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Image Segmentation: A Survey

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Abstract: ***Image segmentation has always been an important topic in the field of image processing and it has a wide application on various fields like object detection, classification, edge detection, medicals fields, face detections etc. Main goal in image segmentation is to find the set of pixel or otherwise known as Super pixels in terms of different characteristics of pixels. In this paper, we are going to discuss some of the image segmentation techniques using various methods like Fuzzy C-Means (FCM) Clustering, Discrete Wavelet Transformation (DWT), Back Propagation algorithm based Neural Network and Image Histogram Analysis. Some papers also based on some hybrid approaches to enhance accuracy than that of traditional methods. In the end, we will compare all the methods to find a novel approach for image segmentation.***

Keywords: Image Segmentation, Fuzzy C-Means (FCM) Clustering, Neural Network (NN), Discrete Wavelet Transformation (DWT)

1. Introduction

Image segmentation always has been a challenging topic for researcher. It deals with various fields like medical fields for tumor detection, retina scan, detection procedures like face recognition, eye detection, edge detection etc. Image segmentation is a process of separation and partition of a whole image to different regions on basis of relevant attributes of all pixels in an image like quality, color, sharpness etc. [3][9]. The depth of segmentation decided particularly based on problem type and on the purpose to get a solution to given problem. Due to this, it still considered one of the hard problems in field of image investigating procedures [7][12]. The image segmentation problem broadly classified into two category based on which the pixels be categorized. First method based on texture of image and the second one based on grey levels of pixels [5][17]. In first method, target image categorized into various homogeneous areas in accordance to different textures. However, when the image possess similar texture for two different object area, the segmentation problem will be difficult for defining the segmented area for those regions. In second method, the segmented area decided by some pre-defined threshold values of pixel in grey level image. Main problem in this method is to decide an exact threshold value of grey level to get the exact solution to our segmentation problem [11][19]. Normally, there are five category of threshold estimation method such as statistic method, preserving moment method, entropy method, quad tree method and class variance method [14][16]. In this paper, we are going to discuss some of the methodologies for image segmentation proposed by researchers in last five years.

2. Image Segmentation Methods

In this survey, we are concentrating on three basic methods such as Fuzzy C-Means (FCM) clustering, Discrete Wavelet Transformation (DWT) and Back Propagation Neural Network algorithms for image segmentation process. Some hybrid methodology adopted by researchers also discussed here.

2.1 Suman Sedai et al., 2017

In this study, a fully convolutional neural network proposed for multi stage segmentation to find the fovea in retinal fundus images [2]. Fovea is a most significant anatomical landmark in an eye. The methodology adopted here consists of two important components. The first one consists of a Coarse network that will generate coarse-grained localization for the targeted fovea in the whole fundus image. The output of the Coarse network i.e. the localization will be the input for the second component of the methodology i.e. the Fine network. The localization considered as the Region of Interest (ROI) in the Fine network. Then Fine network performs a fine grained segmentation in the fovea region.

Both network structure are fully convolution artificial neural network with skip connection. Initialization of Coarse network done by a pre-trained VGA-16 model. The authors has not entertained all the 13 convolution layers originally present in this pre-trained network as it will reduce the memory as well as time cost during the simulation of testing and training. By application of 1 x 1 convolution in each intermediate step. Excluding the first block, all other blocks gives a side feature map (SFM). Then, all the blocks concatenated to form a complete feature map of input image size. Then a pixel wise segmentation has done in the fine network to get a segmented image from the received ROI. The network trained about 30000 iterations with a momentum factor 0.9 and learning rate is a quite small. The entire data set contains 400 images of resolution of 2600 x 2100. Accuracy of this methodology is 74-82% in Coarse network and 81-86% in multistage segmentation.

2.2 Anna Fabija´nska, 2017

In this paper, image segmentation of corneal endothelium done by application of feed forward network [8]. In this method, peak value of image pixels are detected using neural network, which will be considered as cell borders candidates. In any healthy cornea, up to 3000 endothelial cells are available, which is a very difficult for a manual image segmentation for this problem. The main problem here cause here is the heterogeneous corneal endothelium microscopic images. This reduce chances of identification of cell borders

in the sample image. In this research work, endothelium image Alizarine data set used. Total 30 images are used each having resolution of 576 x 768 pixels. The proposed method is designed get a binary representation of endothelial cell borders. The output format is in {0,1}, where the cell borders are shown as white pixels i.e. "1" and the cell bodies are shown as black pixels i.e. "0". The entire methodology is shown in the below figure. In this methodology, color space transformation done to convert the color space from RGB to HSV. The authors are interested in in the V component, as rest unit does not contain significant information on cell borders. For background removal done and after that feature are determined. The features are average value intensity of 5 x 5 pixels, standard deviation of intensity, scale and Vesselness. Then a simple feed forward neural network training done using these feature and {0,1} as output space. The neural network detect the picks in the features and assigns them to the significant cell borders.

