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MODIFIED ALGORITHM OF EXTRACTION OF REGION OF INTEREST (ROI) FOR PALMPRINT IDENTIFICATION

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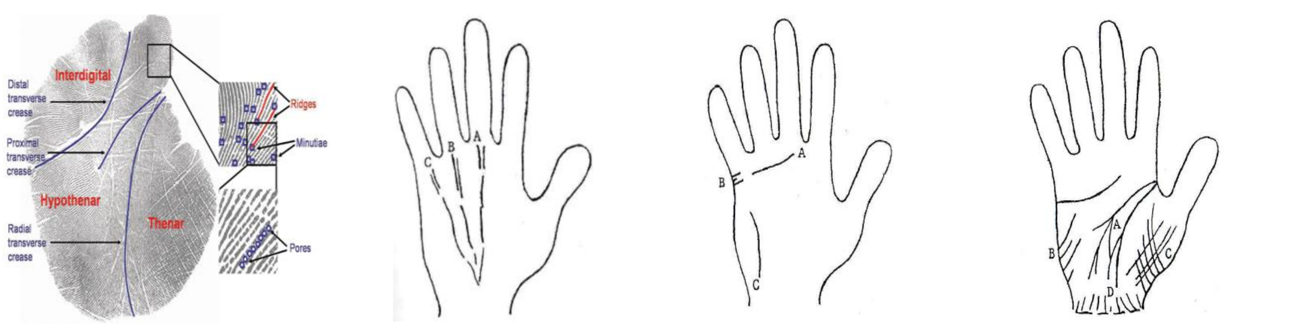
Abstract: Palmprint trait has emerged as a means of new and practical biometric recognition system. Palmprint is divided into three regions known as interdigital, hypothenar and thenar. These regions contain a bundle of patterns such as creases, ridges, minutiae and pores that are believed to be unique and distinct in establishing the identity of a person. The process of extracting the palmprint ROI is a crucial and important initial process for personal identification. In obtaining palmprint ROI, there are numerous algorithms that have been proposed by past researchers. However, to the best of our knowledge, all of these developed algorithms only extracted a small part of the palmprint region. Due to this limitation, some important features that are used as an individual identification have been neglected. In this research, a modified algorithm for extracting the palmprint ROI has been proposed. The performance of the proposed algorithm is compared to three other existing algorithms. These four algorithms are then tested on palmprints in order to identify the size of ROI area and the features extracted. The result is encouraging. It shows that the proposed algorithm has successfully extracted a larger ROI compared to existing algorithms. These results are useful in providing prior information for future development of biometric recognition system.

Keywords: Biometric; Palmprint Extraction; Region of Interest; Creases.

I. Introduction

Each individual possesses unique characteristics with distinct features to be used as a means of personal identification. The identification itself provides data privacy and secrecy. The traditional automated personal identification is classified into two categories: "Possession-based" refers to a hardwire device that can be stored and carried around by a person such as physical key, magnetic card, or passport; and "knowledge-based" requires a person to provide information before being able to be granted access such as pin number or password. However, these methods have some limitations. In the possession-based, the "possession" might be stolen or lost and the "knowledge" can be wrongly guessed or forgotten for the knowledge-based [1]. Therefore, the third personal authentication known as "Biometric-based" is developed. This identification system has emerged as a powerful medium for automatically recognizing the identity of a person. Individual identification using biometrics-based is governed by physiological characteristics such as iris, retina, fingerprint, palmprint and face; and behavioral characteristics such as gesture and signature [2]. Biometric identification system have been extensively used for application by legal purposes, forensics and law enforcement to identify illegal aliens, corpses and positive identification of convicted criminals [2-3].

