Development of Content-Based Trademark Retrieval System on the World Wide Web

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ABSTRACT

In this paper, we describe a new trademark retrieval system based upon the content or the shape of trademark. The system has an on-line graphical user interface for the World Wide Web (WWW) that allows user to provide a query in forms of a sketch or a visual image to search for similar trademarks from database. User interfaces for the WWW were implemented by utilizing HTML and Java applets. The query can occur in arbitrary size and orientation. A shape representation scheme invariant to scale and rotation was developed to measure the similarity between two trademarks using the magnitude of Zernike moments as a feature set. Performance evaluation has been carried out with a database of 3,000 trademarks. It takes only about 0.6 second for the retrieval on a 200 MHz Pentium PC. The average recall of the original one among top 30 candidates queried by noisy or deformed images was 100%.

I. INTRODUCTION

An ever-increasing usage of digital images and the wide acceptance of very large volume image databases naturally give rise to a difficult problem of organizing them for the best and rapid access to their information contents. As a consequence, a lot of challenges have been made to retrieve images using their content information. A content-based image retrieval technique can be applied to manage various kinds of large volume image databases such as trademark and copyright, digital art galleries and museum, geographic information system (GIS), and picture archiving and communication system (PACS), to name a few [1], [27].

There are millions of registered trademarks in the world, and the number of registered trademarks is increasing rapidly. Registered trademarks should be protected through legal processes from misuse or imitation. So, there have been steadily increasing requests for the registered trademark retrieval in order to ensure its uniqueness and privilege not to be infringed by newly applied trademarks. So far, the current procedure of classifying trademarks is first by grouping the trademarks into several similar shaped groups according to a specific class order, followed by performing the matching process manually by human operators [2]. As a consequence, the task of designing and registering a new trademark without inadvertent infringement of the copyright becomes more difficult. Therefore, the development of an on-line automatic trademark retrieval system for similar shaped trademarks becomes more and more crucial.

In this paper, we presented a prototype system [to automatically retrieve similar shaped trademarks using their content on the World Wide Web (WWW) [28]. Interactive user interfaces provided for the WWW were implemented by utilizing HTML and Java applets. A user can query the system by either providing a pictorial example or by sketching to browse retrieved results. A scale and rotation invariant shape-based pattern-matching algorithm was developed to measure the similarity between two trademarks using Zernike moment magnitudes (ZMM's) as a feature set. ZMM's are generally known to be very robust to noise or small variance of a pattern, and to have rotation invariant characteristics [20]-[25]. With a proper normalization method, the scale invariance has also been achieved [3].

To evaluate the performance of our proposed similar shaped trademark retrieval system, some trademarks were submitted as query images to the database of 3,000 trademarks. The average retrieval time is only about 0.6 second with a 200 MHz Pentium PC. The average recall of the original one among top 30 candidates queried by noisy or deformed trademarks was 100%.

II. PREVIOUS WORKS

A conventional image retrieval system using the content usually consists of two consecutive steps: the feature extraction step and the similarity-measuring step using the extracted features. In most conventional approaches, global features such as texture and color have often been used because these features are relatively easy to extract. The resulting retrieval performance using these features only, however, is not so satisfactory because these features do not consider the spatial information. Recently, there have been many researches to combine color and texture with the spatial information using segmentation or grouping to increase the retrieval performance. And the shape-based retrieval technique, although it is much more complicated, is recognized as one of the most important research topics [4] because it can retrieve images with high accuracy. It also is very closely related to the object oriented coding in MPEG-4 [5] and the multimedia information description in MPEG-7 [6].

