Ear Biometrics Using Images Similarity Matching Measures

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Abstract

This paper interest in studying the structure of the human ear, justification for using ear as biometric for Person identification / authentication, and investigating a new approach using image processing, normalize the image by using (Closest Row-Column) method, and matching with similarity measures. A matching performance in the training images set of recognition method achieved a rate of about 89 %

1-Introduction

The term "Biometrics" stems from Greek words bio and metric, meaning "life measurements". The science of life measurement is based on the "measurable body characteristics" that include both the physiological and behavioral characteristics. Physiological or static biometrics verifies fingerprints, hand geometry, facial features and iris/retina patterns, that is, characteristics that do not change over a person's lifetime. Behavioral or dynamic biometric systems analyze voice, lip movements, signing movements and keyboard dynamics. These change from instance to instance because an individual never speaks, signs a document or types exactly the same way every time. These characteristics are unique to each individual and are therefore unmistakable, indisputable and undeniable. Hence, biometrics is a science that verifies a person's identity by measuring their physiological or behavioral characteristics.

Biometrics based upon the ear are viable in that the ear anatomy is probably unique to each individual and that features based upon measurements of that anatomy are comparable over time.

Ear is also smaller than face which mean that is possible to work faster and more effetely with the images with lower resolution.

In the process of acquisition, in contrast to face identification systems, ear images cannot be disturbed by glasses, beard nor make-up. However, occlusion by hair or earrings is possible, but in access control applications, making ear visible is not a problem for user and takes just single seconds (see figure 1).

Identification by ear biometrics is promising because it is passive like face recognition, but instead of the difficult to extract face biometrics it can use robust and simply extracted biometrics like those in fingerprinting[1].

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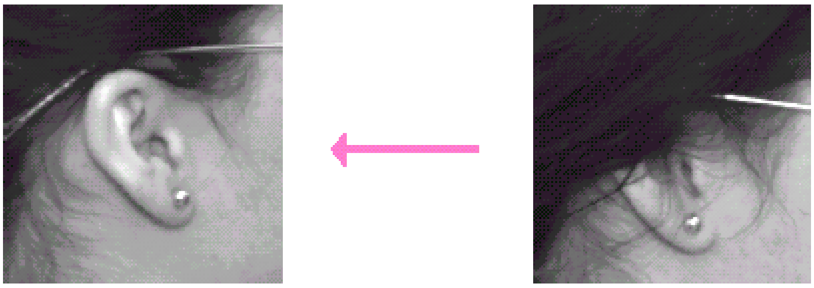


Fig. 1. Ear visibility can be easily achieved in applications allowing interaction with the user (for example access control systems).

The ear structure is quite complex as shown in figure 2, but the question is, if it is unique for all individuals.

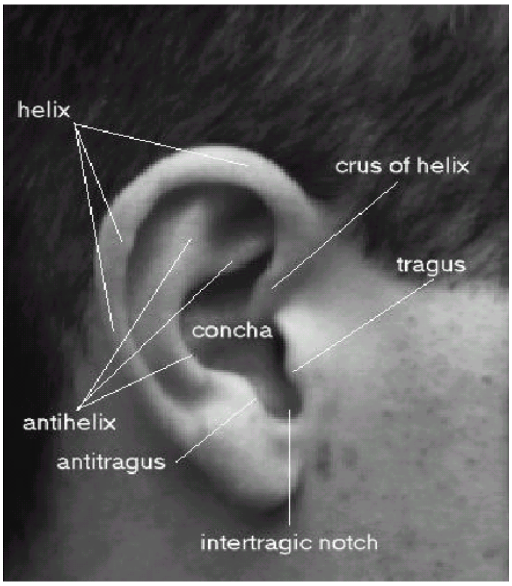


Fig. 2. Ear Structure.

Here is some researchers have been investigated the ear biometric for recognition system.

Hurley, 2001 [5] have introduced a method based on energy features of the image. He used force field transformations in order to find energy lines, wells and channels for ear recognition. The image is treated as an array of Gaussian attractors that act as the source of the force field.

Chang, et. al.,2003 [2] have made another comparison between ear and face images in appearance-based biometrics. There were 197 subjects in the training set; each had both face image and ear image taken under the same conditions and the same image acquisition session. If the face or ear was covered in the picture, they were leaved out from this research.

