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# A Study of History Document Fingerprint Image Enhancement and Tinning Algorithm

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**ABSTRACT**: History documents fingerprint, generally of not good quality, are collected under controlled conditions from a known subject using ink on paper or digitally with a live scan device. The history document fingerprint images are often small, unclear, distorted, smudged, or contain few features; can overlap with other prints or appear on complex backgrounds, and can contain artifacts from the collection process and we need to enhancement old fingerprint image. We present a fingerprint enhancement algorithm, which can adaptively improve the clarity of ridge and furrow structures of input fingerprint images based on the estimated local ridge orientation and frequency. In this research shows the Gaussian and Fast filtering techniques, Mathematical operators, Canny and Sobel edge detection methods, enhancement Sharpen techniques and Morphological, Zhang-Suen and Stentiford thinning methods and combined their methods and some experiment results in history fingerprint images. The enhancement, sharpen techniques, Canny edge detection, Gaussian filter and Zhang-Suen thinning methods combined gave the good result and much more reduced noise, increased edges, gave the lightning and enhanced fingerprint image.

**KEY WORDS**: Fingerprint, minutiae, thinning, algorithm, latent

## I. INTRODUCTION

In history, fingerprint image was acquired by using so-called "ink technology" for law enforcement applications [1]. The subject finger should be smeared with black ink and pressed on a paper card, and then the card is scanned by a general scanner to produce the digital image. This acquisition process is called off-line sensing. However, it is not convenient in civil applications or other fields. Nowadays, most individuals and enterprises are preferred to use the automated fingerprint identification system (AFIS) which can sense the finger surface with fingerprint reader directly [2]. No ink is required for capturing fingerprint image, and all things needed to do are to present a finger to an electronic scanner. The scanner will read the ridge pattern of the fingerprint and send the image to a computer. After pre-processing and matching, a personal identity can be verified. But, images traditionally need enhancement, such as contrast improvement, noise reduction, and unrolling to provide reasonable accuracy. Traditionally, the fingerprint images are acquired with a scanner giving images with ink stains, translation and rotation problems. The above hindrances make very hard the fingerprint verification task and very robust algorithms need to process the noisy fingerprint images. A lot of noise problems can arise with ink-on-paper fingerprint images [3]. History documents fingerprint, generally of not good quality, are collected under controlled conditions from a known subject using ink on paper or digitally with a live scan device. The history document fingerprint images are often small, unclear, distorted, smudged, or contain few features; can overlap with other prints or appear on complex backgrounds, and can contain artifacts from the collection process and we need to enhancement old fingerprint image [4]. Also, fingerprint identification plays a major role in crime scene investigation. Latent fingerprints are the irregular fingerprints which do not contain any clear ridge structures. In fingerprint matching techniques, the ridge lines are important to extract the features in the finger image [5]. Lifting of latent's may involve a complicated process, and it can range from simply photographing the print to more complex dusting or chemical processing [6]. Concerning these two approaches, this work proposes three methods for old fingerprint image enhancement. The first one is carried out using various thinning methods for direct grayscale enhancement. The second method uses to edge detection techniques and mathematical operators. Finally fingerprints the results of a comparative study of our approaches and the methods described in this paper.

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## II. METHODS

### A) Thinning algorithms

Thinning algorithm is a Morphological operation that is used to remove selected foreground pixels from binary images [7]. It preserves the topology of the original region while throwing away most of the original foreground pixels. Thinning is somewhat like erosion or opening. It can be used for several applications but is particularly useful for skeletonization and Medial Axis Transform [8]. In this mode, it is commonly used to tidy up the output of edge detectors by reducing all lines to single pixel thickness [9]. Mathematical Morphology is the analysis of signals in terms of shape. This simply means that morphology works by changing the shape of objects contained within the signal [10]. Mathematical morphology was developed in the 1970’s by G. Matheron and J. Serra [11]. The Template-Based Mark-and-Delete Thinning Algorithms are very popular because of their reliability and effectiveness. This type of thinning processes uses templates, where a match of the template in the image, deletes the center pixel. They are iterative algorithms, which erodes the outer layers of the pixel until no more layers can be removed [12]. Almost all iterative thinning algorithms use Mark-and-Delete templates including Stentiford Thinning Method. Zhang-Suen Thinning Algorithm is skeletonization algorithm is a parallel method that means the new value obtained only depend on the previous iteration value. It is fast and simple to be implemented [13]. This algorithm is made by two sub-iterations [14]. Thinning can be used for several applications such as hand-written character recognition, but it is particularly useful for skeletonization [15].

