A Modified Histogram Approach to Trademark Image Retrieval

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Summary
Trademarks are considered as valuable intellectual properties. They play very important roles for successful business or companies. The logos or trademarks are also very significant objects in consumer world applications, because they are specially designed marks to identify and represent not only the quality of actual products but also the reputation of companies, products and services. With the continuously increasing number of registered trademarks, how to avoid designing a new trademark similar to an existing the registered trademarks or logos becomes an important problem. To treat this problem developing an automatic and efficient content based trademark retrieval system is imperative. In this paper, we propose a modified composite histogram approach for trademark image ranking and retrieval. The histogram represents the composition of distance and angle pair-wise histogram as a feature vector of trademark shape for retrieving similar registered trademarks. Then, based on the rank of the feature distance, a similarity measure is provided to do the similar trademark retrieval. Experiments have been conducted on registered trademark databases. Impressive results are shown to demonstrate the robustness of the proposed approach. Moreover, it is quite simple to construct the distance–angle pair-wise histogram for a trademark object.
Key words:
Histogram approach, trademark, image retrieval, histogram intersection

1. Introduction

In recent years, due to the increased numbers of registered trademarks which results more and more difficult in manual works on comparing the similarity degree of them, to establish an accurate and high-effective trademark retrieval system is very important, especially for strengthening the trademark management, protecting the private trademark right. Owing to the constant development of commercial activities the number of registered trademarks increases dramatically by the year and they are protected from imitation through legal proceedings. Consequently, registering a newly designed trademark without conflicting with the previously registered trademarks has become a critical and complex issue. Thus, to establish an accurate and high-effective trademark retrieval system is very important, especially for examining the content of the newly designed trademark with the ones that have been registered, strengthening the trademark management, and protecting the private trademark right. With the advent of computers, traditional ways of archiving many documents have been replaced by computerized methods, which feature automated processes and fast and accurate information retrieval. When it comes to trademarks, unfortunately, there is no universally accepted sorting and retrieval scheme so far.

In general, trademarks can be divided into three types: character-in-mark, device-mark and composite mark. Some sample trademarks are shown in Fig. 1. Analyzing trademark image similarity is a complex process [1]. However, due to the continuously increasing number of registered trademarks an accurate and effective automatic retrieving system needs to be established [2, 3].

Currently, several researches conducted on trademarks retrieval adopted retrieval techniques based on single features such as shape attributes to represent a trademark. The results obtained from these researches were not satisfactory especially for large databases, [4]. On the other hand, in [3], they suggest to use a combination of features, the process which includes measuring the perceptual similarity and defining an appropriate similarity measure between shape features vector. Often this is done by using Euclidean distance based on dissimilarity function as discussed in [5]. In these works, the image retrieval system has two important phases. The first phase, called image feature extraction, is how to extract the image feature to represent the content of that digital image. The second is how to compute the distance of features for representing the similarity among images. A complete process can be roughly described as in Fig. 2.

Fig. 1 Example of three kinds of trademark: (a)character-in-mark, (b) device-mark and (c) composite mark.

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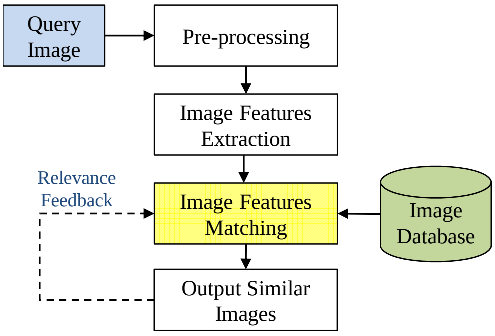


Fig. 2 The flow diagram of content-based image retrieval.

As for content-based trademark image retrieval, some methods proposed in the earlier literatures make use of moments as the features in their schemes. These schemes include moment invariants [6], Zernike moments [7], pseudo-Zernike moments [8] etc. Several papers have revealed that using the feature set of Zernike moment magnitudes or moment invariants can achieve better results than others [9]. In this paper, we propose a new composite histogram based scheme for retrieving similar trademarks from the trademark database. The proposed scheme makes use of the distance–angle pair-wise histogram of trademark object in the simulations, the proposed scheme achieves good results and outperforms conventional histogram-based and k-means retrieval methods in general cases.

