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Face Recognition based on Logarithmic Fusion of SVD and KT

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Abstract*: The identification of a person based on biometric is accurate and robust compared to traditional methods of identifying a person using PIN, ID cards etc., In this paper Face Recognition based on Logarithmic Fusion of SVD and KT (FRLSK) is proposed. The Singular Value Decomposition (SVD) is applied on face images to derive Co-efficients. The Co-efficient Matrix of SVD are resized to 64x64 to form features. The test image SVD features are compared with SVD feature of database images using Euclidian distance, Equal Error Rate (EER) and Total Success Rate are computed (TSR). The Kekre Transform (KT) is applied on Resized (64x64) face images to form features. The test image KT Features are compared with KT features of Database images using Euclidian distance to compute EER and TSR. The EER and TSR values obtained by SVD techniques are fused with the value of EER and TSR obtained from KT using logarithmic transforms to get better value of EER and TSR. It is observed that the value of EER and TSR are better in the case of proposed algorithm compared to existing algorithm.

***Index Terms*: Biometrics, SVD, KT, Total Success Rate.**

I. INTRODUCTION

A variety of Face recognition applications such as access to buildings, computer systems, laptops, cellular phones and ATMs require sophisticated security systems for verification to confirm the identity of an individual. In the absence of robust verification schemes, these systems easily accessed by an impostor. The traditional methods of identifying persons are Passwords (knowledge-based security) and ID cards (token-based security). The disadvantages of traditional methods are, security can be easily ruptured when a password is disclosed and badge is stolen or lost. The biometrics is an alternative to the existing traditional methods to overcome the disadvantages. The biometrics are characteristics of human body parts and also behavior of a person and cannot be lost or stolen.

The Biometric are broadly classified into two groups viz., (i) *Physiological* traits based on parts of body such as Face, Finger, Palm, Iris, DNA etc., are constant throughout life time of a person and (ii) *Behavioral* traits based on the behavior of a person such as Gait, Signature, Keystroke, Voice etc., are not constant throughout life and varies depends on mood or circumstances. The Biometric System operates in two Modes such as (i) *Verification Mode*, it is process of one-to-one comparison to claim an identity of a person. The test image is compared with an image in the stored database. (ii) *Identification Mode*, it is process of one-to-many comparison of the test set with database to identify an unknown person.

The General Biometric System Consists of *Enrolment*, *Tests* and *Matching Sections*. In the *Enrolment Section* biometric data of persons are enrolled with several numbers of samples are loaded. The each sample is preprocessed by resizing, cropping, and color conversion. The features are extracted from preprocessed images using Spatial domain/Transform domain technique or by combing both which results in Hybrid domain technique. In the *Test Section* only one sample of each person is processed similarly to that of enrolment section to obtain features. In *Matching Section* the features of test image are compared with features of all samples of data base using distance formulas such as Euclidean Distance (ED), Hamming Distance, Housedarf, Chi Square etc., and comparators such Neural Network (NN), Support Vector Machine, Linear Discriminant Analysis, Random Forest etc., to Identify/Verify a person. As demand for security is increasing in the present day scenario, automated personal Identification and Verification based biometrics has been receiving extensive attention over the past decade. Biometric System which is extensively used in applications such as Banking, Airport checking for personal authentication, Home security applications, Electronic Voting Machine, Military force to authenticate refugee, Corporate office for employee authentication, Entry to high security zones like parliamentary houses, Defense Establishments, Legal Documentations like land and business etc.,

Contribution: In this Paper FRLSK algorithm is proposed to identify a person. The SVD is applied on face images to obtain features. The features of test image are compared with features of database images using ED and EER/TSR is computed. The KT is applied on database and test images to obtain features. The test features are compared with data base features using Euclidian distance to compute EER and TSR. The values of EER and TSR obtained from SVD and KT are fused using logarithmic transform to find better EER and TSR.

***Organization*:** This paper is organized into following sections. Section II is an overview of related work. The proposed model is described in Section III. Section IV discusses the matching methods; Section V gives algorithm for proposed system. Performance analysis of the system is presented in Section VI and Conclusions are contained in Section VII.

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II. RELATED WORK

S. Zeenathunisa et al., [1] proposed a biometric identification system for frontal static face image subjected in various dark illuminations. An automatic Face Recognition Biometric System has been developed using Local Binary Pattern and k – Nearest Neighbor classifier. Jinxia Ni and Zhongxi Sun [2] implemented Inverse Fisher discriminant analysis for face recognition.The intrinsic feature is characterized using Gabor wavelet transform and image discriminant features are extracted by selecting principal components and Inverse Fisher Discriminant vectors. Seyed Omid Shahdi and Abu-Bakar [3] proposed a method to recognize non-frontal faces with high performance by relying only on single full frontal gallery faces. Small regions of the face or patches and Fourier coefficients are computed and transform them into a single vector. The vectors are used to estimate the frontal face vector and then compare it with the actual frontal feature vector.