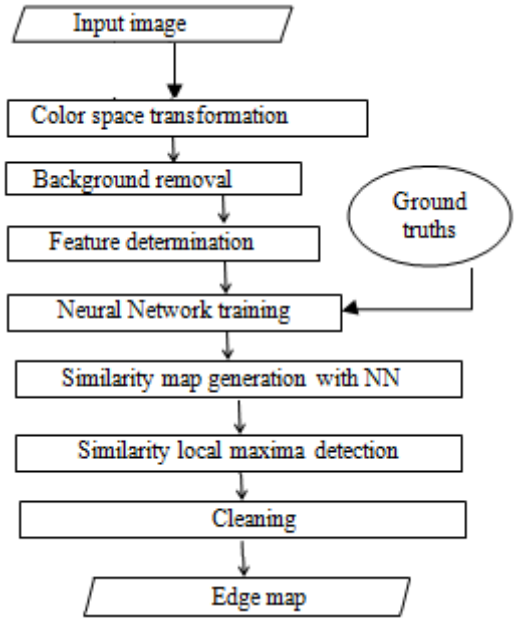

Figure 1: Methodology of corneal endothelium image segmentation

To test the accuracy Mean Square Error (MSE) and Correlation Co-efficient (CC) are calculated. The average MSE is 0.017 and average CC is 0.817, which shows a very good result.

2.3 Mukesh Chandra Arya and Dr. Bhumika Gupta, 2016

In this study, image segmentation applied on lung X-ray images to detect mass tissue by the application of Discrete Wavelet Transformation (DWT) [13]. They have used various image-processing techniques like image enhancement, image segmentation, image extraction and matching of templates using DWT. The proposed methodology in this paper divided into three major steps. For preprocessing of image, it passed through Weiner filter, which is a statistical approach based linear filter. It successfully eradicates the noises. After preprocessing, in segmentation process, it extracts objects from the images. The segmentation of target done by intensity based threshold technique. By this, process, the boundary of right and left lung identified. For detection of mass tissue, DWT comes to play. The original 1760 x 2140 X-ray image is divided into multi size blocks like "8 x 8", "16 x 16", "32 x 32" and "64 x 64" and DWT is applied to multi-sized blocks. Then after the threshold is set, according to calculated Euclidian distance, the pixels categorized as higher distance value as mass tissue pixels and smaller values are not. The whole procedure described in below figure. To test the results of the experiments, accuracy and precision calculated by below equation.

$$Accuracy = \frac{tp + tn}{tp + fp + tn + fn} \times 100$$

……Eq.1

$$Precision = \frac{tp}{tp + fp} \times 100$$

……Eq.2

Where tp = True positive, tn = True negative, fp = false positive, fn = false negative.

True positive is mass tissue and false positive can be considered as mass muscle.

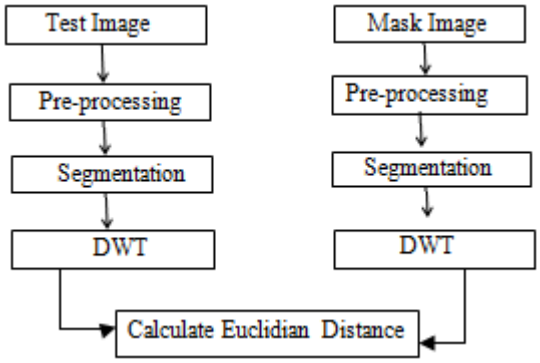

Figure 2: Methodology of mass tissue detection using image segmentation and DWT

The average accuracy found to be 86.20% and average precision is 83.32% on multi-stage segmentation.

2.4 Bharti Sharma and Kamaljeet Kaur Mangat, 2016

In this research paper, authors proposed a improved nucleus segmentation using hybrid approach comprising of FCM clustering and backpropagation algorithm based neural network for Cervical cells [15]. The entire methodology divided into three steps. In first step, anisotropic diffusion filter used to remove noise from target object. It is a gradient-based filter method. One of the gradient vector favors to high contrast edges and other gradient favors wide regions of images. After gradients are calculated, FCM clustering algorithm applied to the given image to form two or more clusters by below membership function.

$$f = \sum_{i=1}^{N} \sum_{j=1}^{c} u_{ij}^{m} \left\| x_i - v_j \right\|^2$$

……Eq.3

Where f = membership function, (i,j) is pixel location, u_{ij} =

membership degree, v_j = cluster center

After the clusters formed, back propagation algorithm based neural network used to discard the false regions detected earlier. The entire methodology of this research work is given by below figure.