There were three experiments: (i) day variation experiment, (ii) lightning condition variation experiment, and (iii) pose variation experiment with 22,5 degree rotation. The null hypothesis was that there is no significant difference between using the face or the ear as a biometric when using the same PCA-based algorithm,

same subject pool and controlled variation in the used images. The recognition rate for ears was 71.6 percent and for face 70.5 percent.
According to the researchers this feature extraction technique is robust and reliable and it possesses good noise tolerance.

Burge, et. al., 2005 [1] have build neighborhood graph from Voronoi diagram of its curve segments for automating ear biometrics. They have used a novel graph matching based algorithm for authentication, which takes into account the possible error curves, which can be caused as an example by lightning, shadowing and occlusion.

Victor, et. al., 2005 [6] have made a comparison between face and ear recognition. They used principal component analysis (PCA, also known as "eigenfaces"). The process consists of three steps: i) Preprocessing, ii) Normalization, and iii) Identification. In the preprocessing step, two distinct points are supplied to the normalization routine: Triangular Fossa and the Antitragus. The normalization step includes geometric normalization, masking and photometric normalization. Next all non-ear areas, like hair, background etc. are masked. Different levels of masking are experimented for finding the best one to get as good performance as possible for the algorithm. Finally the images are normalized for illumination.

There are two phases in the identification phase: training and testing. In the training phase the eigenvalues and eigenvectors of the training set are extracted and the eigenvectors are chosen based on the top eigenvalues. They have decided not to use any specific gallery but have a general representation of both ears and faces. Training set is a set of clean images without any duplicates. In the testing phase the algorithm is provided a set of known ears and faces and a set of unknown ears and faces as the probe set. The algorithm matches each probe to its possibly identity in the gallery.

2- Justification for Using Ear Biometrics.

Human ears have been used as major feature in the forensic science for many years. Recently so called earprints, found on the crime scene, have been used as a proof in over few hundreds cases in the Netherlands and the United States [4]. However, still the automated system of ear recognition hasn't been implemented even though there are several reasons for using the ear as a source of data for person identification as described as follows.

Distant and Size for Passive Identification. With comparable to the iris biometrics which represent as a passive identification, iris-based recognition has been reported to be successful at distances of up to 46 cm [1], while ear-based recognition has been reported to be successful at distances of up to 4 m. The size of the ears are relevant. The decided disadvantage of the iris is the small size which make the image acquisition from a distance, and therefore passive usage, problematic. With comparable to the face image, the ear is smaller than the image of the face which mean that it is possible to work faster and more efficiently with the images with lower resolution.

Face Changes Due to Expresses. The ear expression does not suffer from changes. Face can change due to makeup, facial hair, hair style and cosmetics. Face can also change expression including sadness, happiness, fear or surprise.

Position. The ear is firmly fixed in the middle of the side of the head so that the intermediate background is predictable, whereas face recognition usually requires the face to be captured against a controlled background [5].

From Point of View of Medical Aspect, ear does not change considerability during human life. It is obvious that the structure of the ear does not change radically over time. The medical literature reports that ear growth after the first four months of birth is proportional. It turns out that even though ear growth is proportional, gravity can cause the ear to undergo stretching in the vertical direction. The effect of this stretching is most pronounced in the lobe of the ear, and measurements show that the change is non-linear. The rate of stretching is approximately five times greater than normal during the period from four months to the age of eight, after which it is constant until around 70 when it again increases [1].

From point of view of hygiene issue. Ear measurements 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 [5].

3- Matching With Similarity Measure.

The set of training images, consist of data for 100 subjects, each of whom had an ear image under the same conditions of lighting, distant and high resolution.

The establishment of this study is design a general form to reflect both the positioning of the feature points (in image A and image B) and the contribution of any attribute in image B that may be associated with these feature points in image A.

A method consists of the following steps, acquisition the image, edge extraction**,** edge linking**,** normalization, the similarity measure and the matching process.

Color Images Acquisition is taken of the subject's head in profile using a digital camera, and transform these images to grayscale to be able to extract edge detection in the later step, see figure 3(a).

