based approach. Thresholding based techniques divide the image into two parts based on [2] discontinuity of pixels values. Thresholding can be implemented locally or globally. Other techniques used to implement thresholding are based on histogram, clustering and local adaptive segmentation. Many methods are used for thresholding e.g. maximum entropy method, Otsu’s method (maximum Variance) and K-means clustering, Fuzzy logic.

There are two types of thresholding algorithms

- Global thresholding algorithms
- Local or adaptive thresholding algorithms

B. *Discontinuity Based Approach*: - This approach is based on the variations in the intensity value [2] of pixels near edges and boundaries of image thus follow edge detection approach. Edge detection segmentation is done using two methods.

- Gray Histogram Technique
- Gradient Based Method

Spatial masks can be used to detect all the three types of discontinuities in an image.

All the edge detection [1] operators are grouped under two groups as

1st order Derivative

Prewitt operator
Sobel operator
Canny operator
Test operator

2nd Order Derivative

Laplacian operator
Zero-crossings

C. Similarity Based Approach: - This is also called Region Based Segmentation. These methods divide the image into different parts based [2] on similarity criteria. In comparison to edge detection methods these are simple and more effective in removal of noise. Watershed transformations related to region based similarities. Also histogram based segmentation works well when pixels values are similar in nature throughout the image. Region based methods are divided into [1] two parts:-

i) Region growing methods

- Seeded region growing method
- Unseeded region growing method

ii) Region split and merges methods

D. Theory Based Approach: - This is the type of segmentation technique which includes various algorithms that includes derivatives from different fields.

i) Clustering Techniques:

Clustering is used when there is prior knowledge of classes and homogeneous pixels are grouped together on the basis of some already stated criteria. Principle of maximizing the intra class similarity and maximizing the inter class similarity is used while grouping of pixels which also determines the quality of clustering. E.g. K-means clustering and Fuzzy-C means clustering. There are various techniques of clustering:-

- Hard Clustering
- Fuzzy Clustering

ii) Artificial Neural Network-based segmentation:-

In this technique every pixel represents a neuron. The network of neurons consists of a training set to find the connection and weights between different nodes.

E. Graph Based Approach: - This approach is an effective method of image segmentation. In this image is taken as a weighted undirected graph. Pixel values are assigned to the nodes of graph and graph is divided on the basis of [2] some already stated criteria. This method includes different algorithms e.g. random walker, minimum cut, isoperimetric partitioning, minimum spanning tree-based segmentation, and segmentation-based object categorization.

F. Hybrid Approach: - This method combines the approach of one or more segmentation methods and provides better results in comparison to [2] its parent method. Morphological operations are performed on images in this approach.

III. DISCRETE WAVELET TRANSFORM

The DWT is a linear transformation that separates data into different frequency components and then studies each component resolution by matching the value to its scale. 2-D wavelet is used to decompose an image into [3] [4] four sub-images (LL, HL, LH and HH).

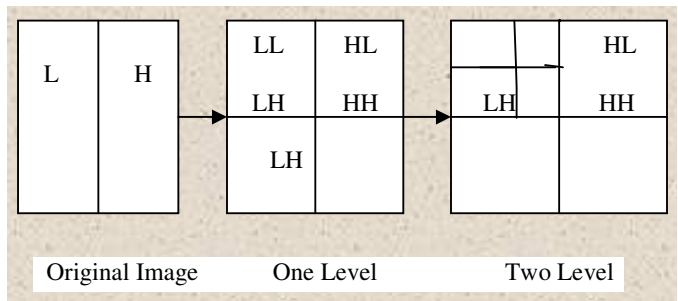


Fig. 3 2-D DWT Processing

2-D wavelet transform is performed by consecutively applying [27] one- dimensional wavelet transform in both horizontal and vertical directions of the image. Each unit of 1-D wavelet produces low and high frequency filters. These sub-bands contain the image as well as horizontal, vertical and diagonal details of image.

