Biometric Identification System By Lip Shape

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***Abstract*— Biometrics systems based on lip shape recognition is an interesting topic scarcely developed in the scientific literature. This is perhaps due to research's generalized belief of its scarcely discriminative power. However, a careful study shows that the difference among the outline of people's lip is greater than the difference among the shape at different lip images of the same person. So, biometric identification by lip outline is possible. In this paper the lip outline is obtained from a face color picture: the color image is transformed to gray scale by Chang, Huang and Novak transformation and binarized with the Ridler and Calvar threshold. Considering the lip centroid as origin of coordinates, each pixel lip envelopes is parameterized with polar (ordered from -π to +π) and cartesian coordinates (ordered as heights and widths). To asses the identity multilabeled multiparameter hidden Markov model is used with the polar coordinates and a multilayer neural network is applied to Cartesian coordinates. With a database of 50 people an average classification hit ratio of 96.9% and an Equal Error Ratio (EER) of 0.015 are obtained.**

I. Introduction

Biometric identification is an automatic identification procedure or verification of a person based on his/her physiological or behavioral traits. Some human traits currently utilized included fingerprints, speech, facial patterns, iris, retina and hand-written signature. Using a correctly chosen and designed biometric identification system, we may be able to prove with reasonable certainty that we are, or are not, someone previously registered in the users database.

No matter what method one uses, the underlying process is similar. To enroll a new user, one must store a template file of the user's biometric information (e.g. fingerprint, hand geometry or voice). After the verifying procedure, the template is compared with the new live information from the user who wants to be identified by the system. We can summarize four main steps in every biometric recognition system as follows:

Creation of the Database: A physical or behavioral sample is captured by the system during the enrollment phase. We need to extract several samples from the users in order to make our system robust.

Feature Extraction: A set of characteristics is extracted from the samples and a user template is created.

Comparison: When a new user needs to be identified, a real-time sample is taken and matched against the stored samples. Different distances (e.g., Euclidean and Hamming), statistics methods (e.g., Gaussian Mixture Models) and classifiers have been successfully applied to perform this comparison task [2],[3].

Decision: The system decides if the set of features extracted from the new sample is a match or a miss-match.

Figure 1 describes the above steps, necessary for the authentication of a previously registered user by the system.

Biometrics systems based on lip shape recognition is an interesting topic scarcely developed in the scientific literature, perhaps shadowed by face based biometrics systems. This paper explores the scope of the biometrics systems based on lip shapes, enhancing the possibility of its real application in a multimodal biometric system.

It seems difficult that a shape lip biometric system works properly because the similarity among the people lips. But the little variability of a person lip along the time encouraged ourselves to try it and the experimental results show the biometric identification by lip outline is possible. Obviously, some restriction must be taken into account, e.g., the pictures must be taken with the face muscles relaxed in order to assure low inner class variability. This kind of problems also appears with face recognition.

The most related literature about lip shape detection has been found in the automatic speech recognition (ASR) topic [4]. The algorithms used in this application were not useful in our case, because they trace the moving mouth positions for speech recognition purposes instead of working out the static lip shape description for identity validation. Literature about lip detection for biometrics purposes has not been found.

So, this paper proposes a new biometric identification system based in the biomeasures from lips shape. The identification is done in four steps: lips detection and envelope calculation, envelope parameterization and recognition by means of a classifier.

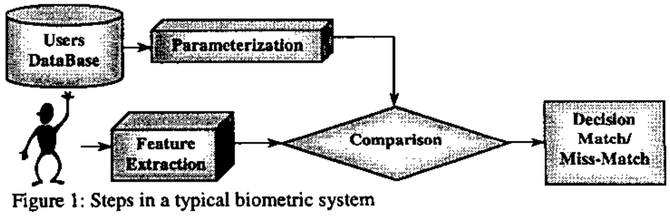

Figure 1: Steps in a typical biometric system

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I. DATABASE CREATION

The database built and used in the experiments consists on 10 repetitions of 50 different faces. The pictures have been taken in 10 different sessions of 5 persons. Each session, the people shifted form one picture to the next one. In order to avoid a lot of signal processing looking for the lips, each picture was taken with people seated at the same distance of the digital camera. Each time we take a person picture, we ask him/her to relax the face muscles. Obviously a discrete smile is allowed. An example of six repetition of a person can be seen at figure 2. The distribution of the enrolled people by sex and age can be seen in Table I

