

## *Adaptive Agent System for Ear Recognition Using Mathematical Model Approach*

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### **Abstract:**

Person's identification or recognition is a first problem step in all security systems. In these systems, Ear biometric was suggested to be a crucial tool for recognizing people in critical, important organizations and government security agencies. It is unique to each individual and relatively unchanging during lifetime. The proposed system in this study presents a new algorithm for ear recognition. It offers a mathematical model based on centroid and related cluster analysis which tries to find a reciprocal twin sample to the nearest neighbors and then they are grouped as a cluster. System is trained on individual subjects with the same conditions. Each enrolled image subject is converted to a gray scale. Experimental results reflect that the proposed system can be offered 93% accuracy, less complexity and can make more accuracy with subjects who are those have a short hair.

### **1. INTRODUCTION**

Biometric systems play a major role in security aspects [1]. Many human traits can be used as a biometric like fingerprint, faces, voice and iris. Ears are used as human traits for the identification purpose that cannot be stolen or lost. They are proved to be a better solution than pins and passwords. The problem of recognition is harder than that of identification since the system must determine if the subject's identity can be verified against any previously enrolled subject [2].

The ear structure is rich, it changes a little with age and is unaffected by facial expressions [3]. It is firmly fixed on the side of the head so that the immediate background is predictable, unlike that of the face. Comparing the ear with the iris, the retina and the fingerprint declares that it is large and therefore more easily captured at a distance. Moreover it has the same visual complexity as the face but it is unlike the face which lacks symmetry. So that the information is not duplicated. This study presents first anatomy of the ear depicted in Fig.1a [2] and then it shows the locations of the anthropometric measurements used in the proposed system shown in Fig.1b[2]. A new algorithm for ear recognition is performed after reprocessing the image pixels using canny edge detection such that after choosing appropriate mask.

## **2. Approaches to ear biometrics recognition**

Different approaches have been suggested to be fundamental methods for recognizing ears.

The potential for using the ears appearance as a means of person identification was recognized and advocated as early as 1890 by the French Criminologist Alphonse Bertillon [4].

Lannarellies manual classification system was developed around 1950. It essentially consists of taking a number of measurements around the ear by placing a transparent compass 8 spokes at 45° intervals over an enlarged photograph of the ear. Recent attempts have been made to automate lannarellies [5]. Burge and Burger [2] show through the implementation of a computer vision based system that each subject's ear was modeled as an adjacency graph built from vornoi diagram of its canny extracted curve segments.

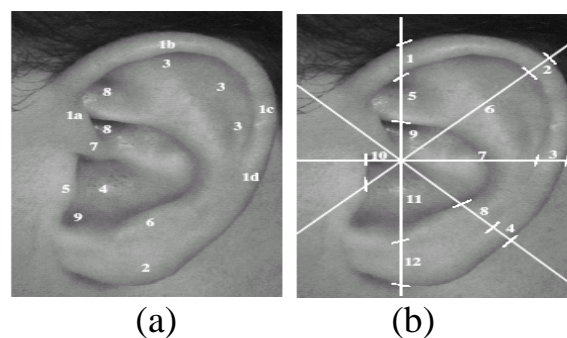


Fig. 1: (a): Anatomy; (1) helix rim; (2) lobule; (3) antihelices; (4) concha; (5) tragus; (6) anti-tragus; (7) crus of helix; (8) triangular fossa; (9) Incisure intertragica; (b) measurement

They desired a novel graph matching algorithm for authentication which takes into account the erroneous curve segments which can occur in the ear image due to changes such as lighting, shadowing and occlusion. They found that the features are robust and could be reliably extracted from a distance.

Principal Component Analysis (PCA) [8] has been one of the most popular approaches to ear recognition. It is an elegant, easy to implement and easy to use technique, which produces excellent results providing that the images are accurately registered and closely cropped to exclude extraneous information.

Hurley *et al.* [7] used it on a subset of 252 ear images to achieve a recognition rate of 98.4%.

Hurley *et al.* [8] have developed an invertible linear transformation which transforms an ear images into a force field by pretending that pixels have a mutual attraction proportional to their intensities and inversely to the square distance between them.

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Chen and Bhang [9] have tackled (3D) ear biometrics using a Minolta range scanner as the basis of a complete 3d recognition system on a data set of 52 subjects consisting of two images per subject. The ear are detected using template matching of edge clusters against an ear model based on the helix and antihelix and then a number of feature points are extracted based on local surface shape. A signature called a Local Surface Patch (LSP) based on local creature is computed for each feature point and is used in combination with ICP to achieve a recognition rate of Akkermans *et al.*[10] have exploited the acoustic properties of the ear recognition. It turns out that the ear by virtue of its special shape behaves like a filter, so that a sound signal played into the ear is returned in a modified form. This acoustic transformer function forms the basis of the acoustic ear signature.

