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Personal identification using lip print furrows

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ABSTRACT

There are common techniques for personal identification such as fingerprint recognition, face recognition, and iris recognition. In this paper, we suggest a new method for personal identification using lip print furrows. This method will be useful in forensics services. This study aims to identify people by their lip print patterns that are unique for each person. Lip print features are extracted from the lip print images by using the vertical Sobel operator, diagonal ±45 lines, and hough transform. A lip print pattern was formed for each person containing only the furrows (the extracted features) that were extracted from 3 lip print images for that person. The correlation coefficients and the mean squared error (MSE) are provided and passed to the support vector machine (SVM) for the classification process. The suggested method gives good results. A comparison between the results of the proposed method and other methods was presented.

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1. INTRODUCTION

In recent years, biometric systems have become a popular method of identifying a person. Many methods are used to identify the person, such as the face, finger, veins, skin, iris, palm, retina, nails, and DNA [1]-[3]. Tsuchihasi and Suzuki reported at the University of Tokyo, from 1968 to 1971, that humans have unique lip features. A lip print may be used to detect crime. It can be used to trace evidence of the crime and to identify the person and their gender. The study of furrow patterns occurring in the human lip is called cheiloscopy [4]. In several countries, like Poland, lip traces are effectively used to identify criminals during investigations [5]. Lip print is one of the most difficult ways because the lip is soft and very flexible. The surface of the lip is formed by several furrows that form a network of lines. Lip prints bring large and wide benefits in various fields such as personal identification [6]-[9]. In 1999 in Illinois, lip print was used for personal identification of criminals [10].

Recently many authors in the literature analyzed and manipulate lip prints manually from the medical point of view as [4], [11]-[15]. In recent years, scientists have shown a large increase in this important concept. In general, features can be classified into texture, shape, and color. The form and position of the lip furrows were analyzed in texture features such as Markov models [16], radon transform [17], Bifurcation's analysis [18], HT [19], Top_Hat [20], gabor filter, local binary pattern (LBP) [21], dynamic time warping (DTW) [22], [23], statical analysis [24], [25], scale invariant feature transform (SIFT), speeded up robust features (SURF) [26], location and inclination of the furrows [27], LBP, area and perimeter [28] and principal component analysis (PCA) [29]. Shape features include general geometric properties of the lips [30], Rotation, scale, and translation invariant image [31], and Shape descriptors [32]. Color features such as Moments of the color [33], histogram of the color [34]. In the following, we will discuss textures feature methods in the literature related to our work. Many studies in the literature concerned the identification and verification of lip prints. These studies are abbreviated in Table 1. In this manuscript, we suggested a technique for personal identification using lip print. The method consists of three stages pre-processing, feature extraction, and classification. Features of lip print are extracted using diagonal line operator, sobel operator, canny operator, and hough transform, then support vector machine (SVM) is used for classification. The rest of this paper is organized as the following: section 2 presents the proposed method, results, and discussions were introduced in section 3, and finally, section 4 presents the conclusion.

Table 1. A brief description of some studies of lip print identification

Author and year	Techniques Used	Dataset	Accuracy rate	Loopholes of the Method
Bakshi *et al.* [26]	SIFT and SURF techniques	Lip images are captured by Canon PowerShot A1100IS camera in constrained illumination avoiding reflection of surrounding light on the lip.	>90%	This algorithm uses regular images only.
Porwik and Orczyk [22]	DTW and voting system	http://biometrics.us.edu.pl	88.5%	This algorithm requires high-quality lip print images.
Bhattacharjee *et al.* [24]	The statistical method used to find the average direction of groves (horizontal, vertical, and diagonal) used edge detection	http://biometrics.us.edu.pl	96%	Using only 20 images
Wrobel *et al.* [19]	GHT, and the line segments used three parameters (The length, the angle of inclination to the X-axis, and the location of the midpoint of the section) as features	The lip print images are converted into a digital form using a scanner with a resolution of 300 dpi.	85.1%	The location of the midpoint of the section is maybe changed because the lip is very soft which affects the accuracy
Wrobel *et al.* [18]	Bifurcation analysis	http://biometrics.us.edu.pl	77%	The error rate was 23%. In their method some pixels imitated bifurcations that did not exist in the lip print pattern.
Wrobel *et al.* [27]	Creation of lip pattern	http://biometrics.us.edu.pl	92.73%	They used two techniques one for high quality images and the other for low-quality images.
Roshan *et al.* [28]	LBP are used to obtain texture-based features from the segmentation process upper and lower lip	http://biometrics.us.edu.pl	97%, 85.8%, 81.84%, and 80%.	They used the shape features in lip print which are changed with opening or closing the mouth.