Personal identification using fingerprint has drawn substantial attention over the last 40 years. However, the drawback of using fingerprint is blurred or damaged fingerprints especially those of the elderly and labour workers. The unclear or damaged fingerprints are caused by problematic skins appearance and physical hard works [1]. Therefore, researchers such as Saleem and Ullah [4] and Apampaet *al.* [5] are looking into other types of biometric identification system. As a result, various biometric identification systems such as palmprint identification system have been developed. Palmprint identification however has gained much attention as a biometric identification system due to its many unique features. The palmprint image not only contains creases, ridges, minutiae and pores, but is also rich in textures and patterns which are also useful and can be used as an important feature for palmprint representation [6-7]. Generally, palmprint are formed from the combination of two distinctive features, palmar friction ridges and the palmar flexion creases. The wavy skin patterns with sweat glands without oil glands or hair are called palmar friction ridges. The palmar flexion creases are the discontinuities of epidermal ridge patterns [7]. There are two types of palmar flexion creases; major flexion creases and thin flexion creases. The palmprint contains three types of major flexion creases that are visibly clear for observation. The three types are radial transverse crease, proximal transverse crease and distal transverse crease as shown in Figure 2(a). The major flexion creases divides a palmprint to three regions: thenar, hypothenar and interdigital. The thin creases are divided into three creases types which are minor finger creases, minor flexion creases and secondary creases as shown in Figure 2 (b-d) [8].



a) Major flexion creases
A. Radial transverse crease
B. Proximal transverse crease
C. Distal transverse crease

b) Minor finger creases
A. Middle finger crease
B. Ring finger crease
C. Little finger crease

c) Minor flexion creases
A. Accessory distal transverse flexion crease
B. “E” lines
C. Hypothenar crease

d) Secondary creases
A. Major accessor creases
B. Hatch creases
C. Checker creases
D. Wrist hatch creases

Figure 2: Features in a palmprint [Source: Ashbaugh [11], Jain & Feng [10]]

Palmprint features can be observed using different levels of image resolutions. The major flexion creases can be observed at resolutions less than 100 pixels per inch (*ppi*), while ridges, minutiae and thin creases can be visualized at approximately 400 *ppi* and pores can only be observed for resolutions greater than 500 *ppi*[7].

In terms of evidence found in a crime scene, the U. S. law enforcement agencies stated that at least 30% of prints that have been collected at the crime scenes are from palmprint type of evidences [9].These palmprint evidences were collected from gun grips, window panes, knife hilts and also steering wheels. For this reason, the U. S. law enforcement agency has developed an interest to capture and scan palmprints for criminal identification. The criminal identification is analyzed based on the unique features of the palmprint that contained inside the palmprint region of interest (ROI).The process of palmprint ROI extraction is very important since its result has high impact on the result of individual identification [10].There are many palmprint extraction methods that have been proposed by past researchers. Generally, most methods of extraction are based on palm boundary or key points between fingers and valleys [11].In order to extract the palmprint ROI, researchers used moment central, midpoints between two fingers, fingers valleys detection algorithm, Cartesian coordinates to obtain circumference of palmprint, parabola technique and fixed palmprint ROI 128x128 pixels [12-15].The process of palmprint ROI extraction using different numbers of key points between fingers and valleys have been done by many researchers [16-17]. However, most of these algorithms only extract a small region of the palm. Due to this limitation, some important features that can also be used as an individual identification might be neglected. Thus, this paper aims it to develop a new algorithm to extract a larger palmprint ROI compared to the existing algorithms.

The paper is organized as follows: Section 2 gives a brief description on steps for image pre-processing. The proposed algorithm for extraction palmprint ROI is detailed out in Section 3. Section 4 reports the performance evaluation using existing algorithms and the modified proposed algorithm. Finally, the conclusion is presented in Section 5.

II. IMAGE PREPROCESSING

The first step to extract a palmprint ROI is called an image preprocessing. The process deployed in this research is based on the procedures by Han et al. [15] and Michaelet al. [18]. The preprocessing module includes three (3) major steps. The process consists of image filtering; boundary tracking and ROI extraction algorithm. The overall image preprocessing procedures are shown in Figure 3.

