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IRIS RECOGNITION BASED ON KERNELS OF SUPPORT VECTOR MACHINE

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Abstract

Ensuring security biometrically is essential in most of the authentication and identification scenario. Recognition based on iris patterns is a thrust area of research cause to provide reliable, simple and rapid identification system. Machine learning classification algorithm of support vector machine [SVM] is applied in this work for personal identification. The profuse as well as unique patterns of iris are acquired and stored in the form of matrix template which contains 4800 elements for each iris. The row vectors of 2400 elements are passed as inputs to SVM classifier. The SVM generates separate classes for each user and performs matching based on the template's unique spectral features of iris. The experimental results of this proposed work illustrate a better performance of 98.5% compared to the existing methods such as hamming distance, local binary pattern and various kernels of SVM. The popular CASIA (Chinese Academy of Sciences – Institute of Automation) iris database with fifty users' eye image samples are experimented to prove, that the least Square method of Quadratic kernel based SVM is comparatively better with minimal true rejection rate.

Keywords:

Iris Preprocessing, Iris Template, Quadratic Kernel, Support Vector Machine, Hamming, Local Binary Pattern

1. INTRODUCTION

Biometric recognition system is a widely preferred system to ensure robust security areas such as finance and immigration. Recognition system based on iris traits was researched and in practice for the past three decades. It is still experimented, in various dimensions, to support large volume of data rapidly and easily. The unique textures of iris possess all the biometric characteristics such as accuracy, collectability, tampering, longevity, universality, and uniqueness excellently, which ensure more security and not viable to covert by impostor [5]-[9].

The Fig.1(a) depicted the human eye image with iris parts. It is an internal part of the eye which exists between the pupil's low intensity part (dark black) and sclera's high intensity part (white) in front view. It is readily visible. It controls the amount of light that enters the eye through the pupil by using the dilator and sphincter muscles and supports to control the pupil size [5]. Its plenty of textures are unique from one user to another, among twins and even between the left and right eye of an individual. Some of the iris features are arching ligaments, crypts, furrows, ridges and zigzag collarettes [5]-[8]. Its uniqueness is developed from the third month of fetal to eighth month of gestation period. There are several colors of iris. Brown, blue and hazed colors are quite common. The pupil size varies from 10 to 80 percent of 12 mm iris average diameter [19]. The biometric architecture is depicted in the Fig.1(b) which describes the working process of recognition and authentication system. The first system captures the image and the second subsystem recognizes it, performs preprocessing and feature extraction. The feature values are stored in the database as biometric templates. The decision making was done in testing phase by classifying the given input with biometric templates in the database.

