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Normalization of Facial Occlusion in Face Recognition

Tashev Komil Akhmatovich, Khudoykulov Zarif Turakulovich, Islomov Shahboz Zokir ugli, Salimova Husniya Rustamovna

Abstract. ***Face recognition accuracy is determined by face detection results. Detected faces will be in view of clear and occlusion faces. If detected face has occlusion than recognition accuracy is reduced. This research is directed to increase recognition rate when detected occlusion face. In this paper is proposed normalization occlusion faces by Principal component analysis algorithm. After applying normalization method in occlusion faces false reject error rate is decreased.***

Keywords: ***face recognition, occlusion, face normalization, deep learning, error, eigenvector, eigenvalue, average matrix.***

I. INTRODUCTION

Face recognition processes consists of face detection, feature extraction and comparison. In [1] is given triangle method for faster and errorless face detection. Detected face is sent to recognition process. In fig 2 is presented face detection and recognition processes. Here, a – face detection, b – detected face, c – extracted face features, d – comparing with classes. Nowadays, researchers build face recognition systems with artificial intelligence methods and algorithms. These algorithms recognize faces with 99,9% [2] accuracy when dataset is collected with enough face poses and situations.

If in detected face has occlusion than recognition accuracy decreases. Because, face key points are significant for efficiently face recognition. If in detected face has occlusion than recognition accuracy decreases.

II. MAIN PART

If dataset is collected with occlusion and clear faces than recognition time is increases. To train labeled face datasets are used deep face recognition methods and nets. In deep networks are trained face images with different size of random filters. In this case the face processing methods are categorized as "one-to- many augmentation" and "many-to-one normalization" [3].

- "One-to-many augmentation": generating many patches or images of the pose variability from a single image to enable deep networks to learn pose-invariant representations.
- "Many-to-one normalization": recovering the canonical view of face images from one or many images of a non-frontal view, then face recognition can be performed as if it were under controlled conditions.

In fig 3 is presented deep learning network architecture.

Deep learning network consists of filtering, pooling, padding and fully connected layers. In addition, these types of networks don't detect face or not face. Therefore, occlusion decreases recognition accuracy. One step of calculation with filters are calculated by following formula:

$$x_j^{(l+1)} = s\left(\sum_i F_{ij}^{(l)} * x_i^{(l)} + b_j^{(l)}\right)$$

Here, $x_j^{(l+1)}$ – calculated value, $F_{ij}^{(l)}$ – connected filter to $x_i^{(l)}$, l – filtering space, $b_j^{(l)}$ - j- bias, $s()$ – nonliner function for 2D filter.

There are following problems in deep face recognition networks:

- different collection of face datasets with all of the face poses;
- facial occlusion;
- training time is more.

Several face datasets have faces with occlusions, but there are natural and random occlusions, datasets can't include (Fig1).

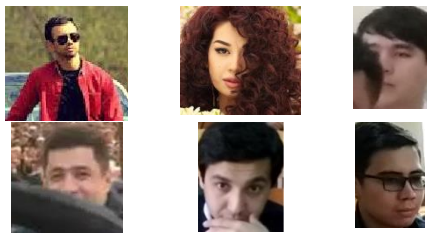

Fig. 1. Random occlusions

Table-I. Analysis of recognition algorithms of face occlusion

Errors (%) / Algorithms	FAR	FRR
Edge Detection + Geometric Analysis	16,67	0
Gabor Band + Geometric Analysis	8,33	25
Skin Color Ratio	29,17	8,33
Principal component analysis + Support Vector Machines	72,22	16,67

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***Correspondence Author(s)**
Tashev Komil Akhmatovich, Vice Rector for Scientific Affairs, Tashkent University of Information Technologies named after Muhammad al-Khwarizmi, Tashkent, Uzbekistan.
Khudoykulov Zarif Turakulovich, head of the Cryptology department, Tashkent University of Information Technologies named after Muhammad al-Khwarizmi, Tashkent, Uzbekistan.
Islomov Shahboz Zokir ugli *, Phd student of the Cryptology department, Tashkent University of Information Technologies named after Muhammad al-Khwarizmi, Tashkent, Uzbekistan.
Salimova Husniya Rustamovna student of the Department of Computer engineering, Tashkent university of information technologies, Tashkent, Uzbekistan.

