New algorithm of extraction of palmprint region of interest (ROI)

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Abstract. Palmprint contains numerous patterns that are unique and distinct in detecting human identity. The process of extracting the palmprint ROI is very important since its result provide initial information for personal identification. In obtaining palmprint ROI, there are numerous algorithms that have been proposed by past researchers. However, as best to our knowledge, the extracted ROI using these algorithms only cover a small part of the palmprint. Due to this limitation, some important features that can be used as an individual identification might be neglected. In this research, a new algorithm for extracting the palmprint ROI is proposed. The performance of the proposed algorithm is compared to two other existing algorithms. The three algorithms are tested based on the location and size of the extracted ROI. The result obtained shows that the proposed algorithm has successfully extract larger palmprint ROI compared to existing algorithms. The results provide platform for further use on identifying and verifying the identity of an individual.

1. Introduction

Every individual possesses unique characteristics with distinct features that can be used as a means of personal identification. Identification itself provides data privacy and secrecy. Identification using biometric-based has emerged as a powerful medium for automatically recognizing the identity of a person [1]. This identification system is governed by physiological characteristics such as iris, retina, fingerprint, palmprint and face; and behavioral characteristics such as gesture and signature [2]. Biometrics 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. Recently, the application of biometrics identification system are also increasing among civilians and private sectors in order to establish personal recognition [4]. Personal identification using fingerprint has drawn substantial attention over the last 40 years. However, the drawbacks of using fingerprint is rejected identification due to blurred or damaged fingerprints of the elderly and labour workers. The unclear or damaged fingerprint are caused by problematic skins appearance and physical hard works [1]. Therefore, researchers such as [5] and [6] are looking to other types of biometric identification.
system. As a result, varieties of biometric identification systems such as palmprint identification system have been developed.

Generally, palmprint identification system has gained much attention as a biometric identification system due to many unique features in palmprints. Other than that, the U. S. law enforcement agencies also specify that at least 30% of prints which have been collected at the crime scenes are from palmprint type of evidences [9]. These palmprint evidences have been collected from gun grips, window panes, knife hilts and also steering wheels. For this reason, the U. S. law enforcement has develop an interest to capture and scan palmprint features that can be used for criminal identification. The palmprint image not only contains creases (principal lines), wrinkles, minutiae, pores and ridges, but palmprint is also rich in textures and patterns which are also useful and can be used as an important features for palmprint representation [7] as shown in figure 1. Generally, palmprint are formed from the combination of two distinctive features, palmar flexion creases and palmar friction ridges. The wavy skin patterns with sweat glands without oil glands or hair are called palmar friction ridges. The palmar flexion creases are epidermal ridge patterns the discontinuities [8]. The palmprint contains three major types of palmar flexion creases that are visibly clear for observation. It is the radial transverse crease, proximal transverse crease and distal transverse crease. These palmar flexion creases divides palmprint to three regions: thenar, hypothenar and interdigital. Palmprint features can be observed using different levels of image resolutions. The palmar flexion creases can be observed at resolutions less than 100 pixels per inch (ppi), while ridges, minutiae and thin creases can be visualized only at approximately 400 ppi and pores can only be observed for resolutions greater than 500 ppi [8].

The criminal identification is analyzed based on the unique features of the palmprint region of interest (ROI). There are a lot of method to extract the ROI in the palmprint. In general, majority of the methods will extract palmprint ROI based on palm boundary or key points between fingers [10]. In order to extract the palmprint ROI, researchers like [11] used midpoints between two fingers while [12] used three-key-points based. [13] used fixed palmprint ROI 128x128 pixels and [14] used four-key-points with 45° and 60° angles. From previous studies, it can be seen that most of these algorithms only extract the small centre part of the palmprint. According to [15], the size of ROI is important. Larger ROI gave better result compared to smaller ROI since more information are contained inside the ROI. Because of that, this research will be focusing on developing new algorithm to extract the largest possible palmprint ROI in order to provide the most number of features that can be used for identification purposes.

The paper is organized as follows: Section 2 gives a brief description on proposed approach for extraction of palmprint ROI. The experimental result between proposed and existing algorithms for extraction palmprint ROI is detailed out in Section 3. Finally, the conclusion is presented in Section 5.

