PROJECT REPORT

(COMPUTER GRAPHICS)

IMPLEMENTATION OF OTSU'S METHOD FOR IMAGE SEGMENTATION

Submitted to

Dr. Sushma Jain

Submitted by

Abhinav Garg (101303004)

Akshit Arora (101303012)

Akul Gupta (101303013)

Anmoldeep Kang (101303027)

Department of Computer Science and Engineering

THAPAR UNIVERSITY, PATIALA

1516 ODDSEM

CONTENTS

1. AREA OF PROJECT

Image segmentation can be applied in variety of different fields, e.g. pattern recognition, image compression, and image retrieval. The several other areas of Image Segmentation are:

Pattern recognition:

Pattern recognition involves study from image processing and from various other fields that includes machine learning (a branch of artificial intelligence). In pattern recognition, image segmentation is used for identifying the objects in an images and then machine learning is used to train the system for the change in pattern. Pattern recognition is used in computer aided diagnosis, recognition of handwriting, recognition of images etc.

Video processing:

A video is nothing but just the very fast movement of pictures. The quality of the video depends on the number of frames/pictures per minute and the quality of each frame being used. Video processing involves noise reduction, detail enhancement, motion detection, frame rate conversion, aspect ratio conversion, colour space conversion etc.

Medical Applications:

The need for accurate segmentation tools in medical applications is driven by the increased capacity of the imaging devices. Common modalities such as CT and MRI generate images which simply cannot be examined manually, due to high resolutions and a large number of image slices. Furthermore, it is very difficult to visualize complex structures in three-dimensional image volumes without cutting away large portions of, perhaps important, data. Tools, such as segmentation, can aid the medical staff in browsing through such large images by highlighting objects of particular importance. In addition, segmentation in particular can output models of organs, tumours, and other structures for further analysis, quantification or simulation.

Object Detection:

Object detection is a computer technology related to computer vision and image processing that deals with detecting instances of semantic objects of a certain class (such as humans, buildings, or cars) in digital images and videos. Well-researched domains of object detection include face detection and pedestrian detection. Object detection has applications in many areas of computer vision, including image retrieval and video surveillance.

2. ABSTRACT

A nonparametric and unsupervised method of automatic threshold selection for picture segmentation is presented. An optimal threshold is selected by the discriminant criterion, namely, so as to maximize the seperability of the resultant classes in grey levels. The procedure is very simple, utilizing only the zeroth- and the first-order cumulative moments of the grey-level histogram. It is straightforward to extend the method to multithreshold problems. Several examples are also presented to support the validity of the method.

3. PROJECT BACKGROUND

The history of segmentation of digital images using computers can be traced back to 40 years ago. In 1965, an operator for detecting the edges between different parts of an image, Roberts operator (also called Roberts edge detector), was introduced and used for partition of image components. Since then, the field of image segmentation has evolved very quickly and has undergone great change. This report explains of one of the initial methods called Otsu's method which is based on Thresholding.

It is important in picture processing to select an adequate threshold of grey level for extracting objects from their background. Before Otsu, A variety of techniques have been proposed in this regard. In an ideal case, the histogram has a deep and sharp valley between two peaks representing objects and background, respectively, so that the threshold can be chosen at the bottom of this valley \. However, for most real pictures, it is often difficult to detect the valley bottom precisely, especially in such cases as when the valley is flat and broad, imbued with noise, or when the two peaks are extremely unequal in height, often producing no traceable valley.

There have been some techniques proposed in order to overcome these difficulties. They are, for example, the valley sharpening technique, which restricts the histogram to the pixels with large absolute values of derivative (Laplacian or gradient), and the difference histogram method, which selects the threshold at the grey level with the maximal amount of difference. These utilize information concerning neighbouring pixels (or edges) in the original picture to modify the histogram so as to make it useful for thresholding. Another class of methods deals directly with the grey-level histogram by parametric techniques. For example, the histogram is approximated in the least square sense by a sum of Gaussian distributions, and statistical decision procedures are applied. However, such a method requires considerably tedious and sometimes unstable calculations. Moreover, in many cases, the Gaussian distributions turn out to be a meagre approximation of the real modes.

In any event, no "goodness" of threshold has been evaluated in most of the methods proposed before. Otsu's method is the right way of deriving an optimal thresholding method to establish an appropriate criterion for evaluating the "goodness" of threshold from a more general standpoint.