If in detected face has occlusion, than system need to process under face before recognition [4]. Also, special methods to recognize face occlusion are used and their comparative analysis is given in table-I.

Table-I shows that error rate is large in recognition algorithms of face occlusion. To decrease error rates, developed normalization of face occlusion.

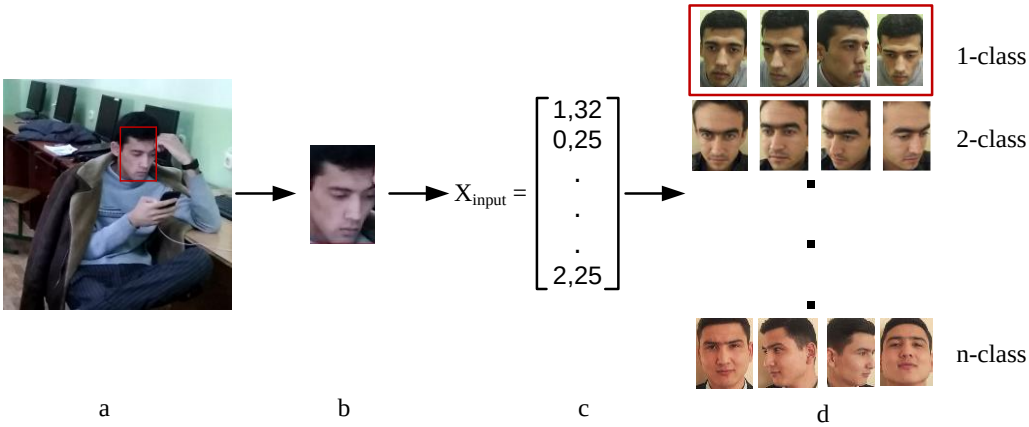

Fig. 2. Face detection and recognition processes

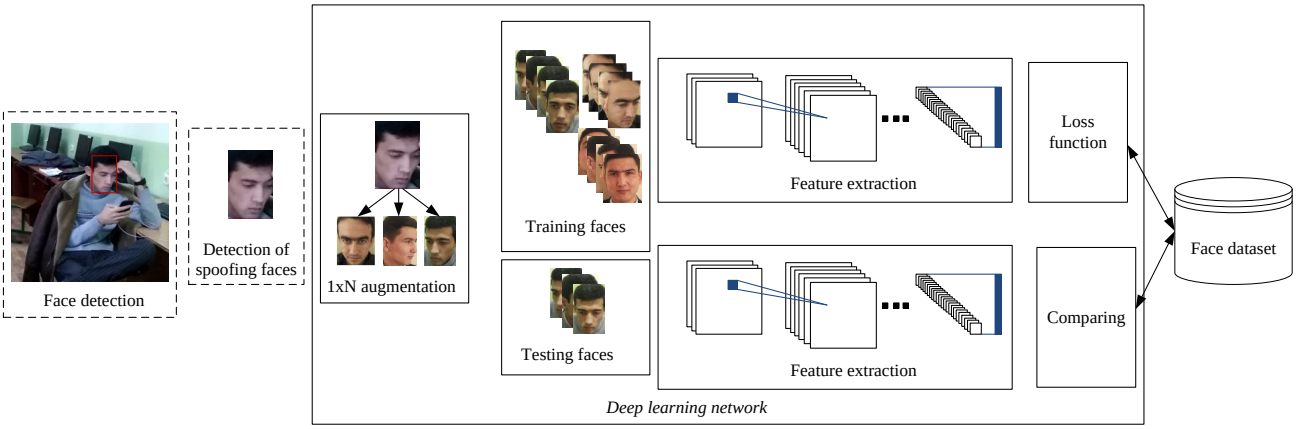

Fig. 3. Deep learning network architecture

$$a = \sqrt{(X_{left.eye.left.edge} - X_{left.eye.right.edge})^2 + (Y_{left.eye.left.edge} - Y_{left.eye.right.edge})^2}$$
$$b = \sqrt{(X_{right.eye.left.edge} - X_{right.eye.right.edge})^2 + (Y_{right.eye.left.edge} - Y_{right.eye.right.edge})^2} \quad (1)$$

III. NORMALIZATION METHOD

For normalization face occlusion is used PCA (Principal component analysis) algorithm. This process contains following steps:

- detection of face class;
- generation of normal face images;
- normalization of input image.

