Content-based Trademark Retrieval using Zernike Moment and Color-Spatial Techniques

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Abstract: - Today, the number of registered trademarks is huge and is increasing rapidly. Thus, the job of identifying infringement of trademarks by solely using manual inspection is tiring, laborious and time consuming. To cope with the tremendous amount of available registered trademarks and to protect the infringement of trademarks, a new automatic and efficient trademark retrieval system is necessary and urgent. This paper presents an efficient content-based trademark retrieval based on the synergy between the color-spatial technique and zernike moment method. Zernike moments could be used as an effective descriptor of global shape of a trademark while the color-spatial feature could be used to obtain color spatial distribution in the trademark image. To retrieve visually similarly look trademark, we use a weight Euclidean distance measure. Experimental evaluations conducted on a database containing 1000 trademark images shows that the proposed methodology is very effective in retrieving visually similar look trademarks.

Key-Words: - Zernike moments, color-spatial, content-based, image retrieval and trademark

1 Introduction

Digital images play an important role in fields of advertising, design, education, entertainment, journalism and medicine, [1,2,3,4,10,11]. Thus, the interests in the content-based image retrieval (CBIR) techniques have been up surged over the last few years.

It had been long recognized that trademark registration is one of the prime application areas for CBIR [5]. Trademark registration involves comparing a new candidate marks with the existing marks of companies, products or services. This is to ensure that no confusion in identifying different companies, products or services. Registered trademarks are protected trough legal proceedings from misuse or imitation in the granted territories [2]. Copyright owners are able to seek out and identify unauthorized copies of trademarks, particularly if they have been altered in some way.

The task of manually registering new trademark, which is mostly done manually at present, is laborious and time consuming. As a consequent, the development of an effective automatic trademark retrieval system is necessary and urgent.

Since shape and color are the fundamental properties of a trademark, this paper presents a new method of retriving visually similar look trademarks from the trademark database by integrating these two features. An effective shape descriptor must be used in order to retrieve a visually similar look trademark from a large trademark database. It should also have enough discriminating power and insensitive to noise, invariant to scale as well as rotation. One of the best candidates for this purpose is to use the Zernike moment method (ZMM) [6].

Color is one of the most obvious requirement for image indexing features employed in CBIR. Further, along with shape, color is added as an additional feature to enhance the retrieval efficiency and effectiveness. The popular most commonly used color histogram method [7] has the problem of high-dimensionality although this method provide good color characterization. This leads to more computational time, inefficiency in indexing and therefore results in low performance. To overcome these problems, use of color-spatial technique [8] is proposed in this paper.

In this paper, we propose a new approach for content-based trademark retrieval (CBTR), which is able to efficiently retrieve the visually similar look trademark from the large trademark database. This paper is organized as follows. In Section 2 provides an overview of Zernike moment method [6] while color-spatial technique [8] is described in Section 3. A problem solution is defined and discussed in Section 4. Experimental results are given in Section 5, and Section 6 summarizes this paper.

2 Zernike Moments Method

Moment functions are used to capture the global feature of applications in image analysis [9]. A set of moments computed from a digital image, generally represents global characteristics of the image shape, and provides a lot of information about different types of geometrical features of the image. In 1934, Frist Zernike proposed the Zernike function [6]. His moment formulation appears to be one of the most popular, outperforming other alternatives in terms of noise resilience, information redundancy and reconstruction capability. Zernike moments are complex orthogonal moments whose magnitude has rotational invariant property [6,9]. They form a complete orthogonal basis set defined on the unit disc $\left(x^2 + y^2\right) \leq 1$.

2.1 Zernike Polynomial

Zernike polynomial is a set of orthogonal functions with simple rotation properties which forms a complete orthogonal set over the interior of the unit circle [12]. The form of these polynomials is as folows:

$$V_{pq}(\rho,\theta) = R_{pq}(\rho)e(-jq\theta) \quad (1)$$

where $j = \sqrt{-1}$, and:

p :positive integer or zero; i.e. $p = 0,1,2,...,\infty$.

q :positive integer subject to constraint $p-|q|= even, q \leq p$.

