Improved Connected Region Based Approach for Extraction of Principal Lines from Palm Images

Aditya Mehta[1], Shitala Prasad and Sateesh K. Peddoju

Computer Science & Engineering Department, Indian Institute of Technology, Roorkee, India.
e-mail: [1]316.aditya@gmail.com

Abstract. An automated intelligent algorithm for extracting principal lines from colored images of human palm is proposed in this paper. This algorithm is based on computer vision techniques that use gradient operations to separate the principal lines from palm images. The implementation is divided into three major phases. The first phase includes hand-image acquisition and preprocessing techniques to segment the hand. The second phase deals with extraction of palm as the region-of-interest. The last phase is responsible for the post-processing and extraction of the principal lines from the palm. For the same, gradient operations are followed by improved connected region identification approach. On the basis of experiments, it can be concluded that the results obtained from our approach are much better than the other existing approaches. To verify the results, extracted lines are mapped over the lines which are in original colored palm image.

Keywords: connected region identification, gradient operations, image filtering, palm extraction, principal lines extraction.

1. Introduction

Computer Vision (CV) is one of the emerging fields of information technology which provides the ability to analyze the images and videos and to obtain the same results as obtained by the manual systems. It includes methods for acquiring, processing, analyzing, and understanding images and modifying them in order to make them suitable for the applications.

The main aim of this paper is to develop a CV based system that extracts principal lines from palm images, which can be used in a number of applications ranging from biometrics [1] to palmprint matching [2], and many more. Palm print is one of the popular and important human features as it contains a lot of information like texture, indents, principal lines, wrinkles, marks and epidermal ridges. The three principal lines are: i) the heart line, ii) the head line, and iii) the life line which are present in every human palm. This paper focuses on identifying and extracting these three lines only.

In this paper, palm is extracted from the hand image by exploiting a novel method that uses mid points on the boundary of the fingers of the hand. Gradient operations with improved connected

K. R. Venugopal, K. B. Raja and L. M. Patnaik (Eds.) ICSIP 2013, pp. 104–112.
© Elsevier Publications 2013.

region approach through multiple filtering operations are then used to detect the principal lines of palm.

The rest of the paper is organized as follows: Section 2. briefly explains the related work done in this field. Section 3. presents the details of the proposed system. In section 4. and 5., results and discussions along with the conclusions are presented.

2. Related Work

Various systems [3] to recognize the palm print have been developed recently. Most the developed systems are used in biometrics technology [4] to authenticate the user. D. Zhang and J. You [5] have developed an online palmprint identification system using gabor encoding to represent palm features. Their system does not include the texture feature and consider only partial principal lines. Similarly, Jun Kong *et al.* [6] proposed a neural network based approach for person identification system using palmprint.

Sakdanupab *et. al*. [7] have proposed and implemented a palm print classification method based on principal lines. The extraction of principal lines was carried out using masks of gray values in four directions (0°, 45°, 90°, and 135°). However, the amount of noise was considerable in the output.

S. Palanikumar, M. Sasikumar and J. Rajeesh [8] have given a method to enhance the palmprint to remove the noise and improve the contrast of the image using discrete curvelet transformation.

Kanchan S. *et al.* [9] discusses a robust approach for palm extraction that is based upon localization of the point features, line features such as canny edge detectors, and texture features for extracting the palm as the region of interest. The method described by them is lossy as it does not extract the complete lines.

Tunkpien P. *et al.* [10] have discussed an efficient and simple method of extracting principal lines from the palm using simple gradient filters. Their method does not work for the many cases where the palm has many messy lines. Our proposed method is an extension of their work. Zhang D. *et al.* [11] have established a unique relationship between the principal lines of the palm, that can be used to identify them from the palm.

3. Proposed System Methodology

Complete framework has been divided into three major steps: hand image acquisition and preprocessing; region-of-interest (ROI) extraction; and principal lines extraction. The proposed system assumes that the background is black during hand image acquisition to make the system independent of it. The detailed flow of the processes is shown in Figure 1.

3.1 *Hand image acquisition and preprocessing*

Proposed system takes either the captured images of the hand or the scanned images as the colored input image, $I_c(x, y, \text{color})$ (Figure 2 (a)). But noise and arbitrary orientation are inherent to $I_c(x, y, \text{color})$. So, to remove noise and to correct the orientation, preprocessing has to be done.

