# Feature Extraction & Image Registration of the Palma Dorsa by Using Bifurcation Structures

**Shweta Dhawan**

***Abstract*—*In this paper, we perform feature extraction of venal pattern of hand dorsal images. Various minutiae points are discussed. Bifurcation points and endpoints are calculated and plotted for the hand images. The three branching angles are used for the characteristic vector of a bifurcation point. Further, Bifurcation structures are proposed for Palma Dorsa. The bifurcation structure is composed of a master bifurcation point and its three connected neighboring bifurcation points for Image Registration. Bifurcation structures make the method robust to image translation and scaling. Affine model has been used for the transformation. Mosaic hand and vein images are generated. In this work, we have used MATLAB R2009a, version 7.8.0 for coding.***

***Index Terms*—*Bifurcation Structures, Characteristic Vector, Feature extraction, Image registration.***

## I. INTRODUCTION

During the last few years, biometric systems have gained immense popularity. Vein recognition systems are amongst the newest biometric technologies to have emerged in the recent past. Vein recognition works on the fact that everyone has distinct vein patterns. When a user's hand is placed on a scanner, a near-infrared light maps the location of the veins. The red blood cells present in the veins absorb the rays and show up on the map as black lines, whereas the remaining hand structure shows up as white. After the vein template is extracted, it is compared with previously stored patterns and a match is made. In this work, we will be using the dorsal hand images. The main idea behind the vein recognition is Palma Dorsa. Palma Dorsa is the network of veins at the back of the hand. For this work, IIT Kanpur database consisting of 1750 images has been used. In this research paper, first the vein features have been extracted and then image registration has been accomplished. Similar to fingerprints, vein patterns also contain minutiae. Minutiae are local discontinuities in the vein pattern. The four classes of minutiae classification proposed by ANSI are: ridge endings, bifurcations, trifurcation and undetermined [I]. Most automatic systems are based on a two class minutiae classification: ridge ending and bifurcation [2]. A ridge ending is defined as the point where a ridge ends abruptly. A bifurcation is defined as the point where a ridge forks or diverges into branch ridges.

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Image registration is the process of overlaying two or more images of the same scene taken at different times, from different viewpoints, and/or by different sensors [3]. It geometrically aligns two images—the reference and sensed images into a common coordinate system to monitor subtle changes between them. The registration techniques can be mainly categorized as feature based approach, gradient technique and correlation methods [4]. Image registration essentially consists of following steps as per Zitova and Fusser [3].

- Feature detection: Salient and distinctive objects (closed-boundary regions, edges, contours, line intersections, corners, etc) in both reference and sensed images are detected.
- Feature matching: The correspondence between the features in the reference and sensed image established.
- Transform model estimation: The type and parameters of the so-called mapping functions, aligning the sensed image with the reference image, are estimated.
- Image resembling and transformation: The sensed image is transformed by means of the mapping functions.

## II. RELATED WORK

Many concepts have come up for feature extraction from the vein pattern. A method based on quadratic inference function [5] to the dorsal hand vein features was used to extract its features. Combination of fuzzy theory, the image segmentation algorithm and concave detection algorithm was used for extracting finger vein features [6]. An approach to authenticate individuals using triangulation of hand vein images and simultaneous extraction of knuckle shape information was given [7]. Deng and Zhang [8] combined Discrete-time Cellular Neural Network (DT-CNN) and morphology to extract the vein features. An algorithm based on oriented filter for finger vein extraction was used in [9].

A number of research work on image registration have been reported so far. In feature-based registration methods, salient and distinctive objects (e.g. edge and corner) are manually or automatically selected for estimating the transformation between image pair, such as translation, rotation, scaling and distortion [10]. Gradient approaches originated from optical flow estimate the translation parameters using linear partial difference equations [11]. A tree matching approach was followed to register retinal images in which each vessel in a retinal image was modeled as a tree called Vessel


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Feature Tree [12]. Combination of Principle Component Analysis (PCA) based registration method which can perform object alignment in real-time and gradient registration method which can perform precise registration with minor image movement [13] was proposed.

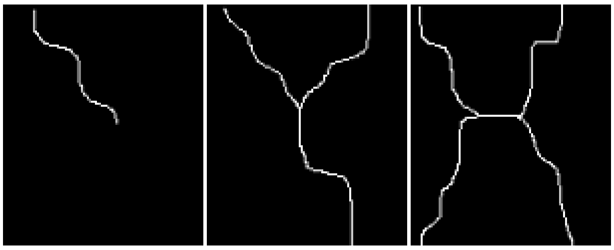
## III. Feature extraction

Vein minutiae points can be categorized in following three ways.

