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A ROI image retrieval method based on CVAAO

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ABSTRACT

A novel image feature called color variances among adjacent objects (CVAAO) is proposed in this study. Characterizing the color variances between contiguous objects in an image, CVAAO can effectively describe the principal colors and texture distribution of the image and is insensitive to distortion and scale variations of images. Based on CVAAO, a CVAAO-based image retrieval method is constructed. When given a full image, the CVAAO-based image retrieval method delivers the database images most similar to the full image to the user. This paper also presents a CVAAO-based ROI image retrieval method. When given a clip, the CVAAO-based ROI image retrieval method submits to the user a database image containing a target region most similar to the clip. The experimental results show that the CVAAO-based ROI image retrieval method can offer impressive results in finding out the database images that meet user requirements.

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1. Introduction

In content-based image retrieval (CBIR) methods, query-by-example (QBE) is by far the most widely supported method in research prototypes and commercial products [16]. A user formulates a query by giving an example image I_Q; the method then extracts the feature of I_Q and compares it with the features of pre-feature-extracted images in the database. After that, the method delivers to the user the database images most similar to I_Q.

QBE image retrieval method has numerous advantages for many practical applications [1,2,5,7,11,15]. For instance, trademarks are specially designed marks used to identify companies, products or services. The imitation of a registered trademark is illegal. However, there are so many trademarks around the world; how to avoid designing a trademark that is similar to an existing one is very difficult. Developing an automatic and fast content-based trademark image retrieval method is hence necessary. In addition to trademark copyright query, the QBE image retrieval method can still be used in many other application fields such as medical image archiving, computer aided design, and geographic information systems.

The CVAAO (color variance among adjacent objects) proposed in this study is a color histogram of the color differences between two adjacent objects in an image. The CVAAO can not only effectively depict the principal color and the texture distribution of an image, but also distinguish the objects with inconsistent contours. Based on the CVAAO, this paper provides a CVAAO-based image retrieval method which submits to the user the database images most similar the query image assigned by the user.

However, in many cases, users are interested in only a small region on a database image. We call this region "*region-of-interest* (ROI)". For example, to automatically classify goods by a computer according to manufacturers, a supermarket can employ a camera to record the images of all articles and use the trademarks of their manufacturers as the query images. Then the articles, whose images are retrieved when given a query image, are made by the manufacturer. We call it ROI image retrieval in which a user may be interested in only finding the database images containing a required region disregarding their backgrounds. Unfortunately, the image of an article typically contains not only ROI but also irrelevant areas. To solve this problem, this paper proposes a CVAAO-based ROI image retrieval method.

In a ROI image retrieval method [3,10,15], a user may select a region image as a query image I_Q; then the method delivers to the user the database images I_D, and each of which contains a region R that is most similar to I_Q. Here, we call R the ROI, and I_D a target database image. R may appear on I_D at different locations with varied sizes and rotation angles. For instance, Fig. 1 shows a query image and the target database images that contain shift, rotation, and scale variations and hold a ROI encircled by a red rectangle. An excellent image retrieval method should be insensitive to these variations.

The distribution of pixel colors in an image generally contains a lot of interesting information. Recently, many researchers deter-

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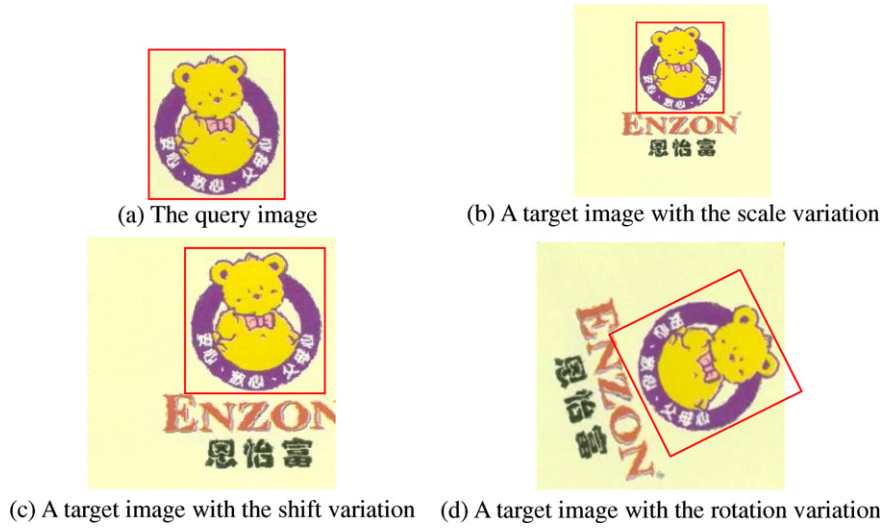

