

Query-by-Sketch Image Retrieval Using Edge Relation Histogram

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Abstract

In the Query-by-sketch image retrieval, feature extraction method is important, because the retrieval result depend on image feature. In this paper, we propose the query-by-sketch image retrieval using Edge Relation Histogram (ERH) as global and local feature. ERH focuses on the relation among edge pixels, and ERH is shift-, scale-, rotation- and symmetry-invariant feature. This method was applied to 20,000 images in Corel Photo Gallery. Experimental results show that the proposed method is effective in retrieving images.

1 Introduction

The use of large image databases is becoming increasingly popular with the popularization of digital consumer electronic products and high-speed networks in recent years. As the number of images in database increases, it is difficult for users to find desired images from database. Therefore, it is becoming desirable to develop a method that enables efficient retrieval of desired images [1]. Currently, the most popular image retrieval method is text-based image retrieval. However, text-based image retrieval has issues. First, keyword annotation is laborious work. Second, users are sometimes not satisfied because keyword annotation is very subjective. Against such a backdrop, various studies on content-based image retrieval have been conducted with great success [2-17]. In CBIR, image features such as color, shape and texture are used, queries such as example images and sketch images are used. Considering the simplicity of the query, query-by-sketch image retrieval is efficient. In the query-by-sketch image retrieval, the edge-based feature of shape and texture is required. One of edge-based feature is Edge Histogram Descriptor (EHD) in MPEG-7 [3]. The EHD represents local edge distribution in the image. The authors previously have proposed ERH as edge-based feature for query-by-sketch image retrieval. ERH focuses on global relations among binary edge images [17]. In [17], ERH is only global feature, not local feature. Query-by-sketch image retrieval using ERH enables shift-, scale-, rotation- and symmetry-invariant retrieval. Therefore, the purpose of this study is to improve the retrieval accuracy using ERH as not only global feature but also local feature.

2 Query-by-Sketch Image Retrieval

2.1 Overview

Figure 1 shows an overview of the proposed query-by-sketch image retrieval. Sketches are drawn as bi-

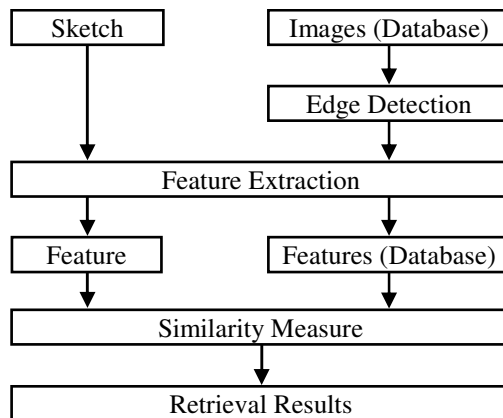


Figure 1. Overview of the proposed query-by-sketch image retrieval.

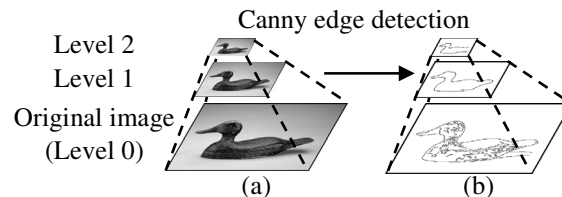


Figure 2. Canny edge detection for the multiple resolution images. (a) multiple resolution images, (b) multiple resolution edge images.

nary line image by users. The proposed feature extraction is applied to this binary line image. The proposed feature extraction is applied to edge images that are detected from the original images in the database in advance. The image features of the original images in a database are stored in a feature database in advance. The features of sketch image and database images are compared by calculating the similarity. The images are ordered according to decreasing similarity.

2.2 Edge detection

In the proposed method, effective edge detection is required, because the retrieval result depends on the edge image. The Canny edge detection is effective edge detection method. In the Canny edge detection, it is difficult to adjust parameters, because three important parameters exist, and the optimum parameters differ among images. Using the multiple resolution images enables the optimum parameters to be used in the Canny edge detection, as shown in Fig. 2 [18].

