Face recognition on the base of local directional patterns

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***Abstract*—In this paper, local directional pattern (LDP) based methods for frontal face recognition are discussed (summarized). LDP based face feature extraction and comparison methods and their performance results are given. Although, in the paper method for normalizing illuminations of face images is given. Were performed the results of experimental research of the developed algorithms.**

Keywords—facial image; normalization; local directional pattern; histogram; recognition.

I. INTRODUCTION

Today, automatic person identification systems is playing main role in development of information technologies. Hence, there research works on improving intelligent systems with human face identification. Especially this scientific direction is used to ensure security systems.

In the direction of research to get high performance detecting face features and recognition should be reliable.

Nowadays “Local Directional Pattern” (LPD) operators are used to describe digital images in particular, to recognize them. Especially, this operator is used to extract features of the faces [1-3].

In this paper detecting important features of frontal face images with normal and abnormal illuminations using LDP operator and human recognition methods by comparing the faces are highlighted briefly.

Noteworthy, our researches give attention to improve methods and algorithms currently available.

II. STATEMENT OF THE PROBLEM

Until now was developed some methods to extract local features of face. Nowadays there are several methods for extracting local features of a face. Among them “Local Binary Patterns” (LBP) operator [4-5] is fundament for them. Extracting face features using LBP is used until now and in turn made different versions of LBP. Notwithstanding LBP has some limitations. For instance, factors such as noise in image and abnormal illumination can influence to accuracy of LBP. New issues come with reducing mistakes on extraction of local features of face.

Now, we should use other method, which is the steady to interference of the image, especially uneven distribution of the light.

Starting from above, during our research, we found the “Locally directed pattern” (LDP) is very effective. Accordingly, we will learn opportunities of using this operator in this article.

In addition, there are some operations before using the LDP operator, the operations needed to work out important algorithms at this stage. Particularly, we are faced with the question to determine the area of the face at the image, to find the coordination of eye pupils, bearing on them to separate the essential area of the face (interior matrix) and in case of need to normalize the separated picture of the face in geometrical or lighting terms.

III. THE ALGORITHM OF NORMALIZING FOR ABNORMAL ILLUMINATED IMAGES

It is important stage of the image preprocessing. There were work out several algorithms to normalize uneven lighted pictures. Among them the method based on Gausse’s distribution, especially, the method Multi Scale Retinex [6] is more effective. It has following main formulation:

$$R_{MSR_i} = \sum_{n=1}^{N} \omega_n R_{n_i} = \sum_{n=1}^{N} \omega_n \left[\log I_i(x,y) - \log\left(F_n(x,y) * I_i(x,y)\right)\right] \quad (1)$$

Here N – the number of scale ($N=3$), ω_n - the coefficient of each scale ($\omega_n = 1/3$) and $F_n(x, y) = C_n \exp\left[-\left(x^2 + y^2\right)/2\sigma_n^2\right]$; $C_1 = 15, \quad C_2 = 80, \quad C_3 = 250$.

Next we can see the result of algorithm (picture 1).

a) b)

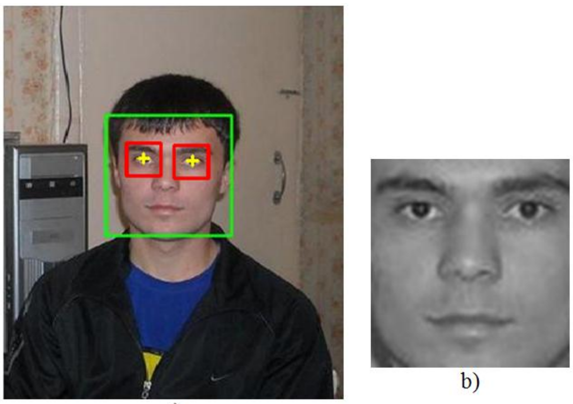
Picture 1. Image light normalization by Multi Scale Retinex method. a – input image; b – the result of algorithm.

IV. The algorithm of the definition the face, eyes and central face area at the images

It is necessary to define (or to find) the coordination of the face area and face elements (for example, the pupils of eye) at the picture and its correctness affects the accuracy of common system. Therefore, it is required to fulfill the operation at this stage in high quality.

The operations like determination the face area at the image, finding the coordination of pupils of eyes, geometrical normalization of the face, separating the central area of the face (matrix) were done by us before [7, 8], therefore we don't engage on it detail. At picture 2 we can see the results on base of algorithms, which developed by this stage. At the picture 2a there shown the coordination of the face area and eyes, which were found at the photo, at the picture 2b there shown the separate the face area matrix (the central - important area with full reflected features).

We will work at normalized face area only at the next stage. It is significant, this matrix is grayscale (between 0 and 255) image with $w \times h$ size, the pupils of the left and right eyes lay horizontal (picture 2b).

