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Transition Region-Based Thresholding using Maximum Entropy and Morphological Operations

M.Chandrakala[1], P. Durga Devi[2]

Abstract— **Thresholding method based on transition region is a new approach for image segmentation. In this paper, a novel transition region extraction and thresholding method based on maximum entropy and morphological operations. Hence, the proposed algorithm can accurately extract transition region of an image and get ideal segmentation result. The proposed algorithm was compared with maximum entropy and Niblack algorithm on a real world images, and the experimental results show the effectiveness and efficiency of the algorithm.**

Index Terms—Image thresholding, Image segmentation, Misclassification error, Transition region.

I. Introduction

Image segmentation separates an object from a background depending on some characteristics such as gray level, color, texture and location [1–4]. Applications of threshold based image segmentation are biomedical image analysis [5], handwritten character identification [6], automatic target recognition [7] and change detection [8]. Threshold based image segmentation plays important role in image analysis. Transition region-extraction using thresholding is new approach for image segmentation in recent years.

Transition region is located between objects and background, and is composed of pixels having intermediate gray levels between object and of background [9]. The available transition region-based thresholding methods can be classified as the bidirectional and unidirectional approaches. The effective average gradient approach [9] is a representative among the bidirectional methods. The unidirectional restriction approaches include higher gradient-based method [10, 11], gray level difference-based method [13], and local entropy-based method [12]. For the noisy images, the gradient-based and gray level difference-based methods often misclassify most of object or background regions into transition region and cause serious deviation of the transition region. As a consequence, the two methods often yield bad segmentation results for the noisy images.

M.CHANDRAKALA, Electronics and Communication Department, Jawaharlal Nehru Technology University/Mahatma Gandhi Institute of Technology, Hyderabad, INDIA

P.DURGADEVI,.Electronics and Communication Department, Jawaharlal Nehru Technology University/Mahathma Gandhi Institute of Technology, Hyderabad, INDIA.

The local entropy-based method describes pixel with the local entropy concept. The local entropy is larger for heterogeneous region but smaller for a homogeneous neighborhood. The pixels with larger local entropy value belong to the transition region with higher probability. However, when the heterogeneity of the object or background region is close to or even exceeds that of the transition region, it is difficult for the local entropy method to extract the transition region from the object or background.

The paper is structured as follows. In Section 2, presents theory and implementation of the proposed method, Section 3 discusses experimental results for the selected threshold methods and proposed method .Finally, Conclusion is drawn in section 4.

II. PROPOSED THRESHOLDING METHOD

To overcome the limitations in global thresholding and improve threshold based segmentation effect on images, we present Transition region-based thresholding using maximum entropy and morphological operations. As illustrated in fig.1, the steps of proposed algorithm are as follows, (1). Thresholding based on maximum entropy, (2). Area open image is to remove unwanted regions from an image, (3).Canny edge detector to detect image edges, (4). Dilated gradient mask, (5).Binary image filled with holes,(6).Border removal image,(7).Eroded image, (8).Image segmentation result.

A. Maximum entropy threshold segmentation

The main advantage of maximum entropy segmentation is that the threshold is chosen to divide the image into two classes. When the sum of their average entropy is maximized, the largest amount of information can be extracted from the image. Performance of 2D entropy method is more advantageous than 1D entropy method [14]. Maximum entropy threshold segmentation based on gray-level change. Average gray level values of each pixel neighborhood from *0* to L, as well as the gray level values of each pixel. First, P_i is the probability distribution pair of gray level pixel and its neighborhood gray level pixel.

