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Trademark Image Retrieval System using Neural Networks

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Abstract - The Image retrieval plays an important role in several applications such as trademark registration, fingerprint classification and face recognition. Trademarks are considered as valuable intellectual properties. They play very important roles for successful business or companies. A huge amount of trademarks have been registered, and they are protected from imitation through legal proceedings. Therefore, registering a newly designed trademark without conflicting with the previously registered trademarks has become more and more difficult. To avoid inadvertent infringement of copyright, one must have an automatic trademark retrieval system for examining the content of the newly designed trademark with the ones that have been registered. In Chamber of Commerce in Saudi Arabia, the trademarks are classified into groups and the closest trademarks are identified manually to the one we want to register it as a new trademark. This process takes very long time. In this research project, a new approach for retrieving Trademark images is proposed based on integrating multiple classifiers. This approach is suggested to speed up the retrieving process and to improve retrieving accuracy. The proposed system is divided into feature extraction and classification or retrieving. Feature extraction is the most important step in this system for obtaining good selected features to utilize them in the classification stage. The classification process is based on multiple classifiers which get different features from the previous stage. The main goal of this research is to develop a complete automatic trademark retrieval system with intelligent issues surpass the systems introduced in literature and to reduce many of the restrictions in the working environment.

Keywords - *Image retrieval, Trademark image, Feature extraction, Multiple classifiers*

1. Introduction

The Content-based retrievals are most preferable in multimedia database systems. Content-based retrieval of multimedia database has attracted wide interest among researchers from different fields and applications. In many applications, the databases may be very large. For example, there may be several hundred thousands facial images in a criminal identification system. The concept of content-based indexing and the challenges of content-based indexing of multimedia objects are discussed in [1].

Image retrieval plays an important role in many applications, such as trademark registration, art picture database and scene picture database queries, fingerprint identification, and face identification. However, all of these applications need to handle tremendous amount of images. The development of an automatic image retrieval system is thus a must to resolve the retrieval problem [2].

There are two ways to increase the accuracy of a pattern recognition system. One is to improve the performance of a single classifier; another is to combine the results of multiple classifiers (decisions combination). Ordinarily, a pattern recognition problem may involve a number of pattern classes with each class consisting of various features. It is difficult for a single classifier to achieve perfect solution. The multiple classifier method thereby becomes the best choice for solving pattern recognition problems. Generally, a multiple classifier method is superior to a single classifier method if the classifiers are selected carefully and the combination algorithm can take the advantages of each individual classifier to avoid its weakness [2].

Image-based summarization requires that content descriptions be extracted from Web images and used to determine the importance of images. However, general purpose image analysis approaches for extracting meaningful and reliable descriptions for all image types are not yet available. To achieve consistency of image content representation and high-quality results, image-based summarization needs to be geared toward specific image types. For this, the problem of logo and trademark images is chosen as a case study for the evaluation of the proposed methodology [3, 4].

With the increase in the number of trademarks, trademark imitation has become a serious problem. Thus, building an efficient trademark retrieval system is imperative. Dealing with trademarks is a challenging task for Content–Based Image Retrieval systems. The number of registered trademarks in the world is enormous and rapidly growing; a performing system for automatic retrieval would save a lot of time when trying to avoid copyright infringement. The proposed system will be constructed based on multiple classifier system (MCS) to increase the trademark classification and retrieval rate.

2. Previous Work

Today, a lot of images are being generated at an ever increasing rate by diverse sources such as earth orbiting satellites, telescopes, reconnaissance and surveillance planes, finger printing and mug-shot-capturing devices, biomedical imaging, payment processing systems, and scientific experiments. The goal of content-based image retrieval is to retrieve database images that contain certain visual properties, as opposed to retrieving images based on other properties such as creation date, file size or author/photographer name [5, 6].

