www.ijiarec.com

ISSN:2348-2079

Volume-8 Issue-3

International Journal of Intellectual Advancements and Research in Engineering Computations

Enhancing the dactylogram standard to extract the unique minutiae points

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ABSTRACT

Fingerprint recognition has been with success utilized by enforcement agencies to spot suspects and victims for nearly a hundred years. Recent advances in automated fingerprint identification technology, in addition the growing would like for reliable person identification, have resulted in an increased use of fingerprints in both government and civilian applications such as border control, employment background checks, and secure facility access. Fingerprint confusion alludes to the conscious change of the unique finger impression design by a person to cover his personality. Order adjusted fingerprints into three classes dependent on the adjustments in edge design because of change as wrecked, mutilated and imitated. Fingerprints are the most generally utilized boundary for individual distinguishing proof among all biometrics based individual verification frameworks. As most Programmed Unique finger impression Acknowledgment Frameworks depend on nearby edge highlights known as particulars, stamping details precisely and dismissing bogus ones is basically significant. In this paper we propose a calculation for separating particulars from a Fingerprint picture utilizing the paired Hit or Miss change (HMT) of numerical morphology. We have created and tried organizing components for various kinds of particulars present in a Fingerprint picture to be utilized by the HMT in the wake of preprocessing the picture with morphological administrators. This outcomes in productive details recognition, consequently sparing a ton of exertion in the post handling stage. The algorithm is tested on a large number of images. Experimental results depict the effectiveness of the proposed technique.

Keywords: Biometrics, fingerprint image, minutiae extraction, Hit or Miss transform, mathematical morphology

INTRODUCTION

In today's advanced digital technology world, there is an increased requirement of security measures leading to the development of many biometrics based personal authentication systems. Biometrics is the science of uniquely recognizing humans based upon one or more intrinsic physical (e.g., fingerprint, iris, face, retina etc.) or behavioral (e.g., gait, signature etc.) traits. Fingerprints are the most broadly utilized boundary for individual recognizable proof among all biometrics. The purpose for the notoriety of finger impression based acknowledgment among the biometrics-based security frameworks is the unchangeability of fingerprints during the human life expectancy and their uniqueness [7]. Anyway to meet the presentation prerequisites of high security applications, multimodal biometrics [1, 5] is additionally utilized as it assists with limiting framework mistake rates. Fingerprint distinguishing proof is generally utilized in measurable science to help criminal examinations and so on A unique finger impression is a one of a kind example of edges and valleys on the outside of finger of a person. An edge is characterized as a solitary bended section, and a

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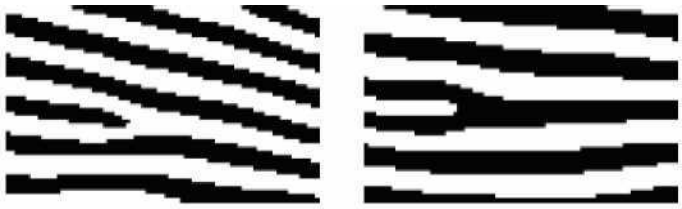
valley is the area between two adjoining edges. Most Programmed Fingerprint Recognition Frameworks depend on neighborhood edge highlights known as details. Sir Francis Galton (1822-1922) was the principal individual who watched the structures and lastingness of particulars. Subsequently, particulars are likewise called "Galton subtleties".



(a) Ridge Ending **(b) Ridge Bifurcation**

Figure 1: Example of a ridge ending and a bifurcation.

They are utilized by scientific specialists to coordinate two fingerprints. There are around 150 distinct kinds of details [2] classified by their arrangement. Among these minutia types, "edge finishing" and "edge bifurcation" are the most usually utilized, since different kinds of particulars can be viewed as blends of "edge endings" and "edge bifurcations" (figure 2). Figure 1 represents the two most essential sorts of particulars: edge endings and bifurcations. It is these particulars focuses which are utilized for deciding uniqueness of a unique finger impression.

