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An Efficient Automatic Fingerprint Recognition System for Overlapped Images-Survey

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Abstract: Each human being has distinctive fingerprints. Speed and accuracy are the prerequisites of a Biometric Authentication System. There are some cases several fingerprints can be merged or overlapped in nature they are in low quality also. These kind of overlapped fingerprints create a complicated problem to recognize the person because of separating images is very monotonous and time consuming task without the help from fingerprint experts. In low quality images feature extraction becomes a serious problem. The proposed research describes the Novel Automatic Fingerprint Recognition System (NAFRS) for overlapping images. This research deals with study of various image processing steps for overlapped images. A novel fingerprint separation algorithm is proposed. The proposed system includes preprocessing, feature extraction, fingerprint classification, recognition and retrieval of information that have been considered extensively. The challenge in the existing system is that in all fingerprint databases only a few fingerprint samples from each individual are available for training and testing. The proposed research is planned to improve the performance for overlapped image in terms of accuracy and speed with the increased number of samples for testing and training. This proposed research research tries to reduce false accept rate and false reject rate for latent images.

Key words: Fingerprint authentication, latent images, novel fingerprint separation algorithm, overlapped images, testing, training

INTRODUCTION

Biometrics system refers to the recognition of a person based on their physical (fingerprint, iris, face, toe and palm print) or behavioral (sign and voice) characteristics. A good biometric system should be easily assessable, unique and secure over period time. It should be accurate, fast, robust, secure and inexpensive. Biometric identification techniques prevent the need to remember a PIN or password which may be forgotten or the need to carry the tokens like passports and driver's licenses which may be forged, stolen or lost. With the increasing use of biometrics it is necessary to restrict access to sensitive or personal data. The biometric techniques can potentially prevent unauthorized access to or the fraudulent use of ATM, cellular phones, smart cards, desktop PCs, workstations and computer networks. Fingerprints are the most widely recognized biometric, particularly for criminal applications and forensic applications. Fingerprints have been routinely used as a method for person identification for more than decades. While fingerprints have been used in law enforcement for >100 years, civil identification and commercial applications are currently the most popular markets for fingerprint biometric technology. A fingerprint image shown in Fig. 1 contains of ridges and valleys on the surface of a fingertip. In crime investigation to identify the suspects based on impressions of fingers lifted from crime scenes, i.e., latent prints (Jain and Feng, 2011) shown in Fig. 2 is extremely important to law enforcement applications. Fingerprints obtained from the crime scenes are in very bad quality due to presence of some noise. One of the exceptional functionality of fingerprint recognition is its capability to link partial prints found at crime scenes to suspect whose fingerprints are previously enrolled in a large database of rolled fingerprints. These partial prints called latent fingerprints or simply latent are lifted from surfaces of objects that are inadvertently touched or handled by a person. Since, manual fingerprint identification is extremely tedious and time consuming, automatic and reliable fingerprint recognition systems are in need of great demand. Compared to plain or rolled fingerprints which are captured by inking methods or live scan devices in an attended mode, latent fingerprints are

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Fig. 1: Fingerprint image

Fig. 2: Latent image

smudgy and unclear which capture only a small finger area and have large nonlinear distortion due to pressure variations. Due to their poor quality and small area, latent have a significanly smaller number of features compared to rolled or plain prints. With well known and established large-scale Automatic Fingerprint Identification System (AFIS) in place to manage fingerprint records and searches, friction ridge recognition technology has advanced in a number of significant ways since 2006. Many research achievements on fingerprint recognition and identification have been published in literature recently. Each fingerprint image has minutiae and texture information that is used to increase the better recognition