The user who tested for authentication must wear a black cap and extract only the ear from it. This cap isolated the ear and acts as a black background for the ear image as shown in figure 3(b).

(A) **(B)**

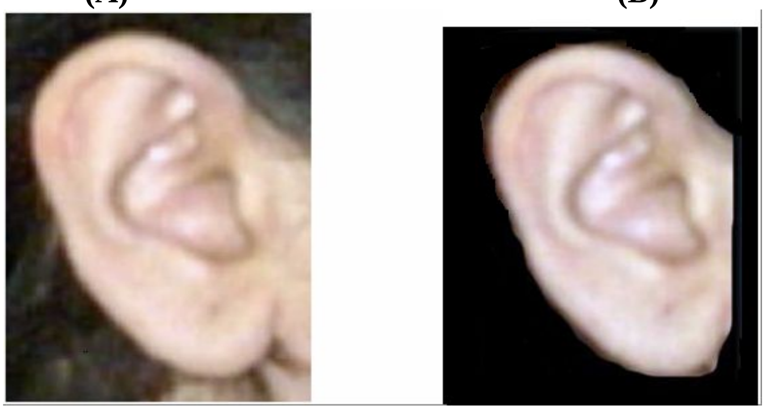


Figure (3) Original Image. (a) Before Wearing a Cap.(b) after Wearing a Cap.

Edge Extraction is computed to detect major outer and inner curves of the ear. We tested many known methods such as sobol, robert, prewitt, sobol filter determined empirically, but there is a problem that the edges are discontinuous in some portions of the images. To link these portions, Directional Potential Function (DPF) method is used.

This method is appropriate for a preprocessing technique. It is indispensable to use an edge linking for boundary edges in order to avoid the leakage of diffusion at gabs between the boundary edge segments. The **D**irectional **P**otential **F**unction (DPF) is used to link discontinuous boundary edge segments to close edge gabs by seeking the edge pixels that are most likely connected in the neighborhood of edge terminal points.. The PDF calculates the force strength for every pixel at the edge discontinuous points and use it as an indicator for the likelihood of an edge connection.

Linking Edge Algorithm is implemented after using Edge detection algorithm will computed. Edge linking is designed to assemble edge pixels into a meaningful set of object boundaries [3], and can be illustrated as follows:

Step 1 : create edge detection using sobol filter.
step 2 : classify the edge pixels into four pixel types.
Step 3 : search the terminal edge pixels.
step 4 : compute DPF for 8-directions around a terminal edge pixel.
Step 5 : execute edge linking toward the direction of maximum DPF.
Step 6 : if the value of the evaluation does not exceed a certain threshold go to step2.
Step 7 : remove the isolated edge pixels to obtain the edge linking.

At the first step, edge extracted by using sobol filter, at the second step, edge pixels are classified into four types: a terminal edge pixel (TEP), an isolated edge pixel (IsoL), an interior edge pixel (InterI), and an intersecting edge pixel (InterS). Then the TEPs are searched at the third step. At step 4, the DPF defined by the following equation is computed for eight directions around a TEP. Let x_i be an edge pixel (a TEP) at position (x_i, y_j)in an image. Then the DPF between a TEP x_i and another edge pixel x_j (see figure 5) is given by

$$DPF = q(x_i)\, q(xj)\, \frac{\cos(\alpha)\cos(\beta)}{\| x_i - x_j \|} \quad (1)$$

where $q(x_i)$ and $q(x_j)$ are the energy charges, and they are defined for four different edge types TEP: 1.0, IsoL: 0.5, InterI:0.1, and InterS:0.05. The DPFs in equation (1) are evaluated at eight directions around a TEP, and the linking between two pixels is executed, in principle, toward the maximum DPF at step 5. At step 6, linking is evaluated over the whole image based on the ratio of the number of TEPs to the number of edge pixels (the value of 0.1 % is the threshold value for this evaluation) and the linking process is executed repeatedly until the threshold is satisfied [7] see figure (4) which describe the edges before and after linking edges based on DPF.