2. METHOD

The proposed method involves three cascaded stages (pre-processing, features extraction, and classification). The Pre-processing has executed the following steps converting test images to grayscale images, region of interest, thresholding, and smoothing images. In the features extraction stage, it is executed the following steps are furrow's detection and HT. SVM using in the classification stage. Figure 1 shows the block diagram of the proposed method.

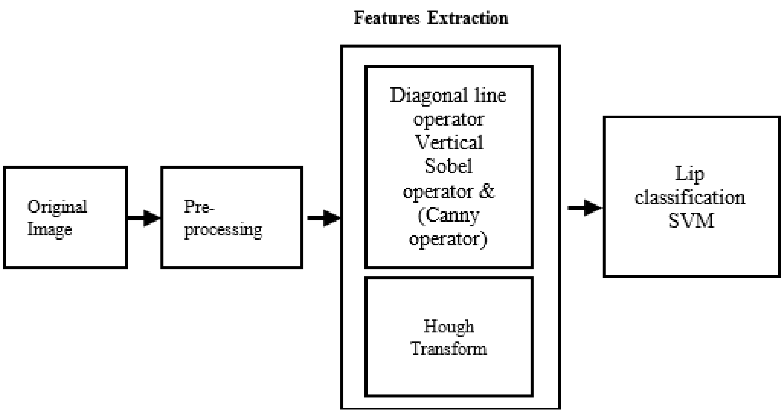

Figure 1. Block diagram of the proposed method

2.1. Pre-processing stage

2.1.1. Pre-processing stage 1: converting test images to grayscale images

The test images are colored images. It is converted into greyscale images. Cropping the image around the lip print to remove unnecessary areas. This procedure reduces the area that should be focused on for this work. Figure 2 shows an example image fors lip print. Topographically in [3], was divided the lip print into six parts; each lip has three zones: upper right (UR), upper middle (UM), upper left (UL), lower left (LL), lower middle (LM), and lower right (LR), as shown in Figure 3. In this study, (LM) part of the lip print was selected manually as a region of interest and used in the experimental testing because the lines of features are clear and visible [10].

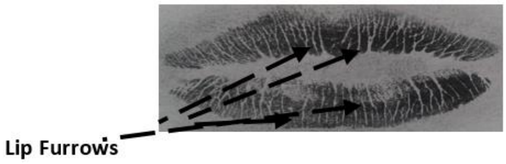

Figure 2. Lip print image with simple furrows

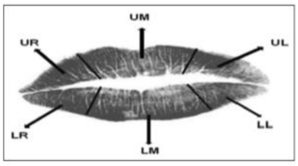

Figure 3. Topographic subdivisions of lips into six parts: UR, UM, UL, LL, LM, and LR

2.1.2. Pre-processing stage 2: region of interest

Select the lower middle part of the lip for three lip print images for each person. The selected part of all the images had the same size (65×80) pixels. Figure 4 shows the interesting region in the original images, Figure 4(a) shows the original three lip print images for a person, and Figure 4(b) shows the selected lower middle part of each lip.

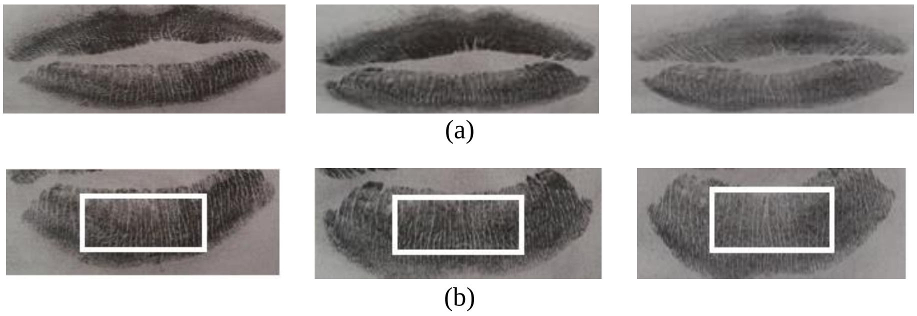

Figure 4. Shows the interesting region in the original images (a) the original three lip print images for a person and (b) lower middle lip with crop part equal 65∗80 pixels

2.1.3. Pre-processing stage 3: thresholding

The thresholding process is used to separate the background from the object [35]. Figure 5 shows the three lip prints after thresholding, using Otsu's method. Figure 5(a) The three lip prints after converting to grayscale and selecting the lower middle lip, and Figure 5(b) the three lip prints after thresholding.

