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USING LOCAL BINARY TEMPLATE FOR FACES RECOGNITION ON GRAY-SCALE IMAGES

The paper describes methods for faces recognition, which use the local binary templates. There had been suggested the method for faces recognition, which uses local binary template in the form of elapse. For research of the method there had been used the faces base ORL.

Key words: *faces recognition, local binary template, gray-scale image, distance x – square.*

Introduction

Today there are many applications which use the methods for image recognition, such as: identification of personality, using the interface «man-computer», etc. The main difficulties during the recognition of faces – great number of changes during the representing of faces, such as: different illumination, expression of the face, head rotation, age changes, etc. That is why the problem of automatic face recognition remains unsolved [1].

The process of personality identification, which is based on recognition of face representation, means the following procedure: the face image of the unknown person is submitted to the entrance of the recognition device, which compares it to the images of the known faces which are in the image base.

The identification process may be divided into three basic steps:

– registration and normalization of face image;
– selection of signs;
– classification.

Methods for selection of signs from the face image, which use the local binary templates (LBT) have been recently attracting the attention of the researchers. LBT were first suggested in 1996 for analysis of texture of gray-scale images [2]. Methods for identification of faces, which are used for selection of LBT signs and their modification, demonstrate high results on both, speed and accuracy of recognition [3-5]. Such methods are robust during the usage of images with different mimicry, different illumination, head rotation.

The objective of the work is the modification of LBT, which would allow improving the accuracy of recognition of faces in comparison with the usage of classical LBT and their modification, as well as classical methods for faces recognition (analysis of the main components, comparison of elastic graphs).

1. Local binary templates

LBT represent the description of pixel vicinity image in the binary form. LBT operator, which is only applied to the image pixel, uses eight pixels of vicinity, accepting the central pixel as a threshold. Pixels with the values, higher then the central one (or equal to it), accept the value <1>, those which are lower then the central one, accept the value of <0>. Thus, we accept the eight-bit binary code, which describes the pixel vicinity. Fig.1 shows the example of LBT operator work on grey scale picture.

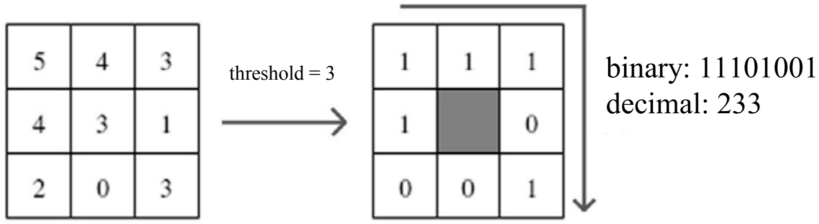


Fig.1. Example of LBT operator work

The work [3] describes the LBT modification, using the vicinity pixels, which are some distance from the central pixel. In this case the vicinity pixels are on the circle with the radius R. The number of dots on this circle may be chosen arbitrarily, we mark them as P. For the calculation of values in these dots for different radius R and number of dots P, the bilinear interpolation shall be used. For the representation of LBT with the radius R and distance P we will use the sign $LBP_{P,R}$. Fig. 2 presents the set of pixels of vicinity for different P and R.

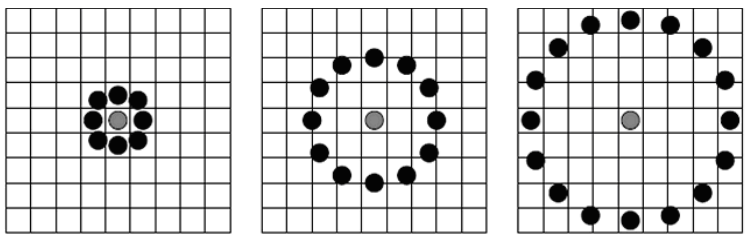


Fig2. Modified LBT for different P & R:
number of dots P=8, Radius of vicinity R=10
number of dots P=12, Radius of vicinity R=2,5
number of dots P=16, Radius of vicinity R= 4

The paper [2] suggested to use not all LBT for analysis, but only those, which may have not more but two transitions from (1) to (0) or otherwise. Such templates are called uniform pattern, we mark them as $LBP^{u}_{P,R}$. For example, such LBT as 1111 or 000111 – are $LBP^{u}_{P,R}$, and 11001100 or 10101010 – are not LBR . The usage of $LBP^{u}_{P,R}$ have two advantages. First, there is the economy of memory, as using for image analysis requires only P (P-1) + 2 LBP

