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A Singular points detection based Fingerprint Representation and Matching Algorithm: A Survey

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Abstract: This Paper Propose a study of crime sense and law enforcement in Altered Fingerprint using singular point detection. In crime range and forensic the altered fingerprint is not clearly identified. The poor image quality cannot easy to extract. It is necessary to extract the features for efficient to improve the matching accuracy. While several issues related to fingerprint system security have been investigated. The Analysis and detection of different altered fingerprint identification techniques are discussed.

Keywords: Fingerprints, AFIS, alteration, ridge pattern, image quality, minutiae distribution.

I. Introduction

An impression left by the friction ridges of a human finger is known as a Fingerprint. Fingerprints are the traces of an impression from the friction ridges of any part of a human or other primate hand. A footprint can also leave an impression of friction ridges. A friction ridge is defined as a raised portion of the epidermis on the digits (Fingers and toes), the palm of the hand or the sole of the foot, and it consists of one or more connected ridge units of friction ridge skin, sometimes known as epidermal ridges. These ridges may also assist in gripping rough surfaces and may improve surface contact in wet conditions.

Fingerprint impressions may be left behind on a surface by the natural secretions of sweat from the eccrine glands, that are present in friction ridge skin or they may be made by ink or other substances transferred from the peaks of friction ridges on the skin to a relatively smooth surface such as a fingerprint card. Since the early 20th century, Fingerprint analysis and detection has been one of the most common and import forms of crime scene forensic investigation. More crimes have been solved with fingerprint evidence that for any other reason.

Fingerprint identification, is the process of comparing two instances of friction ridge skin impression (Finger points), from human fingers or toes or even the palm of the hand or sole of the foot and determining whether these impressions are from the same individual known as dactyloscopy. Human Fingerprints are rich in details called finger points, which can be used as identification marks for fingerprint verification. Including the use of fake fingerprints for hidden identity. The problem of fingerprint alteration or obfuscation has received very little attention. Fingerprint obfuscation refers to the deliberate alteration of the fingerprint pattern by an individual for the purpose of masking his identity.

1.1 Ridges

The narrow lines which are completely ridged on the rubbing skin are called Rides are studded with sweet pores.

Rubbing ridges serve the examiner directly in the solution of crimes. Ridge patterns establish positive identity of the individual whose skin made them. These ridges make it possible for the fingers and palms to hold objects. They increase the roughness between the skin and the object handled.

Rubbing ridges are the result of joining together of glandular elements of the skin into rows. Ridges are somewhat wider than dominant spaces that shows in fig 1. Sweet pores open into the high flat surfaces of the ridges. The papillary system, glands, ducts, ridges and pores were perhaps designed by nature for the purpose of increasing friction, where it was most needed on the pals of the hands and soles of the feet.

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Fig 1: Ridge Ending and Ridge Bifurcation and other fingerprints characteristics

1.2 Patterns

The ridges on the finger bulbs from various patterns which are capable of classification. Fingerprints are classified into three classes.

a) Arch – the ridges run from one side to the other side. There is no backward turn. There is ordinarily no delta, but when there is an appearance of a delta, There is a no ridge must intervene between the Inner and Outer terminus as shown in fig 2a

It is classified in to

i) Tented Arch – In patterns of the arch type, the ridges near the middle way have an upward thrust, arranging themselves as it were on both sides of a spine or axis, towards which adjoining ridges converge as shows in fig 2b.