There is a rich collection of publications on image retrieval techniques based on the shape similarity. Some important works are as follows. T. Kato introduced a content-based similar shaped trademark retrieval system based on graphical features such as the spatial outline of overall figures, spatial frequency, local correlation measure and local contrast measure [7]. G. Cortelazzo *et al.* presented the trademark shape description method using string matching technique [8]. J.P. Eakins presented the shape analysis for automatic retrieval of images (SAFARI) system with curvature-based feature [9]. He also developed the improved version of SAFARI, so called the automatic retrieval of trademark images by shape analysis (ARTISAN) that utilized more complex features: circularity, aspect ratio, discontinuity angle irregularity, etc. [10]. C.P. Lam *et al.* presented a trademark retrieval system, the system for trademark archival and retrieval (STAR). The system consisted of two parts each of which handles device-marks (the trademarks that contain characters or words only) and word-in-marks (the trademarks that contain graphical or figurative elements only), separately [11]. For device- marks, invariant moments and Fourier descriptors extracted from manually preclassified distinct objects were used for shape features, and the similarity between two trademarks is measured by fuzzy thesaurus. For word-in-marks, the system performed sub-string and phonetic matching to retrieve trademarks having similar linguistic contents. A.D. Bimbo *et al.* presented another image retrieval system using a hierarchical model of the curve which was derived from its multi-scale analysis [12]. F. Mokhtarian *et al.* proposed a similar shape retrieval method using the maxima of curvature zero-crossing contours in the curvature scale space [13]. J. Bigun *et al.* proposed an image retrieval system using orientation radiograms similar to the histogram of the edge direction [14]. A.K. Jain *et al.* proposed another hierarchical image retrieval system and tested the system performance on a trademark database [15]-[18]. The system used a two-stage hierarchy: a fast screening stage using a histogram of the edge directions and invariant moments, and a detailed matching stage using deformable template matching [19].

Boundary based techniques such as boundary matching [8]-[10], Fourier descriptors [11], and multi-scale curve matching [12], [13] may not be suitable for similar-shaped trademark retrieval, because the boundary shape can be changed drastically when there is a small crack like an opening or an object touch neighboring objects.

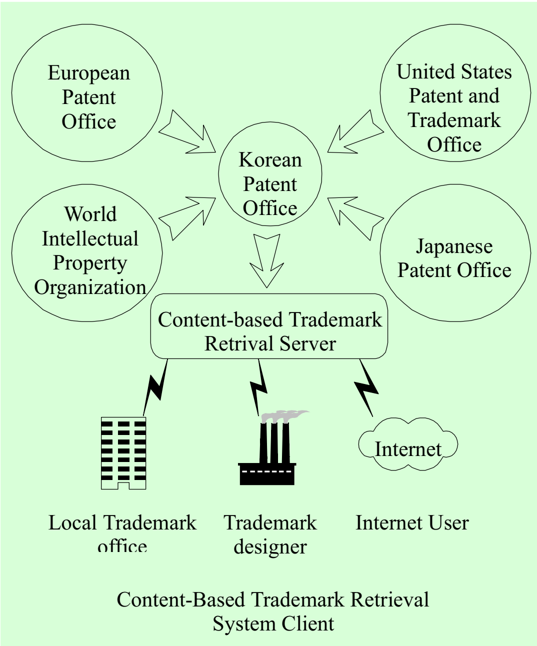

Fig. 2. The concept of content-based trademark retrieval system.

Fig. 3. User interface for client system.

applets to perform trademark retrieval as shown in Fig. 3. As depicted in this figure, the client interface is simply Java enabled web browser that allows worldwide on-line access.

2. User Interface

A. Query Input

There are two methods of formulating queries on the client side. The first one is by a visual image query as shown in Fig. 4. A user can also browse registered trademarks provided by the server and select one of them by clicking the icon to submit it as a query. The server provides several brows-

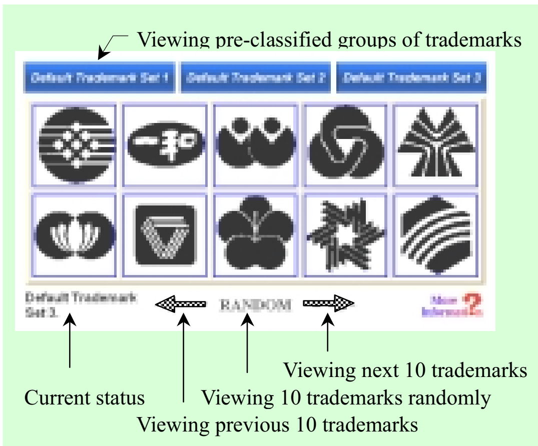

Fig. 4. User interface for visual image query.

ing methods as follows.