Whereas for the representation of all $LBP^{u}_{P,R}$ it is necessary to use 2^{P} LBP. Second, $LBP^{u}_{P,R}$ determine only important local textures, such as ends of lines, edges, angles, spots. Examples of such $LBP^{u}_{P,R}$ are shown on fig.3, on which pixels, values of which equal <0> are marked by light circles, and pixels values of which equal <1> are marked by dark circles

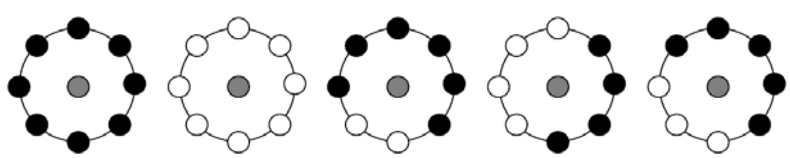


Fig.3. Examples of $LBP^{u}_{P,R}$

In work [5] the authors use the liquid approach for the description of face image in which the images are described both locally and globally. First , the face image is divided into k*k regions, then the $LBP^{u}_{P,R}$ code is calculated for each image pixel in each region. The value of the column, responsible for this code increases by a unit. Each $LBP^{u}_{P,R}$ code in the bar graph corresponds to separate column; one more column in the bar graph corresponds to all $LBP^{u}_{P,R}$ codes, which do not have $LBP^{u}_{P,R}$ properties. Thus each bar graph of the region consists of P (p – 1) 3 columns. After that all bar graphs are united into one bar graph for representing the global description of the face image. This graph bar will consist of $k^2(P(P-1)+3)$ columns and will form vector of face signs. Fig.4 presents the example of division of the face image into regions and bar graphs corresponding to them.

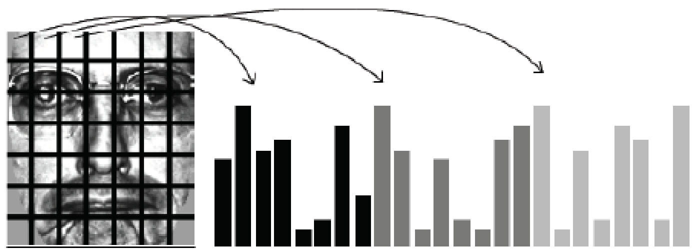


Fig.4. Bar graphs of the region image

For the image of the size N*M, the vector of face signs shall be built by calculation of LBT code for each dot (x_c,y_c), $x_c \in \{R+1,...,N-R\}$ $y_c \in \{R+1,...,N-R\}$. If the image is divided into k*k regions, the bar graph of region (k_x, k_y), where $k_x \in \{1,...,k\}$ and $k_y \in \{1,...,k\}$ and will be determined as:

$$H_i(k_x,k_y) = \sum_{x,y} I\{LBP_{P,R}(x,y) = L(i)\}, i = 1,...,P(P-1)+3\,, \tag{1}$$

where

$$x \in \left\{ \begin{array}{ll} \{R+1,...,N/k\} & k_x = 1 \\ \{(k_x-1)(N/k+1,...,N-R)\} & k_x = k \\ \{(k_x-1)(N/k+1,...,k_x(N/k)\} & else \end{array} \right\}$$

$$y \in \left\{ \begin{array}{ll} \{R+1,...,M/k\} & k_y = 1 \\ \{(k_y-1)(M/k+1,...,M-R)\} & k_y = k \\ \{(k_y-1)(M/k+1,...,k_y(M/k)\} & else \end{array} \right\}$$

and L – name of the i^{th} column

$$L(i) = \left\{ \begin{array}{ll} 1, & i - true \\ 0, & i - false \end{array} \right\}.$$

During the classification of the face image with an aim of finding the smallest distance between the bar graphs which represent faces, there shall be used the distance xi^2. The distance between the images S and M shall be determined according to the formula:

$$\chi^2(S,M) = \sum_{j=1}^{k^2}\left(\sum_{i=1}^{P(P-1)+3}\frac{(S_{i,j}-M_{i,j})^2}{S_{i,j}+M_{i,j}}\right). \tag{2}$$

In formula (2) $S_{i,j}$ and $M_{i,j}$ – are sizes of the column "I" from the region "j" (number of appearance of LBT *L(i)* in region "j")

Since some regions of faces (region of eyes, for example) may bear more important information then other regions, it is possible to assign weight to each region, depending on its importance for recognition.

