

Mechanism for Detection and Rectification of Distorted Fingerprints

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ABSTRACT: One of the disadvantage of fingerprint confirmation is the lack of robustness against image quality degradation. Low quality images result in misleading and missing features, thus degrading the performance of the overall system. Hence it is of utter importance for a fingerprint acknowledgement system to estimate the quality and validity of the captured fingerprint image samples. One more major cause is the elastic distortion of fingerprints for false non-match. While this problem causes impact on all fingerprint acknowledged applications, more particularly its unsafe in negative recognition applications, including watch list applications, reduplication applications etc. In such applications, malicious users may purposely distort their fingerprints to hide identification. The paper proposes new algorithms to detect and rectify the skin distortion which is based on a single fingerprint image. The distortion notification is viewed as a two-class classification problem, for which registered ridge orientation map and also the period map of a fingerprint are used as the feature vector and a SVM classifier is designed to perform the classification job. The Distortion rectification (or equivalently distortion field estimation) is assumed to be a regression problem, in which the input used is a distorted fingerprint and the outcome is the expected distortion field. To solve this problem, a database called as a reference database of multiple distorted reference fingerprints and having corresponding distortion fields is created in the offline stage, and then in on-line stage, the nearest neighbor of the input fingerprint is found in the reference database and the corresponding distortion field is used to convert the input distorted fingerprint into a regular one.

KEYWORDS: Fingerprint, distortion, registration, nearest neighbor regression, rectification, classifiers.

I. INTRODUCTION

Fingerprints are one of the forms of biometric measures used to identify an individual and verify their identity. Fingerprint authentication means an automated method of verifying a match between two human fingerprints. Basically skin of human fingertips includes patterns like ridges and the valleys and mixing of these two together form the distinctive patterns. These distinctive patterns are fully developed during pregnancy and are permanent throughout the whole lifespan, and these patterns are called as the fingerprints. It has been stated by different researchers that no two individuals have the identical fingerprints, they are unique for each individual. Fingerprint matcher is very sensitive to the image quality, the matching accuracy of the same algorithm is significantly different among various datasets due to variation in image quality. Imaging sensor inaccuracies can be considered as a unique fingerprint identifying a specific acquisition device, enabling various major forensic operations, such as device identification, device linking, and recovery of processing history, etc. The effect of low quality fingerprints depends on the type of the fingerprint

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recognition system. The fingerprint recognition system can be classified as either a positive or negative system. In a positive recognition system, for example, the physical access control systems, the user is assumed to be cooperative and is willing to get identified. In a negative recognition system, such as identifying individuals in watch lists and identifying multiple entries or enrolments under different names, the user of interest (e.g., criminals) is assumed to be uncooperative and does are not willing to be identified. In a positive recognition system, low quality will result in to false rejection of legitimate users and as a result bring inconvenience. The consequence of low quality for a negative recognition system, is more serious since malicious users may purposely reduce fingerprint quality such that fingerprint system fails from finding the true identity. In fact, law enforcement officials have encountered a number of cases in which the criminals tried to avoid identification by damaging or surgically altering their fingerprints. Elastic distortion occurs due to the flexibility of fingertips, contact-based fingerprint acquisition procedure, and an explicitly applied lateral force or torque. The skin distortion increases the intra-class variations and thus leads to false non-matches due to limited capacity of initial existing fingerprint. Matchers in recognizing severely distorted fingerprints. As shown in fig 1, the left two are normal fingerprints, and right one contains severe distortion. According to Veri-Finger, the matching index in between the left two is much higher than the matching index amongst the right two. This major difference is a result of distortion rather than the overlapping area. While it is possible that matching algorithms can handle bigger skin distortion, it may result into to more false matches and slow down matching speed.



Fig No 1 Sample Fingerprints

Hence it is certainly important for negative fingerprint recognition systems to recognize poor quality fingerprints and enhance their quality so that the fingerprint system is not misused by malicious users. Degradation or Deterioration of quality of the fingerprints can be of two types: photometric degradation, geometrical degradation. Photometric degradation occurs due to non-ideal skin conditions, dirty sensor surface, and complex image background. Geometrical degradation is many a times result of skin distortions. On the contrary, geometrical degradation is the result of skin distortion and has not yet received much attention, despite of the importance of this problem.