In [7], a system for detection and retrieval of trademarks is described appearing in sports videos. A compact representation of trademarks and video frame content is proposed based on SIFT feature points. This representation can be used to robustly detect, localize, and retrieve trademarks as they appear in a variety of different sports video types. Classification of trademarks is performed by matching a set of SIFT feature descriptors for each trademark instance against the set of SIFT features detected in each frame of the video. Localization is performed through robust clustering of matched feature points in the video frame [7].

Image retrieval research efforts may be divided into three types of approaches: the traditional text based annotation, content based image retrieval and the automatic image annotation [8].

In general, an image retrieval system (IRS) composed of two parts. The first part consists of describing the image: this description may be textual, in this case the image is associated with a set of words (annotations) that describe it. These techniques are widely used in the internet IRS. The second part of an IRS is indexing descriptors. The indexing consists of organizing the image descriptors to ensure access as quickly as possible to the relevant images [9].

The trademark image retrieval system in [10] consists of an offline database construction part and an online image retrieval part. The off line database construction part is intended to ensure high retrieval efficiency by extracting a feature set for each of the images in the data base in an offline manner and storing the feature set along with its corresponding image in the database so that when a query image is presented to the system, the system does not have to perform online feature extraction on each database image. To access the database, the user initiates the online image retrieval process by providing a query image as input, and then the system starts with extracting the features from the query image. After wards, the system measures the similarity between the feature set of the query image and those of the images stored in the database.

A new effective system [11] is proposed for content-based retrieval of figurative images, which is based on size functions, a geometrical–topological tool for shape description and matching.

For any image retrieval system, a suitable representation or feature for representing these objects should be chosen to facilitate a meaningful comparison of the input query to the images in the database. To choose this feature, the amount of distortion expected from the object is taken into account. As there are many different features to use when performing logo and trademark retrieval, one may suggest that a hybrid approach is necessary: combining more than one feature into a single feature descriptor [12].

A simple but efficient similar trademark retrieval scheme has been proposed in [13]. It is based on the statistical information, the distance–angle pair-wise histogram, of trademark object to generate feature vector that represents the trademark itself. Since the proposed distance–angle pair-wise histogram is rotation, scaling and translation invariant, the retrieved trademarks are similar to the query sample. Experimental results reveal that the proposed scheme outperforms the other schemes.

In [14], HIROMASA IGUCHI et.al model features for measuring the degree of similarity between combinations of image components, and grouping areas in trademark images are recognized based on Gestalt principles. This investigation can be used for content-based image retrieval from the perspective of mirroring human perception of images. The features of proximity, shape similarity, closure, and good continuation are extracted from every combination of two components in an image. After that, based on the decision results, a grouping pattern for the query is fixed. Besides changing combinations of features, the proposed method can output multiple grouping patterns.

In [15], an image retrieval approach based on decomposition of the images is presented. It consists to split image into two components where the first contains the texture and the second is referred to geometrical characteristic. The global texture features are extracted from the texture component image using the Gabor wavelet. The extracted texture features are then used to measure the similarity between images.
To check the retrieval performance, texture database of 1456 textures is created from Brodatz album. This approach is evaluated and the result indicates that the proposed decomposition lead a strong potential towards the improvement of the performance.

With the rapid development of technology of multimedia, the traditional information retrieval techniques based on keywords are not sufficient, content-based image retrieval (CBIR) has been an active research topic [16,17,18,21]. CBIR is a method of combining digital image-processing technique with database technique to retrieve image by using the color, shape, and texture features. Color feature is one of the most obvious characteristics of a color image and it can be used for color images in any format. In [17], an effective two-level color image retrieval method is proposed which divides the image into different regions and sets different weight for each region. In addition, corresponding weights are set for each RGB component according to the main hue of the color image.