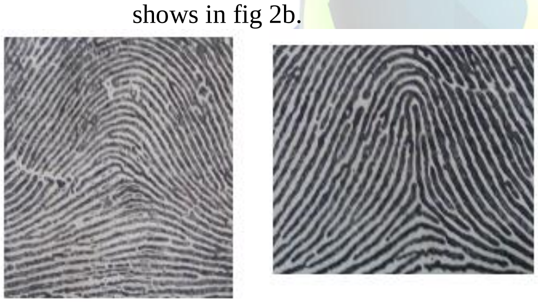

Fig 2a: Arch and Fig 2b: Tented arch

b) Loop – Some of the ridges make a backward turns, but without twist, There is one delta as shown in fig 3a

It is classified in to

i) Central Pocket Loops – In Patterns of loop type the ridges immediately above the core deviate in course from the general course of the other ridges. Some impressions may therefore be said to process features which require their being defined as loop in respect of the majority of their ridges and whorls in respect of the appearance of the few ridges which occupy a space immediately about the centre, a delta more or less slightly defined having in consequence made its appearance. Upon the correlation of nomenclature adopted in mining, the space so occupied by ridges surrounding them as shown in fig 3b.

ii) Twinned Loops – An impression in which the patterns in reality consists of two well defined loops, the one super incumbent on or surrounding the other, is termed as Twinned Loop as shown in fig 3c.

iii) Lateral Pocket Loops – When the ridges constituting the loop bend sharply downwards on one side before recurring, thereby forming on that side an inter-space or "Pocket" ordinarily filled by the ridges of another loop, such impression is termed as shown in fig 3d.

Fig 3a: Loop

Fig 3b: Central Pocket Loop

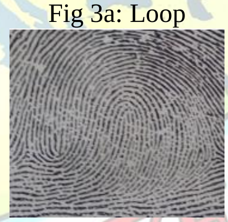

Fig 3c: Twinned Loop

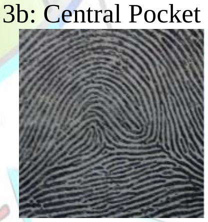

Fig 3d: Lateral Pocket Loop

c) Whorl – Some of the ridges make a turn through at least one complete circuit. There are two deltas. Whorls are single cored and double cored as shown in fig 4.

Fig 4: Whorl Pattern with single cored and double cored

1.3 Characteristics

Characteristics or Minutia or Galton details are defined as the minute peculiarities of the ridges such as unexpected beginning or ending. Forking in to two or bifurcation, forming island, enclosures and dots etc. The ridge characteristics are positive means to fix up the identity without any doubt.

Characteristics are those individual ridge details which distinguish one print from another considered either singly or in conjunction with the rest of the print.

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1. Continuous ridge
2. Ridge beginning
3. Ridge ending
4. Fork or a bifurcation downwards
5. Bifurcation upwards
6. Hook down
7. Hook up
8. Enclosure
9. Change over
10. Intersection
11. Fragment
12. Short ridge
13. Dot or Spot or Point
14. Deviated break
15. Recurving or return.

The success of fingerprint recognition system in exactly identifying individuals has prompted some individuals to take on in extreme measures for the purpose of condition of the system. The primary purpose of fingerprint alteration [1] is to evade identification using techniques varying from abrading, cutting and burning finger to performing plastic surgery. The use of altered fingerprints to cover one's uniqueness constitutes a serious attack next to a border control biometric system in view of the fact that it defeats the very reason for which the system was identify individuals in a watch list.

In this Fingerprint Illustration

1,6→ A Short Ridge
2,5,10 – 14→ A Bifurcation of a Ridge
3,8,9,15→ A Termination of a Ridge
4 →An Enclosure
7 →A Small Island
16 →A Ridge Bifurcation and meet at a point
17 →It makes it a long enclosure

It should be noted that altered fingerprints are different from fake fingerprints. The use of fake fingers made up of glue, latex or silicone. Altered fingerprints however are real fingers that are used to hide one's identity in order to avoid identification by biometric system. While fake fingers are typically used by individuals to assume another person's identity. Altered fingers are used to mask one's owns identity. In order to detect attacks based on fake fingers, many software [2] and hardware [3] solution have been proposed.

Finger points: In fingerprinting term, finger points are the point of interest in a fingerprint, Such as bifurcations (a ridge splitting in to two) and ridge ending as shown in fig 5.

