

Fingerprint Feature Extraction using Ridges and Valleys

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Abstract—Fingerprint extraction is the process to find the minutiae points from a fingerprint. But the main question that arises in feature extraction is how to increase the accuracy? There are many ways to increase the accuracy like to use pre-processing techniques on the fingerprints or to change the method of feature extraction. Normally we use ridges to extract the minutiae points like “Ridge Ending” and “Bifurcation”, but we can also make use of valleys in the fingerprints for this process. In this paper we have done feature extraction using both ridges and valleys and we have also increased the accuracy of the features that are to be extracted by using pre-processing techniques on the fingerprints. The experimental results prove that pre-processing improve the results that are obtained by the feature extraction to a very large value.

Keywords—Fingerprint, feature extraction, minutiae points, pre-processing, dilation, morphological operations.

I. INTRODUCTION

Biometrics is the science of identifying a person by his behavior as well as physiological properties. These include face recognition, fingerprint recognition or handwriting recognition systems. Out of all these properties fingerprint recognition is most widely used as it is most accurate among all of these.

As we all know that the accuracy of fingerprint is highest among all the biometric trait, the use of these devices is increasing in our day to day life. Now these devices are used for various purposes like for the attendance of the staff before and after their work, use as a login password in computers, used as the key of locker, etc. This is possible only because fingerprints are highly unique i.e. the probability of two fingerprint being same is 1 in 1.9×10^{15} . This make these devices so popular that they are now used in high-security areas also.

Fingerprint are the complex patterns on the finger tips. These consist of ridges and valleys. In a fingerprint, ridges are represented by the dark lines whereas the valleys are represented by the white area between the ridges.

The minutiae points in the fingerprint consist of ridge ending as well as bifurcation. Ridge ending is the pattern where a ridge comes to an end whereas bifurcation is the pattern where a ridge divides into two ridges

We should also keep in mind that the ridge ending can also be viewed as the bifurcation of the valley whereas the bifurcation can also be viewed as the ending of the valley

As we can see in the image provided below, the area marked as ridge ending is the area where a valley divides into two valley and the area marked by bifurcation is the area which shows the end of a valley. Taking this into consideration it is proved that if we want to find the minutiae points in the fingerprint than we can do it by using either ridges or valley.

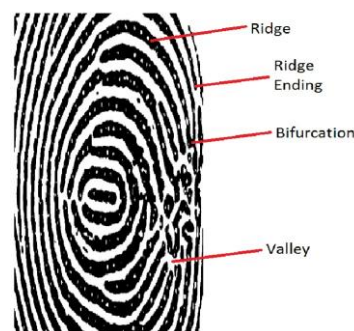


Fig. 1. Minutiae points in Fingerprint

In order to start the feature extraction we first need to enhance the input image that is used for the extraction of features. This is done by applying the pre-processing techniques on the image before it is used in the further processes. These techniques are

Binarization, Filling of Holes, Thinning of Image, dilation & then the Removal of Unwanted Portions. In case we want to find the minutiae points using valley then we also need to do the inversion of the image along with the techniques provided above.

II. FEATURE EXTRACTION

Minutiae points are the abnormal points among the constant patterns of the fingerprint, thus if we know the abnormality that they provide, we can easily detect these points in the fingerprint. If we take the example of ridge ending, these are the points where the ridge comes to an end so to detect these points we need to check for those pattern in the fingerprint where one black point is accompanied by only one black point and the rest all are white. Similarly in case of bifurcation one black point is accompanied by 3 black points while the rest are white.

But in order to do so we first need to transform the fingerprint in such that the minutiae points can be extracted. In order to do so we need to apply some processes in a certain pattern. We can apply these processes in any way we want but it is experimentally proved that it give the most accurate results if we follow the algorithm provided below.

- 1) Change the image to form a binary image.
- 2) Fill all the holes that are present in the image
- 3) Apply thinning on the image by changing the width of ridges to one pixel.
- 4) Perform the dilation of the thinned image we gain in previous step.
- 5) Apply thinning once again so that we can get the image from which minutiae points can be extracted.
- 6) Remove all the unwanted pattern of the fingerprint.
- 7) Compute all the minute points in the image.

If we want to find all the minutiae points in the fingerprint using valleys instead of ridges then we need to do the inversion of the image after filling all the holes in the image. Rest all the process is same for minutiae points' extraction by using both ridges and valley.