In [19], extensive review is provided of various latest research work and methodologies applied in the field of CBIR. The CBIR system has been reviewed based on its fundamental components i.e. feature extraction methods in frequency and spatial domain, similarity measures like distances e.g. Euclidean Distance, sum of Absolute difference, MSE and classifiers e.g. Neural network classifier and algorithmic performance measures like precision, recall, LIRS (Length of Initial Relevant String of Image), and LSRR (Length of String to Recover All Relevant Images). Use of these parameters in various applications of CBIR has been discussed and compared. These parameters play very crucial role in deciding the overall performance of the any CBIR system. The goal of CBIR systems is to operate on collections of images and, in response to visual queries, extract similar images. The application potential of CBIR for fast and effective retrieval of images is enormous, expanding the use of computer technology to a management tool [20].

In [22], the latest research carried out in the domain of large�scale data set information retrieval (IR) based on a grid is reviewed and analyzed. The evaluation is based on scalability, response time, scope, data type, search technique, middleware, and query type. The contribution is to illustrate the features, capabilities, and shortages of current solutions that can guide the researchers in this evolving area.

The purpose of the study in [23] is to access the stability of transformation methods for medical image analysis. The reason for image retrieval is due to the increase in acquisition of images. Imaging has occupied a huge role in the management of patients, whether hospitalized or not. Depending upon the patient's clinical problem, a variety of imaging modalities were available for use. Various distance methods were used and then they are compared for effective medical image retrieval. A transform based approach is followed for effective retrieval. This study describes discrete Fourier transforms (DFT), discrete cosine transforms (DCT), discrete wavelet transforms (DWT), complex wavelet transforms (CWT) and rotated complex wavelet transform filter (RCWF) for medical image retrieval.

A new approach has been proposed in [24] for an image retrieval system based on region growing segmentation on DCT compress domain. It is presented as a different way to develop image indexing by using of DCT descriptors. The method has been carried out for compressed images database to verify its performance in JPEG standard stream line. The proposed method of region growing segmentation on DC images offers huge storage and time saving for Image indexing and retrieving. From the work in [24], it could be concluded that segmentation, while imperfect, is an essential step and very useful in building indexing keys. The presented indexing key method is a promising method for image retrieval on segmented image on compress domain.

In [25, 26], a new method based on combination of Hadamard matrix and discrete wavelet transform (HDWT) in hue-min-max-difference color space is proposed. An average normalized rank and combination of precision and recall are considered as metrics to evaluate and compare the proposed method against different methods. The obtained results show that the use of HDWT provides better performance in comparison with Haar discrete wavelet transform, color layout descriptor, dominant color descriptor and scalable color descriptor, Padua point and histogram intersection.

A new method is proposed in [27] for trademark image retrieval which is based on shape and texture features of trademark images. Zernike moment and curvelet transform is used as shape and texture feature respectively. A weighted average distance is used for similarity measure. Results illustrate that combining shape feature with curvelet based texture feature performs well in precision.

In [28], a hybrid system is proposed where human inputs are incorporated into a computerized trademark retrieval scheme. Various surveys involving general consumers' cognition and responses are conducted, and the results are used as benchmarks in developing the automated part. The core mathematical features used in the scheme are four gray- level Zernike moments and two new image compactness indices. Experimental results show that this hybrid system, when compared with human generated results, is able to achieve an average accuracy rate of 95% while that of the closest competing existing method is 65%.

An overview of the most popular and appreciated image processing techniques and approaches for the trademark distinctness check is presented in [29]. Content Based Image retrieval techniques are widely used for that purpose and some other approaches like shape and texture based similarity finding techniques are also used. In this reference, the most widely used techniques for the trademark distinctness check are summarized.

In [30], the work has been contributed to the research in image retrieval field by proposing an innovative trademark retrieval technique with improved retrieval performance due to the integration of global and local descriptors. The global descriptor employed is the Zernike moment's coefficients. The local descriptor is the edge-gradient co-occurrence matrix, derived from the contour information that is considered very important in human perception of visual similarity. This technique is tested using the standard MPEG-7 shape database of 1400 images and the MPEG-7 trademark database of 3260 images. It achieved good results.

