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An Efficient Two-Stage Trademark Retrieval System

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Abstract

Recently, content-based trademark retrieval has received wide attentions. Contour and region are two important attributes in similarity measure of two trademarks. This paper presents a two-stage trademark retrieving system that integrates contour and region attributes. In the first-stage, the contour signature of an input trademark is extracted and used to filter out unlikely matched candidates from the database. In the second stage, the region feature represented by MPEG-7 ART is used to search the best match from the possible candidate trademarks. To further improve the retrieval performance, a simple user interaction scheme is added in the second-stage matching. The simulation results indicate that the proposed method improves retrieval accuracy and speed significantly, as compared to ART.
Keyword: MPEG-7, Angular Radial Transform

1. Introduction

Trademarks play an important role in providing unique identity for companies, products and services in the marketing environment. Due to the significant increase of trademarks registered, the study of content-based trademark retrieval has received intensive attentions in recent years. The major issue in trademark retrieval is how to design a mechanism that can search perceptually similar pictorial data in a good accuracy and reasonable response time. It is extremely challenging and instructive to address the issue on huge complex pictorial data [1].

Shape is a key visual feature for trademark retrieval issue. Many shape descriptors have been developed in the literature. Recently, Zhang and Lu presented an excellent reviews on the shape representation and description techniques [2]. The techniques are generally classified into two types: contour-based and region-based. The classification is based on whether shape features are extracted from the contour only or from the entire shape region. MPEG-7 group suggested two types of shape descriptors: curvature scale space (CSS) and angular radial transform (ART) [3]-[4]. The former is contour-based and used to describe an object shape with single contour; whereas the latter is region-based used for complex objects which consist of multiple contours. Most of trademarks belong to complex type; thus region-based descriptor is feasible.

Our study indicates that the trademarks are similar in contour sense and in region sense. Thus the similarity measure for trademark should consider contour of the object of a trademark as well as the interior region of the object. To exploit the two attributes efficiently, a new two-stage trademark system is developed. In the first stage, the contour of an input trademark is first extracted, and used to reject unlikely matched trademarks from the database. In the second stage, the region feature obtained by ART is then used to search the best match from the possible candidate trademarks. The simulation results indicate that the proposed method improves retrieval accuracy and speed significantly, as compared to ART.

In Section 2, we will present the concept of similarity measure with contour signature. Based on the contour signature and ART, a new two-stage trademark retrieval system is described in Section 3. Simulation results are given in Section 4, and the conclusion is drawn in Section 5.

2. Image Similarity with Contour Signature

A complex trademark image consists of contour (boundary) information and region (interior) information. Our investigation indicates that human eyes are more sensitive to contour shape than to region details. For examples, both Figure 1(a) and 1(d) are obviously considered as a bull head from human perception. The rough contours of the images are very similar, as shown in Figure 1(c) and 1(f). However, the interior regions are obviously different, leading to a large matching distance if region-based descriptors are used (the ART distance of the two images is 1.44, which is relatively large). The observation indicates that contour may be more important from human perception. Therefore, the contour information should be considered as the cue for rough classification of trademarks. And the region detail is suitable for detail discrimination of the trademark within the same class.

In general, a complex trademark often contains multiple disjoint objects such that its contour is complicated and difficult to be described precisely and exquisitely. In addition, from the viewpoint of human perception, too much detailed contour is not good in similarity matching. For example, Figure 1(c) and 1(f) are the rough contours extracted from Figure 1(a) and 1(d) respectively. Also, Figure 1(b) and 1(e) are the detail contour extracted from Figure 1(a) and 1(d) respectively. From human perception, Figure 1(c) and 1(f) are more similar each other than that of Figure 1(b) and 1(e). Based on these concepts, we consider extracting a rough contour instead of a fine contour. The rough contour concept can also be derived from the design of MPEG-7 trademark database. The dataset CE-2-B of MPEG-7 is designed for similarity matching. The images in CE-2-B were manually classified into 10 groups according to the contour types such as triangle, square, polygon, pentagon, hexagon, etc., as shown in Figure 2. The contour type is used to represent the rough contours of trademarks classified into the same group.

A signature is 1-D (one-dimension) representation of a boundary (contour). A simple method of the signature extraction is to plot the distance from the centroid to the boundary as a function of angle. The basic idea is to reduce the original 2-D boundary to a 1-D function [5].

Figure 3 shows distance-versus-angle signatures for artificial simple shapes. It indicates that the number of peaks in the signature is equal to the number of angles in the 2-D contour. It means that the contour type of a trademark can be obtained by measuring the number of peaks of its signature. Therefore, in the paper, we use the number of peaks of the signature as a cue for the classification of the query trademark.

