Speeding up Object Attribute Thresholding Technique

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Abstract

Recently, an algorithm for character image binarization called Object Attribute Thresholding (OAT) technique has been proposed. The algorithm is composed of two stages. The first stage performs a pretest to identify the object attribute by Otsu's approach.[1] The second stage is used to eliminate background from object attribute, and again by Otsu's approach. The suitable threshold selection is obtained by repeating Otsu's algorithm until the threshold which is closed to the intensity of character is found. The OAT is wasted because it uses iterative Otsu's approach twice. The suitable threshold separate the character attribute from first stage is not less than the threshold from second stage or it may be the same value. In this paper, we propose a speed-up algorithm to the OAT that reduces the whole process into a single stage. Our technique is two times faster than the OAT for many test images. Also, in comparison with the recursive thresholding technique proposed by Ref. [2], it was found that our technique is faster while providing the comparable results.

Introduction

In document image analysis, many applications such as optical character recognition, signature verification and automatic document processing, acquire optically scanned gray scale images by a flat-bed scanner. The first preprocessing step is usually to threshold the image to separate the foreground (handwriting or text) from the background. This process is commonly performed by a global thresholding. Global techniques are usually effective because the majority of documents have relatively constant contrast. Local adaptive thresholding tends to emphasize the patterns in the background when there is no character present in the local region. We restrict our consideration here to global thresholding techniques.

The Otsu's algorithm[1] is may be the most well-known technique for the threshold selection methods. Various techniques were adapted from this algorithm, including Recursive Thresholding,[2] NAT,[3] Integral Ratio[4] and OAT.[5] Recently, an algorithm for character image binarization called Object Attribute Thresholding (OAT) has been proposed. The algorithm is based on the Otsu's technique and composed of two stages. The first stage performs a pretest to identify the object attribute by Otsu's approach. The second stage is used to eliminate background from object attribute, and again by Otsu's approach. The suitable threshold is obtained by repeating Otsu's algorithm until the threshold which is closed to the intensity of character is found. The OAT is wasted because it tests the attribute of object by iterative Otsu's approach before it finds the threshold by iterative Otsu's approach again. This technique is processed by iterative Otsu's approach twice. In this paper, we propose a speed-up algorithm to the OAT that reduces the whole process into a single stage. Our technique finds the character attribute and the threshold to separate background concurrently.

Global Thresholding

A global thresholding technique is usually based on the histogram of an image. The histogram is separated into two classes of pixels: the foreground (object) pixels and background pixels. Global thresholding techniques attempt to find a suitable threshold value that separates the two classes of pixels in an image.

The background of image can be eliminated by using global threshold technique such that

$$f_{thr}(i,j) = \begin{cases} 0 & \text{if } f(i,j) < Thr \\ 1 & \text{if } f(i,j) \geq Thr \end{cases} \quad (1)$$

where 1 is black pixel and 0 is white pixel.

Object Attribute Thresholding (OAT)

OAT is based on Otsu's approach. The complex background of image is eliminated by object attribute (Intensity of character such as black or blue). The suitable threshold selection is depended on the object attribute. In threshold selection, the process is repeated by Otsu's approach until threshold close by intensity of character.

Threshold selection step is

1. Find the intensity of character for object attribute (Pretest)
   - 1.1 Initial with t=1.
   - 1.2 Calculate histogram (G_t) of image, f (i, j).
   - 1.3 Calculate threshold (P_t) from histogram image by Otsu's approach.
   - 1.4 Test probability distribution of intensity histogram. If high probability between black and P_t or high growth rate of probability, we determine this intensity is the character attribute (A_t)
   - 1.5 Calculate histogram image between black and P_t again and define t = t+1
   - 1.6 Do step 1.3-1.5 until object class cannot be separated and the number of A_{t+1} is greater than half of number of A_t

If the character is the variable intensity, we can use

$$Attribute = A_t + x \tag{2}$$

That x is the variable intensity.

2. Calculate suitable threshold by Otsu's approach
   - 2.1 Initial with t = 1
   - 2.2 Calculate histogram (G_t) of image, f (i, j).
   - 2.3 Calculate threshold (Thr_t) from histogram image by Otsu's approach.
   - 2.4 Calculate histogram image between black and Thr_t again and define t = t+1.
   - 2.5 Do step 2.3-2.5 until Thr_{t+1} < Attribute or object class cannot be separated from background class.
   - 2.6 Determine Thr_t is the suitable of threshold.

The total of image region before background elimination is

$$f_f = \bigcup_{t \in \{1,..,p\}} C_t \tag{3}$$

where C_t is subregion image and the result of background elimination (object region) is

$$f_{bg} = C_p \tag{4}$$

where C_p is the final image that a threshold selection is one that is determined by the suitable threshold.

Speeding up Object Attribute Thresholding (SOAT)

The OAT is wasted because it tests the attribute of object by iterative Otsu's approach before it finds the threshold by iterative Otsu's approach again. This technique is processed by iterative Otsu's approach twice.

The suitable threshold separate the character attribute from first stage is not less than the threshold from second stage or it may be the same value. In this problem, we prefer to reduce this method to one stage by iterative Otsu's approach which find the character attribute and the threshold to separate background concurrently.