1) Ending points: Point where a vein pattern segment finishes. It is not necessary that an ending point is always the end of the vein. Sometimes, a vein descends into the skin and the infrared light cannot penetrate deep enough into the biological tissue resulting in an end point. An endpoint or termination can be detected if one neighbor in a 3 x 3 window belong to the foreground.

2) Bifurcation points: Point where a single vein splits into two veins. Bifurcation points can be detected if three neighbors in a 3 x 3 window belong to the foreground.

3) Double Bifurcation points: This kind of vein minutiae appears when two bifurcation points are very close. Double bifurcation points can be detected if four neighbors in a 3 x 3 window belong to the foreground. Figure 1 shows different kinds of minutiae points.



a) b) c)

**Figure 1 (a) Ending point (b) Bifurcation point (c) Double bifurcation point**

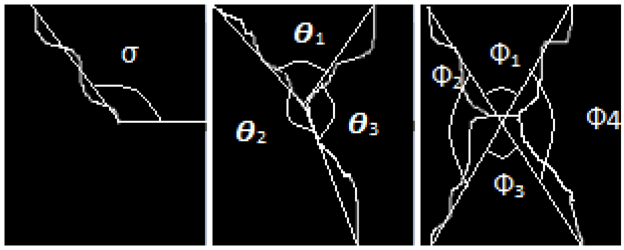
The characteristic vector of each bifurcation point is mainly composed of its three branching angles. The matching process will search the best similarities among all pairs of characteristic vectors. The characteristic vector of each minutiae point is shown as follows:

Ending points: [σ]

Bifurcation Point: [$\boldsymbol{\theta}$1, $\boldsymbol{\theta}$2, $\boldsymbol{\theta}$3]

Double Bifurcation Point: [Φ1, Φ2, Φ3, Φ4]

Where σ is the angle between an ending minutia and the horizontal line and $\boldsymbol{\theta}$i and Φi are the angles between the branches in a bifurcation and double bifurcation point respectively. The index i=1 corresponds to the smallest angle and the rest of the index are assigned in counter clockwise direction. These angles are shown in the Figure 2.




a) b) c)

**Figure 2 (a) Ending point (b) Bifurcation point (c) Double bifurcation point**

## IV. Bifurcation structure for image registration

A bifurcation structure is made of a master bifurcation point and its three connected neighbors. The master bifurcation point has three surrounding branches with lengths numbered 1, 2, 3 and angles numbered 1, 5, 9, where each branch is connected to a neighboring bifurcation point. The characteristic vector for each bifurcation structure is given by (1)

$$\bar{x} = \{lengths, angles\}$$
$$= [l1, l2, l3, \delta_1, \delta_2, \delta_3, \delta_4, \delta_5, \delta_6, \delta_7, \delta_8, \delta_9, \delta_{10}, \delta_{11}, \delta_{12}] \quad (1)$$

A bifurcation structure has been showed in Figure 3

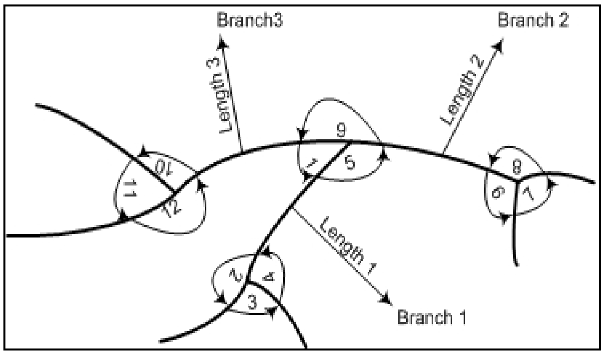



**Figure 3 A Bifurcation Structures**

Where $l_i$and $\delta_i$ represent the normalized length and angle, respectively as given by (2) and (3).

$$l_i = \{i - th\ branch\ length\ /sum\{lenghth1, length2, length3\} \quad (2)$$

$$\delta_i = \{i - th\ branch\ angle\ in\ degree/360^{\circ}\} \quad (3)$$

The longest branch is taken as the first element in $\bar{x}$ to ensure that the characteristic vector is invariant to scaling and translation.