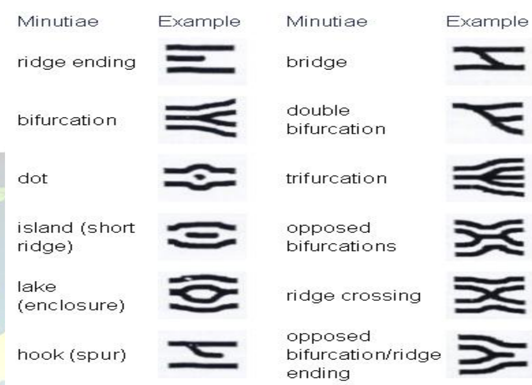

Fig 5: Finger points

II. HISTORY

Fingerprint alteration has a long history. As early as 1933, Gus Winkler, a murder and bank robber was found to have altered the fingerprints of his left hand except for the thumb by slashing and tearing [1] the soft tissue of the fingers. Further, the blueprint type of one finger was altered from double loop to left loop, which corresponds to whorls and loops of the present day and all other types are included in these two classifications.

In more recent cases, a man using the name Alexander Guzman, arrested by Florida officials in 1995 for possessing a fake passport was found to have obfuscated fingerprints. After two weeks search between many databases based on by hand reconstructing the damaged fingerprints. The reconstructed fingerprints of Alexander Guzman were linked to the fingerprints of Jose Izquierdo who was an absconding drug criminal [4]. His fingerprint mutilation process consisted of making a "Z" Shaped cut on the fingertip, lifting and switching two triangular skin patches and stitching them back.

It is not just the criminals who have been found to modify their fingerprints. In December 2009, a woman successfully evaded the Japanese immigration by surgically exchange fingerprints of her left and right hands [5]. Although she was originally arrested for faking a marriage license, scars on her hands made the police suspicious. Fingerprint alteration has even been performed

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at a much larger scale involving a group of individuals. It has been reported that hundreds of protection sealers had cut, abraded and burned their fingertips to prevent identification [6].

III. Types Of Altered Fingerprints

Differentiate altered fingerprints into three categories based on the changes in ridge pattern due to alteration. This categorization will assists us in the following approach.

1. Getting a better understanding of the nature of alterations that can be encountered.
2. Detecting altered fingerprints by modelling well defined subcategories and
3. Developing methods for altered fingerprint restoration.

3.1 Obliteration

Friction ridge patterns on fingertips can be obliterated by abrading, cutting, burning and applying strong chemicals [1] and transplanting smooth skin. Further factor such as skin diseases such as leprosy and side effect of cancer drug can also obliterate fingerprints [7][8]. Friction ridge structure is hardly visible within the obliterated area. Obliteration appears to be the most accepted form of alteration. This may be because obliteration, which fully destroys ridge structures, is much simpler to perform than alteration or reproduction, which requires a surgical procedure. Moreover, detecting twisted or imitated fingerprints is much more difficult for human examiners than obliterated fingerprints.

Obliterated fingerprints can avoid fingerprint quality control software, depending on the area of the damage. If the affected finger area is minute, the existing fingerprints quality assessment software may not succeed to detect it as altered fingerprints. To recognize individuals with severely obliterated fingerprints, it may be necessary to treat these fingerprints as latent images and adopt an appropriate fusion scheme for tenprint search. In rare cases, even if the finger surface is completely damaged, the dermal papillary surface, which contains the same pattern as the epidermal pattern, may be used for identification.

Obliterated fingerprints can defect automated fingerprint matchers and successfully pass fingerprint quality control software depending on the depth and area of damages. If the damage does not reach the generating layer in the epidermis depth of around 1 mm, the skin will regenerate to the original ridge pattern after a few months' time. However if the damage is done to the generation layer, the tissues of well-defined ridge willreplace the damage area. If the affected finger area is small, the automated machine is to successfully match the damage area. But if the affected area is sufficiently large, the automated is failed to identify. Itcan easily identified by the human operator or fingerprint quality control software. Fig 2 shows the different types of altered fingerprints.

a b c

Fig: 2 a. Obliterated fingerprints, b. Distorted fingerprints, c. Imitated fingerprints.