The complete preprocessing phase is described in the equations (1), (2) and (3).

$$I_c(x, y, \text{color}) \xrightarrow{(\frac{R+G+B}{3})} I_{\text{gray}}(x, y) \xrightarrow{T} I_{bw} \tag{1}$$

$$\text{A pixel } p \text{ at } I_{\text{gray}}(x, y) \text{ becomes} \begin{cases} \text{white}, & \text{if } x \geq T \\ \text{black}, & \text{otherwise} \end{cases} \tag{2}$$

$$I_{bw} \xrightarrow{S} I_{bw\_\text{smooth}} \tag{3}$$

where, $T = 0.5$ is the threshold limit; S is the 5×5 average filter.

3.2 *ROI extraction*

This phase includes the extraction of ROI *i.e.* palm from I_{bw_smooth}. It is further divided into 2 steps: i) segmentation and ii) palm extraction.

3.2.1 *Segmentation*

In order to improve the processing speed and accuracy, unnecessary background pixels present in the image are removed. This is achieved by traversing I_{bw_smooth} form the top-left to bottom-right corners and then recording the position of four pixels corresponding to the first white pixel in each side.

Using these points, a window is formed around the hand as shown in Figure 2 (c)) such that it crops I_c to this window size to remove all the unnecessary pixels for obtaining the segmented image, $I_{c\_\text{segmented}}$ (Figure 2 (d)). The corresponding cropped black-and-white image is $I_{bw\_\text{segmented}}$.

3.2.2 *Palm extraction*

To extract palm accurately, orientation of image should be correct. To handle the orientation $w.r.t.$ horizontal axis, the image is first rotated to bring it in portrait mode with fingers pointing in upward direction. Before the palm could be extracted, detection of the hand boundary and correction of orientation of the boundary image $w.r.t.$ vertical axis is necessary.

Boundary detection (Figure 3 (a)) is done in 3 steps [12] as shown in equations (4), (5), (6).

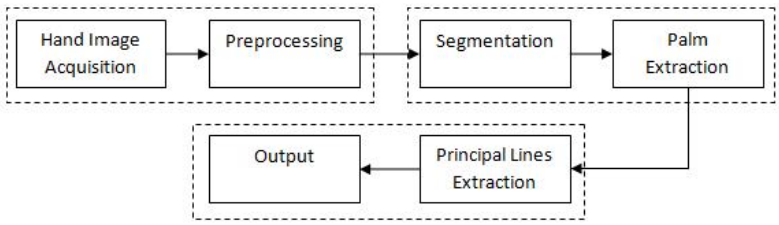


Figure 1. Flow diagram of the proposed system.

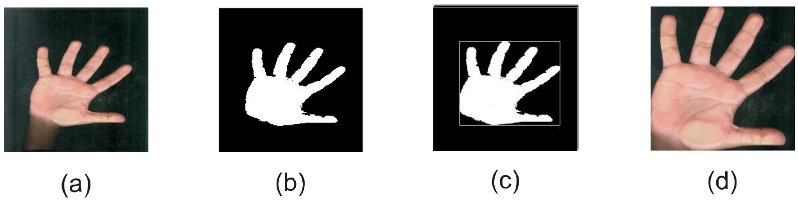


Figure 2. (a) Original hand image (I_c), (b) Image after smoothing and thresholding (I_{bw_smooth}), (c) Rectangle around the hand image, (d) Segmented image ($I_{c\_segmented}$).

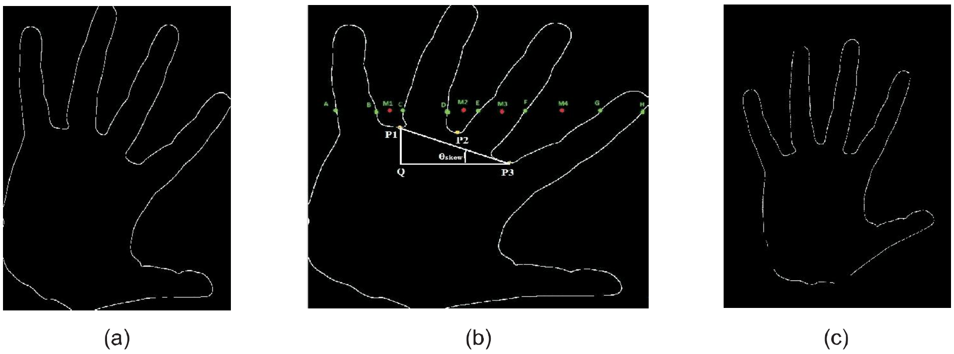


Figure 3. (a) Hand boundary image ($I_{bw\_boundary}$), (b) Boundary with marked points on it, (c) Image after orientation correction (I_{bw_rotate}).

