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METHOD FOR FACES IDENTIFICATION ON COLOR IMAGES

The paper suggests method which allows to identify faces of frontal view in the range of slope of the face from the central symmetry axis within –56 to +56 degrees on color image. There had been presented the results of the research efficiency in identifying faces on test set of images from FDDB base.

Key words: *face identification, Adaboost,color image, model of skin color.*

Introduction

Method, described in [1] allows to identify the front view face in the range of face slope from the central symmetry axis from –56 to +56 degrees on gray scale image. The advantage of the method in comparison with the method of Viola - Jones [2] is lower sensitivity to the changes of illumination, the disadvantages – large . During the processing of color images it is possible to reduce computational complexity keeping the advantages of the method by using the skin color as the feature of identification.

Image segmentation into the pixels of "skin" and "non skin" potentially accelerates the process of identification, since it allows to skip the sections in which the number of pixels "skin" is below the threshold and conduct further identification in sections in which the number of pixels "skin" is above the threshold.

In many methods for identification of skin pixels[3] the researchers try to build accurately the model of skin color to receive high level of probability in identification of skin pixels with low level of failure identification. But in different illumination conditions the values of pixels may exceed the ranges, stipulated by the model, that leads to decrease in accuracy of identification of skin pixels and, in turn, to the decrease in probability of identification of faces and increase in member of failure identifications of faces.

For the solution of the problem with pixels' values exceeding the range, stipulated by the skin model, during the segmentation of color images it is expedient to use skin color model, which, instead of determination of pixels with high quality, belonging to skin color, will exclude pixels which may not belong to the skin color with high accuracy [4].

The aim of research is to increase the rate of faces identification on color images, which are characterized by the wide range of illumination change and faces orientation, in condition of decrease in number of false identifications and increase in probability of their identification.

To reach the objective set, it is necessary to solve the following **tasks:**

1. To describe the model of skin color for making segmentation of color image into pixels of "skin" and non "skin".
2. To describe the process of face identification by boosting method [1] robast to illumination changes.

Segmentation of color image

Let $skin$ and $\overline{skin}$ be subspace of RGB color space, and $RGB = skin \cup \overline{skin}$ and $skin \cap \overline{skin} = \varnothing$, then the pixel in the position *(i,j)* of color two-dimensional image, determined by vector $\langle R_{ij}, G_{ij}, B_{ij} \rangle$, which belongs to space $skin$, is the pixel "skin", and pixel, which belongs to the space $\overline{skin}$ is the pixel "non skin". Pixel $\langle R_{ij}, G_{ij}, B_{ij} \rangle$ belongs to $\overline{skin}$, if it satisfies one or some of the rules:

$$(R_{ij}/G_{ij}) \notin [V^{RG}_{min}, V^{RG}_{max}], \quad (1)$$

$$(R_{ij}/B_{ij}) \notin [V_{min}^{RB}, V_{max}^{RB}]\,, \tag{2}$$

$$(R_{ij} \in [0, V^R]) \cap (G_{ij} \in [0, V^G]) \cap (B_{ij} \in [0, V^B])\,, \tag{3}$$

where V_{min}^{RG} and V_{max}^{RG} – boundary values of relations of component R to component G, V_{min}^{RB} and V_{max}^{RB} – boundary values of relations of component R to component B, V^R, V^G and V^B – threshold values for components R, G and B.

Described in formulas (1 – 3) rules determine the model of skin color, after application of which to the color image each pixel $\langle R_{ij}, G_{ij}, B_{ij} \rangle \in \overline{skin}$ is given the value of unit and each pixel $\langle R_{ij}, G_{ij}, B_{ij} \rangle \in skin$ the value of zero, thus forming the binary image (binary mask) .

Boosting method for face identification

Structural diagram of operation of boosting method [1] during the determination of availability of half-tone face image in the region is presented in Fig. 1.

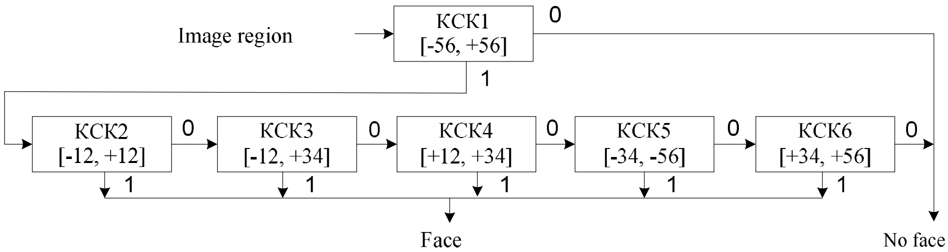

Fig. 1. Structural operating diagram of boosting method for face identification

Each of six cascades of strong classifiers (*КСК1 – КСК6*), presented in Fig. 1, is trained on separate sets of training images, containing images in the corresponding slopes range, for example, the set for *КСК2* contains front face images with slopes from the central symmetrical axis in the range from -12° to $+12^{\circ}$degrees. Each cascade of strong classifiers is formed with the use of training algorithm of Adaboost classification. As indicators for simple classifiers in strong classifiers the modified local binary pictures are used (*RECT-LBP*)..Using of these indicators ensures high robasticity of the method to changing of illumination conditions in comparison with methods where haarolike indicators, sensitive to illumination changes are used.