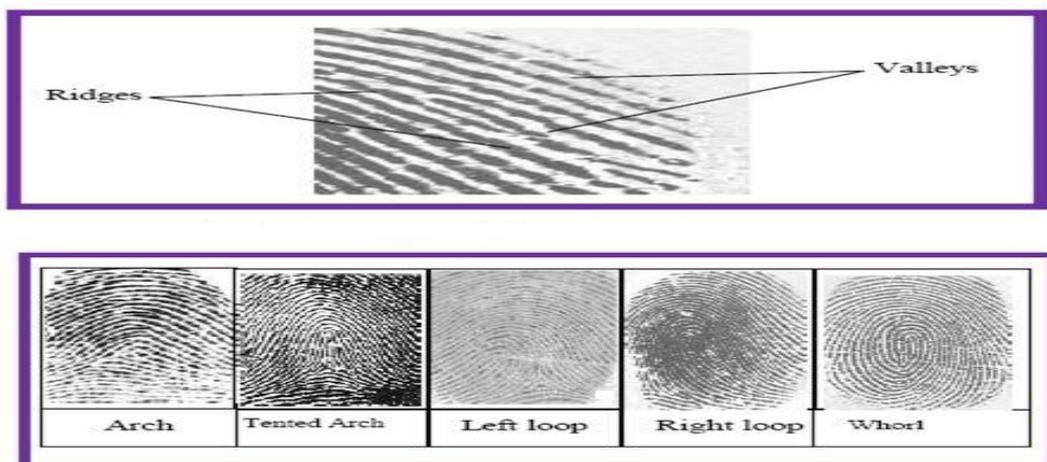


Fig No 2 Types of thumbprints patterns and fingerprint ridges and valleys

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II. MODULES FOR FINGERPRINT IDENTIFICATION

Fingerprint identification is divided into four modules,

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

Classification of Fingerprint

There are three basic fingerprint patterns: Arch, Loop and Whorl. There are also various complex classification systems which further break down patterns to plain arches or tented arches. Loops may be radial or ulnar. They depend on the side of the hand the tail points towards. Whorls also have sub-group classifications including plain whorls, accidental whorls, double loop whorls, and central pocket loop whorls [2].

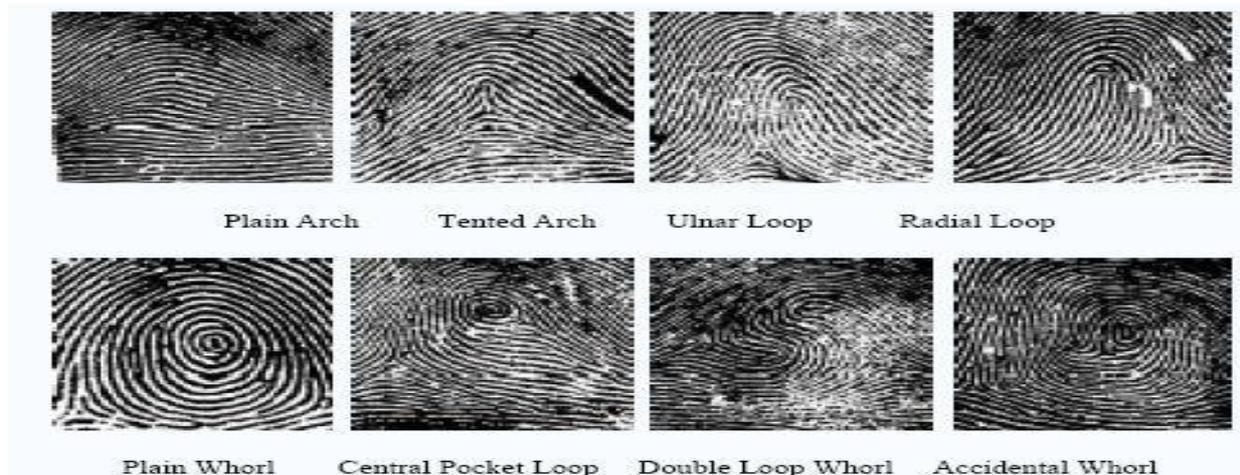


Fig No 3 Classification of fingerprints.

The five classes commonly used by today's categorization techniques are (i)arch, (ii)tented arch, (iii)left loop, (iv)right loop, and (v)whorl. The distribution of the classes in nature is not uniform with the probabilities of each class being roughly 0.037, 0.038, 0.317, 0.029 and 0.279 for the arch, left loop, right loop, tented arch, and whorl respectively [9]. In order to categorize fingerprint images, some features have to be extracted. In particular, nearly all the methods are based on one or more of the following features: directional image, singular points, ridge flow, and structural features. A directional image effectively sums up the information contained in a fingerprint pattern and can be reliably calculated from noisy fingerprints. Also, the local directions in discredited areas can be reconstructed by means of a regularization process and hence, fingerprint directional images are the most broadly used for fingerprint classification. The ridge lines often produce local singularities, called core and delta, by diverting from their parallel flow. The core is clearly delimited as the point at the top of the innermost curving ridge, and the delta is defined as the point where two ridges, running side-by-side, diverge nearest to the core. These singular points can be very utile in order to align the fingerprints with respect to a certain fixed point. Ridge flow is one of the most significant discriminating characteristic and is usually extracted from the directional image or else by finalizing the image, so that each ridge is delineated by a single pixel line. Ridge flow features are more robust than singular points for categorization purposes. Structural features record or enter the relationship between low-level elements like minutiae, local ridge orientation, or local ridge pattern and can be useful for fingerprint classification. To sum up, human fingerprints are unambiguous to each person

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and can be considered as a sort of signature, certifying the person's individuality. The most popular application of this category is in criminology. However these days automatic fingerprint matching is being popularly used in systems which are used to control access to physical locations, computer/network resources, bank accounts, or register employee attendance time in enterprises. To amend the accuracy, a more reliable way is used to acquire the fingerprint data and also preprocessing it becomes essential [6].



