Increasing accuracy and reducing time of face recognition with Euclid norm

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Abstract**—**Biometric parameters are used largely than smart cards, passwords or others in authentication processes. They differ from other methods with stability and indispensable features. In practice, fingerprints, face, iris, and gate based biometric authentication methods are used. Researchers compare biometric parameters by reliability to forgery, no changing, no repeating and convenient to use. Authentication based on face is very popular and suitable to parameters. The major advantage is the only physiological biometric that can be reliable mark at distance and, so, the verification of the users can happen without their accurate interaction with the sensor or their knowledge. Face recognition solutions are used for controlling attendance in airports, stadiums, railway stations, education and other organizations. The main problems of face recognition algorithms are recognition time and accuracy. We will solve this problem by changing Frobenius norm to Euclid norm in proposed method. Ways of optimization and several recommendations for collection face database are proposed.

Keywords*-Positive, negative, sparse coding, Laplace graph, UniverDB, PCA, LRC, SVM, SRC, LBP, YaleB, AR.*

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I. INTRODUCTION

Face recognition systems have emerged as a necessary solution to address many modern needs for identification and the verification of identity claims. These technologies work with visual surveillance systems and can use other security parameters, such as passwords, one time keys.

Nowadays NEC, Cognitec, Verilock and other organizations develop their face recognition solutions and employ in airports, stadiums, railway stations and traffic control. Nevertheless, there are very many problems in this area. Face recognition technologies recognize humans based on real time by camera, video or image. These all contents select image and compare to the face database. Real time video surveillance systems are used more then, others.

Face recognition base on real time video select one or three frames from per second and compare fallowing parameters: varying pose, illumination, expression, resolution, motion blur and walking (w) [1]. Two types of faces are used: 2D and 3D, but several researchers use 2,5D images.

2D Based Method. Many researchers investigated the large positions face recognition problem in recent years, and the popular 2D image based method achieved significant improvement. But all face must be only frontal position.This is main problem of the 2D images. Face recognition technologies detect and recognize faces by spectrum analyse, colour (pixel) based, key (edge) points, continuity based and matching face database. Zhu, Luo, Wang and Tang learned face identity preserving features by using a deep neural network to transform a non-frontal face to frontal [2]. In this case 3D methods solve with different view image positions.

3D Based Method. 3D face bases is generated from 2D face images. For this,researchers take photo and save pose variation up to ±45 in yaw and ±30 in pitch angles [3]. This is the one way and calls passive 3D images. Other method using and creating 3D images is active 3D sensing technique that possible to capture 3D face models without considering the 2D templates. There are two types of active 3D technologies; one is using 3D cameras like Microsoft Kinect, acceptable and fast, but it has low resolution, low precision, and low reliability[4]. Second type of 3D scanners look like Minolta, performance high quality 3D image but usually slow and expensive [5].

II. RECOMMENDATIONS FOR COLLECTION FACE DATABASE

2D and 3D face recognition methods detect and recognize human by saved image on the face database, this images are saved in the base before entering to the system. This process is called registration.

Detection and recognizing processes will be effectively when images were captured on the very high quality, based on the face registration requirements and consideration picture size.

Researchers have to make attention following requirements at the time developing and implementing the face recognition system:

- Quality camera and images;
- Lighting;
- Face position;
- Face marks, key points;
- Detection and recognize time;
- Glasses and cosmetics.

Popular companies MegaMatcher and VeriLook use following requirements:

- ±45° from right to left for frontal face;
- ±15° from top to down for frontal face;
- Saving every face image into face database by the capturing two requirement base.

For the generation face database is used two types of images:

- Positive images: it means that the image has face (figure 1).

Figure 1. Positive image

- Negative images: it means that the image does not have face (figure 2).