The value of *RECT-LBP* after applying to the region of the image is determined as follows:

$$RECT-LBP = \sum_{m=0}^{7} s(k_m - k_c)2^m\,, \tag{4}$$

where k_c – is a sum of values of pixels intensity in the central rectangular, k_m ($m=0,\ldots,7$) –is sum of values of pixels intensity in rectangulars of neighboring to the central $s(x)$: $s(x) = \begin{cases} 1, & if \quad x \geq 0 \\ 0, & if \quad x < 0 \end{cases}$. Parameters of dx and dy of each *RECT-LBP* indicator determine the sizes of central and neighboring to the central rectangulars.

During the formation of each cascade of strong classifiers by Adaboost algorithm, for each image region p for all positive training examples *RECT-LBP* indicator is calculated and massive L_p^{face} is formed, using the set of negative examples, massive $L_p^{no-face}$. is formed. Massives L_p^{face} and $L_p^{no-face}$ consist of *n_LBP* elements, and each element corresponds to the specific *RECT-LBP* indicator. In the elements of massive L_p^{face} the weights of positive examples are summed and in elements of massive $L_p^{no-face}$ weights of negative examples are summed. The weight of the example is added to the element of the corresponding massive, if *RECT-LBP* indicator, received in region p

corresponds to *RECT-LBP* element indicator. The classification failure of the region *p* is determined by the formula:

$$\varepsilon_p = \sum_{j=1}^{n\_LBP} min(L_p^{face}[j], L_p^{no-face}[j]) \tag{5}$$

The simple classifier $h_t(x)$ is being formed, using massives L_p^{face} and $L_p^{no-face}$ of the region *p* with minimum classification error ε_t according to formula:

$$L_p[j] = \begin{cases} 1, & L_p^{face}[j] > L_p^{no-face}[j] \\ 0, & otherwise \end{cases} \tag{6}$$

The strong classifier is formed according to the formula:

$$h(x) = \begin{cases} 1, & \sum_{t=1}^{T} \alpha_t h_t(x) \geq \psi \\ 0, & otherwise \end{cases} \tag{7}$$

where α_t – is the factor, the value of which is determined during training process, ψ is threshold, the value of which is determined during the use of varificational set of examples.

By means of optical device, videocamera, for example, the image with one or more faces is entered the computer. This image is transformed in integral image. The minimum search window, the size of which increases by factor*Ms*, during the change in the scale, is moved by the image along its line with the step of *Kr* pixels and allocates the image region. In case if the filling with units in this region in binary mask does not exceed the threshold *NN*%, the region is supplied to the input of *КСК1*. In other case, there the transfer to processing the next image region takes place. If all strong classifiers *КСК1* according to formula (7) accept the value of $h(x) = 1$, the region of the image is supplied to the input of *КСК2*. If at least one strong classifiers with *КСК1* accepts the value $h(x) = 0$,the face detector will pass to the processing of the next region of the input image. If at least one classifier with *КСК2 – КСК6* accepts the value $h(x) = 0$, the region of the image enters the input of the next *КСК* or the detector transfers to processing of the next image region, if the current *КСК* was *КСК6*. If all the strong classifiers of one of *КСК2 – КСК6* accepted the value of $h(x) = 1$, the region of the image is taken as the identified region-candidate within the slope angles range of the current *КСК*.

After the searching window scans the whole image in all the scales, the face detector for each range of slope angles selects some region-candidates on the image. It is suggested to apply the next stage of verification of region-candidates. The rule of clusterization is used within each range of slope angles, in which all set of region –candidate is divide into sets which do not cross. During the clusterization the two region-candidates refer to one cluster if they cross more than φ percent. Cluster is a candidate for the creation of the combined region, if the set of the regions-candidates in it exceeds the threshold η. The combined region is formed by finding the arithmetic mean of coordinates in candidate regions, which is a part of the cluster. For the formation of face regions between all the ranges of angle slopes there shall be used the factor of quality *w*, determined by the number of candidate regions, which are members of joint region, If the joint regions of different ranges of slope angles intersect more than μ per cent, the region of the face shall be the joint region with higher quality factor. If the joint regions of different ranges of slope angles intersect less than μ per cent, each of the joint regions is accepted as the region of the face.