A. Binarization:

Binarization is the process where we change the input image to a binary image, i.e. 0 or 1. We do so by first computing a threshold value and any pixel whose value is less than threshold is considered black while all the rest are considered white.



Fig. 2. Grayscale Image



Fig. 3. Binary Image

Filling of Holes:

Filling of holes is the process in which we fill all the holes that are present in the ridges of the fingerprint. We do so because in case we don't fill these holes, each of these holes can also be looked as two bifurcations near to each other so when we try to compute the minutiae points in the fingerprint then a lot of wrong entries will be encountered. This will decrease the accuracy of minutiae point that are extracted from the fingerprint.



Fig. 4. Hole Filling

Thinning:

Thinning is the process where we transform the image in such a way that the width of the ridges is changed to one pixel. This is done because it is easy to find minutiae points in the thinned image as compared to the original image, as we can easily check the pattern of the pixels in the thinned image because the width after thinning is only one pixel.

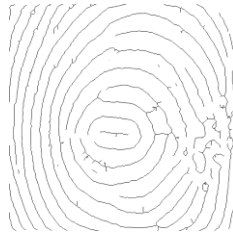


Fig. 5. Thinning

B. Dilation:

Dilation is the process where we increase the width of the ridges once again in such a way that if there is a gap of one or two pixels between any two ridges, then it can be joined to form a single ridge. This is done as a gap of one or two pixels can only be caused due to an error of some sort.



Fig. 6. Dilation

C. Remove Unwanted patterns:

After performing thinning once again on the dilated image, the image is nearly ready for the process of feature extraction. But still there are small patterns in the fingerprint that need to be removed to increase the accuracy. This is done by calculating the number of pixels in each ridge and any ridge that has less than 20 pixels will be removed from the fingerprint.

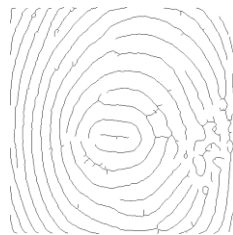


Fig. 7. Removal of Unwanted Patterns

D. Minutiae Points Detection:

After finishing all the preprocessing process, we get the final image from which the minutiae points can be extracted. Thus we can easily find the minutiae points by using the Crossing Number Algorithm. In this we take a 3*3 map and move it across the whole image. In this the properties of the point P is calculated by its crossing no i.e. the no of points from P1 to P8 that are black.

P1	P2	P3
P8	P	P4
P7	P6	P5

The crossing no that is obtained by using the above image map is compared with the table given below to find whether a minutiae point exist there or not. Like if CN=1, then that means that the point P is an end point and thus a minutiae point.

TABLE I
CROSSING NUMBER PROPERTIES

CN	Properties
0	Isolated Point
1	End Point
2	Connective Point
3	Bifurcation

Now we find all the points that have crossing number either 1 or 2 and mark them as the minutiae points. We can do this in both the case of using ridges or valleys, it's just that we find pixel value 1 in case of valley and pixel value 0 in case of ridges.

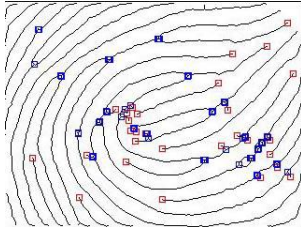


Fig. 8. Minutiae Points Using Ridges

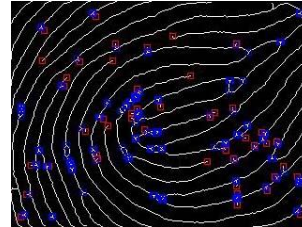


Fig. 9. Minutiae Points Using Valley

III. RESULT ANALYSIS

Program that correspond to the method given above is written in Matlab. In the result analysis 'Method 1' will correspond to the minutiae extraction using ridges whereas 'method 2' will correspond to minutiae extraction using valleys. We have also computed the results with and without the application of the preprocessing methods. Images for testing are taken from DB1_B FVC2004. We use 10 images from the database to compute the results. The algorithm used is as follow.

