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Detecting and Improving Distorted Fingerprints using Rectification Techniques

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ABSTRACT : Elastic distortion of fingerprints is one of the major causes for false non-match. While this problem affects all fingerprint recognition applications, it is especially dangerous in negative recognition applications, such as watchlist and deduplication applications. In such applications, malicious users may purposely distort their fingerprints to evade identification. In this paper, we proposed novel algorithms to detect and rectify skin distortion based on a single fingerprint image. Distortion detection is viewed as a two-class classification problem, for which the registered ridge orientation map and period map of a fingerprint are used as the feature vector and a SVM classifier is trained to perform the classification task. Distortion rectification (or equivalently distortion field estimation) is viewed as a regression problem, where the input is a distorted fingerprint and the output is the distortion field. To solve this problem, a database (called reference database) of various distorted reference fingerprints and corresponding distortion fields is built in the offline stage, and then in the online stage, the nearest neighbor of the input fingerprint is found in the reference database and the corresponding distortion field is used to transform the input fingerprint into a normal one. Promising results have been obtained on three databases containing many distorted fingerprints, namely FVC2004 DB1, Tsinghua Distorted Fingerprint database, and the NIST SD27 latent fingerprint database.

KEYWORDS : Fingerprint, distortion, registration, nearest neighbor regression, PCA.

I. INTRODUCTION

Fingerprints are one of many forms of biometrics used to identify an individual and verify their identity. Fingerprint recognition or fingerprint authentication refers to the automated method of verifying a match between two human fingerprints. Because of their uniqueness and consistency over time, fingerprints have been used for over a century, more recently becoming automated due to advancement in computing capabilities. Fingerprint identification is popular because of the inherent ease in acquisition, the numerous sources available for collection, and their established use and collections by law enforcement and immigration. Basically skin of human fingertips consists of ridges and valleys and they mixing together form the distinctive patterns. At the time of pregnancy these distinctive patterns are fully developed and are permanent throughout the whole lifespan. Those patterns are called fingerprints. From different researches it has been observed that no two persons have the same fingerprints, so they are unique for each individual. Because of the above mentioned characteristic, fingerprints are very popular for biometrics applications. Fingerprint matching is a very complex pattern recognition problem so manual fingerprint matching is not only time taking but experts also take long time for education and training. Fingerprints have remarkable permanency and uniqueness throughout the time.

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Fingerprint matcher is very sensitive to image quality, where the matching accuracy of the same algorithm varies significantly among different datasets due to variation in image quality. The difference between the accuracies of plain, rolled and latent fingerprint matching is even larger as observed in technology evaluations conducted by the NIST. Imaging sensor imperfections can be considered as a unique fingerprint identifying a specific acquisition device, enabling various important forensic tasks, such as device identification, device linking, recovery of processing history, detection of digital forgeries. The consequence of low quality fingerprints depends on the type of the fingerprint recognition system. A fingerprint recognition system can be classified as either a positive or negative system. In a positive recognition system, such as physical access control systems, the user is supposed to be cooperative and wishes to be identified. In a negative recognition system, such as identifying persons in watchlists and detecting multiple enrollments under different names, the user of interest (e.g., criminals) is supposed to be uncooperative and does not wish to be identified. In a positive recognition system, low quality will lead to false reject of legitimate users and thus bring inconvenience. The consequence of low quality for a negative recognition system, however, is much more serious, since malicious users may purposely reduce fingerprint quality to prevent fingerprint system from finding the true identity. In fact, law enforcement officials have encountered a number of cases where criminals attempted to avoid identification by damaging or surgically altering their fingerprints. Elastic distortion is introduced due to the inherent flexibility of fingertips, contact-based fingerprint acquisition procedure, and a purposely lateral force or torque, etc. Skin distortion increases the intra-class variations and thus leads to false non-matches due to limited capability of existing fingerprint matchers in recognizing severely distorted fingerprints. In Fig. 1, the left two are normal fingerprints, while the right one contains severe distortion. According to Veri-Finger, the match score between the left two is much higher than the match score between the right two. This huge difference is due to distortion rather than overlapping area. While it is possible to make the matching algorithms tolerate large skin distortion, this will lead to more false matches and slow down matching speed.



Fig.No 1 Sample Fingerprints

Hence it is especially important for negative fingerprint recognition systems to detect low quality fingerprints and improve their quality so that the fingerprint system is not compromised by malicious users. Degradation of fingerprint quality can be photometric or geometrical. Photometric degradation can be caused by non-ideal skin conditions, dirty sensor surface, and complex image background. Geometrical degradation is mainly caused by skin distortion. Photometric degradation has been widely studied and a number of quality evaluation algorithms and enhancement algorithms have been proposed. On the contrary, geometrical degradation due to skin distortion has not yet received sufficient attention, despite of the importance of this problem.