- Browsing pre-classified groups of trademarks
- Browsing registered trademarks by the

date of registration

- Browsing registered trademark in arbitrary order
- Browsing the retrieved results

Another way of query can occur by sketching a trademark. In other words, a user can actually sketch a trademark using a mouse or any other pencil-like pointing device to submit it as a query. For this purpose, the server provides a painting utility programmed in Java for sketching. The painting utility provides not only the drawing tools for line, rectangle, circle, polygon, and curve, but also the editing tools such as fill, copy, paste, and flip.

The queried trademark image is then converted into a form of character string by Java script to be transmitted to the server because, in HTTP protocol, the client can freely access the files in the server, while it is not possible for the server to access the files in client systems for security reasons.

B. Displaying the Retrieved Results

The transmitted query string is parsed and reconstructed as an image form in the server, to be used as a query. Retrieved results can easily be transmitted to the client's web page in forms of image file (GIF or JPEG format) using the HTTP protocol. The returned items can also be reused as visual image queries with minor modifications. Figure 3 illustrates the example of retrieved results.

IV. RETRIEVAL ALGORITHM

1. Zernike Moments Magnitude as a Feature Set

The magnitudes of Zernike moment are used as a feature set. Zernike moments are complex orthogonal moments whose magnitude has rotational invariant property [20]-[23]. C.H. Teh compared several moments in terms of (1) sensitivity to image noise, (2) aspects of information redundancy, and (3) capability for image representation [24]. They reported that Zernike moments outperform the other moments, such as regular, Legendre, rotational and complex ones, in all aspects. Zernike moments are defined inside the unit circle, and the radial polynomial vector $\mathbf{R}(\rho)$ is defined as

$$R_{nm}(\rho) = \sum_{s=0}^{\frac{n-|m|}{2}} (-1)^s \times \frac{(n-s)!}{s!\left(\frac{n+|m|}{2}-s\right)!\left(\frac{n-|m|}{2}-s\right)!} \cdot \rho^{n-2s}, \quad (1)$$

$$\mathbf{R}(\rho) = \{R_{nm} | n = 0,1,2,\ldots,\infty, |m| \le n, \text{ and } n-|m| \text{ is even}\}. \quad (2)$$

Then the two-dimensional Zernike moment of an image, $I(\rho, \theta)$, in polar coordinate is defined as

$$\mathbf{A} = \frac{n+1}{\pi} \sum_{\rho} \sum_{\theta} [\mathbf{V}(\rho,\theta)]^* I(\rho,\theta), \text{s.t.} \rho \le 1, \quad (3)$$

Here, $\mathbf{V}(\rho,\theta)$ is a Zernike basis polynomial defined as

$$\mathbf{V}(\rho,\theta) = \mathbf{R}(\rho) \exp(-jm\theta). \quad (4)$$

The magnitude of Zernike moment (ZMM) is defined as

$$\mathbf{z} = \|\mathbf{A}\|. \quad (5)$$

So, the $\mathbf{z}$ denotes the vector of z_{nm}. That is,

$$\mathrm{z} = \{z_{nm} | n = 0, 1, 2, \cdots, \infty, |m| \le n, \text{ and } n - |m| \text{ is even}\}. \quad (6)$$

Table 1 lists the ZMM up to the order of $n = 8$.

Table 1. List of ZMM, z up to the order of $n = 8$.

n	ZMM	No. of ZMM
0	z_{00}	1
1	z_{11}	1
2	z_{20}, z_{22}	2
3	z_{31}, z_{33}	2
4	z_{40}, z_{42}, z_{44}	3
5	z_{51}, z_{53}, z_{55}	3
6	$z_{60}, z_{62}, z_{64}, z_{66}$	4
7	$z_{71}, z_{73}, z_{75}, z_{77}$	4
8	$z_{80}, z_{82}, z_{84}, z_{86}, z_{88}$	5

2. Visual Effects Caused by Each Order of ZMM

The order of Zernike moment is determined by two parameters, i.e., n and m. Each order of Zernike moment is computed by multiplying the radial polynomial to the phase term. Real parts of several orders of Zernike moments are shown in Fig. 5. Imaginary parts are π/m radian-rotated version of the real parts. As illustrated in Fig. 5, we can see that the larger the difference between n and m, i.e., $|n-m|$ is, the more high frequency components exist in the radial polynomial. So, an image whose ZMM is large for large value of $|n-m|$ has large degree of high frequency component in the radial direction, in other words, the image is radially complex one. On the other hand, an image with large ZMM for small value of $|n-m|$ can be said radially simple one.