Fig. 3: Overlapped fingerprint image

rate. Normally, fingerprint experts extracting and comparing characteristic points (minutiae) of ridges in the latent image. As a result, reliable ridge extraction is very important for successful matching. Due to the overlapping and low quality, found the features are not applicable. In the proposed NAFRS, minutiae feature extraction is the most important feature. Generally speaking, minutiae extraction from distorted images is not reliable and often gives erroneous results in matching. In some crime scenes there is a chance the surface touched by two or more persons or otherwise in some sensor the residue images of previous users may be left. There are some possibilities for the fingerprint experts to identify the persons incorrectly. Particularly in crime, there is a situation the fingerprint experts done the erroneous individualization. To determine the features of overlapped images as shown in Fig. 3 will be very dangerous and time taken task. Recognition is not possible for overlapped images because the templates for the images are not identifiable. In this proposed research, a cheaper, more secure and more user-friendly solution is found for this problem of separation of overlapped images and recognition of persons. This research investigates the major challenge in latent fingerprint recognition obtained from crimes. The major steps involved in novel automatic fingerprint recognition system is acquisition of input from the scanner or sensor, segmenting the fingerprint and process the corresponding image for enhancing the fingerprint image coordinates, separation of overlapped enhanced image, extraction of features, classify the fingerprints and finally matching the fingerprints.

RELATED RESEARCH

Integrated AFIS, Federal Bureau of Investigation and National Fingerprint Criminal History System (Ho-Wai *et al*., 2010) maintain the criminal records. This database contains >1,00,000 fingerprints which also has the automatic latent search capabilities. But in case of overlapped and noisy image, feature extraction is not possible. Most of the existing fingerprint matching algorithms failed to separate the overlapped image in an efficient manner. VeriFinger and FingerTec algorithms are not able to split the two fingerprints effectively and there is no succeed of extraction of ridges in the overlapped area. To mark the features in overlapped fingerprints and noisy image is very complicated for the state of art matchers and also for latent fingerprint experts. Fourier domain band-stop filtering technique (Bramble and Fabrizi, 1995) can be used to remove overlapping repetitive lines in latent images separating overlapped fingerprints (Fanglin *et al*., 2011) which are not composed of straight lines is much more complicated. For identification of latent image, experts using some gold nanomaterial (Ho-Wai *et al*., 2010) separated overlapped latent fingerprints. While this technique is extremely interesting, it is not convenient and only researchers for a specific type of overlapped latent fingerprints where component fingerprints are assumed to be covered with different lipids. A more universal and convenient solution is to develop an image processing algorithm to perform the separation task. Such an algorithm will not only benefit fingerprint recognition systems but will also simplify manual feature marking as well. To separate overlapped fingerprints based on an image enhancement using a manually marked orientation field method was proposed (Fan *et al*., 2004). However, it is very tedious and time-consuming for the user to manually mark the orientation field for each component fingerprint in the overlapped fingerprint image. Using morphological component analysis (Rui-Min *et al*., 2008) overlapped fingerprints separated. However, experimental results showed that their algorithm can only separate that component fingerprint which dominates the overlapped image. Independent component analysis method also suggested (Singh *et al*., 2008) to separate overlapped fingerprints but they did not provide a separation algorithm. A common limitation of all these studies is that the overlapped images were evaluated using a small database and no objective evaluation was performed to determine whether the separation algorithms improved the matching accuracy which is the ultimate goal. The relaxation labelling algorithm (Fanglin *et al*., 2011) proposed for separation of overlapped fingerprints with the help from latent fingerprint experts. In this method, orientation fields are marked manually in overlapped images. They used the relaxation labelling algorithm to separate the images which requires manually marked region masks and singular points as input. Quality of images taken for the experiments is in good with less noise. It will not be applicable for low quality images obtained from uneven surface, different pressure and various distortions. Constrained Relaxation Labelling algorithm proposed (Shi *et al*., 2011) for overlapped fingerprint separation. This method is not fully automatic. Stochastic resonance approach (Choonwoo *et al*., 2011) method used for feature extraction and it applied only for low quality images and not for latent images. This proposed research deals with the design of a new system to overcome the existing limitations for recognizing the person using overlapped and low quality finger print images.