Fig No 4 Fingerprint Matching

An image above shows different ridge patterns and minutiae types in a sample fingerprint. The uniqueness of a fingerprint is decided by the topographic relief of its ridge structure, which displays anomalies in local regions of the fingertip, known as minutiae. The position and orientation of these minutiae are used to correspond and match these fingerprints [4].

The ridge patterns along with the core and delta clearly characterize the global configuration while the minutiae points define the local structure of a fingerprint. Typically, the global configuration is used to find the class of the fingerprint whereas the dispersal of minutiae points is used to check and set up the quality of similarity between two fingerprints. Fingerprint matching techniques can be placed into two categories: minutiae-based and correlation based. Minutiae-based techniques first determine minutiae points and then establish their relative placement on the finger.

III. ACTUAL WORKING

Block Diagram:

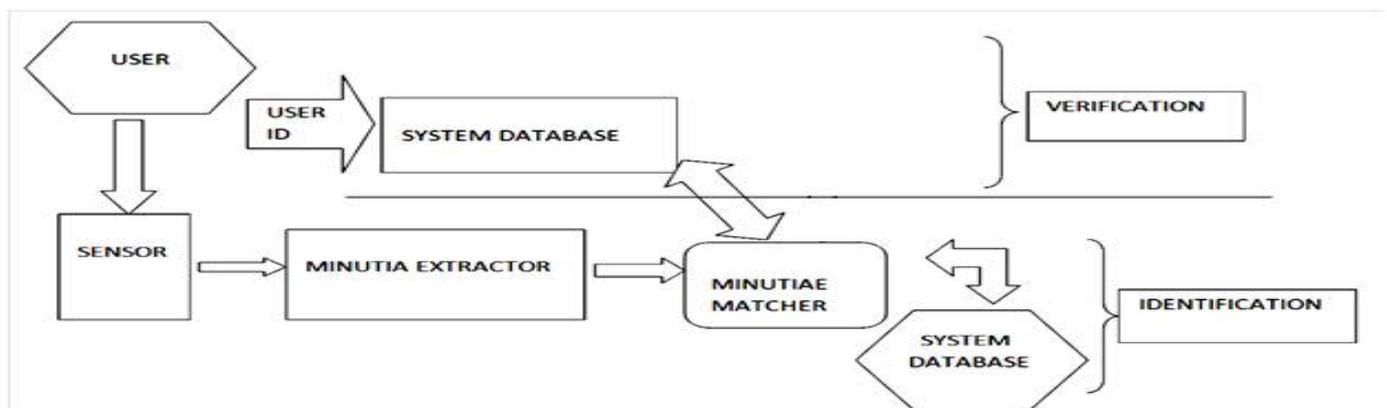


Fig 5. Block Diagram of proposed system

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Explanation-

In this paper, new algorithms are suggested to deal with the fingerprint distortion problem. Given an input fingerprint, distortion detection is performed foremost. If it is determined to be distorted, distortion rectification is executed to transform the input fingerprint into a normal one. In this paper, distortion detection is viewed as a two class classification problem, the registered ridge orientation map and period map of a fingerprint are applied as the feature vector, and further the SVM classifier is trained and utilized to execute the job of classification. Distortion rectification is regarded as a regression problem, in which the input is a sample of distorted fingerprint and the output is the distortion field. To puzzle out this problem, a database of various distorted reference fingerprints and corresponding distortion fields is created in the offline stage, further in the online stage, the nearest neighbor of the input fingerprint is searched in the database of containing the distorted reference fingerprints and the corresponding distortion field is used to correct the input fingerprint. A significant property of the suggested system is that it does not need any changes to existing fingerprint sensors and also existing fingerprint acquisition methods can be used. Such property is important for handling incorporation into existing fingerprint recognition systems. In this project, distortion detection is viewed as a two class classification problem, the registered ridge orientation map and period map of a fingerprint are used as the feature vector and the SVM classifier is trained to undergo the classification task.

Distortion rectification is considered as a regression problem, where the input is taken as a distorted fingerprint and the output is taken as distortion field. For solving this problem, we have built a database of several distorted reference fingerprints and their stand for distortion fields in the offline stage. In the online stage, the nearest neighbor of the input fingerprint is encountered from the database of distorted reference fingerprints. The corresponding distortion field is utilized to correct the input fingerprint. An important dimension of our proposed system is that it does not need any alteration to the existent fingerprint sensors and fingerprint acquisition procedures. A new method is suggested for creating fingerprints matching scores utilizing the spatial parameters existing betwixt the minutiae points. The need to address the problems of matching which arise due to image ridge orientation and size fluctuations is the main motivation behind this algorithm. The algorithm takes benefit of the fact that despite of the image directional flux for a given image size, the distance in-between the core point from particular minutia point does not alter. The point at which the gradient is zero is core the point of maximal turning. The core points A and B shown in Figure 4 are the points of maximal turning of the ridge structures in these two images. These are the points where the directional fields go through the full orientation alteration.