The SOAT is performed by the following steps:

1. Find the intensity of character for object attribute (Pretest)
   - 1.1 Initial with t=1 and Thr[0] = 255 (white).
   - 1.2 Calculate histogram (G_t) of image, f (i, j).
   - 1.3 Calculate threshold (P_t) from histogram image by Otsu's approach.
   - 1.4 Test probability distribution of intensity histogram. If high probability between black and P_t or high growth rate of probability, we determine this intensity is the character attribute (A_t)
   - 1.5 Thr[t] = P_t
   - 1.6 Calculate histogram image between black and P_t again and define t = t+1
   - 1.7 Do step 1.3-1.6 until object class cannot be separated and the number of A_{t+1} is greater than half of number of A_t

If the character is the variable intensity, we can use

$$Attribute = A_t + x \tag{5}$$

That x is the variable intensity.

2. Find suitable of threshold from list of threshold (Thr[t])
   - 2.1 Initial with t = 1
   - 2.2 If Thr[t] < Attribute, we accept Thr = Thr[t-1]

After then, separate background by global thresholding technique from suitable of threshold (Thr).

Experimental Results

In Figure 1 (Thai bank cheque) and 2 (Bank deposit form) is the experimental results are given to illustrate the usefulness of such an algorithm. We used an input 256 gray-scale image. The figures (a) are the original images, (b) are binary images obtained by the OAT where threshold = 182 and 201 for Figure 1 and 2 respectively. The figures (c) are binary images obtained by the SOAT where threshold = 182 and 201 for Figure 1 and 2 respectively. And the figures (d) are binary images obtained by the recursive thresholding technique where threshold = 120 and 143 for Figure 1 and 2 respectively.

Table 1 shows the size of image, computation time and threshold value of the SOAT, the OAT and the recursive thresholding from four different images.

Conclusion

The experimental results show the same suitable threshold when we compare the SOAT with the OAT. The computation time of our algorithm is reduced to about half of OAT for all images. Our technique was compared with the recursive thresholding technique. It was found that our technique is faster while providing the comparable results.

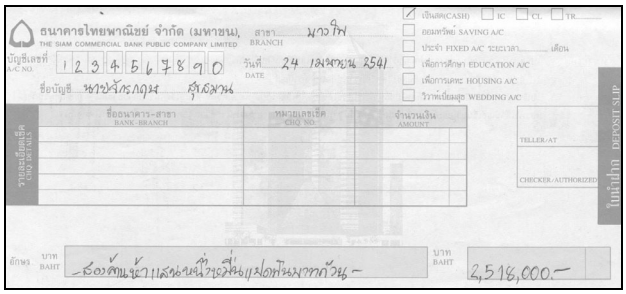
(a)

(b)

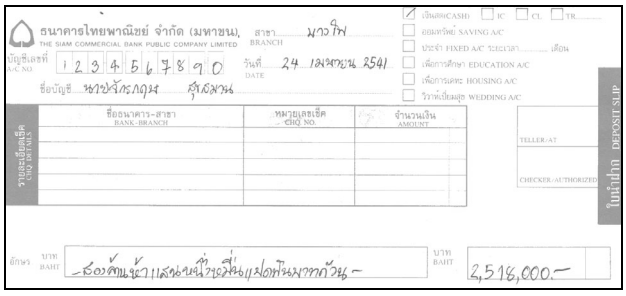
(c)

(d)

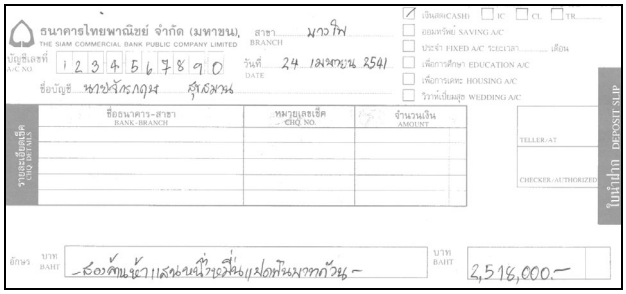
Figure 1. Thai Bank Cheque
(a) Original Image (b) OAT (c) SOAT (d) Recursive Threshold



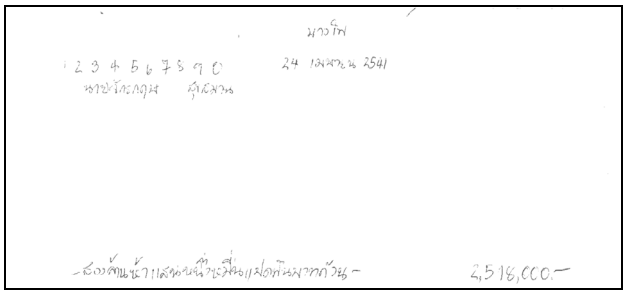
(a)



(b)



(c)



(d)

Figure 2. Bank Deposit Form
(a) Original Image (b) OAT (c) SOAT (d) Recursive Threshold

Table 1. Computation time, threshold value and size of image.

Image	Size of Image (Byte)	Time (Sec.)	Threshold value
Bank Cheque	1095663		
- Recursive		3.075	120
- OAT		4.056	182
- SOAT		2.063	182
Deposit Form	1087946		
- Recursive		3.240	143
- OAT		4.230	201
- SOAT		2.150	201
Advertisement	50982		
- Recursive		3.015	96
- OAT		4.006	155
- SOAT		2.013	155
Text Book	631974		
- Recursive		3.045	68
- OAT		4.066	151
- SOAT		2.042	151

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Biography

Mrs. Rapeeporn Chamchong was born in Bangkok, Thailand in 1969. She received her B.Sc. degree in statistical from Srinakarintwirot University (Mahasarakham) in 1990 and a M.Eng. in electrical engineering from King Mongkut's Institute of Technology Ladkrabang (Bangkok) in 2001. She is currently a lecturer in Faculty of Informatics, Mahasarakham University. Her current research interests include image processing, document analysis and computer vision.