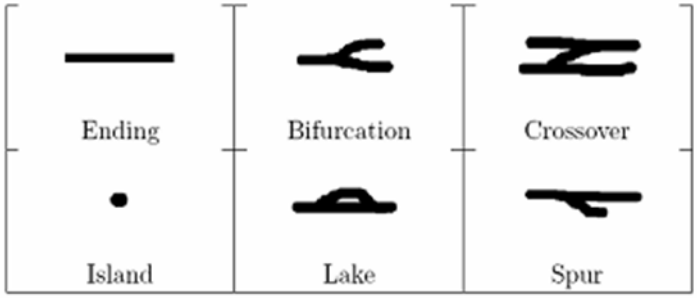


Figure 2 : Some common minutiae types.

Mechanized Fingerprint Recognition frameworks can be ordered as: check or distinguishing proof frameworks. The check cycle either acknowledges or dismisses the client's character by coordinating against a current Fingerprint information base. In distinguishing proof, the personality of the client is set up utilizing fingerprints. Since precise coordinating of fingerprints relies to a great extent upon edge structures, the nature of the Fingerprint picture is of basic significance. Notwithstanding, practically speaking, a Fingerprint picture may not generally be all around characterized because of components of clamor that degenerate the clearness of the edge structures.

Related Works

This debasement may happen because of varieties in skin and impression conditions, for example, scars, dampness, earth, and non-uniform contact with the Fingerprint catch gadget. Numerous calculations [2, 16, 26, 27, 28] have been proposed in the writing for minutia investigation and Fingerprint grouping for better unique finger impression check and recognizable proof. A few calculations characterize the Fingerprint design into various gatherings at the hour of enlistment [30]. Their outcomes additionally rely generally upon the nature of the info picture. Hence, picture improvement methods

are regularly utilized to diminish the commotion and to upgrade the meaning of edges against valleys so that no deceptive details are distinguished. A few strategies have been proposed for improvement of Fingerprint pictures which depend on picture standardization and Gabor sifting (Hong's calculation) [11], Directional Fourier separating [3], Binarization Technique [23], Directional Channel Based Examination [25], Unique finger impression picture diminishing utilizing PCNNs [9] and so on The Hong's calculation inputs a Fingerprint picture and applies different strides for upgrade. A few other fluffy strategies for picture improvement are likewise accessible [4, 20, 21, 32, 33].

When the Fingerprint picture is improved details focuses can be separated. There are a ton of particulars extraction calculations accessible in the writing like direct dim scale edge following system [7, 31] which chip away at dim scale pictures straightforwardly, details extraction by run length encoding strategy [34] which doesn't need the Fingerprint picture to be diminished and different procedures dependent on removing particulars from skeletonised pictures utilizing the intersection number calculation [8, 10, 14, 15, 18, 19, 24]. The intersection number strategy removes edge endings and bifurcations from a binarized skeletonised picture by inspecting the nearby neighborhood utilizing a 3X3 window of every pixel and checking the quantity of 0 to 1 changes in it. This technique for extraction separates countless false particulars along with genuine ones, accordingly depending intensely on gigantic post handling methodology including individually minutia approval and invalidation, [14. 15].

In this paper we propose a novel calculation for extricating details from a Fingerprint picture utilizing the double Hit or Miss change (HMT) of numerical morphology. Morphological administrators are fundamentally shape administrators and their piece permits the common control of shapes for the ID and the creation of articles and item includes. We have created and tried organizing components for various sorts of particulars present in a Fingerprint picture to be utilized by the HMT to separate substantial details, subsequent to preprocessing the picture with such morphological administrators. As referenced before, the issue with different strategies is the age of an enormous number of deceptive details along with genuine ones while our calculation brings about effective particulars identification, accordingly sparing a great deal of exertion in the post handling stage. The calculation is tried on countless pictures. Trial results portray the viability of the proposed strategy.

The remainder of the paper is sorted out as follows: Area 2 presents fundamental ideas and activities of numerical morphology to be utilized in this paper. Area 3 depicts the proposed calculation. Test results are accounted for in Area 4. Segment 5 finishes up the paper.