R : length of vector from origin to (x, y) pixel, i.e. $\rho = \sqrt{x^2 + y^2}$.

θ :angle between the vector ρ and the $x-$axis in the counterclockwise direction.

The radial polynomial, R_{pq}, is defined as follows:

$$R_{pq}(\rho) = \sum_{s=0}^{(p-|q|)/2} \frac{(-1)^s (p-s)!}{s!\left(\frac{(p+|q|)}{2}-s\right)!\left(\frac{(p-|q|)}{2}-s\right)!}\rho^{p-2s} \quad (2)$$

2.2 Computation of Zernike Moments

The complex Zernike moments of order p with repetition q for an image function $I(\rho,\theta)$, in polar coordinate is defined as:

$$A = \frac{q+1}{\pi}\sum_{\rho}\sum_{\theta}\left[V(\rho,\theta)\right]^{*} I(\rho,\theta), s.t. p \leq 1 \quad (3)$$

If N is the number of pixels along each axis of the image, then Eq. (3) can be written in the discrete form as follows:

$$Z_{pq} = \frac{(p+1)}{\pi(N-1)^2}\sum_{x=1}^{N}\sum_{y=1}^{N} V_{pq}^{*}(\rho,\theta) f(x,y), \quad (4)$$

where

$$\rho = \left(x^2 + y^2\right)^{1/2} / N, and \theta = \tan^{-1}(y/x). \quad (5)$$

Since Zernike moments are defined in terms of polar coordinates (ρ,θ), the Zernike polynomials have to be computed at each pixel position, thus the computations involved are significantly large compared to other moments. The polar form of Zernike moments suggests a square-to-circular image transformation [6] had to be employed. The resultant Zernike moments, although differ from the true moments of the rectangular image, could be used as feature descriptors for image identification and reconstruction applications.

2.3 Computational of Shape Features

Zernike moment of different orders were computed for the monochoromatic trademarks. Thus, any chromatic trademark images will have to be first converted to the monochromatic counterparts before shape features could be extracted. The real-valued Zernike moment components in Eq. (4) can be written in the discrete form using the coordinates of the transformed circular image as:

$$Z_{pq} = \frac{2p+2}{N^2}\sum_{\gamma=1}^{N/2} R_{pq}\left(\frac{2\gamma}{N}\right)\sum_{\xi=1}^{8\gamma}\cos\left(\frac{\pi q \xi}{4\gamma}\right) f(\rho,\theta) \quad (6)$$

3 Color-Spatial Technique

The use of color histogram method is very popular in CBIR perhaps because of it is quite easy to compute. The main issue of using this method is, it does not provide spatial information of pixels in an image. As a consequent, any two or more images could posses similar color distribution characteristics. Therefore, the use of this technique alone in image retrieval could results in false retrieval results.

Chan and Chen [8] proposed a color spatial technique to embed the color distribution with spatial relationship knowledge of pixels in an image. The color features of an image could be extracted by using a simple and quick process. The original image I is divided into 3 x 3 blocks of the same size. Each block consist of three color components: red (R), green (G) and blue (B). In each block, the mean of these primary color is computed. As a result, every block contains 3 mean values of R, G and B. In other words, each image after division process contains a color-spatial feature totaling 27 dimensions.

The purpose to compute the mean of each primary color is to reduce the effect of noise and image size. Hence, the color-spatial feature is highly tolerant to noise variation and scale variation in image. However, due to the spatial information is taken into consideration; this technique is easily affected by transformation variation of objects and rotation variation in images. It should be noted that transformation variation is already been assumed negligible in this study, as the trademark images collected in the trademark database doesn't include transformation variation in the trademark. In the case of rotation variation, this has already been taken into consideration in the zernike moment method.

4 The Proposed Approach

The block diagram of the proposed approach is shown in Fig. 1. It can be separated into two modules. In the query module, user can submit a trademark image query and predetermined features were extracted. Similar image features were also extracted from the trademark image database and subsequently these features were stored in feature database. Details on specific image features will be described in the later section. In this study, a Microsoft Access® had been used. This is followed by feature matching between the query trademark features and the features which have already been stored in the feature database. The weighted Euclidean measure was employed for finding the visually similar look trademark based on specific identified features.