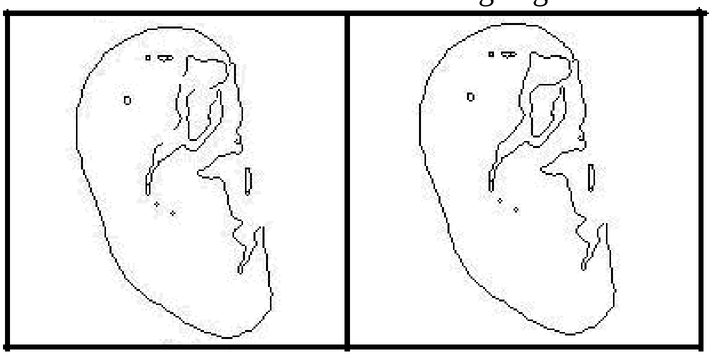


Figure (4) edge linking. (a) before using linking edges based on DPF.(b) after using edges linking based on DPF.

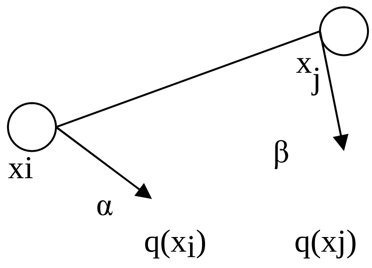


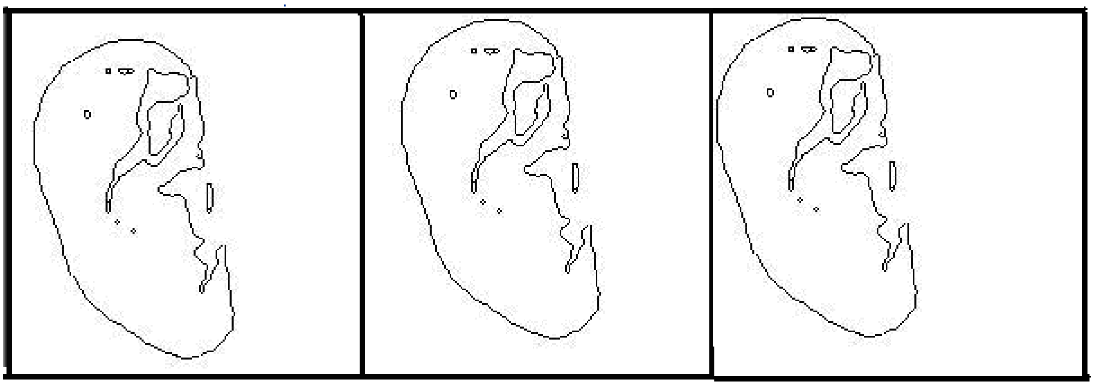
Figure (5) potential force between two points x_i and x_j.

The result will be a wide edges that contain all possible details, it must use thinning operation to get the exact representation of the edges that resulted from edge detection operation [3]. Thinning is the process of reducing a pattern into a one-pixel width skeleton, the ideal skeleton approximates the centerline of a pattern [8].

All the next computations will depend on the results of this stage.

Normalization using (Closest Row-Column) method to supplied the ear image for matching step.

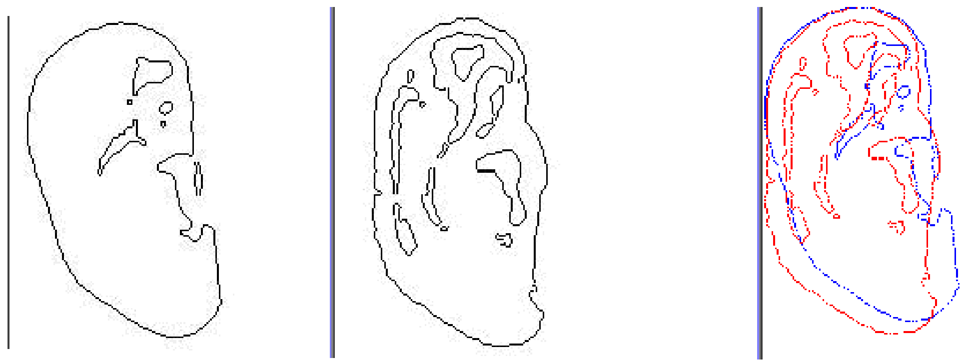
Closest Row-Column Method : To normalize the ear-image, it must raise the ear to the first row of the image, as described in figure (6.a). And then shift the image to the first column, as shown in figure (6.c).



