Informatics Bulletin, Faculty of Computers and Artificial Intelligence, Helwan University
Published Online *Vol 5 Issue 2, July 2023*
(https://fcihib.journals.ekb.eg)

A Comparison of Methods for Extracting Lip Print Features

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Abstract— **Lip prints and other biometric methods are increasingly used to identify people at crime scenes. Since the early 2000s, researchers have shown increased interest in using these methods. A lip print is biometric, like fingerprints, iris, or another feature in the body. Lip prints are unique to everyone, so they do not change over time. The images are classified through various methods to extract the features from the image based on color, shape, and texture features. A texture feature was the most critical extraction feature. This study examines the challenges and accuracy of previous lip print biometric methods and the various available techniques. In this survey, most researchers used feature extraction based on texture techniques like Hough Transform (HT), Dynamic Time Wrapping (DTW), statistical analysis, edge detection operators, and Local Binary Patterns (LBP). Our literature review covered the past ten years. Hough Transform was the most accurate at 98.49%, followed by Local Binary Patterns and Triangle feature set-based fuzzy at 97%.**

Index Terms—**Biometric human identification technology, Cheiloscopy, features extraction, lip print, personal identification.**

I. INTRODUCTION

Currently, there is an increasing need to introduce digital systems to verify or identify people. The most common biometric identification methods include signatures, fingerprints, and facial recognition [1]. Cheiloscopy is a criminology to examine lip prints for personal identification. The identification of a person depends on an analysis of the features located on the lip [2]. Recently, police and courts started using lip prints as a new identifying feature. Lip prints are traces of human lips left on items such as drinking glasses, cigarettes, aluminum foils, and drink containers. There are several methods available for lip print, such as statistical analysis [2], examination of lips [3], Dynamic Time Warping (DTW)[4], Hough Transform (HT)[5], and segmentation [6]. Tsuchihasi and Suzuki have published a study on identifying individuals by their lips [7]. Lip prints have the same basic properties as fingerprints: permanence and uniqueness [2],[7],[8].

To identify a person, four steps are typically involved: dataset, preprocessing, feature extraction, and measuring accuracy. The preprocessing applied the localization and normalization of a lip. Localization means identifying the exciting area and normalizing the pixel intensities to extract the features properly. Features of the lips were extracted after preprocessing. These features are used to create a dataset of features and applied to measure the accuracy; the output of these processes will be classification, recognition, identification, etc., as shown in Figure 1. This study compares some techniques to identify a person using lip prints. The rest of the paper is divided as follows: Section 2 describes approaches for feature extraction techniques, section 3 is the literature review, the discussion is in section 4, and the challenges and conclusions are mentioned in sections 5 and 6.

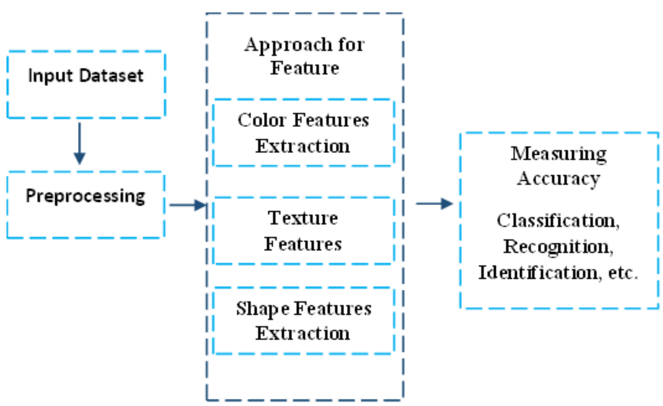

Fig. 1. The Block Diagram of The Steps into Four Parts to Identify a Person.

II. APPROACHES FOR FEATURES EXTRACTION

Analyzing feature extraction and organizing features into groups are important requirements for image classification. Therefore, an image is classified according to its contents, and the classification model greatly affects the accuracy rate. Various feature extraction techniques have been developed in recent years, each with its own strengths and weaknesses.

Feature extraction lips have been documented in the literature as color, texture, and shape approaches. These techniques are described in the following points.

A. Color features extraction

Color is an important feature that enables humans to distinguish images quickly. The images are easy to analyze and extract. There is more independence within color features than in other features. The characteristics of colors can be represented by moments of color, moments of blurred color, a histogram of colors, etc.