2. Proposed Approach
The process of palmprint ROI extraction starts by acquiring the palmprint image using a smartphone. The palmprint is placed inside a mini studio for a shadow-free environment. The device is pegs free, therefore users are free to place their right hand in any orientation. The palmprint extraction algorithm is modified based on the algorithm by [13] and [16]. The algorithm consist of three (3) major steps. The
steps are image filtering, boundary tracking and proposed palmprint ROI extraction. The details for each step are as follows.

Step 1: Image thresholding.
An image of the hand in 256 RGB colors is acquired using a platform scanner as shown in figure 2(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 [16] for resultant binary pixel image C_1, C_2 and C_3:

\[
C_1(u,v) = \begin{cases} 
0 & \text{if } |r(u,v) - b(u,v)| < T \\
1 & \text{otherwise}
\end{cases}
\]

The procedure in equation (1) are also repeated for C_2(u,v) using \(|r(u,v) - g(u,v)| < T\) and C_3(u,v) using \(|b(u,v) - g(u,v)| < T\). The local minimal threshold value is usually set between 50 and 100. However, for our research purpose, the threshold value is set to be 70 since the image captured is in controlled and stable environment [13]. This threshold value is then used to filter the gray level to white and other colors to black.

\[\text{Figure 2.} \quad \text{The image thresholding and boundary tracking: (a) original hand image, (b) binary image, (c) hand shape contour, (d) Mapping the coordinate system to the image of a hand, (e) Image of extracted square palmprint ROI.}\]

Step 2: Boundary tracking.
The binary image, I are from the resultant binary pixel image C_1, C_2 and C_3:

\[
I = \sum_{v=1}^{h} \sum_{u=1}^{w} C_1(u,v)
\]

where u and v represent the coordinates of the screen, and w and h are the width and height of image respectively. The binary hand shape image from the following procedure is shown in figure 2(b). Then, the boundary tracking algorithm is used to trace the contour of hand shape image from binary image as in figure 2(c). The purpose in determining the boundary of the hand is to identify the five fingers and valleys locations so that the area of palmprint ROI can be generated.

Step 3: Proposed Palmprint ROI extraction.
In this step, the algorithm to extract palmprint ROI will be carried out based on boundary of the hand and locations of fingers and valleys that have been determined from the previous step. The suitable combination of fingers and valleys will be pinpointed according to the palmprint ROI extraction algorithm. The output of this algorithm which based on the combination of fingers and valleys will form a square palmprint region. This square region is defined as the palmprint ROI where the palmprint ROI area is calculated by multiplying the length, y and width, x of the ROI as shown in figure 2(d) and 2(e). The region will then be extracted from hand image and can be used for identification purposes as shown in figure 2(e). The size of palmprint ROI area is calculated based on palmprint ROI extraction algorithm. However, most of these algorithms only extract the small centre part of the palmprint. Because of that, we want to propose new algorithm to extract the largest possible palmprint ROI in order to provide the
most number of features that can be used for identification purposes. The algorithm starts by identifying point \( P_A \) is the valley between little finger and ring finger, point \( P_B \) is the valley between ring finger and middle finger and point \( P_C \) is the valley between middle finger and index finger. Next, draw the valley line \( P_B P_C \) to connect points \( P_B \) and \( P_C \) to intersect with the hand boundary which lead to intersection point \( P_D \). Then, draw the perpendicular line \( P_D P_E \) at point \( P_D \) to obtain point \( P_E \) as the length is the same as line \( P_B P_D \). Next, draw the valley line \( P_A P_D \) and identify its length. Then, draw the reference line \( P_C P_F \) from points \( P_C \) through \( P_E \) and extend the line to \( P_F \). The length of line \( P_C P_F \) is the equal to length of line \( P_A P_D \). Based on this reference line \( P_C P_F \), a perpendicular line at points \( P_C \) and \( P_F \) is drawn to form a line. A square ROI \( P_C P_F P_G P_H \) is made from point \( P_C \) and \( P_F \) using the same length as line \( P_C P_F \). Reference line \( P_C P_F \) is parallel to line \( P_H P_G \) while the perpendicular lines \( P_C P_H \) and \( P_F P_G \) are parallel as shown in figure 3(a).

![Figure 2](image)

**Figure 2.** ROI extraction algorithms: a) Proposed ROI extraction algorithm b) ROI extraction by [13] c) ROI extraction by [14].