Figure 2. Six repetitions of a person

So, we have 500 color pictures of 768 by 1024 pixels, saved in JPEG (Joint photographic experts group) format which reduce the picture size to 20 times. This format save the image broken down in three matrixes: The red, blue and green matrixes. We will detect the lips from these three matrixes

TABLE I. AGE AND GENDER DISTRIBUTION OF THE LIPS DATABASE

	Age (years old)			
Gender	10 to 20	20 to 40	40 to 60	Total
Male	22 %	30 %	2 %	54 %
Female	18 %	24 %	4 %	46 %
Total	40 %	54 %	6 %	100 %

II. LIPS OUTLINE DETECTION

Detection is the first step in lips parameterization for later identification. In this paper we have only work with the area around the lips. Because of all pictures were taken with the seated people and at the same distance, this area is selected in all the pictures in the same position, i.e., we suppose that the lips area inside a predefined block of 230 by 400 pixels.

Usually lip or mouth detection, from a face picture, is done by means of an image transform. That image transform must highlight the lips in order to make easier its shape extraction.

In this paper we use the image transform proposed by Chang, Huang and Novak in [5]. This transform consists on a linear combination of the red R, green G, and blue B matrixes that make up the image. The transformed image It is obtained as follows:

$$It=R+G-Cte*B$$

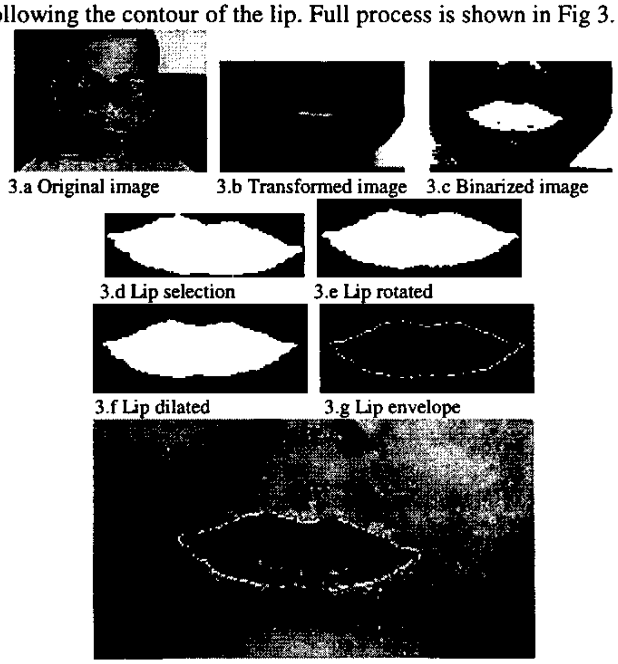
Although $Cte=2$ is suggested in [5], we have used $Cte=6$. This value achieves greater robustness against facial hair and illumination, which were the main problems found.

The effect of the above transform on the image can be seen in Figure 3b. It is easy to see the effect of the highlighted lips from the face background.

Previous to lip's area binarization, a high-pass filter is applied to the image in order to highlight the discriminative details of the lip envelope. This filter is a two dimensional filter designed with the window method. A 21 points hamming window is used and the cut-off frequency is 0,1. The image to be binarized is obtained averaging the high pass filtered image and the input image.

The next step is to binarize the lip area. The threshold for binarizing the image is obtained with the standard adaptive Ridler and Calvar [6] algorithm with an improved initial point given by the triangle algorithm [6]. Results are shown in Fig.3.

Once the image has been binarized, we select as lip the biggest object inside this image. We work out the orientation of that object and eventually rotate the object in order to have all lips horizontally placed. In order to smooth the lip envelope, we dilate the rotated lip with a mask of five-dimensional ones and fill the holes. The envelope is obtained following the contour of the lip. Full process is shown in Fig 3.



