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Digitization of Inked Fingerprints

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Abstract

Many applications of biometric identity technology have emerged as a result of the development of access control systems, including facial recognition, iris recognition, handwriting recognition, fingerprint recognition, and speech recognition, among others. Fingerprint recognition is one of the most popular biometric identifiers due to its lifetime Universality, permanence, distinctiveness, and convenience. Fingerprint extraction is the first step in fingerprint recognition. Finding the numerous minutiae points in a fingerprint image that can then be used for fingerprint matching is referred to as fingerprint extraction. However, if we use an unprocessed fingerprint for feature extraction, we will get a lot of minutiae points among the many that arise due to noise in the fingerprint image, and such erroneous points cannot be used for accurate fingerprint matching. This paper proposes a simple preprocessing technique that uses enhancement techniques and morphological operators to digitize an inked fingerprint and extract important features from it for individual recognition.

Keywords: *Biometric, fingerprint, minutiae points, feature extraction, preprocessing, digitization.*

1. Introduction

Biometrics is obtained from the Greek words bios (life) and metron (measurement); biometric identifiers are measurements taken from a living human body. Biometric recognition is the use of distinguishing anatomical (e.g., fingerprints, face, iris) and behavioural (e.g., speech) characteristics, known as biometric identifiers, traits, or characteristics, to automatically recognize individuals. Since biometric traits cannot be misplaced or shared, and they inherently represent the personal's bodily identity, they are becoming crucial components of successful person recognition solutions. Because of its consistency and uniqueness in life, fingerprint recognition technology is one of the most well-known biometric technologies. Biometric recognition is important for maintaining accuracy in identifying individuals. The extraction of Minutiae from input fingerprint images is a critical step in automatic fingerprint recognition. As we all know, fingerprints are unique and easy to distinguish between two fingerprint images that are completely the same or different, but even the same finger cannot leave two completely identical scanning images every time. Furthermore, there are numerous bad conditions in fingerprint scanning, such as finger marks, an incomplete fingerprint image, a rotation in the fingerprint image, and so on. Many of these issues may result in the fingerprint system being unable to correctly identify the user's fingerprints. As a result, some algorithms must be developed to improve the fingerprint identification system and reduce the error rate. The fingerprint digitization method discussed in this paper composed of pre-processing and minutiae extraction. The inked fingerprint contains much noise, and the purpose of pre-processing is to enhance the quality of an image and remove unnecessary noises. In this paper histogram equalization, FFT, and some morphological operations are used for fingerprint enhancement.

2. Related Work

G. Sambasiva Rao et al., [1] proposed a fingerprint verification scheme based on a grey level watershed method to estimate the ridges existing on a fingerprint image acquired from directly scanned fingerprints or inked impressions. V. Vijaya Kumari and N. Suriyanarayanan [2] proposed an approach for evaluating the performance of local operators in fingerprints by identifying the edges of fingerprint images using five local operators: Sobel operator, Roberts operator, Prewitt operator, Canny operator, and LoG operator. The image obtained after edge detection edge detected image is further segmented in order to obtain individual fingerprint segments. Raju Sonavane, and B.S. Sawant [3] proposed a method for estimating the orientation field by presenting a special domain fingerprint enhancement technique that breaks down the fingerprint image into a set of filtered images. A quality mask differentiates the recoverable and unrecoverable corrupted areas in the resulted input image. The input fingerprint image is greatly improved in the recoverable regions by using estimated orientation field. Paramvir Singh and Dr. Lakhwinder Kaur [4] presented a method for feature extraction from fingerprint using morphological operations like hole filing, dilation, and thinning then the comparison is done between the original Image and the two other preprocessed images one is obtained by using dilation operations, and the other is obtained by using hole filling and then dilation. Nirmal. K, Madhubala. G [6] proposed the method to extract significant features from images that are useful in the representation and description of region shapes, a well-suited approach is the Morphological (Shape-Based) processing which refers to the operation where an object is HIT or FIT with structuring elements. Thus, the two-valued images are reduced to a more informative shape.