3.2 Distortion

Friction ridge patterns on fingertips can be twisted into abnormal ridge patterns by removing portions of skin from a fingertip and whichever grafting them back in different position or replacing them with friction ridge skin from the palm or sole [9]. Distorted fingerprints have unusual ridge patterns which are not found in natural fingerprints. These abnormalities include abnormal spatial distribution of singular points or abrupt changes in orientation field along the scars.

Distorted finger can also successfully pass the fingerprint quality test since their local ridge structure remains similar to natural fingerprints while their global ridge pattern is abnormal. Over the entire fingerprint area retains the same ridge property a distorted fingerprint as a result of swapping skin patches in the same finger.

Before alteration of the original fingerprints enabling reconstruction and retain their original ridge structure of the fingerprints altered by "Z" cut. To detect the distorted fingerprint it is imperative to upgrade current fingerprint quality control software.

3.3 limitation

Here a surgical procedure is performed in such a way that the altered fingerprints appear as a natural fingerprint ridge pattern. Such surgeries may involve the transplantation of a large area friction skin from other parts of the body such as finger, palms, toes and sloes. The surgical area due to the transplantation are small, it can even deceive inexperienced human operator. As long as the transplanted area is large, matching altered fingerprints to the original fringerprints is not likely to succeed. Plain images captured by fingerprint scanners used in most border control application may not be able to expose the surgical area in large transplantation. To avoid identification areas exhibiting clusters of minutiae have to be altered as shown in fig 3. While it is difficult to match altered fingerprints that have been generated by extracting small portions of friction skin from either the original

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print or donor print, there may be obvious surgical scars present in both rolled and plain impressions of the altered fingerprints. To reconstructed original fingerprints in small area transplantation an efficient automatic solution is preferred over tedious manual search [10].

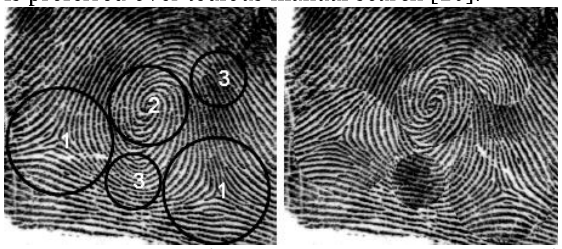

Fig 3: Simulation of small area transplantation with in a finger

In this fig 3 shows the simulation of small area transplantation with in a finger with original finger prints. The next picture shows the altered fingerprints. Simulation is performed by exchanging and rotating circular region to match the local ridge orientation or just rotating circular regions marked with 2 by 180 degrees. To detect scars caused by large area transplantation, rolled fingerprints instead of plain fingerprints have to be captured and analyzed [11]. In the case of the contributor print is taken from other finger prints of the identical person, the finger print corresponding without using finger position information. The right index finger or the left thumb may help in determining the right unique and the response time will much increase. To modify the old fingerprints in small area transplantation a good method is preferred.