(a) (b) (c)

Figure(6) Edge Detection.
(a) Before First Row Operation (b) After First Row Operation.
(c) First Row-Column Method.

The similarity measure matches the features depend on the pixels have value "1". Given two pixels in feature maps P^a and P^b in image A and image B respectively; a matching measure is established to quantify the matching of the patterns in the two images. The matching measure between two images is denoted by μ(A , B) In this notation, image (B) is considered the reference image, whereas image (A) is considered the nonreference image as illustrated in figure (7).



(A) (B) (C)

Figure (7) The Similarity Measure, a- The Nonreference Image, b-The Reference Image, c-Similarity Measure Process.

For the pixel has value "1" in image A and the corresponding pixel has value "0" in image B, compute the following:[9]

$$\mu(A , B) = \sum_{i=1}^{d} \frac{K}{(C_i+1)} \qquad (2)$$

where K given by $K= 1/W_B$ is the weight associated in matching a feature, and is the total number of ones contained in the reference image B denoted by W_B ; parameter d used in the summation term is the minimum number of total ones found in either image A or B; that is $d = \min(W_A, W_B)$; and C_i is the minimum Euclidean distance (see equation 3) between the ith pixel in the reference image corresponding to the pixel in the nonreference image. In finding C_i; the minimum Euclidean distance of the nearest position from the corresponding pixel in the reference image (image B) is computed. This process continues until all d features are considered.

$$D = \sqrt{(x1-y1)^2 + (x2-y2)^2} \qquad (3)$$

Where D is Euclidean distance

In the same manner, reverse the images, such that image A represent reference while image B represent the non reference image and computed using the following equation :-

$$\mu(B , A) = \sum_{i=1}^{d} \frac{K}{(C_i+1)} \qquad (4)$$

The Matching Process: In general, a comparison between equation (2) and equation (4) is done as follows:

$$M = ax\,(\mu(A , B) , \mu(B , A)) \qquad (5)$$

The result of matching process represent the matching performance rate.

4-The Similarity Measure Algorithm.

Begin of algorithm :

propose that image B is a reference and image A is a nonreference.

Step 1 : For I = 1 to the end of row
For j = 1 to the end of column

Step 2 : if pixel (i,j)of nonreference image = 0 then go to step1.

Step 3 : perform equation(2) to obtain the similarity measure from A to B.
end of loop I.
end of loop J.

step 4 : reverse the images by putting image A as a reference and image B as a nonreference

Step 5 : For I = 1 to the end of row
For j = 1 to the end of column

Step 6 : if pixel (i,j)of nonreference image = 0 then go to step5.

Step 7 : perform equation (4)

to obtain the similarity measure from B to A.

end of loop I.

end of loop J.

step 8 : perform matching process in equation (5)

End of algorithm.

5-Experimental work

An example and applied it on the similarity measure algorithm was illustrated in this section.

Create the template: to create the templates, the subject/individual must undergo an enrollment process . The enrollment process typically requires that the individual submit his/her image size (140 x 200) pixels under the same conditions of lighting, distant and conditions of lighting, extract the edge detection, link the discontinuous edges and normalized the edges. The training set consist of data for 100 subjects. The database of the training set consist of the image of a person named by the name of the person (ID).

Input stage: an image size (140 x 200) pixels will be captured under the same condition of that create the temporary template, preprocessing the image like the operation done in the previous step, and store the image corresponding to the name of person (ID) in the temporary template .

The matching process: In the temporary template image, the number of one's "1" is 172 pixels, and the rest is zero's pixels.

Search the database for the template that have the same name, and extracts the one's "1" which equal to 175 pixels, and the rest is zero's pixels.

Apply equation (2) to compute the similarity measures of temporary image to the corresponding template. The result of this equation to is 0.6105.

Apply equation (4) to compute the similarity measures of the corresponding template to the temporary image. The result of this equation to is 0.7622 .

Perform matching process as follows :

Since the results of equation (2) are less than the results of equation (4) then matching process = 76 %

6-Improving Matching Similarity Method.