3.Proposed Work

In this paper an algorithm is proposed for enhancement and digitization of inked fingerprint this inked fingerprints are captured from Redmi note 5 pro mobile phone. Further this fingerprint is processed and are compared with the digital fingerprint database obtained from the app named “mymarq” (for fingerprint scanning by mobile phone).
The flowchart of proposed method is shown with detailed explanation and obtained results using MATLAB R2020b are also shown.

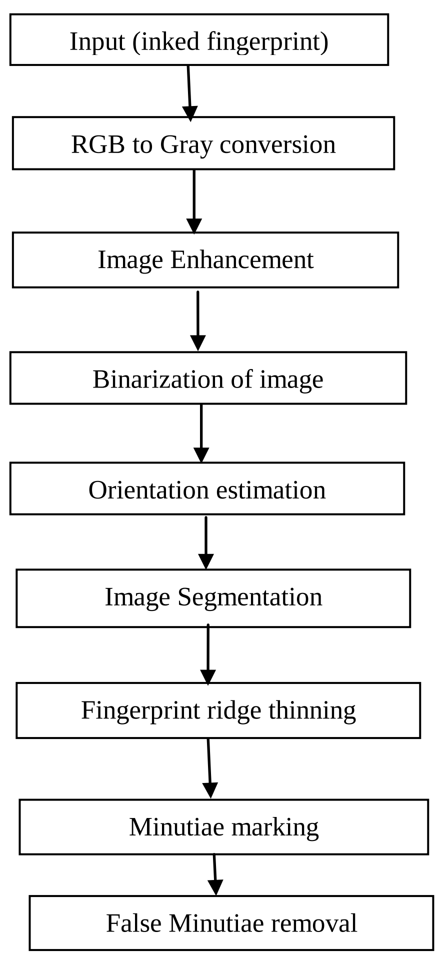

Fig.1. Flowchart of proposed methodology

Step 1- Input (inked fingerprint)

An off-line image is typically obtained by applying ink on the fingertip and creating an inked impression of the fingertip on paper. Firstly, this off-line image (Fig.2) is converted to grayscale (Fig.3) because color increases the complexity of the model. A gray-level fingerprint image I is defined as an N x N matrix, where I (i, j) represents the intensity of the pixel at the ith row and jth column.

Fig.2. Input image (Inked)

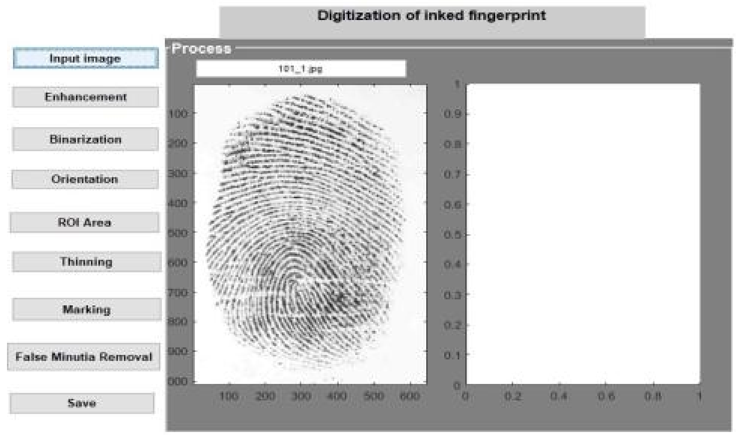

Fig.3. RGB to Gray conversion

Step 2- Image Enhancement

The quality of fingerprint images influences the performance of minutiae extraction and matching algorithms. A good quality fingerprint image has high contrast between the ridges and furrows, whereas a poor-quality fingerprint image has low contrast, is smudgy, and contains spurious and missing minutiae. The goal of fingerprint Image enhancement is to reduce these noises and to improve the clarity of the ridge structure in a fingerprint. Two methods have adopted in this paper for Fingerprint Image enhancement. First is Histogram Equalization used to expand the pixel value distribution of an image so as to increase the perceptional information. Second is Fourier Transformation which enhances the fingerprint by multiplying the Fourier Transform of the block by magnitude of power ‘k=0.45’. This enhanced image (Fig.4) has the improvements to connect some falsely broken points on ridges and to remove some spurious connections between ridges.