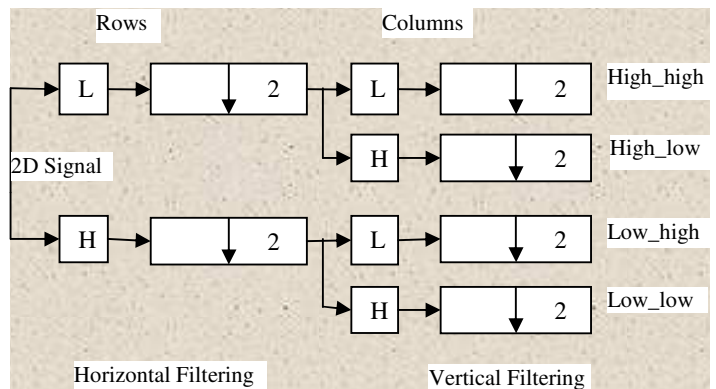


Fig. 4 Wavelet decomposition for two 2D pictures

IV. GRAY STRETCH & THRESHOLD ALGORITHM

In this paper, in order to obtain threshold accurately, [27] discrete wavelet transform (DWT) method is used which decompose the image into four sub-bands via high and low pass filters. To determine threshold value, Otsu's method is applied on low pass filter and on high pass filter edge enhancement is implemented.

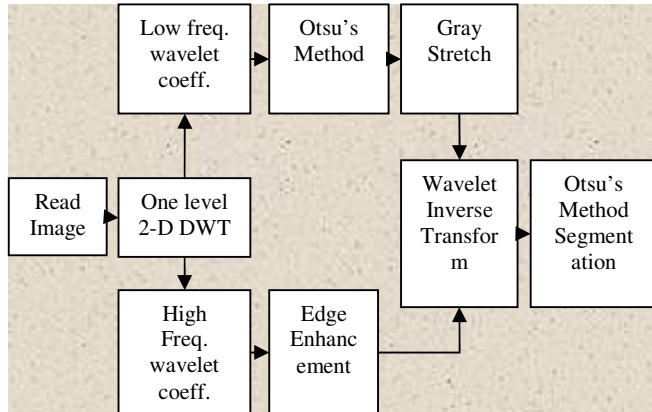


Fig. 5 Existing Method Procedure [27]

V. LITERATURE SURVEY

Bissau, Ranita et al. (2012), [5] has proposed an improved method based on type-2 fuzzy sets for images distorted by Gaussian noise and other discontinuities. Lan, Jinhui, et al. (2013), [6] has proposed based on maximum fuzzy entropy in 2D histogram which divides the image into different sizes according to densities. Gyu Jeong, Bo et al. (2012), [7] has proposed a method is based on edge segmentation in wavelet domain. It uses standard deviation and Kurtosis in both edge and smooth regions on detail coefficients. CF moments of both detail and gray levels are calculated for comparison and SVM is used to differentiate them. Experiment shows effective results.

Raja Kumar, T.C. et al. (2011), [8]-[29] the author emphasizes on the idea of Fuzzy statistic for contrast stretching in medical image processing. Fuzzy histogram provides gray level values which are used to improve the quality of source image in spatial domain. This method removes the problem of narrow gray values and result shows that the images formed consists of less noise and are smooth in nature. Saleh Al-amri, Salem et al. (2010), [9] the author emphasizes on the different threshold segmentation techniques on the basis of similarity of intensity values of pixels. A comparative study of different techniques which include Mean technique, P-tile technique, HDT technique, EMT technique and visual technique, reveals that HDT and EMT gives best result as compared to other techniques.

Rongrong, Wang et al. (2015), [10] has proposed a method based on quadratic spectrum modeling and high order double spectroscopy methods to extract amplitude and phase of segmented wavelet based on mixed phase time varying feature of adaptive segmentation. This method can give secondary evaluation of wavelet precision using deconvolution results. After comparison, result shows that the proposed method provides value of amplitude accurately and also reflect phase of distorted wavelet which is closer to real value.

