CHAPTER 4
MULTI-LEVEL THRESHOLDING

4.1 INTRODUCTION
Preprocessing is the first phase of image analysis. The purpose of preprocessing is to improve the quality of the image being processed. It makes the subsequent phases of image processing like recognition of characters easier. Thresholding is one of the preprocessing methods discussed in this chapter. The improve edge-detection method based on a multi-level thresholding concept. Multi-level OTSU thresholding method keeps the Canny good performance in fine detection, good edge localization and only one response to a single edge, improves the capability of preventive the fake edge \[^2\]. In image processing and computer vision, OTSU’s method is used to perform automatically clustering-based on image thresholding. In thresholding, the color-image or gray-scale image is reduced to a binary image.

4.2 THRESHOLDING
Thresholding is a process of converting a grayscale input image to a bi-level image by using an optimal threshold. The purpose of thresholding is to extract those pixels from image which represent an object (either text or other line image data such as graphs, maps). Although the information is binary the pixels represent a range of intensities. Thus the objective of convert pixels value in binary is to mark pixels that belong to true foreground region with a single intensity and background region with different intensities\[^7\].

Thresholding is the simplest method of image segmentation. It can be used for changing a grayscale image to binary images. Once computed a measure of edge strength (typically the gradient magnitude), the next stage is to apply a threshold to decide whether edges are present or not at an image point. The lower the threshold, the more edges will be detected and the result will be increasingly susceptible to noise and detecting edges of irrelevant
features in the image. Conversely a high threshold may miss subtle edges or result in fragmented edges.

![Diagram](image)

**Figure 4.1** The process of thresholding along with its input and output

If the edge thresholding is applied to just the gradient magnitude image, the resulting edges will in general be thick and some type of edge thinning post-processing is necessary \[25\]. For edges detected with non-maximum suppression however, the edge curves are thin by definition and the edge pixels can be linked into edge polygon by an edge linking procedure. On a discrete grid, the non-maximum suppression stage can be implemented by estimating the gradient direction using first-order derivatives, then rounding off the gradient direction to multiples of 45 degrees, and finally comparing the values of the gradient magnitude in the estimated gradient direction.

### 4.3 THRESHOLDING ALGORITHMS

For a thresholding algorithm to be really effective, it should preserve logical and semantic content. There are two types of thresholding algorithms

1. Global thresholding algorithms
2. Local or adaptive thresholding algorithms

In global thresholding, a single threshold for all the image pixels is used. When the pixel values of the components and that of background are fairly consistent in their respective values over the entire image, global thresholding could be used. In adaptive thresholding, different threshold values for different local areas are used.
4.4 OTSU ALGORITHM

In computer vision and image processing, OTSU’s method, named after Nobuyuki OTSU, is used to automatically perform clustering-based image thresholding, or, the reduction of a gray level image to a binary image. The algorithm assumes that the image contains two classes of pixels following bi-modal histogram (foreground pixels and background pixels), it then calculates the optimum threshold separating the two classes so that their combined spread (intra-class variance) is minimal, or equivalently (because the sum of pair-wise squared distances is constant), so that their inter-class variance is maximal. Consequently, OTSU’s method is roughly a one-dimensional, discrete analog of Fisher's Discriminant Analysis. The extension of the original method to multi-level thresholding is referred to as the Multi OTSU method.

Threshold selection is used in OTSU algorithm. The OTSU method is one of the applied methods of image segmentation in selecting threshold automatically for its simple calculation and good adaptation. The major problem with thresholding is that it considers only the intensity, not any relationships between the pixels. There is no guarantee that the pixels identified by the thresholding process are contiguous. But it is most preferable method to segment the image. The steps of the OTSU algorithm: For each potential threshold T,

1. Separate the pixels into two clusters according to the threshold.
2. Find the mean of each cluster.
3. Square the difference between the means.
4. Multiply by the number of pixels in one cluster times the number in the other.

