

# Contactless Palmprint Alignment based on Intrinsic Local Affine-invariant Feature Points

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**Abstract**— A Palmprint, biometric characteristics, was mostly found in civil and commercial applications for security system because it has more reliable and easy to capture by low resolution devices. This paper was to develop a new contactless palmprint alignment with general USB camera on tripod. The palmprint image is acquired by this camera and using intrinsic local affine-invariant key points residing on the area patches spanning between two successive fingers to align palmprint image. The key points are relative affine invariant to affine transformations so this algorithm does not need the guidance pegs in acquisition process to fix hand position to avoid the scaling, translation and rotation problems for correctly palmprint image alignment. Finally, the developed algorithm was tested by 10 left-handed palmprint images collected from different subjects. The simulation results indicate by distance map error of 1.4899 pixels.

**Keywords**—Biometric; Palmprint identification; Palmprint alignment; Otsu's thresholding; Convex hull

## I. INTRODUCTION

Biometric characteristics such as palmprint [1], hand and finger geometry [2], fingerprint [3], Iris [4], etc. are mostly popular used in security systems over the traditional secure measures, password or ID cards. The biometric systems are more reliable because they cannot easily be lost, stolen, shared and duplicated.

Palmprint features have advantages compared with other features. For example, palmprint has more information than fingerprint and it can be captured by low resolution devices such as digital camera, video camera. Furthermore, iris capture devices are more expensive than palmprint capture devices. The Principal lines and wrinkles are normally features extracted from palmprint image. The most researchers usually used them for identification process. The palmprint alignment which is the crucial preprocessing steps prior to the identification steps in the palmprint recognition system [5].

The previous works almost used three approaches for palmprint alignment. At the first approach, tangent-based approach [6] is a tangent calculation between two boundaries to find the key points for further used in palmprint alignment. A bisector-based approach [7, 8] is constructed the lines from the center of gravity of a finger boundary to find the key points. The last approach is a finger-based approach [9]. This

method used a wavelet to detect the fingertips to assign the key points. Most of the previous approaches usually used hand acquisition devices with guidance pegs [2, 6, 8, 9] to fix the hand position to avoid the scaling, translation and rotation problems for correctly palmprint image alignment. But this mechanism makes some user feel uncomfortable and the palm must be contacted to image capture device during acquisition process so it is not hygiene for the user.

In this paper, we proposed a new contactless palmprint image alignment method based on a set of key points residing on area patches spanning between two successive fingers. The key points are intrinsic, local and preserved under affine transformation and the alignment is achieved by establishing correspondences between key points. Moreover, we establish corresponding area patches without longest string [10] by using the ray from edge of hand convex hull contour for solving the different of hand open between reference and inquiry palmprint images problem. Finally, the general web camera which can be easily found in office environments and the black screen without guidance pegs was used in the acquisition process to capture reference and inquiry palmprint images from the user.

The rest of this paper is organized as follows: Section II describes the proposed method. Section III shows the experimental result from this paper. Section IV provides some discussion and conclusion.

## II. PROPOSED METHOD

Area has been known to be preserved under an affine transformation. The area patches which are the area spanned by successive fingers including the area spanned by thumb and index finger, the area spanned by index and middle finger, area spanned by middle and ring finger and finally area spanned by ring and little finger. The area patch sequence subjecting to affine transformation as  $[A_a(1), \dots, A_a(n)]$  where  $n = 4$ . The affine-transformed area patch is related to that of the original area before subjecting to transformation by the following relative invariant as shown in (1).

$$A_a(k) = \begin{vmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{vmatrix} A(k), \quad k = 1, 2, \dots, n \quad (1)$$

where  $|A|$  represents determinant of transformation matrix.

The algorithm for establishing correspondences area patches and finds the key points between reference and inquiry palmprint image is summarized as follows:

#### A. Extract the set of four area patches

Find the set of four area patches which are the area spanned by thumb and index finger, the area spanned by index and middle finger, area spanned by middle and ring finger and area spanned by ring and little finger for both reference and inquiry palmprint image by using Otsu's thresholding which was used to convert color palmprint image to binary palmprint image and applying convex hull process to extract the set of four area patches. This process was shown in Fig. 1.