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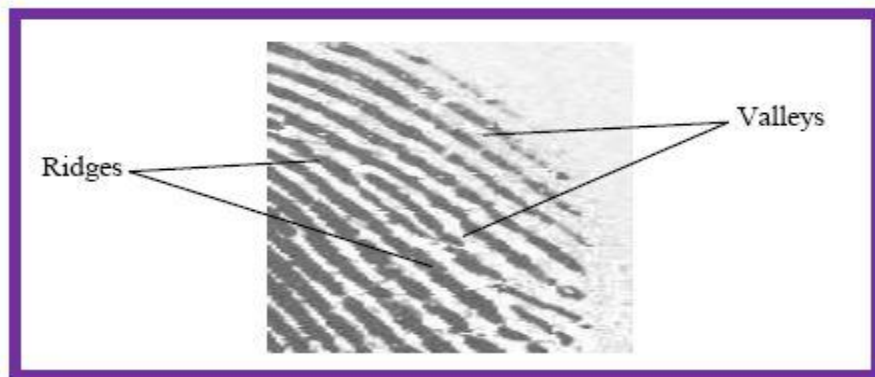


Fig 1: Fingerprint Ridges and Valleys

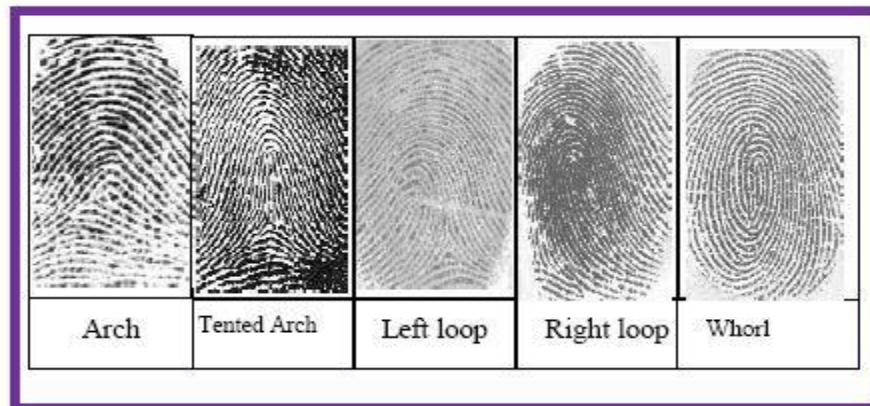


Fig No 2 Types of thumbprints patterns

A fingerprint is an impression of the friction ridges of all or any part of the finger. Fingerprint identification is the process of comparing questioned and known friction skin ridge impressions from fingers, palms, and toes to determine if the impressions are from the same finger. Among all the biometric techniques, fingerprint-based identification is the oldest method which has been successfully used in numerous applications. Everyone is known to have unique, immutable fingerprints. The science of fingerprint Identification stands out among all other forensic sciences for many reasons, including the following:

The history of fingerprinting can be traced back to prehistoric times based on the human fingerprints discovered on a large number of archaeological artifacts and historical items. In 1686, Marcello Malpighi, a professor of anatomy at the University of Bologna, noted in his treatise; ridges, spirals and loops in fingerprints. He made no mention of their value as a tool for individual identification. A layer of skin was named after him; "Malpighi" layer, which is approximately 1.8mm thick. During the 1870's, Dr. Henry Faulds, the British Surgeon-Superintendent of Tsukiji Hospital in Tokyo, Japan, took up the study of "skin-furrows" after noticing finger marks on specimens of "prehistoric" pottery. A learned and industrious

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man, Dr. Faulds not only recognized the importance of fingerprints as a means of identification, but devised a method of classification as well. Explanation of his classification system and a sample of the forms he had designed for recording inked impressions, to Sir Charles Darwin. Darwin, in advanced age and ill health, informed Dr. Faulds that he could be of no assistance to him, but promised to pass the materials on to his cousin, Francis Galton. Also in 1880, Dr. Faulds published an article in the Scientific Journal, "Nature" (nature). He discussed fingerprints as a means of personal identification, and the use of printers ink as a method for obtaining such fingerprints [14]. He is also credited with the first fingerprint identification of a greasy fingerprint left on an alcohol bottle. Later, Juan Vucetich made the first criminal fingerprint identification in 1892 .

Today, the largest AFIS repository in America is operated by the Department of Homeland Security's US Visit Program, containing over 63 million persons' fingerprints, primarily in the form of two-finger records (non-compliant with FBI and Interpol standards). Fingerprint identification is divided into four modules,

- (i) Acquisition,
- (ii) Preprocessing,
- (iii) Feature extraction
- (iv) Feature matching.

II. OBJECTIVE OF THE WORK

1. To design a system that will recognition and rectify the distortion for identification of error.
2. To detect the distortion area complete with high accuracy.
3. To rectify the distortion completely .in this process we need to detect the distortion type and then we need to correct the type distortion related error.

III. LITERATURE SURVEY

We study the distortions of the fingerprints in three public available databases. To simulate the real scenarios of fingerprint matching, we distort fingerprint minutiae templates with the following three methods: 1) Randomly remove certain number of minutiae; 2) Randomly replace certain number of minutiae; 3) Randomly disturb the locations and orientations of the minutiae. Our experimental results show how and to what extent the fingerprint minutiae templates can be distorted without causing increases in false non-match rates and false match rates [1]. False non-match frequency of fingerprint matchers is relatively high in severely distorted fingerprints. It creates a security hole in automatic fingerprint detection systems that could be used by criminals and terrorists. So, building up of fingerprint distortion scrutiny and reformation algorithms to fill the hole is a must. The paper illustrates a new distorted fingerprint detection and rectification algorithm. Distortion detection is done by the use of registered ridge orientation map and period map of a fingerprint as the feature vector, a SVM classifier is made to classify the input fingerprint as distorted or normal. In distortion rectification (or distortion field estimation), a nearest neighbor regression method is employed to anticipate the distortion field from the input distorted fingerprint , later the inverse of the distortion field is used to change the distorted fingerprint into a normal one. One of the open come outs in fingerprint confirmation is the lack of robustness against image quality degradation. Poor-quality images result in specious and missing features, thus degrading the performance of the overall system. Therefore, it is very important for a fingerprint acknowledgement system to estimate the quality and validity of the captured fingerprint images. Also the elastic distortion of fingerprints is one of the major causes for false non-match. While this problem impacts all fingerprint acknowledged applications, it is especially unsafe in negative recognition applications, such as watch list and reduplication applications. In such applications, malicious users may purposely distort their fingerprints to elude identification [2].The implementation of a new fingerprint pattern matching algorithm has been presented. The algorithm