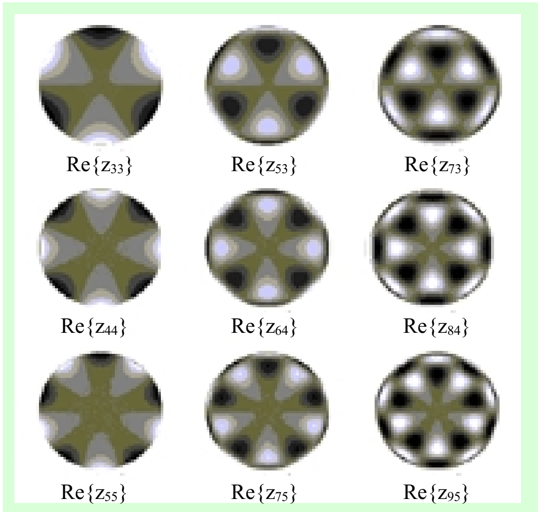

Fig. 5. The real part of each order of 2-D Zernike basis functions.

The phase term of each Zernike moment is m-fold circular symmetric. That is, an image with a large value of ZMM corresponds to an m-fold circular symmetric image. For example, the ZMM of $m = 2$ becomes a dominant feature for a narrow and elongated pattern, the ZMM of $m = 3$ for a triangular-shaped, the ZMM of $m = 4$ for a square-shaped, and the ZMM of $m = 5$ for a pentagonal-shaped pattern, etc.

3. Trademark Database and Its Distribution Model

Three thousand Korean and worldwide trademarks (mostly device-mark) were collected. All trademark images were binarized, and normalized to the size of 100×100 pixels by using maximum extent circle (MEC) method [25]. Color was not considered in our current system. ZMMs were computed by adopting the lookup-table method [3] and stored in a database up to the order of $n = 17$. The total number of moments corresponds to $n = 17$ is 90.

The feature distribution model plays an important role in our system to determine the very feature that distinguishes the query trademark best from the rest in the database. As mentioned, the order of ZMM is determined by two parameters, i.e., n and m. Ninety ZMMs were computed and stored in the database for all 3,000 trademarks. The probabilistic distribution of ZMM for each (n,m) was modeled by a Gamma distribution, which is defined as

$$f(\mathbf{z};\alpha,\beta) = \frac{1}{\beta^{\alpha}\Gamma(\alpha)} \mathbf{z}^{\alpha-1}\exp(-\mathbf{z})U(\mathbf{z}) \quad (7)$$

$$\Gamma(\alpha) = \int_0^{\infty} x^{\alpha-1}e^{-x}dx. \quad (8)$$

The parameters of the Gamma distribution, α and β, can be readily estimated with the mean and variance by solving the following equations [26].

$$E(\mathbf{z}) = \alpha\beta,\ E(\mathbf{z}^2) = \alpha(\alpha+1)\beta^2. \quad (9)$$

So, the parameters of the Gamma distribution are

$$\hat{\alpha} = \frac{\{E(\mathbf{z})\}^2}{E(\mathbf{z}^2) - \{E(\mathbf{z})\}^2},\quad \hat{\beta} = \frac{E(\mathbf{z}^2) - \{E(\mathbf{z})\}^2}{E(\mathbf{z})}. \quad (10)$$

Here, $\hat{\alpha}$ and $\hat{\beta}$ can be easily updated when a new trademark is added to the database because only the mean and the variance of feature are used in the estimation. The distribution model was verified by Kolmogorov-Smirnov goodness-of-fit test and accepted with significance level of 0.05.

4. Similar Trademark Retrieval Using Visually Salient Feature

With 90 Zernike moment features to be used for retrieving similar trademarks from a database, one of the common approach is to make use of the Euclidean distance in feature space along with a proper weight on each feature [22]. The one having the minimum distance to the query would be selected. When the number of patterns in a database to be compared is very large, however, the number of features should also be increased, and this naive approach may impose a computational problem. In addition, as the size of the database grows, this method may not be feasible especially when the system needs to run in real-time for on-line applications. Furthermore, the determination of the weight for each feature to yield an optimum result is not a trivial matter even with a neural network based approach since the weight should be updated as more data are merged to the database. For these reasons, instead of using all 90 features, we decided to use as few features for each trademark as possible.