### 3. Experimental Result
The performance evaluation based on the size of palmprint ROI will be carried out using three (3) extraction palmprint ROI algorithms on five (5) images. The first extraction algorithm is proposed in this research is shown in figure 2(a). While the comparison extraction algorithms are by [13] and [14] as in figure 2(b) and figure 2(c) respectively.

#### 3.1 Location of palmprint ROI extracted
Table 1 is the location and the extracted palmprint ROI using proposed and the existing algorithms.

| Hand | Algorithm by [13] | Algorithm by [14] | Proposed Algorithm |
|------|-------------------|-------------------|--------------------|
|      | Before            | After             | Before             | After             | Before             | After             |
| A    | ![Image](image)  | ![Image](image)  | ![Image](image)  | ![Image](image)  | ![Image](image)  | ![Image](image)  |
| B    | ![Image](image)  | ![Image](image)  | ![Image](image)  | ![Image](image)  | ![Image](image)  | ![Image](image)  |
If we enlarged the image of hand E and resize all extracted image regardless the algorithm of extraction as equal, the result are shown in table 2 below.

Table 2. Enlarged extracted palmprint ROI.

| Hand | Algorithm by [13] | Algorithm by [14] | Proposed Algorithm |
|------|-------------------|-------------------|--------------------|
| E    |                   |                   |                    |

From table 2, by looking at the extracted image, it can be seen that the three creases lines; radial, proximal and distal transverse creases lines are seems like a straight lines when using algorithm [13]. Almost similar case happen when using algorithm [14]. Distal and proximal transverse creases lines looks like a straight lines whereas the radial transverse crease line looks like a parabolic curve if using algorithm [14]. However, the proposed palmprint ROI extraction algorithm shows that the distal and radial transverse creases lines looks like a parabolic curve while only proximal transverse crease line looks like a straight line.

3.2 Size of palmprint extracted

The performance evaluation between algorithm [13], [14] and the proposed algorithm based on the size of extracted palmprint ROI are tabulated as in table 3. The size of the cropping using [13] is fixed. Because of that, the size of the extracted image is the same for all palmprints. The results in terms of size is however different using [14] and the proposed algorithm.

Table 3. Performance based on the size of extraction palmprint ROI between [13], [14] and the proposed algorithm at different hands.

| Hand | Algorithm by [13] | Algorithm by [14] | Proposed Algorithm |
|------|-------------------|-------------------|--------------------|
| A    | 0 ≤ x,y ≤ 6.7     | 0 ≤ x,y ≤ 12.4    | 0 ≤ x,y ≤ 12.8     | 163.84 |
| B    | 0 ≤ x,y ≤ 6.7     | 0 ≤ x,y ≤ 11.3    | 0 ≤ x,y ≤ 11.4     | 137.05 |
| C    | 0 ≤ x,y ≤ 6.7     | 0 ≤ x,y ≤ 10.9    | 0 ≤ x,y ≤ 11.3     | 127.69 |
| D    | 0 ≤ x,y ≤ 6.7     | 0 ≤ x,y ≤ 11.1    | 0 ≤ x,y ≤ 11.5     | 132.25 |
| E    | 0 ≤ x,y ≤ 6.7     | 0 ≤ x,y ≤ 13.6    | 0 ≤ x,y ≤ 14       | 196   |

In term of size of palmprint ROI extracted, it can be seen that the smallest area of palmprint extraction is using extraction algorithm by [13], $S_H$; followed by using extraction algorithm by [14], $S_B$; while the proposed extraction algorithm, $S_P$ extract the biggest size of ROI. The size can be written as
Since the region contains ridges, minutiae and pores are bigger when using the proposed palmprint ROI extraction algorithm, more features can be extracted for matching and identification purposes.

4. Conclusions
This paper has proposed a new algorithm of extraction of palmprint ROI. The performance of proposed algorithm is tested and compared with [13] and [14] algorithms. In term of size of extraction, it can be seen that the proposed algorithm has successfully captured larger region of ROI as compared to the other two existing algorithms. A larger region implies preservation of more information of the palmprint. Consequently, this may facilitate further analysis of the palmprint. Hence, the results of the palmprint extraction provide platform for further analysis of the palmprint in the process of identifying and verifying the identity of an individual.

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