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AUTOMATIC MULTILEVEL THRESHOLDING BASED ON TWO-STAGE OTSU'S METHOD WITH CLUSTER DETERMINATION BY VALLEY ESTIMATION

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Abstract. *The modified two-stage multithreshold Otsu (TSMO) method based on a two-stage Otsu optimization approach is proposed for multilevel thresholding. The proposed method yields the same set of thresholds as those obtained by using the conventional Otsu method, but it greatly decreases the required computation time, especially for a large number of clusters. In addition, an effective method of histogram-based valley estimations is presented for determining an appropriate number of clusters for an image. Various real-world images were used to evaluate the performance of the proposed method. Experimental results show that the speed of computation for the proposed method is about 19000 times faster than that for the conventional Otsu method when the number of clusters is 7.*
Keywords: Multilevel thresholding, Otsus method, Image segmentation

1. **Introduction.** Image multilevel thresholding is a very straightforward and effective approach that is widely used in the fields of image processing, pattern recognition and computer vision. The main goal of image segmentation is to isolate regions that represent objects or meaningful parts of objects from the rest of the image. The image is generally separated into two or more regions that are homogeneous in features such as gray level, color and texture. The practical applications of image segmentation include video security [1], human-computer interfaces (HCI) [2], optical character recognition (OCR) [3], content-based image retrieval (CBIR) [4], moving object tracking [5], image enhancement [6,7] and medical image diagnoses [8,9].

Image thresholding methods can be roughly divided into two groups: parametric and nonparametric approaches. In parametric approaches, a statistical model is first assumed to fit the gray level distribution of an image, and a set of parameters that control the fitness of the model are found using a histogram. Bazi et al. [10] proposed a parametric global thresholding method, which searches for the threshold by estimating parameters based on the expectation-maximization (EM) method under the assumption that the object and background classes follow a generalized Gaussian distribution. In nonparametric methods, thresholds are chosen by optimizing an objective function, such as maximizing between-class variance [11] or minimizing entropy [12,13]. Nonparametric approaches have proven to be more accurate and robust than parametric ones.