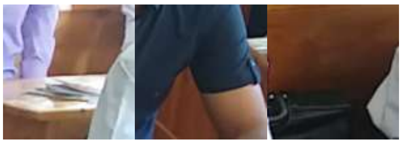

Figure 2. Negative image

III. MAIN CONCEPTS

A. Face detection model

This system was tested at the auditorium of Tashkent university of information technologies, there for we used students' images. In figure 3 is given several images in different sizes form UniverDBface database:

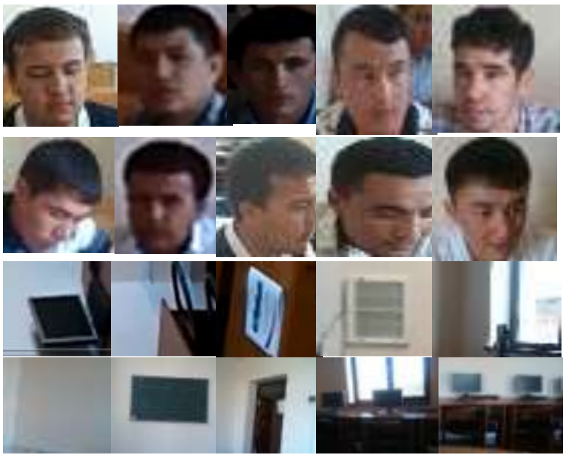

Figure 3.Simple images from base

There are several positive and negative images in the base. System separates face images from base and generate face database. System generates face model for every human and face recognition system. For this is collected all face images and created face model for everyone. In figure 4 is given face images for one user in same size from UniverDBdatabase.

Figure 4. Examples from UniverDB face database for one user

B. Separating

System separates face images from video frame by the method HOG and Haar. Martin and otherssaid that [6] as mentioned previously SIFT has emerged as one of the most used detection/description schemes for its ability to handle image transformations like scale changes (zoom), image rotation, and illumination. The major steps of the SIFT algorithm are:

- Scale based extrema detection.
- Orientation assignment.
- Keypoint descriptor.

C. Detection

Face detection system comparesgenerated model with separated model and if they compliant than here is called detected face image. Viola Jones and SVM methods are used in face detection systems. In figure 5 is shown detection process.

Figure 5. Students' face detection at the auditorium

D. Face recognition

System compares detected image with saved image in the face database, if comparing is successfully than this human is registered or legal user. In face recognition are used PCA, LDA, LPP, GW, DCT, ICA and other algorithms [7].

IV. MATHEMATICAL MODEL OF THE PROPOSED METHOD

Proposed algorithm is developed based on a sparse coding [8] and Laplace graph [9]. These algorithms were developed a long time ago but they are used widely.

Terminologies:

$X_{tr} \in R^{(d,n)}$ – base for training model. Where, d – number of properties, number of templates.

$X_{te} \in R^{(d,n)}$ – base for testing model.

$X_{tr} = [X_1, \dots, X_C]$ - number of groups.

D – dictionary of templates, so, D = X, every row of the dictionary is called atom.

Z – presenting templates by dictionary base, it means which atom is similar to given template and consists of combination of atoms.

A. Sparse coding

Sparse coding has been successfully used in face recognition. It based on every templates generated by combination of templates in the base. For face recognition systems, every face template is generated by other face combinations in the base. Because any human faces are like to others. Mathematical model of this idea is given in (1):

$$min_Z \; L(Z) + R(Z) \qquad (1)$$

Where, $L(Z)$ – rate of similarity isone face template to others. It means that if this function value is very small, then property is successfully.

$R(Z)$ – regular function. This function manages sparse rate given template with templates in the base. For example, if there are one hundred templates in the base, regular function uses only eighty templates. So, this function chooses necessary templates and does not make attention to others. We can express mathematical model of this function in (2):

$$min_Z||X - DZ||_F^2 + \lambda||Z||_1 \quad (2)$$

Here, $L(Z) = ||X - DZ||_F^2$ and $R(Z) = \lambda||Z||_1$.Where, λ - parameter of manage. It means sparse of templates. F - Frobenius norm, $||.||_1$– first norm. Actually, sparse coding term has been origin by this first norm. This mathematic model has been developed after PCA algorithm, so, this is the important model for face recognition. By history, PCA has been generated in 1991y. and this model in 2009y. After then researchers develop this model with experiments. For improving reliability are used different norms.