ARCHITECTURE DESIGN

The design of the proposed NAFRS shown in Fig. 4 contains fingerprint acquisition, image preprocessing, feature extraction, fingerprint classification and fingerprint recognition. The planned methodology deals with the above mentioned stages and compared with the earlier related research and tries to improve the overall performance of NAFRS.

Fingerprint acquisition: Historically, in law enforcement applications, fingerprints were mainly acquired offline. Now a days, most commercial and forensic applications accept live-scan digital images acquired by directly sensing the finger surface with a fingerprint sensor. In this planned methodology, the images are acquired as input from online devices (sensors ten prints) or offline

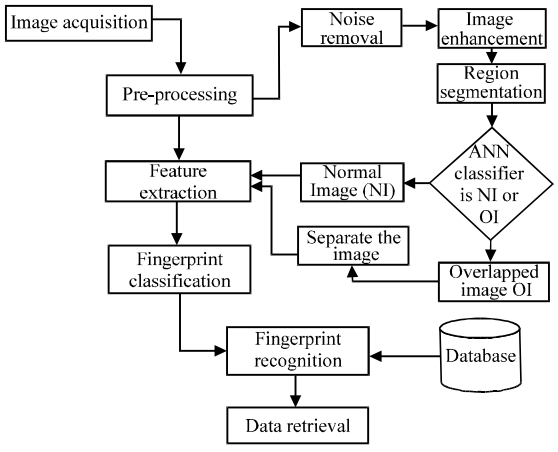

Fig. 4: Architecture of proposed system

(latent) using scanners. It is advisable to acquire good quality images but a significant percentage of acquired images are of poor quality from crime scenes due to some environmental factors or user's body condition.

Image preprocessing: The main steps involved in the image preprocessing are noise removal, region segmentation, image enhancement and classification. The input image is preprocessed using enhanced Gabor Filtering Method.

Noise removal: Gabor filter (Gonzaga *et al*., 2008) is used to remove all type of noises and improves the image enhancement. If a pixel is accidentally changed to an extreme value caused by various reasons then the noise can be removed by this filter which achieves excellent result.

Image enhancement: Image enhancement techniques are used to reduce the noise and enhance the structure of ridges and valleys for minutiae detection. A fast fingerprint enhancement algorithm is proposed to improve the clarity of ridge and valley structures of low quality input fingerprint images based on the estimated local ridge orientation and frequency.

Region segmentation: A critical step in automatic fingerprint recognition is the accurate segmentation of fingerprint images. Segmentation in low quality images faces several challenging technical problem. Especially in low quality overlapped images, finding the region mask is very important. The objective of fingerprint segmentation is to decide which part of the image belongs to the foreground which is of the interest for extracting features for recognition and identification and which part belongs to the background which is the noisy area around the boundary of the image. This proposed research makes investigation to segment fingerprint images. To identify the region, researchers planned to use one of the existing segmentation algorithms named edge detection algorithm.

Image classification: Artificial Neural Network (ANN) classifier (Chatterjee *et al*., 2010) shown in Fig. 5 is used to classify the images into two categories. It may be either overlapped or normal image. In this research planned to train and test the classifier, more number of samples are acquired from databases Fingerprint Verification Competition (FVC), National Institute of Science and Technology (NIST) and real images obtained from crimes. Then categorize the images using the ANN classifier.

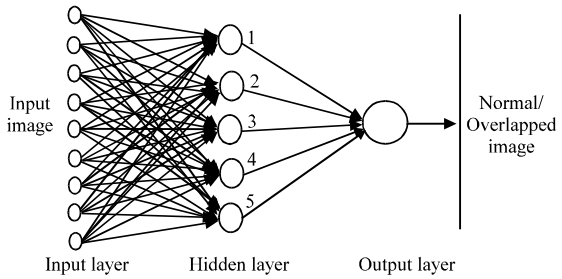

Fig. 5: ANN classifier

Feature extraction: Automatic feature extraction is a difficult problem due to low quality of most latent such as broken ridge structures, overlapped lines. It plays an important role in the fingerprint recognition system. In the overlapped images feature extraction is a very complicated task. Researchers try to obtain reliable and significant features from fingerprint image. The features (Maltoni *et al*., 2003) are Global: (Level 1) deals with singular point are core and delta, Local: (Level 2) deals with ridge endings, bifurcations and extended features include (Level 3) pores, dots and ridge contours. Ridge ending, bifurcation and core are called as the minutiae points. Ridge ending is the point where a ridge ends abruptly. Ridge bifurcation is the point where a ridge forks or diverges into two branch ridges. Core: the maximum curvature point.