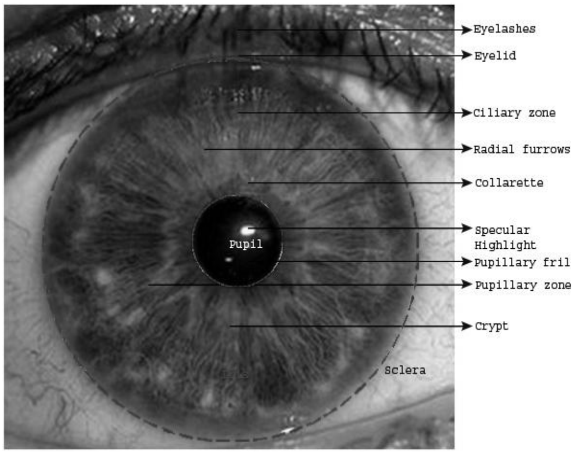


Fig.1(a). Human Eye Image

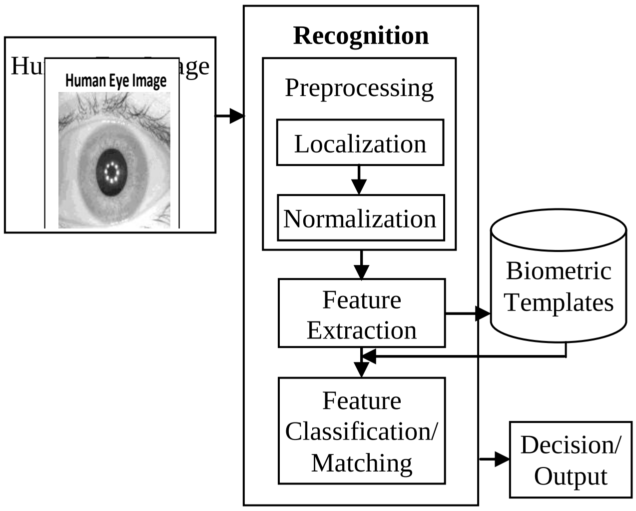


Fig.1(b). Biometric Iris Recognition System

Iris uniqueness was first noticed by Albert Bertillon in 1880 and later by many researchers and got patterned: (Daughman in 1994, Richard P. Wildes et.al. in 1998, Mit Matsushita in 1999). In 1992 support vector machine was originally proposed by Boser, Guyon and Vapnik. In late 1990s SVM was accepted and attained popularity. SVM based learning classifier that is used to classify the iris patterns more accurately than the above mentioned types of techniques [2]-[4], [17], [18].

Several difficulties in stages such as localization of iris regions, extracting required features, data storage format, storage space and techniques to classify or matching, performance and speed are faced in iris recognition system. This paper is concerned with reducing the false rejection rate, false acceptance rate and increasing the speed among large dataset using a simple method.

1.1 RELATED WORK

Researchers worked on this automatic recognition system using various approaches. These approaches can be broadly classified into four types:

- Phase based [5], [6], [12]-[14].
- Zero crossing representation [7], [10].
- Texture analysis based and [8].
- Intensity variation analysis [9].

Features in an image are classified into three types: (i) Geometric features such as edge, lineament, shape, size etc., (ii) Spectral features such as gradient, special color, spectral parameter etc., (iii) Textural features such as homogeneity, pattern, spatial frequency, etc.,[18]. John Daughman and Richard P. Wildes concentrate on entire automatic recognition system from image capturing to decision making [5]-[7]. Other researchers tried to improve the performance of iris recognition system on specific phases, such as noise removal [1], [20], dimensionality reduction [2], features based [3], classification phase [4], and so on. Many researchers combine these phases with slight variations to improve the performance. Classifiers such as Neural Network [11] and SVM play an important role since 1990. SVM prove to be fast and better than other methodologies [1]-[4], [16]-[19].

2. PROPOSED WORK

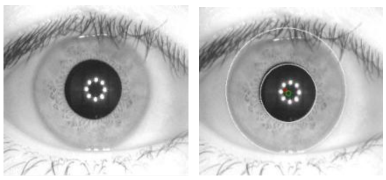
This work presents four experiments to support automatic iris recognition system. In general, iris preprocessing methods and template generations are common for all the four experiments. To enhance the speed and accuracy the feature dimensions are minimized by obtaining the required minimal traits from the inner boundary to middle region of iris [2]. In this work the distinctive iris traits of collarettes region, some degree of furrows and ridges are included in template generation phase. The classifying process in the first experiment by hamming distance algorithm based on binary value of the templates result in moderate performance. In the second experiment, local binary pattern algorithm based neighbour values result in relatively better performance than hamming distance. In the third experiment the neural network algorithm was applied which slightly had improved the performance compared to the previous experiments. Finally, supervised learning algorithm support vector machine was applied and resulted in a good performance. The generated template is passed to all the three methods of linear, polynomial and quadratic kernels of SVM. The three methods are SMO (Sequential Minimal Optimization), QP (Quadratic Polynomial) and LS (Least Square) respectively. The least square method of quadratic kernel function provides good performance with maximum true rejection and least false rejection rate at maximum speed for the given data set. The novelty of this work supports both authentication and recognition. The classification can be done on the basis of both identity and without identity that means classification process of both one to one or among gallery. The classification speed is enhanced due to the minimal and unique features that are passed to the SVM classifier.