In [31], the problem of trademark image retrieval (TIR) is addressed by proposing a novel solution which consists of an effective shape description method and an effective feature matching strategy. In the shape description method, two feature descriptors are presented. The contour-based feature descriptor not only includes the histogram of centroid distances, but also represents the relationship among two adjacent boundary points and the centroid. The region- based feature descriptor includes the feature points matching and the spatial distribution of feature points. In the feature matching strategy, a statistics-based method was proposed to compute the dissimilarity values between shape feature vectors of images. Large number of experiments are conducted based on the standard image set to evaluate the performance of our solution. The experimental results show that the proposed technique outperforms two existing solutions for the widely used performance metrics.

In [32], an algorithm is presented that extends the Color Edge Co-occurrence Histogram (CECH) object detection scheme on compound color objects, for the retrieval of logos and trademarks in unconstrained color image databases. More accurate information is introduced to the CECH, by virtue of incorporating color edge detection using vector order statistics. This produces a more accurate representation of edges in color images, as compared to the simple color pixel difference classification of edges seen with the CECH. The proposed method in [32] is thus reliant on edge gradient information, and so it is called the Color Edge Gradient Co-occurrence Histogram (CEGCH). This method performed better results than the others.

A conceptual model of trademark retrieval [33] is proposed based on conceptual similarity. The model employs natural language processing techniques, knowledge sources and a lexical ontology to compute conceptual similarity between textual trademarks. The proposed model improves on existing trademark search models by providing a means of refining the search to conceptually related trademarks.

A comprehensive literature review is presented in [34] to cover multiple classifier system (MCS) or classifier ensemble. In the past twenty years, MCS has developed rapidly and been widely used in various fields such as pattern recognition, image processing and target identification. Besides, MCS has become a hot topic in the attractive series international workshops, mainly because of its capability to improve accuracy and efficiency. Many researchers investigated the scheme of combining several classifiers to generate a single result. Both theoretical and empirical studies indicate that a good MCS is one where individual classifiers are accurate and at the same time disagree on some different parts of the input space. Two popular approaches for creating accurate ensemble are Bagging and Boosting. Bagging uses bootstrap sampling to generate accurate ensemble. Boosting is a general method of producing a very accurate prediction rule by combining rough and moderately inaccurate learner [34].

Multiple Classifier Systems [35] have emerged as a viable alternative to make pattern recognition systems achieve lower and lower error rates. This kind of system can be composed of either existing classifiers, aiming at enhancing their individual performances, or classifiers constructed by an automatic method. In both cases, nonetheless, it is well-known that the set of classifiers must contain members that are complementary and diverse, so that the combined classifiers outperform the best member of the set [35].

3. Feature Extraction

The feature is defined as a function of one or more measurements, each of which specifies some quantifiable property of an object, and is computed such that it quantifies some significant characteristics of the object. Feature extraction is the process of creating a representation for, or a transformation from the original data. Features such as shape, texture, color, etc. are used to describe the content of the image. Image features can be classified into primitives [37, 38, 39]. In the following subsections, we will give different feature extraction methods to be used in our experiments.

3.1 Moments Invariants

Moment invariants (MI) were firstly introduced to the pattern recognition community in 1962 by Hu, who employed the results of the theory of algebraic invariants and derived his seven famous invariants to rotation of 2-D objects. Since that time, numerous works have been devoted to various improvements and generalizations of Hu's invariants and also to its use in many application areas [37,38].

Computation of moment invariants is completely dependent on the algebraic relation with geometric or complex moments. Therefore, accurate computation of geometric and complex moments consequently led to accurate moment invariants.

Image or shape feature invariants remain unchanged if that image or shape undergoes any combination of the geometric changes: Change of position -Translation, change of size -Scaling and change of orientation - Rotation and finally Reflection. The moment invariants can be subdivided into skew and true moment invariants where the skew moment invariants are invariant under change of position, size and rotation (Rotation-Scaling-Translation) only. True moment invariants are invariant under all of the previous changes including reflection.