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used the relative distances between the minutiae and the core points. The algorithm hinged on the premise that irrespective of image orientation, each minutia point maintains constant distance with the core point for a given image size. The results obtained showed the effectiveness of the algorithm in distinguishing fingerprints from different sources with average FMR of 0%. However, the ability to match images from same source depends on the qualities of such images. Since the corruption levels vary across the used datasets, the algorithm yielded different FNMR values. The first dataset is mostly affected with FNMR values of 22.23% while the third dataset is least affected with FNMR value of 14.51%. The same order of performance was recorded for the FNMR and the average matching time over the datasets. A comparative review of the obtained FNMR, FMR and the computation time values with what obtained for some recently formulated algorithms over the same datasets revealed best performance for the proposed algorithm [3]. We conduct a study on fingerprint distortion and develop an algorithm to detect fingerprint distortion from a single image which is captured utilizing traditional fingerprint sensing techniques. The detector is predicated on analyzing ridge period and orientation information. Promising results are obtained on a public domain fingerprint database containing distorted fingerprints [4]. Elastic distortion of friction ridge skin is one of the major challenges in fingerprint matching. Since existing fingerprint matching systems cannot match seriously distorted fingerprints, criminals may purposely distort their fingerprints to evade identification. Existing distortion detection techniques require availability of specialized hardware or fingerprint video, limiting their use in real applications. In this paper we refer a study on fingerprint distortion and develop an algorithm to detect fingerprint distortion from a single image which is captured using traditional fingerprint sensing techniques. The detector is based on analyzing ridge period and orientation information. Promising results are obtained on a public domain fingerprint database containing distorted fingerprints [5]. Future research direction aims, on short term, at the optimization of the proposed algorithm for increased performance. On long term, future research aims at the development of an integrated interoperable platform for the unique human identification. The specific objectives are: a. Development of a multi-modal biometric system for the unique identification and authentication of the individuals in Nigeria. In this paper, a minutiae-based algorithm for fingerprint pattern recognition and matching is proposed. The algorithm uses the distance between the minutiae and core points to determine the pattern matching scores for fingerprint images. Experiments were conducted using FVC2002 fingerprint database comprising four datasets of images of different sources and qualities. False Match Rate (FMR), False Non-Match Rate (FNMR) and the Average Matching Time (AMT) were the statistics generated for testing and measuring the performance of the proposed algorithm. The comparative analysis of the proposed algorithm and some existing minutiae based algorithms was carried out as well. The findings from the experimental study were presented, interpreted and some conclusions were drawn [6]. Existing fingerprint scanners are unable to scan fingerprints having mehendi drawn on finger. So, we use multispectral fingerprint scanners. There are two types of distortions: photometric and geometric distortions. In this paper we focused on geometric distortions which occur due to skin distortions, fingerprint displacement, wrinkled fingerprint, etc. Due to poor quality of images, minutiae are extracted using crossing number concept. To remove spurious minutiae, fuzzy logic is applied as fuzzy logic handles uncertainties and more efficient. Orientation field is reconstructed using enhanced feedback which uses prior knowledge. So, it improves the accuracy of fingerprint matching. Enhanced fuzzy feature matcher (EFFM) is used for fingerprint matching which provides accuracy [7]. Spurious minutiae are removed using fuzzy rules. This paper introduces a novel method to detect a distortion using fuzzy classifier and rectify it. Then, Enhanced fuzzy feature match (EFFM) is proposed to match fingerprints. The orientation field and minutiae are attribute vectors for fuzzy classifier. The proposed method upgrades the performance and the accuracy of fingerprint matching [8]. The image quality is evaluated and analyzed using NIST fingerprint image software. A comparison is performed between the converted 2-D unraveled equivalent fingerprints and their 2-D ink rolled counterparts. Then, NIST matching software is applied to the 2-D unraveled fingerprints, and the results are given and analyzed, which shows strong relationship between matching performance and quality of the fingerprints. In the end, some incremental future works are proposed in order to make further improvements to our new 3D fingerprint scan system. A fingerprint is an impression of the friction ridges of all or any part of the finger. A friction ridge is a raised portion of the

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epidermis on the palmar (palm and fingers) or plantar (sole and toes) skin, consisting of one or more connected ridge units of friction ridge skin. Fingerprint identification (sometimes referred to as dactyloscopy) or palm-print identification is the process of comparing questioned and known friction skin ridge impressions (see Minutiae) from fingers or palms to determine if the impressions are from the same finger or palm. The flexibility of friction ridge skin means that no two finger or palm prints are ever exactly alike (never identical in every detail), even two impressions recorded immediately after each other. Fingerprint identification (also referred to as individualization) occurs when an expert (or an expert computer system operating under threshold scoring rules) determines that two friction ridge impressions originated from the same finger or palm (or toe, sole) to the exclusion of all others. And Fingerprint Identification has been used for centuries [9]. Fingerprints are the most widely used biometric feature for person identification and verification in the field of biometric identification. Fingerprints possess two main types of features that are used for automatic fingerprint identification and verification: (i) global ridge and furrow structure that forms a special pattern in the central region of the fingerprint and (ii) Minutiae details associated with the local ridge and furrow structure. This paper presents the implementation of a minutiae based approach to fingerprint identification and verification and serves as a review of the different techniques used in various steps in the development of minutiae based Automatic Fingerprint Identification Systems (AFIS). The technique conferred in this paper is based on the extraction of minutiae from the thinned, binarized and segmented version of a fingerprint image. The system uses fingerprint classification for indexing during fingerprint matching which greatly enhances the performance of the matching algorithm. Good results (~92% accuracy) were obtained using the FVC2000 fingerprint databases [10].