Let X and Y represent the feature groups of the two images that contain the number of M1 and M2 bifurcation structures, respectively. The similarity measure si, j for any bifurcation structure pair is as given by (4)

Si, j =d (xi, yj) (4)

where xi and yj denote the characteristic vectors of i-th and j-th bifurcation structure in two images. The term d (·) denotes the distance measure between the characteristic vectors.The characteristic vector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of a single bifurcation point contains three angles while the characteristic vector of the bifurcation structure contains ordered length and angles. The extended features help in reducing the number of multiple correspondence in the matching process.

## V. EXPERIMENTAL RESULTS

Figure 4 (a) and (b) show a pair of dorsal hand images. Both the images are of the same hand taken at different time.

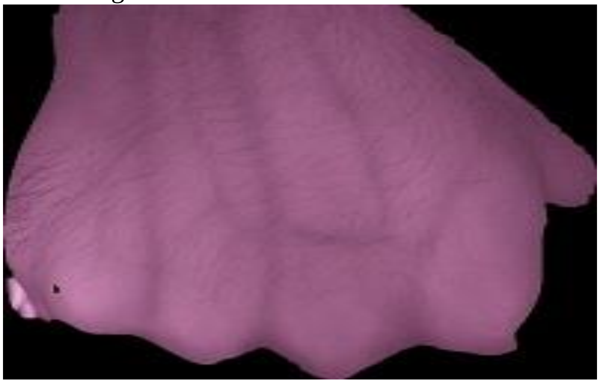

**Figure 4(a) One dorsal hand image**

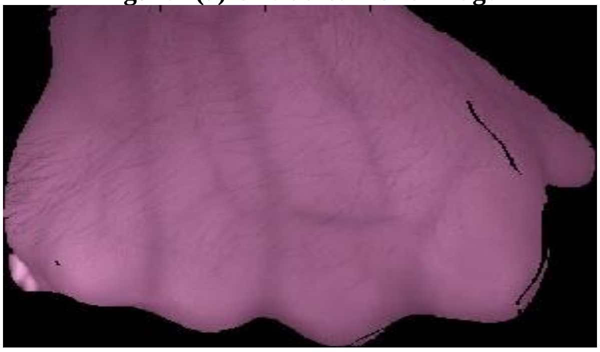

**Figure 4(b) Another dorsal hand image captured at a different time**

The above pair of images were subjected to image enhancement techniques i.e. gray scale normalization, median filtering, Gaussian smoothing, Contrast enhancement, followed by thresholding, dilation, thinning to produce venal pattern of the hand images.

Then we find the junction points and the endpoints of the vein pattern. Junction points include the bifurcation and double bifurcation points. We test the entire image by taking 3 x 3 neighborhood one by one. The centre pixel of the 3 x 3 neighborhood is a junction point if the centre pixel is one and the number of transitions between 0 & 1 as we traverse the perimeter of the 3 x 3 neighborhood is 6 or 8. The centre pixel of the 3 x 3 neighborhood is an endpoint if the centre pixel is one and the number of transitions between 0 & 1 as we traverse the perimeter of the 3 x 3 neighborhood is 2.

The endpoints are marked as green squares and the junction points are marked as the red squares. The venal pattern of Figure 4(a) contains 45 junction points and 51 endpoints as shown in Figure 5(a) and the venal pattern of Figure 4(b) contains 37 junction points and 45 endpoints as shown in Figure 5 (b).