The organization of this paper is as follows. In section 2 we begin by reviewing on the distance-angle histogram based approach to image retrieval. In section 3 we develop the modified composite histogram approach to trademarks image retrieval systems. Experimental results are presented in section 4, conclusions and future works are given in section 5.

2. Distance-Angle Histogram Based Approach

Histogram is the most commonly used scheme to represent the global feature composition of an image. It is invariant to translation and rotation of the images and normalizing the histogram leads to scale invariance. Exploiting the above properties, the histogram is considered to be very useful for indexing and retrieving images [10-11]. For the purpose of image indexing and retrieval, it is important to keep the size of the histogram as small as possible without deteriorating the retrieval performance. If the histogram has hundreds or even thousands of bins, then it may be of no practice use. With such a big histogram, we need more memory to store the histogram bins for each image in the database and more computational complexities for the similarity calculations between the query and all images in the database. From the database point of view, the search performance is degraded drastically as the number of bins increases. Having less than 20 bins have great advantage in terms of indexing and retrieval [11].

Note that most of the previous histograms contain only a single image feature, namely a color feature. This may be the reason why they need hundreds of bins to represent the image. To reduce the size of the histogram, we propose to use a composite histogram, which includes other features such as distance and angle histograms. We now introduce the angle histogram and distance histogram of trademark object to be used as features of trademark.

2.1 Angle Histogram

Let $C(c_x, c_y)$ be the center of the object, r be the radius of the circum-circle and the point $C(c_x, c_y)$ is the center. The center coordinate and circum-circle can be obtained by the following equation:

$$c_x = \frac{\sum x_i}{n}, \quad c_y = \frac{\sum y_i}{n},$$

where n is the number of pixels in the objects.

$r = \sqrt{(x_i - c_x)^2 + (y_i - c_y)^2}$ $\forall p(x_i, y_i)$ in the rotated object.

Let m_{ij} be the central moments of a region R, with order i+j of a region R. Then, the principal angle of R is defined as:

$$\theta = \frac{\arctan(2m_{11}/(m_{20} - m_{22}))}{2}, \qquad (1)$$

where $0 < \theta < 2\pi$.

Suppose the rotated region R is divided into N bins, for every point $p(x_i, y_i)$ in R, the angle of the point θ_i is defined as:

$$\theta_i = \begin{cases} -\theta & \text{if } c_x = x_i \text{ and } c_y = y_i, \\ \frac{\pi}{2} - \theta & \text{if } c_x > x_i \text{ and } c_y = y_i, \\ -\frac{\pi}{2} - \theta & \text{if } c_x < x_i \text{ and } c_y = y_i, \\ \arctan\frac{x_i - c_x}{y_i - c_y} - \theta & \text{if } c_y < y_i, \\ \pi - \arctan\frac{x_i - c_x}{y_i - c_y} - \theta & \text{if } c_x > x_i \text{ and } c_y > y_i, \\ \pi + \arctan\frac{x_i - c_x}{y_i - c_y} - \theta & \text{if } c_x \le x_i \text{ and } c_y > y_i. \end{cases} \qquad (2)$$

Then, a one dimensional angle histogram H_A with N bins can be constructed based on the following rule:

$$H_A(k) = H_A(k) + 1 \quad \text{for } k = 0,1,\ldots,N-1 \qquad (3)$$

when $\theta_i \in (\frac{2k\pi}{N}, \frac{2(k+1)\pi}{N}], \forall \theta_i$.

The angle histogram H_A can be normalized into h_A by Eq. (4), and n is the number of pixels on the trademark object:

$$h_A(k) = \frac{H_A(k)}{n}. \qquad (4)$$

On the basis of the above definitions, the normalized angle histogram is rotation, scaling and translation invariant. An example for constructing the angle histogram of a trademark object is shown in Fig. 3.

