CMU TRADEMARK RETRIEVAL SYSTEM

October 2002

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In traditional trademark retrieval systems, the trademarks are first annotated with keywords that are then used for retrieval. The Vienna Classification [1] is a well-known scheme to achieve this purpose and it constitutes a hierarchical system that proceeds from the general to the particular, dividing all figurative elements into categories, divisions and sections. The STAR system developed by Wu et al. [2] is an example trademark system that makes use of the Vienna Classification with user interaction. However, this process requires a lot of manual labor in order to assign keywords. Also, the annotation for the same trademark may not be consistent with different users. As a result, it is more desirable to allow the user to input a query by providing a rough sketch and then the system is smart enough to automatically extract features from this query sketch and use them for comparison in order to search for similar trademarks in the database.

The TRADEMARK system proposed by Kato et al. [3] used the graphical features that consist of the spatial distribution, spatial frequency, local correlation and local contrast. The spatial distribution is computed as the pixel density for each 8×8 block while the local correlation and the local contrast are computed among 4×4 block. The spatial frequency is computed as the run-length distribution of black pixels after dividing the image into 4 rectangular blocks in the horizontal and the vertical direction. These block-based features are not good to describe lines or contours.

In the ARTISAN project [4], the boundaries of the components of a trademark are extracted and analyzed. The distance measure is computed by a linear combination between the distance of whole-image shape feature vectors and the distance between each query component and the closest-matching component of each image in the database on the basis of shape, size and absolute position. In this system, each component is considered independently and the spatial relation between components within the same image is not considered.

The Zernike and Pseudo-Zernike Moments are used in Kim and Kim's content-based trademark retrieval system [5]. Manmatha et al. [6] used the seven Hu moment invariants [7] as well as curvature and phase histogram for trademark retrieval. In Ciocca and Schettini's work [8] on trademark retrieval, Hu moment invariants, histogram of edge directions and wavelet coefficients are used as the features. Jain and Vailaya [9] also used Hu moment invariants and histogram of edge directions in the initial stage to find potentially matched trademark candidates. These systems typically compute the *global* similarity between the query and the database trademark. When an additional component is present or when a component is missing from the image, these features (especially the moments) will lead to rather different statistics. Therefore, the retrieval system will not be robust if the query is merely a rough sketch or if the query consists of multiple components.

In Jain and Vailaya's work [9], during the refined matching stage, deformable template matching is used to compare the edge map of the query trademark and the edge map of the retrieved trademarks from the initial stage. Kwan et al. [10] proposed to use relaxation matching to evaluate the compatibility of relative relations among segments extracted from the query trademark and the database trademark. These energy minimization methods are computational intensive thus they are not suitable for retrieval with a large database.

The content-based retrieval system of trademark images in Alwis' thesis [11] performs multiple component matching by categorizing each component into a line, an arc or a closed figure. The component features include end-point proximity, parallelism, co-linearity and co-curvilinearity. This component analysis is similar to our work with the difference that we categorize the components (strokes) into primitives such as circle, polygons and lines, each with a likelihood measure and then the primitive and the associated likelihood are both used for matching strokes.

In our trademark retrieval system [12], the trademark images are first filtered to remove noise. Then the filtered image is segmented into regions based on pixel connectivity. For each region, a decision is made about whether thinning or edge extraction is applied since one method is preferred to the other under different situations. For example, for a solid region in which the shape conveys a lot of visual information, it is better to perform edge extraction to that region to extract the contour. On the other hand, for a region that contain curves, thinning should be performed to that region to extract the skeleton that is a better representation. After the contour-skeleton classification, stroke tracing is performed to extract the sketch. The user can provide a query sketch that will be compared with those extracted sketches from the database trademark images in order to retrieve similar trademarks based on both the shape similarity and the spatial relation similarity between the strokes [13].