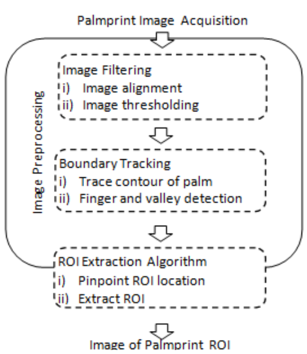


Figure 3: Image preprocessing procedures

A. Image Filtering

An image of the palm in 256 RGB colors is acquired using a platform scanner as depicted in Figure4(a). The image-thresholding procedure are then applied to filter the background color according to the values of color components which are red, green and blue represented by r, g and b. The resultant binary pixel image are represented as C_1, C_2 and C_3. The image thresholding procedures are executed based on procedures by Michael *et al.* [18] for resultant binary pixel imageC_1:

$$C_1(u,v) = \begin{cases} 0 & |r(u,v) - b(u,v)| < T \\ 1 & otherwise \end{cases} \qquad (1)$$

Other resultant binary pixel image C_2 and C_3also repeated the same procedure as in equation (1) using different colors components:$C_2(u,v)$ used$|r(u,v) - g(u,v)| < T$ while $C_3(u,v)$ used$|b(u,v) - g(u,v)| < T$.The local minimal threshold value, T is usually set between 50 and 100. This threshold value is then used to filter the RGB colors to binary image, $I$from the resultant binary pixel image:

$$I = \sum_{v=1}^{h} \sum_{u=1}^{w} \bigcap_{i=1}^{3} C_i(u,v) \qquad (2)$$

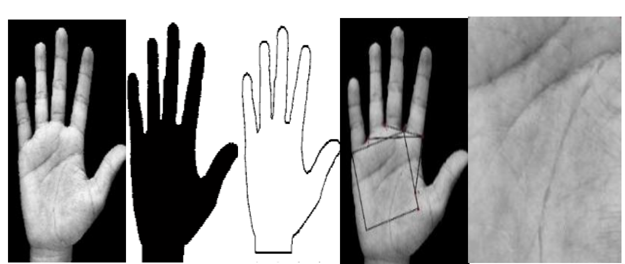
Where u and v represent the coordinates of the screen, and w and h are the width and height of image respectively. The binary palmprint shape image is shown in Figure4(b).

B. Boundary Tracking

The purpose to determine the boundary of the palmprint is to identify the locations of fingers and valleys so that the area of palmprint ROI can be generated. In this stage, the boundary-tracking algorithm is used to trace the contour of palm shape image from binary image as shown in Figure 4(c).

C. ROI Extraction Algorithm

In order to standardise the orientations of different palmprint images rotations, a coordinate system needs to be defined. The coordinate system is determined by building a square parameter based on the locations of fingers and valleys. The locations of points that will be used to build up a square parameter are selected using palmprint ROI extraction algorithms. The area of palmprint ROI will be calculated based on the length multiply by height of the square parameter. This square parameter will be the area extracted from the palmprint and defined as palmprint ROI as shown in Figure 4(d). The image of palmprint ROI is extracted from the palmprint image based on the location of these four points as shown in Figure 4(e).



(a) (b) (c) (d) (e)

Figure 4: Image thresholding and boundary tracking: (a) original palm; (b) binary image; (c) boundary tracking; (d) mapping the coordinate system to the image of a palm; (e) image of extracted square palmprint ROI.

III. PROPOSED PALMPRINT ROI EXTRACTION ALGORITHM

This section will introduce a modified proposed algorithm to extract the palmprint ROI based on the algorithm proposed by Han *et al.* [15], Badrinath *et al.* [16] and Harun *et al.* [17]. The result of extraction will be in the form of a square palmprint ROI. The modifications are done based on the location and number of the key points used. Han *et al.*[15] algorithm used two (2) key points between fingers: the key points used is the valley between ring finger-middle finger and middle finger-index finger as shown in Figure 5(a). The size of palmprint ROI extraction using this algorithm are fixed even though using different image of palmprints. However, the size of palmprint ROI extraction using algorithm Badrinath *et al.*[16] and Harun *et al.*[17] are dynamically changing with respect to the size of palmprint. Larger palmprint will obtained larger palmprint ROI. Algorithm by Badrinath *et al.*[16] also used two (2) key points between fingers: the key points used is the valleys between baby finger-ring finger and middle finger-index finger as shown in Figure 5(b). However, Figure 5(c) is the algorithm by Harun *et al.*[17] using three (3) key points between fingers: the key points used is the valleys between baby finger-ring finger, ring finger-middle finger and middle finger-index finger.