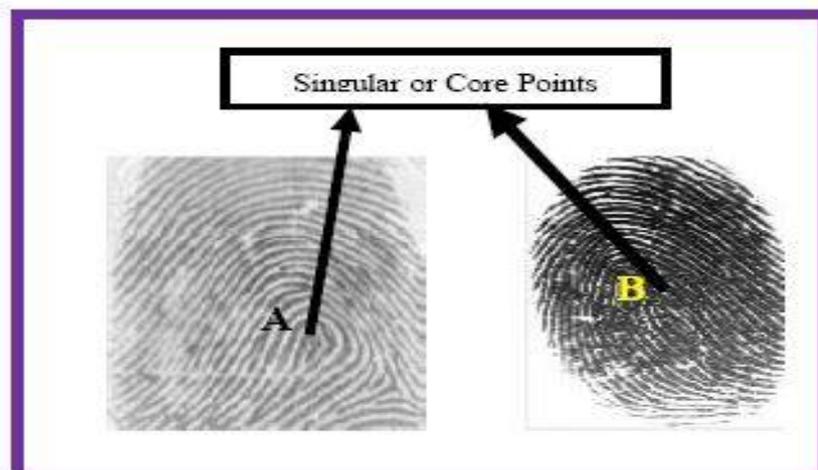


Fig 6: Fingerprint images and their core points

Among the common feature points that unambiguously depict a fingerprint image are bifurcations and ridge endings that are represented by circles and squares severally. Thick diamonds are used to represent the core points.

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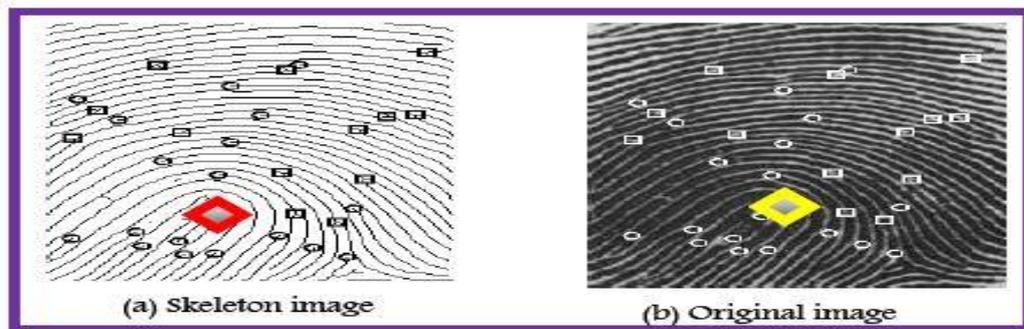


Fig 7: Feature points for skeleton and original images

Figure 8 illustrates distinctive interconnecting lines between nine (9) minutiae points labeled as A, B, C, D, E, F, G, H and I and point O is represented as the core region of an image.

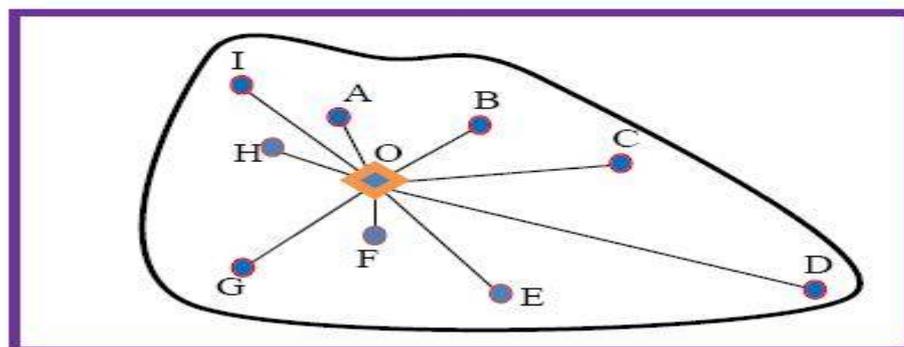


Fig 8: Interconnecting lines between feature and the core points

The connecting lines are in distinct directions with lengths proportionate to the distances from point O to the connecting minutiae points.

IV. MODULES OF IMPLEMENTATION

I. Fingerprint distortion detection

This can be considered as a two class classification problem. We have utilized the registered ridge orientation map and period map as the feature vector, which is further assorted by SVM classifier.

II. Fingerprint Registration

We register the fingerprints in a secure coordinate system in order to take out meaningful feature vector. A multi-reference based fingerprint registration approach is advised in which we depict how the reference fingerprints are trained in the offline stage, and how to register the input fingerprints in the online stage.

III. Reference Fingerprints

In order to acquire statistics of realistic fingerprint distortion, we create a database of various distorted fingerprints using a biometric scanner. Each participant is asked to press his/her finger on the scanner in a usual way, and then by applying a sidelong force or a torque and bit by bit increase the force the fingerprint is distorted. In the online stage the online fingerprint registration is done, given an input fingerprint, we make the registration w.r.t. the registered fingerprints.