4. DESCRIPTION OF PROJECT WORK

a. INTRODUCTION

Image segmentation is one of the basic techniques of image processing and computer vision. It is a key step for image analysis, comprehension and description. Among all the segmentation techniques, thresholding segmentation method is the most popular algorithm and is widely used in the image segmentation field. The basic idea of automatic thresholding is to automatically select an optimal or several optimal grey-level threshold values for separating objects of interest in an image from the background based on their grey-level distribution. Otsu method is one of thresholding methods and frequently used in various fields

Segmentation subdivides an image into its constituent region or object. Image segmentation methods are categorized on the basis of two properties discontinuity and similarity [1].Based on this property image segmentation is categorized as Edged based segmentation and region based segmentation. The segmentation methods that are based on discontinuity property of pixels are considered as boundary or edges based techniques. Edge based segmentation method attempts to resolve image segmentation by detecting the edges or pixels between different regions that have rapid transition in intensity and are extracted and linked to form closed object boundaries. Region based segmentation partitions an image into regions that are similar according to a set of predefined criteria. There are different type of the Region based method like thresholding, region growing and region splitting and merging.

Thresholding is an important technique in image segmentation applications. The basic idea of thresholding is to select an optimal grey-level threshold value for separating objects of interest in an image from the background based on their grey-level distribution. While humans can easily differentiable an object from complex background and image thresholding is a difficult task to separate them. The grey-level histogram of an image is usually considered as efficient tools for development of image thresholding algorithms. Thresholding creates binary images from grey-level ones by turning all pixels below some threshold to zero and all pixels about that threshold to one.

There are two types of thresholding methods.

1) Global thresholding: The threshold value depends on the grey values and the value of Threshold solely relates to the character of pixels, this thresholding technique is called global thresholding.

2) Local thresholding: This method divides an original image into several sub regions, and chooses various thresholds T for each sub region reasonably.

Otsu method is type of global thresholding in which it depend only grey value of the image. Otsu method was proposed by Scholar Otsu in 1979. Otsu method is global thresholding selection method, which is widely used because it is simple and effective.

b. AIM AND OBJECTIVE

The aim is to find the threshold value where the sum of foreground and background spreads is at its minimum. Otsu's thresholding method involves iterating through all the possible threshold values and calculating a measure of spread for the pixel levels each side of the threshold, i.e. the pixels that either fall in foreground or background.

c. ALGORITHM

1. Compute histogram and probabilities of each intensity level
2. Set up initial $\omega_i(0)$ and $\mu_i(0)$
3. Step through all possible thresholds $t = 1 \ldots$ maximum intensity
1. Update ω_i and μ_i
2. Compute $\sigma_b^2(t)$
4. Desired threshold corresponds to the maximum $\sigma_b^2(t)$
5. You can compute two maxima (and two corresponding thresholds). $\sigma_{b1}^2(t)$ is the greater max and $\sigma_{b2}^2(t)$ is the greater or equal maximum
6. Desired threshold = $\frac{\text{threshold}_1 + \text{threshold}_2}{2}$

d. TECHNIQUES USED

In Otsu's method we exhaustively search for the threshold that minimizes the intra-class variance (the variance within the class), defined as a weighted sum of variances of the two classes:

$$\sigma_w^2(t) = \omega_1(t)\sigma_1^2(t) + \omega_2(t)\sigma_2^2(t)$$

Weights ω_i are the probabilities of the two classes separated by a threshold t and σ_i^2 are variances of these classes.

Otsu shows that minimizing the intra-class variance is the same as maximizing inter-class variance:[2]

$$\sigma_b^2(t) = \sigma^2 - \sigma_w^2(t) = \omega_1(t)\omega_2(t)\left[\mu_1(t) - \mu_2(t)\right]^2$$

Which is expressed in terms of class probabilities ω_i and class means μ_i.

The class probability $\omega_1(t)$ is computed from the histogram as t:

$$\omega_1(t) = \Sigma_0^t p(i)$$

While the class mean $\mu_1(t)$ is:

$$\mu_1(t) = \left[\Sigma_0^t p(i)\, x(i)\right] / \omega_1$$

Where $x(i)$ is the value at the centre of the i th histogram bin. Similarly, you can compute $\omega_2(t)$ and μ_2 on the right-hand side of the histogram for bins greater than$t$.

The class probabilities and class means can be computed iteratively. This idea yields an effective algorithm.