3.a Original image 3.b Transformed image 3.c Binarized image

3.d Lip selection 3.e Lip rotated

3.f Lip dilated 3.g Lip envelope

3.h Superposition of original image and lip envelope

Figure 3. Example of lip outline detection process.

In order to have an intuitive look of interclass and inner class variability, we show in Figure 4 lip envelopes of the same person and in Figure 5 lip envelope of different people.

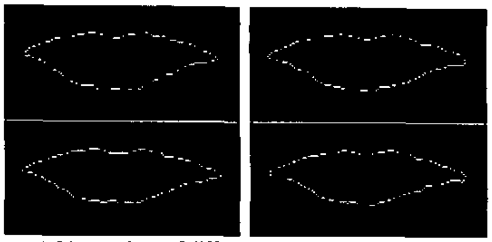


Figure 4. Lip envelope of different pictures of the same person

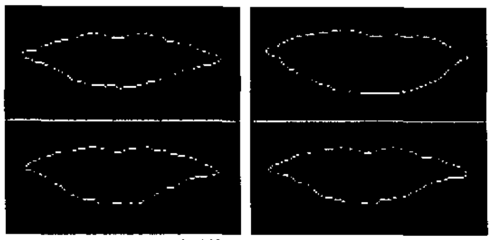


Figure 5. Lip envelope of different people

As can be seen, the inner class variability seems lower than interclass variability. Nevertheless, both variabilities are small. So, we have to look for parameters that describe the lip envelope and highlight the interclass variability

I. FEATURES EXTRACTION

Once the mouth shape has been extracted we use two kinds of features: the first builds a features sequence from the polar coordinates of the envelope, and the second features vector are samples of the lip envelope height and width.

The first method works out the centroid of the lip and trace radius from that point to each envelope pixel as can be seen in figure 6. Each pixel is described by its radius and angle. So, the lip envelope description is a two-dimensional sequence which first and second row are the radius and the angle in radians respectively ordered form $-\pi$ to π. As this sequence is too long for the posterior classifier, we shorten it reducing the lip image by a factor of 0.5. Additionally, we eliminate the envelope corners. Hence, the medium length of this sequence is 198 points with standard deviation equal to 20.8.

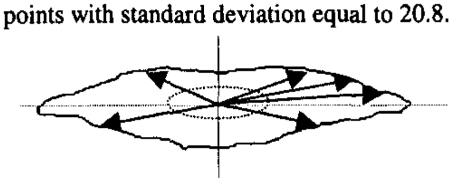


Figure 6. First feature extraction of lip envelope: pixels' polar coordinates.

A representation of a typical lip envelope radius, which presents peaks at 0 and $\pm\pi$ radians and minimums around $\pm\pi/2$, can be seen in figure 7.

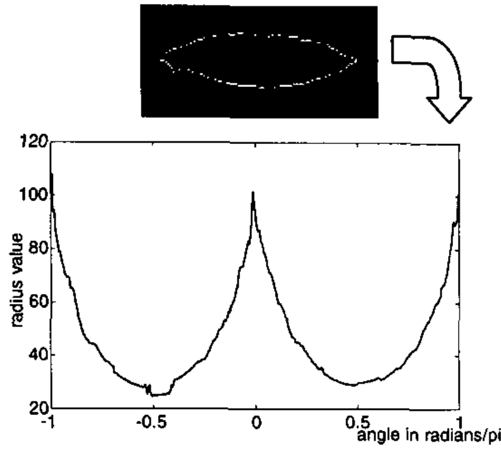


Figure 7. Lips envelope and its envelope radius sequence

The second features vector describes the lip envelope by means of the height and width measures of the envelope. As height we means the number of pixels from the y centroid ordinate to the envelope, and as width we means the number of pixels from the x centroid ordinate to the envelope as can be seen in *figure* 8. *Concisely, the features vector consists on two* columns. The first column is 60 samples of the upper half height and 30 samples of the righter half width. The second column is 60 samples of the lower half height and 30 samples of the lefter half width.

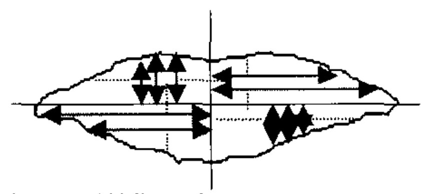


Figure 8. Height and width lip envelope parameters

An example of typical height and width lip envelope vector can be seen in figure 9. It is easy to see how the envelope is characterized by this measure.