2.1 PREPROCESSING

The preprocessing of eye image is essential for getting the required and accurate input for further processing.

Image capturing is the first step and the quality of input image helps to store the biometric distinctive feature extraction easier and faster. The input must not be in the state of close, off-angle, aniridia diseased and cataract surgery undergone eye images. Blurred images are neglected for further processing. Images can be obtained from the database or through scanners. The height and width of eye image is passed as x and y value. Grey scale image helps to find the boundaries of iris easily for localization. In this work CASIA database image of grey scale was experimented.

2.1.1 Iris Localization:



(a) (b)

Fig.2(a). Input Image, 2(b). Expected Image

Iris localization is the process of finding the iris' lower and upper boundary values. The input image in grey scale format is depicted in the Fig.2(a). The expected two concentric circles of iris boundaries are depicted in the Fig.2(b). To obtain the expected iris boundaries, the pupil outer boundary and sclera inner boundary are needed to compute based on the intensity value.

Pupil boundary algorithm was applied over the image to retrieve the pupil boundary by setting threshold value lowest intensity 0 (black) and for limbic boundary highest intensity value 255 (white).

The canny edge detection algorithm was applied to retrieve the edges and the inbuilt Gaussian filtering helps to retrieve the smooth and sharpened image edges.

The Hough transform algorithm finds the possible circle. The set of edge points are accurately captured with this transformation technique. It is well supported to find the possible circle even though with the presence of noise and gap between pixels. The Fig.2(c) and Fig.2(d) depicts the pupil boundary and limbic boundary.

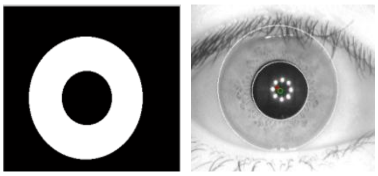
(c) (d)

Fig.2(c). Pupil Boundary, 2(d). Limbic boundary

Algorithm 1: Finding pupil boundary

Step 1: Start
Step 2: Get input (Eye_Image[][])
Step 3: Let T = x = y = 0
Step 4: do x← 0
Step 5: do y← 0
Step 6: If Eye_Image[x][y] <= T
a .true: Let Eye_Image[x][y] ← 0
b. false: Let Eye_Image[x][y] ← 255
Step 7: If Loop ends
Step 8: Let y ← y+1
Step 9: Execute Step 6 to Step 8 until y = width-1
Step 10: Let x ← x+1
Step 11: Execute Step 5 to Step 10 until x = height-1
Step 12: ResultEye_Image[][], Threshold_Image[][]
Step 13: End.

The Fig.2(e) depicts the iris boundaries as a result of differencing Fig.2(c) and Fig.2(d).



(e)

Fig.2(e). Iris boundaries (d - c)

In Matlab Imoverlay function was applied to get the expected iris boundaries. The algorithm 2 was used to retrieve the upper and lower boundaries of iris. Where, X_c denotes the pupil boundary coordinates and Y_c denotes the limbic boundary coordinates Result Iris_Image is the iris boundaries and its resultant diagram depicted in the Fig.2(e).

2.1.2 Iris Normalization:

Normalization is the process of transforming cartesian format of iris into polar format.

Masking was applied over the localized image of the eye to acquire the actual iris part. In this work eyelid, eyelashes and specular highlights are replaced with lowest intensity value 0 as noise. The occlusion of pupil helps to reduce the computational complexity. Daugman's rubber sheet model was applied to get the fixed dimensions of iris by transforming cartesian into polar format [14]. Keeping pupil centre as reference point the iris boundaries are fixed and remapped by each point within the iris region as a pair of polar coordinates (r, θ) where r is on the interval [0, 1] (rows) and θ is angle [0, 2π] (column). The outcome of Daugman's rubber sheet model was depicted in Fig.3.