Experimental research of the method

The suggested method comprises two stages. The first stage segmentates the image into pixels “skin” and “non skin” using color model of the skin, determined by rules (1 - 3), creates binary mask, the color image turns into gray scale image. On the second stage the regions of gray scale image are processed according to the diagram, presented in Fig. 1, the region will be supplied to the input of *KCK1* in case if the filling with unites in this region in the binary mask does not exceed *NN*%.

For the research of this method there had been used the standard and image base of faces FDDB [4]. Images in this base are characterized by wide range of changes: in face orientation, background, illumination and appearance. The standard contains the annotations to each face in the form of elliptical regions as well as set of programs for the evaluation of identification efficiency. During the research of segmentation by color of skin on the test set with 200 color images there had been determined the following parameters of the model of skin color: $V_{\min}^{RG}=1{,}1$, $V_{\max}^{RG}=3{,}1$, $V_{\min}^{RB}=1{,}04$, $V_{max}^{RB}=5$, $V^{R}=55$, $V^{G}=35$ and $V^{B}=25$. The example of segmentation of color images from FDDB base on pixels of "skin" and "non skin" are presented in Fig. 2.

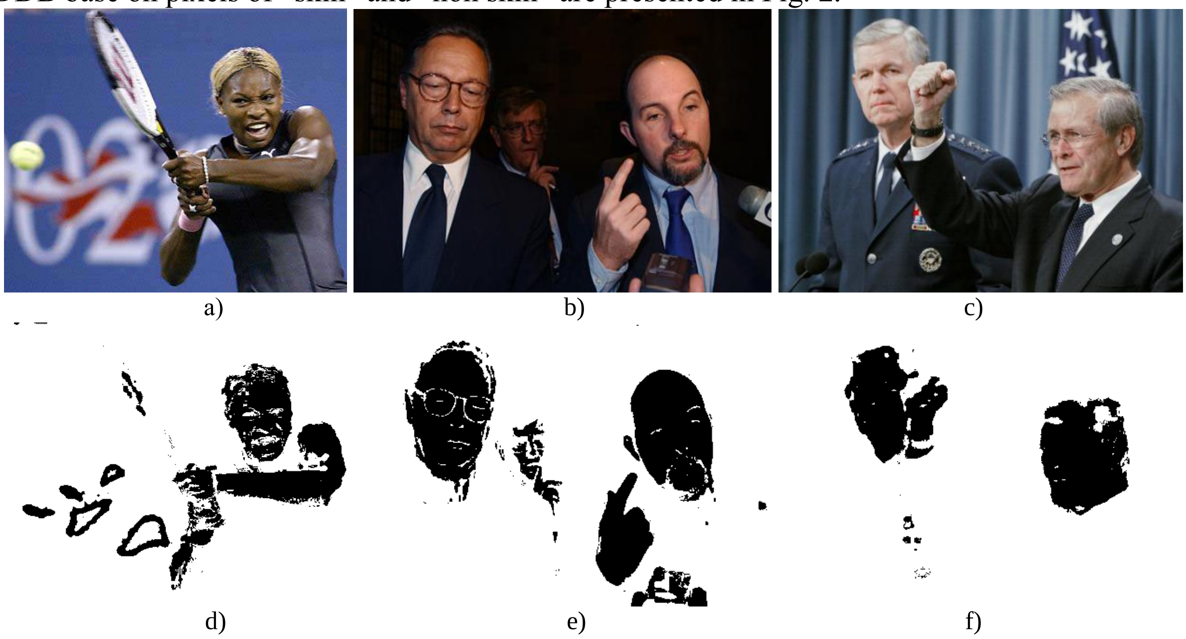

Fig. 2. Example of segmentation of color images from FDDB base on pixels of "skin" and "non skin"»: a – b) original color images; d – f) binary masks, received during the usage of model of skin color

The research of the method had been done at such parameters: number of windows $\eta=2$, scale factor $Ms=1.2$, size of minimum search window (48×48 pixels), size of the kernel *RECT-LBP* – 3×3 pixels, *n_LBP* = 256, shift of search window *Kr* = 1 pixel, percentage of windows intersection φ = 70 %, threshold η = 2, quality factor *w = 2*, percentage of windows intersection μ = 60%, filling the search window in binary mask with unites *NN* = 60%.

For the evaluation of efficiency of identification the test set of 120 color images using AMD 3000+ computer with processor frequency of 1,81 GHz was used. The research results of the developed method and boosting method [1] are presented in Table 1.

Table 1

Results of the research of methods for identification of faces

Evaluation criteria of identification efficiency	Boosting method without segmentation by color of skin [1]	The developed method
Identification probability, %	76,4	75,9
Number of false identifications, pcs	38	31
Identification speed, frames/ per sec.	2 – 4	3 – 6

Conclusions

The developed method of faces identification allows to increase the image processing speed in comparison with boosting-method [1], achieving the decrease by 18% in number of false identifications with insignificant decrease in identification probability on test set from FDDB base.

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