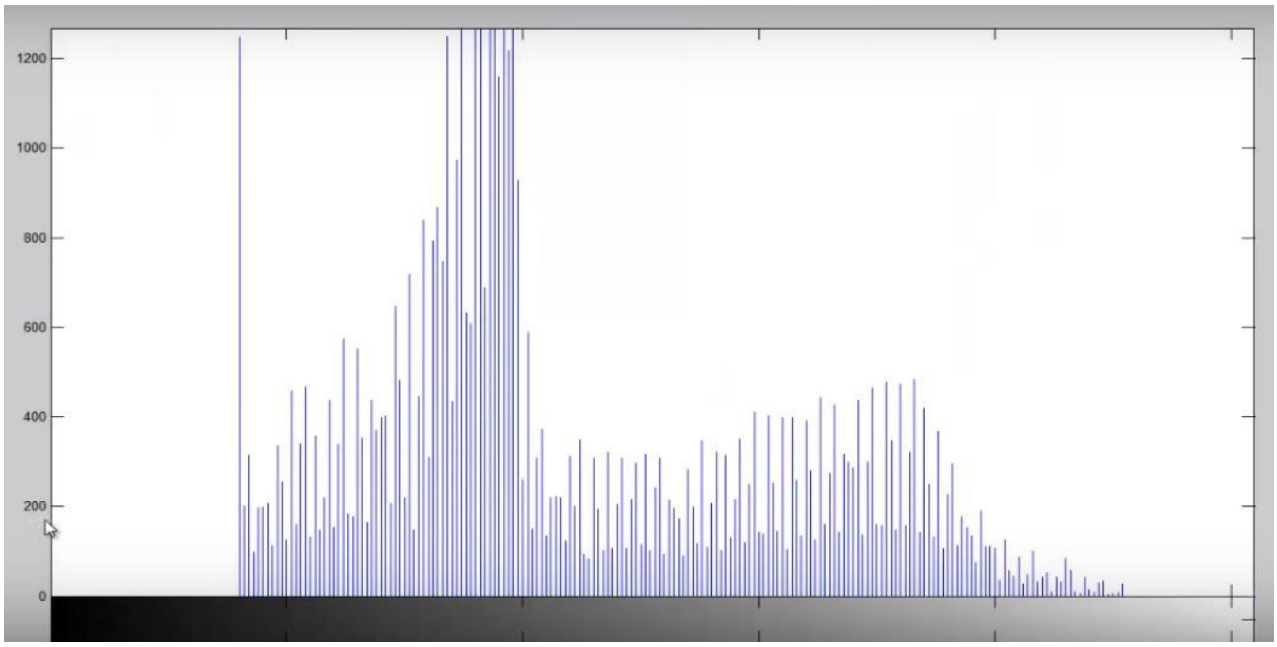
INPUT

INPUT (rgb2gray)

e. METHOD

The threshold value can be obtained by one of the following ways:

1. Histogram Analysis: By using the imhist(I) command, we can generate the histogram of intensity levels. The intensity values range between 0 to 255. On analysing the histogram, we can divide the intensity values into two classes. One acting as foreground and the other acting as background.



In the histogram above, the Y-co-ordinate 115 is chosen as the deciding value. The grey image is then converted to binary using the im2bw() function. Since the function takes the threshold values between 0 and 1, therefore the value 115 is divided by 255 to change the scale from 0 to 1. This threshold value the separates the background and the foreground.

2. Using graythresh () function: graythresh (I) computes a global threshold level that can be used to convert an intensity image to a binary image with im2bw. Level is a normalized intensity value that lies in the range [0, 1].The graythresh function uses Otsu's method, which chooses the threshold to minimize the interclass variance of the black and white pixels. Multi-dimensional arrays are converted automatically to 2-D arrays using reshape. The graythresh function ignores any nonzero imaginary part of 'I'.

Example:

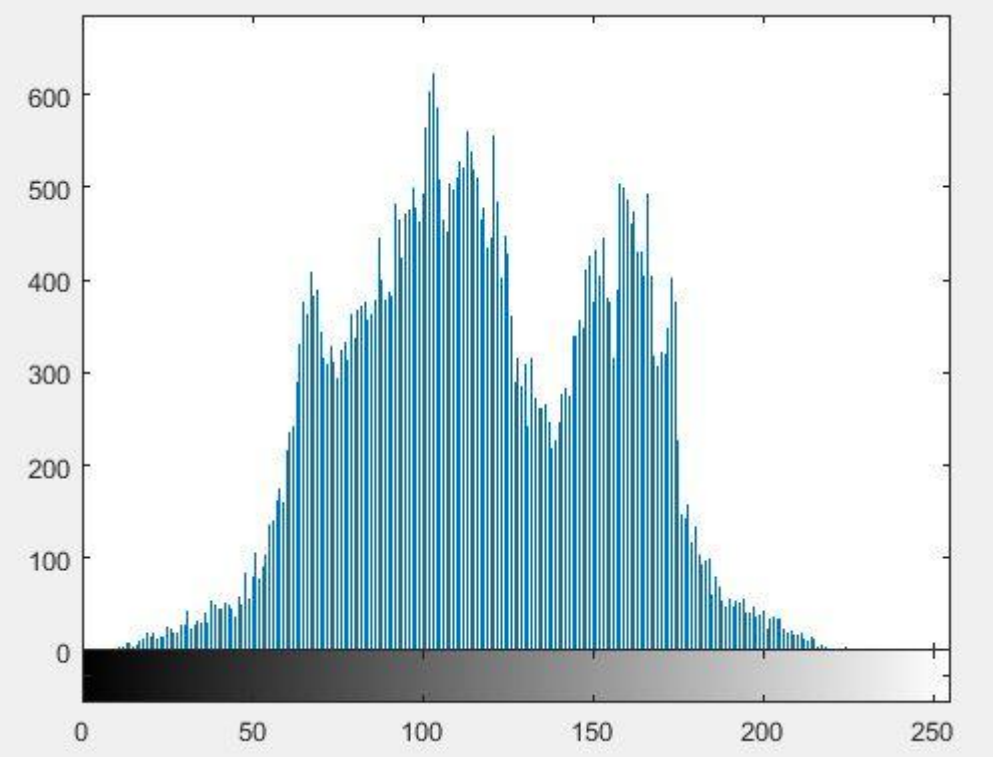
```
I = imread('coins.png');

level = graythresh(I);

BW = im2bw(I,level);

imshow(BW)
```