Ngoc-Son Vu and Alice Caliper [4] describes Patterns of Oriented Edge Magnitudes (POEM) the recent feature descriptor. The feature descriptor is desired to be discriminative, robust, and computationally inexpensive in both terms of time and storage requirement. The POEM parameters are optimized and then applied to the whitened principal-component-analysis to get a more compact, robust, and discriminative descriptor. For face recognition, the efficiency of algorithm is strong for both constrained and unconstrained data sets in addition with the low complexity. Shih-Ming Huang and Jar-Ferr Yang [5] implemented a face recognition framework using the Improved Principal Component Regression Classification algorithm, which overcome the problem of multi collinearity in linear regression. The first principal components are intentionally dropped to boost the robustness against illumination changes. Then, the linear regression classification is executed on the projected data and the identity is determined by the minimum reconstruction error. Suzaimah Reza Ebrahimpour et al., [6] proposed a face recognition method in which the first four different representation of face are generated using Gabor filters which vary in angle. Base classifier is assigned for each of them and also for original image. Finally EMV technique combines the Base-classifiers.

III. PROPOSED MODEL

The block diagram of Face Recognition based on Fusion of Singular Value Decomposition (SVD) and Kekre Transform (KT) is shown in Figure 1.

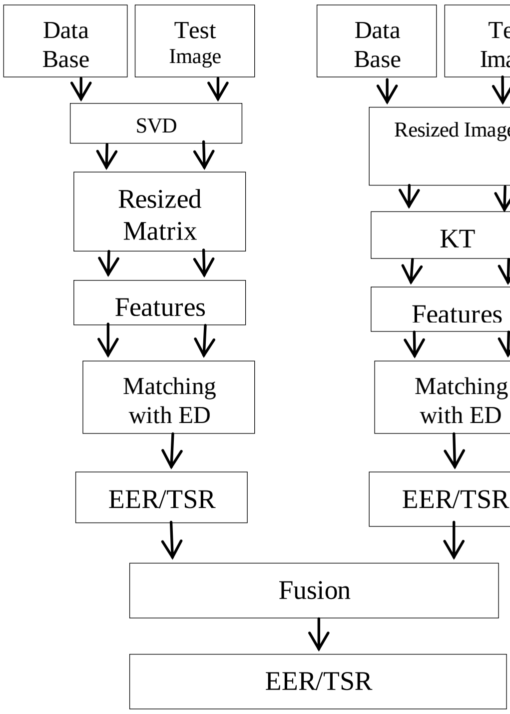

Figure 1: Block diagram of FRLSK model

A. Face database

(i) Olivetti Research Laboratory *(ORL)* [7] face database contains four hundred images of size 112 x 92 , it has forty persons with ten images for each person. The images are taken in different poses, expressions and scales with constant lighting conditions. Figure 2 shows the samples of ORL face images of a person with different pose.

Figure 2: Samples of ORL face images

(ii) *Yale* [8] face database includes variation of pose, expression, Illumination, scale and blurring, it has one hundred and sixty five images of size 320 x243 of fifteen persons with ten images for each person. Figure 3 shows the samples of Yale face images of a person with different poses.

Figure 3: Samples of Yale face database

(iii) Japanese Female Facial Expression *(JAFFE)* [9] ace database consists of seventy images of size 256 x 256 from ten persons with seven images for each person. The images were taken in seven different emotional facial expressions. Out of ten subjects present eight were considered for gallery. Figure 4 shows the samples of JAFFE face images of a person with different poses.

Figure 4: Samples of JAFFE database

(iv) *Combined* [10] face database consists of two thousand, two hundred and eighty images of size 280x320. It is from one hundred and twenty persons with nineteen images for each person. The images were taken in seven different emotional facial expressions. Figure 4 shows the samples of combined face images of a person with different poses.

Figure 5: Samples of Combined database

B. Preprocessing

The images in the database and test image are processed before extracting the features. It involves, Color to gray scale image conversion and the gray scale image with intensity values between 0 and 255 is obtained from color image to reduce processing time.

C. Feature Extraction

The features of each face image are extracted using SVD [11] and KT [12][13][14]. The features of SVD and KT are fused using logarithmic transformations to obtain better results compared to individual techniques.

(i) Singular Value Decomposition

The Feature Vectors are extracted using SVD, by considering image of size *m x n* matrix *I*. This image can be compressed and stored by *n x n* matrix *M* and elements are non-negative. The amount of storage is reduced from n^2 to *n*. The obtained matrix has Singular Value Decomposition given by Equation (1)

$$M=USV^{*} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where,

U is m x m real or complex unitary matrix,

$$U= I\,I^{*}$$

I^{*} is transpose of *I*

S is *m x n* diagonal matrix with non-negative real numbers on the diagonal, and

*V** is Conjugate transpose of *V*, *n x n* real or complex unitary matrix.

$$V=I^{*}I$$

Expanded version of *M* is given in Equation (2)

$$M=u_1s_1v_1^{*}+.\ .u_rs_rv_r^{*}+u_{r+1}s_{r+1}v_{r+1}^{*}.\ .+u_ns_n\,v_n^{*} \quad \ldots\ldots (2)$$

The nearest matrix of rank *r* is obtained by taking,

$$s_{r+1}\ \ldots.\ +\ s_n = 0\ ,r << n$$

The rank of *r* considered to be approximately sixteen percent of *n*, still the image is close to original image. The Equation (2) is reduced by considering rank *r* is given in Equation (3)

$$M=u_1\,s_1\,v_1^{*}+.\ .\ .\ .\ u_r\,s_r\,v_r^{*} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

From equation 3, dimension of matrix *M* is reduced from *n* to *r*.