The modifications of the proposed algorithm are done based on the different combination of locations and numbers of the key points used. The proposed algorithm used three (3) key points. However, the locations and algorithms to determine the area of palmprint ROI are shown in Figure 5(d). This algorithm is constructed to obtain the larger area of palmprint so that the palmprint rich textures and patterns can be found in the selected region. The six major steps of the algorithm are:

Step 1: Obtained the boundary of the palm image using boundary tracking algorithm. Identify point P_A which is the valley between little finger and ring finger, point P_B the valley between ring finger and middle finger and point P_C the valley between middle finger and index finger.
Step 2: Draw the reference line $P_A P_B$ to connect points P_A and P_B and reference line $P_B P_C$ to connect points P_B and P_C.
Step 3: Extend the two reference lines to intersect with the boundary that lead to point P_D from line $P_A P_B$ and point P_E from line $P_B P_C$.
Step 4: Draw line $P_C P_E$ to connect points P_C and P_E. Point P_F is the midpoint along the line $P_C P_E$.
Step 5: Draw the line $P_D P_F$ to connect points P_D and P_F.
Step 6: Draw a perpendicular line at points P_D and P_F to get the point P_H and P_G respectively. The length of the perpendicular lines $P_D P_H$ and $P_F P_G$ are equal to the line $P_D P_F$. Draw line $P_H P_G$. These four lines will form a square ROI $P_D P_F P_G P_H$. Line $P_D P_F$ is parallel to line $P_H P_G$ while the perpendicular lines $P_D P_H$ and $P_F P_G$ are parallel (refer Figure 6).

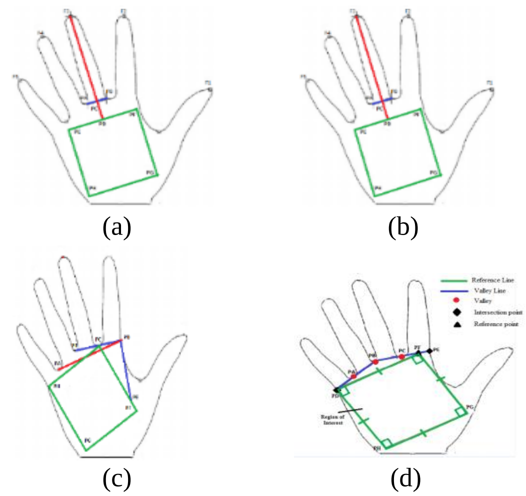


Figure 5: Extraction palmprint ROI using different algorithms: (a) Han *et al.* [17]; (b) Badrinath *et al.* [18]; (c) Harun *et al.* [19] and (d) proposed algorithm

IV. PERFORMANCE EVALUATION

In order to evaluate the performance of the proposed approach, experiments have been conducted on the collected images. The algorithm of extracted palmprint ROI are tested on five (5) images of palmprint using four (4) extraction algorithms; Han *et al.*[15], Badrinath *et al.* [16], Harun*et al.* [17] and the newly proposed algorithm based on two characteristics: i) area of ROI extracted and ii) comparison of creases in palmprint ROI extracted. The images are collected from five 23 years old subjects using a scanner platform. The device is pegs free; therefore users are free to place their right palm in any orientation of the scanner. In the process to determine the location of the palmprint ROI, there exist some variances on calculating the reference points. The existence of these variances is actually caused by the different degree of stretching among the individual palm. Nevertheless, the variances on calculating the reference points does not produce substantial effect on the process of feature extraction since the majority of the significant palmprint information features located in the center part of ROI [16].

A. Area of palmprint ROI extracted

The process of the palmprint ROI extraction using different algorithms are shown in Table 1. For each palmprint, the left image is the original images while the right image is the result of palmprint ROI extraction. From Table 1, it can be observed that there are various sizes and location on where the ROIs lie.

