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Letter

Seeking multi-thresholds directly from support vectors for image segmentation

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Abstract

Threshold selection is an important topic and also a critical preprocessing step for image analysis, pattern recognition and computer vision. In this letter, a novel automatic image thresholding approach only from the support vectors is proposed. It first fits the 1D histogram of a given image by support vector regression (SVR) to obtain all boundary support vectors and then sifts automatically so-needed (multi-) threshold values directly from the support vectors rather than the optimized extrema of the fitted histogram in which finding the extrema is, in general, difficult. The proposed approach is not only computationally efficient but also does not require *prior* assumptions whatsoever to be made about the image (type, features, contents, stochastic model, etc.). Such an algorithm is most useful for applications that are supposed to work with different (and possibly initially unknown) types of images. The experimental results demonstrate that the proposed approach can select the thresholds automatically and effectively, and the resulting images can preserve the main features of the components of the original images very well.
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Keywords: Image segmentation; Support vector regression; Automatic thresholding; Histograms; Image processing

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1. Introduction

In many applications of image processing, abstractions of objects or features, which are used in high-level tasks, are derived from images. For the purpose of abstraction, the pixels in an image have to be grouped into meaningful regions by a process called image segmentation.

In many cases, the gray levels of pixels belonging to the object are substantially different from the gray levels of the pixels belonging to the background. Thresholding then, becomes a simple but effective tool to separate objects from the background. Its applications include: document image analysis, where the goal is to extract printed characters [1,7], logos, graphical content, or musical scores; map processing, where lines, legends, and characters are to be found [14]; scene processing, where a target is to be detected [3]; and quality inspection of materials [12,13], where defective parts must be delineated.

Thresholding in its simplest form involves mapping all pixels above a threshold value to one gray value, say white, and the rest to another, say black. Since the result is an image with two gray values, the process is called bilevel segmentation. When multiple threshold values are used, the result is a multilevel image, and the process is called multilevel segmentation. The bilevel segmentation is appropriate for some of the "classical" image processing applications such as the automatic image analysis of documents or industrial parts. But for the applications dealing with more complex scenes, automatic multilevel image segmentation methods have to be adopted.

Many automatic thresholding techniques use the histogram of a given image to select a good threshold. An image histogram is a frequency distribution of its gray levels. If, in an image, the objects have distinctly different gray values from the background, the histogram will exhibit two different peaks with a valley between them. The determination of a suitable threshold value, usually selected at the bottom of the valley between these two peaks, is relatively simple. However, in many real-world images, this assumption is unrealistic. There have been a number of methods for threshold selection discussed in the literature, including those based on entropy [4,8,11], moment preservation [15], error minimization [9] and maximum likelihood [10]. One common characteristic of these existing methods is that the histogram is viewed as a mixture density function, and usually the problem of threshold determination is treated as a case of classification. In this paper, we propose a new threshold selection technique different from the existing approaches mentioned above. It first fits the 1D histogram of a given image by support vector regression (SVR) to obtain all boundary support vectors (BSV) and then sifts or selects automatically so-needed (multi-) threshold values directly from the BSVs rather than the extrema of the fitted histogram. Since there are more than one support vectors, this approach can consequently lead to multilevel thresholding.

This paper organizes as follows. In Section 2, the automatic threshold determination approach based on the functional regression of the histogram is described. Experimental results for the proposed approach and comparison with two other approaches are presented in Section 3. We compare the performance of our approach with the two other approaches from the literature, namely Belkasim et al.'s

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