For example if SVD is applied on ORL image of size 112 x 92 with r = 15 the image is compressed to 3075 pixels by keeping image size same instead of original 10304 pixel using Equation (4)

Number of Pixels = r x m + r x n + r ………………….... (4)

(ii) Kekre Transform:

The traditional transforms should have the matrix of size equal to the integer power of two, whereas Kekre's transform matrix can be of any size *NxN*, the diagonal and the upper elements of Kekre's transform matrix are unity, while the lower diagonal part except the elements just below diagonal is zero. Generalized *NxN* Kekre's transform matrix can be given in determinant.

The elements Kxy are generating using the relation given in Equation 5.

$$K_{xy} = \begin{cases} 1 & : x \le y \\ -N+(x+1) & : x = y+1 \\ 0 & : x > y+1 \end{cases} \qquad \ldots\ldots\ldots\ldots (5)$$

Where x, y are rows and columns

The image is resized to 64x64 and taken as *f*, the feature vector *F* is calculated by Equation 6

$$[F] = [K]\,[f]\,[K]^{*} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

[K]* is the transpose of KT

IV. MATCHING

A primitive type of matching is finding similarity between the database image and a test image. Euclidean Distance (ED) is one such matching technique which is used to verify whether the test image is present in database or not. If p_i and q_i are two points in a 2D plane,

Where i =1and 2

Then the Euclidean distance is given by the Equation 7

$$d(p,q)= \sqrt{(p_1-q_1)^2 + (p_2-q_2)^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

A. Matching with SVD

The feature vectors for the images are calculated using SVD. The database is created using different available face database such as ORL, YALE, JAFFE, COMBINED, The test image is one of the images of a person from database and the ED value is compared with the predefined threshold value to compute FRR and TSR. The values of FAR is computed for test image considered from out of database by calculating ED with the images present in database. EER is noted by taking equal values of FAR and FRR.

B. Matching with KT

The feature vectors for the images are computed using KT. The database is created using different available database such as ORL, YALE, JAFFE, COMBINED. The test image is one of the images of a person from database and the ED value is compared with the predefined

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thresh hold value to compute FRR and TSR. The value of FAR is computed for test image from out of database by calculating ED with the images present in database. EER is noted by taking equal values of FAR and FRR.

C. Fusion of SVD and KT Parameters

$$K_{NxN} = \begin{bmatrix} 1 & 1 & 1 & \cdots\cdots & 1 & 1 \\ -N+1 & 1 & 1 & \cdots\cdots & 1 & 1 \\ 0 & -N+2 & 1 & \cdots\cdots & 1 & 1 \\ . & . & . & \cdots\cdots & . & . \\ . & . & . & \cdots\cdots & . & . \\ . & . & . & & . & . \\ 0 & 0 & 0 & \cdots\cdots & 1 & 1 \\ 0 & 0 & 0 & \cdots\cdots & -N+(N-1) & 1 \\ . & & & & & \end{bmatrix}$$

The effectiveness of face recognition system is evaluated by FRR, FAR, EER and TSR. The values of FRR, FAR, EER and TSR are computed using SVD and KT. the EER and TSR values of SVD and KT are fused using Equation 8 and 9 respectively to obtain better performance compared to individual techniques.

$F_{EER} =$ abs ($1/\log_2$(SVD) -$1/\log_2$(KT)) ……………..…. (8)

$F_{TSR} =$ 1- abs ($1/\log_2$(SVD) -$1/\log_2$(KT)) ………….. (9)

V. ALGORITHM

Problem definition: The face recognition based on fusion of SVD and KT used to identify a person.

The objectives are

(i) To increase the recognition rate (TSR).

(ii) To decrease Equal Error Rate (EER).

Algorithm of proposed face recognition system is as given in Table 1.

VI. PERFORMANCE ANALYSIS

The variations of FRR, FAR and TSR with thresh hold for YALE face database using SVD are tabulated for PIDB with 4, 6, 8, 10 and PODB 10, 8, 6, 4 are given in Table 2, as the thresh hold increases the values of FAR and TSR increases whereas FRR decreases. The value of TSR is 75%, 66.66%, 62.5%, and 70% for a threshold of 0.21 for PIDB: PODB of 4:10, 6:8, 8:6 and 10:4 respectively.

