Segmentation of Latent Fingerprint using Neural Network

Neha Chaudhary, Priti Dimri, Harivans Pratap Singh

Abstract**: *Latent fingerprints are the fingerprints that are left by the criminal unintentionally on the surface of the crime scene. The qualities of the latent fingerprints are very poor due to the overlapping patterns and structured noises. Latent fingerprint segmentation is a difficult task due to low visibility, structured noise, and complex structure. In this paper, a fusion of morphological and neural network approach is purposed for latent fingerprint segmentation. This method automatically segments the fingerprints and non-fingerprints patterns without human intervention. The morphological method is used for segmentation of the fingerprint region. Fingerprint region then divides into y*y blocks and extracts the features of each block and uses them as an input of NN to classify the blocks into fingerprint and non-fingerprint blocks. We are using the IIIT-D database and the shows that this model batters then the existing model.***

Keywords**: *Fingerprint Segmentation, Fingerprint Image Pre-Processing, Image Recognition, Ridge Orientation, Total variation.***

I. INTRODUCTION

Fingerprint impression is used for identification purpose. Fingerprint impression is the combination of valleys and ridges. The darker part in the fingerprint impression is called the ridge and the brighter part is called the valley.

The biometric system [22] is an example of a fingerprint recognition system. The local features of a fingerprint are called minutiae. The common minutiae are the lake, termination point or island, crossover, and bifurcation [19]. Fingerprint Images are classified into three parts (1) plain Fingerprint [14] (2) Rolled Fingerprint [14] (3) Latent Fingerprint .

Plain fingerprints are captured by pressing the finger on to a flat surface. Rolled fingerprints are captured by rolling the finger from one side to another. Latent fingerprints are the fingerprint that is left by the criminal on the surfaces of an object unintentionally. The quality of the latent fingerprint is very low due to structured noise (arch, lines, and characters), overlapped print, and low visibility. The latent fingerprints are collected by the latent examiner using some physical or chemical technique [12], [13] and then the Latent examiner marks the fingerprint features (such as minutiae) manually.

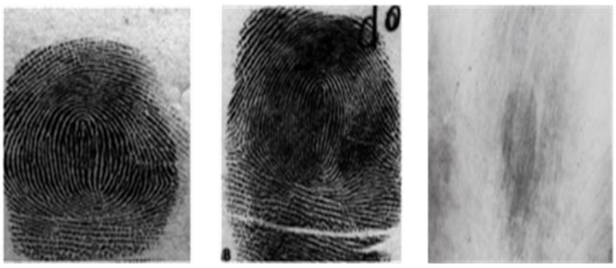

Fig. 1: Types of fingerprint images. (a)Plain fingerprint (b) Rolled fingerprint ,(c) Latent fingerprint (IIIT-D)

There are many reasons so that the automatic feature extraction system comes in picture.

(1) Large number of latent fingerprints are collected by the latent examiner from the crime scene. If the latent examiner marks the features of the fingerprints manually it will take more time.

(2)The minutiae that are marked by the different latent examiner or either same latent examiner of the same fingerprint are not the same. This is the region why one latent examiner at a different time and different latent examiner mark different matching decisions on the same latent fingerprint[9][15].

To identify the criminal, latent fingerprints that are collected by the latent examiner from crime location match with the ten-print database [21] of known criminals.

Segmentation is the main step of the Automatic fingerprint identification system (AFIS). It [11] is a process to separate the foreground and background. The foreground consists of the part of fingerprint and background consists of the noisy area in a latent fingerprint.

In this paper, the fusion of morphological and Neural Network based segmentation Algorithm is proposed to process poor quality latent fingerprints. This algorithm separates the latent fingerprint from the background using a neural network with multiple hidden layers.

II. TYPES OF STRUCTURED NOISES PRESENT IN LATENT FINGERPRINT IMAGE

The quality of the latent fingerprint is very poor due to the pressure variation and structured noise. The rolled fingerprint contains approximately 80 minutiae while the latent fingerprint contains approximately 15 minutiae [23]. Segmentation of a latent fingerprint is a very difficult task due to structure noise and poor quality.