Algorithm 2: Expected Iris boundaries

Step 1: Start
Step 2: Get input (Eye_Image[][], height, width, X_C, Y_C, pupil_r, limbic_r)
Step 3: Let r_2 = 0, pupil_r_2= pupil_r_2, limbic_r_2= limbic_r_2
Step 4: do x← 0
Step 5: do y← 0
Step 6: Let $r_2 \leftarrow (X-X_C)^2+(Y-Y_C)^2$
Step 7: If r_2<pupil_r_2 or r_2>limbic_r_2
True: let Eye_Image[x][y] ← 0
Step 8: If Loop ends
Step 9: Return Iris _Image
Step 10: Result Iris_Image
Step 11: End.

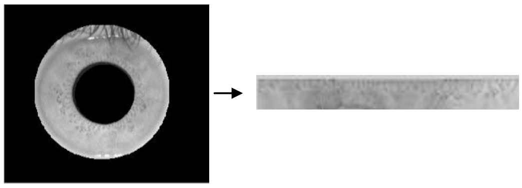


Fig.3. Normalized iris image

2.2 FEATURE EXTRACTION

In this work the unique features that are abundant in the iris template ranges from lower to middle were extracted. The iris image has the intensity ranges from 0 to 255. The iris template was generated in the form of matrix. The intensity values of unique patterns in the iris template are efficiently used for further classification. The template generated in matrix format, consists of 20 rows and 240 columns. The r radius of iris was limited to 20 rows and the θ value to 240 columns and it is depicted in Fig.4(a).

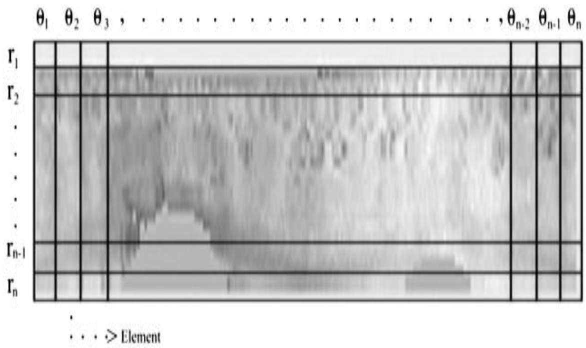


Fig.4(a). Iris Template

The template consists of adequate unique features of iris such as collarette, crypts, certain degree of furrows and ridges in 1 to 10 rows. The value of 2400 elements with less occlusion of eyelashes as noises in the template helps to reduce the storage space and to classify rapidly. The single row vector was generated to pass as inputs for further classification. Fig.4(b) depicts the single row vector of iris template.

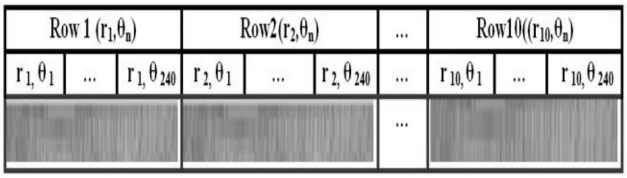


Fig.4(b). Single row vector

2.3 CLASSIFICATION OF IRIS

2.3.1 Hamming Distance:

This algorithm is the simplest method of finding the sum of difference between the given and the stored templates based on XOR operation. The normalized hamming distance was applied as mentioned in the Eq.(1).

$$HD = \frac{1}{N}\sum_{i=1}^{N} Xi(XOR)Yi \quad (1)$$

where, *Xi* and *Yi* are the coefficient of two iris images. *N* is the size of the feature vector.

2.3.2 Local Binary Pattern:

This is another familiar method to find the matching operation based on the histogram computed for each block of normalized iris [15].

2.3.3 Neural Network:

It is mainly classified into two types - supervised and unsupervised. The supervised learning process of feed forward neural network was applied for classifying the authorized and unauthorized user [11].

2.3.4 Support Vector Machine (SVM):

A supervised machine learning technique supports classification easily and accurately. In this paper multi-class SVM was applied based on the best features available in the reduced dimensions of template to upgrade the performance ratio. Multi-class SVM generated 40 classes separately for authorized users. Sample of multi-class SVM is depicted in Fig.5(a).

