ADAPTIVE THRESHOLDING IN DYNAMIC SCENE ANALYSIS FOR EXTRACTION OF FINE LINE

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Abstract: This paper presents an adaptive threshold method whereby fine thin line of one-pixel width lines could be detected in a gray level images. The proposed method uses the percentage difference between the mean of the pixels within a window and the center pixel. The minimum threshold value however is heuristically set to 32. If the percentage different is greater than 40% then the threshold value will be set to the difference value. This method has been applied in detecting moving objects with fine lines and the results showed that the method was able to pickup straight thin edges that belong to the moving object.

Keywords
Adaptive threshold, fine line extraction, moving object detection.

I. INTRODUCTION

Thresholding has been one of the major image processing algorithms in accomplishing certain image processing tasks. Its basic operation is simply to compare a given data with a preset constant or a vector of constants. If a given sample exceeds the threshold value, the given sample will be assigned to a value pertaining to a certain group and if the sample is less than the threshold value it will be assigned a value denoting other group. In general then, its basic goal is to segment the image area into some meaningful regions. In doing so, some of the information from the original data will be lost. Traditionally, due to demand of speed, thresholding operation is done globally on an image. While it may prove advantages to permanently set the threshold value in still images, the effect is undesirable for dynamic scene analysis where a sequence of images is involved.

This paper shows and compares the result of global thresholding of a sequence of moving image with the proposed adaptive threshold technique. Especially in detecting fine lines, it is shown that global threshold is not capable of detecting these fine lines. One possible solution might be to lower down the threshold value. However, this has the effect of picking up more unwanted pixel values that will contribute more noise pixels in the output image. It will be proven that the best way to deal with this problem is to take the approach of adaptively change the threshold value according to the characteristic of the surrounding pixels.

Adaptive threshold is not a new concept. Depending on the nature of the image involve, the criteria set for the adaptation will differ. Thus, the method for a particular adaptive algorithm might be not be suitable for other type of images. In this paper, a new criterion for establishing adaptation algorithm is proposed. The objective of the adaptive algorithm is to extract, among valid edge pixels, fine lines that could not be obtained using global thresholding technique in the area of moving edges.

II. ADAPTIVE CRITERION

In this paper, the image being dealt with is an edge image (without non-maximum suppression being applied). This implies that the variance in the pixel intensity is huge and this is particularly true in the vicinity of edges. Even at low intensity edge pixels, the variance is still large. Thus, we can use the variance as a criterion towards establishing an adaptive thresholding algorithm. This variance-based technique has been applied in *Zhang, etal.*[1]. However, the calculation of variance is very computationally expensive even in an edge image. This is because the mean of the pixels as well as the sum of the squared of the difference between each pixel and the mean within a specified window needs to be calculated. For a real-time processing with so many frames in a second, this method will fail to do its job properly.

To alleviate this problem, the paper proposes a simple solution. Instead of computing the variance, the proposed method first computes the mean of the pixels within a window. The size of the window used was 3x3. Next, it calculates the absolute difference between the mean value and the center pixel value. Finally, a percentage difference based on the mean value is calculated. The criterion will be based on this percentage difference while the adaptive threshold value will be based on the absolute difference itself.

In order to express this computation mathematically, let τ be the difference between the mean and the center pixel, i.e.

$$\tau_k = \left| p_k^i - \mu_k \right| \qquad (1)$$

where p_k^i is the center pixel of the k[th] window, and μ_k is the mean pixel of the k[th] window computed using the following formula $\mu_k = \frac{1}{N}\sum_{j=1}^{N} p_k^j$ where N is the size of the window and p's are the pixels within the window.

Let also ξ be the percentage of the difference over the mean i.e.;

$$\xi_k = \frac{\tau_k}{\mu_k} \text{ x } 100\% \qquad (2)$$

The adaptive threshold value, χ, can then be defined as:

$$\chi_k = \begin{cases} \tau_k & \xi_k > 40\% \\ 32 & otherwise \end{cases} \qquad (3)$$

The above technique is applied in conjunction with detection of moving object based on the neighborhood compactness method [2]. In this technique the edge pixels are first compared to a value of 32. If there are exactly 3 pixel above this value then the adaptive mechanism will take place. The reason is because in 3x3 window, a one-pixel width line will take only 3 pixels. If the comparison with value 32 results in more than 3 edge pixels, then global threshold value of 32 will be used.