Central moments of (p+q)th order for binary images are written as

$$\mu_{pq} = \sum_x \sum_y \left(x - \bar{x}\right)^p \left(y - \bar{y}\right)^q \quad (1)$$

Normalized central moments, denoted by η_{pq} , are described as

$$\eta_{pq} = \frac{\mu_{pq}}{\mu_{00}^{\gamma}} \quad (2)$$

where $\gamma = \frac{(p+q)}{2} + 1$

for $p + q = 2,3,\ldots$

In this paper, the following seven Hu moment invariants expressed in terms of normalized central moments are given as,

$$v_1 = \eta_{20} + \eta_{02} \quad (3)$$

$$v_2 = (\eta_{20} - \eta_{02})^2 + 4\eta_{11}^2 \quad (4)$$

$$v_3 = (\eta_{30} - 3\eta_{12})^2 + (3\eta_{21} - \eta_{03})^2 \quad (5)$$

$$v_4 = (\eta_{30} + \eta_{12})^2 + (\eta_{21} + \eta_{03})^2 \quad (6)$$

$$v_5 = (\eta_{30} - 3\eta_{12})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} + \eta_{03})^2] + (3\eta_{21} - \eta_{03})(\eta_{21} + \eta_{03})[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2] \quad (7)$$

$$v_6 = (\eta_{20} - \eta_{02})[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2] + 4\eta_{11}(\eta_{30} + \eta_{12})(\eta_{21} + \eta_{03}) \quad (8)$$

$$v_7 = (3\eta_{21} - \eta_{30})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} + \eta_{03})^2] + (3\eta_{12} - \eta_{30})(\eta_{21} + \eta_{03})[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2] \quad (9)$$

3.2 Singular Value Decomposition Transform (SVD)

SVD [39] is a mathematical tool used to analyze matrices. In SVD, a square matrix is decomposed into three matrices of same size. For example, a real matrix *A* of size $N \times N$ can be decomposed into a product of 3 matrices $A = UDV^T$, where *U* and *V* are orthogonal matrices such that $U^TU = I$, $V^TV = I$ and $D = \text{diag}(\lambda 1, \lambda 2, \ldots)$. '*I*' is an identity matrix. The diagonal entries are called the singular values of *A*, the columns of *U* are called the left singular vectors of *A*, and the columns of *V* are called the right singular vectors of *A*. This decomposition is known as the Singular Value Decomposition (SVD) of *A*, and can be written as

$$SVD(A) = [U\ D\ V] \quad (10)$$

$$SVD(A) = \lambda_1 U_1 V_1^T + \lambda_2 U_2 V_2^T + \ldots + \lambda_r U_r V_r T \quad (11)$$

$$A' = UDV^T \quad (12)$$

U and *V* are the real $N \times N$ unitary matrices with small singular values. *D* is a diagonal matrix of $N \times N$ size with

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large singular values. Here, r is the rank of matrix A. A' is the reconstructed matrix after applying the inverse SVD transformation. The singular values (SV) satisfy the relation $\lambda_1 \geq \lambda_2 \geq \ldots \geq \lambda_r \geq 0$.

3.3 2D Discrete Cosine Transform

The DCT [40] transforms a signal from a spatial representation into a frequency representation. In an image, most of the energy will be concentrated in the lower frequencies, so if we transform an image into its frequency components and throw away the higher frequency coefficients, we can reduce the amount of data needed to describe the image without sacrificing too much image quality.