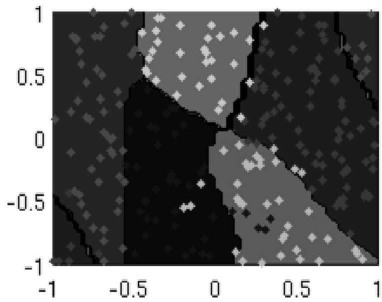


Fig.5(a). Multi Class SVM

The Fig.5(b) depicts the SVM classes generated for 40 authorized users with three templates for classification. Each template consists of unique spectral features of iris.

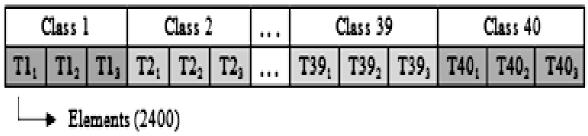


Fig.5(b). SVM Classes for authorized Users

Selecting a specific kernel and parameters are usually done in a try-and-see manner. SVM classifier's retrieved data from the template was generated in feature extraction stage. It draws the hyper plane to classify the given data.

Table.1. Kernels of SVM

SVM Kernel	k(x , y)
Linear	$x^T y + c$
Polynomial	$(\alpha x^T y + c)^d$
Quadratic	$\frac{1}{\sqrt{\lVert X - Y \rVert^2 + c^2}}$

Tuning kernels such as Linear, Quadratic and Polynomial and the three methods SMO, QP and LS were implemented to classify the authorized and unauthorized users accurately. The given input was verified by three kernels with three methods of nine possible combinations.

3. EXPERIMENTAL RESULTS

This proposed work was experimented with the CASIA (Chinese Academy of Science Institute of Automation) database [21]. It consisted of human eye images in proper illumination. The images were grey scaled and the maximum radius of iris 20mm. Database was trusted as reliable and extensively used by various researchers doing their research in iris. The images are in jpeg format that supports type conversion for further process [16].

3.1 TRAINING PHASE

During training phase 3 samples of eye images of all the 40 users were obtained from CASIA database. 120 templates were generated and stored by underwent localization, normalization, feature extraction using various algorithms as described in previous sections. The templates stored in database for those 40 users were considered as authenticated in the recognition subsystem. Each template consisted of 4800 elements in matrix format at the beginning and transformed to single row vector consisted of 2400 elements.

3.2 TESTING PHASE

The iris row vector consisting of plenty of distinctive traits was obtained from lower to middle region of iris matrix template. The remaining parts of iris from middle to upper region consisted of more noise values and due to the presence of upper and lower eyelids, eyelashes were not included for classification. The row vector template was passed to classification by a classifier. During testing phase 6 samples of the eye images of 50 users were taken for classification. The 6 × 50 samples of 300 images (including 40 × 6 (3 + 3) = 240 authorized user's template 10 × 6 = 60 unauthorized templates) were experimented and the reduction of size help to improve the performance rapidly. In this experiment 40 classes were generated for each authorized users by multi-class SVM. During testing phase the given input eye image preprocessed and then underwent further template generation phase. After template generation, instead of being stored as authenticated template, it was compared with the available 120 templates of 40 labeled classes. The input given from 40 authorized users with 6 samples (which includes trained 3 samples and additional new untrained 3 samples) were passed for classification by the SVM kernels. If it matched with stored templates then true acceptance rate would increase else false rejection rate would increase. Thus the performance results for authorized 40 users' true acceptance rate are depicted in Fig.6. The overall performance of SVM kernels with 300 eye images ((40 + 10) × 6) are shown in Fig.7.

The Table.2 depicts the time taken to classify the input for authorized and unauthorized users using quadratic kernel. The time taken is common for both SMO and LS, but the performance of least square become better. Least square method takes lesser time in both authorized and unauthorized compared to the other two methods.