Our database consists of close to two thousand trademarks. The ground truth of the database is obtained by classifying the trademarks in groups. Under each group the trademarks are similar to each other and one may be a transformed version of the other such as translation, rotation and scaling or may be at a different noise level. We first analyze the performance of our classifier for deciding whether an edge or a skeleton should be extracted for each region. We pick 154 trademarks out of 43 classes as queries and then examine the rankings of the trademarks from the same classes. The same queries were used under 3 different conditions for the sketch extraction: 1) when thinning alone is applied to each region to extract the skeleton strokes; 2) when edge extraction alone is applied to extract the contour strokes; 3) when a classifier is used to decide whether thinning or edge extraction should be performed for each region so that a sketch may consist of both the skeleton strokes and the contour strokes. The overall retrieval performance is shown in Figure 8 and is presented as the precision-recall graph [14]. The precision-recall curve with higher precision at the same recall values means better retrieval performance. It can be seen that by classifying the sketch into skeleton strokes and contour strokes, the retrieval performance is better than the other two cases: 1) when thinning alone is performed for all regions to divide the sketch into only skeleton strokes; and 2) when edge extraction alone is performed for all the regions to divide the sketch into only contour strokes. As a comparison, we perform the retrieval using the seven Hu moments and the histogram of edge directions as features. As shown in Figure 1, the lowest two curves correspond to the cases when the Hu moments and the histogram of edge directions are used alone with the Mahalanobis distance as the similarity measure. When the resulting distances from these features are combined linearly, the retrieval performance is better than using any of those features alone yet it is still worse than our proposed scheme.