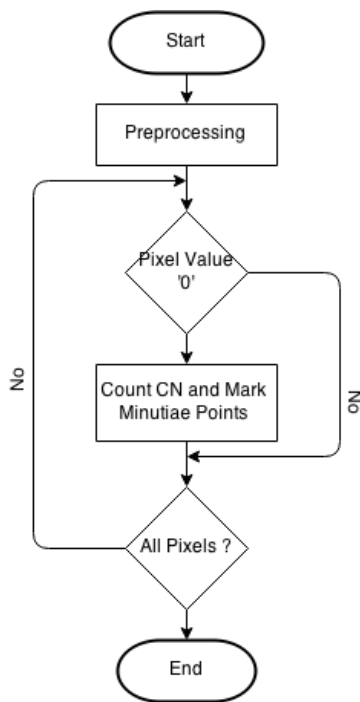


Fig. 10. Method 1

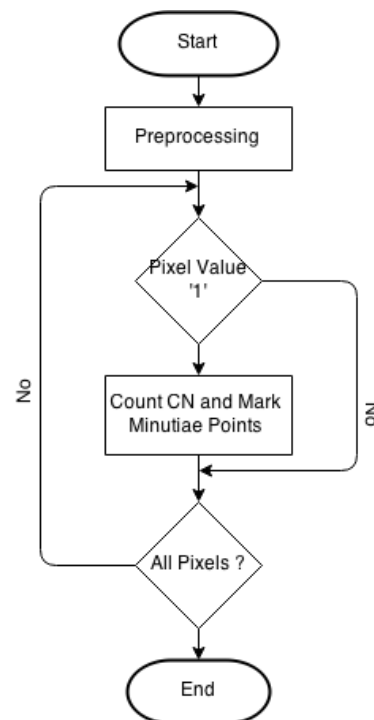


Fig. 11. Method 2

TABLE II
MINUTIAE POINTS DETECTED

No	File	Method 1	Method 2
1	101_2.tif	545	499
2	102_2.tif	1139	1131
3	103_3.tif	971	965
4	104_4.tif	998	1000
5	105_7.tif	736	704
6	106_4.tif	374	364
7	107_3.tif	614	614
8	108_5.tif	266	246
9	109_3.tif	646	626
10	110_2.tif	836	832

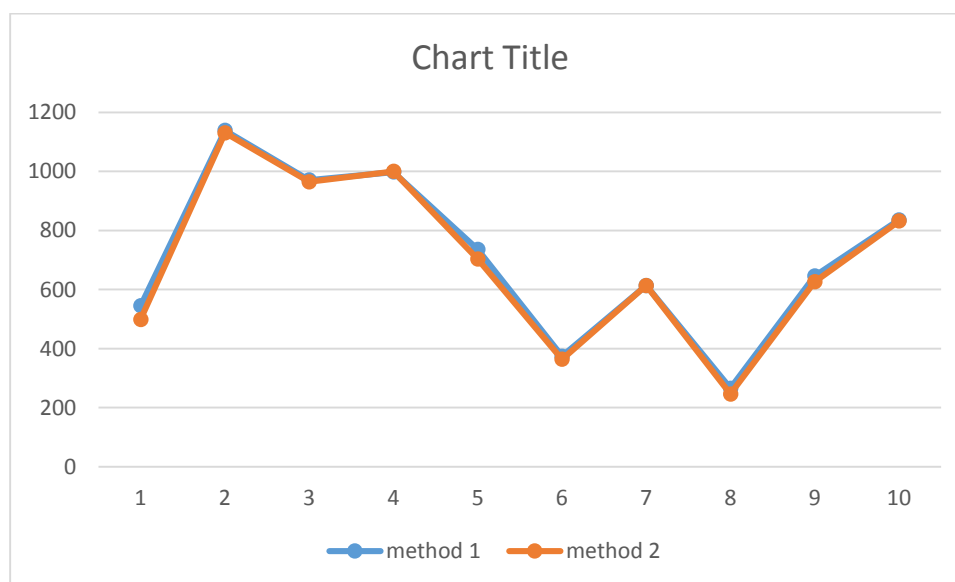


Fig. 12. Comparison of various methods

IV. CONCLUSION AND FUTURE WORK

By the results provided above, it is concluded that the Method 2 is better than Method 1 for the extraction of minutiae points in the fingerprint. It is also seen that we can increase the accuracy of feature extraction by using the preprocessing techniques. The future work will be to improve the method of feature extraction even further to get even better results. In future work, Post processing should be included to eliminate the false minutiae points and to improve the accuracy of feature extraction.

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