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An Improved Normalization Method for Ear Feature Extraction

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Abstract

As a new biometric identification technology, the theory and application research of ear recognition has attracted more and more attention of scholars in recent years. Image-preprocessing and normalization of ear image is very important for the feature extraction. In this paper we apply the improved morphological filtering method to preprocessing the ear image. And we propose the angle normalization method by geometrical parameters. This method has the advantages of scaling invariance, translation invariance and rotation invariance. The normalization results are reasonable and good for later feature extraction.

Keywords: *ear recognition normalization image preprocessing*

1. Introduction

Ear recognition is a new biometric identification technology, the interest in ear recognition has grown greatly in recent years. There are many advantages of using ear feature for person identification. The appearance if ear does not change over the curse of human life. Ear features are relatively fixed and unchangeable; it is not affected by the expression, age and other effects. According to the advantages of uniqueness and stability, ear recognition has board space for development and application [1].

As a new biometric identification technology, the theory and application research of ear recognition has attracted more and more attention of scholars in recent years. Burge and Burger [4] proposed an approach based on voronoi diagrams. Hurley, Nixon and Carter have given a system based on force field feature extraction. The system proposed by Choras is based on geometric feature extraction. Ear recognition from 2D images is developed in Chen and Bhanu proposed an approach based on contour matching. The static image of ear recognition problem can be divided into three categories according to the input image: ear recognition based on the two-dimensional image, the 3D ear recognition and ear pattern recognition. In general, ear recognition system consists of the following steps: (1) Image acquisition (2) Image preprocessing (3) Feature extraction (4) Template matching and identification.

Ear recognition system still has many problems. The major problems in ear recognition are attitude problem, the noise on the ear image and the extraction of the specific key points. These problems will severely affect the recognition performance. In this paper we apply the improved morphological filtering method to deal with the problem of the noise on the ear image. And we propose a straightforward geometrical method to extraction ear features. We use a relatively constant volume – the longest ear axis in the ear contour image, and the center of mass as the reference parameters. We perform the angle normalization by the geometrical parameters, so the description of ear characteristic data will not affected by the image scaling, translation, rotation

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changes. It better solve the attitude problem. Experiments show that the recognition performance can be improved compared to that of PCA method.

2. Image Pre-processing

The main purpose of image preprocessing is to eliminate irrelevant information of the ear image, recovery of useful information, and strengthen the relevant information and maximally simplified ear feature data, thereby improving the recognition rate. In general, image preprocessing consists of geometric transformation, normalization, smoothing, restoration and enhancement. Commonly used image processing methods include histogram method, gray stretch processing and filtering technology.

2.1. Morphological Reconstructions

The image preprocessing method based on morphological reconstruction algorithm improves the simple morphological expansion, corrosion, open operation, closing operation, has better filtering effect, and greatly improves the image quality. Morphological reconstruction is a powerful operation in Mathematical Morphology that inserts the concept of connectivity in images, both for binary and gray scale. Morphological filters by reconstruction have the property of simplify the images while preserving contours. This property makes them really attractive to an extensive number of applications as noise reduction and segmentation.

In specific two filters were used for these experiments which are opening by reconstruction and closing by reconstruction. Opening by reconstruction requires removing pixels of the foreground from an image by any given criteria and in reconstructing all connected components of the image that had not been totally removed. Closing by reconstruction is the dual of the opening by reconstruction.

The basis of an opening by reconstruction is the reconstruction of image f from an arbitrary marker g. This is usually defined using geodesic dilations $\overline{\delta}_f$ defined as [5]:

$$\overline{\delta}_f^1(g) = f \wedge \delta(g) \tag{1}$$

This operator is used iteratively until stability, to perform the reconstruction ρ

$$\rho(f \mid g) = \lim_{n\to\infty} \overline{\delta}_f^n g = \underbrace{\overline{\delta}_f^1 \cdots \overline{\delta}_f^1 \overline{\delta}_f^1(g)}_{untilstability} \cdot \tag{2}$$