3. Two Stage Trademark Retrieval System

The proposed retrieval system includes two main stages: (1) Candidate Selection, (2) Region Feature Extraction and Matching. The database of trademarks is categorized into 10 classes by contour types, as shown in Figure 4. The first stage of the system extracts the rough contour of a query trademark. The number of the peaks of the contour signature is used to reject unlikely classes of trademarks which are very dissimilar to the query in contour. In the second stage, the possible candidates of trademarks that passed the test of the contour are used to match the query using the ART feature. If the users do not satisfy the query results, the trademark images in the remaining pool are retrieved and matched with the query by ART feature vector. The user interaction process can compensate the classification errors in the first stage and get the more accurate retrieval. The interaction is very simple but efficient to improve retrieval performance. The details are described in the following.

3.1. Candidate Selection with Contour

For a query image, the rough contour is obtained and transformed into 1-D signature. Then we detect the peaks of the signature, and count the number of the peaks. According to the result of peak detection, we separate database into likely matched candidate and unlikely matched one. The classes that have the same number of peaks as that of the input query are put into the likely matched candidate. The remaining classes of trademarks are rejected. We refer to this as signature filtering.

For a simple trademark, the contour (boundary) and signature can be extracted easily and accurately. However, most trademark images are very complicated, so the contours obtained by a simple boundary extraction scheme are often broken, too much noisy, and even more than one boundary. Figure 5 and Figure 6 are the examples. Obviously, the extraction of contour signature of a trademark is not straightforward. We develop an efficient scheme shown in Figure 5, and the procedures are described briefly in the following.

1) Closing Operation: The morphological operation of closing used to remove some small breaks on the boundary.
2) Object Boundary Extraction: Background flooding is performed first. Then by scanning the object pixels near the background, we obtain object boundary.
3) Size Normalization: Perform scaling and translation such that the center and the farthest pixel of the object coincides with the circle which touches the image boarder.
4) Signature Extraction: Obtain distance-versus-angle signature function, $r(\theta)$.
5) Elimination of Redundant Points: On the outer boundary, each angle corresponds to only one distance; i.e., $r(\theta)$ must be a single-value function. Thus we remove the interior points, and keep only the point with maximum r for each θ. The purpose of this step is to generate rough contour mentioned before. An example of the signature after the elimination of interior points is Figure 6(c). Figure 6(d) is the reconstructed contour of Figure 6(c). The contour is obviously the approximated version of the original contour in Figure 6(a). The rough contour indicates that the original contour belongs to the square type, which matches the human perception.
(6) Interpolation: The removing of interior points in the above step will yield some breaks in signature waveform. This step is to fill in the breaks using cubic interpolation. Figure 6(e) is the resulting signature waveform and Figure 6(f) is its reconstructed contour.

After the above process, we obtain a 1-D waveform ranging from 0° to 360°. We then detect peaks on the waveform, and determine which class of the trademark image belong to. Our observations indicate that the waveform is still too noisy, which may results in false alarm of peck detection. Therefore we design a peak detection scheme based on progressive filtering to avoid the false peak problem. The procedure is shown in Figure 7 and described in the following.

1) Low-Pass Filtering: The 1-D signature waveform is processed with a low-pass filter with kernel (0.25, 0.5, 0.25). The process mainly filters out some noises and small peaks to avoid false peaks detected in the next step.
2) Peak Number Determination: detect the peaks of the filtered signature using a simple derivative rule, and then count the number of peaks.
3) Repeat Step (1) and (2) until the preset number of iterations reaches. Figure 8 displays the processed results.

CE-2-B dataset that addresses similarity retrieval is classified into 10 groups (classes) according to the contour types. In our retrieval system, for each query, we select likely matched classes from the database using the cue of peak count, and put the results into a candidate pool. The mapping of peak count and the classes is listed in Table 1. The basic rule for the mapping is to use the number of angles of a trademark, e.g., peak count of 4 maps to C2 (square), C6 (diamond) and C9 (rectangle). C8 (circle) is a special case. In the ideal case, circle has no peak on its signature. However, the extracted contour of a real circle-shaped trademark is not perfect. Therefore, we assign 0, 1 and 2 of peak counts to C8 (circle) to avoid the missing selection of candidates.