A. Detection of face class

Detection of face class contains following iterations:

1. Detection of face class: front, right and left (fig 4). To detect face class is calculated difference between eyes as in(1).

2. Following conditions are checked based on results of parameters a and b.

If, $\frac{a}{b} = [0{,}8 - 1{,}2]$, than first class is looked.

If, $\frac{a}{b} > 1{,}2$, than second class is looked.

If, $\frac{a}{b} < 0{,}8$, than third class is looked.

There, a - size of the left eye, b - size of the right eye.

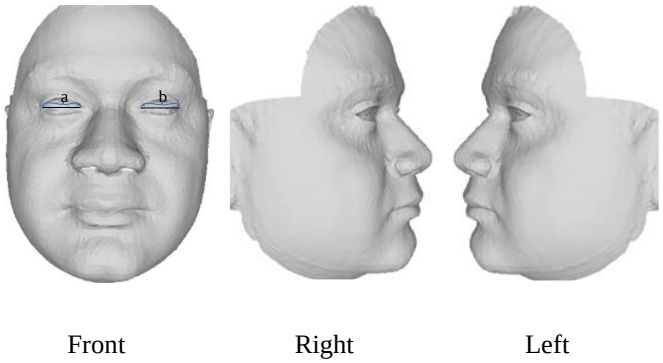

Fig. 4. Clasess based on face positions

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B. Generation of normal face images

Generation of normal faces consists of following steps:

1. Face images of 100 peoples by 3 total 300 are collected. Average face image is generated by following:

a) $M \times N$ is size of the face image $Z_i\,\{Z_{1,}\,Z_2, \dots, Z_{100}\}$ is number of faces. For testing is selected image size 256×256 and calculated size of the vector 65536. Average face vector is calculated by following formula, here Z_i (i=100):

$$\bar{Z} = \frac{1}{N}\sum_{i=1}^{N} Z_i$$

$\overline{Z_r}$, $\overline{Z_g}$ and $\overline{Z_b}$ – for red, green and blue is calculated by following formula.

b) For checking of separation of vector values is calculated covariance vector:

$$C_m = \frac{1}{N}\sum_{i=1}^{N}(Z_i - \bar{Z})(Z_i - \bar{Z})^T$$

There, T – Transpose of matrix. covariance vector for red, green and blue is calculated by following formula:

$$C_{mr} = \frac{1}{N}\sum_{i=1}^{N}(Z_{ir} - \overline{Z_r})(Z_{ir} - \overline{Z_r})^T$$

$$C_{mg} = \frac{1}{N}\sum_{i=1}^{N}(Z_{ig} - \overline{Z_g})(Z_{ig} - \overline{Z_g})^T$$

$$C_{mb} = \frac{1}{N}\sum_{i=1}^{N}(Z_{ib} - \overline{Z_b})(Z_{ib} - \overline{Z_b})^T$$

c) Eigenvectors and eigenvalues are calculated by following formula:

$$C_m V = V\lambda.$$

There, V - eigenvector ва λ - eigenvalue. Eigenvalue is calculated by extended matrix and eigenvector is calculated by multiplication matrix [5].