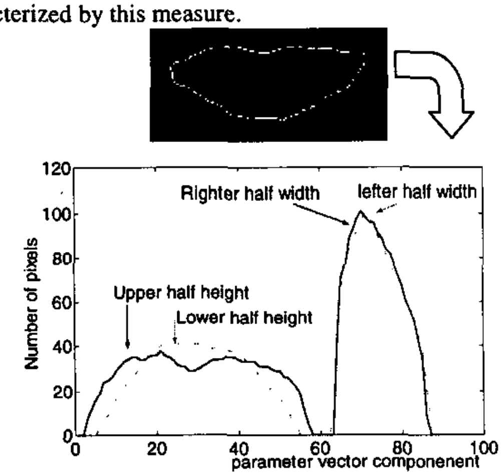


Figure 9. Lip envelope and its height and width features vector

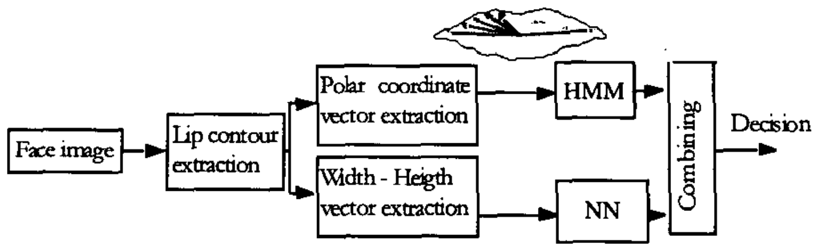


Figure 10 Automatic biometric lip identifier proposed

I. Comparison system

The comparison system, or identification stage, will give the probability of the input lip belongs to an individual. Threshold exceeding performs successful identification.

Hence, we have two kinds of features. So, we will use two independent identification systems, and will combine the probability given by each one for final decision.

As identification system with the sequence of polar coordinate we have used a multilabeled discrete hidden Markov model (HMM) [7][8], which has proved a very successful tool for sequence pattern recognition. Concisely, we use 35 states, 32 symbols, a left to right topology, and 10 labels. Radius and angle rows are considered independently by the HMM. The Baum and Welch algorithm was used for training.

A multiplayer neural network (MLP) is used for the geometric height and width lip envelope description. The MLP used was trained with back propagation algorithm and a hidden layer containing 120 neurons.

The outputs of both systems are independently normalized in the range [0,1] and averaged, giving the probability of an input image belonging to the claimed identity, as can bee seen in Figure 10

II. Experiments and results

To train and test the biometric system, we use the database of 50 persons with 10 pictures of each person mentioned before. The training is performed using 50% of the database chosen randomly and the remainder 50% is used for testing purposes. This process is done ten times in order to get a good measure of system performance. The average±variance results obtained for classification are shown in Table II

TABLE II. RECOGNITION RATIO OF THE BIOMETRIC LIP CLASSIFIER

Parameterization	Classifier	Recognition ratio	Combination
Polar	HMM	96.2±2.5	96.9±1.2
Cartesian	MLP	86.1±2.8	

The averaged Receiver Operating Characteristic (ROC) curve is shown in Figure 13.

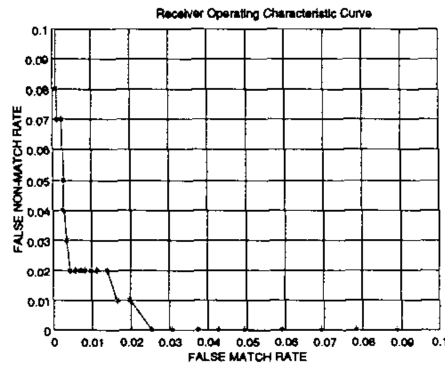


Figure 13. ROC curve of Biometric lip system

III. Conclusion

This paper introduces a new biometric identification system based on lip shape biomeasures, a field in which little research has being done, with a recognition ratio of 96.9% and EER of 0.015. This is considered as good result and encourage for its use combined with other biometrics systems.

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