During assigning the weight w_j to the region "j", the formula may be written as follows

$$\chi_w^2(S,M) = \sum_{j=1}^{k^2} w_j\left(\sum_{i=1}^{P(P-1)+3}\frac{(S_{i,j}-M_{i,j})^2}{S_{i,j}+M_{i,j}}\right). \tag{3}$$

2. Method for recognition

The given work suggests to use LBT on form of ellipse (ELBT), i.e. those pixels, which lie on ellipse relating to the central pixel will be used for LBT formation. Let us mark the bigger ellipse radius as A, the smaller radius as B, number of dots in LBT as m. Then, the coordinates g_{ix} and g_{iy} for each vicinity pixel g_i (i=1,2,…,m) will be determined according to the formulas (4) and (5)

$$R_i = \sqrt{\frac{A^2B^2}{A^2\sin^2\theta_i + B^2\cos^2\theta_i}}, \tag{4}$$

$$g_{ix} = R_i\cdot\cos\theta_i,\quad g_{iy} = R_i\cdot\sin\theta_i, \tag{5}$$

where $\theta_i = \left(\frac{360}{m}*(i-1)\right)^{\circ}$.

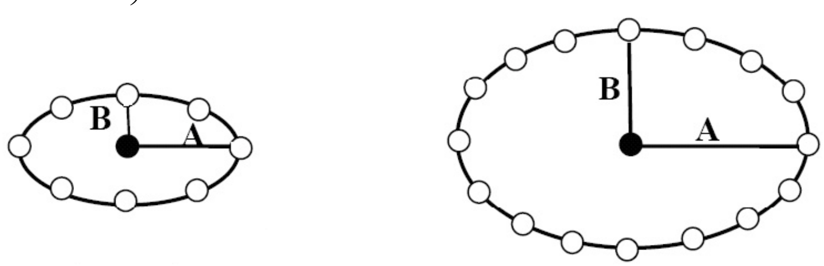
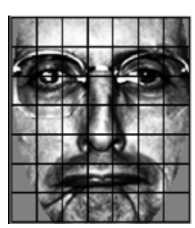


Fig 5. Presents the example of ELBT with different values of A,B and m.

Coordinates of vicinity dots are not always in the center of pixel, therefore the bilinear interpolation is used to calculate their value. The vector of ELBT signs of one region of the image shall be formed according to formula (1). For the classification of the face image, formula (2) and (3) shall be used in the given work. Usage of formula 3 requires setting weight for some regions of the face. Regions weight w, selected in the empirical way, are presented on fig. 6.



2	1	1	1	1	1	2
2	4	4	3	4	4	2
1	1	1	2	1	1	1
0	1	1	2	1	1	0
0	1	1	1	1	1	0
0	1	1	2	1	1	0
0	1	1	1	1	1	0

Fig 6. Weight of the regions of face image

3. Results of the experiment

With an aim of researching the suggested method, the given work uses the faces of the ORL-Olivetti research laboratory. The base consists of 400 images of faces of 40 persons (10 different images of one person face) with different expressions (open/close eyes, smiling/not smiling) as well as with glasses or without. All images of face are on dark background, in front position with forwarding flexions of head and the scale changes up to 10%. All images are gray – level with the volume of 92*112 pixels. Fig 7. presents the example of the image of the face from the ORL base.

Fig 7. Image of the face from ORL base

LBT in the form of ellipse with the following parameters *A*, *B and m*: $A1 = 1$, $B1 = 1$, $m = 8$ (ELBT $_1$); $A2 = 3$, $B2 = 1$, $m = 16$ (ELBT $_2$); $A3 = 3$,$B2 = 2$, $m = 16$ (ELBT $_3$) were used in the experiment.

Table 1 shows the accuracy of recognition of classical method for recognition (analysis of the main components with the use of LBT, as well as exactness of recognition of the developed methods, using modified LBT).

Table 1

Method for recognition	Accuracy of recognition
АГК [6]	85%
ПЕГ [7]	87.5%
LBT [5]	94%
ELBT $_3$	92%
ELBT $_1$ + weights of the regions	93.5%
ELBT $_2$ + weights of the regions	94.5%
ELBT $_3$ + weights of the regions	95%

Table 1 shows that the developed methods for recognition, which use the modified LBT, during the usage of ORL base, demonstrate better accuracy of recognition method in comparison with the classical methods of MCA, EGC which LBT uses in [5], the developed methods demonstrate close results.

Conclusion

There had been experimentally researched the appropriateness of using of ELBT for face recognition. Together with the applying weight to the regions of the face, using of ELBT allowed to improve accuracy of recognition up to 95% using the base of the ORL faces. To improve the accuracy of recognition it is planed to improve the method for face division into regions, find the optimal regions weights using algorithm AdaBoost.

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