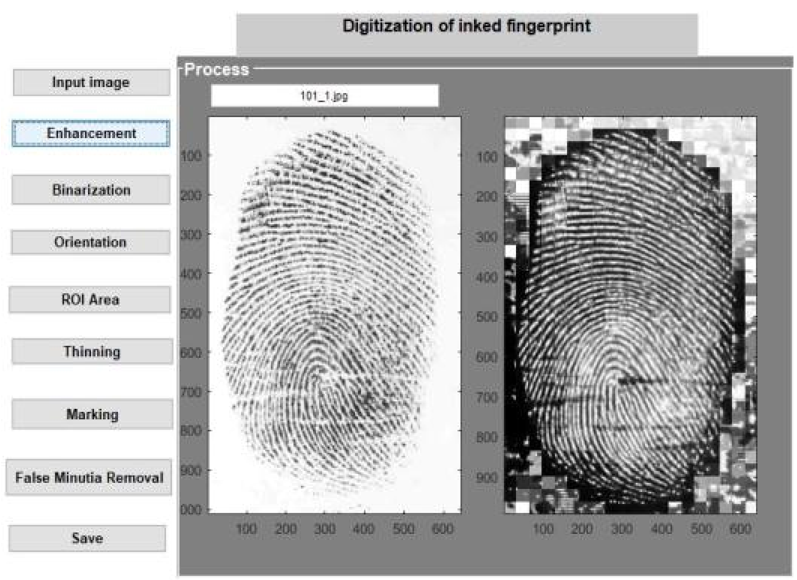

Fig.4. Enhanced Fingerprint Image.

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Step 3- Binarization of image

Locally adaptive Binarization was applied to binarize the fingerprint image (Fig.5) which transforms a pixel value to 1 if the value is larger than the mean intensity value of the current block (16 x16) to which the pixel belongs and this way the threshold changes dynamically throughout the Image.

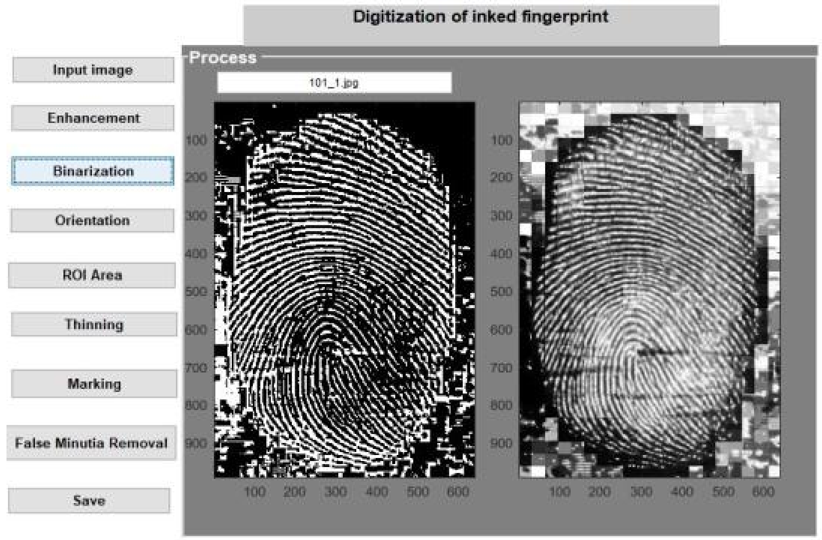

Fig.5. Binarized Image

Step 4- Orientation estimation

A fingerprint image's orientation field defines the local orientation of the ridges contained within the fingerprint. Because the subsequent Gabor filtering stage relies on the local orientation to effectively enhance the fingerprint image, orientation estimation is a critical step in the enhancement process. The orientation image is computed using the least mean square estimation method. However, instead of estimating the orientation block-wise, its been computed direction wise After completing the direction estimation for each block, blocks with no meaningful information on the stripe and groove will be removed.