The similarity matching process is achieved 76% rate. To improve this rate, it can compare a pixel of nonreference image (A) at position (x,y) with a pixel of reference image(B) at position (x,y) (the same position) and it's neighboring (8-pixel neighboring). The algorithm of this method as follows:-

Begin of algorithm :

propose that image B is a reference and image A is a nonreference.

Step 1 : For I = 1 to the end of row

For j = 1 to the end of column

Step 2 : if pixel (i,j)of nonreference image A = 0 then go to step1.

Add 1 to the total-account.

Step 3 : if pixel(i,j) of reference image B or one of it's neighbor = 1 then

Add 1 to the matching-account$_A$.

end of loop I.

end of loop J.

match-percentage$_A$ = matching-account$_A$ * 100/ total-account

step 4 : reverse the images by putting image A as a reference and image B as a nonreference

Step 5 : For I = 1 to the end of row

For j = 1 to the end of column

Step 6 : if pixel (i,j)of nonreference image B = 0 then go to step5.

Step 7 : if pixel(i,j) of reference image A or one of it's neighbor = 1 then

Add 1 to the matching account $_B$.

end of loop I.

end of loop J.

$match\text{-}percentage_B$ = matching-account$_B$ * 100/ total-account

step 8 : perform matching process :

matching process =(match-percentage$_A$+ match-percentage$_B$) / 2

End of algorithm.

For example take two images for the same person, one of these is obtained from input-stage as illustrated in section 6, and the other is obtained from the template according to the name of the person (ID).

Image A (temporary template) have the size (140 x 200) pixels and image B (template) have the size (140 x 200) pixels.

After applying the steps 1,2 and 3, the match-percentage$_A$ = 88.2 %

After applying the steps 4,5,6 and 7, the match-percentage$_B$ = 91.1 %

Matching performance = 89.65 %

7-Conclusion.

We believe that human ear is a perfect source of data for passive person identification in many applications. In a growing need for security in various public places, ear biometrics seem to be a good solution. Here are several concluding remarks have been drawn.

a- **From point of view of accurately and security**

Since the ears are visible and their images can be easily taken, even without the knowledge of the examined person. Then the robust feature extraction method can be used to determine personality of some individuals, for instance terrorists at the airports and stations. Access control to various buildings and crowd surveillance are among other possible applications.

b- From point of view of automating biometrics

A matching performance with similarity measure is achieved a rate about 76%. After improving matching performance, the pixel of the reference image is checked with the corresponding pixel and it's neighboring pixels (8-neighboring pixels) in the nonreference image instead of searching the minimum Euclidean distance of the nearest position from the corresponding pixel in the reference image. A matching performance after improving the similarity method is achieved a rate about 89 %.

c- From point of view of constraint conditions

In this research, the image of the ear is obtained under fixed conditions of lighting, distant, high resolution, in addition to that, the person who he/she want to authenticate must wearing a cap.

d- From point of view of automating biometrics

Although , the matching performance of the two methods have a highest matching rate, the authenticated user need to wear a cap to prepare the image for edge detection step. This means the person authenticated in these methods is (unpassive) and will be with knowledge of the examined person.

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الصفات البشرية التقيسية للاذن بمطابقة قياس التشابه للصورة

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الخلاصة

منذ مئة عام أستخدمت الاذن البشرية في تعريف الاشخاص ولحد الآن فأن الابحاث تدرس فيما اذا كانت الاذن تحمل خصائص منفردة أو كافية لكي تستخدم كصفة بشرية للتقيس. ان التطبيقات لشكل الاذن لم تستخدم في مجال الصفات البشرية التقيسية لكن هناك تطبيقات استخدمت في مجال البحث الجنائي.

ان ما تم انجازه في هذا البحث هو دراسة هيكلية الاذن البشرية ، شرح الأسباب اللازمة لاختيار الاذن كصفة بشرية تقيسية و استخدامها في تعريف /اثبات الهوية الشخصية و تقديم طريقة جديدة لأستخدام الاذن في الصفات البشرية التقيسية باستخدام معالجة الصورة و تحسينها من خلال استخدام طريقة (أقرب صف-عمود) والمطابقة مع قياس التشابه للصور. بعد اجراء التحسينات على هذه الطريقة حققت عملية التطابق للتعرف على هوية الشخص نسبة ٨٩%.