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ALGORITHM FOR EXTRACTION OF IDENTIFICATION FEATURES IN EAR RECOGNITION

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ABSTRACT
The algorithm for feature extraction with the help of cosine transformation in ear recognition is presented. The software was developed on the base of proposed algorithm. The proposed algorithm was tested on solving the problem of person identification by ear images.
KEYWORDS: biometrics, digital image, image processing, recognition, cosine transform, feature extraction.

INTRODUCTION
Biometric personal identification is an important research area aiming at automatic identity recognition and is receiving growing interest from both academia and industry [1]. There are two types of biometric features: physiological (e.g. face, iris pattern and fingerprint) and behavioral (e.g. voice and handwriting).
In machine vision, ear biometrics refers to the automatic measurement of distinctive ear features with a view to identifying or confirming the identity of the owner. It has received scant attention compared with the more popular techniques of automatic face, eye, or fingerprint recognition [2]. Ears have certain advantages over the more established biometrics; as Bertillon pointed out, they have a rich and stable structure that is preserved well into old age. The ear does not suffer from changes in facial expression and is firmly fixed in the middle of the side of the head so that the immediate background is predictable, whereas face recognition usually requires the face to be captured against a controlled background [9-13]. Collecti on does not have an associated hygiene issue, as may be the case with direct contact fingerprint scanning, and is not likely to cause anxiety, as may happen with iris and retina measurements. The ear is large compared with the iris, retina, and fingerprint and therefore is more easily captured, although less so than the face or gait.

STATEMENT OF THE PROBLEM.
Let’s assume that m ear images with the same size are given (Fig. 1.):

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

here n-image width, m-image height.
The problem is to extract identification features from ear images with the help of cosine transform.

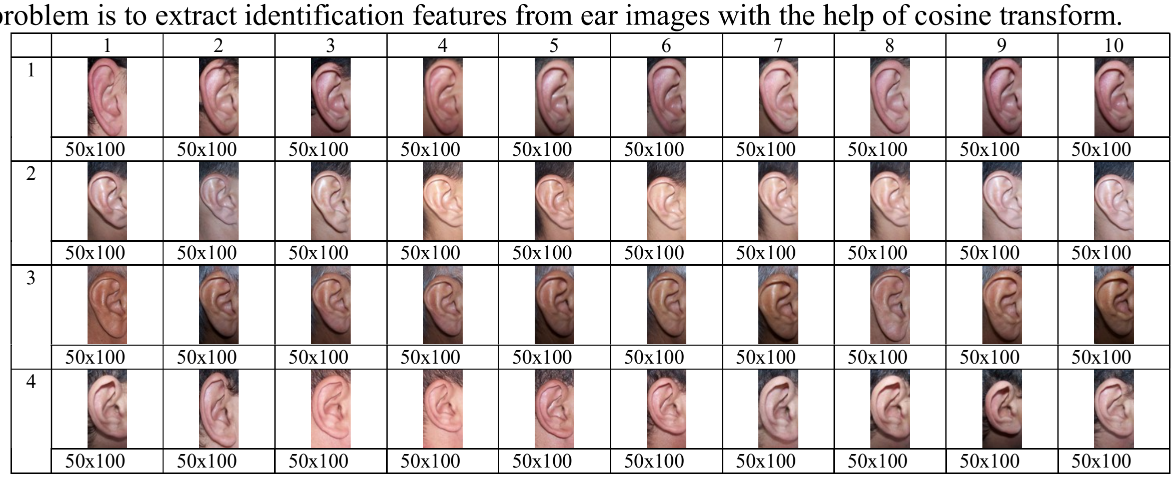

Fig.1. Initial images.

METHOD OF SOLVING THE PROBLEM.

Images with ear rings, other artifacts and occluded with hairs have not been processed in this research work. Each image is gone through the following steps before feature extraction: (i) ear image is cropped manually from the complete head image of a person; (ii) cropped ear image is resized; (iii) colored image is converted to grayscale image [3]. Manual cropping has been done in the work because automated ear cropping is under process. The sizes of cropped ear image are different. In order to find same number of features from each ear image, resizing the images to unique fixed size is made. Each image was converted from RGB to grayscale (if not in grayscale). Then it was sent to feature extraction module. The feature extraction is carried out on the base of cosine transform. General form of the discrete cosine transform is as follows [4-8]:

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

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

where $T(x,y)$ - color values at the point with coordinates x and y.

