A review on latent fingerprint enhancement based ondirectional total variation model with lost minutae construction

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Abstract - **Fingerprint recognition has been successfully used in law enforcement and forensics to identify suspects and victims for over a century. Recent advances in automated fingerprint identification systems (AFIS), coupled with the growing need for reliable person recognition, have resulted in an increased deployment of AFIS in broad applications such as border control, employment background checks, secure facility access, and user authentication in laptops and mobile devices. Despite the success of fingerprint recognition technique in many large-scale and diverse person identification applications, several challenging issues in fingerprint recognition still need to be addressed.**

keywords - **Image enhancement; Latent fingerprint; structured noise; ridge structure**

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1. INTRODUCTION

Person identification carries significance in all authentication systems ranging from access control systems to transaction systems. Biometrics is the science of uniquely identifying individuals by means of one or more biological traits an individual possess. Biometrics has the unique advantage of "something that you are" instead of "something that you possess" like a key, ID Card or "something that you know" such as passwords and Personal Identification Number (PIN) [1]. Hence, in the age of biometric authentication it is not required to carry an authentication device or remember additional passwords. Some of the most popular and commonly used biometric modalities include voice, face, fingerprint, iris, and signature.[2]
Fingerprint is one of the most popular and oldest biometric used by mankind. Fingerprint is the ridges and furrow patterns found in the upper skin layer of fingers. The scientific and systematic study of human fingerprints is called dermatoglyphics.[3] Usage of fingerprints could be traced back to the cave-man era where thumb prints were left on the walls along with other carvings to identify sculptures and family members. As shown in Figure 1, plenty of ancient carvings and written manuscripts have been discovered proving that fingerprint based identification has been in use for centuries. These traces can be found in most of the civilizations including Babylonian history, Egyption history, and Roman history showing the natural tendency of biometric identification. One of the ancient puzzles in the Indian history, still not demystified by scientists is Naadi Jothidam, the usage of fingerprints to individually identify people through centuries and predict their future.[4]

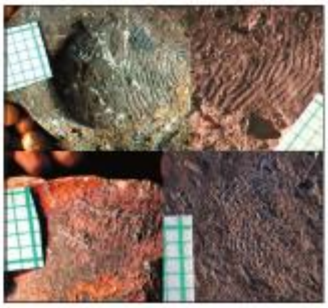

Fig.1 Examples of imprints common on ceramic pots from various periods

2. LITERATURE SURVEY

Abdilahi Liban et. al (2018) :- Latent fingerprint Image enhancement plays a significant role in automatic latent fingerprint identification systems. Even though significant development was made for both plain and rolled fingerprint enhancement, latent fingerprint enhancement still is a challenging problem. Poor quality images and existence of structured noise contribute to the challenges of latent fingerprint enhancement. The paper reviewed the current techniques used in latent fingerprint enhancement that leads to the identification of current issues and challenges in the searched area. Thus, it proposed hybrid model which is combination of edge directional total variation model and quality image enhancement with lost minutia reconstruction. The proposed techniques are tested using NIST SD27 data set. PSNR and RMSE is deployed to measure the performance of the hybrid technique. There is a statistically significant difference in the mean length of PSNR and RMSE for different categories of the latent fingerprint images (good, bad and ugly). It's observed that the proposed technique performs well for the good latent fingerprint images compare to bad and ugly images. The proposed technique can be further enhanced by taking into account the overlapped latent fingerprint images.

Jian Li et. al (2017): - In this work, we propose a novel latent fingerprint enhancement method based on FingerNet inspired by recent development of Convolutional Neural Network (CNN). Although CNN is achieving superior performance in many computer vision tasks from low-level image processing to high-level semantic understanding, limited attention has been paid in fingerprint community. The proposed FingerNet has three major parts: one common convolution part shared by two different deconvolution parts, which are the enhancement branch and the orientation branch. The convolution part is to extract fingerprint features particularly for enhancement purpose. The enhancement deconvolution branch is employed to remove structured noise and enhance fingerprints as its task. The orientation deconvolution branch performs the task of guiding enhancement through a multi-task learning strategy. The network is trained in the manner of pixels-to-pixels and end-to-end learning, that can directly enhance latent fingerprint as the output. We also study some implementation details such as single-task learning, multi-task learning, and the residual learning. Experimental results of the Finger Net system on latent fingerprint dataset NIST SD27 demonstrate effectiveness and robustness of the proposed method. Keywords: Latent Fingerprint Enhancement, Convolutional Neural Network, Pixels-to-Pixels and End-to-End Learning, Multi-Task Learning.