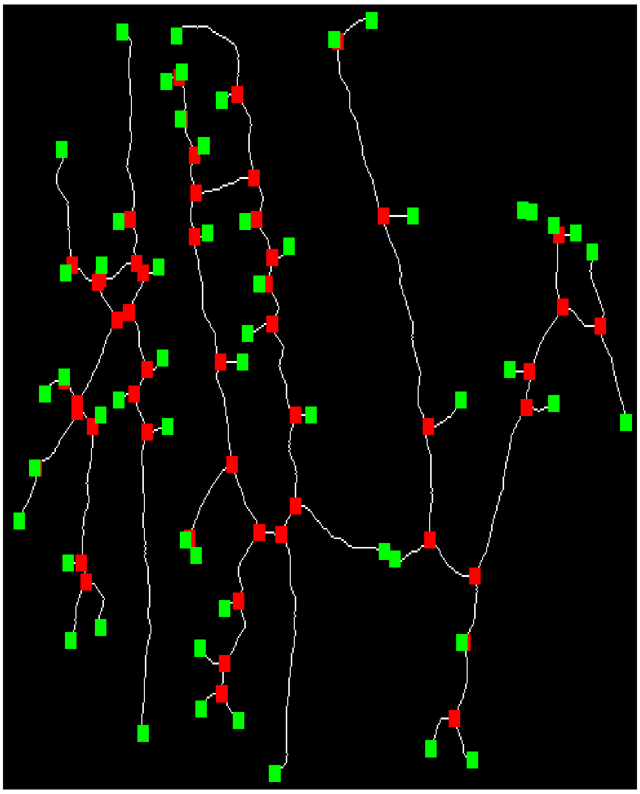

**Figure 5 (a) Junction and endpoints of image 4(a)**

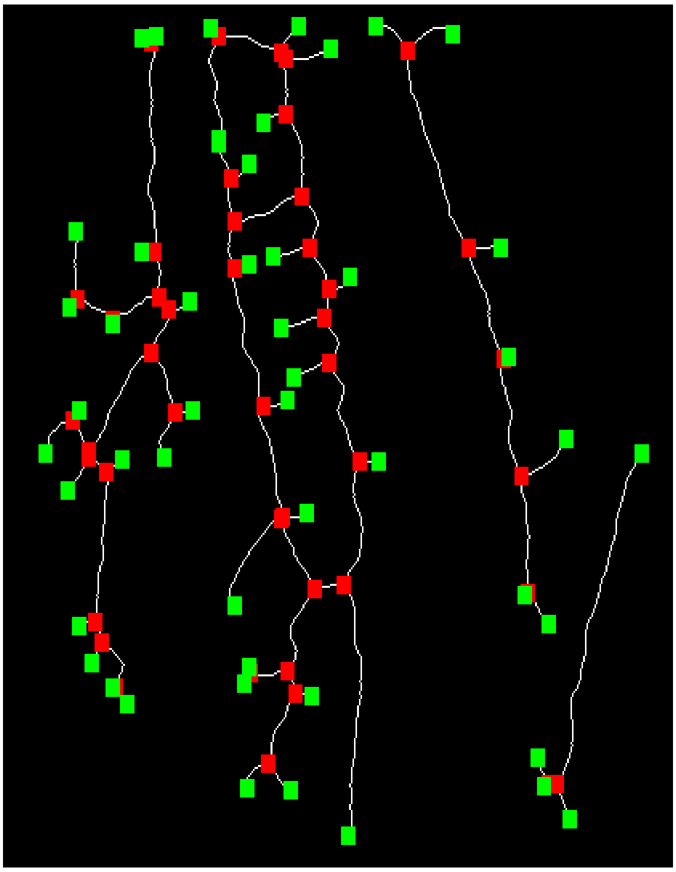

**Figure 5 (b) Junction and endpoints of image 4(b)**



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For this pair of images, 9 bifurcation structures were detected in the Figure 4(a) and 7 bifurcation structures were detected in Figure 4(b). The 3 best matched bifurcation structures are shown in Figure 6(a) and Figure 6(b).