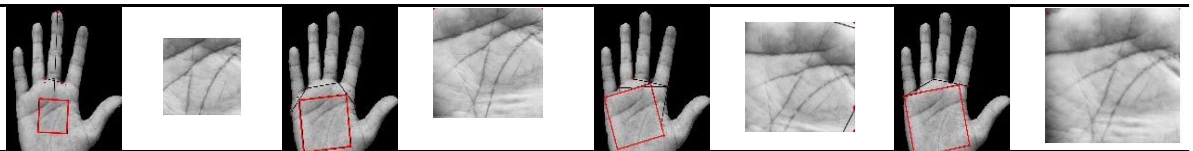
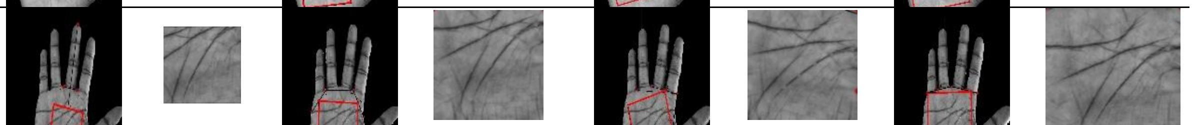
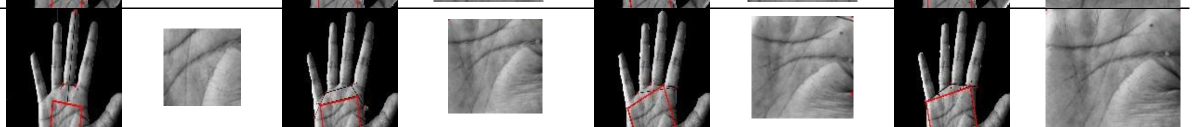
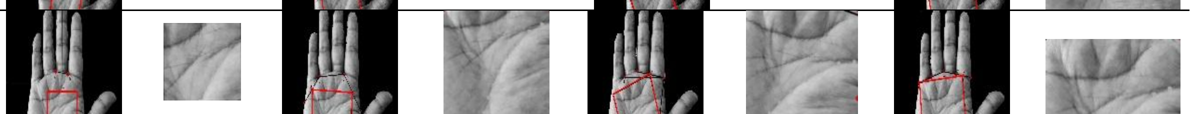
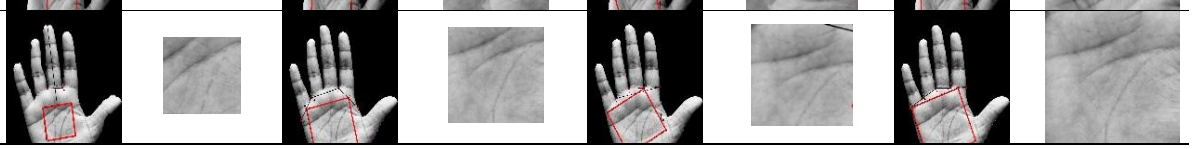
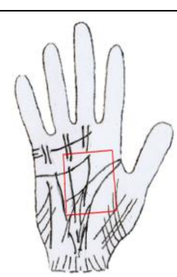
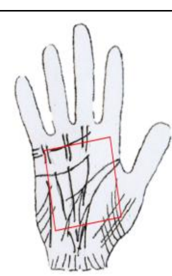
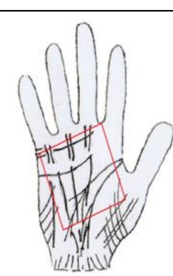
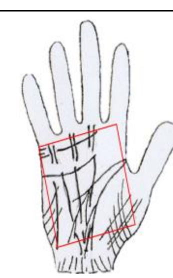
Palm	Algorithms of Extraction of Palmprint ROI							
	Algorithm Han *et al.* [15]		Algorithm Badrinath *et al.* [16]		Algorithm Harun *et al.* [17]		Proposed Algorithm	
	Before	After	Before	After	Before	After	Before	After
A								
B								
C								
D								
E								

Table.1: Result of the palmprint ROI extraction using different algorithms

Table.2: Comparison on the size of area of palmprint ROI using different algorithms

Palm	Algorithm Han *et al.* [15] (unit^2)	Algorithm Badrinath *et al.* [16] (unit^2)	Algorithm Harun *et al.* [17] (unit^2)	Proposed Algorithm (unit^2)
A	45.89	154.51	161.80	216.68
B	45.89	127.69	137.05	157.50
C	45.89	118.81	129.50	171.09
D	45.89	123.21	131.79	158.01
E	45.89	186.87	196.00	259.21