#### B. Establish corresponding area patches

The corresponding area patches was established by the sequence of area patches. The area patches were ordered by the ray which starts from edge of hand convex hull contour to centroid. Finally, the ordered reference and inquiry area patches are matching. The process was shown in Fig. 2.

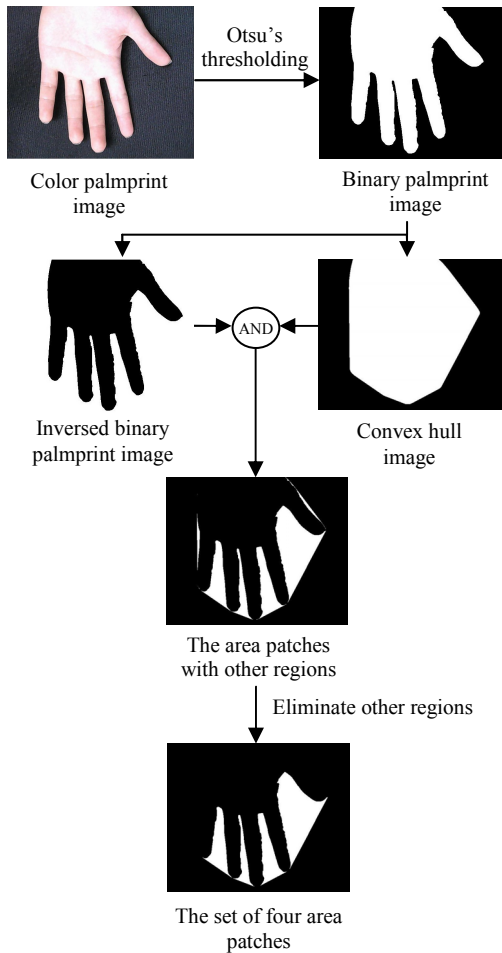


Fig. 1 The process of finding the set of four area patches.

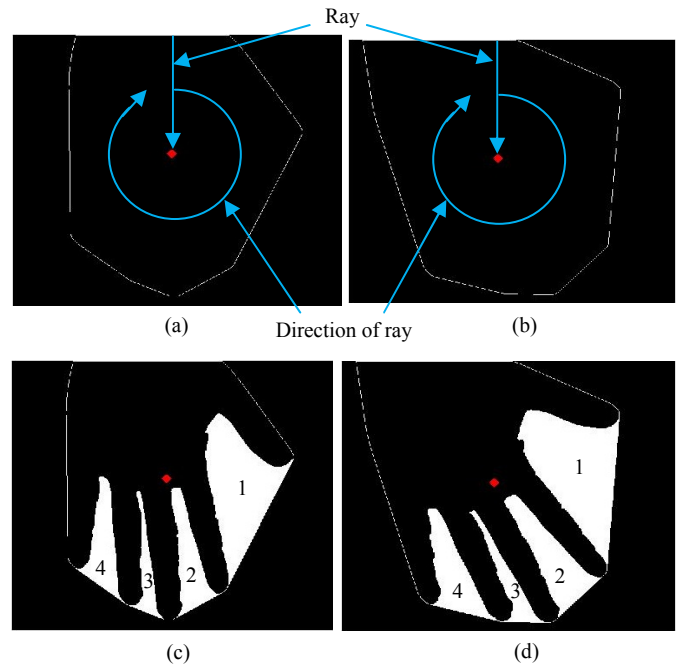


Fig. 2 (a) and (b) Hand convex hull contour and centroid of reference and inquiry images; (c) and (d) Ordered area patches of reference and inquiry images.

#### C. Find the key points

The key points which are the points on tips and valleys of the fingers of reference and inquiry palmprint image were found by applying convex-hull to the area patches, the key points are the convex-hull vertices of the each particular area patch that the convex hull is also affine-invariant features [11]. We find the three vertices of convex hull points by using three small-angles between two vectors that the angles were calculated by (3). The process to find the key points was shown in Fig. 3 and the all key points of based and input palmprint images were shown in Fig. 4.

$$\theta = \arccos\left(\frac{\overrightarrow{PP_1} \cdot \overrightarrow{PP_2}}{|\overrightarrow{PP_1}| |\overrightarrow{PP_2}|}\right) \quad (3)$$

where  $\theta$  is the angle between two vectors  $\overrightarrow{PP_1}$  and  $\overrightarrow{PP_2}$ .  $\cdot$  denotes the dot product.

