Lip Imprint Based Biometric Identification: A Survey

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Abstract— The aim of this paper is to present a survey on different approaches to use human lip-imprints as a mode of Biometric Identification. The different approaches discussed in the series of papers could be classified broadly into two categories: Manually Implemented Methods and Automated methods based on Digital Image Processing and other machine learning algorithms. The method of accepting input imprints and the method of matching those imprints are distinct in different approaches, but basis of nearly all the approaches is the study of the groove patterns present in the lip imprints.

Index Terms— Digital Image Processing, Machine Learning

1 Introduction

THE science of lip imprint study and its use for biometric identification is known as "Chelioscopy" (from Greek word 'cheilon' which stands for lips). The theory of Chelioscopy been used as a mode of Biometric Identification, was considered by Criminologists and Scientists since 1932. But it was only proved in 1970 by Japanese doctor Suzuki when he studied lip-imprints of 107 Japanese women aged between 20-36 years and proved that, lip-imprint can be used as biometric identification [1]. This theory was further seconded by Tsuchihasi in 1974. In 1975, Suzuki and Tsuchihasi summarized their findings and listed five different categories of grooves present in each of the lip-imprints [2]. This categorization is famously known as Suzuki's Classification. Suzuki's Classification is applied to nearly all lip-imprint matching techniques, and sometimes it is used for gender detection. The categories are shown in Table 1.

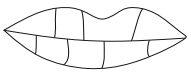
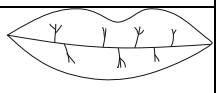
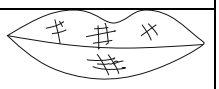
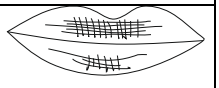
Generally all lip-imprint identification techniques follow the following steps:

Step 1: Pre-process the input lip-imprint image
Step 2: Extract Features from processed image
Step 3: Train the system
Step 4: Identification/verification of new Lip-imprint by trained system

In Manual Techniques, generally adapted in the field of dentistry and forensic science, the lip-imprint registration is done on some transparent sheet or glass with some colouring agent like lipstick or charcoal dust. The groove patterns are then studied and measured using magnifying glasses and mechanical measuring tools like scales. So, in this type of approaches, human intelligence is used for processing data.

In case of automated computer algorithm based approaches, the registered lip imprints are represented as digital image, sometimes the imprints are extracted from a cluster of other neighbouring images. The input image is then pre-processed to improve the quality, reduce noise and distinctly visualize lines and patterns present ion it. The pre-processed images are then used for further classification. The entire process is computed by automated systems. The different approaches differ from one another in terms of choice of algorithms for pre-processing and classification. Depending on their adapted techniques, the automated approaches can be further categorized into two subcategories: Structure analysis oriented methods and Statistical analysis oriented methods.

TABLE 1
Suzuki's Classification

Type	Description	Image
Type I	A clear-cut line or groove running vertically across the lip	
Type I′	Straight grooves that disappear half way into the lip, instead of covering entire breadth of the lip, or partial-length groove of Type I	
Type II	Grooves that fork in their course or a branched groove (like Y)	
Type III	An intersected groove (crisscross pattern)	
Type IV	A reticular groove	
Type V	Grooves that doesn't fall in any of the above categories and cannot be differentiated morphologically	

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2 MANUAL LIP-IMPRINT IDENTIFICATION METHODS

After categorization on grooves, found in every lip imprint, by Suzuki & Tsuchihasi in the year of 1975 [2], lots of researchers worked on this matter to utilize the variety of lines in detecting gender, age, family of a person along with using them as a mode of biometric identification. In their article published in 2009 [3], researchers tried to establish the fact of gender identification by the means of lip imprint. They recorded,

• If Type I and Type II patterns dominate the lip imprint, it should belong to a female, whereas

• If Type III, Type IV and Type V patterns dominate the lip imprint, it should belong to a male.

This research was carried out on 20 male and 20 female participants, and the result showed that,

• All the imprints were unique in nature and identification of a person was possible using lip imprints.

• In this test 18 females and 17 male participants were correctly identified along with their corresponding genders.

In the same year another group of researchers conducted a study [4] on 300 male and female participants from North India of the age group 18-65 years and also proved that using lip imprint human being can be identified. They also used the Suzuki's Classification to match presence of groves in imprints. In the above two studies, the imprints were registered on paper after applying some colouring agent on the lips of the participants. The methods were completely manual and to measure distances between grooves and to study nature of the grooves they used tools like scales and magnifying glasses.

In 2010, a group of researchers studied grooves of the lip imprint based on Suzuki's Classification to detect gender, blood group and family of the participant [5]. They did not supported the claim of using lip imprint to detect blood groups and family of a person, where as this research supported that lip imprint can be used to detect gender of a person and also can be used for personal identification. The lip-imprints were collected on bond papers with the help of lipstick and cellophane tape and Quadrants were drawn on paper influenced by Zsigmondy-Palmer system of dental charting. The lip-imprints studied using magnifying glass and grooves were classified according to Suzuki's classification. A statistical analysis of the presence of different type grooves on the imprint quadrants was prepared and summery of which derived the predominant type in each quadrant.