The variations of FRR, FAR and TSR with thresh hold for YALE face database using KT are tabulated for PIDB with 4, 6, 8, 10 and PODB 10, 8, 6, 4 are given in Table 3, as the thresh hold increases the values of FAR and TSR increases whereas FRR decreases. The value of TSR is 75%, 66.66%, 75%, and 80% for a threshold of 0.6 for PIDB: PODB of 4:10, 6:8, 8:6 and 10:4 respectively.

Table 1: Algorithm of FRLSK.

INPUT: Database Face images, Test Face images

OUTPUT: Matched /Non-matched Test image

1. Color image is converted into gray scale image.
2. SVD is applied on images in database.
3. Coefficients obtained are resized to 64 x 64 and forms features.
4. Steps 2 and 3 are repeated for test image to derive SVD features.
5. Test set features are compared with database images using ED to Compute FRR, FAR, EER and TSR.
6. The original Face Image is resized to 64 x 64.
7. KT is applied on images in database.
8. KT Coefficients are considered as features.
9. Steps 6 to 8 are repeated for test face image to obtain KT features.
10. Test image features are compared with database images using Euclidean Distance (ED) to Compute FRR, FAR, EER and TSR.
11. Results of step 5 and step 10 are fused using Equations

    $F_{EER} =$ abs ($1/\log_{2(SVD)}$-$1/\log_{2(KT)}$) --------(1)

    $F_{TSR} =$ 1- abs ($1/\log_{2(SVD)}$-$1/\log_{2(KT)}$)------(2)

The variations of FRR, FAR and TSR with threshold for ORL face database using SVD are tabulated for Person In Data Base (PIDB) with 10, 20, 30, 35 and Person Out of Data Base (PODB) 30, 20, 10, 5 are given in Table 4. As the threshold increases the values of FAR and TSR increases whereas FRR decreases. The value of TSR is around 100% for a threshold of 0.13 for PIDB: PODB of 10:30, 20:20 and 30:10 whereas TSR reduced from 100% to 97% for PIDB: PODB 35:5.

The variations of FRR, FAR and TSR with threshold for ORL face database using KT are tabulated for PIDB with 10, 20, 30, 35 and PODB 30, 20, 10, 5 are given in Table 5. As the threshold increases the values of FAR and TSR increases whereas FRR decreases. The value of TSR is around 90% for a threshold of 0.31 for PIDB: PODB of 10:30 and 20:20 whereas TSR reduced from 90% to around 83% for PIDB: PODB 30:10 and 35:5.

The variations of FRR, FAR and TSR with thresh hold for JAFE face database using SVD are tabulated for PIDB with 4, 6, 8 and PODB 6, 4, 2 are given in Table 6, as the thresh hold increases the values of FAR and TSR increases whereas FRR decreases. The value of TSR is 100% for a threshold of 0.12 for PIDB and PODB of 4:6, 6:4 and 8:2.

The variations of FRR, FAR and TSR with thresh hold for JAFE face database using KT are tabulated for PIDB with 4, 6, 8 and PODB 6, 4, 2 are given in Table 7, as the thresh hold increases the values of FAR and TSR increases whereas FRR decreases. The value of TSR is 100% for a threshold of 0.31 for PIDB and PODB of 4:6, 6:4 and 8:2.

The variations of FRR, FAR and TSR with thresh hold for COMBINED face database using SVD are tabulated for PIDB with 20, 40, 60, 80, 100 and PODB 100, 80, 60, 40, 20 are given in Table 8, as the thresh hold increases the values of FAR and TSR increases, whereas FRR decreases. The value of TSR is 95%, 97.5%, 98.3%, 98.7% and 98% for a threshold of 0.17 for PIDB and PODB of

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20:100, 40:80, 60:60, 80:40 and 100:20 respectively.

The variations of FRR, FAR and TSR with thresh hold for COMBINED face database using KT are tabulated for PIDB with 20, 40, 60, 80, 100 and PODB 100, 80, 60, 40, 20 are given in Table 9, as the thresh hold increases the values of FAR and TSR increases, whereas FRR decreases. The value of TSR is 90%, 95%, 96.6%, 97.5% and 98% for a threshold of 0.55 for PIDB and PODB of 20:100, 40:80, 60:60, 80:40 and 100:20 respectively.

Table 2: FRR, FAR and TSR for SVD technique on YALE face data base.

