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A novel image thresholding algorithm based on neutrosophic similarity score

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ABSTRACT

Image thresholding is an important field in image processing. It has been employed to segment the images and extract objects. A variety of algorithms have been proposed in this field. However, these methods perform well on the images without noise, and their results on the noisy images are not good. Neutrosophic set (NS) is a new general formal framework to study the neutralities' origin, nature, and scope. It has an inherent ability to handle the indeterminant information. Noise is one kind of indeterminant information on images. Therefore, NS has been successfully applied into image processing and computer vision research fields. This paper proposed a novel algorithm based on neutrosophic similarity score to perform thresholding on image. We utilize the neutrosophic set in image processing field and define a new concept for image thresholding. At first, an image is represented in the neutrosophic set domain via three membership subsets *T*, *I* and *F*. Then, a neutrosophic similarity score (NSS) is defined and employed to measure the degree to the ideal object. Finally, an optimized value is selected on the NSS to complete the image thresholding task. Experiments have been conducted on a variety of artificial and real images. Several measurements are used to evaluate the proposed method's performance. The experimental results demonstrate that the proposed method selects the threshold values effectively and properly. It can process both images without noise and noisy images having different levels of noises well. It will be helpful to applications in image processing and computer vision.

1. Introduction

Image thresholding, one of the simple image segmentation procedures, is a crucial step for several image-processing applications such as object detection, shape recognition, and optical character recognition [1]. In the image thresholding process, a threshold value is selected, and the pixels on the images are classified into background or objects according to their values. Image thresholding can convert the gray level images into binary ones [2]. Thresholding is quite efficient when the object pixels and background pixels have distinct gray level distributions. Furthermore, it is easy to be implemented and usually be run fast [3,4].

A variety of algorithms have been proposed. Generally, image thresholding methods are classified into two groups based on the criteria to select the threshold value: global and local methods [5]. Global methods select the threshold values according to the characteristics of the entire *images*, and local ones adopt threshold values using the local information on the images. *Threshold value selection method*

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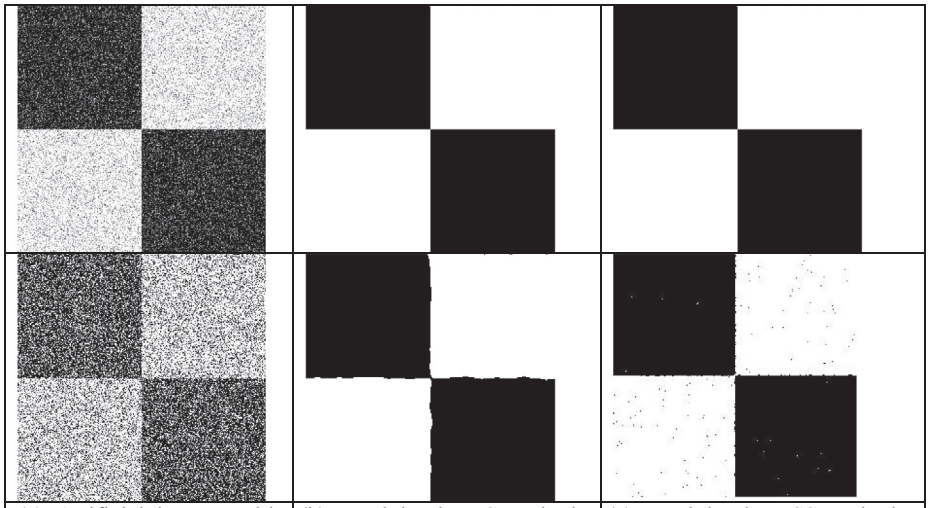
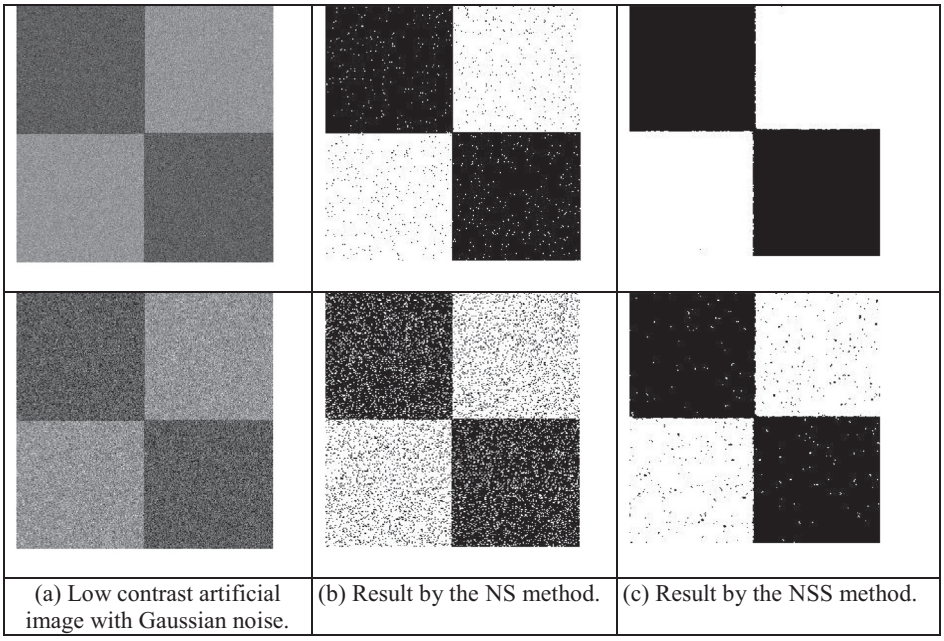
0263-2241/



(a) Artificial images with Gaussian noise. (b) Result by the NS method. (c) Result by the NSS method.

Fig. 1. Performance comparison on a high contrast artificial noisy image.



(a) Low contrast artificial image with Gaussian noise. (b) Result by the NS method. (c) Result by the NSS method.

Fig. 2. Performance comparison on a high contrast artificial noisy image.

based on image histogram is a kind of the global methods [6]. For a high contrast image, the histogram has two distinguished peaks, and a wide valley between the two peaks. The threshold value is selected the value in the valley. *However, the histogram based methods fail to find a proper value to segment the image on a low contrast image because the histogram does not have distinguished peaks and valleys*. A variety of methods have been presented to select the thresholds based on histogram and fuzzy logic [7–14].

A fuzzy based image thresholding scheme was proposed by Pal and Rosenfeld [7]. The authors used the fuzzy compactness by using the S-function for membership evaluation. Huang and Wang proposed an efficient fuzzy thresholding method based on Yager's measure which is a measure of fuzziness depending on the relationship between the fuzzy set and its complement [8,9]. Chaira and Ray [10] used the Gamma membership function to compute the membership values of the pixels, and proposed the fuzzy divergence for image thresholding. Ramar et al. proposed the neural networks for selecting the optimum threshold value using fuzzy measure [11]. Cheng and Chen used fuzzy homogeneity and fuzzy co-occurrence