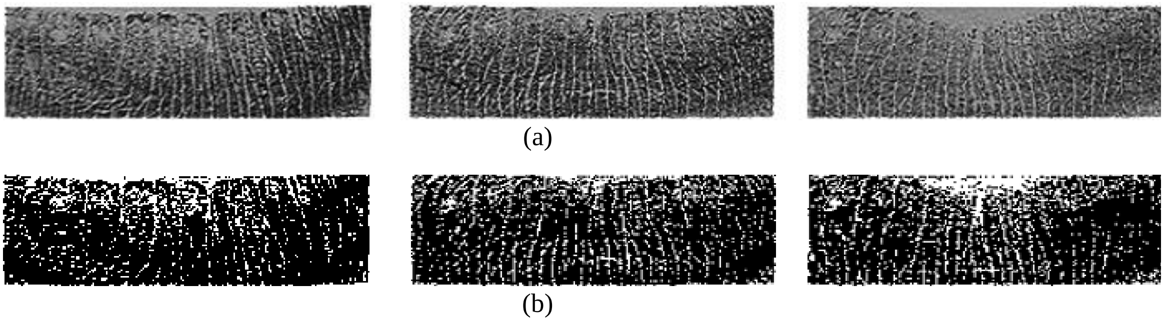

Figure 5. A thresholded stage for lip prints (a) the three lip prints after conversion into grayscale and select lower middle lip and (b) the three lip prints after thresholding

2.1.4. Pre-processing stage 4: smoothing

Gaussian smoothing is used to smooth lip prints. Figure 6 shows the lip prints after passing through the Gaussian 3x3 filter. Smoothing is performed frequently four times to reduce all the noises in the images and to find only the major furrows of the lip prints [36] a Gaussian filter can be described as in (1).

$$Gauss[a(x,y),\sigma] = 1/2\pi\sigma^2 \exp\left(-(x^2+y^2)\right)/2\sigma^2 \quad (1)$$

Where a (x, y) is the original image, and σ =0.5.

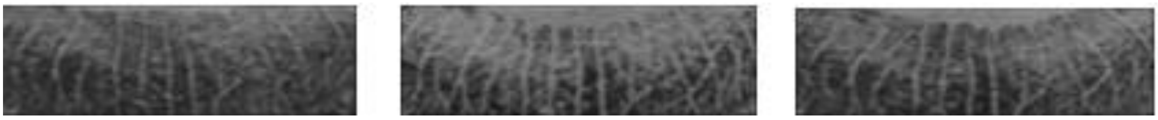

Figure 6. The three lip print images after applying the Gaussian filter

2.2. Feature extraction stage

2.2.1. Furrows detection

The furrows are detected by applying the operator's matrices as Figure 7. In Figure 7(a) diagonal line operator +45, Figure 7(b) diagonal line operator -45, and Figure 7(c) vertical Sobel operator. Then the three images are combined in one image. This image displays all features of the original image, as in (2). This equation is performed on each lip print image for a person. Finally apply the Canny Operators. The main reason to use a Sobel operator before the Canny operator is that the Sobel operator is used for image segmentation, it is running in a vertical direction and it is less sensitive to noise, while the Canny operator is used for image enhancement, and it is sensitive to the weak edge. In our study, the Canny edge detector is implemented on the result of $Icom(x,y)$as in (2). Figure 8 shows a sample implementing these operators on lip prints for a person in Figure 8(a) the three-lip prints applying diagonal line +45, Figure 8(b) the three-lip prints applying diagonal line -45, Figure 8(c) the three lip prints applying vertical Sobel operator, Figure 8(d) the result of combined the three operators for a lip, and Figure 8(e) applying a Canny edge detector in the result of the combined three operators for a lip. The following steps are used to combine lip print features into one image as described.

Input: Suppose a(x,y) //represents the region of interest of the lip print image after executing preprocessing stage on it.
Output: Icom(x,y) // The image that combine all the features for a person.
Initialization:
Step 1: for j=1 to number of lip print for a person // number of lip print for a person
Step 2: apply diagonal mask + 45 lines on a(x,y) as shown in Figure 8(a) // call it d1[a(x,y)]
Step 3: apply diagonal mask - 45 lines on a(x,y) as shown in Figure 8(b) // call it d2[a(x,y)]
Step 4: apply Vertical lines using Sobel operator on a(x,y) as shown in Figure 8(c)// call it VS[a(x,y)]
Step 5: union of results of Steps 2,3 and 4 to perform Icom(x,y) as shown in Figure 8(d) // this image gathers all features using the equation is given by (2).
Step 6: end (For)

1	1	0
1	0	-1
0	-1	-1

(a)

0	1	1
-1	0	1
-1	-1	0

(b)

-1	0	1
-2	0	2
-1	0	1

(c)

Figure 7. The operator's matrices (a) diagonal line +45, (b) diagonal line -45, and (c) vertical Sobel operator

$$Icom(x,y) = \{d1[a(x,y)] \cup d2[a(x,y) \cup VS[a(x,y)]\} \quad (2)$$

Where: $Icom(x, y)$ is the image, which combined the features from steps (a, b, and c) a(x,y) is the lip print region of interest after applying preprocessing stage for a person, d1 a(x,y) diagonal lines+ 45, d2 a(x,y) diagonal lines -45, and VS a(x,y) is the extracted vertical lines using Sobel operator.