2.2 Distance Histogram

Suppose the rotated region R is divided into M bins, for every point $p(x_i, y_i)$ in R, the distance d_i between $p(x_i, y_i)$ and $C(c_x, c_y)$ is defined as:

$$d_i = \sqrt{(x_i - c_x)^2 + (y_i - c_y)^2}, \qquad (5)$$

$$D_i = d_i / r.$$

Then, the distance histogram H_D with M bins can be constructed by the following rule:

$$H_D(M) = H_D(M-1) + 1 \quad \text{if } d_i = 1 \quad \forall d_i.$$

$$H_D(k) = H_D(k) + 1 \quad \text{if } d_i \in (\frac{kr}{M}, \frac{(k+1)r}{M}], \qquad (6)$$
$$\text{for } k = 0,1,\ldots,M-1.$$

Finally, H_D is normalized into h_D by the following formula, and n is the number of points on the trademark object:

$$h_D(k) = \frac{H_D(k)}{n}. \qquad (7)$$

On the basis of the above definitions, the normalized distance histogram is rotation, scaling and translation invariant. An example for constructing the distance histogram of a trademark object is shown in Fig. 4.

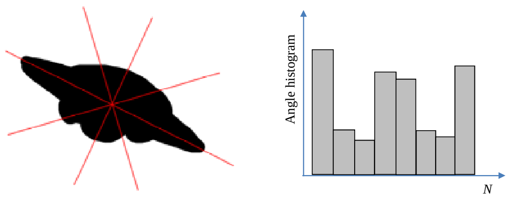


Fig. 3 Example of angle histogram.

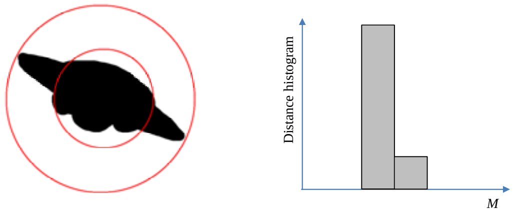


Fig. 4 Example of distance histogram.

2.3 Measure of Similarity

To measure the similarity of two normalized angle (distance) histograms we use the histogram intersection method. In this two normalized histograms are intersected as a whole, as the name of the technique implies. The similarity between the histograms is a floating point number between 0 and 1. Equivalence is designated with similarity value 1 and the similarity between two histograms decreases when the similarity value approaches to 0. Both of the histograms must be of the same size to have a valid similarity value. Let $H_1[1::n]$ and $H_2[1::n]$ denote two histograms of size n, and Sim (H_1, H_2) denote the similarity value between H_1 and H_2. Then, Sim (H_1, H_2) can be expressed by the distance between the histograms H_1 and H_2 as:

$$\text{Sim}(H_1, H_2) = \frac{\sum_{i=1}^{n} \min(H_1[i], H_2[i])}{\min(|H_1|, |H_2|)}, \qquad (8)$$

In the proposed system, this technique is employed for similarity calculations as a result of angle and distance histogram comparisons between database images and query image.

3. Modified Angle-Distance Histogram Approach

The separate usage of angle histogram or distance histogram of trademark object is not sufficient to deal with the trademark image retrieval. In the proposed scheme, a modified angle-distance pair-wise histogram is constructed based on the angle histogram and distance histogram of trademark object. Let the resultant histogram H_{DA} be horizontally with M distance bins and vertically with N angle bins. By Eq. (3) and Eq. (6), an arbitrary entry of H_{DA} can be obtained by the following rule:

If $\theta_i \in (\frac{2k\pi}{N}, \frac{2(k+1)\pi}{N}]$,

when $d_i \in (\frac{tr}{M}, \frac{(t+1)r}{M}]$, $H_{DA}(t,k) = H_{DA}(t,k) + 1$, when $d_i = 1$, $\quad H_{DA}(M-1,k) = H_{DA}(t,k)+1. \quad (9)$

Finally, H_{DA} is normalized as h_{DA} by Eq. (10) and distance-angle pairwise histogram is constructed at the same time:

$$h_{DA}(t,k) = \frac{H_{DA}(t,k)}{n}, \tag{10}$$

where $t = 0,1,\ldots,M-1$, $k = 0,1,\ldots,N-1$, and n is the number of pixels on the trademark object. The modified composite distance-angle pair-wise histogram is used as the feature vector of trademark object.