A well-known problem in pattern recognition is that more features do not necessarily imply a better classification. Therefore,

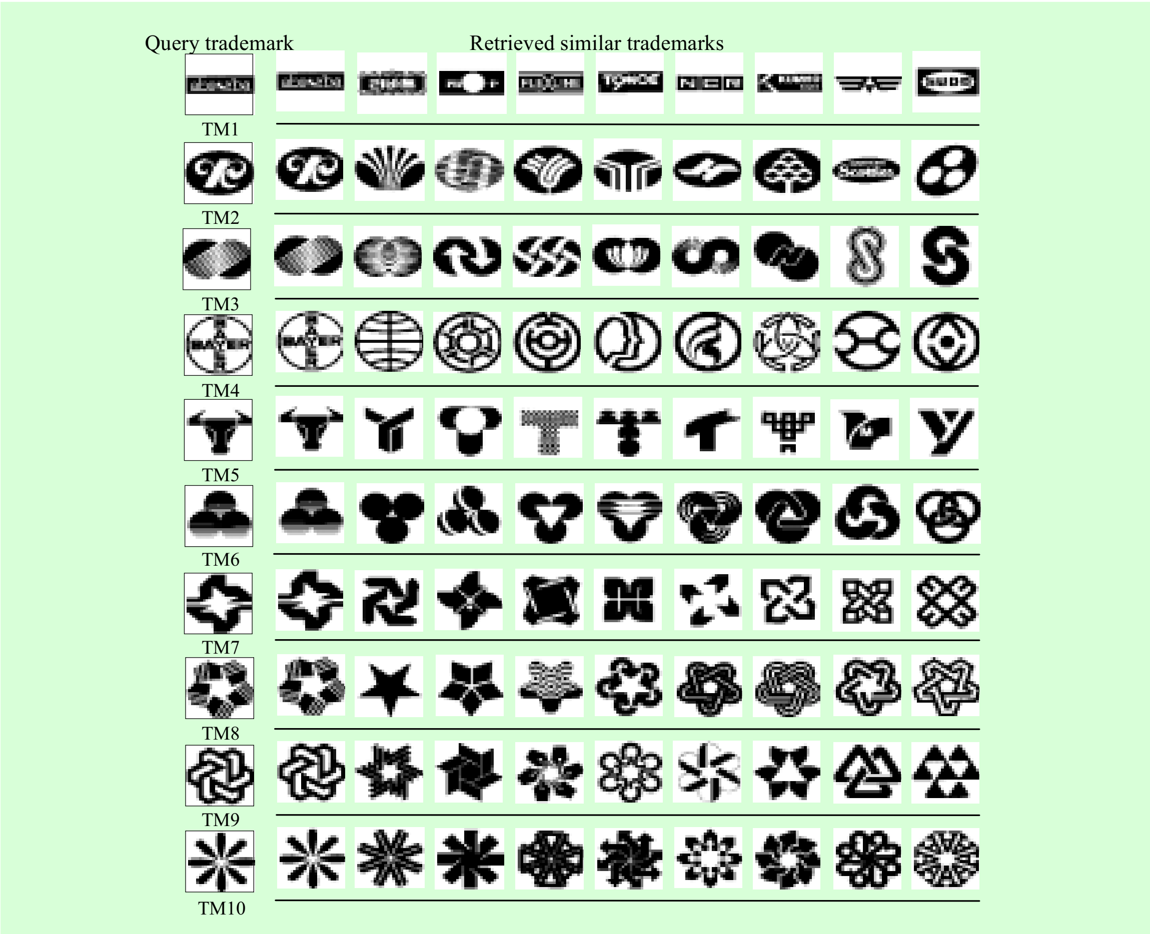

Fig. 6. Trademarks in the left most column are the query trademarks, the rest are the selected retrieved results arranged in the order of similarity distance among the top 30 candidates.

the effective selection of useful features is an important issue. As defined in [27], the most expressive feature (MEF) has to yield the minimum squared error in reconstruction, while the most discriminating feature (MDF) has to distinguish an image best from the rest of images in the database. A specific feature for either MEF or MDF, or any specific orders of moments in our applications, may not be the same for all queries. Therefore the selection scheme plays an important role because every trademark might have its unique characteristics. For that purpose, we developed a new feature selection method that can comply with the requirements for both MEF and MDF.