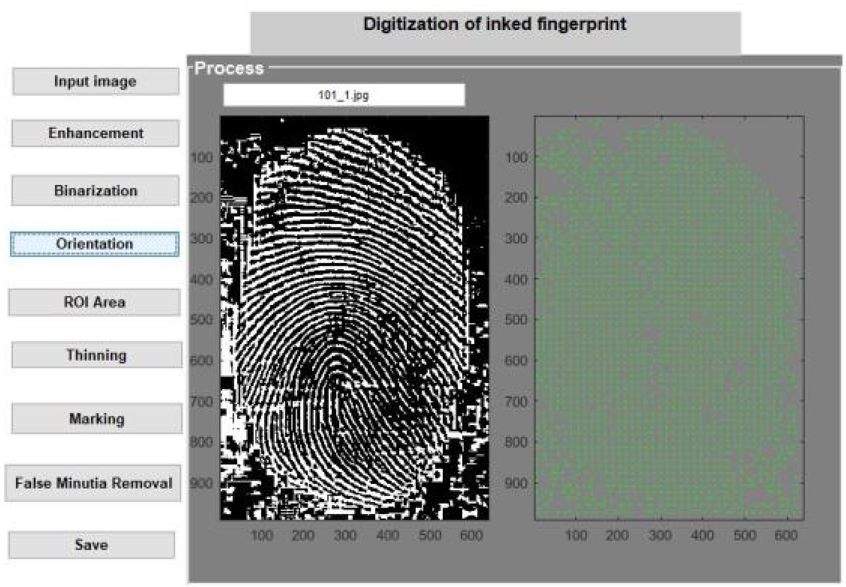

Fig .6. Orientation Estimation

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Step 5- Image segmentation

Image segmentation is the process of separating the regions of an image that correspond to the objects of interest from the regions of the image that correspond to the background. In general, for each fingerprint image, only a Region of Interest (ROI) (Fig.7) is useful for recognition. Morphology, as we know, is a tool for extracting image components that can be used in the representation and description of objects. These methods are often used for pre- or post-processing operations such as morphological thinning, filtering, and pruning. Two Morphological Smoothing Operations, 'OPEN' and 'CLOSE,' are used to estimate the Region of Interest. The 'OPEN' operation can be used to expand images and remove peaks caused by background noise. The 'CLOSE' operation can be used to shrink images and remove small holes or cavities.

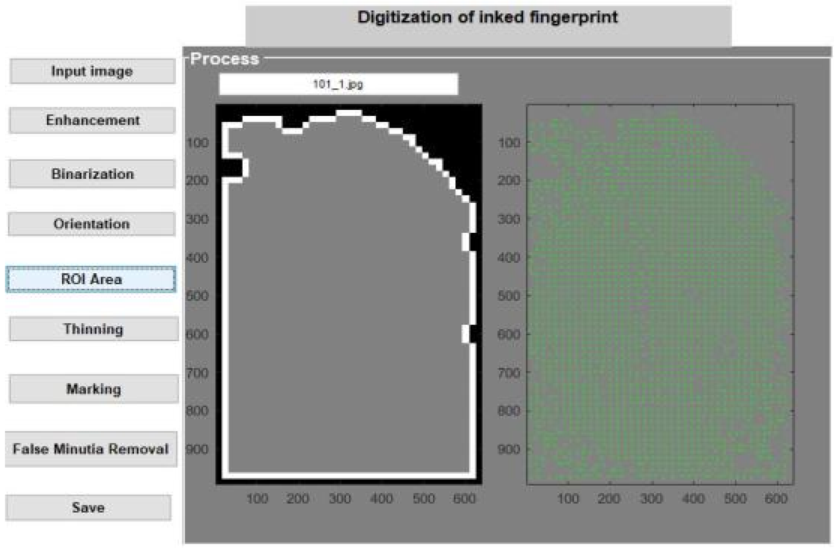

Fig.7. ROI area

Step 6- Fingerprint ridge thinning

As the fingerprint ridges are relatively thick, it is preferable for subsequent shape analysis to thin the ridges so that each is one pixel thick, and the single-pixel width ridges aid in detecting endings and bifurcations. The thinning method will reduce the width of the ridges while retaining connectivity and minimizing the number of artifacts introduced due to this processing. In this Thesis, thinning for ridges has been done using the ‘bwmorph’ function of MATLAB. (Fig.8) shows the thinned ridges of fingerprint image after applying ‘bwmorph’ function in the binarized segmented image. The thinning image is then filtered by the other three morphological operations to remove some H-breaks, isolated points, spurs, and spikes.

