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Data preprocessing for person identification based on color face images

Stepanov D.Y.
Scientific adviser: Lange M.M., Ph.D., ass.prof.
Moscow State Institute of Radioengineering, Electronics and Automation (technical university)
E-mail: DmitryStepanov@mail.ru

Introduction

Pattern recognition is used in such areas as: bioinformatics (molecular modeling, genomic analysis), data mining (data forecasting), document classification (table and scheme detection on images), remote sensing (object classification on images taken from the space), biometrical identification (person identification based on biometrical features) etc. [1].

Applied applications of biometrical identification used in criminalistics, banking area, security services [2]. Nowadays this problem is very important due to high level of economical crimes, fraud, terrorism etc.

There are a lot of methods which can be used for person identification by biometrical features, however, most of them are restricted by input data [3]. In general, person identification process involves information about: face, fingerprint, signature, eye, gesture, speech wave etc. (fig.1).

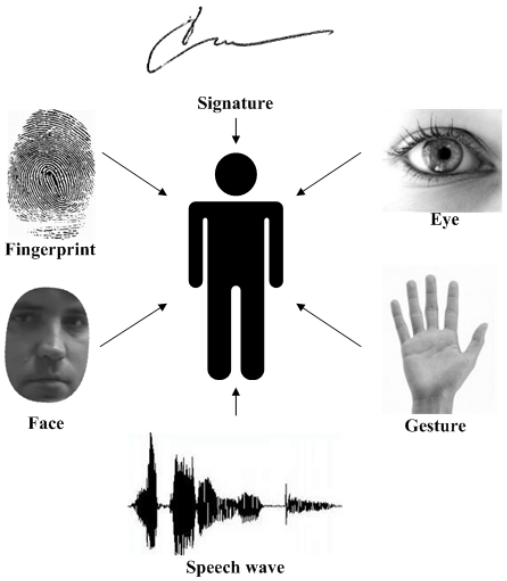

Fig.1. Biometrical features

The problem of data preprocessing is still urgent for any recognition methods because the efficiency of recognition system depends on the quality of input data. Face recognition is the simplest way to identify person, inspite of it we are faced with the necessity to preprocess face images. But how we can do it in the right way?

Statement of problem

Let's restrict problem domain only by taking into consideration face images in color palette. We have to extract face outlines from color images excepting noises like haircut, beard, and ears of the person, which is not relevant for biometrical person identification.

Input data

In our case input data are presented by a set of color face images given by different expressions and views of a person (fig.2), see table 1.

Table 1

Expressions and views

Views / Expressions	full face	raised head	hanged head	head rotation on the left	head rotation on the right	head bending on the left	head bending on the right
normal look	✔	✔	✔	✔	✔	✔	✔
closed eyes	✔	✔	✔	✔	✔	✔	✔
squinted eyes	✔	✔	✔	✔	✔	✔	✔
increased eyes	✔	✔	✔	✔	✔	✔	✔
smile	✔	✔	✔	✔	✔	✔	✔
opened mouth	✔	✔	✔	✔	✔	✔	✔
different positions of eyes		✔	✔	✔	✔		

All images differ from each other by age (time interval between shooting sessions), technical equipment of shooting (digital camera Olympus mju 810 and digital video camera Sony Handycam HDR-SR10E) and illumination (natural and artificial light, different angles of source of light). There are 2852 face images in database (31 persons, 96 realizations per person).

Fig.2. Input images

Data preprocessing

Data preprocessing means face detection and noise erasing on input images. Our proposed procedure consists of follow steps: eyes detection, calculation of face geometrical characteristics and object of interest extraction [4].

We use eyes detection procedure of freeware *OpenCV* to find coordinates of left and right eyes $(x_L, y_L)(x_R, y_R)$ [5]. According to [6] this procedure gives one of the best results in comparison with other methods, moreover, we escape from developing a new technique to solve typical problem. Found coordinates are used to calculate distance *r*:

$$r = \sqrt{(x_R - x_L)^2 + (y_R - y_L)^2} \qquad (1)$$

and parameters of mask-oval which defines informative region of the face. Mask-oval is specified in coordinates (U,V) (fig.3b) calculated next way: axis *U* crosses the center of eyes line and is vertical to this line; center of mask-oval is specified by point on axis *U*, which is far from eyes line on βr where $\beta > 0$; axis *V* crosses this center and moves forward.

Mask-oval is defined by parametrical oval in coordinates (U,V):

$$\frac{U^m}{(\beta_u r)^m} + \frac{V^m}{(\beta_v r)^m} \le 1, \qquad (2)$$

where form parameter $m \ge 2$ and radiuses are specified by $\beta_u > 0$, $\beta_v > 0$ and distance *r* (1). Transformation of rotation and drift connects mask coordinates (U,V) and image coordinates (X,Y) by:

$$\begin{pmatrix} U \\ V \end{pmatrix} = \begin{pmatrix} -\sin\theta & \cos\theta \\ -\cos\theta & -\sin\theta \end{pmatrix} \begin{pmatrix} x - x_0 \\ y - y_0 \end{pmatrix}, \qquad (3)$$

where $x_0 = \frac{1}{2}(x_L - x_R) + \beta r \sin\theta$, $\sin\theta = \frac{y_R - y_L}{r}$,

$y_0 = \frac{1}{2}(y_L - y_R) - \beta r \cos\theta$, $\cos\theta = \frac{x_R - x_L}{r}$.

If we specify parameters β, β_u, β_v, formulas (1) – (3) will allow us to find informative outline of face constrained by oval-mask (fig.3c).

The proposed procedure is invariant to rotation and drift of face images. Image scaling and light normalization can be carried out at the subsequent steps in recognition system.

Experimental results

For experiment, parameters in (2) and (3) were defined as *m* = 2.5, β = 0.5, β_u = 0.8, β_v = 0.6. Face outlines were extracted almost from all images (5% error, due to biometrical features of each person) excepting images with hanged head views (10% error, as it's difficult to describe triangle shape by mask-oval). As a result, it's advisable to exclude hanged head views of images from recognition system input.

Conclusions

In this paper a new method was proposed for face outline extraction from color images using freeware *OpenCV* for eyes detection purposes. This method allows us to normalize all input images to the onlygeneral presentation in which image noises (unimportant features) are deleted.

The method mentioned above was developed [4] and used in [7] for person identification using tree data structures [8].

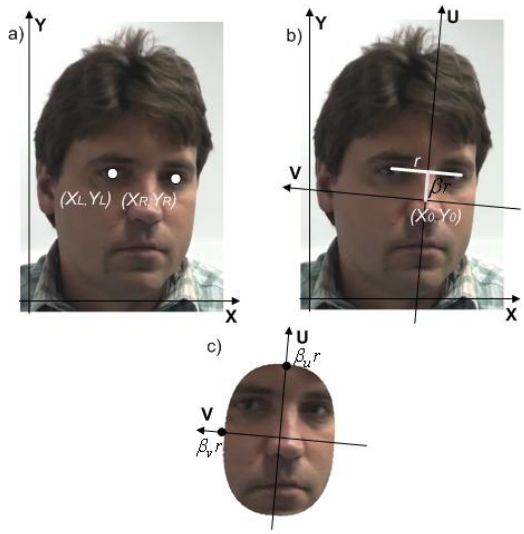

Fig.3. Basic steps to extract face outline.
a) eyes detection; b) calculation of face geometrical characteristics; c) object of interest extraction

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