IV. LITERATURE SURVEY

In 2006, Xudong proposed a fingerprint retrieval [12] for identification. In this work, retrieval is defined as: given an input fingerprint, filter out a subset of candidate fingerprints for the finer matching by coarsely searching the data base. If one of the retrieved candidates originates from the same finger as the input, the retrieval is successful for this input fingerprint; otherwise, it is a failure. Therefore, the retrieval accuracy/error is calculated by the percentage of the input fingerprints with retrieval success/failure. As retrieval is to reduce the number of finer matchings for identification, the average percentage of the retrieved fingerprints from the data base over all input fingerprints represents the retrieval efficiency. The performance of a retrieval technique is measured by its accuracy and efficiency. The continuous classification retrieves fingerprints in the data base whose features fall in a neighborhood centered at the input. It usually provides better performance and can balance the efficiency and accuracy more easily than the exclusive classification. However, the continuous retrieval is required to compare the input feature vector with those of all fingerprints in the data base. This results in substantial longer retrieval time than the exclusive classification. To reduce the time consumption. The author proposed to partition the data base into clusters. The number of clusters is much smaller than the number of fingerprints in the data base. It is only need to compare the input feature vector with the cluster prototypes and retrieve fingerprints of one or few clusters. This integrates merits of continuous and exclusive classification in the retrieval.

In 2008 Jin Bo proposed a fingerprint singular point detection algorithm [13] by Poincare index. a multi-scale detection algorithm for singular points in fingerprint images based on both the continuous orientation field and the modified Poincare Index. Firstly, the blocks which may contain singularities are detected by computing the Poincare Index. Then, the singularities are detected in the block images accurately and reliably. So the new algorithm can locate the singularities at pixel level with an accuracy of only one pixel. The main steps of our structural approach to fingerprints classification are as follows: 1) Computation of the directional image of the fringerprints. This directional image is a 28×30 matrix. Each matrix element represents the ridge orientation within a given block of the input image.

The boundary region, surrounding the actual fingerprint in the image, inherently contains discontinuities in the ridge pattern since beyond that boundary is background with relatively constant (but often noisy) pixel intensity. To address the border discontinuities, the fingerprint is segmented from the background. The blockwise coherence to segment the images. The block is considered as foreground if its coherence of its direction field satisfies some predefined threshold, otherwise, the background. Then two iterations of dilation and erosion are used to remove holes resulting from in homogenous regions. All the process discussed below is carried out on such foreground regions.

In 2004 Afsar, proposed a fingerprint identification and verification system using minutiae matching [14]. The fingerprint database stores the fingerprint images for this purpose. The features extracted from these fingerprints are stored in the features database along with the person ID. The objective of the enrollment module is to admit a person using his/her ID and fingerprints into a fingerprints database after the process of feature extraction. These features form a template that is used to determine or verify the identity of the subject, formulating the process of authentication. The component of the AFIS used for authentication is referred to as the authentication module. Figure 1 illustrates the different steps involved in the development of the AFIS. The details of these steps are given in the following subsections.

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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).

Fingerprints are usually divided into six main classes according to their macro-singularities [15] ie., arch, tented arch, left loop, right loop, twin loop and whorl. A global feature of fingerprints the orientation field is very important for automatic fingerprint recognition. Fingerprint recognition system consists of two parts there are processing part and matching part, and the processing part mainly includes the effective region segmentation, orientation field estimation, ridge enhancement, ridge thinning and minutiae extraction.

Effective region segmentation is performed the fingerprint image is divided into many blocks. Each block contains the variance of the gray levels is computed. Uncertainty the value exceeds the predefined threshold in this block is regarded as an effective block. Next the Orientation field estimation is performed this steps the model-based orientation field estimation method and the hierarchical gradient-based method are using. Pixels are identified to be ridge pixels based on this property.

In Minutiae matching a Hough transform is used to convert point pattern matching to a problem of detecting the highest peaks in the Hough space of transformation parameters. Then the coarse field is computed by using the gradient-based algorithm to the result gained by using the model for a weighted approximation. Developed a novel algorithm for orientation field estimation and then the orientation field is rather smooth except for several singular points. And can establish a polynomial model to globally represent the orientation field and use a point-charge model to improve the accuracy locally at each singular point. The orientation field of a fingerprint can be estimated globally by only using the polynomial model assuring the performance of our model-based method in cases of displaced false or lost singular points though dealing with poor-quality fingerprint images. The global approximation model-based orientation field estimation algorithm has a robust performance on different fingerprint images. The new algorithm is a better performance on robustness, accuracy and computational cost for orientation field estimation than the existing method works.