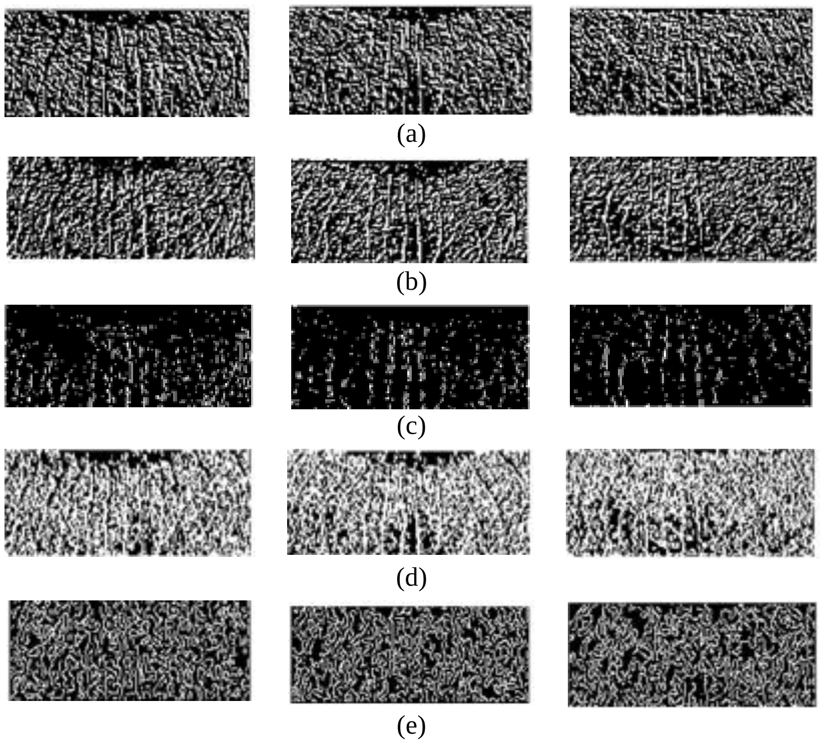

Figure 8. An implementation of the furrows detection: (a) the three-lip prints applying diagonal line +45, (b) the three-lip prints applying diagonal line -45, (c) the three lip prints applying vertical Sobel operator, (d) the result of combined the three operators for a lip, and (e) applying a Canny edge detector in the result of the combined three operators for a lip

2.2.2. Hough transform

Paul hough published the (HT) in 1962. HT is used to detect geometric objects in images (e.g., straight lines, circles, or ellipses) [37]. In this paper, HT is used to detect straight lines. It is applied on the images results from applying the Canny operator. Based on cartesian coordinates (x, y), the length of the vector r for each angle θ value is calculated according to (3). The aim of using HT is to extract a collection of the straight lines, which represent a furrow in lip print. Figure 9 is selected straight lines detected using HT for three lip print images.

$$r = x\cos\theta + y\sin\theta \quad (3)$$

Where: -90° $<= \theta <=$ 90°.

Figure 9. Shows a graphical analysis of straight lines detected using HT, in which vertical lines are selected only

2.3. Classification stage

To obtain the pattern for a person from the features extracted from three lip prints can use the in (4). Figure 10 is shown an example of the pattern. The correlation coefficients between the pattern and the lip print features are stored in an accumulator array. We get the maximum value in the accumulator array when the pattern correlates with the same person's lip prints and calculate the mean-squared error (MSE) between the pattern and lip print features. Then correlation coefficients and MSE of features are passed into SVM to classify the dataset. Cross-validation is used to distribute the Training set and Testing set by the Holdout Method. This paper also shows that a lip print identification based on SVM classification can be satisfied in two classes to identify the person.

$$\mathrm{Ipattern}(x,y) = \begin{cases} 1 & \text{if } HT_1(x,y) + HT_2(x,y) + HT_3(x,y) \geq 2 \\ 0 & \text{if } HT_1(x,y) + HT_2(x,y) + HT_3(x,y) < 2 \end{cases} \quad (4)$$

Where: $\mathrm{Ipattern}(x,y)$ is the pattern image for the person. $HT_1(x,y)$, $HT_2(x,y)$, and $HT_3(x,y)$ are the gathers of all the features for image 1, image 2, and image 3 respectively for the same person (since we have 3 images for each person). (i.e., the pixel in the pattern equals one if at least the pixels in two lip prints feature images=1).