MATHEMATICAL MORPHOLOGY

Numerical morphology discovers its place in PC vision as it accentuates fit as a fiddle data. It alludes to a part of nonlinear picture preparing and examination that focuses on the mathematical structure inside a picture, it is numerical as in the investigation depends on set hypothesis, geography, cross section, arbitrary capacities, and so forth Numerical morphology is viewed as an integral asset to separate data from pictures. We quickly talk about some numerical morphology changes [22] in this part.

PROPOSED TECHNIQUE

In this paper we propose a minutiae extraction algorithm which extracts minutiae using the morphological Hit or Miss Transform. The achievement of any details extraction procedure relies upon the nature of the information picture, the picture should be improved before handling it for particulars extraction. Given in figure 3 is the schematic graph of the proposed procedure. The subtleties of the different advances are clarified in the accompanying subsections.

Image enhancement

The performance of any minutiae detection algorithm relies heavily on the quality of the input fingerprint image. For a fingerprint image of low quality, a large number of false minutiae are extracted during minutiae extraction. Hence, it is important to enhance the input fingerprint before

performing minutiae extraction to cater to the following two aspects:

- Noise
- Broken ridges.

A great deal of Fingerprint upgrade strategies dependent on input picture quality have been proposed in the writing [4, 9, 11, 12, 20, 23, 32]. We have utilized the Hong's calculation [11] for the improvement of our info Fingerprint picture, which depends on the convolution of the picture with Gabor channels tuned to the neighborhood edge direction and recurrence. Right off the bat, the picture is portioned to separate it from the foundation. Next, it is standardized so it has a prespecified mean and fluctuation. Subsequent to figuring the nearby direction and edge recurrence around every pixel, the Gabor channel is applied to every pixel area in the picture. Therefore the channel upgrades the edges situated toward nearby direction. Hence the filter increases the contrast between the foreground ridges and the background, while effectively reducing noise [figure 4].

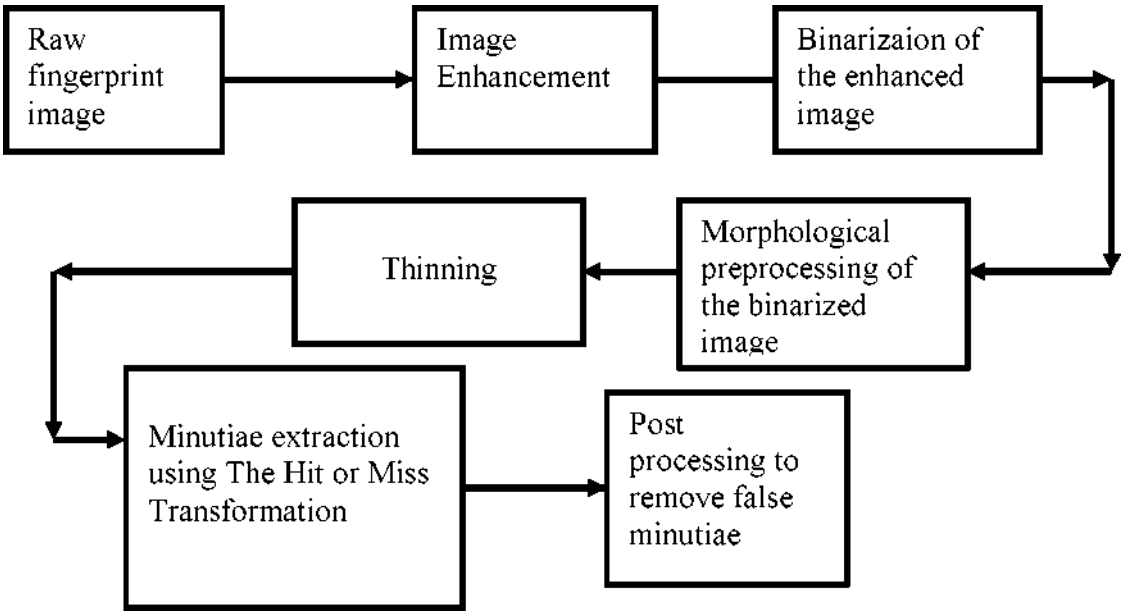


Figure 3: Block diagram of the proposed Algorithm.