#### D. Establish corresponding key points

To establish correspondence between key points of two corresponding area patches is constructed by using the alignment of each area patches. The affine transformation matrix was computed based on three key points of each area patch by (4) and used it to align inquiry area patch against reference area patch to establish correspondence between key points of reference and inquiry images. The cross-correlation coefficient is applied to find the similarity of the area patches after alignment for checking the correctly matching between the three key points of reference and inquiry area patches. This process was shown in Fig. 5.

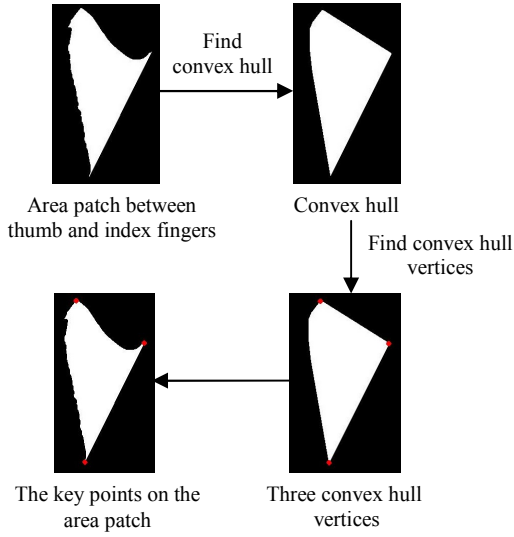


Fig. 3 The process of finding the key points on the area patch between thumb and index fingers.

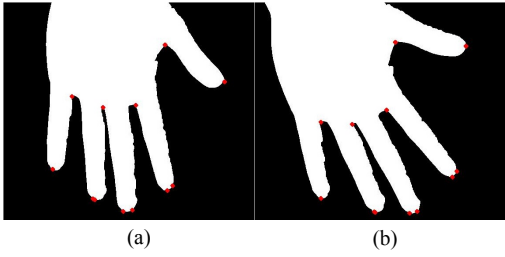


Fig. 4 (a) All key points of reference palmprint image; (b) All key points of inquiry palmprint image.

### E. Construct affine transformation matrix

Affine transformation matrix was computed based on the corresponding key points by (4) and align the inquiry against the reference palmprint image as shown in Fig. 6.

$$Z = (X^T X)^{-1} (X^T Y) \quad (4)$$

where  $Z$  is the affine transformation matrix.  $X$  and  $Y$  are the corresponding key points of reference and inquiry palmprint image respectively.

## III. EXPERIMENTAL RESULT

The captured palmprint image system consists of OKER full HD 386 (HD 1920 x 1080 pixels) web camera on tripod and the black screen which is used to place the user hand. The resolution of these images is 500 x 576 pixels. Fig. 7 shows the whole captured palmprint image system.

To test the performance of the proposed algorithm, 10 subject left hands were captured twice. The first is used for reference and the second as inquiry palmprint image. Furthermore, the palmprint images must not be incomplete (as

in the disabled) finger and do not have the ring or other things on the fingers.

All inquiry images are aligned against all reference images using the proposed algorithm. The distance map error [12] was computed to find the correct matching between inquiry and reference palmprint image and shown on Table I. Clearly the same individual in the reference and inquiry palmprint image yield the smallest error (diagonal element in Table I).

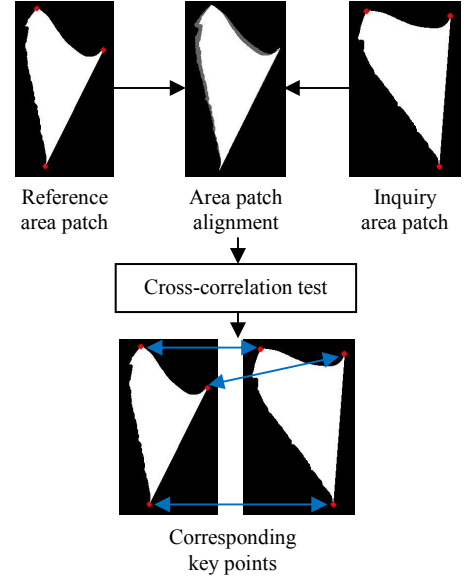


Fig. 5 The process of establishing the corresponding key points.