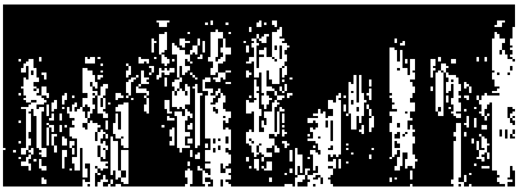

Figure 10. The pattern for a person from the features extracted from three lip prints

3. RESULTS AND DISCUSSIONS

3.1. Dataset

The lip print test images used in this study are taken from two websites [38], [39]. The sample of the lip print test images taken from [38] consists of 60 lip print images (15 persons,4 lip print images for each person, the gender is unknown in this dataset). While data sample of lip print test images given in [39] consists of 88 lip print images (22 persons, 4 lip print images for each person, 9 males, and 13 females). The total number of images used in this study is 148 lip print images (37 persons, 4 lip print images) in our study we used only 3 lip prints to create the patterns.

3.2. Results and discussions

The proposed algorithm was implemented using MATLAB R2013a. The performance of the classification algorithm is measured using different metrics, the statistical metrics defined in Table 2, such as accuracy, which is the probability of performing a correct classification; error rate, sensitivity which is the proportion of actual positive cases that are correctly identified; specificity, which is the proportion of actual negative cases that are correctly identified, and precision which is the closeness of the measurements to each other. The classification produces four types of outcomes-two types of correct classification, true positives (TP), which is the number of observations to which the model correctly assigns true values, and true negatives (TN), which is the number of observations to which the model correctly assigns false values, and two types of incorrect (or false) classification, false positives (FP) which is the number of observations to which the model incorrectly assigns true values since their actual values are false, and false negatives (FN) which is the number of observations to which the model incorrectly assigns false values since their actual values are true.

In our study we used SVM to classify whether a lip print image is for a specific person or not. The instances in each dataset are randomly divided into two sets: 75% as the training set and 25% as the testing set. The average of 20 repeated runs for each person gives the performance. The results of measuring values are shown in Table 3. The proposed method is compared with the other methods, the results have been divided in two tables in Table 4 which are used the dataset in [38], and Table 5 methods which used different dataset. The details of the comparisons are as follows:

- The proposed method gives a better result, as shown in Table 4, in which the average accuracy rate equals 93.6%. The proposed method gives better accuracy than most other methods except for the Statistical method [24], which gives better accuracy, but this may be because it relies on a small sample of only 20 images.
- According to the results shown in Table 5, in [21], [26] the source of the dataset is unknown. The proposed method gives the high accuracy using two datasets in [38], [39] comparisons with methods in Table 5.

Table 2. Classification of performance

Measures	Formula
Accuracy	(TP + TN) / (TP + TN + FN + FP)
Error rate	(FP + FN) / (TP + TN + FN + FP)
Sensitivity	TP / (TP + FN)
Specificity	TN / (TN + FP)
Precision	TP / (TP + FP)

Table 3. Performance the proposed method

Dataset	Accuracy rate	Error rate	Sensitivity rate	Specificity rate	Precision rate	Average Time. sec.
[38]	93.6%	6.4%	98.64%	23%	94.78%	16.54
[39]	91.94%	8.06%	96.1%	4.55%	95.5%	21.60

Table 4. Comparison of the proposed method with other methods using dataset in [38]

Methods	Accuracy rate	The No. of Lip Print Images Used in the Study	Details of Methods
Proposed method	93.6%	60 lip prints obtained from 15 person (4 prints per person)	-Sobel operator, Canny operator, HT, and SVM
The algorithm in [27]	92.7%	350 lip prints obtained from 50 people (7 prints per person)	-Creation of lip patterns, SHT, length of furrow, and classification (KNN, Ridor, J48, Hoeffiding Tree, KStar)
Statistical method [24]	96%	20 lip prints from 4 persons	-Edge detection Technique, performance (FAR, FRR, and ROC)
Bifurcation analysis [18]	77.0%	120 lip prints obtained from 30 people (4 prints per person)	-Bifurcation methods-similarity coefficient
Section Compari-son [19]	85.1%	45 lip prints were obtained from 15 people (3 prints per person)	-HT - similarity coefficient
DTW algorithm + Voting system [22]	88.5%	120 lip prints obtained from 30 people (4 prints per person)	-DTW and voting and rank technique-performed using the histogram and CMC curve-EER
DTW algorithm [23]	78.8%	120 lip prints obtained from 30 people (4 prints per person)	-DTW -lip pattern image projections: horizontal, vertical, and oblique (angle of 45° and 135°).
ROI+ cross-correlation [40]	93%	120 lip prints obtained from 30 people (4 prints per person)	-ROI was determined in the image, then the standardized cross-correlation method, for performance (FAR, and FRR curves for different recognition)