An opening-by-reconstruction $\overline{\gamma}_X$ with structuring element X is computed as

$$\overline{\gamma}_X(f) = \rho(f \mid \gamma_X(f)) \tag{3}$$

In which γ_X denotes an opening of f by X. Reconstructing from this marker preserves any connected component in which X fits at least one position. Closing-by-reconstruction $\overline{\phi}_X$ can be defined by duality:

$$\overline{\phi}_X(f) = -\overline{\gamma}_X(-f) \tag{4}$$

Openings-by-reconstructions are anti-extensive, and closings-by-reconstructions are extensive, removing bright or dark image details respectively. We can compute a leveling of $\lambda(f \mid g)$ of f from maker g as

$$(\lambda(f \mid g))(x) = \begin{cases} (\rho(f \mid g))(x) & if \quad f(x) \geq g(x) \\ -(\rho(-f \mid -g))(x) & if \quad f(x) \leq g(x) \end{cases} \tag{5}$$

Leveling allow edge-preserving simplification of images, by simultaneously removing bright and dark details.

2.2. Complement of Image

We take the complement of image in order to better highlight the ear portions of the image. Take the opposite value of the current point pixel value and then sum with 255, and then take the value as the current point pixel.

2.3. "Top-hat" by Reconstruction

In ear recognition, noise and partial occlusion on the ear image are unavoidable. These two problems will affect the feature extraction and severely degree the recognition performance. In order to improve the contraction of the ear image, this paper uses the top-hat combining with morphological reconstruction filtering method for image enhancement.

Top-hat transformation is based on the morphological dilation and erosion operation function, it is a good high-pass filtering operator. It consists of opening and closing top-hat operator according to the different use of opening and closing operator. Top-Hat operator can detect the peak of the image; Bottom-hat operator can detect the image of the valley. In the gray image analysis, this method is effective to mark dark pixels aggregates in a bright background or bright pixel aggregates in dark background. The morphological top-hat transform combined with morphological reconstruction effectively remove the shadows and reflections of the light in the background. The top-hat transformation operator is defined as:

$$top\text{-}hat(f) = f - (f \cdot g) \tag{6}$$

The bottom-hat transformation operation is defined as:

$$bot\text{-}hat(f) = (f \cdot g) - f \tag{7}$$

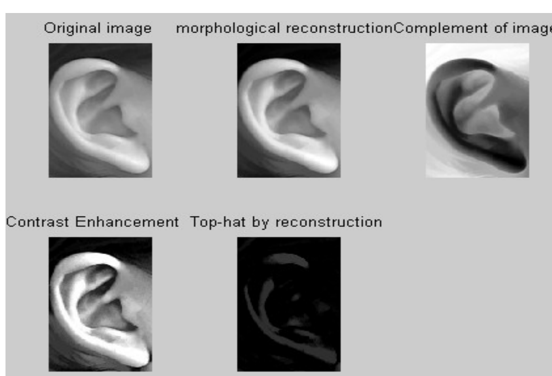
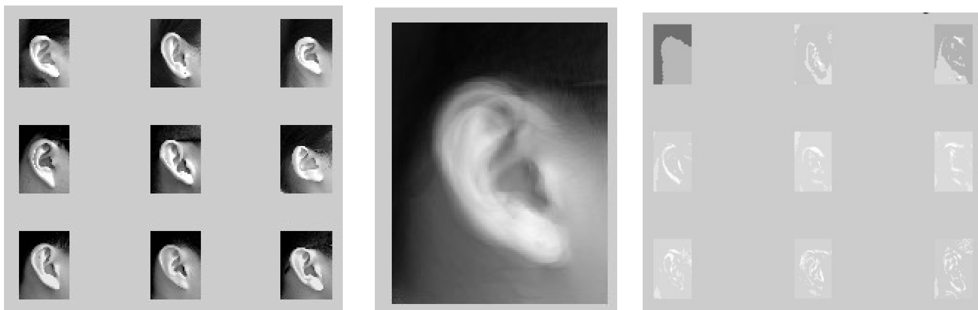


Figure 1. Image Preprocessing

The morphological reconstructions help to smooth the ear shape contours, break narrow isthmuses, and eliminate small islands and occasional sharp peaks of the image. The top-hat operation is quite effective to highlight objects in the complex background. The ear shape contours are enhanced and more effectively connected after this operation. In summary, series of employed morphological operations help to significantly accentuate the structural information corresponding to the ear shape in the images. Figure 1 show the result of image preprocessing.