These results indicate that the least square method using quadratic kernel results 98.5 percent of performance compared to the other methods. Therefore, the true positive or true accept rate is high and sounds good for authorized users. It is likely to have zero percent of false negative or false rejection for unauthorized users. Thus from the series of experiments SVM results better and ensures that imposter cannot tamper the data.

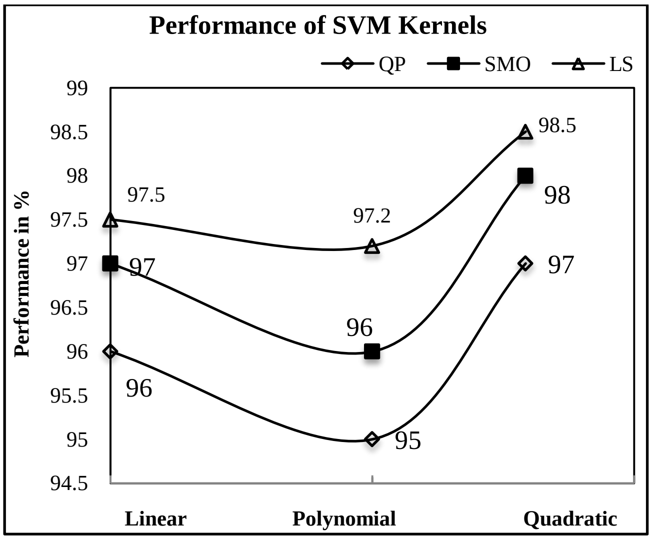


Fig.7. Performance of SVM Kernels

Table.2. Classification Time Taken for Each User's Sample in Quadratic Kernel of SVM

User	SMO Seconds	QP Seconds	LS Seconds
Authenticated (1 to 40)	0.0166	0.0187	0.0125
Non-authenticated (41to 50)	1.1000	1.2666	1.0833