The main deficiency of this model is spending more time for optimisation mathematical model. There for employing this method on the real time systems don't give effectively result. For elimination this deficiency we changed the model in (3):

$$min_Z||X - DZ||_F^2 + \lambda||Z||_2^2 \quad (3)$$

Here, $||.||_2^2$– second norm, so called Euclid norm [10]. This norm is efficiency then fist norm, so faster 1000 times. In our proposed method is used second norm.

B. Laplace graph

Laplace graph is used when you work with face templates. The best side of this graph is that it takes large value to similar template, else, it does not give value or gives minus value (for example: -500). This graph helps to recognise faces with combining similar faces and improves discrimination [11].

In figure 6 is shown grouping processes with Laplace graph, red and blue colour points are for two or more humans.

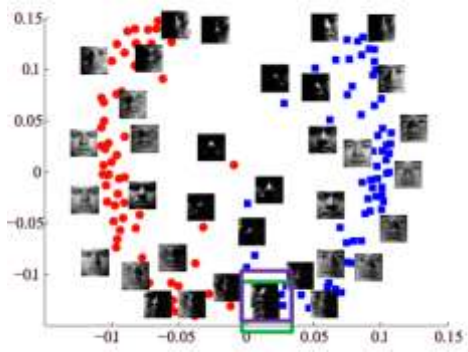

Figure 6.Selection properties with Laplace graph

Mathematical model of this idea is given in (4):

$$R(Z) = \sum_{i,j}^{m,n} W_{i,j}\left||z_i - z_j|\right|_2^2 \quad (4)$$

Where, w – similarity matrix. After several mathematical replacements, our expression is (5):

$$R(Z) = \sum_{i,j}^{m,n} W_{i,j}\left||z_i - z_j|\right|_2^2 = Tr(ZLZ^T) \quad (5)$$

Where, $L = D - W$ Laplace graph, D – level matrix. Level matrix computes by $D_{ii} = \sum_{i,j}^{m,n} W_{ij}$.

Mathematical expression proposed $(R(Z)_{prp})$ method: if $L = USU^T$, then our expression will be in (6),

$$R(Z)_{prp} = Tr(ZLZ^T) = Tr(ZUSU^TZ^T) = Tr\left(ZUS^{\frac{1}{2}}S^{\frac{1}{2}}U^TZ^T\right) = ||A^{-1}Z||_F^2 \quad (6)$$

Where, $A^{-1} = US^{-1/2}$. The main advantage of the proposed method is easy its optimization and has high speed, secondly, we proposed F and its changing very easy to others norms: $\|.\|_1\|.\|_{1,2}$ and others. Final view of the mathematical model is (7, 8):

$$min_Z||X - DZ||_F^2 + \lambda R(Z)_{prp} \quad (7)$$

or

$$min_Z||X - DZ||_F^2 + \lambda||A^{-1}Z||_2^2 \quad (8)$$

Solution: Proposed method is computed step by step.

Step 1: Compute derivative by the variable Z (9).

$$\Phi = ||X - DZ||_F^2 + \lambda||A^{-1}Z||_2^2 \quad (9)$$

Expression consists of matrix, therefor we change second norm $\|.\|_2$to$\|.\|_F$in (10):

$$\Phi = ||X - DZ||_F^2 + \lambda||A^{-1}Z||_F^2 \quad (10)$$

Derivative of this expression in (11):

$$\frac{\nabla\Phi}{\nabla Z} = -X^T(X - DZ) + \lambda A^{-T}A^{-1}Z \quad (11)$$

Step 2: Derivative is equal to zero:

$$\frac{\nabla\Phi}{\nabla Z} = 0$$
$$-X^T(X - DZ) + \lambda A^{-T}A^{-1}Z = 0$$
$$-X^TX + X^TDZ + \lambda A^{-T}A^{-1}Z = 0$$
$$(X^TD + \lambda A^{-T}A^{-1})Z = X^TX$$
$$Z^* = (X^TD + \lambda A^{-T}A^{-1})^{-1}X^TX$$

After M marking in (12, 13):

$$M = (X^TD + \lambda A^{-T}A^{-1})^{-1}X^T \quad (12)$$

$$Z^* = MX \quad (13)$$

Here, M matrix does projection role. We can express by the projection $X_{te}M$ $(X = X_{te})$ templates. Projection improves speed of the proposed method.