To meet the requirements, we first introduce a *salient feature* that dominantly affects the shape globally but not its minor details. The *degree of saliency, DS(n,m)*, for each feature extracted from the query trademark, is defined as a parameter that indicates the degree of relative contribution of each order of moment to the global shape of the trademark:

$$DS(n,m) = P\left(z_{nm} \geq Z_{nm}^{(q)}\right) = \int_{Z_{nm}^{q}}^{+\infty} f(z_{nm}; \alpha_{nm}, \beta_{nm}) dz_{nm}, \quad (11)$$

where, Z_{nm}^{q} is the ZMM of (n,m)-th order of the query trademark. The larger the value of Z_{nm}^{q} is, the more the shape is affected by (n,m)-th order moment compared to other moments. Note that this is the very similar concept to MEF defined in [27]. Namely, the moment with large magnitude is mainly responsible for the global shape of the trademark. A similar argument holds for MDF. That is, the smaller the value for $D(n,m)$ is, it is less probable and more unique for the rest of trademarks to have (n,m)-th order of moment as their MEF. Therefore, the most salient feature (MSF) of the query trademark is defined by the (N,M)-th order of moment that yields the smallest $DS(N,M)$. The degree of the similarity of the trademarks to the query trademark is then determined by the Euclidean distance from the query to all trademarks in the database using only the MSF or (N,M)-th order moment instead of the whole 90 moments. The similarity between the query trademark and those in the database can be determined as follows,

$$S = \left| Z_{NM}^{(i)} - Z_{NM}^{(q)} \right|, \quad (12)$$

where (i) indicates the trademark index.

V. PERFORMANCE EVALUATION

To verify the performance of our proposed similar shaped trademark retrieval system, some trademarks were applied as query images to the database of 3,000 trademarks. Average elapse time for the retrieval is listed in Table 2.

Table 2. Average elapse time for retrieval (200MHz Pentium Pro PC).

Moment computation	Database Query	Total
0.1 s	0.5 s	0.6 s

1. Similar-Shaped Trademark Retrieval

Figure 6 is the similarity-based retrieval results. Trademarks in the left most column are the query trademarks, the rest are the selected retrieved results among the top 30 candidates. Similar trademarks were retrieved regardless of their orientation because the Zernike moments have the rotation invariant characteristics. The retrieved results of TM3, TM6 and TM7 in Fig. 6 were good examples for such desirable property. MSF for each test image is listed in Table 3.

2. Noisy or Deformed Trademark Retrieval

Several sets of deformation transformation as shown in Fig. 7(a)-(e), and two types of noise pattern shown in Fig. 7(f),

Table 3. MSF for each query trademark.

	TM1	TM2	TM3	TM4	TM5	TM6	TM7	TM8	TM9	TM10
MSF	z_{22}	z_{42}	z_{62}	z_{40}	z_{53}	z_{33}	z_{64}	z_{55}	z_{66}	z_{88}

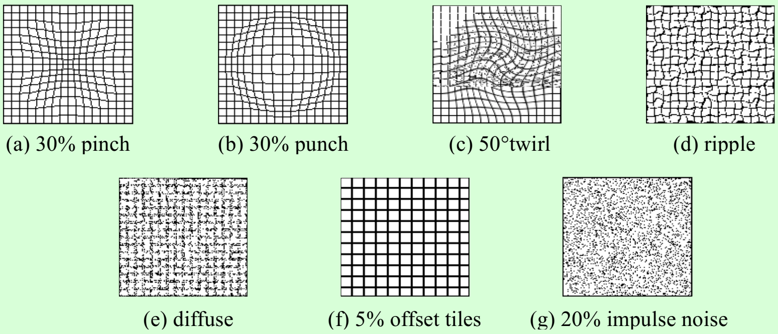

Fig. 7. Deformed sets and noisy pattern ((a)-(f): several deformation transformations, (g) and (h): different types of noise).