Eigenvalue is calculated by following. there, I – unit vector.

$$C_m V = VI\lambda$$
$$V(C_m - I\lambda) = 0$$
$$det(C_m - I\lambda) = 0$$

$$\begin{pmatrix} C_{1,1} - \lambda & C_{1,1} - \lambda & \cdots & C_{1,m} \\ C_{2,1} & C_{2,2} - \lambda & \cdots & C_{2,m} \\ \vdots & \vdots & \vdots & \vdots \\ C_{m,1} & C_{m,2} & \cdots & C_{m,m} - \lambda \end{pmatrix} = 0$$

Eigenvector is calculated by following:

$$\begin{pmatrix} C_{1,1} - \lambda & C_{1,1} - \lambda & \cdots & C_{1,m} \\ C_{2,1} & C_{2,2} - \lambda & \cdots & C_{2,m} \\ \vdots & \vdots & \vdots & \vdots \\ C_{m,1} & C_{m,2} & \cdots & C_{m,m} - \lambda \end{pmatrix} \text{x} \begin{pmatrix} V_1 \\ V_2 \\ \vdots \\ V_m \end{pmatrix} = \begin{matrix} 0 \\ 0 \\ \vdots \\ 0 \end{matrix}$$

After calculations are appeared m eigenvalues and eigenvectors. By these formula is calculated m V eigenvectors. For red, green and blue is calculated by given formula.

d) Eigenvectors and eigenvalues are sorted by up to down.

e) Every averaged centralized images are projected by following formula.

$$W_{ir} = V_{ir}^T(Z_{ir} - \overline{Z_r})$$
$$W_{ig} = V_{ig}^T(Z_{ig} - \overline{Z_g})$$
$$W_{ib} = V_{ib}^T(Z_{ib} - \overline{Z_b})$$

These calculations are done for left and right positions.

2. For three classes are generated three normal face images. Normal faces are saved in databases, and when detected occlusion in faces than is done normalization process. Normalization is extraction occlusion from face. After extraction, clear face is sent to face recognition. If occlusion is not detected, than face is sent to face recognition without preprocessing.

In normalization process is calculated average value between input and class-appropriate images. Here, size of two images are equal.

$$NT_i = \frac{(W_i + Z_i)}{2}$$

Here, NT_i – normal face image, W_i – class-appropriate image, Z_i – input image.

In normalization process class detection is main process. Because, face image after normalization is sent to face recognition step. For minimizong face recognition error is done following cituations:

In detected face:

Normalization is done:

There is left aye, right eye and there is not nose, mouth;

Normalization is not done:

There is left aye, right eye and nose;

There is left aye, right eye and mouth;

Block scheme of generation of normal faces is presented in fig 5.

Block scheme of normalization occlusion face images is presented in fig. 6.

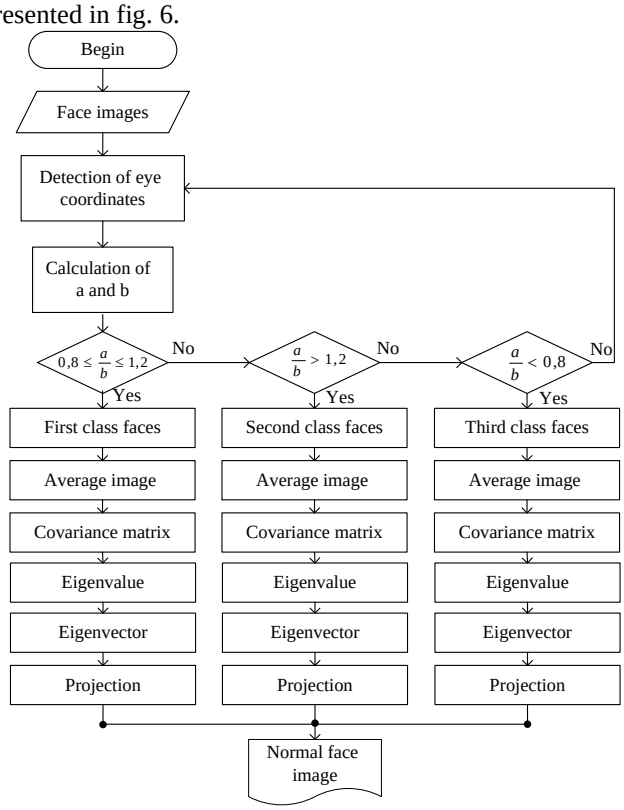

Fig. 5.Block scheme of generation normal face images

Table-II. Comparison results

Method \ Indicators	Error (%)	Accuracy (%)	Number of parameters (Mb)	Recognition time (ms)
Normalization is not used	35	65	14,4	9,9
Normalization is used	14	86	14,41	10

Efficiency of proposed face normalization method is high and comparison results are presented in table-II.