Given an image, S, in the spatial domain, the pixel at coordinates (x,y) is denoted Syx. To transform S into an image in the frequency domain, F, we can use the following:

$$C_u, C_v = \begin{cases} \frac{1}{\sqrt{2}} & \text{if } u = 0 \\ 1 & \text{else} \end{cases} \quad (13)$$

$$F_{vu} = \frac{1}{4} C_v C_u \sum_{y=0}^{N-1} \sum_{x=0}^{N-1} S_{yx} \cos\left(v\pi \frac{2y+1}{2N}\right) \cos\left(u\pi \frac{2x+1}{2N}\right) \quad (14)$$

4. Radial Basis Neural Networks

Artificial neural network methods offer a variety of desirable properties, such as tolerance to noisy or incomplete input, generalization from training data, and the ability to model almost any finite-dimensional vector function on a computer set, given a sufficient number of adaptable parameters (connection weights) [41].

In some existing neural nets based CBIR systems, the weights of neural nets are obtained through two phases: off-line training followed by on-line updating. These two steps correspond to the processes of pattern memory and neural similarity metric adaptation [42, 43].
Probabilistic neural networks can be used for classification problems. When an input is presented, the first layer computes distances from the input vector to the training input vectors, and produces a vector whose elements indicate how close the input is to a training input. The second layer sums these contributions for each class of inputs to produce as its net output a vector of probabilities. Finally, a compete transfer function on the output of the second layer picks the maximum of these probabilities, and produces a 1 for that class and a 0 for the other classes. The architecture for this system is shown in the following figure [44, 45].

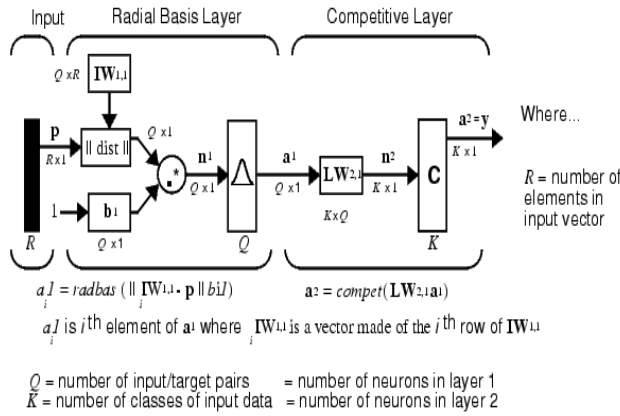


Figure 1. The probabilistic neural network Diagram

The probabilistic neural network is used in the proposed retrieval system.

5. The Proposed Trademark Retrieval System

The proposed system is described as in the following stages (figure 2):

Stage 1 - Acquisition and digitization: The trademark is captured using a scanner and digital camera. The digital image is saved in jpg format.

Stage 2 - Preprocessing: Preprocessing of trademark images prior to classification is essential. The RGB image is converted into grayscale image and then converted and resized into binary image with size of 60 by 60 pixels. The images are filtered and improved to be used in the following stages.

Stage 3 - Feature Extraction: This stage is extracting moment invariants; singular value decomposition transform and 2D discrete cosine transform features from the rectangular image obtained in stage 2.

Stage 4- Image retrieval Process: Three classifiers are constructed based on the three types of features extracted from stage 3. This stage has two parts: the training part and the retrieving part. In the training part, multiple PNN neural networks are trained using the training features vectors. The optimal weights are obtained to be used in the classification part. In this part, the image is classified using the trained PNN neural network. The final decision is made by integrating the three networks [34, 35, 36].