3.2. Region Feature Extraction and Matching

The input trademark image is first normalized in size. In other words, scaling and translation are performed such that the center and the farthest pixel of the object coincides with the circle which touches the image boarder. The normalized trademark is then transformed into 35 moments by ART. Each moment is quantized into 16 bins with a non-uniform quantizer [3]. The quantized 35 moments are formed into a 35-D feature vector. In query, the feature vector is then compared with the feature vectors of possible candidates of trademarks, which are selected from database by the candidate selection stage. The top-k retrieved trademarks are displayed according to the order of Euclidean distances between the query and candidates. If the results are not satisfied by the user, he can request the system to do the second matching. In this case, the query is matched with the trademarks in the remaining pool, which collects the trademarks rejected by candidate selection process. The detail is described in the following.

The contour extraction and peak number detection can not guarantee hundred percentage of detection. Our experiences indicated that a small number of queries yield wrong peak number, so that their corresponding images are put in the remaining pool. To compensate this error, the system adds a function of user checking to decide whether the second matching is performed or not.

We attach a user checking after 1st retrieval. The system list images in the order of ascending ART distances, and then the user check the list. If the user satisfies this list or there are many images similar to the query in this list, the search would stop. Otherwise, one more search is performed for the remaining pool and obtain 2nd retrieval result.

4. Simulation Results

We evaluate the proposed method using the datasets of CE-2-A1, CE-2-A2, CE-2-A3, and CE-2-B, which are used for the tests of rotation invariance, scaling invariance, rotation and scaling invariance, and similarity. The retrieval accuracy is measured with ARR (Average Retrieval Rate) and ANMRR (Average Normalized Modified Retrieval Rank) [6]. The ARR value indicates the ratio of the similar images retrieved by the system to the total of similar images within the specified retrieval amount. In general, the specified retrieval amount is pre-assigned twice of similar images. The lower the ANMRR value, the better retrieval rank, and its range is from 0 to 1, from best to worst. The retrieval measures are listed in Table 2. The experimental results in the datasets of CE-2-A1, CE-2-A2, CE-2-A3 reach to the best measure, e.g. ARR closes to 100% and ANMRR closes to 1. The results indicate that our proposed method and traditional ART descriptor method are both robust to rotation and scaling changes. We also perform similarity test using the dataset of CE-2-B, and the results are listed in Table 3. For two matching case (best case), the proposed method improves 13.5 % of ARR (range from 0 % to 100 %) and 0.15 of ANMRR (range from 0 to 1). Even only one-matching is performed, our method achieves ARR gain of 6.7 % and ANMRR gain of 0.11. We evaluate the improvement of retrieval speed by measuring the average number of image matching The results indicate that our method require only 40 % (247.7/620) and 44 % (272.2/620) of ART for one-matching and two-matching, respectively. Thus we can conclude that the retrieval speed is more than twice of ART.

5. Conclusions

This paper has presented a two-stage trademark retrieval technique that utilizes both contour information and region information. The signature of the contour is employed to select possible candidate trademarks, and then the candidates are matched with the query using MPEG-7 ART feature. The new method achieves significant improvement in ARR and ANMRR measures. In addition, the retrieval speed is more than two times faster than ART.

Acknowledgements

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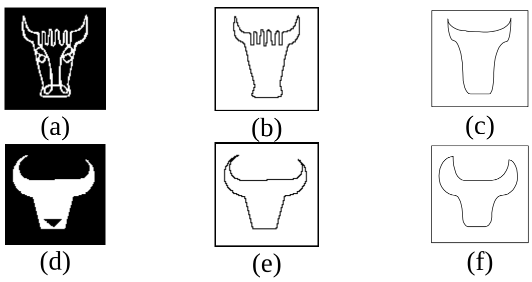


Figure 1. Two perceptually similar images (a) and (d), and their detail contour, (b) and (e), and rough contour (c) and (f)

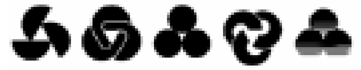
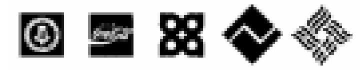
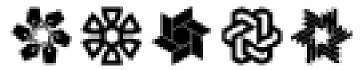
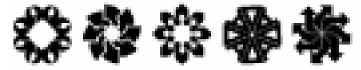
Class	Example	Contour Type
C1		Triangle
C2		Square
C3		Pentagon
C4		Hexagon
C5		Octagon
C6		Diamond
C7		Double Circle
C8		Circle
C9		Rectangle
C10		Ellipse