- Dilation:

$$\begin{aligned} I_{\text{dilute}} &= I_{bw\_\text{segmented}} \oplus G_C \\ &= \{p \mid (\hat{G_C})_p \cap I_{bw\_\text{segmented}} \neq \phi\} \end{aligned} \tag{4}$$

- Erosion:

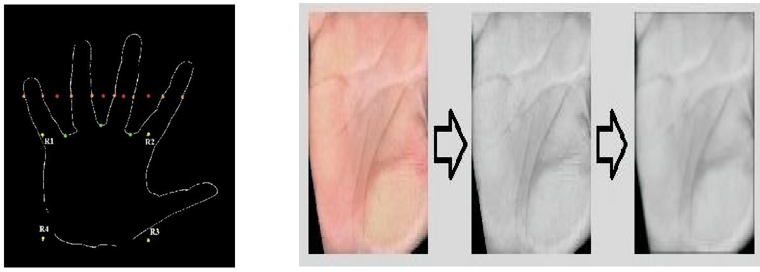
$$\begin{aligned} I_{\text{erode}} &= I_{bw\_\text{segmented}} \ominus G_C \\ &= \{p \mid (G_C)_p \cap I^c_{bw\_\text{segmented}} = \phi\} \end{aligned} \tag{5}$$

- Logical XOR of I_{dilute} and I_{erode}:

$$\begin{aligned} I_{bw\_\text{boundary}} &= \beta(I_{bw\_\text{segmented}}) \\ &= I_{\text{dilute}}\, x \text{ or } I_{\text{erode}} \end{aligned} \tag{6}$$

where, G_C is the 3×3 cross structural element; $I^c_{bw\_\text{segmented}}$ is the complement of the segmented image; β is the boundary of $I_{bw\_\text{segmented}}$.

To correct the orientation *w.r.t.* vertical axis [12], a set of 8 points marked from A to H have to be obtained on I_{bw_boundary} first. Then, the mid-points $M1$, $M2$, $M3$ and $M4$ are obtained and 3 points labeled $P1$, $P2$ and $P3$ as shown in Figure 3 (b) are identified where, $P1$ represents the most distant point from $M1$ on the hand boundary. Similarly, other points are obtained.



(a) (b)

Figure 4. (a) Marked ROI on $I_{bw-\text{rotate}}$, (b) ROI smoothing process.

After obtaining the points, skew of the image is found out by joining $P3$ and $P1$ with a straight line. This line forms an angle, θ_{skew} with the horizontal that is calculated using equation (7). The complete image is then rotated with θ_{skew} to obtain the image $I_{bw-\text{rotate}}$ as shown in Figure 3 (c).

$$\theta_{\text{skew}} = \tan^{-1}\left(\frac{P1Q}{P3Q}\right) \tag{7}$$

In order to extract the palm from $I_{bw-\text{rotate}}$, Rectangle $R1R2R3R4$ with length $R2R1$ and width $R1R4$ is obtained as ROI (Figure 4 (a)), where point $R1$ is the intersection of perpendicular lines from points B and $P1$. Similarly, other points are obtained.

3.3 *Principal lines extraction*

In this phase, principal lines are extracted from I_{roi} by exploiting edge detection algorithm proposed by Tunkpien P. *et al.* [10] followed by connected region identification approach. But to make ROI independent of size, I_{roi} is first preprocessed using equations (8) and (9)

$$I_{\text{roi}} \xrightarrow[300\times300]{\text{resize}} I'_{\text{roi}} \tag{8}$$

$$I'_{\text{roi}} \xrightarrow{\left(\frac{R+G+B}{3}\right)} I'_{\text{roi}-\text{gray}} \xrightarrow{S} I'_{\text{roi}-\text{smooth}} \tag{9}$$

where, S is a standard 3×3 filter.