The overall steps for constructing the modified histogram are summarized as follows:

(i) Calculate the principal angle θ of the trademark object based on the second-ordered central moments, m_{02}, m_{11} and m_{20}, of the object.

(ii) Rotate the trademark object around its center with angle θ. Find out the minimum bounding circle, C and the minimum bounding rectangle, Γ, for the rotated object.
Let the center C and Γ be $C(c_x, c_y)$, the height and width of Γ be a and b, respectively. Then, we locate the reference point at $(c_x + \frac{a}{2}, c_y + \frac{b}{2})$.

(iii) Construct a 2D histogram with M horizontal (distance) bins and N vertical (angle) bins.

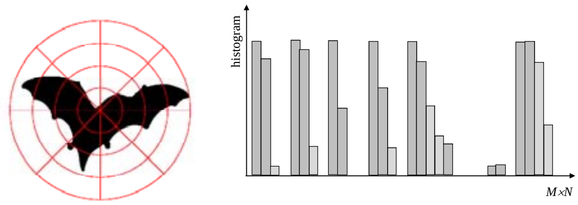
(iv) For every point $p(x_i, y_i)$ on the rotated trademark object, compute the distance d_i between C and p, and compute the angle θ_i based on Eq. (2).

(v) Based on step (iv) and Eq. (10), calculate the value for each (d_i, θ_i) of the modified (distance-angle pairwise) histogram.

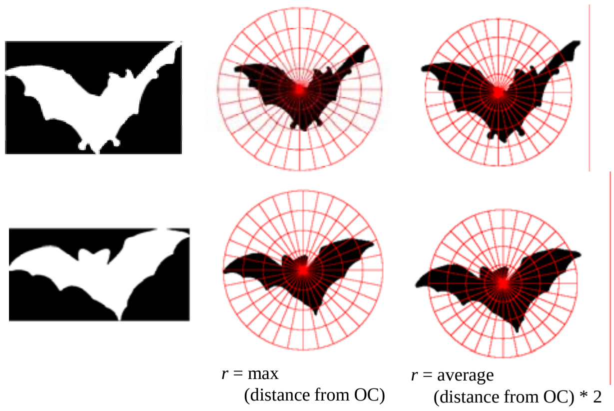
(vi) Normalize the resultant histogram by dividing each entry (d_i, θ_i).

The modified histograms are constructed by using angle-distance representations of an object given in Fig. 5.

From these definitions, this modified composite distance-angle pair wise histogram is insensitive to rotation, scale and transition. To show the invariant properties of the modified histogram, the proposed scheme is applied on two similar trademark objects. It is obvious that the sizes and the principal axes of the two objects are very different. The final normalized modified histograms of these two trademark objects reveal that the proposed histogram is rotation, scaling and translation invariant. Moreover, since the histograms of trademark objects are matrix-like with the same dimension, the similarity between two trademark objects can be measured by the Euclidean distance or histogram intersection technique.



(a)



