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ALGORITHM FOR FEATURE EXTRACTION FROM EAR IMAGES ON THE BASE OF DISCRETE COSINE TRANSFORMATIONS

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Abstract

This article is about one of the important issues of identifying a person on the basis of biometric parameters, a method of distinguishing features characterizing the image. It is implemented on the basis of discrete cosine transformation of image characteristics. The study was carried out on the image of the auricle of a person.

Introduction

Recently, a lot of attention has been paid to solving the issue of identifying a person based on biometric characteristics. At present, technologies for recognizing a person based on biometric features such as face image, pupil, fingerprints, and voice are widely used. Biometric technologies can be widely used to solve the following issues [1-3]:

1) identification of a person (verification of credit card users, passport control, criminal and forensic examinations, etc.);

2) identification of a person's goals, abilities and health based on the analysis of his face (physiognomy), pupil images (iridoanalysis, iridodiagnostics), personality (graphology, graphoanalysis) and voice;

3) control of access to and use of closed buildings (scientific laboratories, warehouses, operating rooms, etc.), personal property (house, garage, means of communication, etc.), computing and information resources, and bank terminals.

Methods and algorithms for identification of a person based on the image of the eardrum occupy an important place among biometric technologies [4-6]. It is known that the accuracy and reliability of personal identification systems based on the image of the eardrum is superior to other types of biometric technologies [7]. According to this technology, biometric technology based on personal identification has several advantages over other biometric technologies. First, unlike the human face, the ear does not change much throughout a person's life and according to his mental state. Secondly, in order to obtain an image of the earlobe, in contrast to biometric technologies based on the pupil, no complex devices other than a simple

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camera are required. It can be concluded from this that biometric technologies based on the image of the eardrum have good prospects. Nevertheless, the development of algorithms for identification of a person based on the image of the eardrum and their application in practical issues have not been sufficiently researched. That is why the issue of identifying a person based on the image of the eardrum is in the center of attention of world scientists.

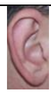
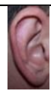
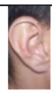
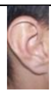
The purpose of the work is to develop an algorithm for extracting features characterizing the image of the eardrum using cosine substitution.

Statement of issue. Suppose we are given an image of an earlobe of approximately the same size (Figure 1):

$$\{T_1, \dots T_i, \dots, T_m\},\ T_i = \|t_{ij}\|_{n\times m},$$

where n is the width of the image, m is the height of the image.

The main problem is to extract the characteristics of given earlobe images using cosine transformation.

	1	2	3	4	5	6	7	8	9	10
1										
	50x100	50x100	50x100	50x100	50x100	50x100	50x100	50x100	50x100	50x100
2										
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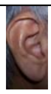
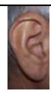
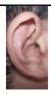
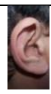
3										
	50x100	50x100	50x100	50x100	50x100	50x100	50x100	50x100	50x100	50x100
4										
	50x100	50x100	50x100	50x100	50x100	50x100	50x100	50x100	50x100	50x100

Figure 1. Initial images.

A way to solve the problem. It is more convenient to work on grayscale images than on color images in the process of segmentation of the earlobe image. Therefore, the image of the auricle is converted to a gray image in many cases during segmentation. Because color images are processed in three channels, i.e. 256^3=16777216 colors are processed, and gray image is processed in one channel, i.e., since the color value of the point in the images is between 0 and 255, the work performed on the gray image is much simpler.

Below is the process of converting a color earlobe image to a grayscale image:

$$T_{ij} = 0{,}3 \cdot R_{ij} + 0{,}59 \cdot G_{ij} + 0{,}11 \cdot B_{ij},$$

where T_{ij} is the gray light value of the pixel at the i, j coordinate of the given color image, and $R_{ij}, G_{ij}, B_{ij}$is equal to the light values of red, green, and blue colors, respectively.

Discrete cosine substitution generally takes the following form[8-10]:

$$D(i,j) = \frac{1}{\sqrt{2N}} C(i)C(j) \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} T(x,y) \cos\left[\frac{(2x+1)i\pi}{2N}\right] \cos\left[\frac{(2y+1)j\pi}{2N}\right] \quad (1)$$

$$C(u) = \begin{cases} \frac{1}{\sqrt{2}}, u = 0 \\ 1, u > 0. \end{cases}$$

where $T(x, y)$ is the color value of the image in the x and y coordinates.

In particular, when the window size is 8×8, the discrete cosine transform looks like this:

$$D(i,j) = \frac{1}{4} C(i)C(j) \sum_{x=0}^{7} \sum_{y=0}^{7} T(x,y) \cos\left[\frac{(2x+1)i\pi}{16}\right] \cos\left[\frac{(2y+1)j\pi}{16}\right]$$

To get formula (1) in matrix form, we use the following formula:

$$P_{i,j} = \begin{cases} \frac{1}{\sqrt{N}}, i = 0 \\ \sqrt{\frac{2}{N}} \cos\left[\frac{(2j+1)i\pi}{2N}\right], i > 0. \end{cases}$$

When we calculate the value of this matrix in an 8×8 window, the result is as follows:

$$P = \begin{bmatrix} 0.35 & 0.35 & 0.35 & 0.35 & 0.35 & 0.35 & 0.35 & 0.35 \\ 0.49 & 0.41 & 0.27 & 0.09 & -0.09 & -0.27 & -0.41 & -0.49 \\ 0.46 & 0.19 & -0.19 & -0.46 & -0.46 & -0.19 & 0.19 & 0.46 \\ 0.41 & -0.97 & -0.49 & -0.27 & 0.27 & 0.49 & 0.09 & -0.41 \\ 0.35 & -0.35 & -0.35 & 0.35 & 0.35 & -0.35 & -0.35 & 0.35 \\ 0.27 & -0.49 & 0.09 & 0.41 & -0.41 & -0.09 & 0.49 & -0.27 \\ 0.19 & -0.46 & 0.46 & -0.19 & -0.19 & 0.46 & -0.46 & 0.19 \\ 0.09 & -0.27 & 0.41 & -0.49 & 0.49 & -0.41 & 0.27 & -0.09 \end{bmatrix}$$

In grayscale images, the color value at a point is between 0 and 255.

