Gradient based adaptive thresholding

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1. Introduction

Thresholding is a simple yet powerful technique to separate the object of interest from the background. Thresholding has found various applications such as in non-destructive testing (NDT) \cite{1,2,3}, document image analysis \cite{4,5,6,7}, medical image analysis \cite{8,9,10,11,12,13}, quality inspection of materials and various image segmentation applications. In an image, if the objects are clearly lighter (or darker) than the background it is natural to separate them by setting a threshold. Once the threshold value is chosen, a label is assigned to all pixels in the image that are higher than the threshold and another label is assigned to the remaining pixels. The result is a binary image where one label represents the objects while the other represents the background. However, under poor illumination or non-uniform background, achieving a proper separation of objects and background using a fixed threshold is rather unlikely. Thus an adaptive thresholding method is required such that the threshold will vary throughout the image to suit the varying lighting condition and changing background. This can be achieved by formulating a threshold surface so that each pixel has its own threshold value.

In the work of Chow and Kaneko \cite{10}, the image is divided into non-overlapping squares and a sub-histogram of grey levels in each square is calculated. Then the sub-histograms which are determined to be bimodal are used to obtain local thresholds for the squares. These local thresholds can be interpolated to produce a threshold surface for the entire image. Niblack \cite{11} proposed a threshold based on the mean and standard deviation of a local neighborhood while Eikvil et al. \cite{12} utilized Otsu method to segment pixels in the local neighborhood into two classes. If the distance between the mean of the two classes is larger than a predefined limit, they are segmented otherwise they are combined. Yanowitz and Bruckstein \cite{13} constructed the threshold surface by keeping the pixel values of the original image at high gradient pixels and smoothing the surface by forcing the low gradient pixels to satisfy the Laplace equation using successive over-relaxation method. On the other hand, Chan et al. \cite{14} translated two (2) of the steps in the Yanowitz’s algorithm using variational theory. However, no performance comparison was made between the proposed method and the original Yanowitz’s method.

Blayvas et al. \cite{15} introduced a new thresholding method using multiresolution representation. The surface was constructed as a sum of function that is based on scaling and shifting of the original function. Meanwhile, Chen et al. \cite{16} proposed another approach for thresholding which is similar to region growing based on edge and intensity information. Initially, the seeds are placed near the image edges and then an edge connection method is performed to close the image edges. Afterward, the closed image edges are partitioned using a high threshold which is obtained by a primary binarization result by filling the partitioned high threshold binary image with the seeds. Finally, the second binarization result is obtained by remedying the primary result with the low threshold binary image. Chen et al. \cite{16} made a performance comparison between the