Binarization

Image binarization converts a 256 gray level image to a binary image (i.e. with only two levels - black and white [Figure 4]. The least difficult approach to utilize picture binarization is to pick limit esteem, and characterize all pixels with values over this edge as white, and all different pixels as dark. The issue is the means by which to choose the right limit. As a rule, discovering one limit viable to the whole picture is troublesome, and by and large even incomprehensible. Accordingly, versatile picture binarization is required where an ideal limit is picked for each picture zone [6].There are other methods also available for image binarization [17].

Figure 4: The first row shows the original images. The second shows the enhanced and binarized images correspondingly.

Morphological preprocessing

After close examination of the binarized image, it can be seen that the misconnections and isolated regions (dots, holes, islands etc.) in a binary image may introduce a number of spurious minutiae in thinned images.

Minutiae extraction using HMT

In this step, we shall extract the two basic types of minutiae points (ridge terminations and ridge bifurcations) from the thinned image obtained from the previous step using

The Hit or Miss Transformation. For this reason, we have created organizing components to for various sorts of particulars present in the Fingerprint picture, to be used by the HMT. Despite the fact that this figures all the details focuses, some bogus particulars may happen because of some pointless data in the diminished picture. They are eliminated in the last advance of the calculation. However, it can be seen from the final results that the number of false minutiae is lesser as compared to other techniques as the image is already preprocessed with morphological operators before thinning.

(a) **(b)**

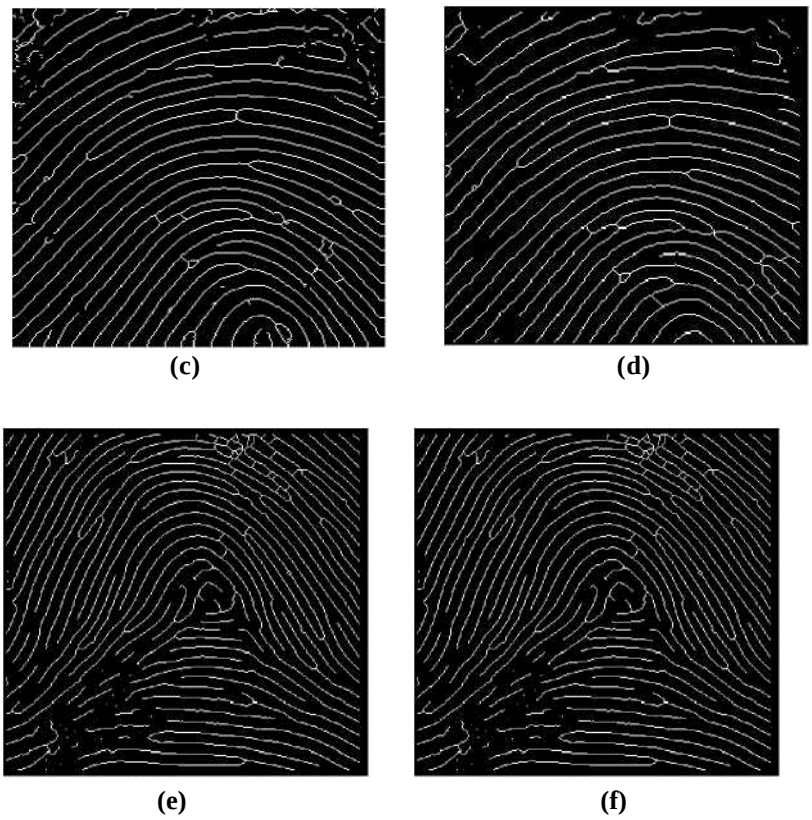


Figure 10: (a), (c) and (e) show the thinned image after applying the thinning operator directly to the binarized images. (b), (d) and (f) show the thinned image after applying the thinning operator to the corresponding morphologically processed binarized images.