Manhua Liu et. al. (2015) :- Latent fingerprint identification plays an important role for identifying and convicting criminals in law enforcement agencies. Latent fingerprint images are usually of poor quality with unclear ridge structure and various overlapping patterns. Although significant advances have been achieved on developing automated fingerprint identification system, it is still challenging to achieve reliable feature extraction and identification for latent fingerprints due to the poor image quality. Prior to feature extraction, fingerprint enhancement is necessary to suppress various noises, and improve the clarity of ridge structures in latent fingerprints. Motivated by the recent success of sparse representation in image denoising, this paper proposes a latent fingerprint enhancement algorithm by combining the total variation model and multistage patch-based sparse representation. First, the total variation model is applied to decompose the latent fingerprint into cartoon and texture components. The cartoon component with most of the no fingerprint patterns is removed as the structured noise, whereas the texture component consisting of the weak latent fingerprint is enhanced in the next stage. Second, we propose a multiscale patch-based sparse representation method for the enhancement of the texture component. Dictionaries are constructed with a set of Gabor elementary functions to capture the characteristics of fingerprint ridge structure, and multiscale patch-based sparse representation is iteratively applied to reconstruct high-quality fingerprint image. The proposed algorithm cannot only remove the overlapping structured noises, but also restore and enhance the corrupted ridge structures. In addition, we present an automatic method to segment the foreground of latent image with the sparse coefficients and orientation coherence. Experimental results and comparisons on NIST SD27 latent fingerprint database are presented to show the effectiveness of the proposed algorithm and its superiority over existing algorithms. Index Terms— Latent fingerprint enhancement, sparse representation, multi-scale patch, Gabor transform function.

Jiangyang Zhang et. al (2013):- A new image decomposition scheme, called the adaptive directional total variation (ADTV) model, is proposed to achieve effective segmentation and enhancement for latent fingerprint images in this work. The proposed model is inspired by the classical total variation models, but it differentiates itself by integrating two unique features of fingerprints; namely, scale and orientation. The proposed ADTV model decomposes a latent fingerprint image into two layers: cartoon and texture. The cartoon layer contains unwanted components (e.g., structured noise) while the texture layer mainly consists of the latent fingerprint. This cartoon-texture decomposition facilitates the process of segmentation, as the region of interest can be easily detected from the texture layer using traditional segmentation methods. The effectiveness of the proposed scheme is validated through experimental results on the entire NIST SD27 latent fingerprint database. The proposed scheme achieves accurate segmentation and enhancement results, leading to improved feature detection and latent matching performance. Index Terms—Fingerprint recognition, fingerprint segmentation, latent fingerprints, total variation.

Irfan Arshad et. al (2014):- In this work, we proposed the algorithm for latent fingerprint segmentation based on K-means clustering. Enhancement of latent fingerprint is achieved using Sobel and Tophat filters. Background and foreground information of latent fingerprint are separated by using K-means clustering. The segmentation of latent fingerprint is obtained by creating and applying mask on the basis of clustered data. The objective comparison using MDR and FDR and subjective comparison using VSR and ORM for proposed algorithm are conducted, and results show that proposed method has significant improvement in comparison with existing methods for good and bad quality of latent fingerprints. The proposed algorithm may be helpful for law enforcement agencies and forensic community to identify the criminals. The proposed research can be extended for effective segmentation of ugly quality of latent fingerprints and on enhancement of segmented fingerprints for feature extraction and matching as future work.

Kai Cao et. al (2014)-: Although state of the art AFIS have already achieved impressive accuracy in tenprint search (rolled prints or slaps), latent matching or search is still a challenging problem due to presence of complex background noise and poor quality of friction ridge structure in many latents. We have Fig. 10. CMC curves for latent matching under different matching scenarios by COTS1 matcher on (a) NIST SD27 and (b) WVU DB and by COTS2 matcher on (c) NIST SD27 and (d) WVU DB. 1856 IEEE TRANSACTIONS ON PATTERN ANALYSIS AND MACHINE INTELLIGENCE, VOL. 36, NO. 9, SEPTEMBER 2014 proposed an automatic latent segmentation and enhancement algorithm based on image decomposition and coarse to fine ridge structure dictionaries. Experimental results on two different latent fingerprint databases, NIST SD27 and WVU DB, in conjunction with three different COTS matchers show that the proposed algorithm is able to improve the performance of two COTS tenprint matchers and can even boost the performance of a state-of-the-art latent matcher by weighted match score fusion. However, the proposed algorithm still does not work well on very poor quality latent fingerprint images. Our algorithm can be further improved along the following aspects:

1. A robust patch quality definition, especially for dry fingerprint images, where ridges are broken.
2. A better definition of confidence measure for the segmentation and enhancement results.
3. Improve the computational efficiency of the algorithm.