Gradient operator has been used to detect the lines as they reduce the processing time. Masks of size 2×2 in two directions (0° and 90°) are created. After that, the lines are enhanced in both the directions by convolving $I'_{\text{roi}-\text{smooth}}$ with these masks. At each pixel, gradient vector is computed by convolving image with horizontal and vertical derivative filters, also called as the gradient filters, using the equation (10).

$$\nabla I'_{\text{roi}-\text{smooth}} = \left[\frac{\partial I'_{\text{roi}-\text{smooth}}}{\partial x}, \frac{\partial I'_{\text{roi}-\text{smooth}}}{\partial y}\right]^T \tag{10}$$

(a) (b)

Figure 5. (a) Horizontal (I_{g_x}) and Vertical edges (I_{g_y}), (b) Filtered horizontal (I'_{g_y}), and Vertical edges (I'_{g_y}).

(a) (b)

Figure 6. (a) Thinned lines, (b) Principal lines.

The corresponding results, I_{g_x} and I_{g_y}, obtained from them are shown in Figure 5 (a). As it can be seen in the figure, by applying the gradient filters, the horizontal and vertical lines gets highlighted.

Once the lines are obtained, further refinement is required to discard all the noise factors obtained due to the detection of other secondary lines apart from the principal. The refinement process is explained in equation (11). The results of this operation are shown in Figure 5 (b).

$$\begin{aligned} I' &= I \circ G_L) \oplus G_D \\ &= ((I \ominus G_L) \oplus G_L) \oplus G_D \end{aligned} \tag{11}$$

where, $I = \{I_{g\_x}, I_{g\_y}\}$; $I' = \{I'_{g\_x}, I'_{g\_y}\}$; G_L is the line structural element in the directions of 0°, 45° and 90° with threshold $k = 4$, the minimum width of the lines considered; G_D is disk structural element of radius 3.

Accuracy of the system is further enhanced by setting some part of I'_{g_x} and I'_{g_y} to black, manually on the basis of the approximations about the position of lines.

To obtain the skeleton of the lines (Figure 6 (a)), basic thinning operation is applied on clearly distinguishable principal lines obtained from previous step. Whole process can be summarized in

Table 1. Comparison of the proposed method with existing principle line extraction methods.

Methods	Accuracy of Detection	Execution Time
Tunkpien P. *et al.* [10]	86.18%	127 msec
Sakdanupab *et al.* [7]	85.49%	5.4 sec
Proposed Method	94.8%	2 sec

the equation (12).

$$\begin{aligned} S(J) &= \bigcup_{k=0}^{K} S_k(J) \\ S_k(J) &= (J \ominus kG_D) - (J \ominus kG_D) \circ G_D \\ K &= \max\{k | (J \ominus kG_D) \neq \phi\} \end{aligned} \tag{12}$$

where $J = \{I'_{g\_x}, I'_{g\_y}\}$; G_D is disk structural element of radius 3.

To remove the unnecessary lines, connected regions are identified using m-connectivity. It has been investigated that if the number of pixels in the region are less than a certain threshold value (*i.e.* 50 in our case), then these regions are discarded as these regions can not be the part of principal lines. Final output of this phase is displayed in Figure 6 (b). The principal lines are highlighted over the original I'_{roi} before it is finally displayed to the user. This is done so that the user can easily identify the principal lines detected by the proposed system.

4. Results and Discussion

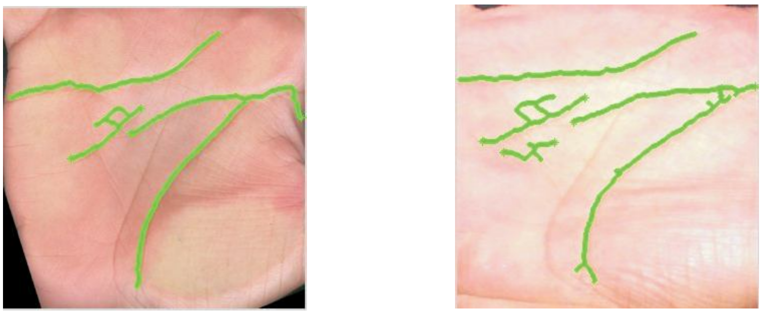
To implement complete framework, MATLAB software with Image Processing Toolbox has been used. The experiments are performed on the colored dataset of 15 hands that are collected as samples. It has been found that the end results of system are very accurate as the noise factor in each of the sample is found very less. Out of the three principal lines, the heart line has been detected very clearly in all the sample images.