B. Texture features extraction

The texture is one of the most useful elements for image analysis. Pixel intensity determines qualities such as roughness, smoothness, silkiness, and bumpiness in textures. It is necessary to find a set of texture features with high distinguishing properties to classify the algorithm. There are many methods for texture features, such as Gabor Filter, Haar Wavelet Decomposition, HT, GLCM Wavelet, etc. Speeded Up Robust Features (SURF) and Scale Invariant Feature Transform (SIFT) algorithms were used to analyze lip grooves using texture-based methods [9],[10]**.**

C. Shape features extraction

The shape is one of the essential factors in extracting the feature. Typically, they are identified when an image is divided into different regions or objects. The shape can be defined either by region or boundary. There are many methods for shape features, such as Invariant translation, rotation, and scaling. A shape-based approach examines the lip outline [11], dimensions [3], or characteristic points [12].

D. Hybrid features extraction

The hybrid feature extraction approach combines different approaches for feature extraction.

III. LITERATURE REVIEW

Lip printing has been widely used in forensic science and human identification laws. According to studies, human lips have unique grooves that can be used to identify individuals. Tsuchihasi and Suzuki introduced it at the University of Tokyo [7]. Figure 2 shows their classification. The scientists compared the lip prints of people of all ages and concluded that human lips are unique, stable, and determined the gender. The Tsuchihasi and Suzuki classification is used by all medical methods [13-15]**.**

Professor Kasprzak has studied 23 unique lip patterns in [2] for identifying human characteristics, such as (lines, bifurcations, bridges, pentagons, dots, lakes, crossings, triangles, etc.). Choras [3] confirmed that the lip could be used as a primary biometric element for successful identification.

The literature review discussed the most popular methods for extracting features over the past ten years, as shown below, and we described the challenges in section 5.

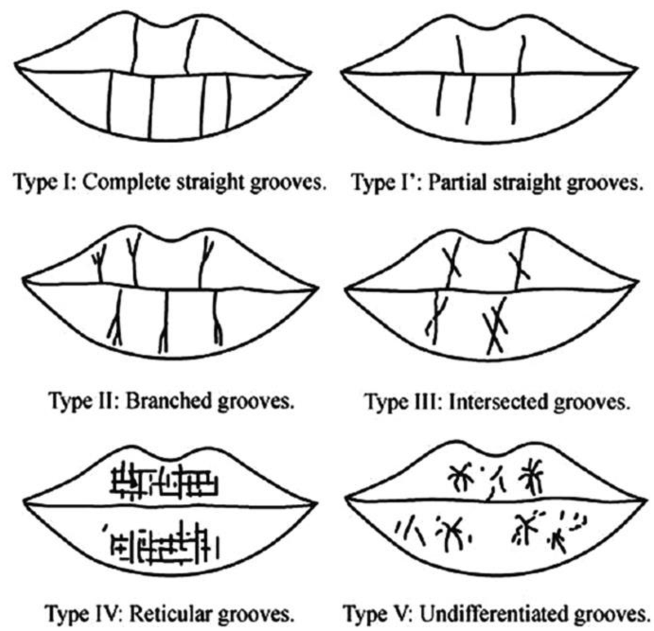

Fig. 2. Suzuki and Tsuchihasi Classification [7].

A. ***Transformation***

Lukasz *et al.* [16] analyzed grooves to recognize human lips. The straight lines are found in the lip pattern using HT. In this analysis, the authors used 40 lip prints with an accuracy of 85%. **Lukasz** [17] examined 60 lip traces to determine their set of characteristics using HT based on the pattern of the lines. The lip print is analyzed by three parameters: the center coordinates, the segment length, and the angle, with an accuracy of 55%. **Lukasz and Wrobel** [18] extracted line segments from a lip print image. They compared them using a similarity measure based on Euclidean distance for the identification person, using Top-Hat Transform to extract features using 120 lip prints. **Ryszard** [19] proposed a method of personal recognition. The paper presented lip feature extraction based on Radon transformation and steerable filters. Feature extraction begins with preprocessing the images. Similarity measures were calculated using Euclidean distance using 64 lips. **Krzysztof and Rafal** [20] proposed a method for identifying lip print fragments based on the Generalized Hough Transformation (GHT) using 30 lip prints. A technique for lip print recognition based on GHT was published by **Wrobel *et al.*** [5]. They extracted features from 45 lip prints using line segments as features. These three parameters are used to describe lip print: the length of the section, the angle of inclination, and the position of the midpoint, with an accuracy of 85.1%. **Lukasz *et al.*** [21] proposed a method using lip print images to recognize persons. The authors implemented a top-hat Transform, and the analysis was carried out on a dataset of 300 lip prints. **Lakshmi and Pushpa** [22] presented a lip printing method for identical twin recognition based on a new approach in the binarized image and applied in HT differently in twins. The authors have used a centroid-based K-Means clustering algorithm that can be used for removing the embedded noise using 856 lip prints, with an accuracy of 98.49 %. **Salim and Rasha** [23] recognized lip prints by HT using the features extracted from the images, with an accuracy of 91.34%.