Sarangi, P.P. et al. (2014), [11] has proposed the contrast enhancement technique based on differential evolution (DE) on gray levels of image using objective function. The function of DE is to maximize the objective fitness criteria. Proposed method is compared with other image enhancement methods and result shows that this method obtains best detail content in all images in comparison to other methods. Dutta, Anirban et al. (2014), [12] has proposed a method based on GMM (Gaussian mixture model) and DWT. The parameters are evaluated by EM algorithm. Experimental result shows that the proposed method provides better results by reducing noise content in SAR images.

Golam Kibria, A.F.M. et al. (2012), [13] has proposed a method to remove the over-segmentation problem of JSEG, an enhanced version of JSEG color image segmentation which combines canny edge information created between every two adjacent segments of JSEG. Experiment shows improved results. Dhar, Rajdeep et al. (2014), [14] has proposed method based on the comparative study of gradient based (canny) and Laplacian based (Gaussian) filters in edge detection of human retinal images. Result shows that canny edge detector is computationally more efficient to recognize both strong and weak edges as compared to Gaussian operator.

Ding, Zishuo et al. (2014), [15] has proposed an article based on the correctness of SIFT (Scale Invariant Feature Transform) algorithm to extract feature points and the feature points using the analysis of Grey Correlative Degree Theory. Comparative study reveals that the proposed method provides more matching correctness and robustness by removing partial occlusion, stretching and image rotation. Shanmugavadivu, P. et al. (2014), [16] the author proposed the modified version of canny edge detection method named as MEDC (Modified-Eight-Directional Canny). This technique detects edges in eight directions which enables MEDC to find almost all edges of a given image. Proposed paper shows that MEDC provide better results than canny method on the basis of ENL, ESL values.

Golam Kibria, A.F.M. et al. (2012), [17] has proposed a paper based on the enhanced version for the JSEG color image segmentation algorithm to prevent over-segmentation of an image. This technique provide better results than classical JSEG and Fractal JSEG by using canny edge detector and measure uniform regions accurately even in the absence of color variations. Sun, Ping et al. (2012), [18] has proposed a method on multi-scale remote sensing images using region segmentation and wavelet transform. Wavelet decomposition is carried out on both low and high frequency coefficients and inverse transformation is applied to get the final image. The proposed method improves high resolution of fusion image and also holds spectrum information of multispectral images.

Ling Jui, Shang et al. (2014), [19] has proposed a method based on fuzzy c-means (FCM) considering noise filtration with wavelet domain to reduce rician noise in medical imaging. Proposed method provides better results in comparison to all existing conventional filters including wavelet denoising filter and also modified FCM algorithms. Kshirsagar, Ravindra et al. (2014), [20] has proposed mean shift technique of image segmentation which clusters the image regions instead of pixels and improves the performance of segmentation. For circle detection a very fast algorithm called Modified Canny edge detection algorithm is used as compared to Circular Hough Transform.

Singh Sengar, Ratnesh et al. (2012), [21] has proposed a method to detect 2DE gel images based on wavelet transform and watershed approach which removes over segmentation problem of watershed method. The proposed method use single threshold parameter and show best results as compared to traditional methods. Zainal Arifin, Agus et al (2006), [22] has proposed a method which work on hierarchal clusters, based on inter-class and intra-class variance in the similarity measurement domain .The proposed method is evaluated under different criteria's and result shows better performance as compared to above three methods.

Sherin M. Youssef (2013), [23] has proposed a method which forth put a new approach on multi-level wavelet decomposition and fuzzy self adaptive digital audio watermarking using local audio frames. Bit error rate and SNR parameters are used to evaluate performance of proposed method and result shows that this method is robust against other signal processing techniques. Hakiem, Nashrul et al. (2013), [24] has proposed a method to

enhance the performance of CBIR system using adaptive histogram method for color images and wavelet transform for Shape/texture of the image. Experimental result shows that threshold algorithm takes less time as compared to Fagin's algorithm.