C. Face recognition algorithm by proposed method

Face recognition algorithm is presented by proposed mathematical model following:

1. Every X normalizes by Euclid distance and gives value to λ.
2. Given X_{te} templates code by templates in the base (14).

$$Z_{te}^{*} = MX_{te} \quad (14)$$

$where, M = X_{tr}^{T}D + \lambda A^{-T}A^{-1})^{-1}X_{tr}^{T}$

3. Computing residue in (15):

$$r_i = \left|\left|X_{te} - X_{tr_i}Z_{te_i}\right|\right|_2 \quad (15)$$

r_i means similarity given face template to the template in the base.

4. Recognition by the residue in (16):

$$recognition(X_{te}) = argmin_i(r_i) \quad (16)$$

V. EXPERIMENTS AND RESULTS

Proposed method is compared with PCA [12], LRC [13], SVM [14] and SRC [15] algorithms based on YaleB [16] and AR[17] face bases.

Database properties consist of simple 2D images, therefor we use only simple images. Initial image matrix is transferred to vector form and normalized.

Extended Yale face database B contains 16128 images of 28 human subjects under 9 poses and 64 illumination conditions. Half of images are used to training and other half for testing. Testing results are shown in the table I.

TABLE I. TESTING ON THE YALEB FACE DATABASE

Algorithm /Number of properties	*84*	*150*	*300*
PCA	85.8%	90.0%	91.6%
LRC	94.5%	95.1%	95.9%
SVM	94.9%	96.4%	97.0%
SRC	95.5%	96.8%	97.9%
Proposed algorithm	**97.2%**	**98.4%**	**98.4%**

AR database contains over 4,000 colour images corresponding to 126 people's faces (70 men and 56 women). Images feature frontal view faces with different facial expressions, illumination conditions, and occlusions (sun glasses and scarf). 7 images for training and other 7 images for testing are used. The size of images are abridges until 60x43.

TABLE II. TESTING ON THE AR FACE DATABASE

Algorithm / number of properties	*54*	*120*	*300*
PCA	68.0	70.1	71.3
LRC	71.0	75.4	76.0
SVM	69.4	74.5	75.4
SRC	83.3	89.5	93.3
Proposed algorithm	**81.0**	**90.7**	**94.7**

Testing results are given in table II. SRC result is high than other algorithms, so proposed algorithms for 54 properties. But for 120 and 300 the proposed method range increases.

Recognition speed: We compared recognition time of PCA, SRC and proposed algorithm on the YaleB and AR face databases. The results are given in table III.

TABLE III. RECOGNITION TIME

Algorithm	*Time (YaleB)*	*Time (AR)*
PCA	5.40s	1.790s
SRC	0.002s	0.002s
Proposed algorithm	**0.005s**	**0.003s**

VI. CONCLUSION

Face recognition systems have several problems depending on the recognition time, accuracy and number of properties. All researchers in the field face recognition try to solve these problems.

In sparse coding method was used Frobenius (first) norm, but this method is not effectively. Therefor we changed this first norm to Euclid (second) norm and expressed mathematical model. We tested proposed method with other PCA, LRC, SVM and SRC on the YaleB and AR face databases and presented results in the tables I-III. Proposed method's accuracy rate is more then, others, so recognition time is less than, PCA. In table II SRC is accuracy than proposed algorithm for 54 properties, but this number of properties improve so, 120 or 300 properties, our algorithm is efficiency. For developing efficiency face recognition systems need to collect face database based on requirements and choose relevant algorithm. Because SRC algorithm is accuracy for less properties and recognition is faster. If number of properties exceed than our proposed method is accuracy.

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