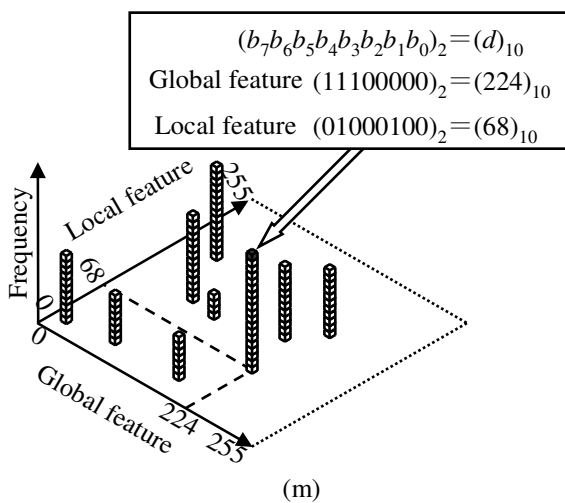
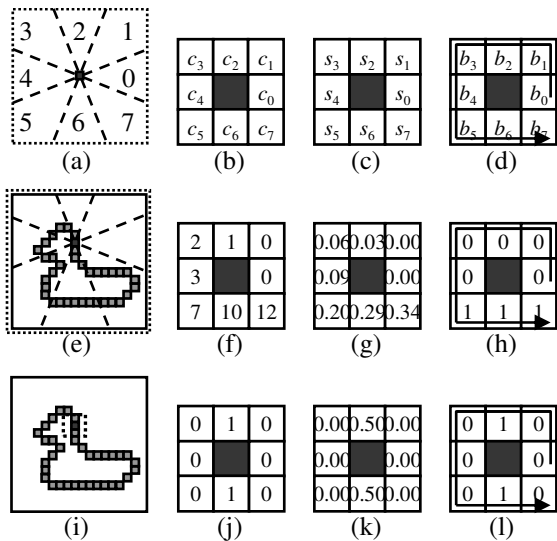


Figure 3. The proposed feature extraction process. (a) Eight regions, (e) and (i) example of edge images, (b), (f), and (j) sum of edge pixels in each region, (c), (g), and (k) normalization of edge pixels, (d), (h), and (l) value of binary pattern b_x is calculated by the thresholding technique, (m) histogram.

2.3 Feature extraction

Figure 3 shows the proposed feature extraction process. The image feature extraction method is applied to binary line images and edge images when the images are sketch images and original images in a database, respectively. The features are extracted by applying ERH as global and local feature. ERH is extracted by defining the each edge pixels as the pixel of interest. On the pixel of interest, the number of edge pixels in each of eight regions, determined as shown in Fig. 3(a), is counted. The regions are whole image (Fig. 3(e)) and region of interest 3×3 (Fig. 3(i)) in global process and local process, respectively. The number of line pixels in each region is denoted as c_x , as shown in Figs. 3(b), 3(f) and 3(j). Then, s_x is the normalized value obtained by Eq. (1), as shown in Figs. 3(c), 3(g) and 3(k). The value of the binary pattern b_x is calculated by the thresholding technique using Eq. (2),

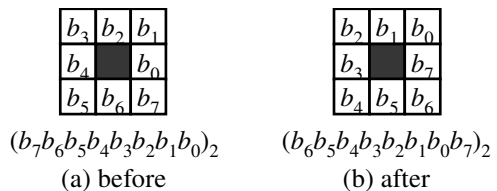


Figure 4. Rotation invariance.

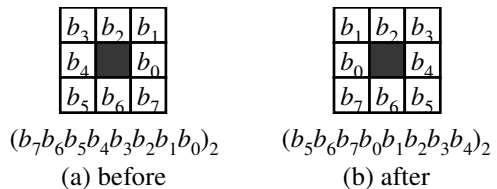


Figure 5. Symmetry invariance.

as shown in Figs. 3(d), 3(h) and 3(l). The values of C and Th denote the total number of line pixels in each of eight regions and the threshold value, respectively. The threshold value is determined empirically to be 0.15.

$$s_x = \begin{cases} \frac{c_x}{C-1} & (C \neq 0) \\ 0 & (C = 0) \end{cases} \quad (1)$$

$$b_x = \begin{cases} 0 & (s_x \leq Th) \\ 1 & (s_x > Th) \end{cases} \quad (2)$$

The values of b_x (0 or 1) in each direction are arranged counterclockwise from b_0 to express an eight-bit binary number. The binary number $(b_7, b_6, b_5, b_4, b_3, b_2, b_1, b_0)$ is transformed into a decimal number d ($0 \leq d \leq 255$). We then vote for the corresponding bin (d_g, d_l) in the histogram shown in Fig. 3(m). d_g and d_l are decimal numbers obtained by global and local process, respectively. A 256×256 -dimensional (65536-dimensional) image feature is obtained by applying the above-mentioned process to all edge pixels and normalizing the histogram by the total number of line pixels. This process enables shift-invariance and scale-invariance to be realized. The rotation invariant feature and the symmetry-invariant feature are easily described by shifting the binary number as shown in Figure 4 and 5, respectively.