Yane *et al.* [11] presented research which has been done at the university of Notre Dame, where they reported 63.8% rank on recognition rate for an “eight ear”, PCA based approach. The same approach was performed Hausdroff matching of edge images achieving 67.5% and experimented for edge matching on 3D ear images which achieved 98.7% rank one recognition rate.

Moreno *et al.* [14] performed experiments with neural network classifiers, where the features extracted from ear images by performing edge detection and extracting seven known features points of the outer ear from the feature vector.

In Moreno’s research, six images per individual were used; these were divided into three images for training, one image for validation and two images for testing. For the classification technique based on feature points a 43% recognition rate was reported and for the ear morphology approach with a neural network classifier of 83% was reported.

Md, Mahbubur Md. Rashedul and Nazmula Bhuiyan[15] presents algorithm for structural features of human ear by measuring geometrical structures observed from pixel value distance. Their experimental result reveals 89% accuracy,

### **3. Reprocessing and Proposed adaptive agent system**

The proposed system focuses on adapting a mathematical model based on exploiting the outer structure of the ear and on extracting its features via studying the shape and geometrical distance between the locations that are shown in Fig. 1a. These geometrical distances are measured using Euclidian distance formula as shown in equation (1) [1]:

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \quad \text{----- (1)}$$

The system focuses only on the ear location part in the whole face image. Then the gray scale image of this region of one side of the face structure is divided horizontally and vertically to different areas. This is achieved by drawing a line between the end points of every location as shown in Fig. 1b. Extraction of ear features is completed using canny edge detection after

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smoothing the image with a Gaussian filter for the edge angles of the endpoints. The sigma value = 1 and the size of the mask = (5×5). From this ( $\theta_i$ ) represents, the angle of end point for line (i). Practically  $\theta$  value ranges between zero and  $\Pi$ . Matching occurs if the two angles and their line lengths match. Another crucial factor in design technique is the ratio of the quality of detecting images that are depending on a threshold value such as:

$$Th_i = \begin{cases} 0 & (\theta_i, l_i) < \omega \\ 1 & (\theta_i, l_i) > \omega \end{cases} \text{----- (2)}$$

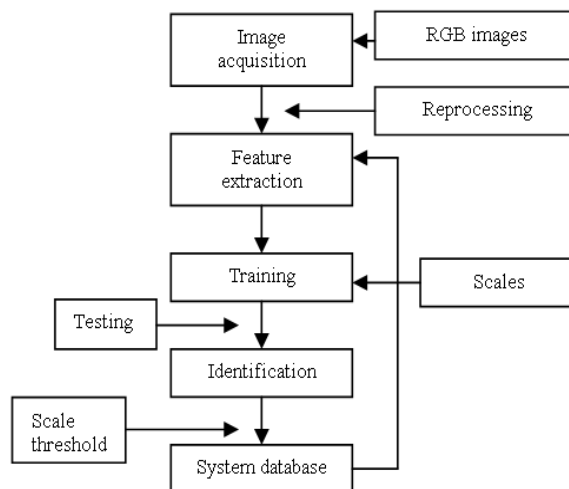
Where,  $\omega$  represent a low and high value threshold. Training data for the adaptive agents contains positive and negative samples as shown in Fig.2. Then the feature extraction is completed by matching the edge angles of the endpoints that are processed previously.

**3.1 Mathematical model**

Centroided and related cluster analysis algorithm can be achieved via producing ( $n \times n$ ) table rows and columns as shown in Table 1. Its fields represent the distance between the two points:

**Table 1: Sample of testing data**

	a	b	c	d
a	-----	<b>0.20</b>	<b>0.50</b>	<b>0.90</b>
b	<b>0.20</b>	-----	<b>0.25</b>	<b>0.41</b>
c	<b>0.50</b>	<b>0.25</b>	-----	<b>0.60</b>
d	<b>0.90</b>	<b>0.41</b>	<b>0.60</b>	-----



**Fig. 2: System block diagram**

then the algorithm proceeds to find reciprocal twin samples to the nearest numbers which are grouped as a cluster. The steps can be summarized as follows:

- i. Find out a minimum distance in the first row
- ii. Find out a minimum distance in the second column
- iii. Repeat step<sub>1</sub> with the second row
- iv. Repeat step<sub>2</sub> with the second column. And so on until the last row and column
- v. Erase resolved rows and columns. Therefore the output is a square matrix (2×2) and its value is reciprocal

Table 1 values represent the final data pixel data distance and edges after the agent was trained. The data of the processed images acquired by Panasonic camera as shown in the block diagram in Fig.2. For side face images the distance between the face and the camera is 15-20 cm. Feature is extracted from the acquired image after converting it to grayscale.