IV. EXISTING SYSTEM APPROACH

In Existing system several challenging research problems, for example, recognizing low quality fingerprints. Fingerprint matcher is very sensitive to image quality as observed in the FVC2006, where the matching accuracy of the same algorithm varies significantly among different datasets due to variation in image quality. The difference between the accuracies of plain, rolled and latent fingerprint matching is even larger as observed in technology evaluations conducted by the NIST. The consequence of low quality fingerprints depends on the type of the fingerprint recognition system. A fingerprint recognition system can be classified as either a positive or negative system. In a positive recognition system, such as physical access control systems, the user is supposed to be cooperative and wishes to be identified. In a negative recognition system, such as identifying persons in watchlists and detecting multiple enrollment under different names, the user of interest (e.g., criminals) is supposed to be uncooperative and does not wish to be identified. In a positive recognition system, low quality will lead to false reject of legitimate users and thus bring inconvenience. The consequence of low quality for a negative recognition system, however, is much more serious, since malicious users may purposely reduce fingerprint quality to prevent fingerprint system from finding the true identity. In fact, law enforcement officials have encountered a number of cases where criminals attempted to avoid identification by damaging or surgically altering their fingerprints.

V. PROBLEM STATEMENT

Geometrical degradation due to skin distortion has not yet received sufficient attention, despite of the importance of this problem. This is the problem we attempt to address. Note that, for a negative fingerprint recognition system, its security level is as weak as the weakest point. Thus it is urgent to develop distorted fingerprint (DF) detection and rectification algorithms to fill the hole.

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VI. PROPOSED SYSTEM APPROACH

In this paper, novel algorithms are proposed to deal with the fingerprint distortion problem. Given an input fingerprint, distortion detection is performed first. If it is determined to be distorted, distortion rectification is performed to transform the input fingerprint into a normal one. A distorted fingerprint is analogous to a face with expression, which affects the matching accuracy of face recognition systems. Rectifying a distorted fingerprint into a normal fingerprint is analogous to transforming a face with expression into a neutral face, which can improve face recognition performance. In this paper, distortion detection is viewed as a two class classification problem, for which the registered ridge orientation map and period map of a fingerprint are used as the feature vector and a SVM classifier is trained to perform the classification task. Distortion rectification (or equivalently distortion field estimation) is viewed as a regression problem, where the input is a distorted fingerprint and the output is the distortion field. To solve this problem, a database of various distorted reference fingerprints and corresponding distortion fields is built in the offline stage, and then in the online stage, the nearest neighbor of the input fingerprint is found in the database of distorted reference fingerprints and the corresponding distortion field is used to rectify the input fingerprint. An important property of the proposed system is that it does not require any changes to existing fingerprint sensors and fingerprint acquisition procedures. Such property is important for convenient incorporation into existing fingerprint recognition systems. The proposed system has been evaluated on three databases, FVC2004 DB1 whose images are markedly affected by distortion, Tsinghua distorted fingerprint database which contains 320 distorted fingerprint video files, and NIST SD27 latent fingerprint database. Experimental results demonstrate that the proposed algorithms can improve the matching accuracy of distorted fingerprints evidently. In this project, distortion detection is viewed as a two class classification problem, for which the registered ridge orientation map and period map of a fingerprint are used as the feature vector and a SVM classifier is trained to perform the classification task. Distortion rectification is viewed as a regression problem, where the input is a distorted fingerprint and the output is the distortion field. To solve this problem, a database of various distorted reference fingerprints and corresponding distortion fields is built in the offline stage, and then in the online stage, the nearest neighbor of the input fingerprint is found in the database of distorted reference fingerprints and the corresponding distortion field is used to rectify the input fingerprint. An important property of the proposed system is that it does not require any changes to existing fingerprint sensors and fingerprint acquisition procedures. A new method for generating fingerprints matching scores using the spatial parameters existing between the minutiae points is proposed. The motivation behind the algorithm is the need to address the matching problems due to image ridge orientation and size variations. The algorithm take advantage of the fact that the relative distance to the core point from each minutia point does not change irrespective of the image directional flow for a given image size. The core point is the point of maximum turning at which the gradient is zero.