Table 4. The recall rate of the original ones among top 30 candidates queried by noisy or deformed trademarks.

	Original	Pinch	Punch	Twirl	Ripple	Diffuse	Tiles	Impulse Noise	Total
Recall rate (%)	100	100	100	100	100	100	100	100	100

7(g) were applied to generate a set of deformed trademarks as illustrated in Fig. 8. In addition, the noisy or deformed trademarks were rotated and scaled arbitrarily and submitted as query images to the trademark database to determine whether the noisy or deformed trademarks can retrieve their original corresponding trademarks. Table 4 presents the results of recall rate in the top 30 candidates queried by noisy or deformed trademarks. All noisy or deformed trademarks can recall their corresponding original within the top 30 candidates. The average recall rate of the original trademark among the top 30 candidates queried by noisy or deformed trademarks was 100%.

VI. DISCUSSION AND FUTURE WORK

This paper described the concept and the general framework for a content-based

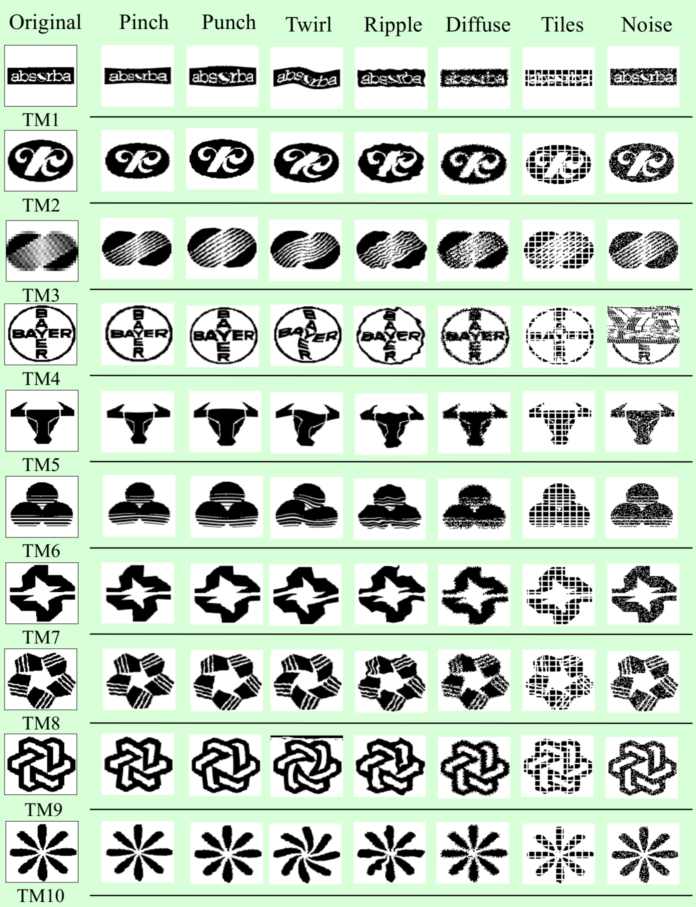

Fig. 8. Trademarks in the left most column are the original ones and the rest are noisy or deformed trademarks that are submitted to the system to search for the original.

trademark retrieval system that takes the queries of visual images or by user's sketches on the WWW. We showed that the Zernike moment magnitude is a powerful descriptor that captures the proper visual features of trademark images. To retrieve similar shapes, the Most Salient Feature that affects the shape most dominantly is taken into account. The advantages of using the MSF are two-folds: quick indexing of similar trademark and the robustness to the minor transformation of the shape. The salient feature considers two visual factors: radial complexity and the degree of circular symmetry of the shape. So the retrieved trademarks using the salient feature have the similar radial complexity and the circular symmetry. The MSF of trademark is barely affected by the noise or deformation as long as the global shape of a trademark remains similar. Through our experiments, the highly successful retrieval of noisy or deformed trademarks is also confirmed. We are still trying to apply other possible pattern recognition techniques such as edge based matching or occluded object recognition technique to improve the retrieval accuracy of our system. And we are also planning to enhance the graphical user interface in order to include relevance feedback.

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