B. (DTW)

Smacki *et al.* [24] examined 120 lip prints using the DTW for lip print recognition. The three directions (horizontal, vertical, and oblique (45° and 135°) are used to extract the features with an accuracy of 78.8%. **Piotr and Orczyk** [4] suggested a method for lip print recognition; DTW was implemented with the Copeland voting technique with an accuracy of 88.5% based on 120 lips.

C. (LBP)

Ben *et al.* [25] suggested a lip print recognition system, where Gabor and LBP are used to extract features and classification by Support Vector Machine (SVM). The authors used 100 lip prints, and the accuracy was 86.7%. **Sandhya *et al.*** [26] used lip prints for personal identification. LBP was used to obtain texture features from the extracted segmented upper and lower lip. Classifiers such as (SVM), K-Nearest Neighbors (KNN), Ensemble classifiers, and Artificial Neural Networks (ANN) were utilized to classify the extracted features using 120, the classifier accuracy of an Ensemble is 97%, (ANN) 85.81%, (SVM) 81.84%, (And k-NN) 80%.

D. Statistical methods and edge detection

Saptarshi *et al.* [27] lip-print can be recognized by analyzing average groove directions in images. They used the Accurate Match algorithm and the Fast Match algorithm. For lip print matching, feature vectors were calculated, and Euclidean distance, with 96% accuracy using only 20 images, the algorithm can be applied to a much larger dataset. **Samir *et al.*** [28] suggested a method to identify individuals based on lip print images. The Sobel edge detector and Canny edge detector are used to determine the lip's vertical and horizontal grooves pattern. **Shilpi *et al.*** [29] proposed a novel method for identifying people using the Sobel edge detection algorithm. The samples were taken from various people. The authors analyzed 80 lips.

E. SIFT and SURF

Sambit *et al.* [9] suggested the method of extracting features from 23 lip print images. Two methods extracted features from SIFT and SURF for lip recognition. The accuracy is greater than 90% in both methods. **Srijan et al.** [30] presented a method to identify a person. SIFT is a method that extracts features from the lips, which are matched using nearest neighbor (NN) matching. The accuracy of the two databases, consisting of 109 and 100 images, with accuracy 92.8% and 92.7%, respectively. **Farrukh and Haar** [31] compared traditional computer vision methods with deep learning methods to identify a person. The first method achieves an accuracy of 95.45% with SURF classification lip using either an SVM or K-NN. Second, using VGG16 and VGG19 deep learning architectures with an accuracy of 91.53% and 93.22%, respectively.

F. Other methods

Pawan *et al.* [10] developed a method for recognizing lips based on physical and biological characteristics. The lip prints can be categorized into six topographical areas. A Brute Force algorithm was used to match the patterns. Based on 200 lip prints, with an accuracy of 89.5%. **Smacki** [32] proposed an algorithm to recognize a person using Fast Normalized Cross-Correlation; the background was first removed. Afterward, the upper and lower lips were separated. A horizontal alignment was applied to the images. In this study, 300 images were used. Lip prints without distortions and blurs were excluded, so the accuracy was 58%. **Krzysztof *et al.*** [33] proposed an approach to identifying individuals based on an examination of 120 lip prints. The method used lower and upper bifurcations were evaluated coordinates, and the orientation angle to assess the similarity of lip prints; the accuracy was 77%. The error rate for the best result was 23%. **Sangeetha and Arul** [34] employed SVM for lip recognition. The authors selected five different mouth corner points (right, left, lower, upper, and middle) as a method for lip detection. **Wrobel *et al.*** [35] proposed a method for lip recognition for a person, and this method used the Region of Interest (ROI) to determine the part of the interest lip in the image. Then the cross-correlation method was applied to estimate the biometric parameters. They were using 120 lip prints with an accuracy of 93%. **Kavitha** [36] analyzed a method to identify lips. Lips are detected by a Triangle feature set-based fuzzy. CETS students and staff compile this database. The accuracy was 97.37%. **Krazysztof *et al.*** [37] proposed a method of identifying a person by lip prints. These patterns consist of the furrows with the greatest lengths for the same person, while the locations and inclinations of these furrows remain similar across the lip prints. The accuracy was 92.73%, using 350 lip prints. **Priya and Pushpa** [38] proposed a multimodal biometric system for personal identification that uses fingerprints, faces, and lips. The ROI method is used to extract the most interesting parts of the image and fuse the biometrics using SVM to classify.