Later in the same year another group of researchers proved that, lip imprints are invariable with age and could be used for a person's identification at any age [6]. But the same paper also claimed that, there are no genetic similarities in lip imprints. Even a single person may have different groove nature present in his upper and lower lip, even in different part of his lip.

3 AUTOMATED LIP-IMPRINT IDENTIFICATION METHODS

The Automated Machine Learning Based lip-imprint detection methods can be broadly classified into two sub-categories: Structure analysis oriented methods and Statistical analysis oriented methods.

3.1 STRUCTURE ANALYSIS ORIENTED METHODS

Structural analysis based Lip-imprint identification methods basically extract various structural features, like distance between axis points, height and width of segments, distance and angle between groove lines, ratios of heights and widths etc., and based on those metrics identify lip-imprints.

In September 2009, Michał Choraś used computer science [7] to detect lip imprints. He considered lip shape features to detect human identity. In this research, he described human lip using geometric patterns extracted from lip shape. This research proved, like lip imprint, the lip shape features are also could be used to identify human beings. Shape of the lip and lip edge parameters are also unique features of a human being.

In 2010 a group of computer scientists from China proposed lip detection and tracking method using Variance Based Haar-like Features and Kalman Filter [8]. They proposed method of combining primitive Haar-Like features and variance values together to detect features of the lip to be used for unique identification and these features are then classified by using Support Vector Machine (SVM) after training the SVM with similar training feature data set.

In the same year of 2010, a group of researchers appointed a well known Image Processing algorithm, namely "Hough Transform", in the field of lip imprint detection [9]. Hough Transform is widely used to detect lined and patterns by linking lines or points from an image. In this research work, the scientists divided the process of identification into three steps:

a) Pre-processing (Background detection and Binarization)
b) Feature Extraction (using Hough Transformation straight lines are detected and segments are identified)
c) Lip pattern creation and recognition by detecting grooves following Suzuki's Classification

They sub-divided the entire process of pre-processing of the lip imprint image into the following four steps:

a) Input Image

b) Background Separation (this part is achieved by the method 'Histogram Equalization' and afterwards applying thresholding using Ridler and Calvard's Method)
c) Quality Improvement
d) Skeletonization (this step is accomplished by emphasizing the image by denoising)

Then they applied Generalized Hough Transform (GHT) on this pre-processed image and this process was divided into three sub-steps:

a) Creation of R table for each object
b) Creation of accumulator array and hyper-surface
c) Searching maximum value, higher than threshold adapted, to determine matching.

They claimed a success rate of 80% by adapting this method for applying lip imprint for a person's identification.

Similar method is adapted by another research work in 2013 [10] where the groove extracted using Generalized Hough Transform are compared on the basis of the linear distances and angle formation between a pair of neighbouring groove lines.

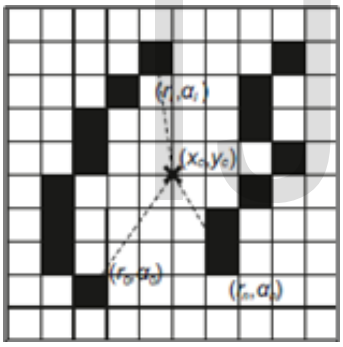


Fig 1: Similarity measurement in Hough Transformed Image

In December 2011, a group of researchers from National Institute of Technology Rourkela, India, proposed another lip pattern recognition technique based on local feature extraction [11]. They involved the following lip shape features along with lip colour features to match lip patterns:

a) Lip's Width to Perimeter ratio
b) Upper to Lower Lip height ratio
c) Upper Lip Height to Width ratio
d) Lower Lip Height to Width ratio
e) Inner to Outer Circle ratio
f) Width to Middle Height ratio
g) Left side Upper to Lower Lip Convexity ratio
h) Right side Upper to Lower Lip Convexity ratio
i) Indent ratio

This research strike remarkable success just based on these structural features of the lip.

In the same year, researchers from Department of Masters of Science in Cyber law and Information Technology, Indian Institute of Information Technology, applied pattern matching using "Brute Force Algorithm" to match lip imprints to reduce False Acceptance Rate (FAR) and False Rejection Rate (FRR) which are the basic measurement of inefficiency of any biometric identification algorithm [12]. Here, they matched lip imprints with stored database of lip imprints and the result could be used for identification or authentication of people.

3.1 STATISTICAL ANALYSIS ORIENTED METHODS

In Statistical Analysis Based Methods, the presence of grooves of different shapes is identified. The grooves are classified according to Suzuki's classification and the counts of categorized grooves are represented statistically. Based on this statistics, lip-imprints are identified. Different statistical models are adapted in different approaches.

In a research work at the University of Silesia, Poland, in the same year, researchers used Mean Differences Similarity Measurement to recognize lip imprints [13]. This research work employed the following two steps in the process of lip imprint identification:

(a) Pre-processing: Lip patterns are extracted from lip imprint and converted to black colour.
(b) Feature Extraction: Lip patterns are approximated as collection of segments.