Fingerprint classification: Identical authentication system using fingerprint classification techniques proposed an approach for identifying a unique person based on characteristics. Automatic minutiae detection becomes a difficult task in low quality fingerprint images where noise and contrast deficiency result in pixel configurations similar to that of minutiae. The minutiae extraction is the phase where to classification of the bifurcation and ridge ending happens. The process ranging and classification factor depends on the pixel coordinates, image visualization and the extraction of minutiae ranging. A fingerprint image can be classified as one of five categories based on Henry classifications. They are arch, left loop, right loop, tented arch and whorl. A human expert can easily perform coarse finger classification. Two hierarchical classifications are applied in the proposed recognition system namely coarse classification and fine classification.

Recognition: Most of the latent fingerprint images are very low quality in nature. The performance of a fingerprint image-matching algorithm depends heavily on the quality of the input fingerprint images. In fingerprint recognition process, the important step which affects on

system accuracy is matching between template and query fingerprint. Matching accuracy will be affected by large intra-class variations and large inter-class similarities. These matching algorithms (Nandakumar *et al*., 2010) may be classified into three types such as minutiae-based matching; correlation-based matching and image based matching algorithms. However, as analyzed, the score of these algorithms is not high for latent fingerprints. So, it is necessary to design a model to standardized fingerprint template in order to improve matching score. In recognition phase planned to do identification in the order (1-N) and verification it is in the order of (1-1).

NOVEL FINGERPRINT SEPARTION ALGORITHM (NFSA)

A NFSA is proposed for separating the overlapped images (Fig. 6). Given the component ridge orientation fields, researchers estimate the ridge frequency map of each component fingerprint. Given the ridge orientation field and ridge frequency map, Gabor filtering can connect broken ridges and remove intervening ridges. In overlapped images, computation of orientation field is a very tedious task. It contains two dominant orientations in each overlapped block.

Novel fingerprint separation algorithm:
Algorithm
Begin
Step1: Compute orientation field
Step2: If difficult to find
It is overlapped images
Go to separation algorithm
Otherwise
Step3: It is normal image.
End

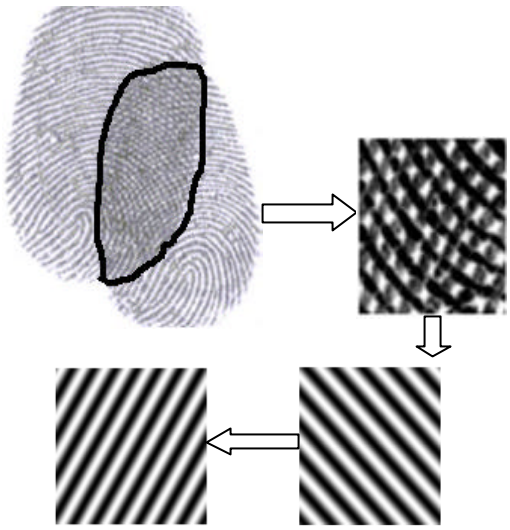

Fig. 6: Separation of overlapping image

Separation algorithm:
Begin
Step1: Separate overlapped and non-overlapped images using region masks. Then
Step2: Divide the overlapped region into four quadrants
$X = x_1, x_2, x_3, x_4$
Apply local fourier analysis
Step3: Overlapped quadrants are transformed into non-overlapping region.
Step4: Find the direction (orientation field) of ridges.
End
Merging algorithm:
Begin
Input: Orientation field of images obtained from separation algorithm.
Output: Join with original image
Step1: Find the matching orientation ridges by mapping Orientation field of images with the separated image.
Step2: Merge with the corresponding orientation fields in the separated image.
End

IMPLEMENTATION OF STUDY

Researchers planned to implement the proposed NAFRS using MATLAB. The objective of this study is to separate the overlapped fingerprints successfully and match the fingerprint images to the corresponding template fingerprints available in the database and tries to retrieve the information. In this planned research, FVC, NIST and the own live database >1000 images are used. Finally, the results are compared with existing approaches and try to get more accuracy, high speed and reliable matching.