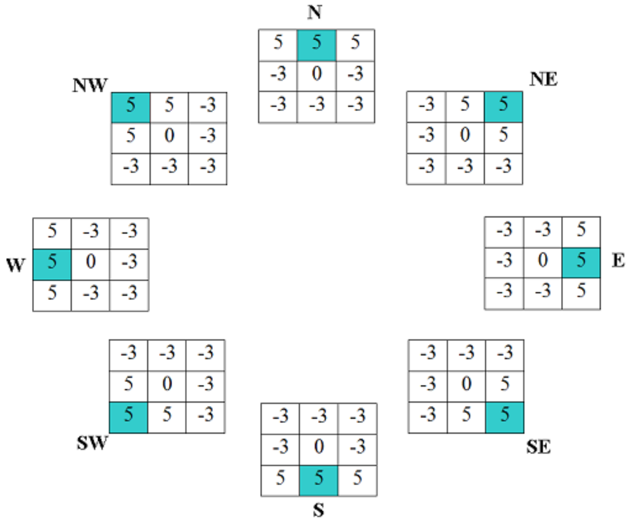


a) b)

Picture 2. Found face elements (a) and matrix of a face (b).

V. Formulation the space of the face elements on base LDP operator

The mask separator of edges Kirsch [9] is used at the operator LDP. We know that the mask Kirsch is used to find the edge points by calculating the value of 8 neighboring pixels towards the center of the 3×3 working windows. Then we can see the mask Kirsch (picture 3).



Picture 3. Kirsch mask with 8 direction.

Here it notes the directions: N – North, S - South, W – West, E – East, NW - North West, SE - South East, SW - South West, NE - North East.

Each pixel of the image and it's eight around values recounted by the Kirsch mask. For example, let it be as follows the values of 3×3 working windows in local region at the grayscale image (picture 4).

25	52	31
210	40	60
180	125	77

Picture 4. The first (example) local region's values.

At first, we use the mask N – North. The calculation will be as follows:

$$N = (5 * 25) + (5 * 52) + (5 * 31) + (-3 * 60) + (-3 * 77) + (-3 * 125) + (-3 * 180) + (-3 * 210) + (0 * 40) = -1416.$$

So, we put number "–1456", which located on the North of the local area instead of number "52". On this order it calculates the mask Kirsch, which is proper to the other pixels of the first local region. Then the values for the eight directional pixels of the local region at the picture 4 changes as follows (table 1):

TABLE I. THE RESULTS OF THE LDP

Direc-tions	NW-North West	N–North	NE-North East	E–East	SE-South East	S–South	SW-South West	W–West
Pixel value	25	52	31	60	77	125	180	210
Mask value	16	-1456	-1136	-936	-184	776	1840	1040

So, the values of the local region changed completely (picture 5). It is significant, the center on the mask Kirsch always equal to “0”.

16	-1456	-1136
1040	0	-936
1840	776	-184

Picture 5. The result – the values of the mask.

Now these values will be binarized. There suggested some variants of binarization at the articles dedicated to the LDP. During the research we selected the most effective of them. Here we will learn it.

At first, eight values of the result mask streamlines in order increase and it put in one array, that it:

$$G^{(8)} = \{g_1, \ldots, g_4, g_5, \ldots, g_8\}$$

(2)

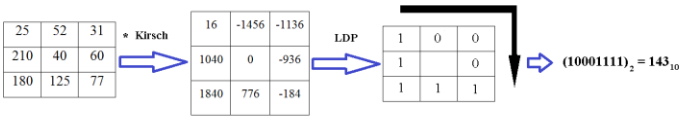
In result the values, which calculated above, changed as follows:

G(8) = {-1456, -1136, -936, -184, 16, 776, 1040, 1840}.

We change first half part of the ordered eight elements, that it the first four little values to “0”, others (larges) to “1”. In the issue, there will be eight “0” and “1”. Then they put in sequence by clockwise and we have binary number, which consists of eight numbers. Then, we turn the binary number to decimal number, that it:

$$LDP(x_c, y_c) = \sum_{i=1}^{8} S(g_i)\cdot 2^i, \qquad S(x) = \begin{cases} 1 & if\ x \ge g_4, \\ 0 & else \end{cases} \qquad (3)$$

The common work system of the LDP (picture 6) is as follows (at example of example value):



Picture 6. The general working scheme of the LDP.

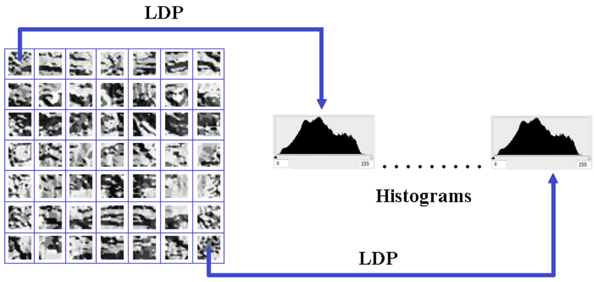
So, we have one decimal number (between 0 and 255) through the calculation above. Then we put into the center of the windows this number. In this case, the primarily central value of the local region, which was the example above, changes number “143” instead of number “40”.

