Adaptive Local Threshold Algorithm and Kernel Fuzzy C-Means Clustering Method for Image Segmentation

Sayana Sivanand
Mtech, Communication Engineering
FISAT,Ernakulam,Kerala,India

Abstract- Image segmentation is widely used in the field of image processing. In this paper a novel method isproposed forperforming image segmentation. To overcome the problem of conventional threshold segmentation method, an adaptive local threshold algorithm is proposed. This method works well with images having non-uniform illumination. The problem of Fuzzy C-Means clustering method can be avoided by using kernel based clustering technique. Kernel Fuzzy C-Means clustering method can be used for images having unequal sized clusters. Experiments on the medical images demonstrate that proposed method has better clustering performance.

Keywords –Image segmentation, Adaptive local threshold algorithm, Kernel Fuzzy C-Means clustering

I. INTRODUCTION

Image segmentation plays an important role in high level image interpretation and image analysis. Based on certain characteristic properties of pixels such as color or intensity image segmentation partition an image into different segments.The resulting segmented image will beeasier to analyze and understand. Different kinds of segmentation methods have been developed [1-3]. According to reference [1] four categories of image segmentation are thresholding, clustering, edge detection and region extraction. Threshold based techniques are mainly used for segmenting images consisting of bright objects against dark backgrounds and vice versa. It also provides fast data processing and data compression. Two types of thresholding techniques are global thresholding and locally adaptive thresholding. Global thresholding method does not work satisfactorily with noisy images as it uses a fixed threshold value for entire image. Adaptive local thresholding can overcome this problem by choosing dynamically changing threshold over the image. However in many real situations this hard segmentation yield poor results because of certain problems in images such as low local contrast, overlapping intensities, noise etc. So soft segmentation techniques based on clustering technique developed. Fuzzy set theory introduced the concept of membership function [5]. In this method a pixel can belong to more than one cluster. The strength of association between pixel and cluster center is given by the membership value. Fuzzy c-means (FCM) algorithm is the most popular fuzzy clustering technique as it has robust characteristics for ambiguity. Also it can keep more information compared to hard segmentation method [6]. However this method does not work well with images consisting clusters of different size and densities. So kernel versions of FCM algorithm proposed to cluster more general dataset.

The rest of the paper is organized as follows.Section II describes theproposed adaptive local threshold algorithmand kernel fuzzy c-means clustering method. Experimental results are given in section III. Finally, some conclusions are drawn in section IV.

II.PROPOSED SEGMENTATION METHOD

A. Adaptive local threshold algorithm –

Threshold value is calculated for each pixel in the image for performing thresholding operation. Two methods that can be used for calculating the threshold are Chow and Kaneko method and local thresholding. Both methods are based on the assumption that small regions in the image are likely to have uniform illumination. In Chow and Kaneko method the input image is divided into a number of overlapping sub images. Threshold value for each sub image is then calculated based on the histogram. Then by interpolating results of the sub images threshold value of each pixel in the image can be obtained. However this method is not used for real-time applications since it is computationally expensive.

Local thresholding compute the threshold value by statistically examining the intensity values in the local neighboring of each pixel. Mean or median can be used as the statistical operator and the choice will depend mainly on the input image. For fast functioning mean of the local intensity distribution is chosen. The neighborhood size should be chosen carefully as too large value can violate the assumption of uniform illumination. Also it should be large enough to cover sufficient foreground and background pixels. This sophisticated thresholding technique can accommodate changing light conditions in the image.

The following outlines adaptive local thresholding

1. Convolve the image with the statistical operator
2. Subtract original image from convolved image
3. Threshold the difference image
4. Invert the threshold image

This adaptive thresholding step can provide an initialization for the sophisticated kernel fuzzy c-means clustering technique.