Figure 2. Example images of 10 classes of CE-2-B

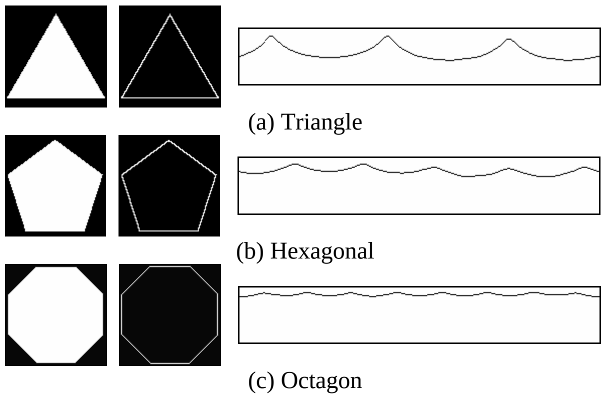


Figure 3. The contours and signatures of artifical trademarks

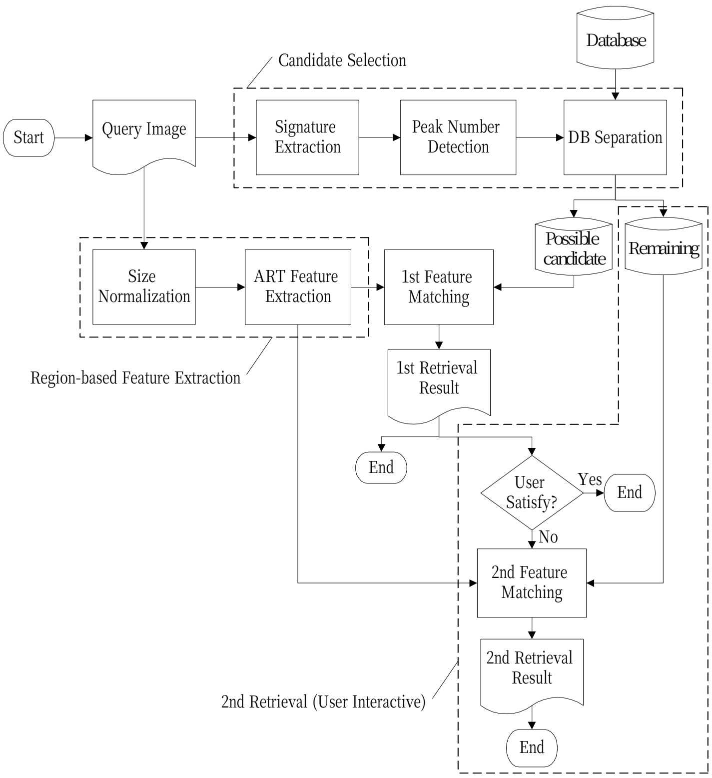


Figure 4. Proposed trademark retrieval system

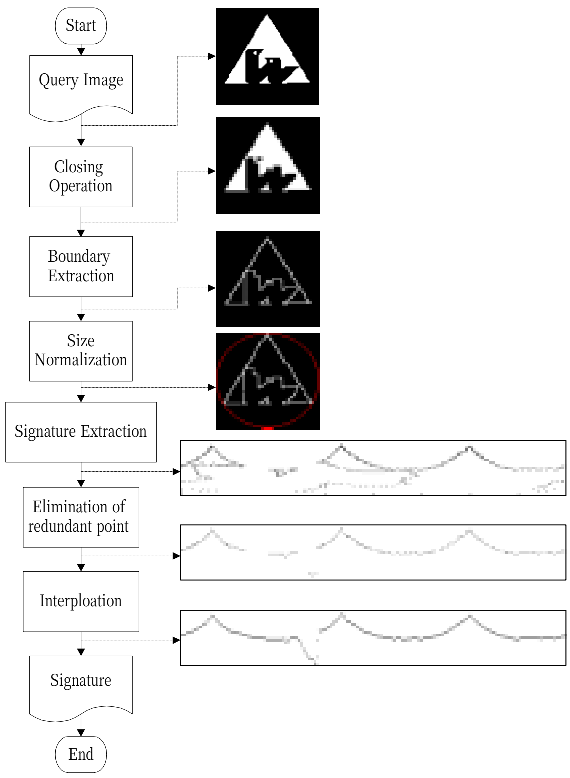


Figure 5. The process of signature extraction

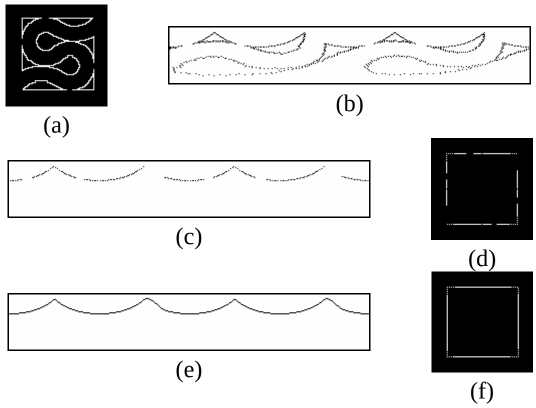


Figure 6. An example of extracted signature and its reconstructed contour

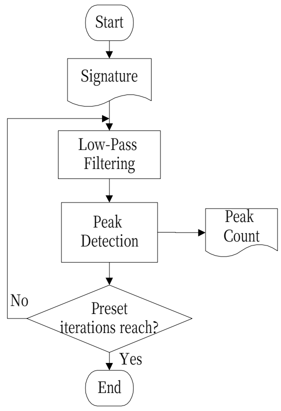


Figure 7. Peak detection scheme

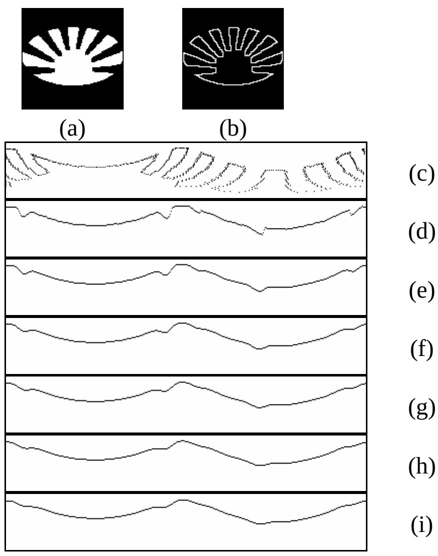


Figure 8 (a) Original image, (b) Boundary, (c) and (d) Signature, (e)-(i) filtered results of 5 iterations

Table 1. Mapping of peak counts to classes

Peak count	0	1	2	3	4	5	6	7	8
Class	C8	C8	C7,C10,C8	C1	C2,C6,C9	C3	C4	X	C5

Table 2. Retrieval performance evaluation in terms of ARR and ANMRR of CE-2-A1, CE-2-A2, and CE-2-A3

				ARR			ANMRR		
Dataset	Testing Type	# of image	# of query	ART	1^{st}	$1^{st}+2^{nd}$	ART	1^{st}	$1^{st}+2^{nd}$
CE-2-A1	Rotation	790	200	100%	95.5%	100%	0.003	0.008	0.003
CE-2-A2	Scaling	790	200	98%	97.4%	98%	0.031	0.037	0.031
CE-2-A3	Rotation & Scaling	790	200	99.9%	97.9%	99.9%	0.010	0.030	0.010