The system achieves an average accuracy of 94.8% with near about 2 sec of execution time. When compared to other existing methods, our proposed method achieves a high accuracy than them. Table 1 summarizes the comparison of our system with the existing systems.

It has been observed that, scanned images show a better performance over the images captured from the mobile device/webcam because of their high resolution but the system performance is not much affected by different resolutions of image as shown in Figure 7.

5. Conclusion and Future Work

This paper discusses a novel and efficient system to extract the principal lines from the human palm using various morphological operations, gradient based edge detection technique and connected region identification. An effective technique to identify the palm as the ROI, the plotting of 8 unique points on the hand boundary has been discussed. A novel mid-point based technique for correcting the orientation of the hand is presented. Gradient based edge detection technique used for the



(a) (b)

Figure 7. Same image but at different resolutions. (a) Scanned image, (b) Image from a mobile phone.

detection of principal lines in both the horizontal and vertical edges has been devised. An improved filtered connected region identification approach to separate out the horizontal and vertical principal lines is proposed. Skeletonization is carried out to reduce the width of principal lines to a single pixel. For showing the accuracy, the detected principal lines are highlighted and overlapped over the original colored image. Since the system works well for both the scanned images as well as for camera captured images, it can be taken as the complete full-fledged system separating out the principal lines from palm.

As future work we can target using such features in biometric applications as well as for predicting the personality of the human using palmistry. Also images of multiple resolutions can be analyzed. Work for using input images from a low quality and low processing mobile devices can be done.

References

[1] Vaidehi, K., Subashini, T. S., Ramalingam, V., Palanivel S. and Kalaimani, M.: Transform Based Approaches for Palmprint Identification. *Int. J. Comput. Appl.*, 41(1), 1–5 (2012).

[2] Fang, L., Leung, M. K. and Chian, C. S.: Making Palm Print Matching Mobile. *Int. J. Comput. Sci. Inf. Security (IJCSIS)*, 6(2), 1–9 (2009).

[3] Tunkpien, P., Phimoltares, S. and Panthuwadeethorn, S.: Palmprint Identification System Using Shape Matching and K-Nearest Neighbor Algorithm. In: *IEEE Conf. Imaging Systems and Techniques (IST)*, pp. 327–330, Penang, Malaysia (2011).

[4] Han, C. C., Cheng, H. L., Lin, C. H. and Fan, K. C.: Personal Authentication Using Palm-Print Features. *J. Pattern Recognition*, 36(2), 371–381 (2003).

[5] Zhang, D., Kong, W. K., You, J. and Wong, M.: Online Palmprint Identification. *IEEE T. Pattern Anal.*, 25(9), 1041–1050 (2003).

[6] Kong, J., Lu, Y., Wang, S., Qi, M. and Li, H.: A Two Stage Neural Network-Based Personal Identification System using Handprint. *J. Neurocomputing*, 71(46), 641–647 (2008).

[7] Sakdanupab, M. and Covavisaruch, N.: An Efficient Approach for Automatic Palmprint Classification. In: *IEEE Int. Conf. Signal Image Technology and Internet Based Systems*, pp. 229–234, Bali, Indonesia (2008).

[8] Palanikumar, S., Sasikumar M. and Rajeesh, J.: Palmprint Enhancement Using Discrete Curvelet Transform. *Int. J. Comput. Sci. Issues (IJCSI)*, 8(4), 313–319 (2011).

[9] Shekhar, S., Kumar, B.S. and Ramesh, S.: Robust Approach for Palm (Roi) Extraction in Palmprint Recognition System. *IEEE Int. Conf. Engineering Education: Innovative Practices and Future Trends (AICERA)*, pp. 1–6, Kottayam, India (2012).

[10] Tunkpien, P., Panduwadeethorn, S. and Phimoltares, S.: Compact Extraction of Principle Lines in Palmprint Using Consecutive Filtering Operations. *IEEE Int. Conf. Knowledge and Smart Technologies*, pp. 39–44, Chonburi, Thailand (2010).
[11] Zhang, D. and Shu, W.: Two Novel Characteristics in Palmprint Verification: Datum Point Invariance and Line Feature Matching. *J. Pattern Recognition)*, 32(4), 691–702 (1999).
[12] Polli, R. M. *et al.*: A Proposal for the Hand Palm Identification, Using Local Binary Pattern. *Int. J. Adv. Eng. Sci. Technol. (IJAEST)*, 9(2), 302–309 (2011).