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VII. SYSTEM ARCHITECTURE

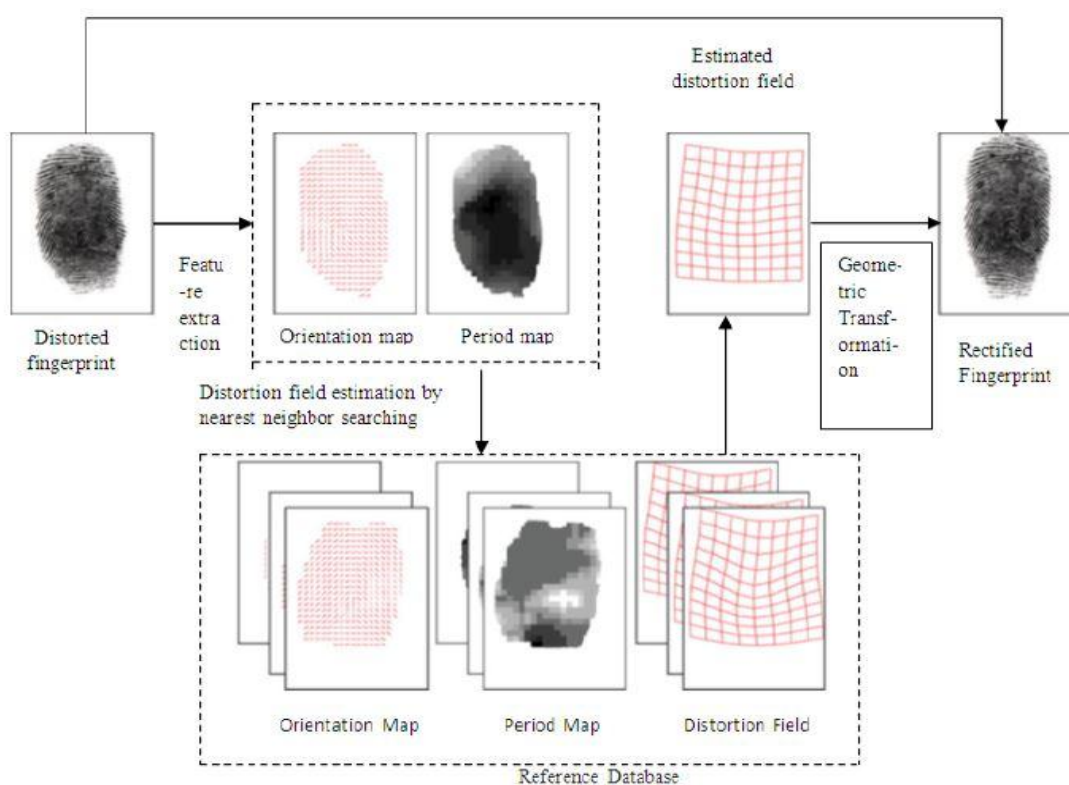


Fig. 3 Rectifying Distorted Fingerprints

Explanation

A distorted fingerprint can be thought of being generated by applying an unknown distortion field d to the normal fingerprint, which is also unknown. If we can estimate the distortion field d from the given distorted fingerprint, we can easily rectify it into the normal fingerprint by applying the inverse of d . So we need to address a regression problem, which is quite difficult because of the high dimensionality of the distortion field (even if we use a block-wise distortion field). In this paper, a nearest neighbor regression approach is used for this task. The proposed distorted fingerprint rectification algorithm consists of an offline stage and an online stage. In the offline stage, a database of distorted reference fingerprints is generated by transforming several normal reference fingerprints with various distortion fields sampled from the statistical model of distortion fields. In the online stage, given a distorted input fingerprint, we retrieve its nearest neighbor in the distorted reference fingerprint database and then use the inverse of the corresponding distortion field to rectify the distorted input fingerprint.

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- 1) Generation of Distorted Reference Fingerprint Database: To generate the database of distorted reference fingerprints, we use $n_{ref} \frac{1}{4} 100$ normal fingerprints from FVC2002 DB1_A . The distortion fields are generated by uniformly sampling the subspace spanned by the first two principle components. For each basis, 11 points are uniformly sampled in the interval $[2,2]$. for an example of generating distortion fields and applying such distortion fields to a reference fingerprint to generate corresponding distorted fingerprints. For visualization purpose, only one reference fingerprint (the fingerprint located at the origin of the coordinate system) is used to generate the database of distorted reference fingerprints, and for each basis, five points are sampled. In practice, multiple reference fingerprints are used to achieve better performance.
- 2) Distortion Field Estimation by Nearest Neighbor Search: Distortion field estimation is equal to finding the nearest neighbor among all distorted reference fingerprints. The similarity is measured based on level 1 features of fingerprint, namely ridge orientation map and period map. We conjecture that distortion detection and rectification of human experts also relies on these features instead of minutiae. The similarity computation method is different depending on whether the upper core point can be detected in the input fingerprint. If the upper core point is detected, we translate the input fingerprint by aligning the upper core point to center point. Then we do a full search of u in the interval $\frac{1}{2}_30; 30$ for the maximum similarity.
- 3) Performance of Distortion Detection: We view distortion detection as a two-class classification problem. Distorted fingerprints are viewed as positive samples and normal fingerprints as negative samples. If a distorted fingerprint is classified as a positive sample, a true positive occurs. If a normal fingerprint is classified as a positive sample, a false positive occurs. By changing the decision threshold, we can obtain the receiver operating characteristic (ROC) curve. The test set of Tsinghua DF database contains 120 pairs of distorted and normal fingerprints. FVC2004 DB1 contains 791 normal fingerprints and 89 distorted fingerprints, which are found by visually examining the images. As we can see from this figure, the current algorithm performs much better. Although most fingerprints can be correctly classified, there are some false negatives and false positives. False negatives are mainly because the distortion is slight. Fortunately, we found that this is not a severe problem since fingerprint matchers can successfully match slightly distorted fingerprints. As the query fingerprint contains slight distortion, the proposed detection algorithm fails to detect it as distorted one, but the matching score between the query fingerprint and the galley fingerprint is 305, a very high matching score according to VeriFinger. If this query fingerprint is rectified by the proposed rectification algorithm, the matching score can be further improved to 512. False positives are mainly due to low image quality, small finger area, or non-frontal pose of finger. In such cases, there is no sufficient information for correctly aligning and classifying the fingerprint.