B. Kernel Fuzzy C-Means (KFCM) clustering –

Kernel corresponds to an inner product in the featurespace F via a map Φ and it is given by Φ: X → F where X denotes the dataspace [7]. For calculating inner product of the form ⟨Φ (*x*), Φ (*y*)⟩ kernel representations of the form *k*(*x*, *y*) = ⟨ Φ (*x*), Φ (*y*)⟩ can be employed. This allows calculating inner product in F without having to perform the mapping Φ. Now the objects can be analyzed in the high-dimensional feature space instead of the input data space. This is the main advantage of the kernel functions. KFCM algorithm partitions n data elements in the data space into c fuzzy clusters based on some criterion. Algorithm outputs a membership matrix U where each element tells the degree to which element x_i belongs to cluster c_k. It is based on minimization of the following objective function

$$J_m(U,V) \quad , \qquad (1)$$

Fuzzier m is an important factor and it controls the degree to which the clusters are allowed to overlap. If m is too small (m=1), then it will become hard c-means algorithm and if m is too large, then it will over emphasize the effect of far away data objects.
From the definition of norm

$$\left\|\Phi(x_i) - \Phi(v_i)\right\|^2 = K(x_k, \qquad (2)$$

Where Φ(y)is the kernel function. Using Gaussian function as a kernel function, i.e., K(x,y)=exp( ),we have K(x,x)=1.Applying this to Eq. (2), Eq. (1) will become

$$J_m(U,V) \qquad (3)$$

Minimizing Eq. (3) under the constraint of we get

(4)

(5)

Eq(2) can be analyzed as kernel-induced new metric in the data space, which isdefined as the following

$$d(x, y) \triangleq \| \qquad (6)$$

And it can be proven that d(x, y) is defined in Eq. (6) is a metric in the original space in case thatK(x, y)takes as the Gaussian kernel function. To prove d(x, y) is a metric, the necessary and sufficient condition is that d(x, y)satisfies the following three conditions

i. d(x,y) > 0, □x≠y, d(x,x)=0
ii. d(x,y) = d(y,x)
iii. d(x,y) ≤ d(x,z) + d(z,y), □z

It's easy to verify that for Gaussian, d(x, y) satisfies □x ≠ y, d(x, y) = d(y, x) >0, and d(x, x) = 0 , so condition (i) and (ii) are satisfied.

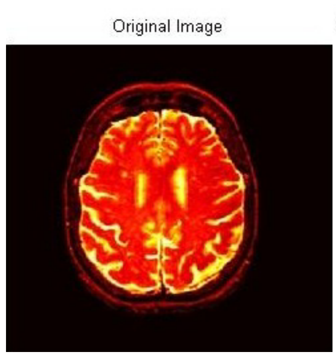
$$d(x,y) = \|\Phi(x) - \Phi(y)\| \leq \|\Phi(x) - \Phi(z)\| + \|\Phi(z) - \Phi(y)\| = d(x,z) + d(z,y)$$

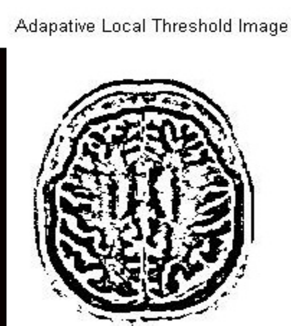
Thus condition (iii) is also satisfied due to the properties of the norm. So d(x, y) is a metric.
According to Eq. (5), the data point is capable with an additional weight K( ) which measures the similarity between and and when is an outlier i.e., is far from the other data points, then K( ) will be very small, so the weighted sum of data points shall be more strong.KFCM has better outlier and noise immunity than FCM. The KFCM algorithm is as follows:

1. Initialize $U=[u_{ik}]$ matrix, $U^{(0)}$
2. Calculate the centers vectors $V=[v_i]$ with Eq.(5)
3. Update membership matrix U with Eq.(4)
4. If$\|V_{new} - V_{old}\| \leq \varepsilon$ then STOP; otherwise return to step 2