Extracting ridge terminations

Ridge endings are those pixels in an image which have only one neighbour in a 3X3 neighbouhood. The minutiae image M1 containing ridge terminations is given by applying Hit or Miss transform on I by J as follows:

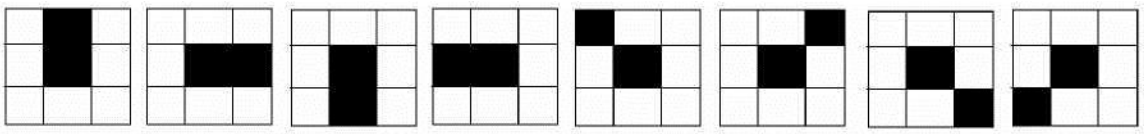
M1 = I ® J (8)

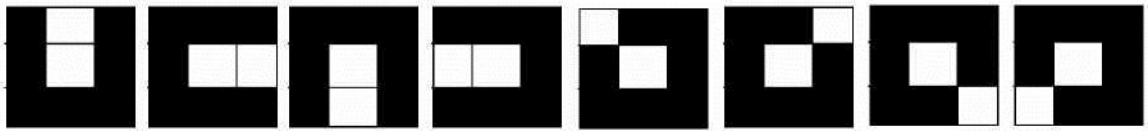
Where, I is the thinned image and J is the sequence of structuring element pairs (J_1, J_2) .

Applying eq. 5,

I ®J = (I © J1) n (I^c © J2) (9)

The structuring element sequence J that we have designed for determining endpoints in an image in this paper is shown in figure 11 .The structuring elements have been designed in such a way so as to select all pixels from image I that have a single neighbour in a 3X3 neighborhood and leave all pixels that have more than one neighbour. Each of the structuring element pairs (J_1^i, J_2^i) , i = 1..8, is applied in sequence and the collective output gives the ridge endpoints in the fingerprint image.





(ix) (x) (xi) (xii) (xiii) (xiv) (xv) (xvi)

Figure 11 : (i) to (viii) The structuring element sequence $J_1 = (J_1^1, J_1^2, J_1^3, J_1^4, J_1^5, J_1^6, J_1^7, J_1^8)$. (ix) to (xvi) The structuring element sequence $J_2 = (J_2^1, J_2^2, J_2^3, J_2^4, J_2^5, J_2^6, J_2^7, J_2^8)$.

Extracting ridge bifurcations

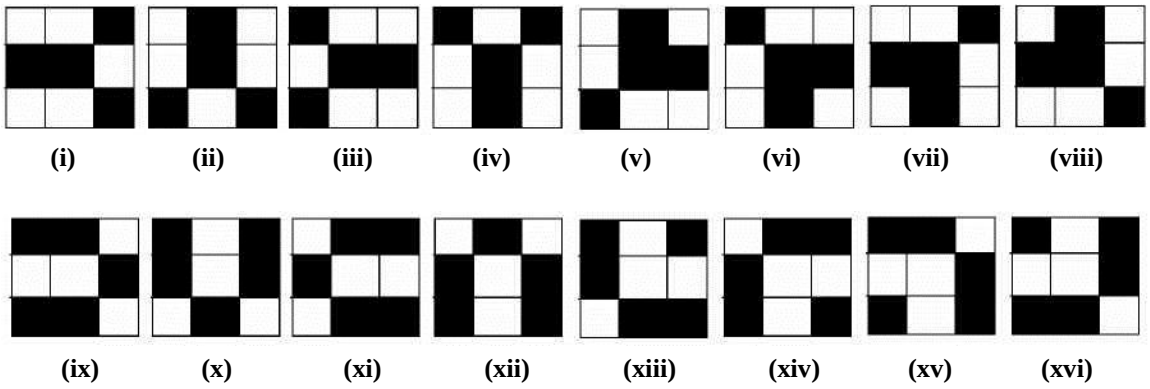
Ridge bifurcations are those pixels in an image which have only three neighbours in a 3X3 neighbourhood and these neighbours are not adjacent to each other. The minutiae image M2 containing ridge terminations is given by:

$M2 = I \circledR J$ (10)

Where, I is the thinned image and J is the sequence of structuring element pairs (J_1, J_2). Applying eq. 5,

$I \circledR J = (I \copyright J1) \cap (I^c \copyright J2)$ (11)

The structuring element sequence J that we have designed for determining endpoints in an image in this paper is shown in figure 12. Structuring elements from (i) to (viii) show the sequence for J_1 and from (ix) to (xvi) show the sequence for J_2(complement of J_1). The structuring elements are designed as per an actual bifurcation point in a fingerprint image, where each pixel has exactly three neighbours which are not next to each other. Each of the structuring element pairs (J_1^i, J_2^i), i = 1..8, is applied in sequence and the collective output gives the ridge bifurcations in the fingerprint image. When the Hit or Miss structuring elements are small, a faster way to compute the HMT is to use a lookup table [21].



(i) (ii) (iii) (iv) (v) (vi) (vii) (viii)

(ix) (x) (xi) (xii) (xiii) (xiv) (xv) (xvi)

Figure 12 : (i) to (viii) The structuring element sequence $J_1 = (J_1^1, J_1^2, J_1^3, J_1^4, J_1^5, J_1^6, J_1^7, J_1^8)$. (ix) to (xvi) The structuring element sequence $J_2 = (J_2^1, J_2^2, J_2^3, J_2^4, J_2^5, J_2^6, J_2^7, J_2^8)$.

POST PROCESSING

The minutiae set extracted in the previous step contains many false or spurious minutiae. The following simple post processing steps remove them.

1. If the separation between two bifurcations is not exactly an edge T and they are in a similar edge, eliminate the two of them (consolidate, connect, stepping stool, lake in figure13).
2. If the separation between two terminations is not exactly an edge T and the distinction between their points of direction is little, at that point the two details are viewed as bogus (break, different breaks in figure 13) and are taken out.
3. If the separation between a bifurcation and an end is not exactly a limit T with the end goal that T is theaverage inter ridge width , then they are removed(spur, break and merge in the figure).

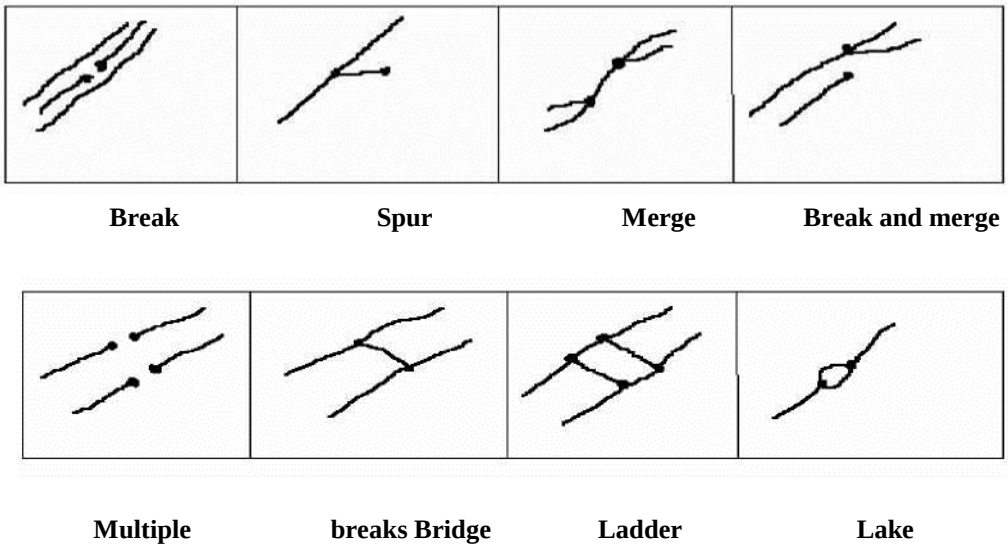


Figure 13: Some common false minutiae points (black dots)

EXPERIMENTAL RESULTS

In our experimental work, we have tested the above algorithm on FVC(2002) fingerprint database. The database contains 40 different fingers and eight impressions of each finger, which makes it a total of 40X8=320 fingerprints. Minutiae are extracted at four stages from the images as follows and the results are tabulated.