Thresh Hold	PIDB:PODB											
	4:10			6:8			8:6			10:4		
	FRR	FAR	%TSR	FRR	FAR	%TSR	FRR	FAR	%TSR	FRR	FAR	%TSR
0	1.0	0	0	1.0	0	0	1.0	0	0	1.0	0	0
0.01	1.0	0	0	1.0	0	0	1.0	0	0	1.0	0	0
0.02	1.0	0	0	1.0	0	0	1.0	0	0	1.0	0	0
0.03	1.0	0	0	1.0	0	0	0.7500	0	25.00	1.0	0	0
0.05	0.5	0	50.00	1.0	0	0	0.6250	0	37.50	0.60	0	40.0
0.06	0.25	0	75.00	0.6667	0	33.33	0.6250	0	37.50	0.50	0	50.0
0.08	0.25	0	75.00	0.5000	0	50.00	0.6250	0	37.50	0.50	0	50.0
0.1	0.25	0	75.00	0.5000	0.1250	50.00	0.6250	0.166	37.50	0.50	0.25	50.0
0.11	0.25	0	75.00	0.5000	0.2500	50.00	0.6250	0.333	37.50	0.50	0.25	50.0
0.13	0.25	0.100	75.00	0.3333	0.2500	66.66	0.6250	0.500	37.50	0.40	0.25	50.0
0.14	0.25	0.200	75.00	0.3333	0.3750	66.66	0.5000	0.500	50.00	0.40	0.50	60.0
0.16	0.25	0.300	75.00	0.3333	0.5000	66.66	0.5000	0.500	50.00	0.40	0.50	60.0
0.18	0.25	0.400	75.00	0.3333	0.6250	66.66	0.5000	0.666	50.00	0.40	0.75	60.0
0.20	0.25	0.600	75.00	0.3333	0.6250	66.66	0.5000	0.833	50.00	0.30	1.0	60.0
0.21	0	0.900	75.00	0	1.0	66.66	0	1.0	62.50	0	1.0	70.0

Table 3: FRR, FAR and TSR for KT technique on YALE face data base.

Thresh Hold	PIDB:PODB											
	4:10			6:8			8:6			10:4		
	FRR	FAR	%TSR	FRR	FAR	%TSR	FRR	FAR	%TSR	FRR	FAR	%TSR
0	1.0	0	0	1.0	0	0	1.0	0	0	1.0	0	0
0.01	1.0	0	0	1.0	0	0	1.0	0	0	1.0	0	0
0.12	0.5	0	50.0	0.6667	0	33.3	0.75	0	25.00	0.70	0	30.0
0.14	0.25	0	75.0	0.5000	0	50.0	0.62	0	37.50	0.60	0	40.0
0.28	0.25	0.10	75.0	0.5000	0.1250	50.0	0.62	0.16	37.50	0.50	0	50.0
0.30	0.25	0.10	75.0	0.3333	0.2500	50.0	0.62	0.33	37.50	0.50	0.25	50.0
0.35	0.25	0.30	75.0	0.3333	0.2500	50.0	0.62	0.50	37.50	0.40	0.25	50.0
0.39	0	0.40	75.0	0.1667	0.3750	50.0	0.37	0.50	37.50	0.30	0.25	50.0
0.41	0	0.50	75.0	0.1667	0.3750	50.0	0.37	0.66	37.50	0.30	0.50	50.0
0.44	0	0.60	75.0	0.1667	0.5000	50.0	0.37	0.66	37.50	0.30	0.50	50.0
0.45	0	0.70	75.0	0	0.5000	66.6	0.12	0.66	62.50	0.10	0.50	70.0
0.46	0	0.70	75.0	0	0.6250	66.6	0	0.66	75.00	0.10	0.50	70.0
0.51	0	0.80	75.0	0	0.7500	66.6	0	0.83	75.00	0	0.50	80.0
0.58	0	0.80	75.0	0	0.7500	66.6	0	0.83	75.00	0	0.75	80.0
0.59	0	0.90	75.0	0	0.8750	66.6	0	0.83	75.00	0	0.75	80.0
0.60	0	0.90	75.0	0	1.0	66.6	0	1.0	75.00	0	1.0	80.0

Table 4: FRR, FAR and TSR for SVD technique on ORL face data base

Thresh Hold	PIDB:PODB											
	10:30			20:20			30:10			35:5		
	FRR	FAR	%TSR	FRR	FAR	%TSR	FRR	FAR	%TSR	FRR	FAR	%TSR
0	1	0	0	1	0	0	1	0	0	1	0	0
0.01	1	0	0	1	0	0	1	0	0	1	0	0
0.02	1	0	0	1	0	0	1	0	0	0.9714	0	2.857
0.03	1	0	0	1	0	0	1	0	0	0.6857	0	31.42
0.04	0.9	0	10.00	0.95	0	5.0	0.96	0	3.33	0.4571	0	54.28
0.05	0.5	0	50.00	0.65	0	35.0	0.63	0	36.66	0.2286	0	77.14
0.06	0.3	0	70.00	0.50	0	50.0	0.43	0	56.66	0.1429	0.4	85.71
0.07	0.2	0	80.00	0.20	0	80.0	0.20	0	80.0	0.0286	0.8	97.14
0.08	0.1	0.0333	90.00	0.150	0.05	85.0	0.13	0.20	86.66	0	1	97.14
0.09	0	0.2000	100.0	0	0.30	100.0	0	0.60	100.0	0	1	97.14
0.10	0	0.6000	100.0	0	0.75	100.0	0	0.90	100.0	0	1	97.14
0.11	0	0.8000	100.0	0	0.95	100.0	0	1.0	100.0	0	1	97.14
0.12	0	0.9333	100.0	0	0.95	100.0	0	1.0	100.0	0	1	97.14
0.13	0	0.9667	100.0	0	1.0	100.0	0	1.0	100.0	0	1	97.14

Table 5: FRR, FAR and TSR for KT technique oORL face data base.

