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An Improved Image Retrieval Method Based On Color Spatial Distribution and Shape Curve of Object

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Abstract. Currently, the low-level image features such as color, texture, and shape are widely used for content-based image retrieval. However, it is rather difficult to realize an exact match between two images by using a single feature. To address this problem, a method combining color spatial distribution and shape of the object is presented. In this method, firstly, an improved mean shift algorithm is presented to segment an image into clusters. Secondly, based on these clusters a novel histogram is defined. Thirdly, based on each cluster, the shape curve of an object is extracted. Finally, integrating the information of color and shape of the objects in an image, a novel similarity measure is presented to realize an exact match between two images. Experimental results show that our method can efficiently increase match precision.

Keywords: image retrieval, principal cluster, shape curve, boundary point, transformation invariance.

1. Introduction

Currently, low-level image features such as color, texture, and shape are widely used for content-based image retrieval. Since color is intuitive, stable and simple, it is natural to use the color feature to express and identify an image. A color histogram is the most commonly used method to express the color feature. To use a color histogram to match two images, Swain and Ballard [1] proposed a histogram intersection method. Since then new methods using a histogram to match two images have been continuously proposed and improved [2-4]. However, the main drawback of histograms for classification is that the representation is dependent on the color of the object being studied, ignoring its shape and structure. Conversely, without spatial or shape information, similar objects of different color may be indistinguishable based solely on color histogram comparisons. There is no way to distinguish a red and white cup from a red and white plate. Usually, Euclidean distance, histogram intersection, or cosine or quadratic distances are used for the calculation of image similarity ratings. However, none of these values reflect the degree of similarity between two images in itself; it is useful only when used in comparison to other similar values. Shape is an important feature to identify a natural object in the real world. In some cases, an image can be regarded as a combination of natural objects. So, if we can express an object as a shape curve, an image can be approximately expressed as a sequence of shape curves of objects.

Currently, the main methods for extracting the shape feature of an object. are classified into two categories: region-based segmentation methods and edge-based detection methods. For the former category, mean shift segmentation and EM-GMM algorithms can be used to segment an image into regions of objects, e.g., clusters[5-10]. In a certain sense, a cluster can be regarded as an abstract expression of a natural object. For the latter category, traditional edge-based detection algorithms, such as Sobel, Laplacian of Gaussian (LoG) and Laplacian algorithm [13], can be used to detect the edge of an object. A novel snake algorithm [14, 15] can also segment an image and yield the edge of an interesting object. However, although the edge-based detection algorithms can detect the edge of an object, it is rather difficult to extract the edge feature of a single object from the detection result, which is a drawback for edge-based detection algorithms.

Based on the analysis above, since the detection result of the first category can be more easily used to extract a single object than the second one, in this paper an improved mean shift is presented to segment an

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image into clusters. Furthermore, each cluster is regarded as a natural object. Hence, it is straightforward to use the cluster to extract the shape curve of a natural object.

In this paper, our framework intends to define a new similarity measure to match between two images, where such a similarity measure integrates both the information from color spatial distribution and shapes of objects. Intuitively it should have higher match precision than one using a single feature.

This paper is organized as follows. In section 2, the mean shift algorithm is briefly reviewed, and an improvement is presented with respect to the algorithm. In section 3, based on clusters of an image, methods for extracting a single object and generating the shape curve of an object are presented. In section 4, integrating information of color spatial distribution and shape of objects within an image, and a similarity measure are presented. In section5, experiments are carried out and comparison made. In section 6, conclusion is given.

2. Segmenting an image into clusters

In this section, we briefly review the basic idea of the mean shift algorithm and give the general process of the two procedures of mean shift filtering and segmenting. Based on the above framework, a new expression of a cluster during the segmentation procedure is presented in order to satisfy the necessity of extracting a single object in successive sections.

2.1 A brief review of mean shift algorithm

Let A be a finite set in n-dimensional space. A formula computing n-dimension mean shift vector at location is defined by

$$ms(x) = \frac{\sum_a k(a-x)w(a)a}{\sum_a k(a-x)w(a)} - x \quad x \in a \tag{1}$$

where $k(x)$ is a kernel function $[15,16]$, w a weight factor, $\boldsymbol{x}$ the center of the kernel(window), and $\boldsymbol{a}$ in the kernel at the center of $\boldsymbol{x}$ .An image is typically represented as a two-dimensional lattice of $p-$dimensional vectors(pixels), where $p=1$ in the gray-level case, three for color images. The space of the lattice is known as the spatial domain, while the gray level or color is represented in the range domain. For the range domain, the RGB color space is not perceptually uniform, while the LUV space is approximately uniform. Hence, to keep the perceived image uniform to human vision, RGB space is transformed into LUV space. For both domains, the Euclidean metric is assumed. When the location and range vectors are concatenated in the joint spatial-range domain of dimension $d = p+2$, their different nature has to be considered by proper normalization. Thus, the multivariate kernel is defined as the product of two radically symmetric kernels and the Euclidean metric allows a single bandwidth parameter for each domain.

$$G_{h_s,h_r}(x) = \frac{1}{h_s^2 h_r^2} g\left(\left\|\frac{x^s}{h_s}\right\|^2\right) g\left(\left\|\frac{x^r}{h_r}\right\|^2\right) \tag{2}$$

where x^s is the spatial part, x^r is the range part of a feature vector, $g(x)$ the common profile used in both two domains antitheism paper a Gaussian profile, h_s and h_r are the used kernel bandwidths.

2.2 Mean shift filtering and segmenting

2.2.1 Mean shift filtering

Smoothing through replacing the pixel in the center of window by the weighted average of the pixels in the window indiscriminately blurs the image, removing not only the noise but also salient information. Therefore, to enhance the robustness of the next segmentation and obtain a better segmented result, filtering an image is indispensable. Let x_i and $z_i i = 1,\cdots,n$, be the n-dimensional input and filtered image pixels in the joint spatial-range domain.

2.2.2 Mean shift segmenting

Image segmentation partitions a gray level or color image into homogeneous regions. Homogeneity is usually defined as similarity in pixel values, i.e., a piecewise constant model is enforced over the image. A mean shift segmentation is given as follows.