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IV. Statistical Modeling of Distortion Fields

The distortion field betwixt a pair of fingerprints can be estimated based on the corresponding minutiae of the two fingerprints. Unluckily, due to the severe distortion betwixt paired fingerprints, the existent minutiae matchers cannot encounter corresponding minutiae reliably. Hence, we extract minutiae in the first frame utilizing Verifier. Since the relative motion betwixt adjacent frames is little, by this method dependable minutiae correspondences betwixt the first frame and the last frame can be encountered.

V. Distorted fingerprint rectification

A distorted fingerprint can be generated by applying some strange distortion field to the normal fingerprint. If we are able to calculate the distortion field 'd' from the granted distorted fingerprint, we can easily rectify this distorted fingerprint into the normal fingerprint by applying the inverse of 'd' on that distorted fingerprint. So we are motivated to turn to a regression problem, which is quite severe because of the high dimensionality of the distortion field. We utilize nearest neighbor regression approach for this job.

VI. Distorted Reference Fingerprint Database

The distortion fields are brought out into view by uniformly attempting to try the subspace spanned by the basic two principle components. 11 points are uniformly sampled in the interval for each basis. For visual image purpose, only one reference fingerprint (the fingerprint placed at the origin of the coordinate system) is utilized to generate the database of distorted reference fingerprints, and five points are sampled for each basis. In reality, multiple reference fingerprints are utilized to attain better execution.

VII. Distortion Field Estimation by Nearest Neighbor Search

Finding the nearest neighbor among all distorted reference fingerprints is equal to the distortion field estimation. The choice of being likewise is measured based on level 1 feature of fingerprint, videlicet ridge orientation map and period map. We conjecture that distortion detection and correction of human experts also depends on these features instead of minutiae.

V. ALGORITHM

The procedure is given in the following phases for the proposed algorithm:

- a. Obtain the core point utilizing the following procedure,
 - I. We divide the fingerprint image, I, into the blocks of size $N \times N$.
 - II. Calculate the orientation approximate for the center pixel A (i, j) for each block.
 - III. Calculate the sine component in radian of each approximate using $\sin(A(i, j))$

An absolutely horizontal ridge has a sine component of 0 whereas vertical ridge has a sine component of

1. Due to property of discontinuity, the sine component value always modifies suddenly from 0 to 1 or contrariwise at the core point. Considering this, the following extra operations are executed:

- I. Initializing a 2 dimensional array B (i, j) and set all the entries to 0.
- II. The sine components that are mapped in a top-to-bottom and left-to-right fashion are to be scanned.

The indicators like false non-match rate (FNMR), false match rate (FMR) and average matching time (AMT) were measured out. We have selected these indicators because they are among the mutual indicators which are utilized for quantifying the performance of any fingerprint pattern matching systems [3]. FNMR is defined as the rate of

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occurrence of a scenario of two fingerprints from similar finger failing to match (the matching score falling below the threshold). On the contrary, FMR is defined as the rate of occurrence of a scenario of two fingerprints from distinct fingers encountered to match (matching score surpassing the threshold). FNMR was measured by matching all the fingerprints from the same finger whereas FMR was measured by matching fingerprint image of each finger with all fingerprints from all other fingers.

•The procured results uncovered the fact that some factors affect the indicators. For example, the nature and quality of the images influence the outcome of false non-match rate and false match rate.

1. Support Vector Machines (SVM)

- I. Finding the best hyper plane that splits all the data points of one class from those of the other class helps in the categorization of data.
- II. For SVM finding the best hyper plane means selecting the one with the largest margin betwixt the two classes.
- III. Margin is defined as the maximum width of the slab parallel to the hyper plane that has no interior data points.
- IV. In the decision function SVM utilizes a subset of training points.
- V. The support vectors are the data points that are closest to the splitting hyper plane; these are the points which are on the boundary of the slab.