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The structured noised can be classified into six category (Shows in Fig.2) stain ,line ,arch, character ,speckle and others .

(1) Stain. When the fingerprint left on the dirty or wet surface then it's called stain. The brightness of the stain is not homogenous and its appearance in sponge shape.

(2) Line. This type of noise present in the fingerprint in the form of a parallel line or a single line. Single line noise can be removed by the Hough Transform.

(3) Arch. Arch marked by the latent examiner in the crime scene around the fingerprint that shows the existence of fingerprint.

(4) Text/Character. The Text can be typed or handwritten. It can be in different sizes and styles. This is a very common structured noise.

(5) Speckle. This type of noise contains a tiny structure (e.g. small dot .dust speckles).

(6) Other. This type of noise contains sign, arrow etc. These types of noise are different from text or arch, mostly they contain sharp edges.

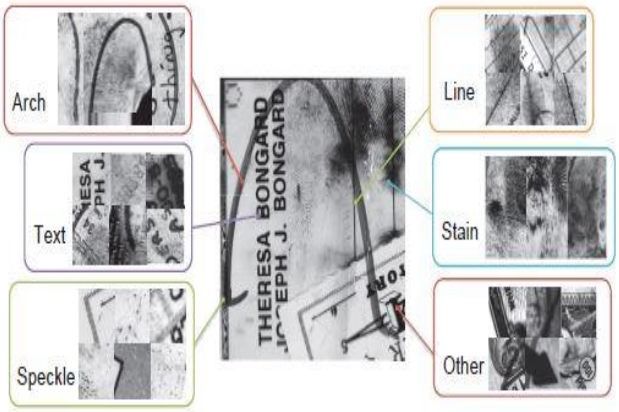

Fig.2: Different Types of Structured Noise Present in Latent Fingerprint [20].

Segmentation using previous methods are mostly feature-based, commonly used features are variance ,mean ,coherence and variant[10], [17], [18].These types of algorithms work effetely on rolled and plain fingerprints but not work properly for latent fingerprint. Therefore, we need to generate a new model that segments latent fingerprint image effectively. In the proposed model we used a morphological method for segmentation of fingerprint region automatically and NN separates the background from the latent fingerprint

III. LITERATURE REVIEW

The goal of the segmentation algorithm is to decompose the latent fingerprint image into two parts Foreground and background. The foreground consists of the fingerprint and the background consists of the noise or unwanted region. A few methods on latent fingerprint segmentation [1,2,3,4,5,6,7,8,10] have been purposed. In Zhang et al. [5], the author used the Adaptive Total Variation Model for fingerprint image decomposition and feature selection of the multiscale image. In this model, they used a total variant model with L1 fidelity denoted by, TV-L1. The Weight coefficient in the TV-L1 model Adjusted accordingly with L1 fidelity that depends on the background noise level.TV-L1 model decomposes the fingerprint image in cartoon and texture. The cartoon contains a piecewise smooth component and texture contains the texture component of a fingerprint image.ATV does not give good results for ugly latent fingerprints. In Lai et al [6], the Purposed Novel Directional total variation (DTV) model for latent fingerprint detection and segmentation. In the DTV model, the author includes a special parameter in TV computation that is special –dependent texture orientation. This parameter is appropriate for an image with oriented textures.DTV not segments multiple overlapped fingerprints. Zhang et al. [4], Purposed Adaptive Directional Total Variation (ADTV) model that takes the advantages of both Adaptive Total Variation Model and Directional total variation.ADTV model used for latent fingerprint enhancement and segmentation. It used orientation and scale two features for image segmentation. It decomposed the fingerprint image into two parts texture and cartoon. The texture contains the fingerprint part while the cartoon contains the structured noise (Character, stain, line, arch, speckle, etc.).ADTV is incapable of handling the overlapped fingerprints region. Xue et al.[7], purposed fingerprint image segmentation based on a combined method, that combines statistical characteristics of gray with orientation field information. To calculate the fingerprint block direction the author used multi-polar blocking and Gabor filter. To calculate the statistical characteristic of gray the author used five indicators Mean value, contrast, variance, low second-order movement, and high second-order movement but this method is not appropriate for too wet and too dry fingerprint image. Short. Et al.[8], purposed Ridge template correlation methods for latent fingerprint segmentation. This method increases the accuracy of latent fingerprint segmentation and reduces the fingerprint area that is detected as a fingerprint from 60.7% to 33.6% of the total fingerprint image. It used a Hough-based method for the detection of structured noise such as line and removes it from the fingerprint image. It also reduces false minutiae detection considered as foreground and true minutiae considered as background from 1.41% to 0.29%. When detection of false minutiae is high its gives wrong segmentation results. Choi et al.[3], purposed automatic extraction of latent fingerprint based on a combined method that uses frequency features and ridge orientation. Ridge frequency of latent fingerprint is found by the local Fourier analysis method and a similar pattern of ridge fingerprint is found by the tensor method. In this model, the foreground area is found by local Fourier analysis and orientation tensor method both and then the authors found the intersected area of both methods, processed that area and found the segmented output. Satisfactory results as far as visual inspection is concerned. For segmentation, it requires accurate confidence measures.