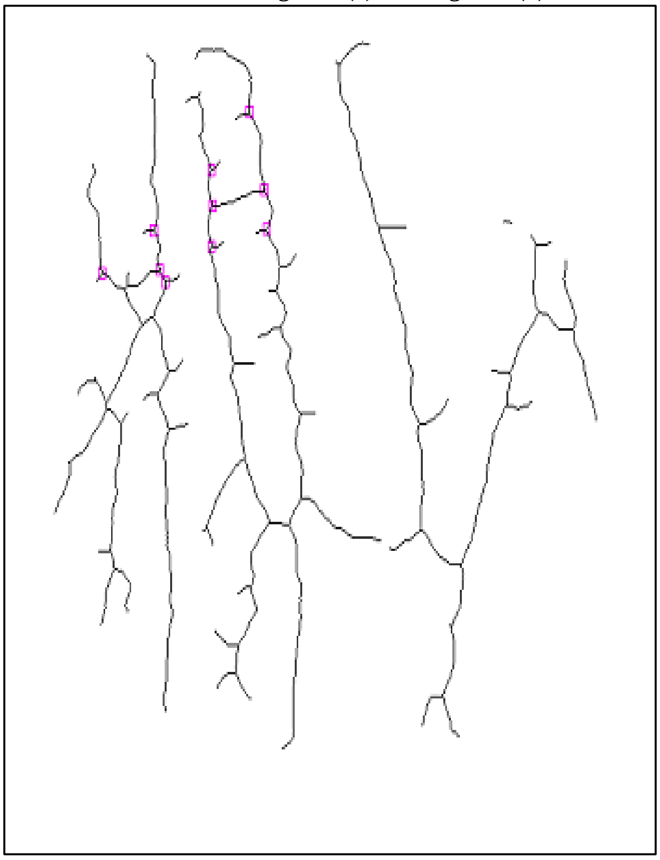

**Figure 6(a) Matched Bifurcation Structures of image 4(a)**

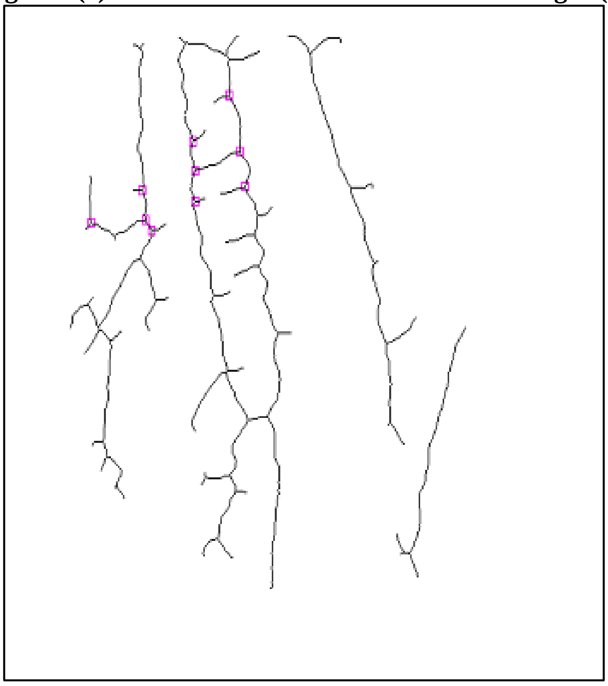

**Figure 6(b) Matched Bifurcation Structures of image 4(b)**

Affine model was used for the transformation. The mosaic image aligned by the affine model is shown in Figure 7(a) and Figure 7(b). The Figure 7(a) shows the overlapping of the hand images while the Figure 7(b) shows the overlapping of the venal patterns. In Figure 7(b), the edges with blue color show the veins of one hand and the edges with red color show the veins of another hand.

**Figure 7(a) The mosaic hand image**

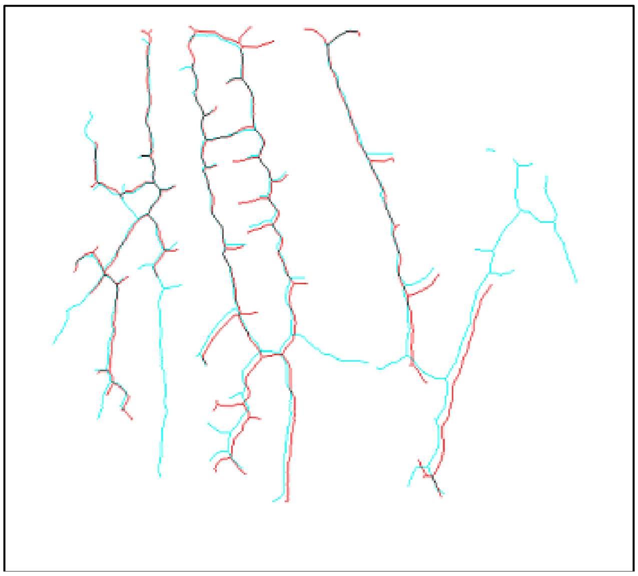

**Figure 7(b) The mosaic vein image**

## VI. CONCLUSION



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In this paper, we have done the feature extraction of the skeletonised venal pattern of the palma dorsa. The junction points and endpoints co-ordinates have been calculated by using 3 x 3 neighborhood, checking the value of centre pixel and the number of 0 & 1 transitions. Further Bifurcation Structures have been discussed. The bifurcation structure is composed of a master bifurcation point and its three connected neighboring bifurcation points. The Bifurcation structures are evaluated for a pair of images. The similarity score for the image pair is calculated and the best matching bifurcation structures are selected. Finally, the affine model is used to align the mosaic images. This work was applied on the database of 1750 dorsal hand images to achieve efficient feature extraction and registration.

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