IV. DISCUSSION

Table I shows an overview of lip print-based identification techniques, the dataset used, and the description of the dataset. The accuracy rate for the methods, the highest was 98.49%, whereas the lowest was 55%. The error rate evaluates in different ways, and the accuracy equal (100-EER) was represented in some methods. False Acceptance Rate (FAR), False Rejection Rate (FRR), Equal Error Rate (EER), and Receiver Operating Characteristic (ROC) curve are used to calculate the performance of methods.

The researchers obtained high accuracy [22], [36] by calculating the maximum accuracy value or by using a few images in [27] . HT is one of the most useful methods for texture feature extraction with high quality. DTW, LBP, and edge detection are given good accuracy, and the accuracy is greater than 90 at most methods.

Table I.
Overview of Lip Print-Based Identification Techniques

Author and year	Techniques used	Accuracy	Dataset	Dataset description	The measure used for evaluating the performance and observations
			A. Transformation Methods		
(Lukasz *et al.*, 2010) [16]	HT	85%	unavailable	10 people 40 images (4 lip prints for every individual).	FAR and FRR
(Lukasz, 2010) [17]	HT	55%	Create a digital database	10 people 60 images (6 lip prints for every individual). The study was conducted on a collection of 20 lip traces and 40 comparatives.	FAR and FRR
(Lukasz and Wrobel, 2011) [18]	Top hat Transform	>78%	**	30 people 120 images (4 lip prints for every individual)	ROC curves applied by FAR and FRR. The error rate <21.3%
(Ryszard, 2011) [19]	steerable filters + Radon Transform		Lip images are acquisition used CCD camera.	16 people 64 images (4 lip prints for every individual).	Results obtained. demonstrated the possibility of using lip imprints in biometric systems.
(Krzysztof and Rafal, 2013) [20]	GHT	80%	unavailable	10 people 30 images (3 lip prints for every individual).	CRR (The Correct Recognition Rate) =80%
(Wrobel *et al.*, 2013) [5]	GHT	85.1%	The lip print images are converted into a digital form using a scanner with a resolution of 300 dpi.	15 people 45 images (3 lip prints for every individual).	Section length greater than 30 resulted in higher error rates.
(Lukasz *et al.*, 2016) [21]	Top hat Transform		unavailable	50 people, 300 images (100 test images and 200 template mages)	Two template matching algorithms were used to measure the similarity rate, available in the OpenCV library: CV_TM_CCORR_NORMED and CV_TM_CCOEFF_NORMED Template Matching - OpenCV 2.4.8.0 documentation, http://docs.opencv.org
(Lakshmi and Pushpa, 2017) [22]	HT, and Centroid Based K-Means Clustering.	98.49%	The lip prints have been digitized using a scanner (Grayscale, 300dpi) and stored as image files for jpg.	428 twin pairs 856 images (428 test images and 428 database images)	FAR and FRR. The optimal threshold = 5.8496.
(Salim and Rasha, 2022) [23]	HT	91.34%	unavailable	unavailable	Euclidean distance

Author and year	Techniques used	Accuracy	Dataset	Dataset description	The measure used for evaluating the performance and observations
			A. DTW		
Smacki *et al.*, 2011) [24]	DTW	78.8%.	unavailable	30 people 120 images (4 lip prints for every individual).	FAR and FRR
(Piotr and Orczyk, 2012) [4]	DTW + voting system	88.5%	**	30 people. 120 images (4 lip prints for every individual).	ROC curves for projections using a DTW methodology: (a) oblique at +45°, (b) oblique at -45°, (c) horizontal, (d) vertical. The error rate= ~11,5%
			B. LBP		
(Ben *et al.*, 2016) [25]	Gabor + LBP	86.7%	unavailable	100 people (73 males and 27 females).	SVM
(Sandhya *et al.*, 2021) [26]	LBP	97 %, 85.81%, 81.84%, and 80%.	**	15 people (120 lip print images)	Precision, F1 Score, and Recall.
			C. Statistical method and edge detection		
(Saptarshi et al., 2012) [27]	statistical method	96%	**	4 people 20 images (5 lip prints for every individual).	FAR and FRR
(Samir *et al.*, 2012) [28]	Sobel edge detector and Canny edge detector.		unavailable	unavailable	By applied methods
(Shilpi *et al.*, 2018) [29]	Sobel edge detection +fast match algorithm.		The images have been taken with a camera.	20 people 80 images (4 lip prints for every individual). The lip print is taken from a different region (5 states in India)	Chart
			D. SIFT & SURF		
(Sambit *et al.*, 2011) [9]	SIFT + SURF	>90%	Lip images are captured by Canon PowerShot A1100IS camera in constrained illumination avoiding reflection of surrounding light on the lip.	10 people 23 images	FAR, FRR and ROC
(Srijan *et al.*, 2019) [30]	SIFT	92.8%& 92.7%	*** ****	Number of Subjects NITRLipV1(15)- NITRLipV2(20) Number of Images NITRLipV1(109)- NITRLipV2(100)	FAR, FRR and ROC