They further applied Hough Transform to describe each lip segment by their length, angle and midpoint coordinates. Lip prints are compared using the Mean Difference Similarity method by obtaining similarities of lip segments.

Later in 2012, a group of computer scientists from Kolkata, India figured out a statistical model to identify people using features extracted from lip imprints [14]. They proposed an algorithm where after pre-processing of the inputted lip-imprint images, features are extracted from them. Then these features are used to match with similar features extracted and stored in a database earlier. This research used Gaussian Filter to generate smoothed image which then passed through Canny Edge Detection to get grooves identified clearly. This processed imprint then passed through Sobel Edge detection processes to detect horizontal, vertical and diagonal edges. Different Sobel Filters are used for these purposes.

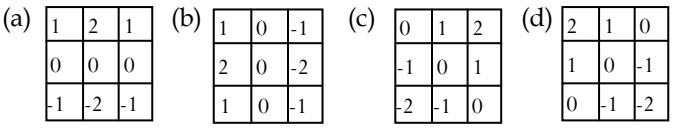
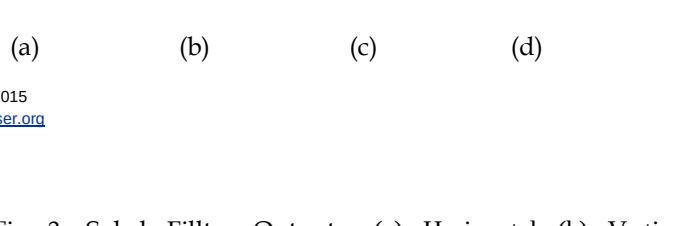


Fig 2: Sobel Fillters: (a) Horizontal, (b) Vertical, (c) 45 degree, (d) 135 degree



The researchers divided the lip imprint into upper and lower lip imprint first, and then each of these segments is again subdivided into four parts as shown in the image below. So in total eight sections are generated.

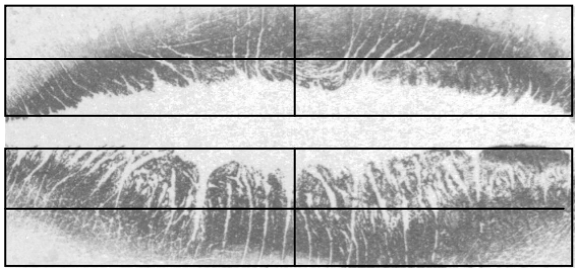


Fig 4: Lip-imprint segments

Now the entire feature extraction process is repeated for each of these eight segments and final result is computed based on the average matching. This process achieves more success rate with increasing number of sample images.

Another approach to detect similarities of lip imprints was prescribed by a group of computer scientists where they applied DTW Algorithm and Coperland Vote Counting Method to achieve their goal [15].

DTW is a Dynamic Time Wrapping Algorithm for measuring similarities between two temporal sequences which may vary in time or speed and Coperland Vote Counting Method is a method where candidates involved in an election are ordered by the difference between number of pair wise victories and number of pair wise defeats.

In this research work, the researchers extracted the furrows from background of a lip imprint and formed lip pattern initially. Then they extracted the lip pattern features and by forming specialized histogram out of the features, the lip patterns are matched using DTW technique. After this, the results are used in Coperland Vote Counting Method to find out the maximum similarity. A commutable success rate was achieved through this process.

Later in March 2015 another group of Computer Scientists from University of Silasia, Poland, used Bi-function Analysis Method to track similarities between lip imprints [16]. Bi-functional Analysis generally compares data on the basis of their features after pre-processing the images where they reduced the noises and increases the contrast of the lip imprints to extract grooves flawlessly.

4 CONCLUSION

Lip-imprint based biometric identification system is a well accepted and evolving trait of research. This is accepted globally as evidence in criminology and now-a-days computer algorithms are being developed to learn automated devices to enable them to identify people uniquely. Lip-imprint of a person can identify him/her uniquely and, unlike palm imprint, it does not change with the age of the person. Scientific researched proved that, lip-imprint can identify the owner's blood group too. There are various research works are being carried out globally on this topic, some of them are using manual methods and the rest on automated methods. Manual methods may incur some human error at the time of decision as that part is done manually with help of devices like Magnifying Glass. But these methods are dynamic and could be moulded as per requirement. But automated systems are based on an algorithm and machine cannot adapt anything beyond the algorithm applying its own mind. But mechanical processes are well adapted due to the amount of precision it achieves while producing result, as well as, it repeats the process any number of times with the same accuracy and precision.

Lip-imprint based Biometric Identification System is very highly adapted in criminology and forensic science. It has high accuracy level to identify people and now-a-days automated devices are also being able to use it for identification of people. So, in near future, lip-imprint based biometry is going to be popularly adapted in every field just like other common biometric identification systems based on finger print, retina scan or signature matching.

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