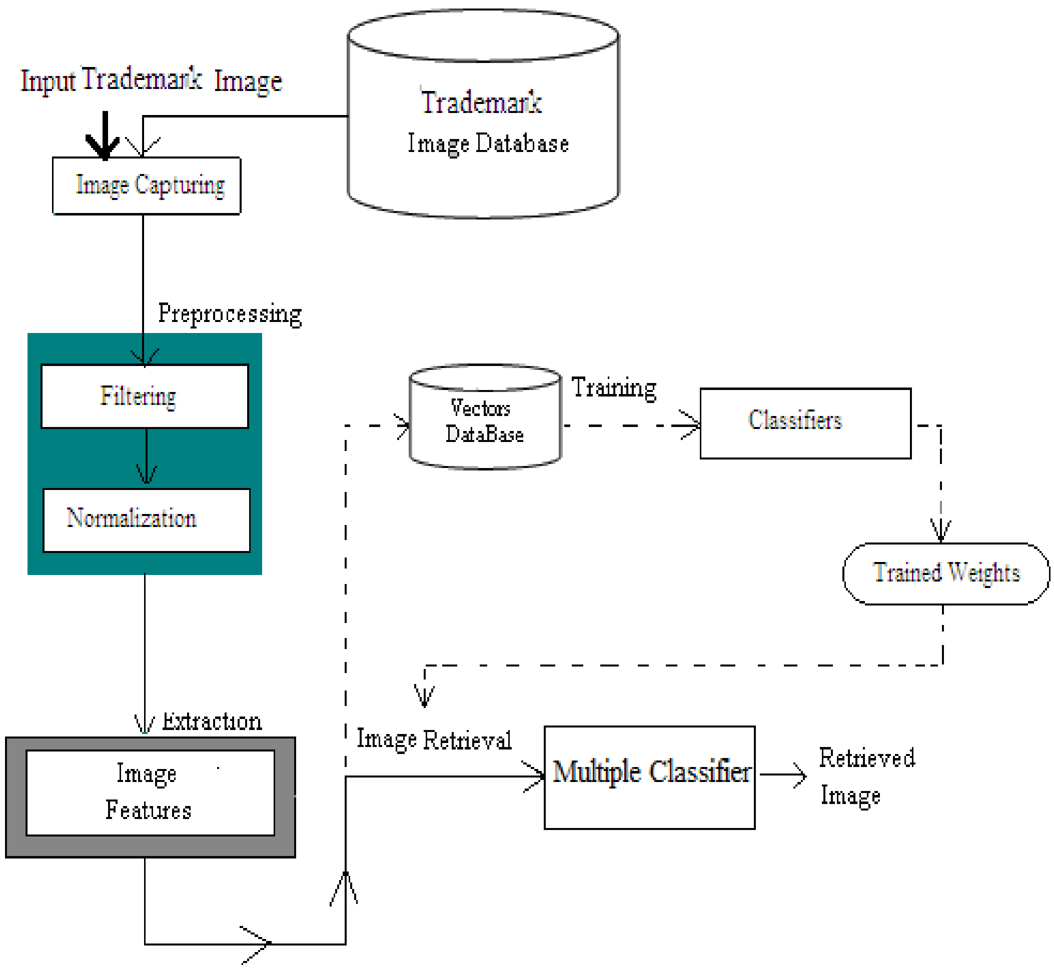


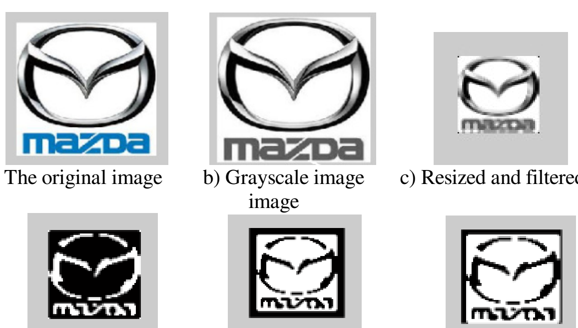
Figure 2. Block Diagram of the Proposed Trademark Retrieval System

6. Results and Discussion

The data set used here is collected from the internet. It consists of 200 images of trademarks. The images are resized into 60x60 pixels. Some examples are given in Fig. 3. The work is implemented using MATLAB R2010a. The proposed trademark retrieval system has been tested on a variety of different trademarks, with varying complexity in shape and color.