### 3.2 Identification system algorithm

*If*  $\exists$  Gray scale image M where  $M \neq \emptyset$

NS := M

While (NS  $< >$   $\emptyset$ ) do

begin

$\forall P_{i,j} (x,y) \in L$  do

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

Mat (i,j) := d ;

end;

$\forall (i,j) < = NS$  do

if  $P_{i,j} < P_{k,L}$  Then

$Mat_{i,j} = P_{i,j}$  else

$Mat_{i,j} = P_{k,L}$

endif;

i :=i+1; j :=j+1;

end;

Matrix :=Max;

N :=NS M :=NS;

While Matrix  $< =$  NS do

Begin

For i :=1 to NS

Begin

For j:= 1 to NS do

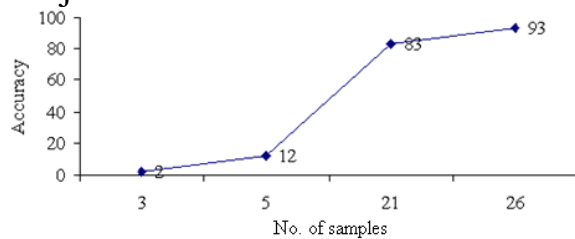
Begin

```
For k = 1 to NS
  If Mat(i,j) < Mat(k,l) then
Mat(i,j) := Null ; Mat(k,l) := Null ;
end; end; end;
  If Mat (M) = Mat (N) then
Threshold >  $\omega$  then
  Verify (match).
```

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## 4. RESULTS

The new algorithm was trained on a database of individual subjects using Panasonic camera with the same lighting condition. The left and right side face image of each subject are the enrollment examples to the database of the proposed system. The extracted features from these trained examples are the basic seeds of the proposed adaptive system. The extracted features are tested on subjects such that number of lines is 16.



**Fig. 3: Accuracy of testing sample**

Figure 3 illustrates that after testing 21 samples, the accuracy increases from 83-93%. Limitations of the noise effects can be reduced if the same circumstances are taken in the consideration. Experimental results show that the appropriate threshold value is 0.4 and 0.8 respectively. The proposed system is implemented in MATHLAB 7.0 on 1.7 GHZ processor and 265 MB RAM. It is clear that increasing the number of training samples will affect the value of the accuracy.

## 5. CONCLUSIONS

The structure and the shape of the ear rises as a basic biometric identification feature in recognizing persons that can be applied in security systems. Experimental results illustrate that the system can offer 93% accuracy and less complexity in comprised with other system. The image is acquired and the data is represented using canny edge detection algorithm. The adaptive agent is trained on a sample data. The mathematical model tests the data using centroid

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and related cluster analysis. This algorithm proves good accuracy and minimum data storage.

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الخلاصة

## **Adaptive Agent System for Ear Recognition Using Mathematical Model Approach ..Dr.Abdul Kareem Murhij Radhi, Mohammad A. AL Jabbar A.AL Wahab**

أن التعرف أو تمييز الأشخاص تعتبر من أولى المشاكل في جميع الأنظمة الأمنية. أن الأنظمة البيولوجية الممكنة التي تعتمد على تمييز الأشخاص من خلال الأذن يمكن أن تكون أداة حاسمة في تمييز الأشخاص وخاصة في الأجهزة والمؤسسات الأمنية . وذلك لأن صفات الأذن لكل شخص لا يمكن أن تتغير بمرور الوقت. أن النظام المقترح في هذا البحث يتبنى أو يتضمن خوارزمية جديدة في التمييز. حيث يوفر نموذج رياضي يعتمد على تحليل الأصناف والتي تعتمد على إيجاد نموذجين توأمين متقاربين في كل صنف. النظام المقترح يبدأ تدريبه على صفات كل كيان وتحت نفس الظروف. كل صورة لكل كيان تحول في البداية الى النموذج الرمادي. عكست النتائج بأن النظام المقترح يمكن أن يوفر دقة بمقدار ٩٣% ، وأقل تعقيدا" من باقي الأنظمة وأكثر دقة، خاصة إذا كان الجسم أو الكيان يمتلك شعر قصير .