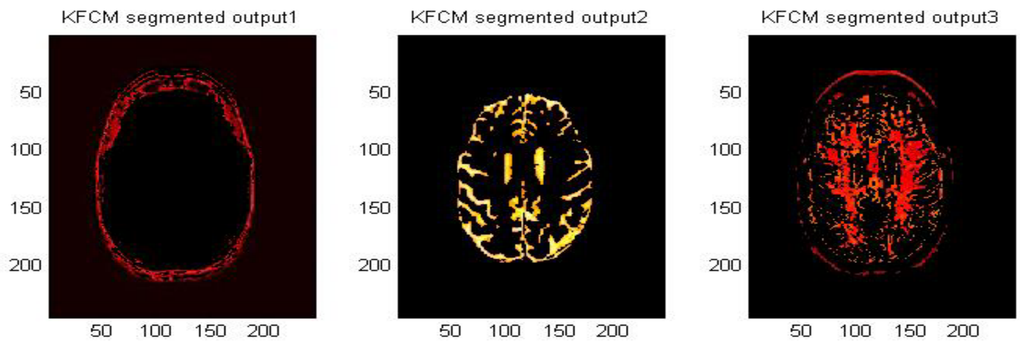
III. Experimental Result

The test was performed on the medical images selected from internet and it was implemented using Matlab 7.0 software. Firstly the original image is given to the adaptive local threshold algorithm. The resulting binary segmented image shows an approximate contour of the white matter. The output of adaptive local threshold algorithm is then given to kernel fuzzy c-means clustering to obtain final segmented image with fuzzy boundaries.



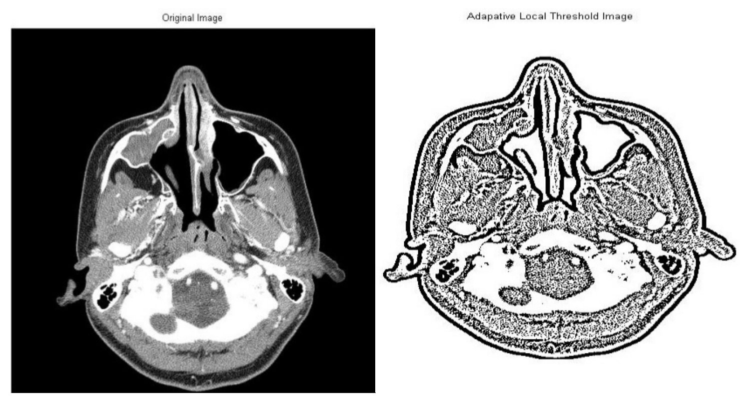


(a) (b)

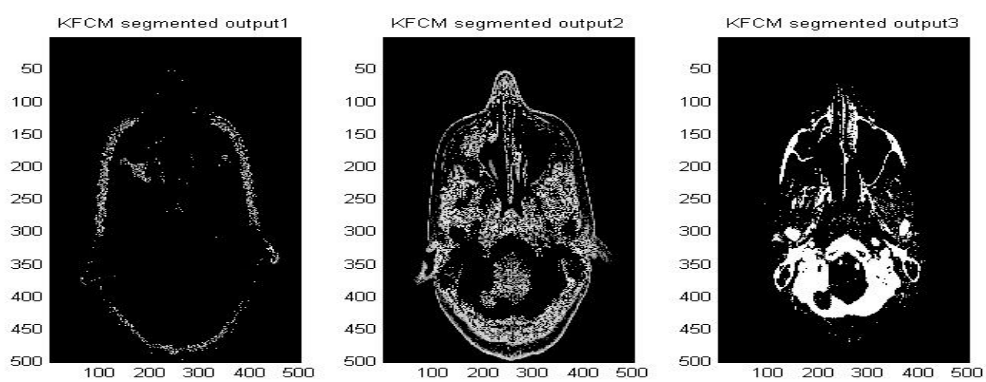


(c)

Figure 1. (a) Original image (b)Adaptive Local Threshold Image (c) KFCM Segmented output



(a) (b)



(c)

Figure 2. (a) Original image (b)Adaptive local threshold Image (c) KFCM segmented output

IV.CONCLUSION

In this paper adaptive local thresholding and kernel fuzzy c-means clustering method has been proposed for performing image segmentation. Adaptive thresholding technique has solved the problems of global thresholding method in the case of low contrast noisy images. Kernel induced fuzzy clustering technique provided segmented fuzzy images. This technique is suitable for segmentation of medical images.

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