Table.3: ROI on palmprint based to the algorithm used

Original Palm	Algorithm Han *et al.* [15]	Algorithm Badrinath *et al.* [16]	Algorithm Harun *et al.* [17]	Proposed Algorithm
				

The size of the cropping using algorithm Han *et al.*[15] is fixed. Because of that, the area size of the extracted image is the same for all palmprints. The results in terms of area is however different using others algorithm because these algorithms will extract the ROI dynamically based on the size of the palmprint. Larger palmprint will extract larger area size of ROI.The results from Table 2 shows that the region of palmprint extraction using proposed algorithm is larger compared to algorithm by Han *et al.*[15], Badrinath *et al.*[16] and Harun *et al.* [17]. The smallest area extracted is using extraction algorithm by Han *et al.*[15], followed by Badrinath *et al.*[16] and Harun *et al.* [17]. This proved that the proposed algorithm captured the biggest size of palmprint ROI compared to the existing algorithms. This is true for every palm tested. It is also found that, the area of ROI varies based on the gender type. Women's palmprint are usually smaller in size compared to men. As an example, the ROI for Palm B is smaller in size since this is the palmprint of a lady compared to ROI by man's Palm E.

B. Comparison of Creases in Palmprint ROI Extracted

Palmprint consist of features such as creases, ridges, minutiae and pores than can be used as an identification system. Table 3 will compared the location of palmprint ROI extracted.

Based on Table 3, the comparison of feature inside the palmprint ROI are shown in Table 4. The comparison is based on the creases that can be captured inside the palmprint ROI.

Table.4: Comparison of creases inside palmprint ROI based on different algorithms

		Algorithm Han *et al.* [15]	Algorithm Badrinath *et al.* [16]	Algorithm Harun *et al.* [17]	Proposed Algorithm
Major flexion creases	- Radial transverse crease	√	√	√	√
	- Proximal transverse crease	√	√	√	√
	- Distal transverse crease	√	√	√	√
Minor finger creases	- Middle finger crease	√	√	√	√
	- Ring finger crease	√	√	√	√
	- Little finger crease	X	√	√	√
Minor flexion creases	- Accessory distal transverse flexion crease	X	X	√	√
	- "E" lines	X	X	X	√
	- Hypothenar crease	X	X	X	√
Secondary creases	- Major accessory creases	X	√	√	√
	- Hatch creases	X	X	X	X
	- Checker creases	X	X	X	√
	- Wrist hatch creases	X	X	X	X

Based on Table 4, it can be seen that the proposed algorithm contained the most number of creases followed by algorithm by Harun*et al.*[17] and Badrinath *et al.* [16] while algorithm by Han *et al.*[15] contained the least number of creases inside the palmprint ROI. This is true since the extracted region by algorithm Han *et al.* [15] produces the smallest region. This shows that the proposed algorithm has successfully extracted extra information compared to the other extraction algorithms. This result also proved that bigger palmprint ROI contained more information compared to a smaller ROI.

V. CONCLUSION

This paper has proposeda modified algorithm for palmprint ROI extraction method that is suitable for features extraction. The process of extracting palmprint ROI is important as it can assist the law enforcement and forensic community by extracting larger palmprint ROI. The effectiveness of the proposed algorithm is tested using database collected on the area of extraction and the comparion of creases in palmprint ROI. The performance evaluation between proposed extraction algorithm are compared with three existing palmprint ROI extraction algorithms. In term of size of extraction, the result clearly indicate that the proposed extraction algorithm has succesfully achieved better result on extracting larger area of palmprint compared to the other existing algorithms. It is also proven that larger region implies preservation of more informationsbased on the comparion of creases contained inside palmprint ROI. Therefore, the probability of capturing the right criminal can be increased since most important features that can be used for personal identification contained inside the palmprint's ROI. Hence, the results of the palmprint extraction provide platform for further analyis of identifying and verifying the identity of an individual.

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