When window size is equal to 8×8, the cosine transform equation has the following form:

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

To convert formula (1) to matrix form we use the following formula:

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

We get the following result when matrix is calculated in the window 8×8:

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

Since the 2D DCT can be computed by applying 1D transforms separately to the rows and columns, we say that the 2D DCT is separable in the two dimensions. As in the one-dimensional case, each element $D(i, j)$ of the transform is the inner product of the input and a basis function, but in this case, the basis functions are *8* x *8* matrices. Each two-dimensional basis matrix is the outer product of two of the one-dimensional basis vectors.

We calculate 2D DCT by the following formula:

$$D=PMP^{'}$$

where P' matrix is transponent to the matrix P.

Then quantization is performed on the obtained matrix.

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

where $Q(u,v)$ - quantization matrix.

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

$$S_q = \overline{1,100}.$$

$$Q(u,v) = (N[u,v] * S_q + 50)/100,$$

where $N(u,v)$ - standard matrix. It has the following general form:

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

This is the step for controlling image compression degree, the low frequency values are filtered in it.
Coding is performed by counting zero numbers before the non-zero elements of the obtained vector.
Image restoring is performed as follows:

$$R_{ij} = Q_{ij} \times C_{ij},$$

$$I = Round(P^{'}RP) + 128.$$

Identification features are extracted from ear images by using cosine transform. These features can be used for person identification on the base of ear images. The simple geometric distance based recognition method is used for comparing images. The main idea of this method is that the distance between objects of the same class is less that the distance between objects of the different classes. The distance between object and objects of the class K_u is calculated by the following formula:

$$D_u = \frac{1}{m_u} \sum_{v=1}^{m_u} \sum_{i=1}^{n} (a_{iv} x_i)^2.$$

Let D_u - be the distance between unknown object S and class $K_u (u = \overline{1,i})$. If $D_j = \min_{1 \le u \le l} \{D_u\}$, then S belongs to the class K_j and it is calculated as follows:

$$d_i = \frac{1}{D_j \sum_{\substack{v=1 \\ v \ne j}}^{l} D_v^{-1}}$$

EXPERIMENTALLY TESTING OF THE PROPOSED ALGORITHM.

The software complex for features extraction from ear images and person recognition was developed in the Delphi programming environment by using the proposed algorithm in. 40 ear images for each person (totally 240 images) were used to test of the software in feature extraction and identification for 6 people.

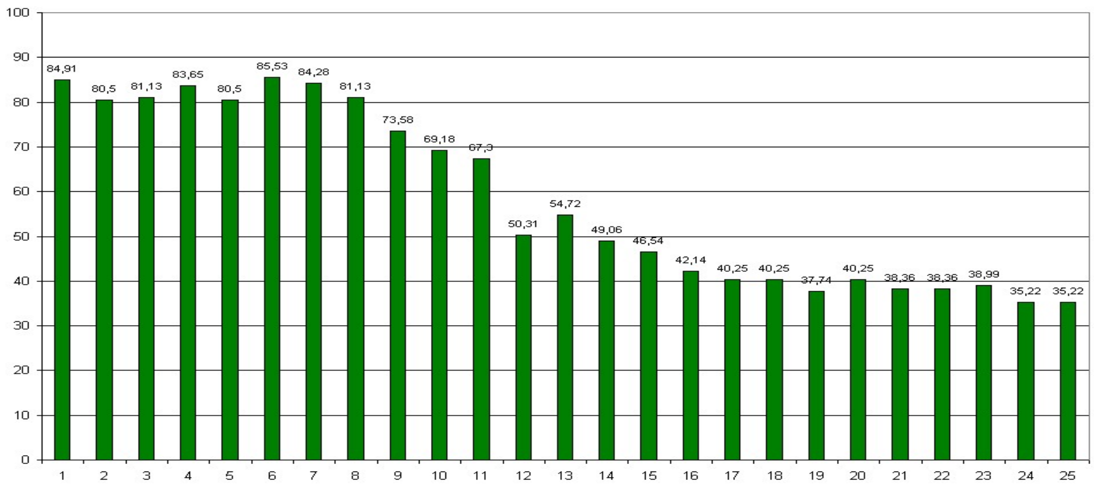

Fig.2. Recognition result

CONCLUSIONS.

The using of DCT for ear feature extraction is new approach in this direction. Using discrete cosine transform for ear images makes it possible to reduce the time and number of calculations for extracting identification features from ear images. This algorithm can be applied to the person identification on the base of ear images.

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