Vatsa et al. [2], purposed Adaptive latent fingerprint segmentation using feature selection and random decision forest classification. In this paper, the author used a machine learning algorithm, feature selection technique and novel SIVV based metric for latent fingerprint segmentation. This method provides low matching accuracy.

Cao et al. [10], purposed A Coarse to Fine Ridge Structure Dictionary for Enhancement and segmentation of Latent Fingerprints. This model used a total variation model (TV) with L1 fidelity and decomposes the image into texture and cartoon.

The cartoon contains the background noise and the texture contains the fingerprint image. Remove the cartoon and textured image divided into overlapping patches. In this method, a dictionary of ridge structure maintained that is developed by high-quality ridge patches, checks the similarity of latent patches with high-quality ridge structure. For segmentation If the similarity of the patches is high then replace the latent patches with high-quality ridge patches .frequency and orientation features are used for image enhancement. This method does not work well on a poor quality latent fingerprint. Stojanović et al. [1], purposed the segmentation of overlapped fingerprint using a deep learning-based approach. This approach segment the overlapped fingerprints by using a convolution neural network. It divides the block into three classes – overlapped, single and the background region. This method does not segment the overlapped fingerprints automatically.

IV. PROPOSED CNN MODEL FOR SEGMENTATION

The proposed Model shows in Fig. 5 that follows the following steps:

(1) Apply the morphological processing to segment the latent fingerprint image into the foreground and background. The foreground consists of the fingerprint region and background consists of the unwanted region. Segmentation is done by using two morphological operations opening and closing. In the opening operation first, perform the erosion then performed the dilation operation by using the same structuring element(SE).In Closing operation first, perform the dilation then perform the erosion operation by using the same SE. Dilation thickens narrow region and erosion removes the small and isolated foreground.

If we are using a morphological method for latent fingerprint segmentation it has some limitation,

- Break down some fingerprints into parts.
- Do not segment poor quality latent fingerprints.
- It segments two fingerprints together in some latent fingerprint images.
- Noise is present in the segmented region in some latent fingerprint images.

To remove these problems we apply block-wise segmentation by using the neural network.

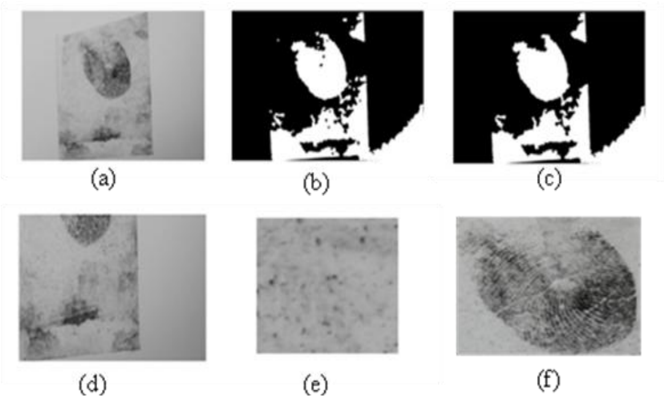

Fig. 3 Segmentation of the image by a morphological method. (a) Latent fingerprint image (b) closing operation (c) opening operation (d),(e),(f) Segmented images.