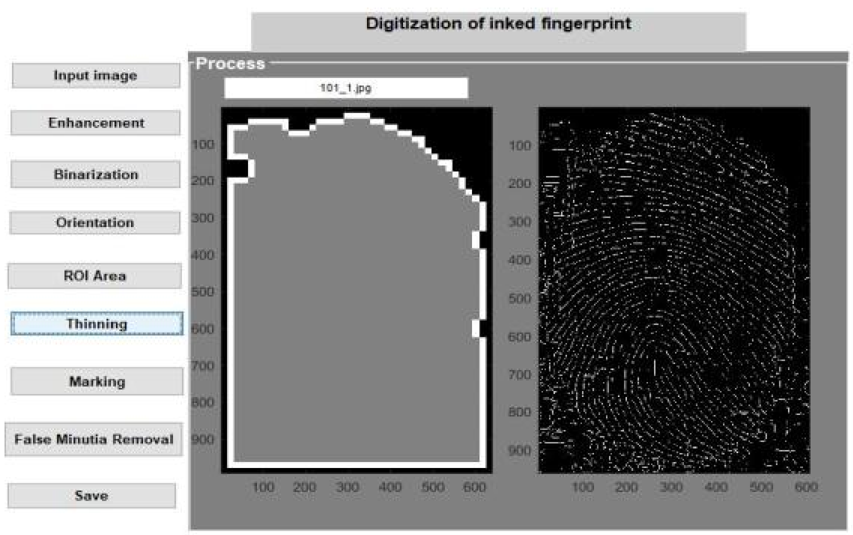

Fig.8. Fingerprint image after thinning

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Step 7- Minutiae marking

The fingerprint minutiae are discovered operating on the thinned image and are simple to detect. Endings are found at the ends of thin lines, and bifurcations are found at the intersections of three lines. Minutia can be detected by examining the 8-neighborhood of ridge thin pixel at (x,y) and classified as:

• a Ridge Ending if $\sum_{i,j=-1 \ldots 1} I(x+i, y+j)=1$ (1)

• a Ridge Bifurcation $\sum_{i,j=-1 \ldots 1} I(x+i, y+j)=3$ (2)

In general, for each 3x3 window, if the central pixel is ‘1’ and has exactly three ‘1’ value neighbors, then the central pixel is considered as a Ridge Branch. If the central pixel is ‘1’ and has only one ‘1’ value neighbor, then the central pixel is considered as a Ridge Ending.