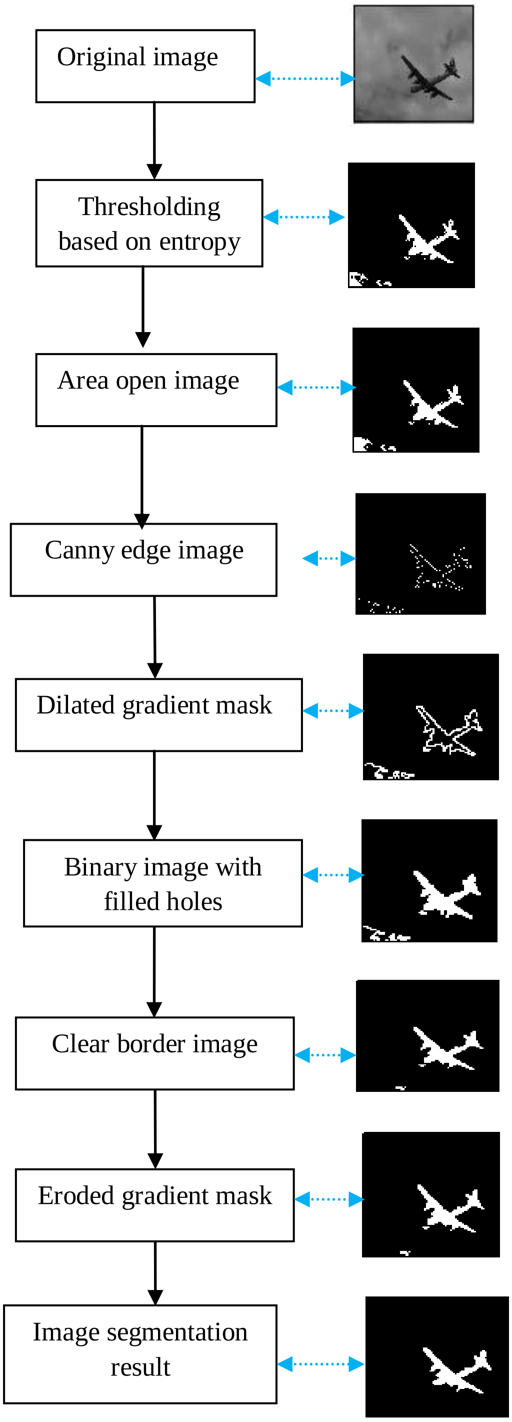


Fig.1. Flow chart of the proposed algorithm.

. Next, an initial threshold 'T' is determined to divide the image into two classes C1 and C_2. The average relative entropies of the two classes are calculated separately as A_1 and A_2.

Where $P_T = \sum_{i=0}^{T} P_i$

$$A_1 = -\sum_{i=0}^{T} \left({}^{p_i}/_{p_T}\right) * \ln\left({}^{p_i}/_{p_T}\right) \qquad (1)$$

$$A_2 = -\sum_{i=T+1}^{L} \left({}^{p_i}/_{(1-p_T)}\right) * \ln\left({}^{p_i}/_{(1-p_T)}\right) \qquad (2)$$

If the image is divided into two c_1 and c_2 classes according to a certain threshold and the resulting entropies satisfy max $\{A_1$ & $A_2\}$, then this threshold is the maximum entropy based threshold.

B. *Extracting object region and morphological processing*

Object region is extracted by utilizing morphological operations. After determining the object area from maximum entropy threshold segmentation result, it is then processed morphologically and final segmented result contain only object. This morphological processing mainly uses MATLAB operators such as *strel, imdilate, imfill, imerode, bwlabel, bwconncomp,regionprops, imclear border and so on.* It consists of following main steps.

(1). After maximum entropy based threshold segmentation, *bwconncomp* MATLAB function compute connected components of all objects including noise in foreground area. MATLAB function *regionprops* can be used to estimate the area enclosed by each object. To extract features from a binary image using regionprops with the default connectivity, labeled matrix was used to obtain the center, length, width, pixel coordinates and the area of each sample using Matlab function *regionprops*. Using morphology function *bwareaopen*, remove pixels which do not belong to the objects of interest and noise pixels. Because, according to characteristics of individual objects, a connected area smaller than a certain size cannot be foreground object.

(2). After extracting valid area next step is edge detection. Edge detectors extract useful edges and contours. There are several edge detection operators in the image processing field and canny edge detector [15] is one of the most effective detectors. Canny detect a wide range of edges in images. Canny method is the best method because it has a good detection, good Localization. For canny method, the output edges closer to the Original image.

(3). Mathematical morphological operations are erosion and dilation [16, 17]. These operations uses structuring element. Selecting a mask in proper shape and size to take morphological actions has a key role in achieving desired results and reducing calculation time. In general, the shape and size of a mask are depending on applications. In some of threshold based segmentation applications object region have number of black spots those black spots can be filled by dilation operation using structuring element. Dilation operation reduces noise pixels present in an image. After dilation operation object region increases. Dilation operation can eliminate dark regions in an image.