According to Asker M. Bazen and Sabih H. Gerez [16] not only analyzed the angle of the gradients is doubled but also the length of the gradient vectors is squared and if the gradient vectors are measured as complex numbers that are squared. This has the effect that strong orientations have a higher vote in the average orientation than weaker orientations. Introduce an efficient implementation of an SP extraction algorithm that is based on the Poincare Â index and makes use of small 2-dimensional filters. The algorithm extracts all singular points from the DF including false SPs that are caused by an insufficiently averaged DF. Additionally the algorithm determines whether a core or a delta isdetected.That singular point extraction method examines the DF at a number of fixed positions in a circle around the SP and takes the position wherever the DF points best toward the SP as orientation of the SP. The method that is described below uses the entire neighborhood of the SP for the orientation estimate so providing much more accurate results.

The four different types of segmentations are used there are No segmentation the whole image is taken a fingerprint region, Manual segmentation, High resolution segmentation algorithm that uses the coherence estimate as feature and morphological operators to smooth the segmentation result then High resolution segmentation algorithm that uses the coherence, the mean, and the variance of the fingerprint image as features and morphological operators to smooth the segmentation result. It would be a better solution to develop segmentation algorithms that are capable of detecting low-quality areas and discard spurious score-delta pairs from these areas. Additionally fingerprints of very bad quality, having a low coherence value in the entire print should be rejected entirely.

A fingerprint image can have two structures there are global and local structure [17]. The global structure containing the overall pattern of the ridges and valleys and the local structure the detailed patterns around a minutiae point. The use of the local structure in the identification / verification process is sensitive to noise that is the poor performance for low quality fingerprints can be predicted. Two different filters are used one for the arch-type core-points and one for the delta-type core-point and the filtering is applied to complex images that are orientation tensor field in different scales.

The relative high number of misclassification of arch type core-points can be tracked to the same global structure of a fingerprint namely plain arch classification scheme. For this failing structure both filters give strong responses and therefore low certainty measures when using the selectivity rule. The innovative is suggested to the prominent symmetry point in the fingerprint they are extracted from the complex orientation field.

V. Summary

This paper provides a comprehensive survey of the different techniques and growth in fingerprint matching technology. The merits and drawbacks of both manual matching of fingerprints and the automated system based matching are discussed. Research in overall automated fingerprint matching technology is still in its preliminary stages and not carefully taken up. The basic challenge can be rooted back to the lack of large public fingerprint database available for research.

There is no publicly available database that contains mated fingerprints lifted from multiple surfaces using multiple lifting methods. A combined database having the fingerprints of the same finger lifted from various surfaces such as a door knob, a plastic handle, a wooden plank, and a bank rupee note can open new research problems and encourage extensive research in latent fingerprint matching.

It can be observed that most of the features have been extended from full fingerprint analysis literature. As the problem of fingerprints have different properties and challenges than full fingerprints, identifying fingerprint specific features can be a good direction to work in the future. The Results are Unsatisfactory for Poor Quality Fingerprint Images. The Insight on the Estimating an Average Gradient problem will be occurred. A border problem was occurred that fingerprint gives high values in the orientation field image and False Core-points. A border problem occurred that generates strong responses in the orientation tensor image and False Singular Points. A reliable feature vector should exclude these corrupted orientations. In large scale fingerprint identification systems were developed to index individuals.

Although improving the matching performance is the eventual aim of an automated matching system, defining some evaluation metrics to examine the different stages as such may help to devise better techniques in the future. We conducted studies to understand the implications and consequences of the technology in AFIS based matching. We put the other opinion that human cognition has not been effectively transformed into fingerprint matching technologies.

Reference

[1]. H. Cummins, "Attempts to Alter and obliterate Fingerprints", *J.Am.Inst. Criminal Law and Criminology*, Vol.25, pp.982-991, 1989.