VI. RESULT

Results of proposed system is shown below,

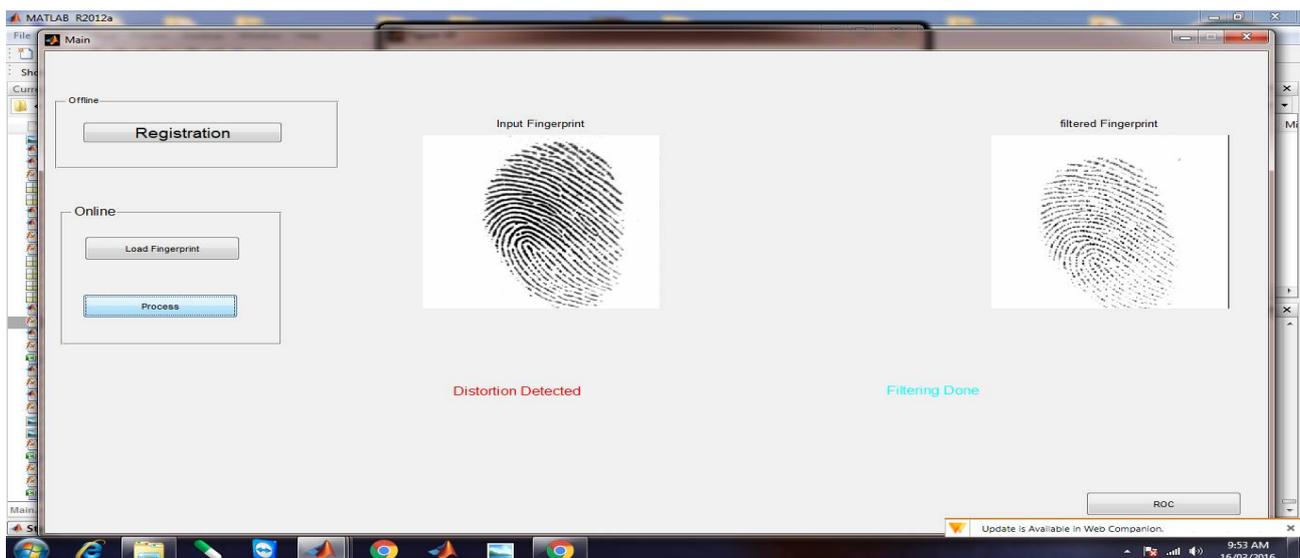


Fig 9: Detection and filtration of finger prints

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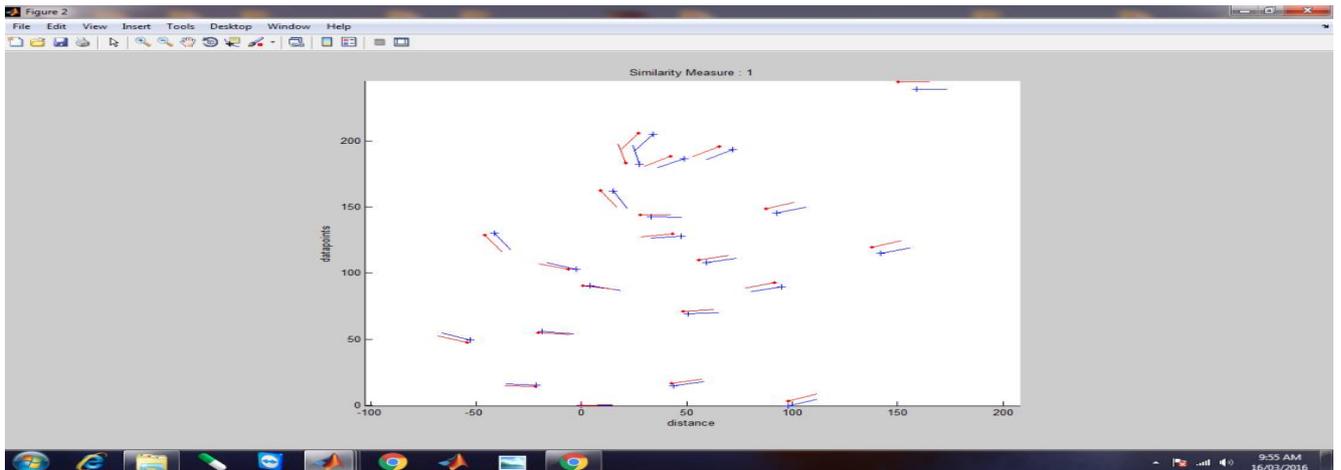
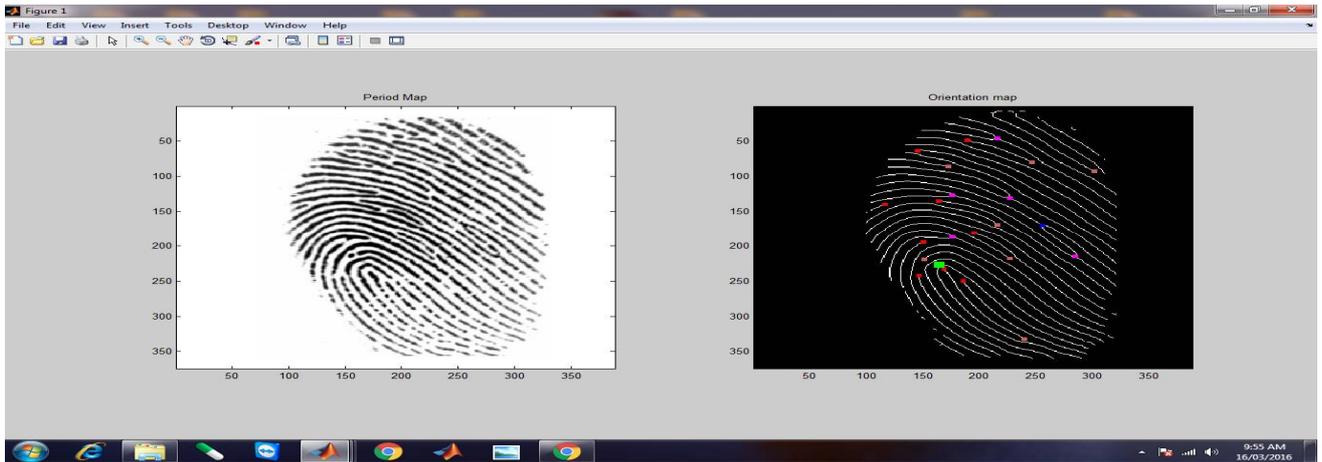
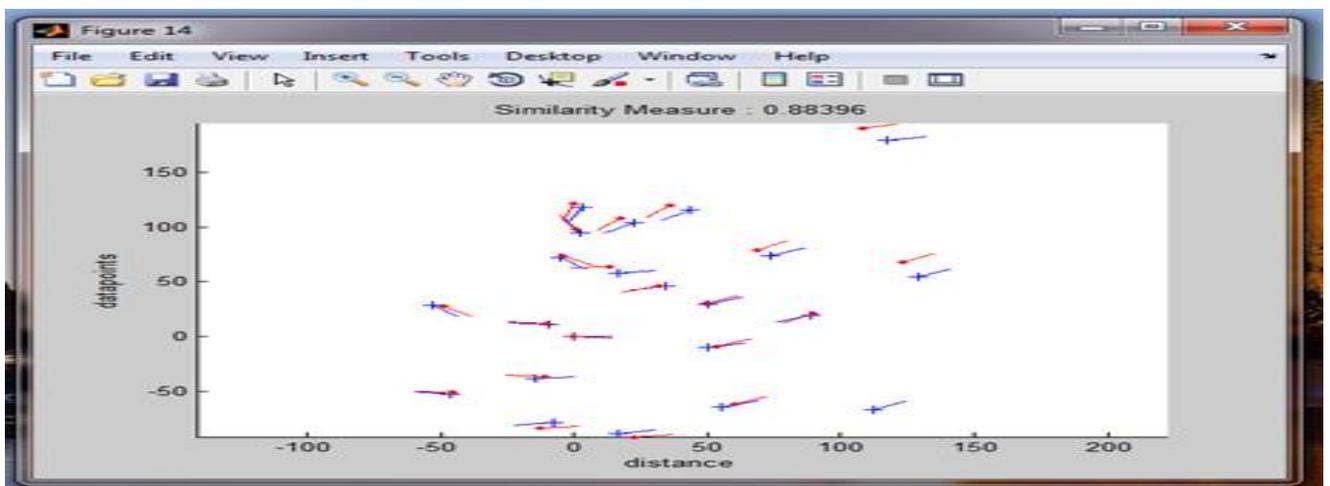