1. Original raw images.
2. Enhanced and then thinned (repairing broken ridges etc.).
3. Preprocessed thinned images (Removal of spurs, spurious bridges, filling holes etc.).
4. Post processing the minutiae to get rid of the spurious ones.

We have tested the proposed algorithm using two quantity measures namely Sensitivity and Specificity which indicate the ability of the algorithm to detect the genuine minutiae and remove the false minutiae for fingerprint image [13]. The performance of the proposed algorithm has been measured based on the missing and the spurious minutiae after each stage (figure 14).

Missed Minutiae
Sensitivity= 1 –
(12)
Ground Truth Minutiae
False Minutiae
Specificity = 1 –
(13)

Table 1 shows the total number of minutiae together with the number of ridge endings and bifurcations separately at each stage. It also shows the reduction in ridge endings and bifurcations after each stage. It also shows the ground truth minutiae in each case. The found truth minutiae have been calculated by manually inspecting the fingerprint image.

Table 1: Total, endings and bifurcations with % reduction in false minutiae after each stage.

Ground Truth Minutiae	Ground Truth Minutiae	Stage	Total minutiae	Ridge endings	Ridge bifurcations	Total Red. (%)	E nd . Red. (%)	Bif. Red. (%)
		Original	347	201	146	-	-	-
I1	59(36+23)	Enhanced	315	180	135	9.2	10.4	7.5
		Preprocessed	215	101	114	31.7	43.9	15.6

		Post processed	62	38	24	71.1	62.4	78.9
		Original	114	75	39	-	-	-
I2	23(12+11)	Enhanced	88	56	29	22.8	25.3	25.6
		Preprocessed thinned	61	42	19	30.7	25.0	34.5
		Post processed	23	11	12	62.2	73.8	36.8
		Original	201	106	95	-	-	-
I3	23(9+14)	Enhanced	73	30	43	63.7	71.7	54.7
		Preprocessed thinned	54	20	34	26.0	33.3	20.9
		Post processed	22	8	14	57.4	60.0	58.8
		Original	360	110	250	-	-	-
I4	32(13+19)	Enhanced	121	52	89	66.3	52.7	64.4
		Preprocessed thinned	76	24	52	37.2	53.9	41.6
		Post processed	33	14	17	56.6	41.7	67.3

Table 2 lists the total, missed and false number of minutiae before and after the post processing stage together with the sensitivity and specificity values the high estimations of affectability and particularity at long last, recommend the adequacy of the proposed method. Since our procedure deals with diminished binarized pictures, the most broadly utilized method pertinent to such pictures in the writing is the intersection number strategy. Subsequently, we have analyzed the two of them and table 3 shows the near aftereffects of our strategy with the much utilized intersection number procedure. It very well may be unmistakably observed that the consequences of the proposed calculation are better at both when post handling stages. This is so in light of the fact that most intersection number procedures depend on confounded and broad post handling calculations to improve their outcome.

Table 2: Total, missed and false number of minutiae before and after the post processing stage together with the sensitivity and specificity in the proposed technique.