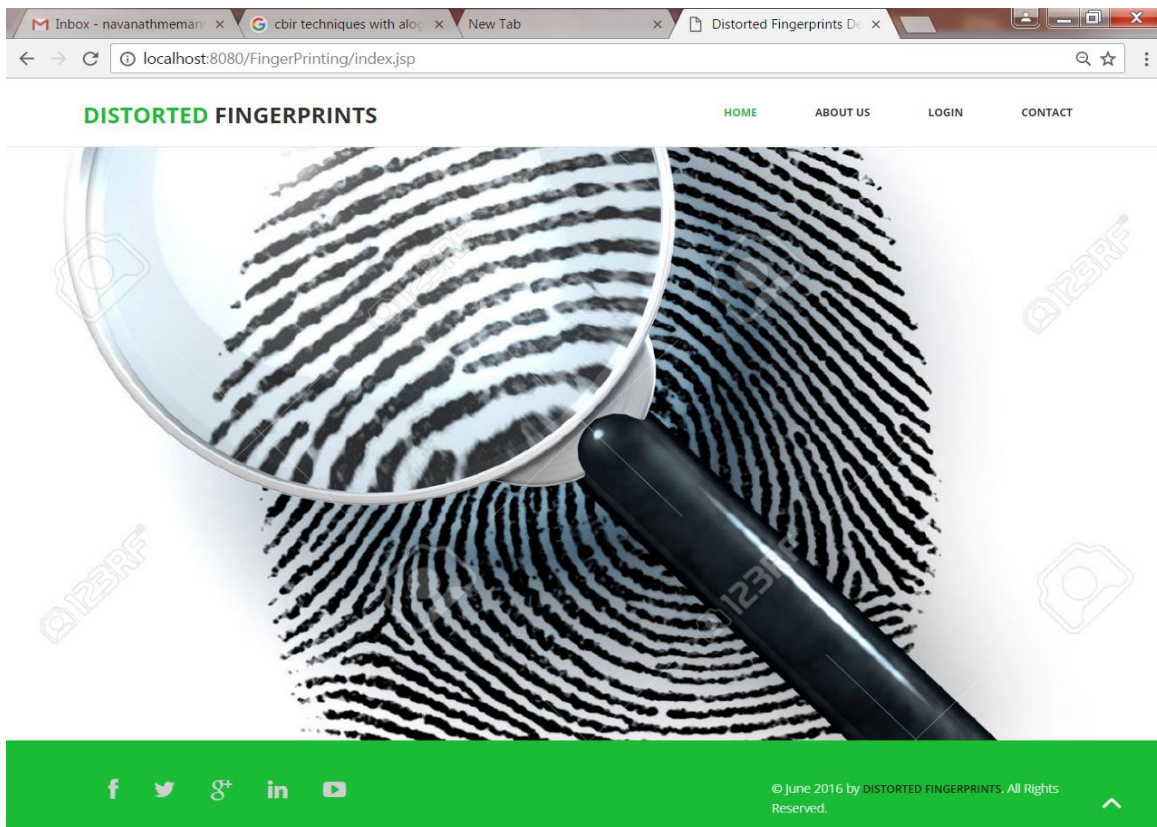
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VIII. EXPERIMENTAL RESULT





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DISTORTED FINGERPRINT HOME UPLOAD IMAGE SIGNOUT

WELCOME ADMIN

correct image



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The screenshot displays a web browser window with the following elements:

- Browser Tabs:** 'Inbox - navanathmema...', 'cbir techniques with alog...', 'New Tab', and 'Distorted Fingerprints'.
- Address Bar:** 'localhost:8080/FingerPrinting/UploadServlet'.
- Page Title:** 'DISTORTED FINGERPRINT'.
- Navigation Menu:** 'HOME', 'UPLOAD IMAGE', 'CHANGE PASSWORD', 'SIGNOUT'.
- Breadcrumbs:** 'HOME / DISTORTED'.
- Left Panel:** Four green buttons labeled 'GrayScale', 'Periodic Map', 'Orientation Map', and 'Check Distoration'.
- Main Content Area:** A large white square containing a grayscale fingerprint image.