Fig 10: SVM Classification



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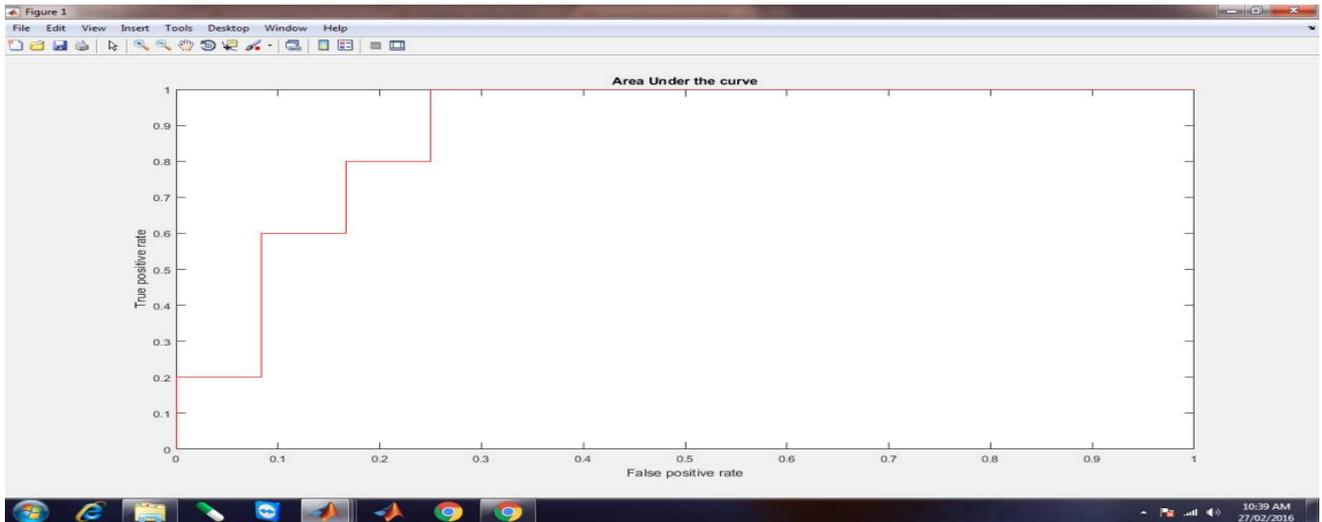