2.4 Similarity Measure

The similarity is calculated by using the histogram intersection between the feature of a query image and the features in the feature database. The images are ordered according to decreasing similarity. The histogram intersection S_i is given by Eq. (3).

$$S_i = \max_{\substack{j=0,1,2 \\ m=0,1,\dots,7 \\ n=0,1}} \left\{ \sum_{g=0}^{255} \sum_{l=0}^{255} \min(F_{sglmn}, F_{ijgl}) \right\} \quad (3)$$

where F_s is the feature of a query sketch, F_i is the feature of database image, j is the level of multiple resolution, g is 256-dimensional global feature, l is 256-dimensional local feature, m is the feature pattern for

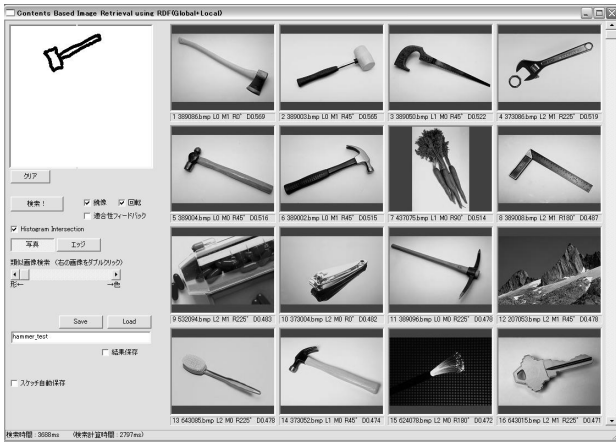


Figure 6. Example of retrieval result for “hammer.”

rotation-invariant retrieval, and n is the feature pattern for symmetry-invariant retrieval. The number of feature pattern m is 8, as shown in Fig. 4.

3 Experimental Results

In order to confirm the effectiveness of this method, retrieval experiments were conducted on 20,000 images in Corel Photo Gallery. The retrieval targets are “hammer,” “duck,” and “flag.” The relevant images are defined by three subjects. The number of relevant images of “hammer,” “duck,” and “flag” is 9, 100 and 100, respectively. Figure 6 shows an example of shift-, scale-, rotation- and symmetry-invariant retrieval result for “hammer.” The images ranked 1st, 2nd, 5th, 6th, and 14th demonstrate the effect of shift-, scale-invariant feature. The image ranked 1st demonstrates the effect of symmetry-invariant feature. The images ranked 2nd, 5th, 6th and 14th demonstrate the effect of rotation-invariant feature. Thus, Fig. 6 shows that the proposed method achieves shift-, scale-, rotation- and symmetry-invariance. Then, we compared the proposed method with ERH (global), ERH (local), and EHD. Figures 7 and 8 are the shift- and scale-invariant retrieval result examples for the retrieval targets of “duck” and “flag,” respectively. Figures 7(a) and 8(a) represent the retrieval results of the proposed method, Figs. 7(b) and 8(b) represent the retrieval results of ERH(Global), Figs. 7(c) and 8(c) represent the retrieval results of ERH(local), and Figs. 7(d) and 8(d) represent the retrieval results of EHD, respectively. The results obtained using the proposed method are more appropriate than those obtained using other methods. We evaluated quantitatively the results using the Precision-Recall graph. Precision is the proportion of retrieved relevant images. Recall is the proportion of retrieved relevant images to relevant images in the database. Precision $p(T)$ and recall $r(T)$ are given by Eqs. (4) and (5), respectively.

$$p(T) = \frac{n(T)}{T} \quad (4)$$

$$r(T) = \frac{n(T)}{N} \quad (5)$$

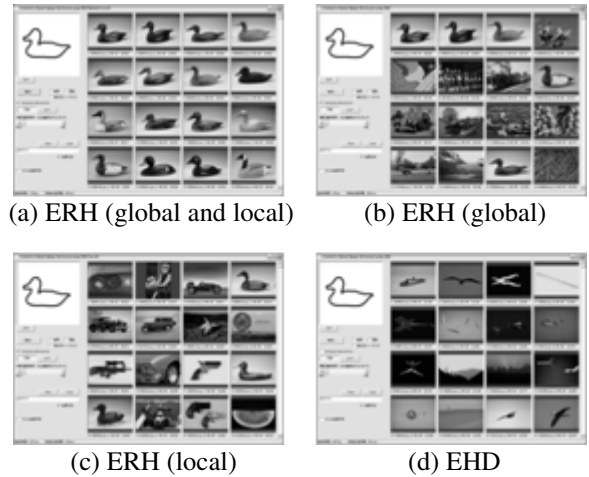


Figure 7. Example of retrieval results for “duck.”