Table 5. Comparative of the proposed method with other methods whose dataset source is unknown

Methods	Accuracy rate	Dataset Description	Details of Methods
Proposed Method	93.6% 91.94%	(4 prints per person) (60 lip prints) [38], (88 lip prints) [39]	Sobel operator, Canny operator, HT, and SVM
Gabor +LBP [21]	86.7%	100 lip prints	Gabor and LBP-SVM
PCA [21]	56.1%	---	PCA
LDA [21]	57.2%	---	LDA
Gabor [21]	81.2%	---	Gabor
LBP [21]	80.6%	---	LBP
(SIFT) [26] (SURF) [26]	93% 94%	23 lip prints were obtained from 10 people	SIFT and SURF methods –performance FAR and FRR

4. CONCLUSIONS

This paper presents a new method for personal identification based on lip print patterns, which can be used in the forensic domain. In this study, three lip print images for each person were used to prepare a pattern. The proposed method is compared with a set of methods, and the results are promising. We have gotten a high accuracy (93.6% and 91.94%) in two different datasets. In future works, we will use a meta-heuristic search or hybrid search in the features selection stage to show its effect on the performance of the classification method.

REFERENCES

[1] S. Prabhakar, S. Member, J. Kittler, and D. Maltoni, “Introduction to the special issue on biometrics : Progress and directions,” *IEEE Trans. on Pattern Anal. and Mach. Intell.*, vol. 29, no. 4, pp. 513–516, 2007, doi: 10.1109/TPAMI.2007.1025.

[2] M. Chora´s, "Merging methods of biometrics human identification," Kummamoto, Japan: IEEE CS Press., 2007, doi: 10.1109/ICICIC.2007.283.

[3] Y. Tsuchihashi, “Studies on personal identification by means of lip prints,” *Forensic Sci.*, vol. 3, pp. 233–248, 1974, doi: 10.1016/0300-9432(74)90034-x.

[4] J. Kasprzak "Cheiloscopy," In: *Siegal JA, Saukko PJ, Knupfer GC (eds). Encyclopedia of forensic sciences*, vol. I, 2nd ed. London: Academic Press, 2000, pp. 358–362, doi: 10.1006/rwfs.2000.0436.

[5] P. Sharma, S. Saxena, and V. Rathod, “Comparative reliability of cheiloscopy and palatoscopy in human identification,” *Indi. Jour Den Rese.*, vol. 20, no. 4, pp. 453–457, 2009, doi: 10.4103/0970-9290.59451.

[6] M. Newton, *The Encyclopedia of Crime Scene Investigation (Facts on File Crime Library), 1st editio,* Checkmark Books; Paperback, 2007.

[7] R. V. Prabhu, A. D. Dinkar, V. D. Prabhu, and P. K. Rao, “Cheiloscopy : Revisited,” *J. Forensic Dent. Sci.*, vol. 4, no. 1, pp. 47–52, 2012, doi: 10.4103/0975-1475.99167.

[8] I. V. G. Nalliapan, M. Ulaganathan, Y. Andamuthu, M. Thangadurai, and T. T. Periyasamy, “Cheiloscopy: An evolving tool in forensic identification,” *J. Indian Acad. Dent. Spec. Rese.*, vol. 5, no. 2, pp. 37–41, 2019, doi: 10.4103/jiadsr.jiadsr.

[9] J. A. Cott and S. M. Standish, *Textbook of outline of forensic dentistry,* Special Tech (Cheiloscopy). 1981.

[10] J. Dineshshankar and N. Ganapathi, “Lip prints : Role in forensic odontology,” *J Pharm Bioallied Sci.*, vol. 5, no. 5, pp. 95–97, 2013, doi: 10.4103/0975-7406.113305.

[11] A. A. I. M. Caldas and T. Magalha˜es, “Establishing identity using cheiloscopy and palatoscopy,” *Forensic Sci. Int.*, vol. 165, pp. 1–9, 2007, doi: 10.1016/j.forsciint.2006.04.010.