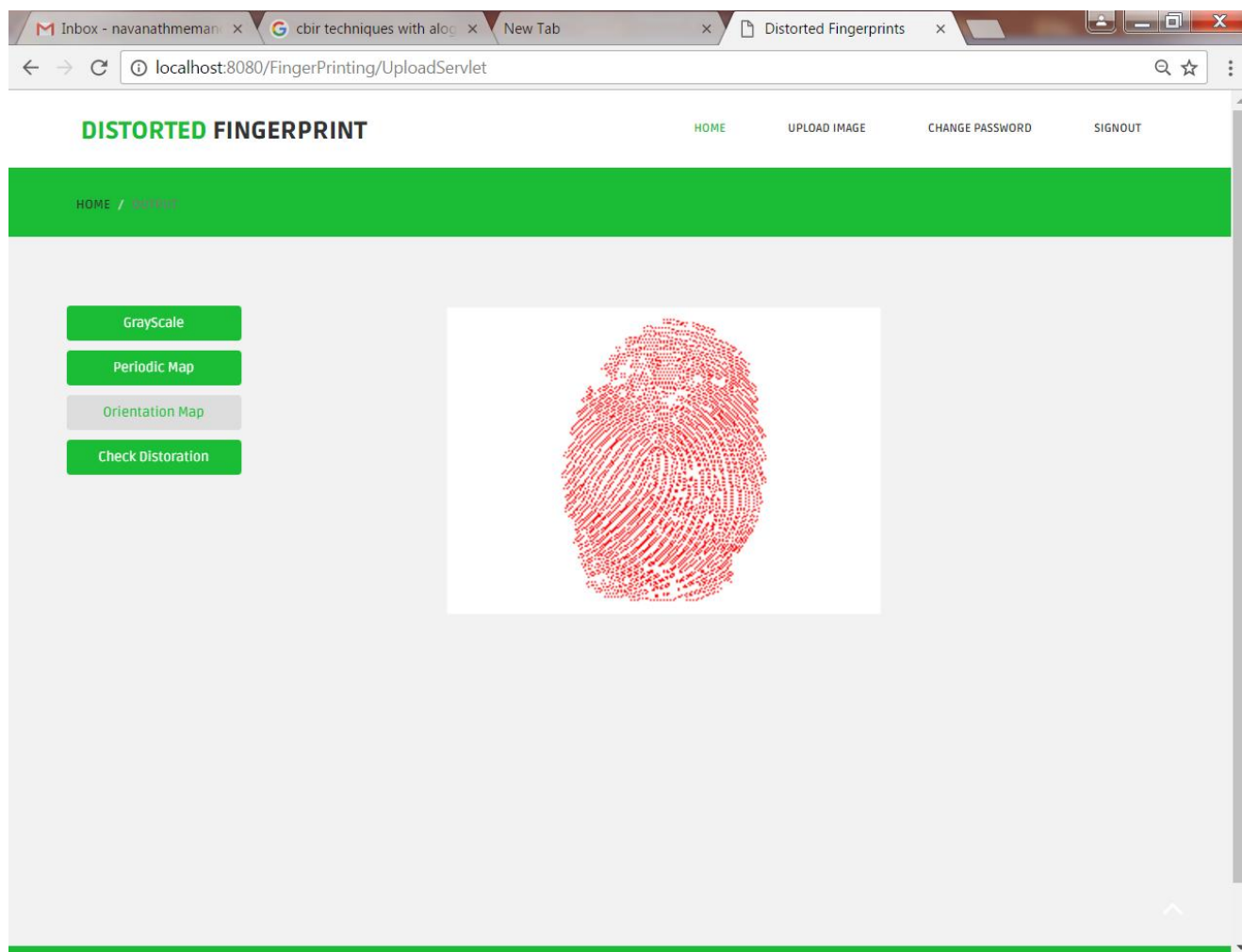
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The screenshot shows a web browser window with the address bar displaying 'localhost:8080/FingerPrinting/UploadServlet'. The page title is 'DISTORTED FINGERPRINT'. The navigation menu includes 'HOME', 'UPLOAD IMAGE', 'CHANGE PASSWORD', and 'SIGNOUT'. A green breadcrumb trail shows 'HOME / SUBMIT'. On the left side, there are four green buttons: 'GrayScale', 'Periodic Map', 'Orientation Map', and 'Check Distortion'. In the center, a red text message reads 'FingerPrint is Distorated' (sic), with a green button below it that says 'Click here Rectification'.

The screenshot shows a JavaScript alert dialog box with the text 'localhost:8080 says: Rectification Sucessfully done...' (sic). There is a close button (X) in the top right corner and an 'OK' button at the bottom right.