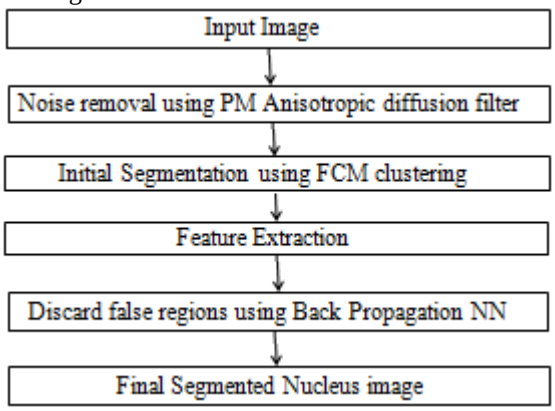

Figure 3: Methodology of nucleus segmentation using FCM clustering and BPNN

To evaluate the methodology, precision, recall and dice co-efficient are calculated. Precision is calculated as same as Eq.2. Recall and dice co-efficient is calculated as below equations.

$$Recall = \frac{tp}{tp + fn}$$

……....Eq.4

Where tp=True positive and fn=false negative

$$Dice = \frac{2 \times |A \cap B|}{|A| + |B|}$$

……....Eq.5

Where A = ground truth, B = Output

Herlev dataset used for this simulation, which consist of 917 Pap smear images. Precision of this proposed algorithm is 0.86±0.24.

2.5 Junpeng Wu et al., 2015

In this study, hybrid approach using fuzzy clustering and wavelet decomposition used for infrared image segmentation for Power equipment failure [18]. In this methodology, cluster centers decided by FCM algorithm with help a membership function. The membership function is same as Eq.3. After the wavelet decomposition of the image is done to decompose the image in 4 segments. This decomposition done by below process.

The test image f(x,y) recorded as A0. The components represented as:

Ai+1 = HAiH* Bi+1=HAiG*(v)

Bi+1=GAiH*(h) Bi+1=GAiG*(d)

Where h,v and d are image of horizontal, vertical and diagonal respectively and H*, G* are the conjugate matrix of high pass and low pass filter H, G respectively. After the image is segmented, the cluster centers are defined again and based on which the segmentation is done again. The contours generated to verify the segmented image.

2.6 Pratibha Singh et al., 2014

Number In this research wok, using FCM and Level Set Method (LSM), an automatic segmentation of brain MRI image simulated [20]. Whole methodology is presented in below figure.

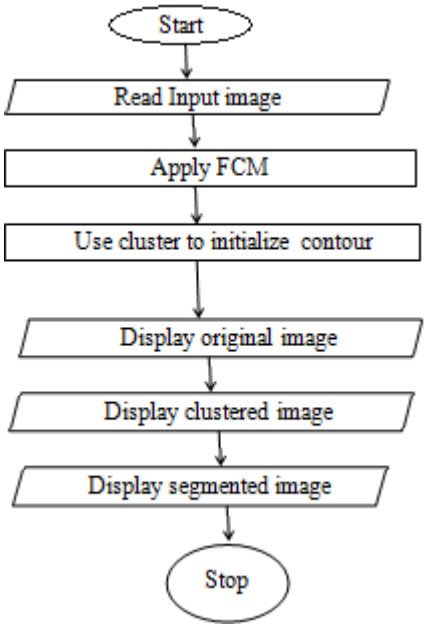

Figure 4: Methodology of brain MRI image segmentation using FCM clustering and LSM

Here, FCM is used find the clusters in the target image and LSM is used to find the image contour. In traditional level set method, re-initialization of contours are needed. But, in this proposed methodology, re-initialization is avoided to save execution time. In proposed algorithm is built by integration of FCM and LSM to get an efficient result. This simulation took only 0.20532 seconds to complete. As the algorithm made the image smooth, there is no possibility that any noise will affect the result.

3. Result Analysis and Discussion

After studying all the literatures, we have analyzed all the methodologies and results. Below table shows the comparison between all the methodologies with corresponding results.

Table 1: Image Segmentation Methodologies

S.No.	Methodology	Result
2.1	Convolutional Neural Network	81-86% Accuracy with ground truth
2.2	Feedforward Neural Network	Mean Square Error:0.017, Correlation Co-efficient: 0.817
2.3	Discrete Wavelet Transformation	Accuracy:86.20% Precision: 0.83%.
2.4	Hybrid approach using FCM and BPNN	Precision: 0.86±0.24
2.5	Hybrid approach using FCM and Wavelet Decomposition	Fits the verification contour
2.6	Hybrid approach using FCM and LSM	Faster execution: 0.20532

From the above comparison, we can see that application of neural network results high accuracy. Using FCM, we can have clusters and cluster center calculations much faster. Discrete Wavelet Transformation results in better feature extraction comparison to other feature extractors in very low time and characteristics of pixel information in different decomposed element are better to analyze and study their behavior.

4. Conclusion

After analysis of all research work, we came to the conclusion that hybrid of all three procedures i.e. FCM, DWT and BPNN with their independent merits, will be a novel approach to solve image segmentation problem. But, to decide the no. of clusters available in the image before starting the simulation will be an advantage for the simulation. To do so, we can analyze the histogram of the image to find out the peaks in the histogram graph. The no. of picks will be no. of clusters. Hence, we can save time for finding the no. of clusters in FCM. Taking Image gradient vector into consideration as feature also will be an advantage and we can feed that feature as input to neural network to have better training.

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