(a) (b) (c)

Figure 2. PCA method (a) is the Original Image, Figure (b) is the Mean Image of the Input Images and Figure (c) is the global Features of the Vector

3. Edge Detection of the Outer Contour

Ear feature extraction methods are mainly divided into two categories, the first category is based on the global characteristics of the integral image. This category of method describes the ear as the integral feature, it uses statistical or algebraic methods to extract global features of the vector and reflects the essence of the image, such as PCA, ICA. But this category of methods is sensitive to the ear pose, size and light conditions. Figure 2 show the main processing of PCA method. Figure (a) is the original image, Figure (b) is the mean image of the input images and Figure (c) is the global features of the vector, it reflects the essence of the image. Experiments show that the description of ear characteristic data will affect by the image scaling, translation, rotation changes. The second category is based on local feature vector expression; it uses the shape feature and curve characteristic point of the era image. This category of method has lower computational complexity; the recognition rate is based on the characteristics of the precision of edge extraction, so the edge detection is very crucial.

The edge detection is a fundamental module in the feature extraction, since it is obvious that lines are the most prominent features that could be obtained from the ear image, and our goal is to detect major outer of the ear image. We test many methods such as Canny operator, Sobel operator, log operator, morphological gradient method. Part of the contour lines are mixed together with the neck and facial skin, the edge contour is not obvious. Most methods are difficult to correctly extract the external edge information, the contour is discontinuity. Canny operator, Sobel operator, log operator are not suitable for the edge detection. Figure 3 show the Edge detection of the outer contour.

In this paper, we firstly convert the images to binary images using Otsu's threshold, and then we track the boundary of binary images to generate the ear shape boundary. They are manually cropped ear images from subjects in different poses. Experiments and performance on the ear image show that this method is efficiently for the outer ear contour extraction in Figure 4.

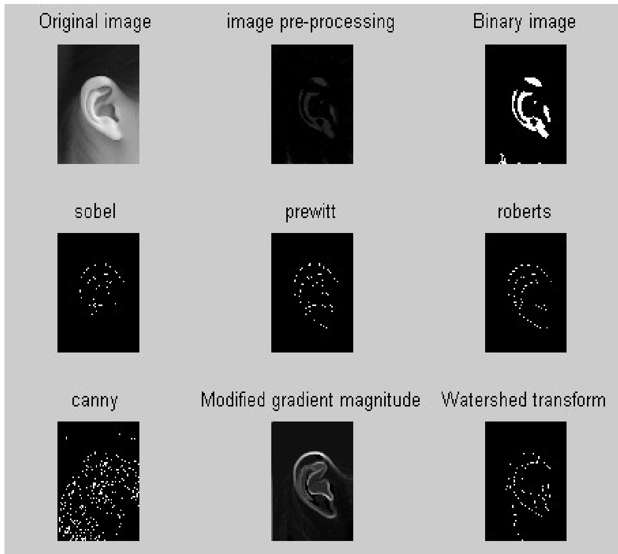


Figure 3. Edge Detection of the Outer Contour

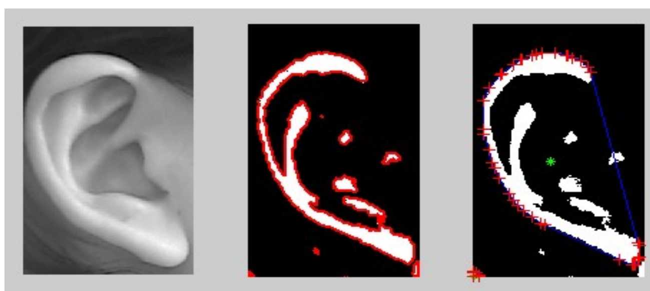


Figure 4. Outer Ear Contour Extraction

4. Geometrical Feature Extraction

Ear feature extraction is the core part of ear recognition. This paper we focused on the extraction of the external ear shape feature. The shape of the outer ear has been recognized as a valuable means for personal identification. The selection of feature vector is to ensure the easy identification, high reliability and good invariance. The characteristic vector will constant or nearly constant in order to facilitate target identification, no matter how image target changes, including translation, rotation and scaling. And the selection of feature vector should also ensure the correctness of target recognition [3].