In (d) Morphological method breaks the latent fingerprint image into parts. (e) Shows the unwanted region. (f) Shows the full fingerprint image that is used for feature extraction.

(2)The Fingerprint image generated by the morphological method divides in to block size y*y.

(3) Extract the features of each y*y block by using features based on ridge, intensity and gradient method.

(4) Trained the neural network model by using the features and its value. After training this model predicts the class of each block which belongs to, If the value is 1 then it belongs to the fingerprint else non-fingerprint class.

(5) Assemble all the blocks of fingerprint class in one group and non- fingerprint class in another group. Group of fingerprint class known as foreground and group of the non-fingerprint class known as background.

(6) Remove all non-fingerprint class blocks that contain the structured noise and consider the fingerprint class blocks.

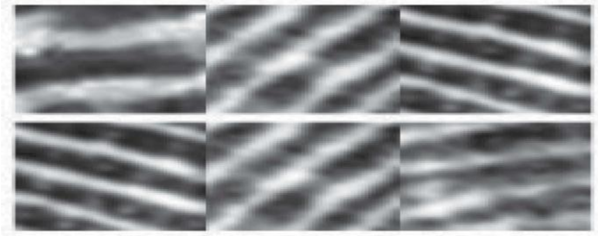

Fig. 4: (a) Fingerprint Patches/Blocks

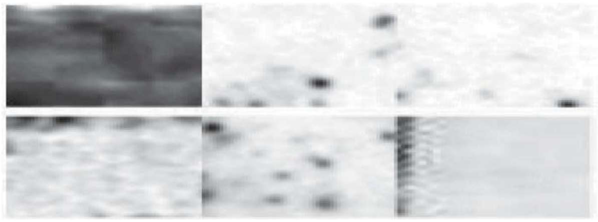

Fig. 4: (b) Non-fingerprint Patches/Blocks

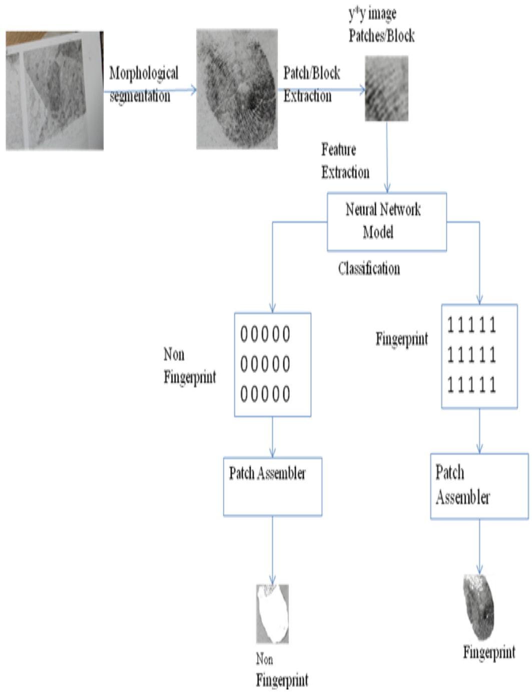

Fig. 5: Purposed Approach

V. CONCLUSIONS AND FUTURE WORK

We have proposed a new model that is a fusion of morphological and neural network approaches for latent fingerprint segmentation. The morphological method finds the fingerprint region from the large image. The fingerprint region found by morphological method divides into patches/blocks. Extract the features of each block and used these features as an input of the NN. The NN model classifies the patches into fingerprint and non-fingerprint patches. We remove the non-fingerprint patches that contain the structured noise and reconstruct the fingerprint patches for finding the original fingerprint. Our future work involves developing new algorithms for improving the accuracy of the classification and feature extraction for the segmented latent fingerprints.

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