Splitting and Merging Algorithm Based on Local Statistics of Sub-Regions in Document Image

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Abstract— This paper presents splitting and merging algorithm based on adaptive thresholding. The algorithm first divides the image into blocks, and then compares each block using the calculated thresholding value. The blocks which are same are merged using the certain threshold value and different blocks are split unless it satisfies the threshold value. When the block has been merged, maximum and minimum block sizes are determined then the average block size is determined. After the average block size is determined the average intensity and standard deviation of average block is calculated. The process of thresholding is applied to binarize the image. Finally, the experimental results show that the proposed method distinguishes clearly the background with text in the document image.

Index Terms— standard deviation, image enhancement, split and merge, mean.

I. INTRODUCTION

THE most important thing that we need is the information. So information should be easily readable. Basically, historical text documents are difficult to read so one of the basic techniques for the extraction of the text is thresholding. It is the conversion of gray level or color image into the black or white image or conversion of the pixel which is in the range of 0-256 into 0 or 1 form. As the time passes we have different documents which have to be preserved for the future references. But the documents which are preserved may be distorted by various means like light illumination, noise, dust and many other factors. So the historical documents are really difficult to read and identify the text written on it. Various algorithms have been proposed by different authors so that the historical documents can be read effectively. If the background is uniform, it can read the text. However it is difficult to read the text when the document is not uniform. Niblack [2] algorithm is based on the local statistics of the image and works well but fails when the background of the image has light texture. Niblack [2] used the following equation to calculate the threshold

value $T(x, y)$ at pixel (x, y) using the following equation:

$$T(x, y) = m(x, y) + k.s(x, y), \quad (1)$$

Where $m(x, y)$ and $s(x, y)$ are the mean and standard deviation of local area. Sauvola [3] proposed a new method which is the modified form of the Niblack's method by adding the hypothesis in the background and text in the image. It uses the following formula for the threshold.

$$T(x, y) = m(x, y) + 1 - k \left(1 - \frac{s(x, y)}{R} \right), \quad (2)$$

Where $m(x, y)$ and $s(x, y)$ are the mean and standard deviation of the local area and R is the dynamics of the standard deviation fixed to 128 and k is fixed value usually set to 0.5.

Gatos [5] proposed the binarization technique for the poor document and he has used Sauvola [3] technique to determine the foreground of an object. Gatos [5] used the following formula:

$$I(x, y) = \mu + ((\sigma^2 - v^2)(f(x, y) - \mu))/\sigma^2, \quad (3)$$

Where $f(x, y)$ is the gray level source image, μ is the local mean, σ^2 is the variance at 3×3 neighborhood around each pixel and v^2 is the average of all estimated variance for each pixel in the neighborhood. These all method works well for the poor quality document image. Since thresholding value of each pixel should be determined. The computational complexity is high.

This paper presents a new algorithm based on the splitting and merging of text image using the local statistics of the image.

II. PROPOSED ALGORITHM

In Fig. 1, splitting and merging is such a recursive approach which takes the image as input and divides the image into four different parts. Then the image consists of four different sub-images. The further split takes place in the sub-images if the homogeneity is not same. It applies the same operation to the non-homogenous sub-image region.

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In this section, the algorithm for enhancement of the text document is proposed which divides the whole image into small blocks based on the local statistics of the pixel. The basic process of splitting is shown in Fig.1 (a). The given image is split into four parts and the sub-region is further sub-divided into different sub-regions unless the some thresholding criteria is satisfied. Fig.1 (b) shows the hierarchical splitting of the Fig.1 (a).

Fig. 1. Normal Split-Merge.

Fig. 2. Procedure of the proposed algorithm.

A. Calculating the basic threshold parameter

For the splitting of the image into different sub-region, some thresholding value should be determined. Therefore the input image is taken and its mean and standard deviation is determined. The determined mean and

standard deviation is the global mean and standard deviation of the image. The basic thresholding value is determined by using the following formula.

$$T = a * m + b * st, \quad (4)$$

Where m and st are the mean and standard deviation of the image, respectively. a and b are any constants whose value is determine experimentally. Using this thresholding value T , the image is split into different sub-regions.