Now then, the calculation by the operator LDP applies to the other pixel of the image and as a result it shapes the image (or the matrix) of the LDP. Below it shown the central image of the face (picture 7a) and its LDP result (picture 7b).

a) b)

Picture 7. The image of the face (a) and its LDP result (b).

The histogram of the image applies as identification features of the LDP. But, fully applying the histogram of the LDP image may adversely affect the result of recognition in future. Therefore, the researchers separate the LDP image to the N parts and then it calculates the histograms for each part. Mostly performs division in size 7×7. In this case it forms 7 * 7 = 49 histograms and they connect successively. There shown the scheme of this process (picture 8).



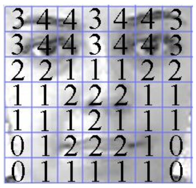
Picture 8. Forming the space of features on base of the 7×7 size LDP.

VI. THE ALGORITHM FOR COMPARING THE FACE FEATURES AND RECOGNIZING OF A FACE

It uses some methods to compare LDP face features that are histograms. For example, Correlation, Chi-Square, Intersection, Bhattacharyya distance an etc. [10]. During our research we found Chi-Square more effective. Below we see the formula of Chi-Square.

$$\chi^2(H_1, H_2) = \sum_{i=0}^{255} \frac{(H_1(i) - H_2(i))^2}{H_1(i) + H_2(i)} \qquad (4)$$

It does not always have good results to estimate all of separated face area in one coefficient (weight). That’s why, most of the researchers give different weights to separated face area. According to the results of our own research, we gave following weights to the parts of LDP image of the face (picture 9):



Picture 9. The weights of the face area.

Here large parts of the number value considered more important, because in this area the quantity of important identification elements of the face is larger.

In comparison, when the coefficient – w considered, the formula of the comparing is as follows:

$$\chi_w^2(H_1,H_2)=\sum_{j=1}^{49} w_j \cdot \sum_{i=0}^{255} \frac{\left(H_1^j(i)-H_2^j(i)\right)^2}{H_1^j(i)+H_2^j(i)} \qquad (5)$$

If the images are the similar, the result by the formula above will be near to zero.

It should be noted that images should be rescaled to the same size into before comparing them.

VII. The analyses of the results

The comparing the images of the face with LDP operator had been tested for different chance. Here with were compared the photos, which were obtained with different technical means (camera, scanner and etc.), in different sizes and lightings.

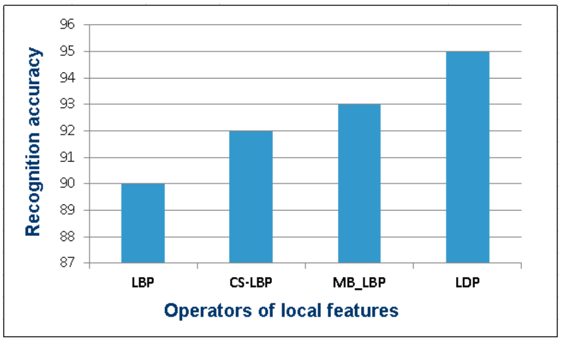
The test of the computer program performed in base with more than 2000 pictures of the face. There are images of the central face area in this base; they are grey pictures in JPG and BMP type. The main pictures in this base are belongs Uzbek nationality, also additionally included the pictures of the base of face from internet “Orl Face Database” and “Yale Face Database”.

The results show, that the accuracy comparison by LDP operator is higher than LBP. Especially, LDP achieved its stability on uneven lighted pictures.

It is significant; when the size of the picture is very small or very big the correctness of the algorithm will decrease. It may reach good results, when the normal distance of eyes will be 100 pixels approximately. Besides, to give the weight to separated face area in comparison also influents positively to the recognition.

Generally the correctness of recognition by the LDP operator increased about 94%. If it is lighted similar and used similar technical means, also there is no change in face expression it will be possible to improve the recognition by the LDP operator during the process of formation of the base the images of the face.

Besides, some methods of the “Binary patterns” were compared with the LDP by their recognition in our experimental study. Particularly, the methods of LBP – Local Binary Pattern, CS-LBP – Center-Symmetric Local Binary Pattern [11], MB-LBP – Multi Block LBP [12] were compared with the methods of the LDP. The graphs show the recognition of the LDP is higher than others.



Picture 10. The graphs of the comparison method by the recognition.

VIII. Conclusion

The researchers note, that the methods of the “Local binary pattern” is the most effective to compare the pictures “one to one”, that is comparing directly and estimate the similar. Especially, the LDP operator achieves efficiency with its correctness. In addition, it expected increasing of the correction by using the weights, which was offered by us, to the separated parts of the face area.

In the regime “real time” the LDP operator could be used by applying different technologies to increase the rate of the algorithm work.

In generally we can say that the identification features of the frontal pictures of the face could be separated with high accuracy on base LDP. These features keep important peculiarities, particularly the form of the face elements and their location, also colors of pixels.

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