3. Using Adaptive Threshold value: This is a local thresholding method in which we create blocks and apply the thresholding on those particular blocks. A function derives the threshold value by calculating the standard deviation using std2 () function. If this value of standard deviation is less than 1, then the block is considered as background otherwise we apply the thresholding using graythresh () function.

f. RESULT

1) Thresholding by histogram Analysis:

Histogram:



The 'rice.jpg' is the input image, whose histogram has been obtained using imhist() function. From analysis of histogram the threshold value of 150 was found to be optimum. The result obtained is a black and white image that shows the black background separated from the white rice grains distinctly. The output image obtained is as following:

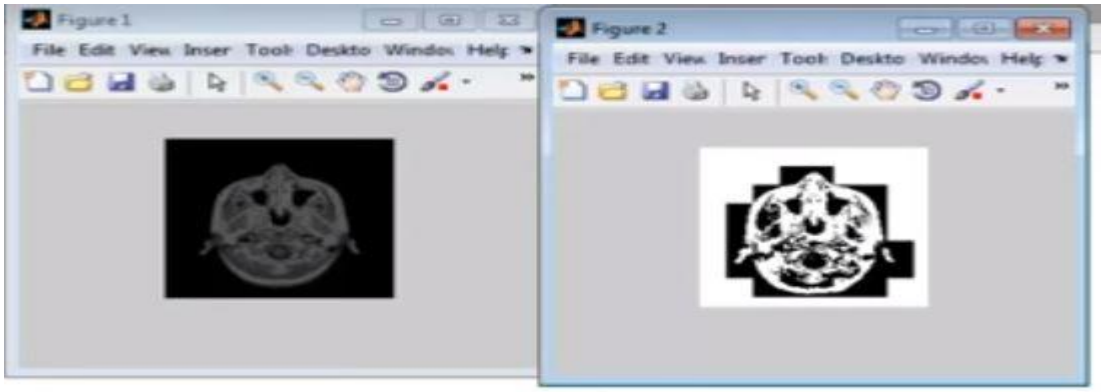
2) Using graythresh function:

Graythresh() is the function that automatically calculates the threshold value from the input image, This threshold value can now be used to separate the image into two classes. The value of threshold is used in im2bw() and the output obtained was better as compared to the guessing of the threshold in the previous method.

OUTPUT

3) Adaptive Threshold

The blocks of size 15 by 15 pixels are passed on to a function which calculates the standard deviation of the pixel intensities and checks if it is less than 1. In case the value is greater than 1, then the graythresh is applied individually to those blocks. If the value is less than one, it indicates very minor changes to the intensity values and it should be probably the part of the background and is filled ones (white colour).



f. CONCLUSION

Image segmentation is one of the basic techniques of image processing and computer vision. It is a key step for image analysis, comprehension and description. Otsu's method has been studied and implemented in MATLAB. The outputs local and histogram analysis have been collected and differences observed.

5. SPECIFIC ACHIEVEMENTS

A method to select a threshold automatically from a grey level histogram has been derived from the viewpoint of discriminant analysis. This directly deals with the problem of evaluating the goodness of thresholds. The range of its applications is not restricted only to the thresholding of the grey-level picture, such as specifically described in the foregoing, but it may also cover other cases of unsupervised classification in which a histogram of some characteristic (or feature) discriminative for classifying the objects is available. Taking into account these points, the method suggested in this correspondence may be

recommended as the most simple and standard one for automatic threshold selection that can be applied to various practical problems.

1) Pattern Recognition
2) Video Processing
3) Object Detection
4) Computational Arts
5) Medical Image Analysis

6. REFERENCES

1. http://web-ext.u-aizu.ac.jp/course/bmclass/documents/otsu1979.pdf
2. https://en.wikipedia.org/wiki/Otsu%27s_method