[2]. A. Antonelli, R. Cappelli, D. Maio and D. Maltoni, "Fake Finger Detection by skin Distortion Analysis", *IEEE Trans. Information Forensics and Security*, Vol. 1, no.3, pp.360-373, Sept.2006.

[3]. K.A. Nixon and R.K. Rowe, "Multispectral fingerprint imaging for spoof detection", *proc. SPIE, Biometric Technology for human identification II, A.K. Jain and N.K. Ratha*, eds., pp.214-225, 2005.

[4]. K.Wertheim, "*An Extreme Case of fingerprint mutilation*", *Forensis identification*, Vol.48, no.4, pp. 466-477, 1998.

[5]. *Surgically Altered Fingerprints Help Woman Evade Immigration*, http://abcnews.go.com / Technology / GadgetGuide / surgicallyaltered - finger prints –woman -evade-immigration / story? id = 9302505, 2011.

[6]. *Sweden Refugees Mutilate Fingers*, http://news.bbc.co.uk / 2 / hi / europe/3593895.stm, 2004

[7]. J. Feng, A.K. Jain, and A. Ross, "*Detecting Altered Fingerprints*," Proc. 20th Int'l Conf. Pattern Recognition, pp. 1622-1625, Aug. 2010

[8]. M. Wong, S.-P. Choo, and E.-H. Tan, "*Travel Warning with Capecitabine*," Annals of Oncology, vol. 20, p. 1281, 2009

[9]. K. Wertheim, "*An Extreme Case of Fingerprint Mutilation*," J. Forensic Identification, vol. 48, no. 4, pp. 466-477, 1998

[10]. *History of Fingerprint Removal*, http://jimfisher.edinboro.edu/forensics/fire/print.html

[11]. J. Feng, A. K. Jain, A. Ross, "*Fingerprint Alteration*", MSU Technical Report, MSU-CSE-09-30, Dec. 2009

[12]. Xudong Jiang, Manhua Liu, Alex C. Kot "*Fingerprint Retrieval for Identification*", IEEE Transactions on Information Forensics and Security, Vol.1, no.4, 2006.

[13]. Jin Bo, Tang Hua Ping, Xu Ming Lan, "*Fingerprint Singular Point Detection Algorithm by Poincare Index*", WSEAS Transactions in system, Issue 12, Vol. 7, 2008

[14]. F.A. Afsar, M. Arif and M. Hussain, "*Fingerprint Identification and Verification System using Minutiae matching*", National Conference on Emerging Technologies, 2004.

[15]. Jie Zhou, Jinwel Gu, "*Model-Based Method for the Computation of Fingerprints Orientation Field*", IEEE Transactions on Image Processing, Vol 13, No. 6, 2004.

[16]. Asker M. Bazen and Sabih H. Gerez, "*Systematic Methods for the Computation of the Directional Fields and Singular Points of Fingerprints*", IEEE Transactions on Pattern analysis and Machine Intelligence, Vol 24,No. 7, 2002.

[17]. Kenneth Nilsson and Josef Bigun, "*Complex Filters Applied to Fingerprint Images Detecting Prominent Symmetry Points Used for Alignment*", Springer-Verlag Berlin Heidelberg 2002, LNCS 2359, pp.39-47, 2002.

[18]. Puneet Gupta n, Phalguni Gupta, "*An efficient slap fingerprint segmentation and hand classification algorithm*", Neurocomputing142 (2014)464–477, 2014.

[19]. Soweon Yoon, Jianjiang Feng, and Anil K. Jain, "*Altered Fingerprints: Analysis and Detection*", IEEE Transactions on Pattern Analysis and Machine Intelligence, VOL. 34, NO. 3, March 2012.

[20]. Jianjiang Feng, Anil K. Jain, Arun Ross, "*Detecting Altered Fingerprints*", International Conference on Pattern Recognition, 2010.