[12] R. Vikash, K. Mysore, and K. Sunil, “Study of lip prints: A forensic study,” *J. Indian Acad. Oral Medic. Radiolo.*, vol. 26, no. 1, pp. 50–54, 2014, doi: 10.4103/0972-1363.141856.

[13] S. Sundharam, A. Prakash, and S. Gopalakrishnan, “Lip prints (Cheiloscopy),” *Indian J Dent Res.*, vol. 12, no. 4, pp. 234–237, 2001, [Online] Available: https://www.researchgate.net/publication/11381939_Lip_Prints_Cheiloscopy

[14] R. V. Prabhu, A. Dinkar, and V. Prabhu, “A study of lip print pattern in Goan dental students – a digital approach,” *J Forensic Leg Med.*, vol. 19, no. 7, pp. 390–395, 2012, doi: 10.1016/j.jflm.2012.04.012.

[15] V. Sonal and B. K. Parekh, “Study of lip prints as an aid to forensic methodology,” *J. Indian Dent. Assoc.*, vol. 17, no. 1, pp. 12–18, 2000, [Online]https://www.researchgate.net/publication/290675256_Study_of_lip_prints_as_an_aid_to_forensic_methodology.

[16] C. M. Travieso, J. Zhang, P. Miller, and J. B. Alonso, “Using a discrete hidden markov model kernel for lip-based biometric identification,” *IMAVIS,* vol. 32, no. 12, pp. 1080–1089, 2014, doi: 10.1016/j.imavis.2014.10.001.

[17] H. Jin. S. S. Jaap, K. Ton, and D. Chang, “A robust image fingerprinting system using the Radon transform,” *Signal Process. Image Commun,* vol. 19, no. 4, pp. 325–339, 2004, doi: 10.1016/j.image.2003.12.001.

[18] K. Wrobel, R. Doroz, and M. Palys, “Lip print recognition method using bifurcations analysis,” in *Proceedings of the 7th Asian Confer. on Intelligent Infor- mation and Database Syst., ACIIDS 2*015, Bali, Indonesia, 2015, pp. 72–81, doi: 10.1007/978-3-319-15705-4.

[19] K. Wrobel, R. Doroz, and M. Palys, “A method of lip print recognition based on sections comparison,” in *International Conference on Biomet- rics and Kansei Engineering (ICBAKE),* 2013, pp. 47–52, doi: 10.1109/ICBAKE.2013.10.

[20] S. Lukasz, L. Jacek, and W. Zygmunt, “Lip print pattern extraction using top-hat transform,” in *Springer International Publishing Switzerland, R. Burduk et al. (eds.), Proceedings of the 9th International Conference, on Computer Recognition Systems CORES 2015, Advances in Intelligent Systems and Computing.*, 2016, p. 403, doi: 10.1007/978-3-319-26227-7_32, 337-346.

[21] N. Ben, S. Jin, and D. Yonghui, “Lip print recognition using gabor, and LBP features,” in *International Conference on Electronic Information Technology, and Intellectualization,* 2016, pp. 675–679, doi: 10.12783/dtcse/iceiti2016/6204.

[22] P. Porwik, and T. Orczyk, “DTW and voting-based lip print recognition system,” in *Procee. of the Eleventh IFIP TC 8 Intern.Confer. Computer Informa. Syste and Indust. Manage.,* Venice, Italy, 2012, pp. 26–28, doi: 10.1007/978-3-642-33260-916.

[23] L. Smacki, K. Wrobel, and P. Porwik, “Lip print recognition based on DTW algorithm,” in *Proceedings of the Third World Congress on Nature & Biolog. Inspired Compu.,* Salamanca, Spain, 2011, pp. 19–21, doi: 10.1109/NaBIC.2011.6089655.

[24] S. Bhattacharjee, S. Arunkumar, and S. K. Bandyopadhyay, “Personal identification from lip-print features using a statistical model,” *Int J Comput Appl,* vol. 55, no. 13, pp. 30–34, 2012, doi: 10.5120/8817-2801.

[25] J. Shilpi, V. Poojitha, and B. Madhulika, “A cheiloscopic approach for unique identification among indian subpopulation,” in *Singh R., Choudhury S., Gehlot A. (eds) Intelligent Communication, Control and Devices, Advances in Intelligent Systems and Computing*, 624. Publisher Name Springer, Singapore, 2018, pp. 1729–1738, doi: 10.1007/978-981-10-5903-2_178.

[26] S. Bakshi, R. Raman, and P. K. Sa, “Lip pattern recognition based on local feature extraction,” in *Proceedings of 2011 Annual IEEE, India Confer. (INDICON),* India, 2011, no. May, pp. 1–4, doi: 10.1109/INDCON.2011.6139357.