In Equation (3), the value of χ_k is set to τ only if ξ is greater than 40%. Otherwise the threshold value will remain 32. In [2] , it was shown that the smallest number of pixels considered as being valid compact edge was 4. For a window of size 3x3, having nine entries, 4 pixels amount to 44.4% from the total entries. As τ_k represents the difference between the centre pixel and the mean pixel intensity in the window, ξ_k actually represents the percentage spread between the centre pixel and the mean. From Equation (1), if μ is close to the centre pixel p_i, then both τ and ξ will be small, which, in turn, sets the threshold χ to 32, or, in other words, the threshold value will be left unchanged. This makes sense because, as μ gets closer to p_i (meaning small τ), it indicates that the surrounding pixels around p_i are closer in value to p_i. This implies that the edge profile in the corresponding observation window is a wide or 'thick' edge, and, therefore, indicates that p_i is not a line edge. On the other hand, when μ is smaller than p_i, then there is a possibility that p_i be part of a line edge, and, as mentioned before, Equation (3) is applied only when there are exactly three pixels in the corresponding observation window that exceed 32. Therefore, the value χ indicates the percentage of pixels, in a given observation window, that may be recovered as edge pixels with respect to the centre pixel. Thus, in order to maintain the same degree of compactness, it is required that χ should be set to 44.4 %. To avoid rounding up errors, a value of 40% was chosen instead.

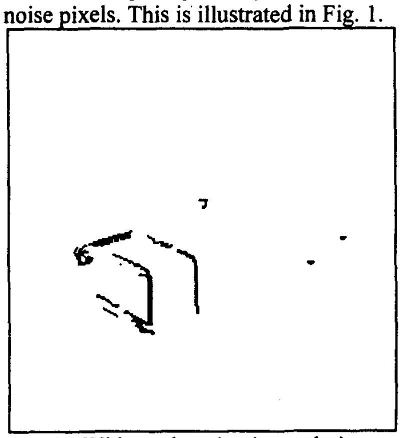
III. ALGORITHM FOR ADAPTIVE TECHNIQUE

The method proposed in the previous subsection works much better than that reported in [1]. In addition, the computation time involved is almost negligible. The method can be easily incorporated into the neighbourhood compactness algorithm described in [2] and [3], and the procedures are as follows:

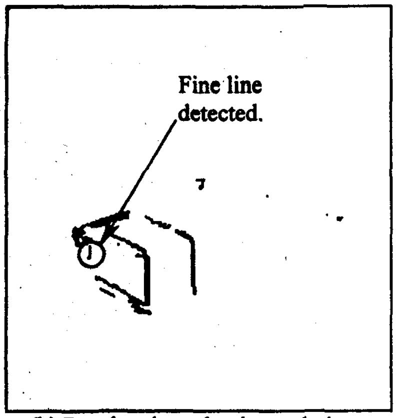
1) Compute the number of pixels whose intensity values exceed 32. If the number is greater than 3, then proceed normally with $\chi_i = 32$; otherwise move to step 2.
2) If the number is exactly three, compute τ_k, ξ_k, and χ_k.
3) If χ_k exceeds 40%, then change the global threshold to τ_k , recount the number of pixels above this new threshold and proceed with the neighborhood compactness algorithm technique. Note: The change of threshold is done **ONLY** for the current frame, and not for the previous frame.

IV. EXPERIMENTAL RESULTS

The adaptive technique method discussed above has been successfully applied. The result shown that the proposed technique is able to pickup straight line edges without increasing noise pixels. This is illustrated in Fig. 1.



(a) Without the adaptive technique



(b) Result using adaptive technique

Figure 1. The left picture was obtained using global threshold with χ = 32 through the image while picture on the right was obtained using the proposed technique. Notice the presence of fine line highlighted within the circle.

V. CONCLUSIONS

This paper has presented an adaptive threshold technique meant for detecting fine thin edges of 1-pixel width. It has been shown that the proposed technique is able to extract a thin line which is a part of the moving box (Figure 1b), which is otherwise not possible under the uniform thresholding scheme (Figure 1a). Therefore, the advantage of the adaptive thresholding technique is that, it enables the neighborhood compactness technique to pick up straight edges that are of 1 pixel width, without incurring significant noise.

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