Thresh Hold	PIDB:PODB											
	10:30			20:20			30:10			35:5		
	FRR	FAR	%TSR	FRR	FAR	%TSR	FRR	FAR	%TSR	FRR	FAR	%TSR
0	1	0	0	1	0	0	1.0	0	0	1.0	0	0
0.11	1	0	0	1	0	0	1.0	0	0	1.0	0	0
0.12	0.9	0	10.0	1	0	0	0.96	0	3.33	0.971	0	2.85
0.13	0.8	0	20.0	0.9	0	10.0	0.90	0	10.00	0.914	0	8.57
0.17	0.6	0	40.0	0.8	0	20.0	0.86	0	13.33	0.828	0	17.14
0.18	0.4	0	60.0	0.6	0	40.0	0.83	0	16.66	0.542	0	45.71
0.21	0.2	0	80.0	0.4	0	60.0	0.80	0	20.00	0.400	0	60
0.23	0.2	0.1000	80.0	0.2	0	80.0	0.63	0	36.66	0.314	0	68.57
0.24	0.2	0.1667	90.0	0.2	0.1000	80.0	0.46	0	53.33	0.200	0	77.14
0.25	0.1	0.3000	90.0	0.2	0.1667	90.0	0.40	0	60.00	0.200	0.4	77.14
0.26	0.1	0.5000	90.0	0.1	0.3000	90.0	0.33	0	66.66	0.110	0.4	80
0.27	0	0.5667	90.0	0.1	0.5000	90.0	0.26	0	73.33	0.085	0.6	80
0.28	0	0.6333	90.0	0	0.5667	90.0	0.16	0	80.00	0.028	1.0	80
0.29	0	0.7000	90.0	0	0.6333	90.0	0.16	0.20	80.00	0	1.0	82.5
0.30	0	0.8000	90.0	0	0.7000	90.0	0.1	0.30	83.33	0	1.0	82.5
0.31	0	0.9000	90.0	0	0.8000	90.0	0.06	0.40	83.33	0	1.0	82.5

Table 6: FRR, FAR and TSR for SVD technique on JAFEE face data base.

Thresh Hold	PIDB:PODB								
	4:6			6:4			8:2		
	FRR	FAR	%TSR	FRR	FAR	%TSR	FRR	FAR	%TSR
0	1.0	0	0	1.0	0	0	1.0	0	0
0.01	1.0	0	0	1.0	0	0	1.0	0	0
0.02	1.0	0	0	1.0	0	0	1.0	0	0
0.03	1.0	0	0	1.0	0	0	1.0	0	0
0.04	0.833	0	16.66	0.75	0	25.00	0.8750	0	12.50
0.05	0.666	0	33.33	0.50	0	50.00	0.6250	0	37.50
0.06	0.500	0	50.00	0.25	0	75.00	0.3750	0	62.50
0.07	0.166	0	83.33	0	0	100.0	0.1250	0	87.50
0.08	0	0	100.0	0	0	100.0	0	0	100.0
0.09	0	0.25	100.0	0	0.333	100.0	0	0.50	100.0
0.10	0	0.50	100.0	0	0.666	100.0	0	0.50	100.0
0.11	0	0.50	100.0	0	0.666	100.0	0	0.50	100.0
0.12	0	1.0	100.0	0	1.0	100.0	0	1.0	100.0

Table 7: FRR, FAR and TSR for KT technique on JAFEE face data base.

Thresh Hold	PIDB:PODB								
	4:6			6:4			8:2		
	FRR	FAR	%TSR	FRR	FAR	%TSR	FRR	FAR	%TSR
0	1.00	0	0	1.0	0	0	1.0	0	0
0.07	1.00	0	0	1.0	0	0	1.0	0	0
0.08	0.75	0	25.00	0.875	0	12.50	0.833	0	16.66
0.11	0.75	0	25.00	0.875	0	12.50	0.833	0	16.66
0.12	0.50	0	50.00	0.750	0	25.00	0.667	0	33.33
0.14	0.25	0	75.00	0.625	0	37.50	0.500	0	50.00
0.18	0.25	0	75.00	0.500	0	50.00	0.333	0	66.66
0.19	0	0	100.0	0.375	0	62.50	0.333	0	66.66
0.20	0	0.333	100.0	0.250	0	75.00	0	0	100.0
0.24	0	0.500	100.0	0	0	100.0	0	0.25	100.0
0.27	0	0.666	100.0	0	0.50	100.0	0	0.50	100.0
0.29	0	0.833	100.0	0	0.50	100.0	0	0.75	100.0
0.31	0	1.0	100.0	0	1.0	100.0	0	1.0	100.0

Table 8: FRR, FAR and %TSR for SVD technique on COMBINED face data base.