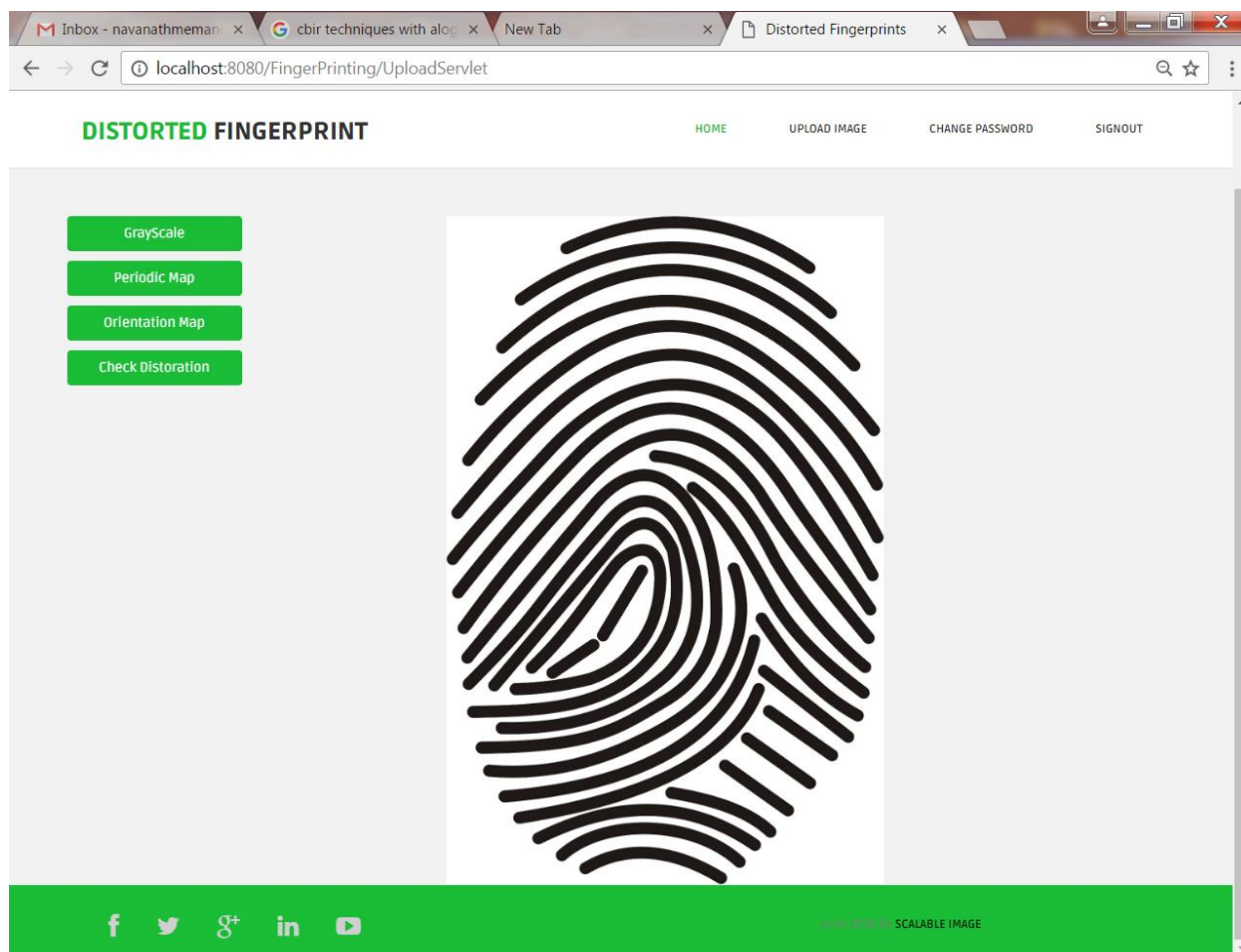
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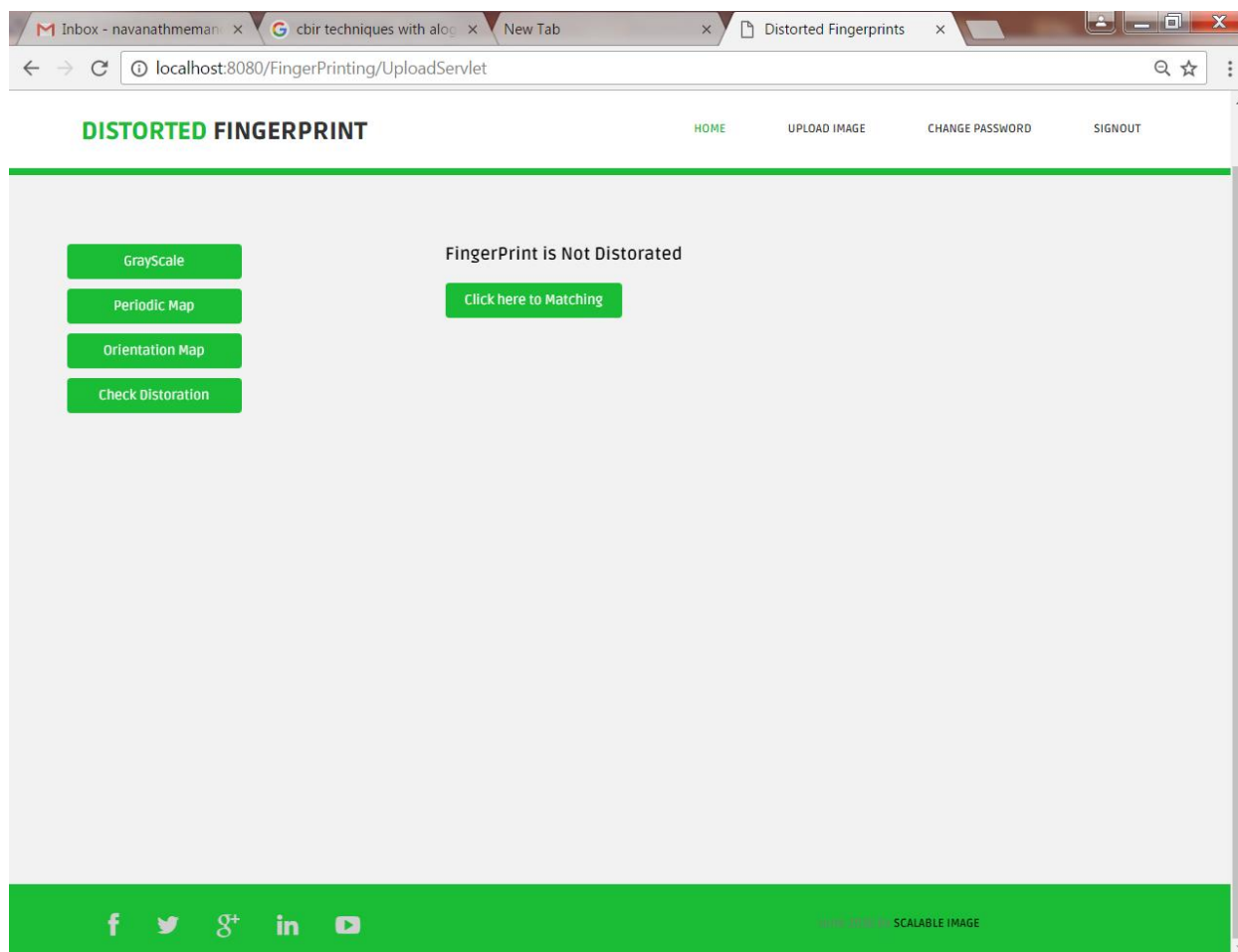


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IX.CONCLUSION

The paper illustrates a new distorted fingerprint detection and rectification algorithm. Distortion detection is done by the use of registered ridge orientation map and period map of a fingerprint as the feature vector, a SVM classifier is made to classify the input fingerprint as distorted or normal. In distortion rectification (or distortion field estimation), a nearest neighbor regression method is employed to anticipate the distortion field from the input distorted fingerprint, later the inverse of the distortion field is used to change the distorted fingerprint into a normal one. The experimental results on FVC2004 DB1, Tsinghua DF database, and NIST SD27 database show that the proposed algorithm can enhance rate of identification of distorted fingerprints unmistakably.

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FUTURE WORKS

Also our future work includes camera/projector lens distortion correction, to obtain more surrounding information and higher ridge depth precision of 3-D fingerprints. Furthermore, the same 3-D sensor may be used to capture face, hand and palm-print images and therefore is ideal for a fusion of comprehensive 3-D biometrics of humans.

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