Here, false reject error rate is high, because in this work is tested only occlusion faces. Also, after using normalization process GFlops distinguishes to 0,01 Mb.

This method of normalization of face images is used when in face is detected occlusion. Random occlusion is detected by three positions: front, left, right. If occlusion is not detected, than normalization is not used.

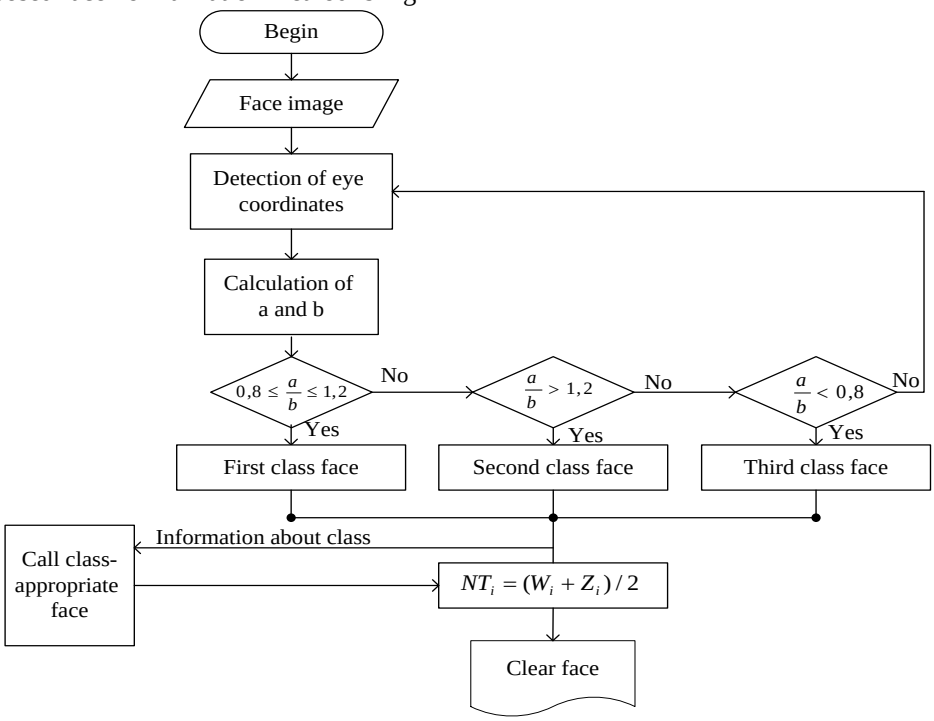

Fig. 6.Block scheme of normalization occlusion face images

IV. CONCLUSION

To creating efficiently face recognition systems is used deep learning methods. Also, in detected face has occlusion, than after pooling, filtering, padding and fully connected layers array of face is calculated wrong. With wrong parameters appear error results. To decrease these types of errors is proposed extract clear face from occlusion face by normalization method. By using PCA algorithm basics and calculation average matrix, face recognition error is decreased until 14%.

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AUTHORS PROFILE

Tashev Komil Akhmatovich received his MS degree in the Department of Computer systems from Tashkent state technical university, Uzbekistan, in 2005. He received PhD degree in 2010. His research interests include data protecting techniques, monitoring, image recognition.

Khudoykulov Zarif Turakulovich received his MS degree in the Department of information security from Tashkent university of information technologies, Uzbekistan, in 2013. He received PhD degree in 2018. His research interests include data protecting techniques, cryptology, image recognition.

Islomov Shahboz Zokir ugli received his MS degree in the Department of Information security from Tashkent university of information technologies, Uzbekistan, in 2014. He is PhD student. His research interests include data protecting techniques, image detection, face recognition, access control.

Salimova Husniya Rustamovna student at the Department of Computer engineering of Tashkent university of information technologies, Uzbekistan. Her research interests include data protecting techniques steganography, identification, authentication, face recognition, access control.