Thresh Hold	PIDB:PODB														
	20:100			40:80			60:60			80:40			100:20		
	FRR	FAR	TSR	FRR	FAR	TSR	FRR	FAR	TSR	FRR	FAR	TSR	FRR	FAR	TSR
0	1.00	0	0	1	0	0	1.0	0	0	1.0	0	0	1.0	0	0
0.01	1.00	0	0	0.975	0	2.50	0.983	0	1.66	0.987	0	1.25	0.98	0	2.0
0.02	0.80	0	20.00	0.750	0	25.0	0.750	0	25.0	0.750	0	25.0	0.75	0	25.0
0.03	0.45	0	55.00	0.400	0	60.0	0.400	0	60.0	0.450	0	55.0	0.45	0	55.0
0.04	0.20	0	80.00	0.200	0	80.0	0.250	0	75.0	0.325	0	67.5	0.30	0	70.0
0.05	0.15	0	85.00	0.150	0	85.0	0.166	0	83.3	0.212	0	78.7	0.19	0	81.0
0.06	0.15	0	85.00	0.150	0	87.5	0.166	0	83.3	0.212	0	78.7	0.19	0	81.0
0.07	0.15	0.01	85.00	0.125	0.012	92.5	0.116	0	88.3	0.125	0	87.5	0.12	0	88.0
0.08	0.10	0.03	90.00	0.075	0.050	95.0	0.083	0.016	91.6	0.075	0.02	92.5	0.07	0	93.0
0.09	0.10	0.10	90.00	0.050	0.125	95.0	0.050	0.066	95.0	0.050	0.10	95.0	0.05	0.10	95.0
0.12	0.05	0.51	90.00	0.025	0.712	97.5	0.016	0.566	96.6	0.012	0.62	97.5	0.02	0.65	97.0
0.13	0	0.72	95.00	0	0.887	97.5	0.016	0.750	96.6	0.012	0.82	97.5	0.01	0.75	98.0
0.14	0	0.88	95.00	0	0.962	97.5	0	0.916	98.3	0	0.97	98.7	0	0.95	98.0
0.15	0	0.96	95.00	0	0.975	97.5	0	0.966	98.3	0	1.0	98.7	0	1.0	98.0
0.16	0	0.98	95.00	0	0.987	97.5	0	1.0	98.3	0	1.0	98.7	0	1.0	98.0
0.17	0	1.0	95.00	0	1.0	97.5	0	1.0	98.3	0	1.0	98.7	0	1.0	98.0

Table 9: FRR, FAR and %TSR for SVD technique on COMBINED face data base.

Thresh Hold	PIDB:PODB														
	20:100			40:80			60:60			80:40			100:20		
	FRR	FAR	TSR	FRR	FAR	TSR	FRR	FAR	TSR	FRR	FAR	TSR	FRR	FAR	TSR
0	1.00	0	0	1.0	0	0	1.0	0	0	1.0	0	0	1.0	0	0
0.01	0.90	0	10.0	0.975	0	2.50	1.0	0	0	1.0	0	0	0.98	0	2.0
0.02	0.85	0	15.00	0.925	0	7.50	0.983	0	1.66	0.987	0	1.25	0.75	0	25.0
0.04	0.65	0	35.00	0.800	0	20.0	0.800	0	20.0	0.837	0	16.2	0.45	0	55.0
0.05	0.40	0	60.00	0.750	0	25.0	0.616	0	38.3	0.637	0	36.2	0.30	0	70.0
0.06	0.30	0	70.00	0.625	0	37.5	0.333	0	66.6	0.400	0	60.0	0.19	0	81.0
0.07	0.20	0	80.00	0.450	0	55.0	0.283	0	71.6	0.300	0	70.0	0.12	0	88.0
0.10	0.10	0.01	90.00	0.250	0	75.0	0.150	0	85.0	0.075	0.075	92.5	0.05	0.10	95.0
0.14	0.10	0.04	90.00	0.225	0	77.5	0.133	0	86.6	0.037	0.225	95.0	0.03	0.25	97.0
0.20	0.10	0.08	90.00	0.175	0	82.5	0.083	0.0333	91.6	0.025	0.250	96.2	0.03	0.30	97.0
0.23	0.05	0.49	90.00	0.100	0.0375	90.0	0.033	0.2667	95.0	0.012	0.900	97.5	0	0.95	98.0
0.28	0	0.93	90.00	0.075	0.0625	92.5	0.016	0.4830	96.6	0	0.950	97.5	0	1.0	98.0
0.30	0	0.97	90.00	0.050	0.1250	92.5	0.016	0.8500	96.6	0	0.975	97.5	0	1.0	98.0
0.38	0	0.99	90.00	0.025	0.2500	95.0	0	0.9500	96.6	0	1.0	97.5	0	1.0	98.0
0.40	0	1.0	90.00	0	0.7125	95.0	0	0.9833	96.6	0	1.0	97.5	0	1.0	98.0
0.51	0	1.0	90.00	0	0.9250	95.0	0	1.0	96.6	0	1.0	97.5	0	1.0	98.0
0.55	0	1.0	90.00	0	1.0	95.0	0	1.0	96.6	0	1.0	97.5	0	1.0	98.0