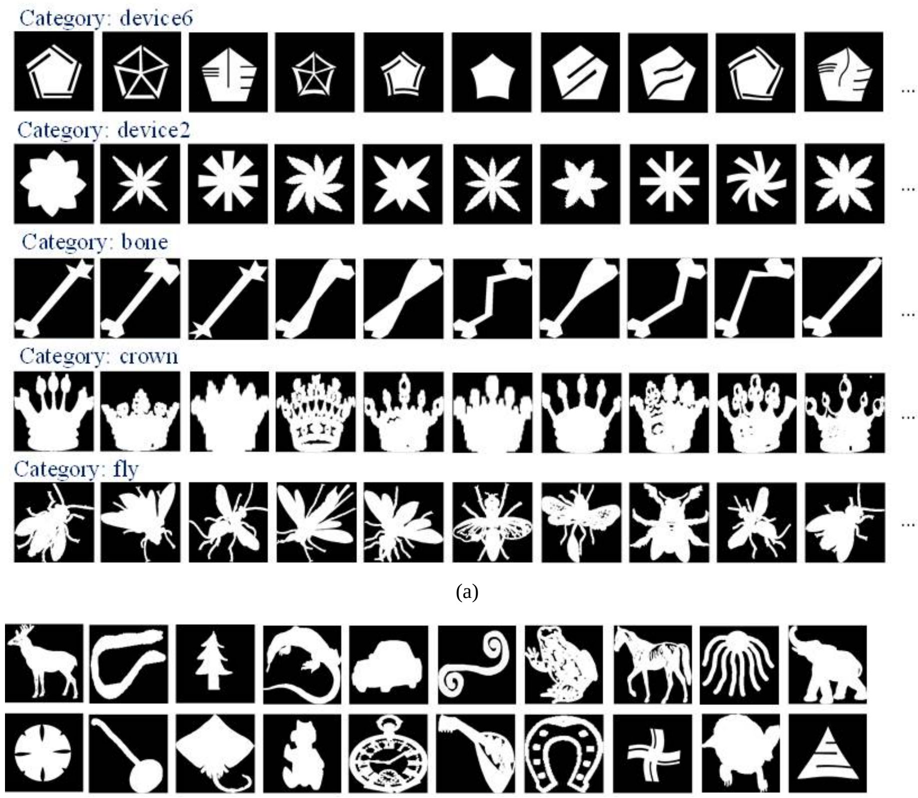
(b)

Fig. 5 Modified histogram: (a) angle-distance representation (b) comparison of radii of bounding rings.

4. Experiments and Performance Evaluation

To demonstrate the performance of the proposed scheme, two kinds of experiments have been performed in this simulation. In the basic experiment, the query trademarks are selected from database (MPEG7 CE Shape-1 PartB) [13], as shown in Fig. 6. Some of the basic experimental results are shown in Fig. 7. A sample query image must be selected from one of the image category in the database. When the system is run and the result images are returned, the user needs to count how many images are returned and how many of the returned images are similar to the query image. Determining whether or not two images are similar is purely up to the user's perception. Human perceptions can easily recognize the similarity between two images although in some cases, different users can give different opinions. After images are retrieved, the system's effectiveness needs to be determined. To achieve this, two evaluation measures are used. The first measure is called *Recall*. It is a measure of the ability of a system to present all relevant items. The equation for calculating recall is given below:

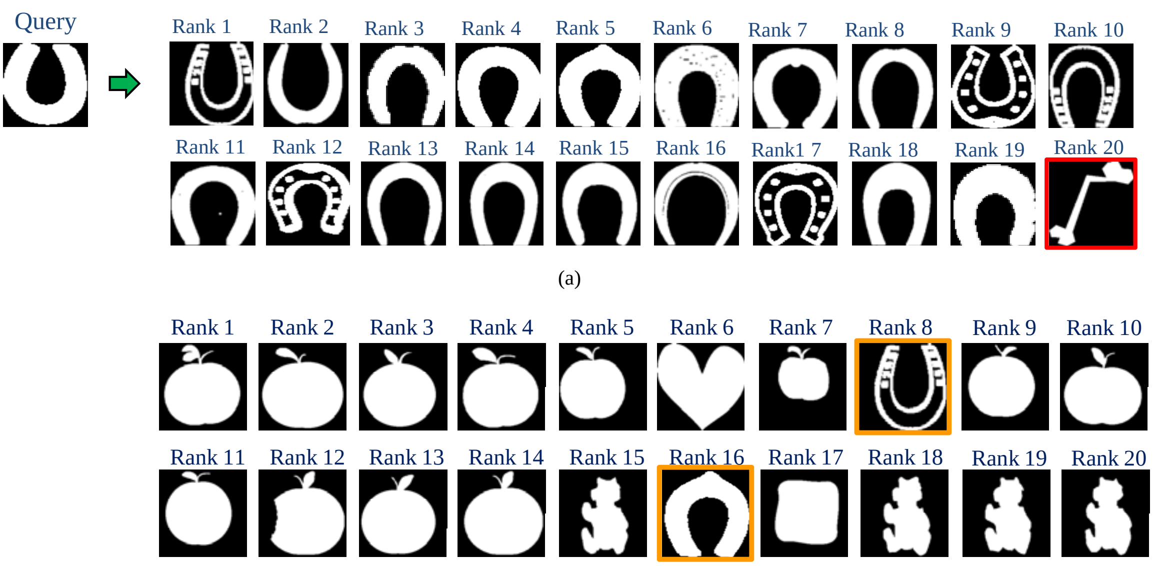
$$\text{Recall} = \frac{\text{the number of retrieved images that are relevant}}{\text{the total number of relevant images}}$$