PERFORMANCE COMPARISON ANALYSIS

In this proposed research, surveyed the various processing steps for NAFRS are from existing research. To acquire the image using sensor and scanner; researchers planned to create the super template because of poor quality image used. Using enhanced Gabor filtering it yields the best result compared to other methods. It removes the noise, segment the image and enhance the image. To obtain the feature from low quality images, it is better to use stochastic resonance, orientation map compared to existing methods. For fingerprint classification researchers planned to use Bayes classifier (Leung and Leung, 2011) and Fingerprint Clustering Method since it gives more speed and accuracy. To separate the overlapped images, researchers planned to propose a NFSA because the existing algorithms for separation are not fully automatic and recognition rate is also <90%. Recognition rate for latent images is also <80%. In some existing methods for automated verification system it gives >90% for matching but methods do not research well for overlapped images. The performance comparison analysis result as shown in Table 1 and recognition rate for latent and overlapped latent images as shown in Fig. 7.

Table 1: Performance comparison analysis

Automatic fingerprint recognition system stages	Existing approach	Accuracy
Image acquisition enrollment	Minutiae based template synthesis algorithm	Storage-729 bytes speed-1.84 msec
Image preprocessing (Gonzaga *et al.*, 2008)	Enhanced gabor filtering technique	98%
Feature extraction for low quality images	Stochastic resonance approach	Extraction (95%)
		Equal error rate (5.03%)
(Choonwoo *et al.*, 2011)	Orientation map	85.5%
Fingerprint classification (Tamer Uz *et al.*,	Bayes classifier	7.2 msec
2009; Leung and Leung, 2011)	FPCLU (Fingerprint Clustering)	98%
Fingerprint Separation (Fanglin *et al.*,	Relaxation labeling algorithm	True acceptance rate (80%)
2011; Shi *et al.*, 2011)	Constrained relaxation labeling algorithm	True acceptance rate (85%)
Fingerprint recognition (Jain and Feng, 2011)	Baseline matching algorithm	True acceptance rate (74%)
Automatic fingerprint verification system	SIFT technique, Level 3 features	Recognition rate (93%)
(Chatterjee *et al.*, 2010; Gupta and Kumar,	Back propagation algorithm	Recognition rate (95%)
2010; Prince and Mittal, 2010)	Minutia matching algorithm	24 msec