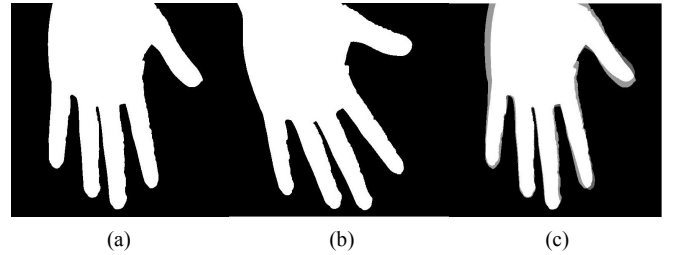


Fig. 6 (a) and (b) Reference and inquiry palmprint image; (c) The reference is then aligned against the inquiry image; Transformed inquiry image is white, reference image is gray.

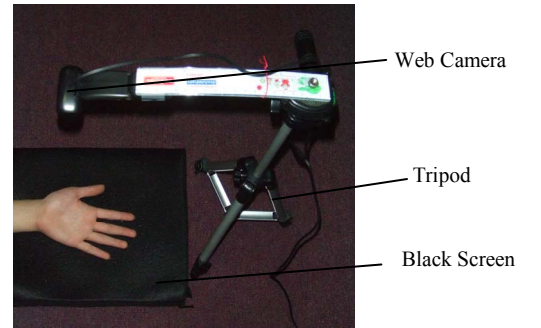


Fig. 7 The captured palmprint image system.

TABLE I. DISTANCE MAP ERROR AFTER PALMPRINT IMAGE ALIGNMENT IN 10 SUBJECTS (UNIT IN PIXEL)

Subject	Reference 1	Reference 2	Reference 3	Reference 4	Reference 5	Reference 6	Reference 7	Reference 8	Reference 9	Reference 10
Inquiry 1	2.2564	10.7915	3.4113	5.6303	6.5689	9.9066	5.7380	8.9200	7.5800	3.3598
Inquiry 2	5.1705	1.7213	5.6086	4.8229	8.6794	8.1932	5.3406	8.6636	11.2114	6.3258
Inquiry 3	3.3451	5.3312	2.5427	6.6215	9.7516	7.3557	6.6188	9.0280	11.3968	3.4578
Inquiry 4	7.4233	5.4355	13.2877	3.2300	69.0982	9.1818	14.4791	18.1669	69.6950	13.6263
Inquiry 5	7.8225	35.3313	6.4253	10.8119	2.5438	19.6887	6.0192	9.5865	6.8634	10.7418
Inquiry 6	6.7078	6.3288	14.4847	6.9433	15.5032	2.5626	14.6322	18.2497	16.3843	14.2355
Inquiry 7	7.2681	15.9714	7.2796	6.2981	11.1371	13.8328	2.1637	10.0911	9.6612	9.2218
Inquiry 8	11.1555	15.3456	10.6011	11.4136	10.1353	16.6119	9.6868	1.4899	8.9217	9.5372
Inquiry 9	9.4795	12.8198	11.6644	13.5471	8.4717	23.4705	7.9946	5.8618	4.2728	10.8826
Inquiry 10	10.0357	6.7427	5.5429	13.8166	9.6727	9.7578	9.6581	12.1599	20.6666	1.8866

#### IV. DISCUSSION AND CONCLUSION

In this paper, we proposed the new contactless palmprint alignment method with the general web camera and the black screen without guidance pegs. This method used the corresponding key points from the convex hull vertices of corresponding affine invariant which is the area patches spanned between two successive fingers to find the affine transformation matrix which was used to align set of inquiry palmprint image against set of reference palmprint image. By comparison to our previous work [10], this proposed method need not to calculate any longest string and less sensitive to any variation of area patch between two adjacent fingers while obtaining a better accuracy.

The developed palmprint image alignment algorithm was limited to work on the hand with closed or unnaturally opened fingers because the hand does not have the area patches spanning between two successive fingers or it has an irregular shaped area patches.

As a conclusion, our proposed method successfully achieved a distance map error between inquiry and reference palmprint image as low as 1.4899 pixels. Moreover, the proposed method can be applied in the occlusion case where some part of palmprint image is missing.

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