Figure 3. Samples of Trademarks images

The results of the preprocessing for Mazda trademark image are shown in figure 4(a-f).



a) The original image b) Grayscale image c) Resized and filtered image

d) Binary Image (0-1) e) Binary Image (1-0) f) 60x60 binary image

Figure 4. The Trademark preprocessing (a-f)

In the following experiments, the number of inputs (v1,v2,…,v7) extracted from the trademark image using Hu moment invariant feature extraction method is 7. The number of inputs extracted using SVD is 60. The number of inputs extracted using 2D discrete cosine transform is 60x60. The number of output classes was 30. The inputs are presented to the PNN classifier for testing to do matching with the feature values in the reference database. The final decision is made by integrating the three networks [34, 35, 36]. In the proposed system, a majority vote [34] is used to integrate multiple classifiers for the mapping of a specific class.

The experimental results showed that the classification rate of the proposed Trademark Retrieval System is higher than the other single systems using one type of features. The results are shown in figure 5.

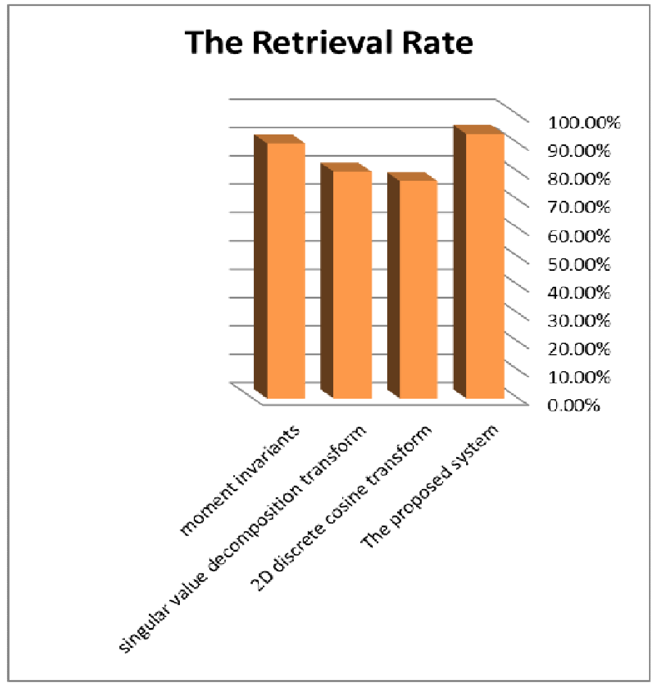


Figure 5. Results of the proposed multiple classifier system and the other single classifiers (Hu, SVD and DCT)

The logo and trademark retrieval algorithms in [32] have been tested on different logos and trademarks. The Color Co-occurrence Histogram (CCH), Color Edge Co-occurrence Histogram (CECH) and Edge Gradient Co-occurrence Histogram (CEGCH) systems [32] are tested on the Ferrari, Alfa Romeo, BMW and Lufthansa trademarks images. The experiments of image retrieval methods [27] using shape-based features, curvelet transform and shape and texture features has been performed on 1, 5, 10, 15 and 20 nearest images. A weighted average distance is used for similarity measure. Results illustrate that combining shape feature with curvelet based texture feature performs well in precision. The proposed method is compared with the previous mentioned methods as shown in table 1. The results in this table demonstrate that the proposed method is effective and accurate for the trademark image retrieval.

Table 1. Overall percentage performance of Existing Retrieval Systems and the Proposed Retrieval System

THE SYSTEM	Retrieval Rate
CCH	51.00%
CECH	66.25%
CEGCH	92.00%
Shape-based [27]	77.08%
Curvelet-based [27]	73.70%
Shape and Texture features-based [27]	83.30%
The Proposed Retrieval System	93.33%

6. Conclusion

The proposed system has been introduced and evaluated. Using PNN neural network, the proposed system gave the highest recognition rate in all the experiments, as compared with single classifiers based on moment invariants, singular value decomposition transform and 2D discrete cosine transform. The proposed system is also compared with other image retrieval systems in the literature.

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