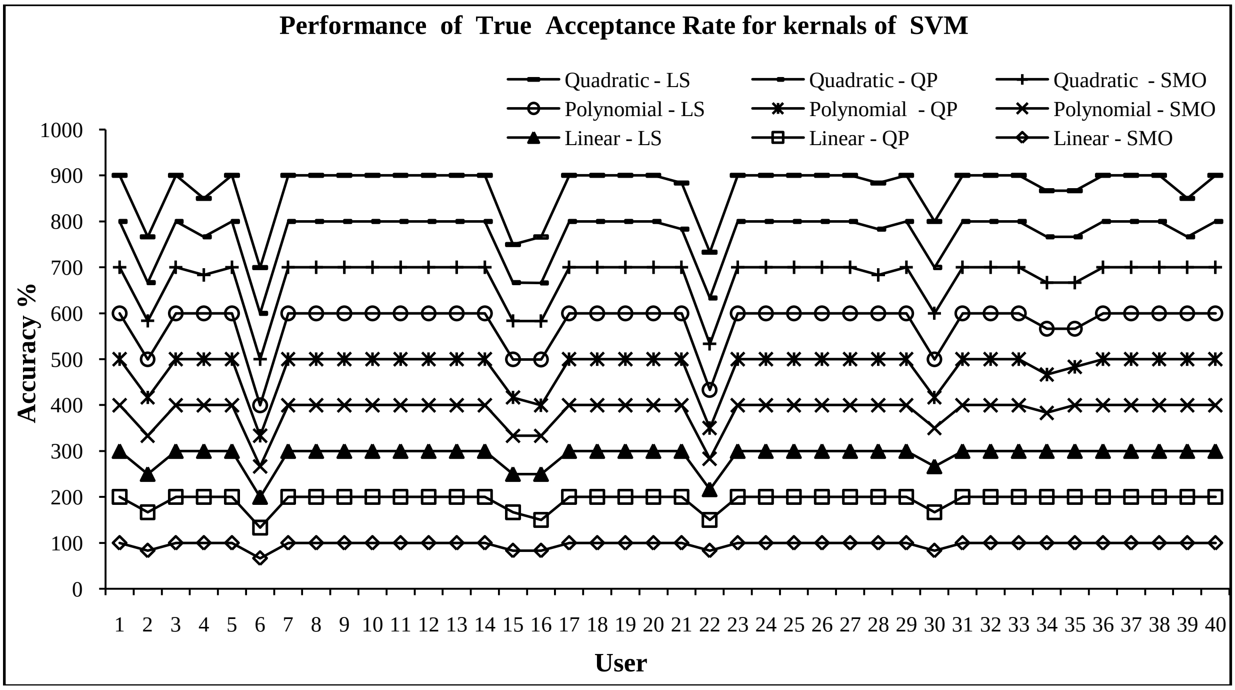


Fig.6. Performance of True Acceptance Rate with Quadratic SVM Methods

4. COMPARATIVE ANALYSIS

Comparative study of few existing and proposed work performance is depicted in Table.3. Comparison among various classifications based on overall performance was provided.

Table.3. Comparative analysis of existing and proposed method of iris recognition system

<table>
<tr><th colspan="6">Existing Method</th></tr>
<tr><th>S. No.</th><th colspan="3">Classification Techniques</th><th>Input (Iris)</th><th>Accuracy %</th></tr>
<tr><td>1.</td><td colspan="3">Weighted Hamming Distance with both weight map and mask</td><td rowspan="5">Iris Image (All possible features)</td><td>99.0</td></tr>
<tr><td>2.</td><td colspan="3">Neural Network</td><td>93.3</td></tr>
<tr><td>3.</td><td colspan="3">SVM and Hidden Markov Model</td><td>97.0</td></tr>
<tr><td>4.</td><td colspan="3">Non Symmetrical SVM</td><td>98.0</td></tr>
<tr><td>5.</td><td colspan="3">SVM</td><td>99.2</td></tr>
<tr><td rowspan="4">6.</td><td rowspan="4">SVM (Textural Features)</td><td colspan="2">Linear</td><td rowspan="4">Iris Image (Collarette)</td><td>98.7</td></tr>
<tr><td colspan="2">Polynomial</td><td>98.1</td></tr>
<tr><td colspan="2">RBF</td><td>99.3</td></tr>
<tr><td colspan="2">Sigmoid</td><td>98.2</td></tr>
<tr><th colspan="6">Proposed Method</th></tr>
<tr><td>1.</td><td colspan="3">Hamming Distance</td><td rowspan="12">Iris Image (Collarette, crypts, Furrows among lower to middle region)</td><td>76.8</td></tr>
<tr><td>2.</td><td colspan="3">Local Binary Pattern</td><td>83.3</td></tr>
<tr><td>3.</td><td colspan="3">Feed Forward Neural Network</td><td>87.0</td></tr>
<tr><td rowspan="9">4.</td><td rowspan="9">SVM (Spectral Features)</td><td rowspan="3">Linear</td><td>SMO</td><td>97.0</td></tr>
<tr><td>QP</td><td>96.0</td></tr>
<tr><td>LS</td><td>97.5</td></tr>
<tr><td rowspan="3">Polynomial</td><td>SMO</td><td>96.0</td></tr>
<tr><td>QP</td><td>95.0</td></tr>
<tr><td>LS</td><td>97.2</td></tr>
<tr><td rowspan="3">Quadratic</td><td>SMO</td><td>98.0</td></tr>
<tr><td>QP</td><td>97.0</td></tr>
<tr><td>LS</td><td>98.5</td></tr>
</table>

5. CONCLUSION

The proposed work supports for automatic recognition based on iris spectral features. This paper examined with four series of experiments using hamming distance, local binary pattern, neural network and SVM. In SVM the three kernels, linear, polynomial and quadratic with three methods SMO, QP and LS were applied and verified. 300 samples of eye images from CASIA database was applied for experimental study and the effectiveness of this proposed system was evaluated. The obtained results proved that least square method of quadratic kernel SVM results in a high performance of 98.5 percent of accuracy especially with zero percentage of false acceptance rates. Therefore this proposed work is suitable for both identification and verification.

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