3. LATENT FINGERPRINT RECOGNITION

As shown in Figure 2, latent fingerprints vary a lot in quality and information content depending on the nature of the skin (pressure of contact, handling of the item, presence of a transferable matrix on the skin) and type of surface. Among the five example latent fingerprints shown in Figure 1.8, only 2 exemplar fingerprints, (a) and (e), are true matches for the latent prints while the remaining three are false matches or erroneous identifications. Due to the observable challenges such as partial and noisy information, latent fingerprint matching can be uncertain and erroneous.[5]

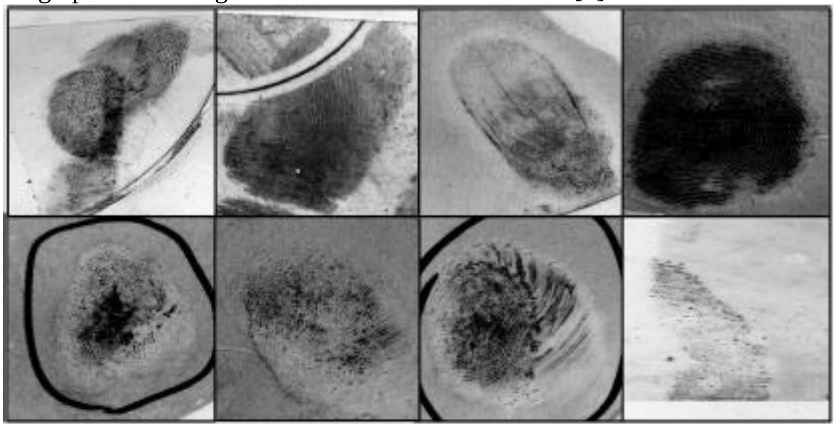

Figure 2: Sample latent fingerprint images from the ELFT-EFS database

In practical scenarios, when the size of the background exemplar database is large, the uncertainty is further increased. Manual matching in such cases is not scalable both in terms of time and performance. Automated latent fingerprint matching system could assist the human examination in performing large number of matches especially under uncertain complex circumstances. However, a “lights-out" matching system is still under development and has received research importance in the last few years. As a first step towards building such a system, it is imperative to understand the difficulties involved in automated latent comparison and provide a perspective of the state-of-art.[6-8]

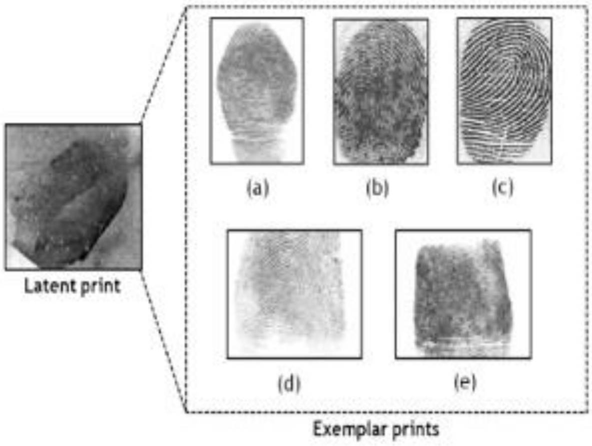

Figure 3: An example illustrating the challenge of latent fingerprints. A sample unknown latent fingerprint along with a pool of known exemplar prints (a)-(e) is shown. Of these five latent fingerprints, only two are mated with the exemplar fingerprint, while the remaining three are false matches.

4. CONCLUSION

Fingerprint recognition has evolved over the decades, providing innumerable applications for improving the modern day security. Based on the method of capture, fingerprints can be classified into four variants: inked, live-scan, latent, and finger photo. Extensive research has been undertaken for inked and live-scanned fingerprints. However, research on latent fingerprints and finger photo matching is still in nascent stages. These two capture methodologies are semi-controlled or uncontrolled which pose significant variations in the feature space and therefore warrant further exploration. The key research challenges involved in building an automated system for latent fingerprint and finger photo matching are as follows: (i) lack of publicly available large scale datasets with diverse variations to motivate reproducible research, (ii) segmentation of foreground regions from the complex background surface, and (iii) lack of robust feature models to represent the noisy and partial finger ridge information. Currently, there are limited end-to-end automated systems for latent fingerprint and finger photo matching. This thesis primarily focuses in contributing towards building a completely automated “lights-out" matching system for these two fingerprint variants. There are four contributions ranging from creating large databases to designing algorithms for segmentation and feature extraction for these two fingerprint variants.

5. REFERENCE

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