Discrete cosine shift is designed to shift pixel values in the range -128..127. Therefore, we subtract 128 from each pixel of the given image.

$$M[i,j] = T[i,j] - 128$$

We calculate the discrete cosine shift in the following form:

$$D = PMP'$$

where the P' matrix is the transpose of the P matrix.

We perform quantization on the resulting matrix.

$$C(u,v) = \left[\frac{D(u,v)}{Q(u,v)}\right]$$

where $Q(u,v)$ is the quantization matrix.

$$S_q = \begin{cases} 5000/S_q, S_q < 50, \\ 200 - S_q * 2, else. \end{cases}$$

$$S_q = \overline{1{,}100}.$$
$$Q(u,v) = (N[u,v] * S_q + 50)/100,$$

where N(u,v) is the standard matrix. It looks like this:

$$N(u,v) = \begin{bmatrix} 16 & 11 & 10 & 16 & 24 & 40 & 51 & 61 \\ 12 & 12 & 14 & 19 & 26 & 58 & 60 & 55 \\ 14 & 13 & 16 & 24 & 40 & 57 & 69 & 56 \\ 14 & 17 & 22 & 29 & 51 & 87 & 80 & 62 \\ 18 & 22 & 37 & 56 & 68 & 109 & 103 & 77 \\ 24 & 35 & 55 & 64 & 81 & 104 & 113 & 92 \\ 49 & 64 & 78 & 87 & 103 & 121 & 120 & 101 \\ 72 & 92 & 95 & 98 & 112 & 100 & 103 & 99 \end{bmatrix}.$$

This step is a level of compression control, which reduces the low frequency values to zero. We can transform the elements of the 8x8 matrix into a vector in the form of a "zig-zag".

We create the encoding process by determining the number of zeros in front of the non-zero elements of our resulting vector. For example, we get the following result from the vector 125 45 0 0 0 -48 96 0 0 0 0 78 ... (0.125), (0.45), (3.48), (0.96) (4.78) . ...

We restore images as follows:

$$R_{ij} = Q_{ij} \times C_{ij},$$
$$I = Round(P'RP) + 128.$$

By compressing the images, the features of the earlobe image were extracted and used in person recognition. The results obtained using the k-nearest neighbors method are shown in Figure 2 below.

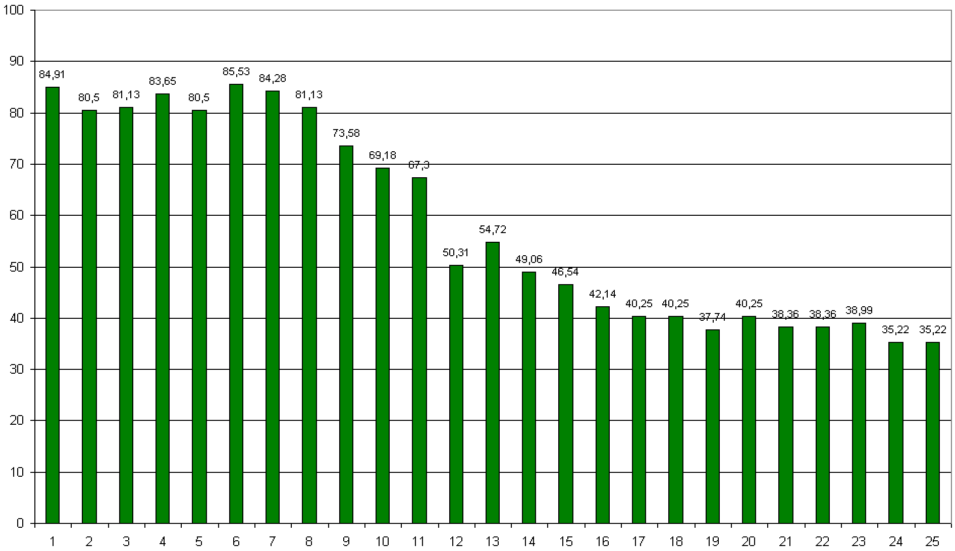


Figure 2. Results obtained by the k-nearest neighbors method.

Experimental study of the developed algorithm. In order to solve a practical problem using the proposed algorithm, a program for distinguishing earlobe image symbols was developed in Python language and Pycharm environment. In order to check the functional capabilities of this program, the problem of distinguishing the characteristics of the images of the eardrum of 30 people was solved. In this, 40 images of the eardrum were taken for each class.

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From the obtained results, it can be seen that the more the image of the auricle is compressed, the more the recognition accuracy increases. This result is a good result in all respects, and by reducing the number of characters, the speed of the program is significantly increased.

An algorithm for identifying characters based on the earlobe image is proposed. The model of these feature extraction algorithms is based on extracting features characterizing the image of the eardrum using discrete cosine transformation of the initial images. The developed model can be used in the organization of software packages of various types aimed at solving the problem of classification of objects given in the form of an image.

Based on the proposed algorithm, an algorithm and a software tool for forming representative symbols of eardrum images were developed. The algorithm presented above is aimed at solving the problem of identification of a person based on the image of the eardrum.

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