(Farrukh and Haar, 2022) [31]	SURF VGG16 and VGG19 deep learning architectures	95.45% 91.53% and 93.22%	available at https://www.chicagofaces.org/ and https://github.com/dvanderhaar/UJLip.	unavailable	SVM or K-NN
			F. ***Other Methods***		
(Pawan *et al.*, 2011) [10]	Physical and biological attributes to classify lips and Brute-Force Algorithm	89.5%	Create a digital database of lip prints the authors used Nikon 300 D 12.5 MP cameras. The analog signal output of the camera is transferred to the computer using a frame grabber. PIXCI.	200 lip prints	EER is the value where the FAR and FRR intersect, and the value is equal for both rates.
(Smacki, 2013) [32]	Normalized Cross-Correlation	58%	unavailable	300 lip prints	The images were divided into sub-images.
(Krzysztof *et al.*, 2015) [33]	Bifurcation analysis	77%	**	120 lip prints	Increase in the value of the angle parameter increases in the value ERR. The error rate = 23%
(Sangeetha and Arul, 2015) [34]	Five various mouth corner points.		unavailable		SVM
(Wrobel *et al.*, 2016) [35]	ROI + cross-correlation	93%	**	30 people 120 images (4 lip prints for every individual).	FAR and FRR The performance of the lip print recognition was recorded as the following: True Positive (TP)=108 True Negative (TN)=3132 False Positive (FP)=12 False Negative (FN)=232 EER%=21.63 Sensitivity (SE)%=31 Specificity (SP)%=99 Accuracy (ACC)%=93
(Kavitha, 2016) [36]	Fuzzy feature + local triangle feature set.	97.37%	Lip's image of Computer Education and Training Society (CETS) students and staff members.		FRR and FAR
(Krazysztof *et al.*, 2018) [37]	Creation of lip pattern	92.73%	**	50 people 350 images (7 lip prints for every individual).	CMC
(Priya and Pushpa, 2020) [38]	ROI. Fusion It integrates fingerprint, face, and lips biometric traits coming from various sensors.		unavailable	20 Sample	SVM
[39],*[40],**** [41]					

V. CHALLENGES

Different methods aim to analyze the lip print and match it. The significant challenge for identifying the person is the technique of getting lip print. There is no gold standard for obtaining lip prints. There are two techniques for recording lip prints: manually or digitally. Various research studies have used different methods, such as photographing the lips or using lipsticks or coloring agents, in addition to the noise in the lip imprints due to facial hair, pressure direction, and the amount of coloring agent to be used. The softness of the lips was a challenge for the researchers, so they tended to use several images to extract a pattern to identify the person. Using enough images and applying a standard method for measuring efficiency is also essential. Developing a traditional and uniform method for obtaining lip prints is imperative. When lip prints are acquired, they can be effectively used as biometrics in commercial applications. They can also be used in criminal investigations and forensic sciences.

VI. CONCLUSIONS

In this study, we review the many techniques used in lip-print for identification and verification. Most designs begin with image preprocessing as the initial step, followed by feature extraction. Manual methods were time-consuming and had the possibility of human errors. Automated methods using the DTW, Top-Hat Transform, Vote counting, and HT proved efficient. According to many studies, the sample size affects the survey's overall accuracy. The highest accuracy was observed when using HT, equal to 98.49% [22], followed by LBP at 97% [26]. When researchers used a hybrid approach that may provide better performance [36], the accuracy was 95.37%. This review can help the researchers willing to work with lip prints to know the basic feature extraction techniques.

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