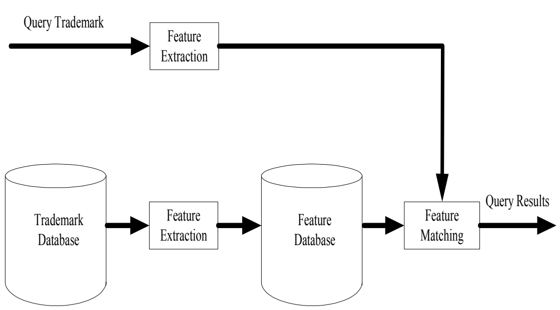

Fig. 1: The block diagram of the proposed approach.

4.1 Data Collection

1000 trademarks were collected solely from the internet. Fig. 2 shows some collected trademarks samples. In data collection process, there are 2 separate processes involved; extracting Zernike moment features and extracting the color-spatial features. To extract Zernike moment features, all of the trademarks images were converted to monochrome image and and normalized to the size of 100 X 100 pixels. For extracting the color-spatial features, the original trademarks were used.

Fig. 2: 12 trademark samples.

4.2 Feature Extraction

The selection of the features are according to the computation of Zernike moment and color-spatial for each trademark in the database and the query trademark. Zernike moments as a feature are constructed using a set of complex polynomials and are defined inside the unit circle and the radial polynomial vector [6]. 25 Zernike moments from order 0 to 8 in p and q, and 27 dimensional of color-spatial are then extracted. Table 1 lists the features of Zernike moment up to the 8th order.

Table 1: List of ZMM up to order 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

4.3 Feature Matching

To retrieve the most visually similar look trademarks in ranking order, feature matching technique using Euclidean distance measures were carried out between the query features and the features stored in the features database. Table 2 shows a schematic of a set of reference feature vectors.

Consider that a feature vector corresponding to a trademark k is given by:

$$V^{(k)} = \left\{ v_1^{(k)}, v_2^{(k)}, v_3^{(k)}, \ldots\ldots v_n^{(k)} \right\} \quad (7)$$

where each component $v_i^{(k)}$ is typically an invariant moment function of the trademark. The set of all $V^{(k)}$'s constitute the reference library of feature vectors. The trademarks for which the reference vectors are computed and stored as above are either a set of patterns or different views of a three dimensional object.

Table 2: A schematic of a set of reference feature vectors.

Image (k)	Feature vector 1 2 3 ..... n
1 2 3 . . . k	$v_1^{(k)}$ $v_2^{(k)}$ $v_3^{(k)}$ ..... $v_n^{(k)}$

4.4 Similarity Measure

Zernike moment features could characterize the global shape of a trademark image while color-spatial feature provides the color distribution with spatial information of pixels in a trademark. To match these 2 feature vectors, first the Zernike moment distance measure, $Dist^{zm}$ is calculated. Let *V'* be the set of feature vectors as follows:

$$V' = \left\{ v_1', v_2', v_3', \ldots\ldots v_n' \right\} \quad (8)$$

The weighted Euclidean distance measure is used in feature vector matching and is defined as:

$$Dist^{zm}\left(V', V^{(k)}\right) = \sqrt{\sum_{i=1}^{n} \rho_i \left(v_i' - v_i^{(k)}\right)^2}\ , \quad (9)$$

where ρ_i denotes the weight added to the component v_i to balance the variations in the dynamic range. The value of k for which the function d is minimum, is selected as the matched image index. In this study, the inverse of the variance of the column $v_i^{(k)}$ is used as the weight ρ_i, i.e.,

$$\rho_i = \frac{N}{\sum_{k=1}^{N} \left(v_i^{(k)} - \bar{v}_i\right)^2}, \quad (10)$$