(4). The dilated image shows the outline of the image quite nicely, a flood fill operation is performed on the dilated binary image, namely the object boundary. MATLAB function *imfill* performs this operation.

(5). The object of interest has been successfully segmented, but it is not only object that has been found. Any objects that are connected to the border of the image and background noise pixels can be removed using the *imclearborder* function in MATLAB.

(6). The erosion operation reduces the size of the object. This operator removes noise in the back ground under mask makes the final image looks better than original image.

III. EXPERIMENTAL RESULTS AND ANALYSIS

In order to demonstrate the effectiveness of proposed method, we used real world images from Berkeley segmentation data set. Real world images with resolution 256x256 pixels and 256 gray levels are shown in fig.2 (a) to 4(a). Ground truth images are shown in fig.2 (b) to 4(b). For comparison, we chose some thresholding algorithms namely maximum entropy based thresholding and Niblack algorithm [18].

As shown in fig. 2(a), Original image gray levels shows the airplane 1 image with uneven background illumination. It can be easily seen that large black areas have been formed in the left-up and down and right down corner of background gray levels identical to object gray levels. Maximum entropy thresholding as shown in fig.2 (c), maximum entropy wrongly divides some non transition region in to foreground. As can be seen, more background pixels are misclassified in to foreground as shown in fig.2 (c). Niblack[18] is a local thresholding algorithm that adapts the threshold according to the local mean and the local standard deviation over a specific window size around each pixel location. The window size recommended by Trier and Tact [19] is 15 by 15 and k = -0.2. The quality of thresholded image determines with the value of 'k' and the size of the sliding window.

In Niblack algorithm, depending on application the size of window and coefficient 'k' changes from image to image. Niblack thresholding results are shown in fig .2(d), we selected window size as 400x400 and 'k'= -0.05.However the segmentation accuracy is poor as illustrated in fig. 2(d). Niblack is sensitive to noise, more background details appears in foreground. Segmentation result of proposed method as shown in fig.2 (e), can clearly distinguish object image from its background. Quality of image segmentation result is only judged by Visual perception. More details of airplane image segmented accurately and better visual quality is acquired by the proposed method. From our experiments and comparison, it can be concluded that our proposed algorithm produces better segmentation result than other maximum entropy and Niblack methods, whether input image is unimodal, bimodal or multimodal, even when the image is unevenly illuminated.

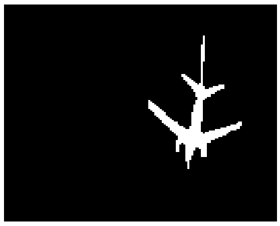
Field image and the corresponding ground-truth images are displayed in Figs. 3(a)–(b), respectively. The field image mainly consists of object and background with different gray level distribution range. The maximum entropy method treats the pixels with higher local entropy as the transition region.

(a) Original image

(b) Ground truth image

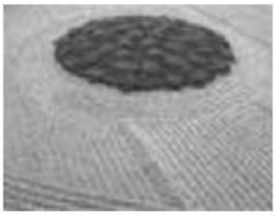
(c) Maximum entropy

(d) Niblack's thresholding

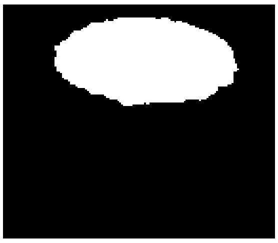


(e) Proposed method

Fig. 2: (a) Original image of airplane1,
(b) Ground truth image, (c) Maximum entropy,
(d) Niblack's thresholding,(e) Proposed method