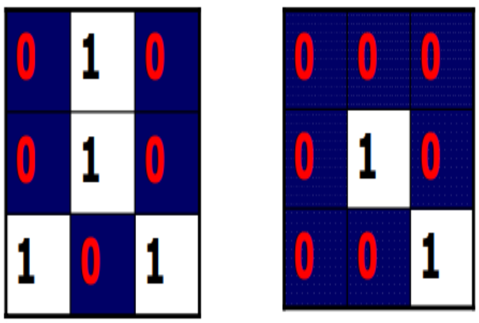

Fig.9. Bifurcation and Termination

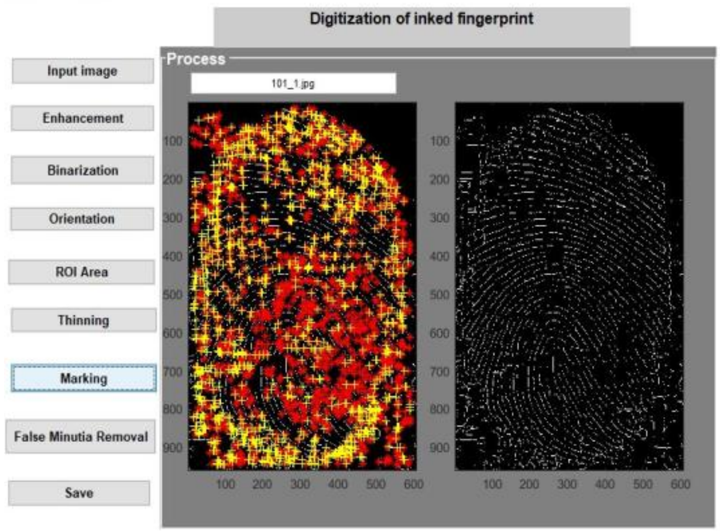

Fig.10. Minutiae Marking

Step 8- False Minutiae removal

The pre-processing stage does not completely cure the fingerprint image; extraneous minutia will always exist as a result of the noisy original image or artifacts are introduced in earlier stages. If these false minutiae are simply treated as genuine minutiae, they will have a significant impact on matching accuracy. so by using empirically determined thresholds, these extraneous features are reduced. A bifurcation with a branch that is much shorter than an empirically determined short isolated line, for example, is eliminated because this line is most likely a spur. Two opposing endings are eliminated because they are most likely on the same ridge that has been broken due to a scar, noise, or a dry finger condition that results in discontinuous ridges. Endings at the fingerprint's boundary are removed because they are not true endings but rather the extent of the fingerprint in contact with the capture device.

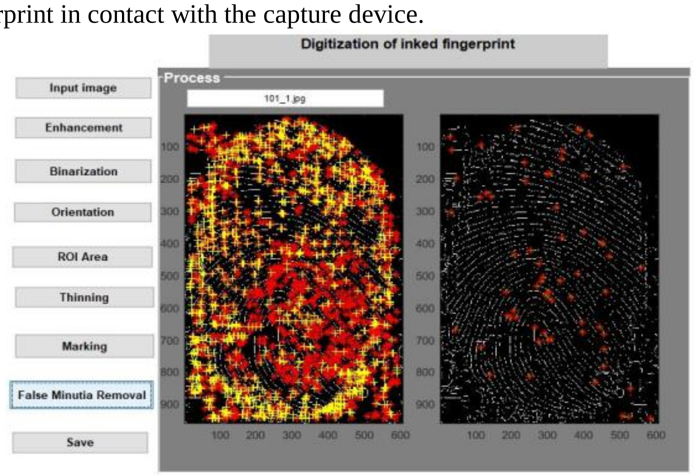

Fig.11. False Minutiae removal

3. Performance evaluation

Here performance evaluation is done considering parameters like accuracy, sensitivity, precision, specificity. The results are obtained by comparing digital images with the inked images which are digitized by using the proposed algorithm.
Referring table.1 parameters are described as;

Table 1. Performance evaluation parameters value

Processed Images	Accuracy	Sensitivity	Precision	Specificity
Image 1	0.72	0.75	0.83	0.61
Image 2	0.74	0.76	0.87	0.67
Image 3	0.71	0.76	0.81	0.56
Image 4	0.70	0.74	0.86	0.60
Image 5	0.70	0.73	0.85	0.62
Image 6	0.71	0.74	0.86	0.62
Image 7	0.73	0.76	0.87	0.65
Image 8	0.72	0.74	0.86	0.63
Image 9	0.71	0.74	0.86	0.60
Image 10	0.72	0.74	0.87	0.65

4. Conclusions

Digitization of inked fingerprint is obtained by using the morphological operation and enhancement techniques like FFT and histogram equalization which proved beneficial for accurately transforming the inked fingerprint to digital one. By comparing the digital fingerprint which for experimental purpose obtained from “mymarq” app in mobile phone and inked fingerprint are obtained by taking thumb impression and paper and captured using Redmi note 5 pro camera of 12MP,so comparing the digital database of fingerprint with the transformed fingerprint through proposed algorithm we get the correctly classified samples i.e. accuracy of 71% , True positive rate is 75%, proposed method is 85%precise one. True negative rate i.e. no. of the correctly classified negative samples is 62%. As we are getting good accuracy and negative sample rate is also good which will reduce the execution time as no false minutiae points will be used for recognition and process will be fast and accurate. Further the better accuracy will be obtained by taking standard databases like NIST, FVC databases which consist of high-resolution images which are obtained from different fingerprint sensors.

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