Fig 11: ROC curve

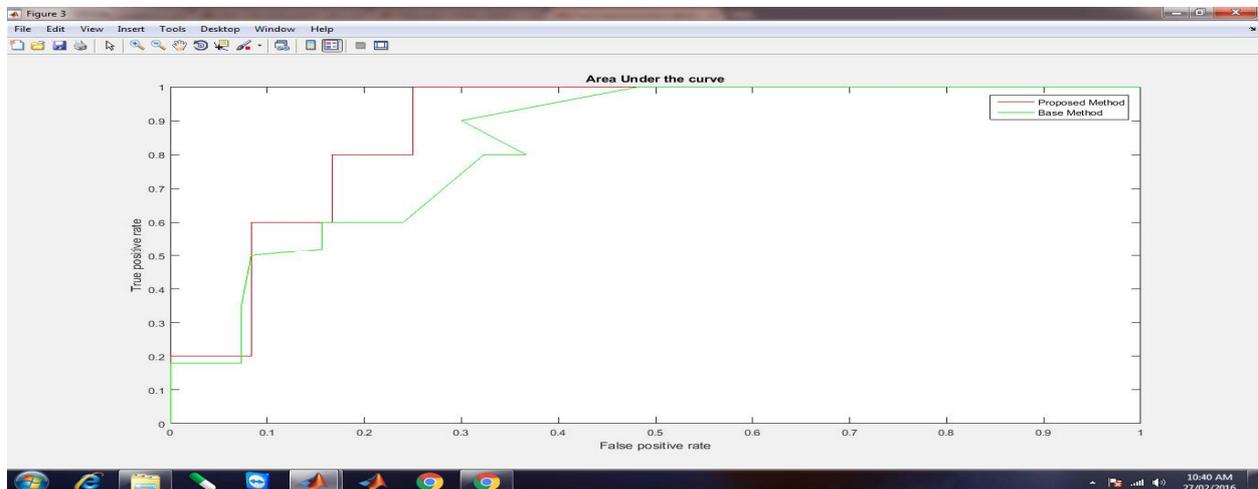
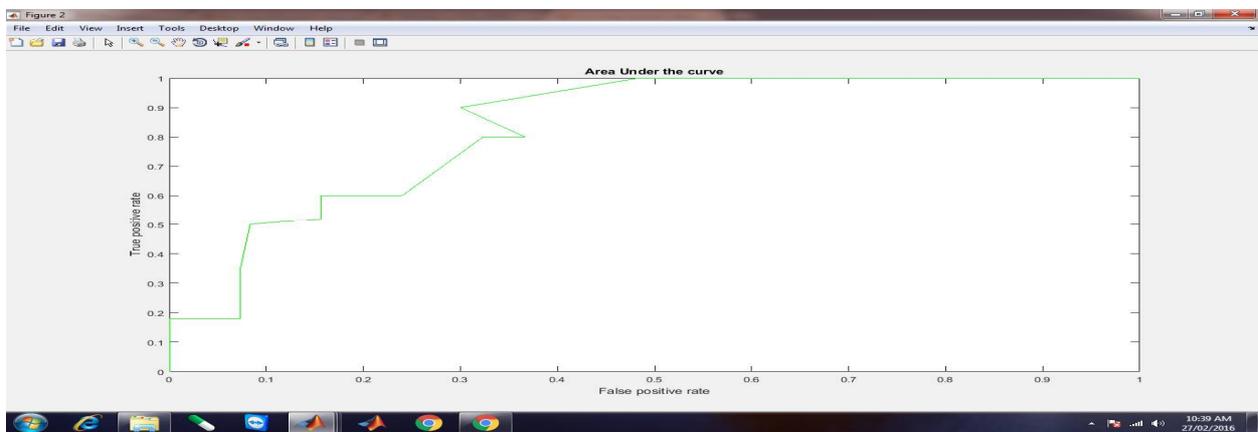


Fig 12: ROC curve / graphs

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VI. CONCLUSION

The above effectuation was an attempt to understand how Fingerprint Recognition is utilized as a form of biometric to sustain individuality of human beings. All the stages are included in this that is, minutiae extraction from fingerprints to minutiae matching that are utilized to generate a match score. Several standard techniques are utilized in the intermediate stages of processing. Comparing with other forms of biometrics the comparative low percentage of substantiation rate indicates that the algorithm utilized is not very robust and is vulnerable to effects like scaling and elastic deformations. Various new methods and algorithm have been deduced which give better results. False non-match frequency of fingerprint matchers is comparatively high in gravely distorted fingerprints. This is creating a security hole in automatic fingerprint detection systems that could be utilized by criminals and terrorists. So, it is a must to fill the hole by building up of fingerprint distortion scrutiny and reformation algorithms. This paper exhibits a new distorted fingerprint detection and rectification algorithm. By the utilization of registered ridge orientation map and period map of a fingerprint as the feature vector distortion detection is done, a SVM classifier is made to categorize the input fingerprint as distorted or normal one. In distortion rectification, a nearest neighbor regression method is utilized to look for the distortion field from the input distorted fingerprint, later the inverse of the distortion field is employed to alter the distorted fingerprint into a normal one. Further betterment in matching accuracy can be anticipated by tuning the matcher to work with the distortion removal system.

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