Table 3. Retrieval performance evaluation in terms of ARR and ANMRR of 10 classes of CE-2-B

				ARR (%)			ANMRR		
Class	Contour Type	# of image	# of query	ART	1^{st}	$1^{st}+2^{nd}$	ART	1^{st}	$1^{st}+2^{nd}$
C1	Triangle	620	20	69.3	99.0	99.0	0.375	0.016	0.016
C2	Square	620	199	89.1	99.5	100.0	0.172	0.033	0.029
C3	Pentagon	620	19	86.4	100	100.0	0.165	0	0
C4	Hexagon	620	17	86.5	94.1	98.6	0.229	0.06	0.021
C5	Octagon	620	20	78.5	95.0	97.8	0.246	0.066	0.046
C6	Diamond	620	14	62.2	52.6	64.8	0.457	0.532	0.434
C7	Double Circle	620	18	63.3	64.5	65.1	0.454	0.447	0.441
C8	Circle	620	204	88.5	91.1	99.2	0.223	0.110	0.040
C9	Rectangle	620	65	75.5	78.5	86.9	0.342	0.316	0.244
C10	Ellipse	620	44	62.0	66.0	73.8	0.491	0.462	0.399
Average	X	620	144	83.1 (1)	89.8 (2)	94.6 (3)	0.254 (4)	0.142 (5)	0.101 (6)

PS:
(1) Improvement ratio
ARR: (1) and (2): |89.8–83.1|/83.1= 8% , (1) and (3): |94.6–83.1|/83.1= 13.8%,
ANMRR: (4) and (5): |0.142–0.254|/0.254= 44.1%, (4) and (6): |0.101–0.254|/0.254= 60.2%
(2) Average number of Matching :
Traditional ART: 620, Proposed 1st retrieval: 247.7 (247.7/620=40%), Proposed 1st+2nd retrieval: 272.4 (272.4/620=44%).