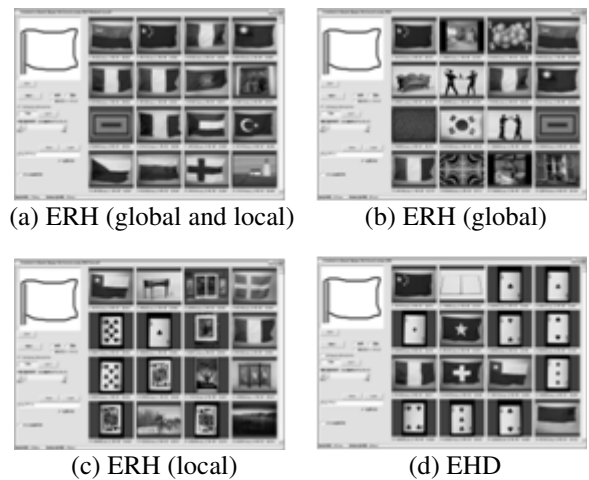


Figure 8. Example of retrieval results for “flag.”

where T is shortlist of the T most similar images, $n(T)$ is the number of retrieved relevant images, and N is the total number of relevant images in the database. Considering a graph with recall on the horizontal axis and precision on the vertical axis, the Precision-Recall graph is obtained. Figures 9 and 10 show the Precision-Recall graph when “duck” (Fig. 7) and “flag” (Fig. 8) are used as the retrieval targets, respectively. The obtained results show that the proposed method is suitable for query-by-sketch image retrieval.

4 Conclusion

In this paper, we proposed a query-by sketch image retrieval using ERH as global and local feature for improving retrieval accuracy. This method was applied to 20,000 images in Corel Photo Gallery, and the results were evaluated quantitatively using the Precision-Recall graph. As a result, it could be confirmed that the retrieval accuracy is improved by using ERH as not only global feature but also local feature, and the proposed method is a valid approach to query-by-sketch image retrieval.

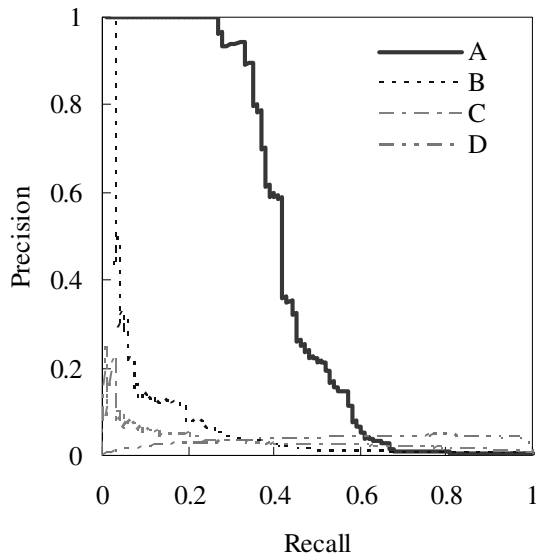


Figure 9. Precision-Recall graph for “duck.” “A” is ERH (global and local). “B” is ERH (global). “C” is ERH (local). “D” is EHD.

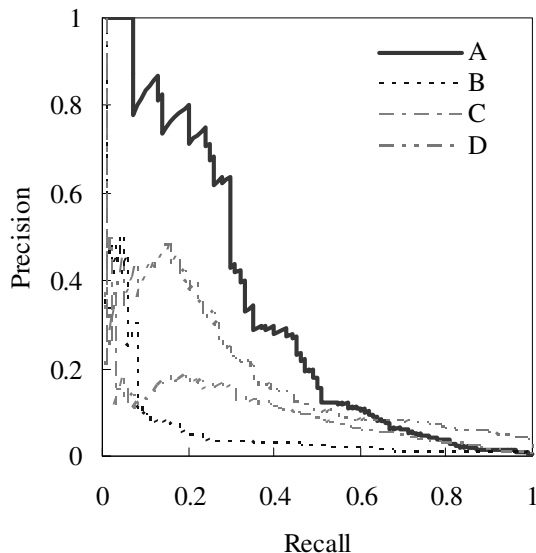


Figure 10. Precision-Recall graph for “flag.” “A” is ERH (global and local). “B” is ERH (global). “C” is ERH (local). “D” is EHD.

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