We propose a straightforward geometrical approach to extract features. It is automated and no manual operations are needed. Outer ear feature extraction is the first step of ear feature extraction, and it is very important for the following step. Therefore, how to extract the outer ear contour feature is the key of the study. The edge information of the ear is rich and stable and it is quite unique in individuals. Due to the differences of ear contours, ratio of the angle and the lines that formed by some special points on the outer ear contour is different. And the curvature of the external edge curves at different locations combines with some inflection points is also different. We defined the longest axis as the connection of the highest point and the lowest point on the outer ear contour. We found the ratio of the longest axis and the arc length between the highest point and the lowest point is different. So this paper we take the long axis and the center of mass as the geometrical parameters for standard vector representation. And we perform the angle normalization by the geometrical parameters.

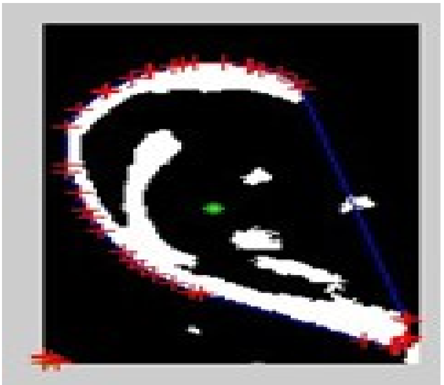


Figure 5. Feature Points Extraction

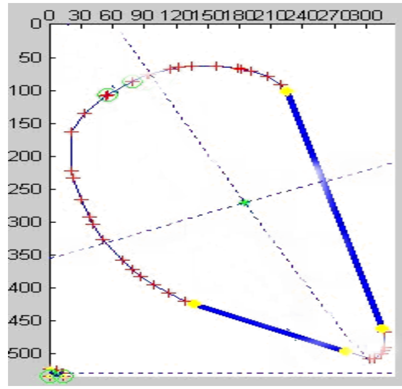


Figure 6. The Convex Polygon

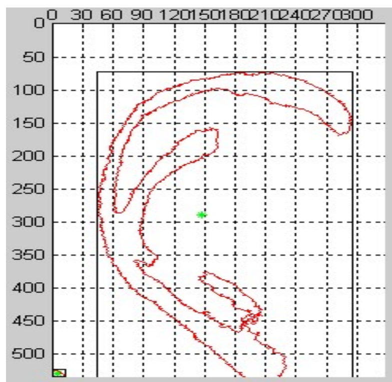


Figure 7. Normalization Results

The angle normalization for the feature extraction is consists of the following steps:

A. The feature extraction of the ear outer shape. Firstly we selected a number of feature points on the edge of the outer ear in order to extract the shape feature. Figure 5 show the results.

B. We find out the distance from the highest point and the lowest point on the outer ear contour. We defined the longest axis as the connection of the highest point and the lowest point on the outer ear contour. In the human ear, the relative position of the longest axis in the ear image is never changed. It has the advantages of scaling invariance, translation invariance and rotation invariance. The contour length is calculated according to:

$$L_C = \sum_{q=1}^{Q=1} \sqrt{\left(x_{q+1} - x_q\right)^2 + \left(y_{q+1} - y_q\right)^2} \tag{8}$$

Q is the Number of contour points. C is the number of contours, for C=1,…,C. (x,y) is the coordinates of contour points. This step is shown on Figure 6.

C. The center of mass is a global descriptor, the coordinates of the center of mass is calculated according to the points that all belong to the region. The coordinate formula of center of mass is calculated as follow (A is the area of the region):

$$\bar{x} = \frac{1}{A} \sum_{(x, y \in R)} x$$
$$\bar{y} = \frac{1}{A} \sum_{(x, y \in R)} y \tag{9}$$

The convex polygon is the smallest convex set containing the boundary. After we get the center of mass, we extract the vertex coordinates of the convex polygon in the labeled ear image. Then we extract the convex polygon of the ear image. Then we can get the centroid axis and the vertical axis of the convex polygon according to the slope and the center of mass. Finally, we performed angle normalization of the ear image according the geometrical parameters we calculated above. Figure 7 show the result of angle normalization. The normalization results are reasonable and good for later feature extraction.

5. Conclusion

In this paper we apply the improved morphological filtering method to deal with the problem of the noise on the ear image. And we propose a straightforward geometrical method to extraction ear features. We use a relatively constant volume – the longest ear axis in the ear contour image, and the center of mass as the reference parameters. We perform the angle normalization by the geometrical parameters, so the description of ear characteristic data will not affected by the image scaling, translation, rotation changes. It better solve the attitude problem. The normalization results are reasonable and good for later feature extraction.

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