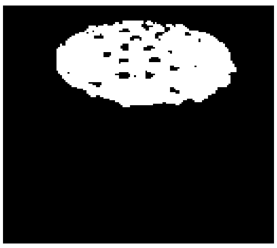


(a) Original image

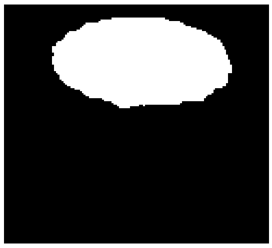


(b) Ground truth image

(c) Maximum entropy



(d) Niblack's thresholding



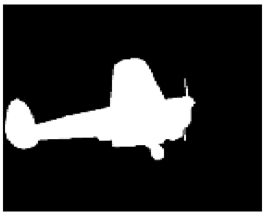
(e) Proposed method

Fig. 3: (a) Original image of field,
(b) Ground truth image, (c) Maximum entropy,
(d) Niblack's thresholding,(e) Proposed method

However, for this field image, the local entropy values of partial pixels in the background are almost equal to those of the transition region. Thus, the maximum entropy method misclassifies partial background region into transition region as shown in fig.3(c). Niblack thresholding result is shown in fig .3(d), we selected window size as 400x400 and 'k'= -0.05.Segmented field image contain some black dots (noise), because Niblack algorithm sensitive to noise. Proposed method can accurately segmented the field image from the background as shown in fig. 3(e). The proposed results are visually much closer to the ground truth image.

Figs. 4(a)–(b) shows airplane 2 image and the corresponding ground-truth image, respectively. Both object and background have a different gray level distribution. Maximum entropy based segmentation result is shown in fig.4(c), pixels are misclassified on the top portion and noisy pixels are on resultant image. Segmentation result of Niblack algorithm conations noisy pixels on airplane 2 image as shown in fig.4 (d). Among these methods, the proposed method more accurately extract transition region of the image and obtains better segmentation result than other maximum entropy thresholding and Niblack methods as shown in fig. 4(e) .

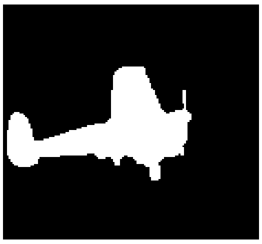
(a) Original image



(b) Ground truth image

(c) Maximum entropy

(d) Niblack's thresholding



(e) Proposed method

Fig. 4: (a) Original image of airplane2,
(b) Ground truth image,(c) Maximum entropy,
(d)Niblack's thresholding,(e)Proposed method

Table 1
Misclassification error Maximum entropy, Niblack and proposed method

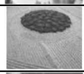
Original image	*Maximum entropy*	*Niblack method*	*Proposed method*
	0.9671631	0.0967712	0.0067596
	0.8046875	0.0231476	0.0046539
	0.8368378	0.0226593	0.0132141

Table 1 reported the quantitative results obtained by using proposed method, Maximum entropy and Niblack techniques. For each experiment quality of thresholded images quantitatively analyzed using misclassification error [20].

The misclassification error (ME) reflects the percentage of background pixels wrongly classified into foreground, and conversely, foreground pixels wrongly assigned to background. Smaller the value of ME indicates the better the segmentation accuracy. ME value varies between '0' and '1'. ME value '0' means segmented accurately and '1' means totally erroneous result.
Moreover by analyzing the result reported in Table1 1, airplane 1 image misclassification error is less in proposed method than other two techniques. Field image ME is less in proposed method than other two methods. Airplane 2 image misclassification error is less in case of proposed method than maximum entropy and Niblack algorithm. From the assessment we concluded that proposed method segmented more accurately than other two methods.

IV.CONCLUSION

Uneven illumination images, global and some local thresholding techniques are enable extract object form background. This paper proposes new thresholding technique. The proposed method can extract transition region more accurately which results in good segmentation on variety of images demonstrates the effectiveness and efficiency of the new method. The proposed method results are visually much closer to the ground truth image. Besides the above advantage, segmentation results fails, when ever canny detector unable to detect closed contours.

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1. **M. Chandrakala** is Assistant Professor, Dept. of E.C.E, Mahatma Gandhi Institute of Technology, Affiliated to JNT University, Hyderabad, Telangana, India. She completed Masters in Electronics and Communication in 2008 from Osmania University, Hyderabad, Telangana, India.

2. **P. Durga Devi** is Assistant Professor, Dept. of E.C.E, Mahatma Gandhi Institute of Technology, Affiliated to JNT University, Hyderabad, Telangana, India. She completed Masters in Electronics and Communication in 2012 from JNT University, Hyderabad, Telangana, India.