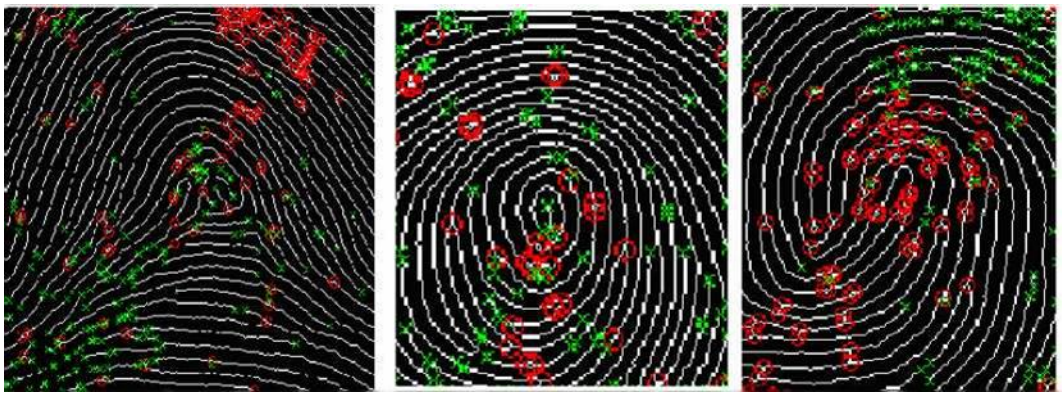
Image	Before Post processing			After Post processing			Final Sensitivity %	Final Specificity %
	Total	Missed	False	Total	Missed	False		
I1	215	1	157	62	1	4	98.3	94.2
I2	61	1	40	23	1	1	95.7	96.7
I3	64	1	43	22	1	0	95.7	99
I4	76	2	45	31	2	1	93.6	93.9

Table 3: Total minutiae together with endings and bifurcations before and after the post processing stage in the proposed as well as the crossing number technique.

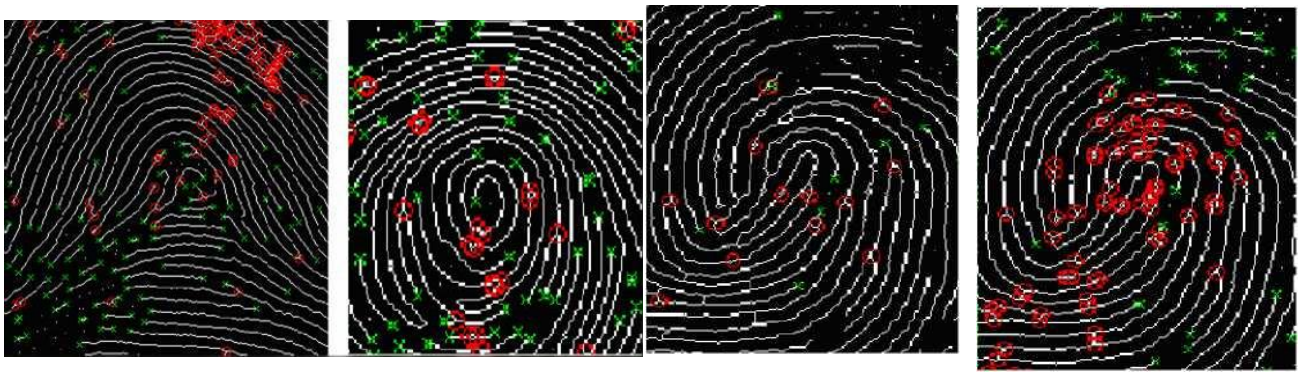
Stage	Image	Proposed Technique			Crossing Number Technique		
		Total	Endings	Bifurcations	Total	Endings	Bifurcations
Before Post processing	I1	215	101	114	589	303	286
	I2	61	42	19	189	109	82
	I3	54	20	34	183	69	113
	I4	76	24	52	189	85	103
After Post processing	I1	62	38	24	145	67	78
	I2	23	11	12	38	24	24
	I3	22	8	14	78	26	42
	I4	33	14	17	41	15	56

CONCLUSIONS

The proposed technique depicts the successful usage of the Hit or Miss Transform on thinned fingerprint images for efficient minutiae extraction. It unmistakably shows that preprocessing a Fingerprint picture with morphological administrators before diminishing eliminates unnecessary data and concentrates a reasonable and dependable edge map structure from the information Fingerprint picture subsequently giving better outcomes in details extraction. This additionally decreases a great deal of exertion in the post handling stage as the quantity of false details is nearly lesser. The high estimations of Affectability and Explicitness at long last and the relative outcomes with the intersection number strategy show the empowering execution of our technique.Our future work would be to consider fuzzy morphology for minutiae detection.



(a) (b) (c)



(d) **(e)** **(f)** **(g)**

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