B. Splitting

Splitting operation splits the image into four different parts. It takes the thresholding value T which is calculated in Equ. (4) and splits the image into four different sub-images. The different sub-regions are checked with the thresholding value T . If the sub-regions satisfy the thresholding value T , they are not further split into sub-regions else they are split into more sub-regions unless they satisfy the thresholding criteria T .

C. Merging

Merging is the process of adding the sub-regions which has been split into different sub-regions. The sub-regions that are similar are merged with one another and sub-region that are not similar are left out. Therefore, the merging of the different sub-regions is done by following the two different steps.

1) *Calculating the average block size and average intensity of block*

After the splitting of image into different sub-region, the average block size of sub-region is calculated. Then the average mean and the standard deviations value of the average block is calculated.

Equ. (5) calculates the average block size. Equ. (6) calculates mean (μ) of an average block. Equ. (7) calculates standard deviation (σ) of average block. The thresholding value is calculated by the addition of the mean and standard deviation of average block which is shown in Equ. (8).

$$avg(block) = \frac{\text{numbers of pixel in each block}}{\text{number of blocks}}, \quad (5)$$

$$\mu(block) = \sigma(avg(block)), \quad (6)$$

$$\sigma(block) = \sigma(avg(block)), \quad (7)$$

$$T = \mu + \sigma, \quad (8)$$

Where μ and σ are the mean and standard deviation of the average block.

2) *Thresholding each block*

As it is known that the standard deviation of the image gives the diversity of the pixel in an image and the mean of the image gives the intensity of the image, therefore the

final thresholding of the image is explained below.

Then mean and standard deviation of the each sub-region is calculated. If the standard deviation of each sub-region is less than the predefined standard deviation ($\sigma \leq \sigma_T$) then the sub-region may contain either the background pixel or foreground pixel. If the mean of the each region is greater than the predefined mean value ($\mu \geq \mu_T$) then the region contains only the brighter pixel. The final binarization of each sub region is done by using the Equ. [9]. If the sub-region has the value greater than T obtained from the Equ. [9] then the region is merged and labeled as object else it is labeled as background. The value of σ_T and μ_T are determined experimentally and found as 7 and 9 respectively for the document images.

III. SIMULATION AND RESULTS

The proposed algorithm is verified by testing in different kinds of document images. The simulation is performed on MATLAB 9.0. Documents are taken from the newspaper and other different sources.

In Fig.3 (a) shows the original input image. This image contains a lot of background noises which makes difficult for people to read the object clearly. The input image is tested using different algorithm. Fig.3 (b), Fig.3 (c), and Fig.3 (d), shows the output image obtained using Otsu method, Niblack method and Sauvola method. Fig.3 (e) shows the output image obtained using the proposed method. The original image when passed through the proposed algorithm gives the better experimental result as compared with other three different algorithms. The text is not clear and noises are retained with three different methods but with the proposed algorithm, the text is clear and noises are removed from the image which makes the text clear and easier to read. Fig.4 also shows the comparison of experimental results between proposed algorithm and other three methods. As it clear from the experimental results that proposed algorithm yields better results than the other three different methods. Fig.5 (a), Fig.6 (a), Fig.7 (a), and Fig.8 (a) are the original text document image and Fig.5 (b), Fig.6 (b), Fig.7 (b), and Fig.8 (b) are the output images respectively, obtained experimentally using proposed algorithm. Therefore, the proposed algorithm was applied to the different types of image and the result achieved was convenient. Thus, the experimental results when applied to different kinds of text documents yields better result than the other three different methods and proves that proposed algorithm is better and gives better result in comparison to other methods.

Fig. 3. Simulation results obtained using different methods and proposed method.

Fig. 4. Simulation results obtained using different methods and proposed method.

Fig. 5. Simulation result of text using proposed method.

Fig. 6. Simulation result of text using proposed method.

Fig. 7. Simulation result of text using proposed method.

Fig. 8. Simulation result of text using proposed method.

IV. CONCLUSIONS

In this paper, we have presented the algorithm for the thresholding of the text document. The algorithm uses the splitting and merging techniques based on the local statistics of the sub-regions. The mean and the standard deviation of the sub-region is calculated and compared with the predetermined value and finally the binarized image is achieved by using the thresholding value T . Since the sub-regions are merged instead of each pixel the complexity is also reduced. Finally, the proposed algorithm works for the text document with the different background.

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