(a) The query image (b) A target image with the scale variation

(c) A target image with the shift variation (d) A target image with the rotation variation

Fig. 1. A query image and the target database images with scale, shift and rotation variant images.

mined the feature for image retrieval by analyzing the color attribute of an image [2,5–8,10,11,13]. Color histogram [2,6,7,10] is the most commonly used feature for color-based image retrieval. Dimai [3] proposed a CCH (conventional color histogram) image retrieval method. By modifying the CCH image retrieval method, Ju et al. [10] presented an FCH (fuzzy color histogram) image retrieval method.

On the basis of CCH and FCH, Dimai [3] and Ju et al. [10] still presented CCH-based and FCH-based ROI image retrieval methods, respectively. To support ROI image retrieval, users must be permitted to query arbitrarily shaped images. In other words, a ROI image retrieval method must be able to identify ROI from database images. The CCH-based and FCH-based ROI image retrieval methods adopt hierarchical overlapping segmentation to partition a database image into several overlapping blocks. Then, both methods cut off ROI from the database image by comparing the color histogram of each overlapping block with the color histogram of the query image. Vu et al. [16] also adopted a sampling-based approach (called SamMatch) to implement the ROI query.

The image features adopted by the methods mentioned above can describe only the distribution of the principle colors of an image, but cannot characterize the texture of the image. In addition, all these methods partition each database image into some overlapping regions of several sizes, and consider that the query image has the same size as one of the overlapping regions. Nevertheless, the users may give arbitrarily sized query images. Hence, these methods cannot precisely decide the size of ROI.

To deal with the aforementioned problems, this paper first introduces the CVAAO which portrays the color variances between contiguous objects in an image. The CVAAO can characterize the principle colors and texture of the image. Based on the CVAAO, this paper presents a CVAAO-based image retrieval method and a CVAAO-based ROI image retrieval method. The CVAAO-based ROI image retrieval method decides the location and size of ROI on a database image via the shape, area, and position of the biggest object in I_Q; then it cuts off ROI from the database image. The experimental results show that the proposed method can more accurately meet user's requirements.

The rest of this paper is organized as follows. The next section briefly reviews the CCH-, FCH-, and SamMatch-based ROI image retrieval methods. Section 3 describes the CVAAO and the CVAAO-based image retrieval method. Section 4 introduces the CVAAO-based ROI image retrieval method. Section 5 investigates the performances of the CVAAO-based image retrieval method and the CVAAO-based ROI image retrieval method by experiments, and compares them with the CCH-, FCH-, and SamMatch-based image retrieval methods and the CCH-, FCH-, and SamMatch-based ROI image retrieval methods. The conclusions are given in the last section.

2. Related works

This section briefly reviews the CCH-, FCH-, and SamMatch-based ROI image retrieval methods whose performances will be compared with that of the CVAAO-based ROI image retrieval method by experiments in this paper. The basic concept of the generic algorithm employed to decide the parameters used in the CVAAO-based ROI image retrieval method, is introduced in this section. This section also introduces ANMRR (average normalized modified retrieval rank) which will be used to measure the retrieval accuracy of an image retrieval method.

2.1. The ROI image retrieval methods reviewing

Dimai [3] proposed an image retrieval method which combines the color histogram of an image with a set of IHD's (inter hierarchical distances) based on a fixed partition of the image. In this paper, the color histogram is defined as the conventional color histogram (CCH), and the image retrieval method as the CCH-based ROI image retrieval method.

Since CCH considers neither the color similarity across different bins nor the color difference in the same bin, it is sensitive to noise interference such as illumination changes and quantization errors. Therefore, Ju et al. [10] proposed a fuzzy color histogram (FCH) which associates the color similarity of each pixel's color to all color histogram bins through fuzzy-set membership function. Based on the FCH, Ju et al. [10] also developed an FCH-based ROI image retrieval method.

The FCH $F(I) = [f_1, f_2, \ldots, f_n]$ of an image I with N pixels can be defined as

$$f_i = \sum_{j=1}^{N} \mu_{ij} P_j = \frac{1}{N} \sum_{j=1}^{N} \mu_{ij},$$

where n is the number of color bins in the FCH; P_j, is the probability of the pixel with color j in image I; μ_{ij} $(0 \leqq \mu_{ij} \leqq 1)$ is the membership value of the jth pixel in the ith color bin.

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