The values of EER and TSR for different combination of persons in the data base for ORL face data base are tabulated in Table 10. The value of EER increases and the value of TSR decrease as number of persons in database increases for both SVD and KT techniques. The values of EER decreases and TSR increases as number of person decreases in the out of database for both SVD and KT. It is observed that the values of EER and TSR are better in the case of proposed fused (FRLSK) algorithm compare to individual SVD and KT algorithms.

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Table 10: Comparison of EER and TSR for different PIDB: PODB of ORL.

PIDB: PODB	EER			% TSR		
	SVD	KT	FRLSK	SVD	KT	FRLSK
10:30	0.07	0.13	0.0791	90	80	99.59
20:20	0.1	0.2	0.1296	85	80	99.78
30:10	0.14	0.17	0.0386	86.66	80	99.72
35:05	0.18	0.2	0.0265	77.14	77.14	100

The values of EER and TSR for different combination of persons in the data base for YALE face data base are tabulated in Table 11. The value of EER increases and the value of TSR decrease as number of persons in database increases for both SVD and KT techniques. The values of EER decreases and TSR increases as number of person decreases in the out of database for both SVD and KT. It is observed that the values of EER and TSR are better in the case of proposed fused (FRLSK) algorithm compare to individual SVD and KT algorithms.

Table 11: Comparison of EER and TSR for different PIDB: PODB of YALE.

PIDB: PODB	EER			% TSR		
	SVD	KT	FRLSK	SVD	KT	FRLSK
4:10	0.25	0.25	0	75.0	75.0	100
6:8	0.33	0.26	0.1107	66.66	50.0	98.79
8:6	0.50	0.50	0	50.0	37.5	98.59
10:4	0.40	0.30	0.1808	60.0	50.0	99.21

The values of EER and TSR for different combination of persons in the data base for JAFFE face data base are tabulated in Table 12. The value of EER zero and TSR is 100% as number of persons in database increases and number of person decreases in the out of database for both SVD and KT techniques. It is observed that the values of EER and TSR are same in the case of proposed fused (FRLSK) algorithm compare to individual SVD and KT algorithms.

Table 12: Comparison of EER and TSR for different PIDB: PODB of JAFFE.

PIDB: PODB	EER			% TSR		
	SVD	KT	FRLSK	SVD	KT	FRLSK
4:6	0	0	0	100	100	100
6:4	0	0	0	100	100	100
8:2	0	0	0	100	100	100

The values of EER and TSR for different combination of persons in the data base for COMBINED face data base are tabulated in Table 13. The value of EER increases and the value of TSR decrease as number of persons in database increases for both SVD and KT techniques. The values of EER decreases and TSR increases as number of person decreases in the out of database for both SVD and KT. It is observed that the values of EER and TSR are better in the case of proposed fused (FRLSK) algorithm compare to individual SVD and KT algorithms.

Table 13: Comparison of EER and TSR for different PIDB: PODB of COMBINED.

PIDB: PODB	EER			% TSR		
	SVD	KT	FRLSK	SVD	KT	FRLSK
20:100	0.1	0.1	0	90.0	90.0	100
40:80	0.05	0.08	0.0431	95.0	92.5	99.91
60:60	0.05	0.06	0.0150	95.0	93.3	99.94
80:40	0.06	0.08	0.0281	92.5	92.5	100
100:20	0.05	0.08	0.0431	93.0	92.0	99.96

The values of Percentage Recognition Rate for existing Enhanced SVD Based Face Recognition (SVDFR) [15] and proposed (FRLSK) are compared in Table 14. It is observed that the Percentage Recognition Rate is better in the case of proposed algorithm compared to existing algorithm for ORL and YALE face data bases.

Table 14: Recognition Rate Comparison between Existing and Proposed.

Method	Recognition Rate	
	ORL	YALE
SVDFR [15]	72	90.3
FRLSK	100	99.21

VII. CONCLUSION

The face recognition is a Physiological biometric trait to identify a person efficiently without a Cooperation of a Person. In this paper FRLSK algorithm is proposed. The SVD Coefficients are generated from face images and resized to Coefficient Matrix of 64X64 dimensions to form features. The EER and TSR are computed by comparing a SVD feature of test image with database image features using ED. The KT Co-efficient are obtained from test and database resized images to form features. The EER and TSR values are computed from test and database features using ED. The EER and TSR values derived from SVD and KT are fused based on logarithmic transformation to obtain better EER and TSR. It is observed that performance parameter values of EER, TSR are better in the case of proposed algorithm compared with existing algorithms. In future the algorithm can be tested by fusing features at feature level.

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