Canonico, Rodolfo et al. (2012), [25] has proposed a method which shows that in segmentation concept Gaussian Distribution (GGD) when used in wavelet domain provide more accurate results for texture classification. Result shows that GGD used as a similarity measure provide good results to be used in tracking applications and other image segmentation applications. Ahmad, Afandi et al. (2012), [26] has proposed an article, based on a modified version of thresholding techniques with translation invariant in discrete wavelet for removal of adaptive non-linear noise. Result shows better performance of HET (Hybrid estimated threshold) method in both SNR and visual effects. This method works fair enough in case of removal of speckle, Gaussian and salt & pepper noise. Verma, Akhilesh et al. (2012), [27] has proposed a method based on the implementation of genetic algorithm (GA) using local contrast enhancement method for enhancement of natural contrast of an image. Local mean, local standard deviation and extended range of parameter values are used in this method that shows better results.

Liu, L. et al. (2015), [28] has proposed a method based on 2-D discrete wavelet transforms method using largest between class variance in the field of image segmentation. Proposed method is efficient in removal of noise and provides a good quality of image segmentation.

Table1. State-Of-Art Techniques (Literature Survey)

Ref No.	Technique Name	Year	Technology Used	Benefits	Limitations
[5]	An Improved Canny Edge Detection Algorithm Based on Type-2 Fuzzy Sets	2102	Single Threshold Selection Technique using Type-2 Fuzzy Logic	Take care of uncertainties involved in the image quiet efficiently.	Computationally poor
[6]	Multi-threshold image segmentation using maximum fuzzy entropy based on a new 2D histogram	2013	New multi-threshold image segmentation method using maximum fuzzy entropy based on the 2D histogram	Provide better Segmentation results and target information	Not work for Images which contain large amount of edge details
[7]	Image Manipulation Detection Using Edge-based Segmentation and Statistical Property of Wavelet Coefficients	2012	Wavelet transform ,edge-segmentation	Classify authentic Images	Not well of JPEG codec images
[8]	Fuzzy Based Contrast Stretching For Medical Image Enhancement	2011	Fuzzy statistic	Solves the problem of narrow gray range images and improves the quality of the input image	Computationally poor
[9]	Image Segmentation By Using Threshold Techniques	2010	Segmentation technique	To find one of the best thresholding technique	No new technique is proposed
[10]	A New Mixed-phase Wavelet Extraction and Evaluation Method Based on Adaptive Segmentation in Non-stationary Seismogram	2015	Mixed-phase wavelet extraction method based on high-frequency attenuation compensation and zero-phase wavelet extraction method	It gives quantitatively Evaluation of wavelet precision.	Not well for complex background images