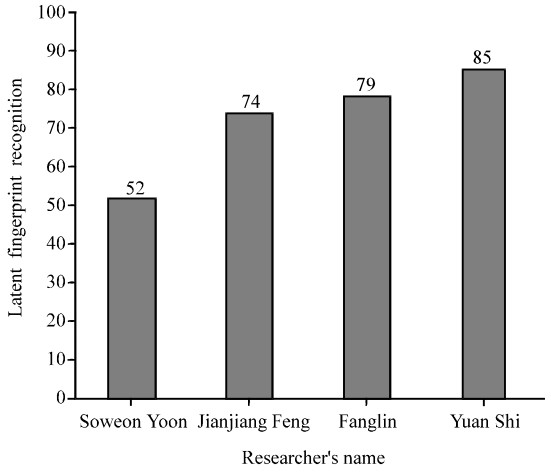

Fig. 7: Recognition rate for latent images

CONCLUSION

Due to the need of automated fingerprint recognition systems in forensics and civilian applications, a new NAFRS has been proposed. In this research a NFSA is designed especially for crime investigation. The aim of this research is to reduce the manual research and also avoid erroneous individualization while preserving the matching accuracy when the images are get overlapped. At the same time in some sensors kept the residue images of the existing users. Fingerprint separation from overlapped fingerprints is a critical problem for fingerprint experts. A novel algorithm is proposed for separating overlapped fingerprints. The two fingerprints are separated by using NFSA algorithm. Researchers planned to collect the data from real crime investigations. Results were obtained on latent overlapped fingerprints. The proposed algorithm will facilitate novel automatic fingerprint recognition systems to process and match overlapped fingerprints with the templates. It will be become an important system for fingerprint experts to mark features in latent. The proposed research is planned to improve the performance in terms of accuracy and speed. This research tries to reduce false acceptance rate and false rejection rate.

REFERENCES

Bramble, S.K. and P.M. Fabrizi, 1995. Observations on the effects of image processing functions on fingermark data in the Fourier domain. Proceedings of the SPIE Investigative and Trial Image Processing, Volume 2567, July 9, 1995, San Diego, CA.

Chatterjee, A., S. Mandal, G.M.A. Rahaman and A.S.M. Arif, 2010. Fingerprint identification and verification system by minutiae extraction using artificial neural network. Int. J. Comput. Inform. Technol., 1: 12-16.

Choonwoo, R., S.G. Kong and H. Kim, 2011. Enhancement of feature extraction for low-quality fingerprint images using stochastic resonance. Pattern Recognit. Lett., 32: 107-113.

Fan, X., D. Liang and L. Zhao, 2004. A scheme for separating overlapped fingerprints based on partition mask. Comput. Eng. Applic., 40: 80-81.

Fanglin, C., J. Feng, A.K. Jain, J. Zhou and J. Zhang, 2011. Separating overlapped fingerprints. IEEE Trans. Inform. Forens. Secur., 6: 346-359.

Gonzaga, O.S.L, F. Viola and A. Conci, 2008. An approach for enhancing fingerprint images using adaptive gabor filter parameters. Pattern Recognit. Image Anal., 18: 497-506.

Gupta, J.K. and R. Kumar, 2010. An efficient ANN based approach for latent fingerprint matching. Int. J. Comput. Applic., 7: 18-21.

Ho-Wai, T., W. Lu, C. Chi-Ming and N. Kwan-Ming, 2010. Gold nanoparticles and imaging mass spectrometry: Double imaging of latent fingerprints. Anal. Chem., 82: 1589-1593.

Jain, A.K. and J. Feng, 2011. Latent fingerprint matching. Pattern Anal. Machine Intell. IEEE Trans., 33: 88-100.

Leung, K.C. and C.H. Leung, 2011. Improvement of fingerprint retrieval by a statistical classifier. IEEE Trans. Inform. Forensic Secur., 6: 59-69.

Maltoni, D., D. Maio, A.K. Jain and S. Prabhakar, 2003. Handbook of Fingerprint Recognition. 2nd Edn., Springer, New York, USA., Pages: 348.

Nandakumar, K., A.K. Jain and J. Feng, 2010. Fingerprint matching. IEEE Comput. Soc., 43: 36-44.

Prince, M.K. and A. Mittal, 2010. Fingerprint matching system using Level 3 features. Int. J. Eng. Sci. Technol., 2: 258-2262.

Rui-Min, G., L. Qiu-Sheng and S. Ma-Qiu, 2008. Fingerprint separation based on morphological component analysis. Comput. Eng. Applic., 44: 188-190.

Shi, Y., J. Feng and J. Zhou, 2011. Separating overlapped fingerprints using constrained relaxation labeling. Proceedings of the International Joint Conference on Biometrics, October 10-13, 2011, Washington, DC., USA., pp: 1-8.

Singh, M., D. Singh and P. Kalra, 2008. Fingeprint separation: An application of ICA. Proceedings of the SPIE, Mobile Multimedia/Image Processing, Security and Applications, Volume 6982, April 14, 2008, Orlando, USA., pp: 1-11.