Image Threshold Using A-IFSs Based on Bounded Histograms

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Abstract. Atanassov's intuitionistic fuzzy sets (A-IFSs) have been used recently to determine the optimal threshold value for gray-level image segmentation [1]. Atanassov's intuitionistic fuzzy index values are used for representing the unknowledge/ignorance of an expert on determining whether a pixel of the image belongs to the background or the object of the image. This optimal global threshold of the image is computed automatically, regardless of the actual image analysis process.

Although global optimal thresholding techniques give good results under experimental conditions, when dealing with real images having several objects and the segmentation purpose is to point out some application-specific information, one should use heuristic techniques in order to obtain better thresholding results.

This paper introduces an evolution of the above mentioned technique intended for use with such images. The proposed approach takes into account the image and segmentation specificities by using a two-step procedure, with a restricted set of the image gray-levels.

Preliminary experimental results and comparison with other methods are presented.

Keywords: Fuzzy Sets Theory Applications, Atanassov's Intuitionistic Fuzzy Sets (A-IFSs), computer Vision, Pattern Recognition, Digital Image Processing.

1 Introduction

Many image analysis techniques take as starting point a segmentation of the image, that is, the image is decomposed into meaningful parts for further analysis, resulting in the partition of the set of pixels in the image into a finite set of regions (subsets) according to a certain criterion.

In reality, the segmentation of digital images is the process of dividing an image into disjoined parts, regions or subsets so that each one must satisfy a distinct and well-defined property or attribute.

The most commonly used strategy for segmenting images is global thresholding that refers to the process of partitioning the pixels in an image into object

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and background regions on the basis of the different intensity levels of gray of the pixels in the image. This partition is made by establishing a threshold, in such a way that all the pixels with intensity greater or equal than the threshold belong to the background (or to the object) and all the pixels with intensity lower than the threshold belong to the object (or to the background).

Extensive research has been conducted in this research field over the last years, and many types of segmentation techniques have been proposed in the literature, each one of them based on a certain methodology to classify the regions [2,3,4,5,6].

The proposed approach is an evolution/extension of the methodology, based on Atanassov's intuitionistic fuzzy sets (A-IFSs), presented in [1] intended for use with specific images within a particular image analysis process. This approach uses a two-step procedure, applying the methodology presented in [1] first to all the image pixels and then to a restricted set of the original image gray-levels' set.

2 Image Threshold Computation by Modelizing Knowledge/Unknowledge by Means of A-IFSs

Being (x, y) the coordinates of each pixel on the image Q, and being $q(x, y)$ the gray level of the pixel (x, y) so that $0 \leq q(x, y) \leq L-1$ for each $(x, y) \in Q$ where L is the image grayscale, many methods have been proposed for determining the threshold t of an image considering fuzzy set theory as an efficient tool in order to obtain a good segmentation of the image considered. The most commonly algorithm used to obtain the threshold is the one that uses the concept of fuzzy entropy and its main steps are the following:

(a) Assign L fuzzy sets Q_t to each image Q. Each one is associated to a level of intensity t, $(t = 0, 1, \cdots, L-1)$, of the grayscale L used.
(b) Calculate the entropy of each one of the L fuzzy sets Q_t associated with Q.
(c) Take, as the *best threshold* gray level t, associated with the fuzzy set corresponding to the lowest entropy.

The main problem of this algorithm is the step (a). In [1] this problem is solved using A-IFSs in the following way: In order to choose/construct the membership function of each pixel of the image to the associated fuzzy set, three numerical values are assigned to each one of them.

- A value for representing the expert knowledge of the membership of the pixel to the background. A membership function, constructed by the expert using dissimilarity functions, is used to obtain this value (see [7]).
- Dissimilarity functions are also used by the expert to construct a membership function to retrieve a value for representing the expert knowledge of the membership of the pixel to the object.
- The expert knowledge/ignorance, in determining the above mentioned membership functions, is represented by a third value obtained trough Atanassov's intuitionistic index.