			based on adaptive segmentation,		
[11]	Gray-level Image Enhancement Using Differential Evolution Optimization Algorithm	2014	DE evaluation using parameterized intensity transformation function	Enhancement of contrast and detail in a gray scale image.	The DV is not always reflecting precisely the detail content level in the image
[12]	SAR Image Segmentation using Wavelets and Gaussian Mixture Model	2014	Gaussian Mixture Model (GMM) along with the combination of wavelets	Reducing the effect of speckle noise SAR image segmentation	Not well for complex background images
[13]	Reduction of Over Segmentation in JSEG Using Canny Edge Detector	2012	Canny edge detector	Removal of over segmentation	May introduce false edges or regions
[14]	An Analysis of CANNY and LAPLACIAN of GAUSSIAN Image Filters in Regard to Evaluating Retinal Image	2014	Canny and Laplacian of Gaussian filter	Canny edge detector is more efficient in detecting both strong and weak edges than Laplacian of Gaussian operator	Not well for complex background images
[15]	An Image Matching Method Based On the Analysis of Grey Correlation Degree and Feature Points	2014	SIFT (Scale Invariant Feature Transform)	Achieves the goal of accurate matching of feature points among images and eliminate the influence of partial occlusion and image rotation	Over segmentation may be presented in certain cases
[16]	Modified Eight-Directional Canny for Robust Edge Detection	2014	Modified Eight-Directional Canny for Robust Edge Detection (MEDC)	Provides greater potential of edge detection	Not well for complex background images
[17]	Color Image Segmentation Using Visible Color Difference and Canny Edge Detector	2012	Visible color difference and canny edge detector with JSEG segmented image	Removes over-segmentation problem	Complex in nature
[18]	An Image Fusion Method Based on Region Segmentation and Wavelet Transform	2012	Region splitting multi-criterion remote sensing phantom fusion method and wavelet Transform	Improves high resolution of the fusion image.	Not well for complex background images
[19]	Fuzzy C-Means with Wavelet Filtration for MR Image Segmentation	2014	Image segmentation technique based on fuzzy c-means (FCM) incorporated with wavelet domain noise filtration	This method allows FCM not only to exploit useful spatial information, but also dynamically minimize clustering errors and noise sensitivity caused by common noise in medical images	Time consuming
[20]	Mean Shift Technique for Image Segmentation and Modified Canny Edge Detection Algorithm for Circle Detection	2014	Mean shift clustering and Modified Canny Edge Detection Algorithm	Reduces the sensitivity to noise and enhances the overall segmentation performance	Not work for Images which contain large amount of edge details
[21]	Segmentation of Two Dimensional Electrophoresis Gel Image Using the Wavelet Transform and the Watershed Transform	2012	Watershed and Wavelet Transform	Uses only single threshold parameter and allows accurate detection of the spots in each watershed region	Problem of detection of faint spots without introducing artifacts
[22]	Image segmentation by histogram thresholding using hierarchical cluster analysis	2006	Hierarchical cluster organization	Provides optimal threshold value and yields better quality images	Multi-level thresholding problem
[23]	HFSA-AW: A Hybrid Fuzzy Self-adaptive Audio Watermarking	2013	Novel fuzzy self-adaptive digital audio watermarking scheme, based on multi-level wavelet decomposition	Increased the tamper resistance of the watermark	Not work for Images which contain large amount of edge details
[24]	Analysis of Image Similarity with CBIR Concept Using Wavelet Transform and Threshold Algorithm	2013	Method of Adaptive histogram for color image and the method of wavelet transform for Shape / texture the image	Provides more reliable performance of CBIR and also able to find more resemblance ornament image Or texture as well as form.	Time consuming
[25]	Image segmentation using wavelet coefficients and geodesic distance between elliptical distributions for applications in street view	2012	Geodesic distance between GGDs in a Segmentation context and wavelet transform	Useful in tracking applications and provide better segmentation results	More dependency on window size
[26]	Efficient Analysis of DWT Thresholding Algorithm for Medical	2012	Advance thresholding methods with translation invariant and block function in	Best method to remove the Speckle, Gaussians and Salt &	Time consuming

	Image De-noising		the DWT domain	Pepper noise	
[27]	Gray Level Enhancement to Emphasize Less Dynamic Region within Image Using Genetic Algorithm	2012	Genetic Algorithm	Provides better image contrast enhancement	Not work for Images which contain large amount of edge details
[28]	Image Segmentation based on gray stretch and threshold algorithm	2015	2D discrete wavelet transform	Removal of noise and improvement of quality	Provide poor results for complex background

VI. GAPS IN EXISTING TECHNIQUE

Gaps are mentioned below:-

- 1) The use of fuzzy enhancement is not considered in gray stretch based method.
- 2) The existing technique provides poor results for complex background image.
- 3) The effect of color image segmentation is also ignored.

VII. CONCLUSION

Image segmentation is the first step from image processing to image analysis. Image segmentation is the partition of image into multiple segments to have clear distinction between object and background of image. In existing method, in order to obtain threshold accurately, discrete wavelet transform (DWT) method is used which decompose the image into four sub-bands via high and low pass filters. To determine threshold value, Otsu's method is applied on low pass filter and on high pass filter edge enhancement is implemented. The use of fuzzy enhancement is not considered in gray stretch based method. The existing technique provides poor results for complex background image. The effect of color images on segmentation is also ignored. In future a new technique will be proposed which modifies gray stretch based segmentation using Fuzzy C-means algorithm. The overall objective is to improve the accuracy for complex background images.

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