[27] K. Wrobel, R. Doroz, P. Porwik, and M. Bernas, “Personal identification utilizing lip print furrow based patterns. A new approach,” *Pattern Recognit.,* vol. 81, pp. 585–600, 2018, doi: 10.1016/j.patcog.2018.04.030.

[28] S. S. Roshan, F. S. Sapna, and A. P. Rodrigues, “Comparative analysis of machine learning algorithms for lip print based person identification,” *Evol. Intell.,* vol. 15, no. 1, pp. 743–757, 2022, doi: 10.1007/s12065-020-00561-y.

[29] H. Erwin, A. Nur, K. Azah, Y. Choo, and A. Sabrina, “A comparative study of feature extraction using PCA and LDA for face recognition,” in 2011 7th *International Conference on Information Assurance and Security (IAS),* IEEE, 5-8 Dec., 2011, pp. 354–359, doi: 10.1109/ISIAS.2011.6122779.

[30] K. Wrobel, R. Doroz, P. Porwik, J. Naruniec, and M. Kowalski, “Using a probabilistic neural network for lip-based biometric verification,” *Eng. Appl. Artif. Intell.,* vol. 64, no. January, pp. 112–127, 2017, doi: 10.1016/j.engappai.2017.06.003.

[31] P. Ayyalasomayajula, S. Grassi, and P. Farine, “Rotation, scale and translation invariant image retrieval method based on circular segmentation and color density,” in *Published 2011, Computer Science 7th International Symposium on Image and Signal Processing and Analysis (ISPA),* OCT., 2011, [Online] :https://www.researchgate.net/publication /224262768 Rotation_scale_and_translation_invariant_image_retrieval_method_based_on_circular_segmentation_and_color_density

[32] K. Al-thelaya *et al.*, “Invariant shape descriptors for visual 2D and 3D cellular and nuclear shape analysis and classification,” *Comput. Graph.,* vol. 98, pp. 105–125, 2021, doi: 10.1016/j.cag.2021.04.037.

[33] M. V. Anusha, M. V. U. Reddy, and T. Ramashri, “Content based image retrieval using color moments and texture,” *Int. J. Eng. Res. Technol.,* vol. 3, no. 2, pp. 2812–2815, 2014, [Online]. Available: https://www.ijert.org/research/content-based-image-retrieval-using-color-moments-and-texture-IJERTV3IS21051.pdf

[34] S. Sergy, “Color histogram features based image classification in content-based image retrieval systems,” in *Conference: Applied Machine Intelligence and Informatics, 2008. SAMI 2008. 6th International Symposium on,* no. February, 2008, pp. 221–224, doi: 10.1109/SAMI.2008.4469170.

[35] E. I. Ershov, S. A. Korchagin, V. V. Kokhan, and P. V. Bezmaternykh, “A generalization of Otsu method for linear separation of two unbalanced classes in document image binarization,” *Comput. Opt.,* vol. 45, no. 1, pp. 66–76, 2021, doi: 10.18287/2412-6179-CO-752.

[36] C. Lopez-Molina, B. D. Baets, H. Bustince, J. Sanz, and E. Barrenechea, “Multiscale edge detection based on gaussian smoothing and edge tracking,” *Knowl Based Syst.,* vol. 44, pp. 101–111, 2013, doi: 10.1016/j.knosys.2013.01.026.

[37] J. Illingworth and J. Kittler, "A survey of the hough transform," *Compu. Vis. Graph Image Proce.*, vol. 44, no. 1, pp. 87–116, 1988, doi: 10.1016/S0734-189X(88)80033-1.
[38] W. Krzysztof, and D. Rafal, "Lip prints database", *Mendeley Data*, V1, 2021, doi: 10.17632/yjxxv9xbds.1
[39] D. Mrozek, E. Ostałowska, and B. Małysiak-Mrozek, "A database of lips traces," *IEEE-dataport*, 2018, doi: 10.21227/H2R04P
[40] K. Wrobel, P. Porwik, and R. Doroz, "Effective lip prints preprocessing and matching methods," in *Proceedings of the 9th International Conference on Computer Recognition Systems CORES 2015, Advances in Intelligent Systems and Computing*, vol. 403, 2016, pp. 347–357, doi: 10.1007/978-3-319-26227-7.

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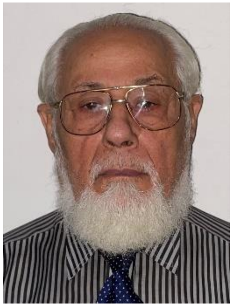

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