where

$$\bar{v}_i = \frac{\sum_{k=1}^{N} v_i^{(k)}}{N}. \quad (11)$$

On the other hand, the color-spatial features of query trademark, Q and index image D were also calculated. Let the query trademark, Q and the trademark database, D be defined as follows:

$$Q = \begin{pmatrix} \left(q_{r,1}^{cs}, q_{g,1}^{cs}, q_{b,1}^{cs}\right), \left(q_{r,2}^{cs}, q_{g,2}^{cs}, q_{b,2}^{cs}\right), \ldots, \\ \left(q_{r,9}^{cs}, q_{g,9}^{cs}, q_{b,9}^{cs}\right) \end{pmatrix} \quad (12)$$

and

$$D = \begin{pmatrix} \left(d_{r,1}^{cs}, d_{g,1}^{cs}, d_{b,1}^{cs}\right), \left(d_{r,2}^{cs}, d_{g,2}^{cs}, d_{b,2}^{cs}\right), \ldots, \\ \left(d_{r,9}^{cs}, d_{g,9}^{cs}, d_{b,9}^{cs}\right) \end{pmatrix} \quad (13)$$

which represent the values of color-spatial feature with 27 dimensions of Q and D, respectively. Similar to the Zernike moments method, matching distance for the color-spatial, $Dist^{cs}$, is also using the weight Euclidean distance measure as follows:

$$Dist^{cs}\left(Q, D^{(k)}\right) = \sqrt{\sum_{i=1}^{27} \rho_i \left(q_i - d_i^{(k)}\right)^2} \quad (14)$$

The integration of Zernike moment and color-spatial features make up the actual similarity index or distance measure, $Dist$, is computed using the following formula:

$$Dist = \alpha Dist^{zm} + (1 - \alpha) Dist^{cs}. \quad (15)$$

where α is called the weighted equilibrium value which could hold the value in the range between 0 and 1. By setting the α to 0, this system will act as a pure color-spatial retrieval system and vice versa. The smallest value of $Dist$ means that closest matching between the query trademark and the index trademark.

5 Experimental Results

To test the performance of this newly proposed approach, extensive test were carried out. For this purpose, 10 randomly chosen trademarks from the database were used as a query trademark.

Table 3 shows the examples retrieval results when α was set to 0.5 and Table 4 shows the trademark retrieval results under 3 conditions, i.e., solely by color-spatial method ($\alpha = 0$), Zernike moment method ($\alpha = 1$), and the integration of both methods ($\alpha = 0.5$),. From Table 4, it can be observed that the use of any single method alone, either Zernike moment or color-spatial method, does not provide good retrieval results. The combination of these techniques will results in more efficient trademark retrieval as illustrated in Table 3.

Table 3: The top 10 retrieval results when α was set to 0.5 for various query trademarks.

Query Image	Trademark retrieval results ranking									
	1	2	3	4	5	6	7	8	9	10

Table 4: Trademark retrieval results under different α value.

Query Trademark: FORTALEZA			
Rank	Color-spatial (α = 0)	Zernike moments (α = 1.0)	Integrated technique (α = 0.5)
1	FORTALEZA	FORTALEZA	FORTALEZA
2	ECUS	ECUS	ECUS
3	A.C.G.	A.C.G.	A.C.G.
4	V.I.F.	C. A. P.	ADBF
5	MERSIN	A A F ASSIS	A A A
6	ADBF	A A A	C. A. P.
7	ECSP	ADBF	ECSP
8	A A A	ECIV	F.A.C.
9			M.E.C.
10		CALA	CALA

6 Conclusions

This paper proposes an integrated color-spatial and zernike moment method for content-based trademark retrieval. The retrieval by using color-spatial feature shows that it can retrieve similar look trademark by color composition, however, it neglects the shape of the trademark. Zernike moment method on the other hand can depict shape of most objects in an image, but it does not consider the color property of the trademark.

Because of color and shape features are mutually complementary for trademark retrieval, this paper integrates color-spatial and Zernike moments to present an integrated color and shape features for content-based trademark retrieval. Experimental results shows that this newly proposed approach can indeed enhance the retrieval performances.

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