(a)

(b)

Fig. 6 Some example images from database (MPEG7 CE Shape-1 PartB):
(a) some sample categories, and (b) sample images from other categories.



(a)

(b)

Fig. 7 Retrieved results using one sample query:
(a) results of modified angle-distance histogram approach (among the first20 highest ranks images, 19 images are similar),
(b) results of conventional histogram approach (among the first20 highest ranks images: only 2 images are similar).

The second measure is called *Precision*. It is a measure of the ability of a system to present only relevant items. The equation for calculating precision is given below.

$$\text{Precision} = \frac{\text{the number of retrieved images that are relevant}}{\text{the number of retrieved images}}$$

The number of relevant items retrieved is the number of the returned images that are similar to the query image in this case. The number of relevant items in collection is the number of images that are in the same particular category with the query image. The total number of items retrieved is the number of images that are returned by the system.

We have conducted several experiments on the test database. In order to compare the performances of the proposed method and others using conventional histogram approach and k-means method, we also implemented those methods and have shown the experimental results in Fig. 8 and Fig. 9. We can see that only using the modified histogram approach has better performance than one of the other features.

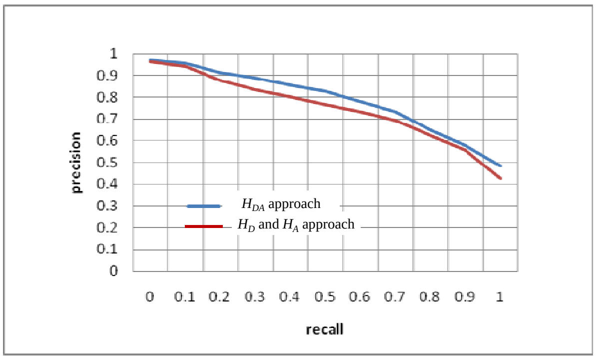


Fig. 8 The precision vs recall rate: comparison of two approaches.

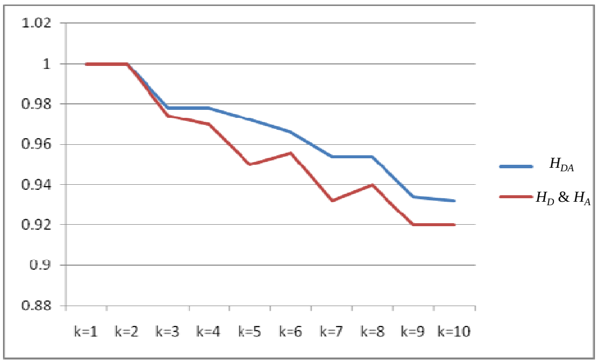


Fig. 9 Comparison of two approaches by using k-means method.

5. Conclusion

A simple but efficient similar trademark retrieval scheme has been proposed in this article. It is based on the statistical information, the modified distance–angle pair-wise histogram, of trademark object to generate feature vector that represents the trademark itself. Since the proposed modified histogram based approach is rotation, scaling and translation invariant, the retrieved trademarks are similar to the query sample. Since the proposed histogram has only a small number of bins, it provides a great advantage in terms of memory and computational complexity in the image retrieval. Experimental results reveal that the proposed scheme outperforms the other schemes especially for the moment-based ones.

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