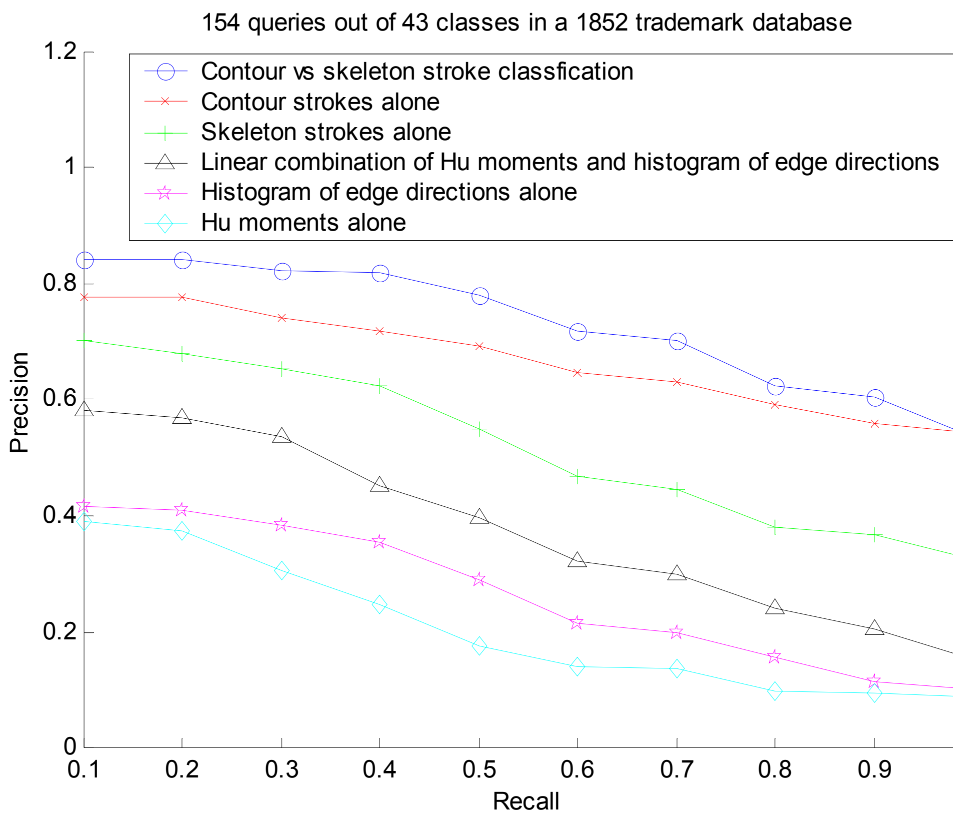

Figure 1 Comparison of retrieval performance

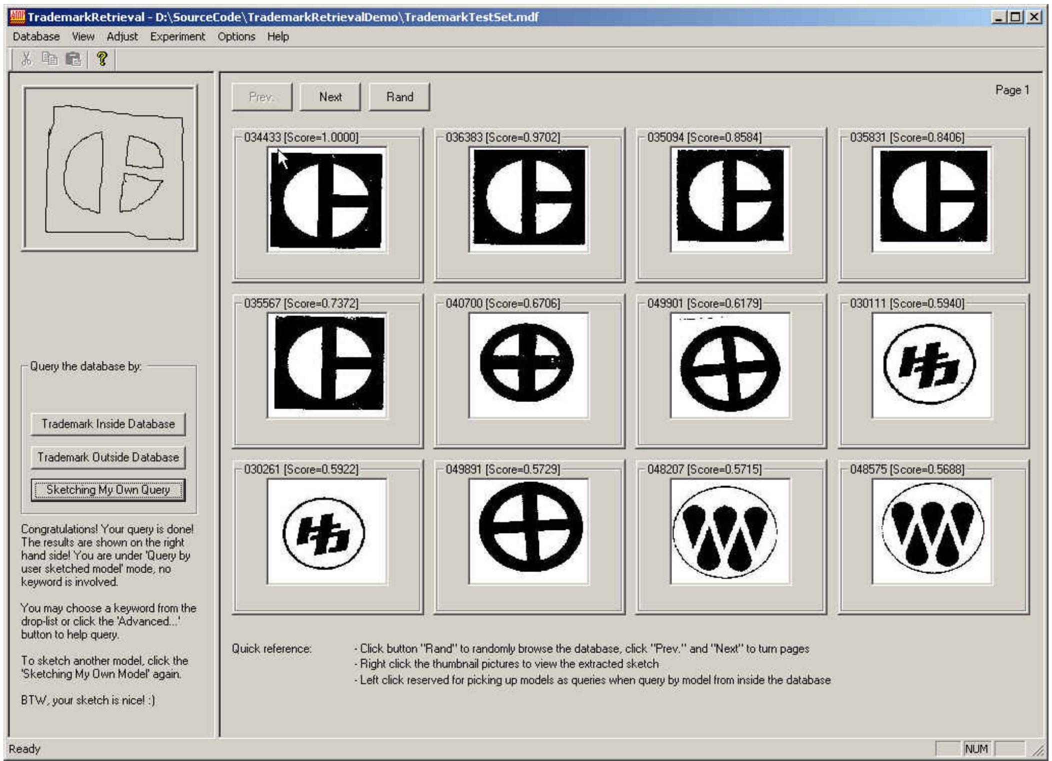

Figure 2 The user interface with the query by sketch

Our trademark retrieval interface is shown in Figure 2. After the user selects a database a trademarks, he/she can browse through the trademarks. A window will pop up after the user right clicks on the trademark image and the corresponding sketch extracted for that trademark will be shown. Moreover, he/she can click on the trademark to select that trademark to be the query and then the trademarks in the database that are similar to the query will be retrieved. The query is shown on the frame in the left hand side. The twelve trademarks that have the highest ranks according to the similarity score are shown on the frame in the right hand side. In addition to trademark image, the user is also able to provide a sketch as a query, and the trademarks whose corresponding extracted sketches similar to the query sketch are retrieved and ranked as shown in Figure 2. Note that the query is merely a rough sketch yet the system is able to retrieve all the relevant trademarks with the highest similarity scores.

For more information about this project, please visit our website at http://amp.ece.cmu.edu.

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