Image Segmentation Using Fuzzy Based Histogram Thresholding

Ajaya Kumar Dash
Department of
Computer Science and Engineering
International Institute of Information Technology
Bhubaneswar, India 751003
Email: dash.k.ajay@gmail.com

Banshidhar Majhi
Department of
Computer Science and Engineering
National Institute of Technology
Rourkela, India 761008
Email: bmajhi@nitrkl.ac.in

***Abstract*—In this paper, a new method of image segmentation by histogram thresholding based on the concept of fuzzy measure minimization is suggested. The concept introduced here, uses extreme value type-1 distribution (Gumbel distribution) in order to define the membership function. The membership function is used to express the unique association between a pixel and its belonging region (the object or the background). The optimal threshold can be effectively determined by minimizing the measure of fuzziness of the image. The result of the proposed approach is compared with some existing methods and the efficacy can be verified over some standard images having various types of histogram.**

Keywords- Image thresholding, Fuzzy Sets, Fuzzy Membership Function, Gumbel Distribution, Fuzzy Measures

I. Introduction

Segmentation in an image is a task of splitting the image into a number of non-overlapping homogeneous regions. On the other hand, it can be seen as separating objects from the background. Although it sounds easy, till now no efficient algorithm exists, which can effectively segment all the images. That's why the image segmentation problem is still one of the challenging research areas of image processing. The various approaches for image segmentation are described in the literature [1, 2].

Segmentation using histogram thresholding is one of the popular techniques because of its simplicity and speed. The bi-level histogram thresholding performs the segmentation by dividing the image into two regions of interest: the object and the background. The pixels having a gray value less than the threshold value represent one region and the pixels having gray values greater than the threshold value represent the other region. On the other hand, in case of multi level thresholding, the image is divided into more than two regions. Generally, if the object and background are clearly differentiated, then the corresponding histogram has a distinct valley region. In this case, it is obvious that the threshold lies in the valley region and can be determined easily. But in real life images, the presence of grayness and spatial ambiguity makes the task of thresholding difficult. In such case, the existing ordinary thresholding algorithms, as described in [3, 4], may generate poor results. The application of fuzzy sets in thresholding based image segmentation perfoms well by removing ambiguity and uncertainty. A comprehensive survey over image thresholding techniques can be studied in [5] and an overall analysis of fuzzy thresholding schemes are described in [6].

By considering all the fuzzy thresholding algorithms available in literature, one can group them into one of these four categories: fuzzy clustering approach, rule-based approach, fuzzy-geometrical approach, information-theoretical approach. Because of the simplicity and high speed of information-theoretical approach, it is one of the most widely used fuzzy thresholding technique.[7]

In this paper, emphasis is given on the *information-theoretical approach*. By using this approach of fuzzy image thresholding segmentation, an image can be partitioned into meaningful regions by optimising the fuzzy measures like index of fuzziness, index of non-fuzziness, fuzzy divergence etc. The application of the above measures for fuzzy image thresholding segmentation is described in the literatures [8–14].

The remaining part of this paper is organized as follows: Section II gives a quick idea on widely used membership functions and different fuzzy measures along with their basic definitions. The idea behind problem formulation and mathematical explanation of proposed membership function is presented in section III and section IV respectively. The implementation results are shown in section V. Section VI concludes the paper.

II. Basic Definitions

A. Measures of Fuzziness

The concept of fuzzy set was first proposed by Zadeh [15]. Fuzzy set gives a way to handle the vagueness present in the real world through membership function. The belongingness of an element in a set can be expressed with a membership function bounded within the interval of **0** and **1**. We can define a fuzzy set 'A' in a space of points $X = \{x\}$, as a collection of ordered pairs denoted by $A = \{(x, \mu_A(x)) \mid x \in X\}$, where $\mu_A(x)$ is the membership function.

In order to represent the uncertainty level associated with the fuzzy set, we generally use the term fuzziness. The functions with the help of which we can express the fuzziness in terms of real numbers are known as the measures of fuzziness [16]. Any measure of fuzziness should satisfy five conditions and they are *sharpness*, *maximality*, *resolution*, *symmetry*, and *valuation* [17].

978-1-4799-1823-2/15/$31.00 ©2015 IEEE