4.5 FLOW CHART OF EDGE-DETECTION BY MULTI-LEVEL THRESHOLDING

Flow chart for edge-detection method is shown below in Figure 4.2. The process of multi-level thresholding works in five steps. First step for the image acquisition, it is a process to eliminate noise from received test image, second gradient calculation along the x and y axis, third block for gradient, the value of gradient help to separate two different threshold, forth for multi-level thresholding, at this stage different threshold level 3 and level 4 are calculated and find the best one, then got the output edge of image.
4.6 DESCRIPTION OF CODING

This part describes the thesis coding. Whole program dependent on these terms-

4.6.1 LINEAR FILTERING: - This block implements two convolutions of the input image (intensity distribution function) with the x- and y-derivatives of a Gaussian function \(^{[14]}\). This Gaussian function is equivalent to first smoothing the input image with a Gaussian function and then computing the x- and y-derivatives. The two convolution results present x- and y-components of the scale dependent gradient of the image intensity distribution function.

4.6.2 ALPHA (\(\alpha\)): - This parameter controls the strength of surround suppression - the higher the value of Alpha (\(\alpha\)), the more the strength (gradient magnitude) of an edge surrounded by other edges will be little reduced. Default is 1 but one may need larger values in order to completely suppress texture edges.\(^{[13]}\)

4.6.3 THINNING AND THRESHOLDING: - These steps operate on the gradient magnitude computed in the linear filtering step and eventually changed by the surround inhibition step. In the original Canny algorithm, only the steps thinning and hysteresis thresholding of edge strength are used. Thinning thins edges in the output to one-pixel wide edges by non-maxima suppression.
4.7 MULTI-LEVEL THRESHOLDING

Otsu’s method is one of the better threshold selection methods for general real world images with regard to uniformity and shape measures. OTSU based multilevel thresholding is a method that segments a gray level image into several distinct regions by using threshold level. This technique uses more than two thresholds to segments the image into certain brightness regions, which correspond to one background and several objects. The method works very well for objects complex backgrounds, on which bi-level thresholding fails to produce satisfactory results. Reddi et al. (1984) proposed an iterative form of Otsu’s method, so as to generalize it to multilevel thresholding. Traditional methods work well for a bi-level thresholding problem, when the number of threshold level increases, complexity of the thresholding problem also will increase and the traditional method requires more computational time. Hence, in recent years, soft computing algorithm based multilevel image thresholding procedure is widely proposed by the researchers. Here, most popular image of pout and its histogram is shown. Histogram shows the graph of pixel intensity of image, it helps to select the threshold level to separate the image into groups.

Figure 4.3 Input image (POUT)
The input to a thresholding operation is typically a grayscale image or color image. In this work grayscale image are used. In the simplest Implementation, by using the segmentation, got output is a binary image. Variation on binary image is depending on the command of program. Let’s take black pixels correspond to background and white pixels correspond to foreground (vice versa). In simple implementations, intensity threshold is used for the segmentation. In a single pass, each pixel in the image is compared with this (obtain threshold value) threshold. If the pixel's intensity is higher than the obtain threshold, the pixel is set to white in the output[43]. If it is less than the threshold-level, it is set to black. In more sophisticated implementations, multiple thresholds level can be observed, so that a band of intensity values can be set to white while everything else part is set to black. For different colors or multi-spectral images, it may be possible to set different threshold-levels for each color channel, and select just those pixels within specified cuboids in Red, Green, Blue space[16]. Another common variant is to set to black all those pixels corresponding to background, but leave for ground pixels at their original intensity so that important information is not lost.
Figure 4.5 Thresholds for (A) Bi-modal (B) Two threshold (C) Two peak of Bi-modal

All images cannot clearly be segmented into foreground and background using simple thresholding. Histogram and original image are shown in Figure 4.3 and Figure 4.4. If it is possible to separate out the foreground of an image on the basis of pixel intensity, then intensity of pixels within foreground objects must be clearly different from the intensity of pixels within the background. In this case, distinct peaks in the histogram are noticed corresponding to foreground objects such that thresholds can be chosen to isolate this peak accordingly. In this case, multi-level thresholding may be a better answer. Different threshold modal are shown in Figure 4.5, Image (A) show a classic bi-modal intensity distribution. This image can be successfully segmented using a single threshold T1. Image (B) is slightly more complicated. Here the central peak represents the objects of interest in image and so threshold segmentation requires two thresholds: T1 and T2. In (C), the two peaks of a bi-modal distribution have run together and so it is almost certainly not possible to successfully segment this image using a single global threshold[40,44]. In this case it provides good result for two threshold values are taken as separation parameters with intermediate data values in the image representation from the gray image.