### B) Minutiae types

Fingerprints are characterized by a system of lines having a certain bending, by terminal points and by bifurcation of lines [3]. Human fingerprints are rich in details called minutiae, which can be used as identification marks for fingerprint verification [16]. To achieve good minutiae extraction in fingerprints with varying quality, pre-processing in form of image enhancement and binarization is first applied on fingerprints before they are evaluated [17]. Many methods have been combined to build a minutia extractor and a minutia matcher. Minutiae, in fingerprinting terms, are the points of interest in a fingerprint, such as bifurcations *(a ridge splitting into two)* and ridge endings. Approximately 80 percent of vendors base their algorithms on the extraction of minutiae points relating to breaks in the ridges of the fingertips [18]. Other algorithms are based on extracting ridge patterns. A good quality fingerprint typically contains about 40-100 minutiae [19]. Sir Francis Galton (1822-1922) was the first person who observed the structures and permanence of minutiae. Therefore, minutiae are also called “Galton details”. They are used by forensic experts to match two fingerprints. There are about 150 different types of minutiae [20] categorized based on their configuration. Among these minutiae types: Ridge termination or endings *(a ridge that ends abruptly)*, Ridge bifurcation *(a single ridge that divides into two ridges)*, Short ridges, island or independent ridge and dot or island *(a ridge that commences, travels a short distance and then ends)*, Ridge enclosures or lake *(a single ridge that bifurcates and reunites shortly afterward to continue as a single ridge)*, Spur *(a bifurcation with a short ridge branching off a longer ridge)* and Crossover or bridge *(a short ridge that runs between two parallel ridges).* An ideal matching fingerprint task is immune from translation, rotation and non-linear deformations of fingerprints. Classic matching consists on counting and maximizing the number of the matching minutia pairs between two fingerprints [21-22]. In fact, matching latent fingerprints from crime scenes is difficult because of their poor quality and the fingerprint matching accuracy is improved by combining manually marked minutiae with automatically extracted ones [23].

### C) Mathematical operators

Mathematical morphology operations allow object identification based on shape and are useful for grouping a cluster of small objects into one object [24]. More detailed treatments of binary and grayscale mathematical morphology theory are given by Serra [11] and by Haralick et al [25]. Image arithmetic applies one of the standard arithmetic operations or a logical operator to two or more images. The operators are applied in a pixel-by-pixel fashion which means that the value of a pixel in the output image depends only on the values of the corresponding pixels in the input images [26]. Hence, the images normally have to be of the same size. One of the input images may be a constant value, for example when adding a constant offset to an image. Although image arithmetic is the simplest form of image processing, there is a wide range of applications. The main advantage of arithmetic operators is that the process is very simple and therefore fast. In this research used to LoG, And, Or, Min, Max, Exp, Square root, Square and Reciprocal mathematical operators, Sobel and Canny edge detection methods, Enhancement, Sharpen techniques, Fast, Sobel Gx, Gy and Gaussian filters. Gaussian filtering is used to blur images and remove noise and detail. It is used in mathematics and smoothing operator. Sharpen techniques improve the clearness of digital images by enhancing the marks of the objects which are present in the scene

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[27]. Canny edge detector an optimal edge detection technique to provide good detection, clear response and good localization [28]. Our experiments combined their methods and gave the good results.

## III. METHODOLOGY

The performance of a minutiae extraction algorithm relies heavily on the quality of the input fingerprint images. We can good quality live scan fingerprint image. But, in practice, due to variations in impression conditions, ridge configuration, skin conditions, acquisition devices, and non-cooperative attitude of subjects, a significant percentage of an acquired fingerprint image is of poor quality and we need enhancement fingerprint images. The ridge structures in poor quality fingerprint images are not always well defined and hence they cannot be correctly detected. Our methodology is trained enhancement filtering methods, correct edge detection method chooses and combined morphological thinning methods *(figure 1*).

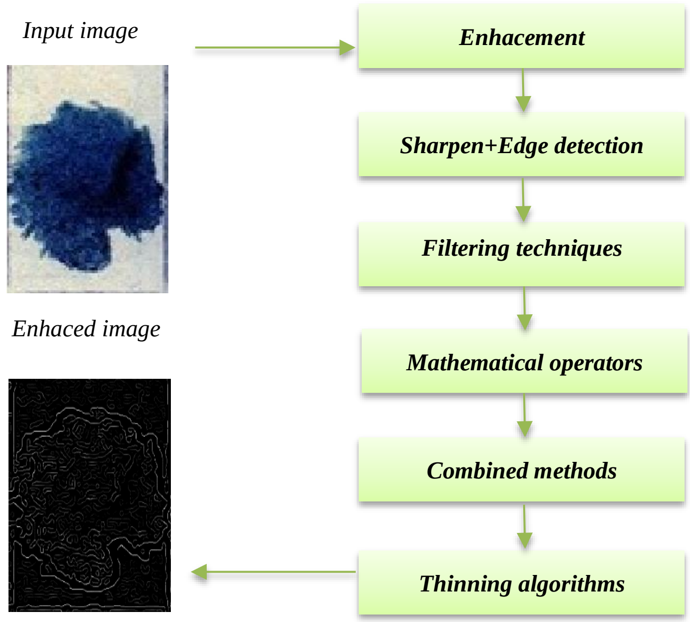


Fig 1: A flowchart of the proposed history fingerprint image enhancement method

## IV. RESULTS AND DISCUSSION

The goal of an enhancement algorithm is to improve the clarity of ridge structures of fingerprint images in a recoverable region and to remove the unrecoverable regions. A fingerprint enhancement algorithm should not result in any spurious ridge structures. This is very important because spurious ridge structure may change the individuality of input fingerprints. This research used to Mongolian archive history documents. We trained various mathematical operators, edge detection methods and various morphological thinning methods combined and show an example of some result images *(figure 2 to 4*).

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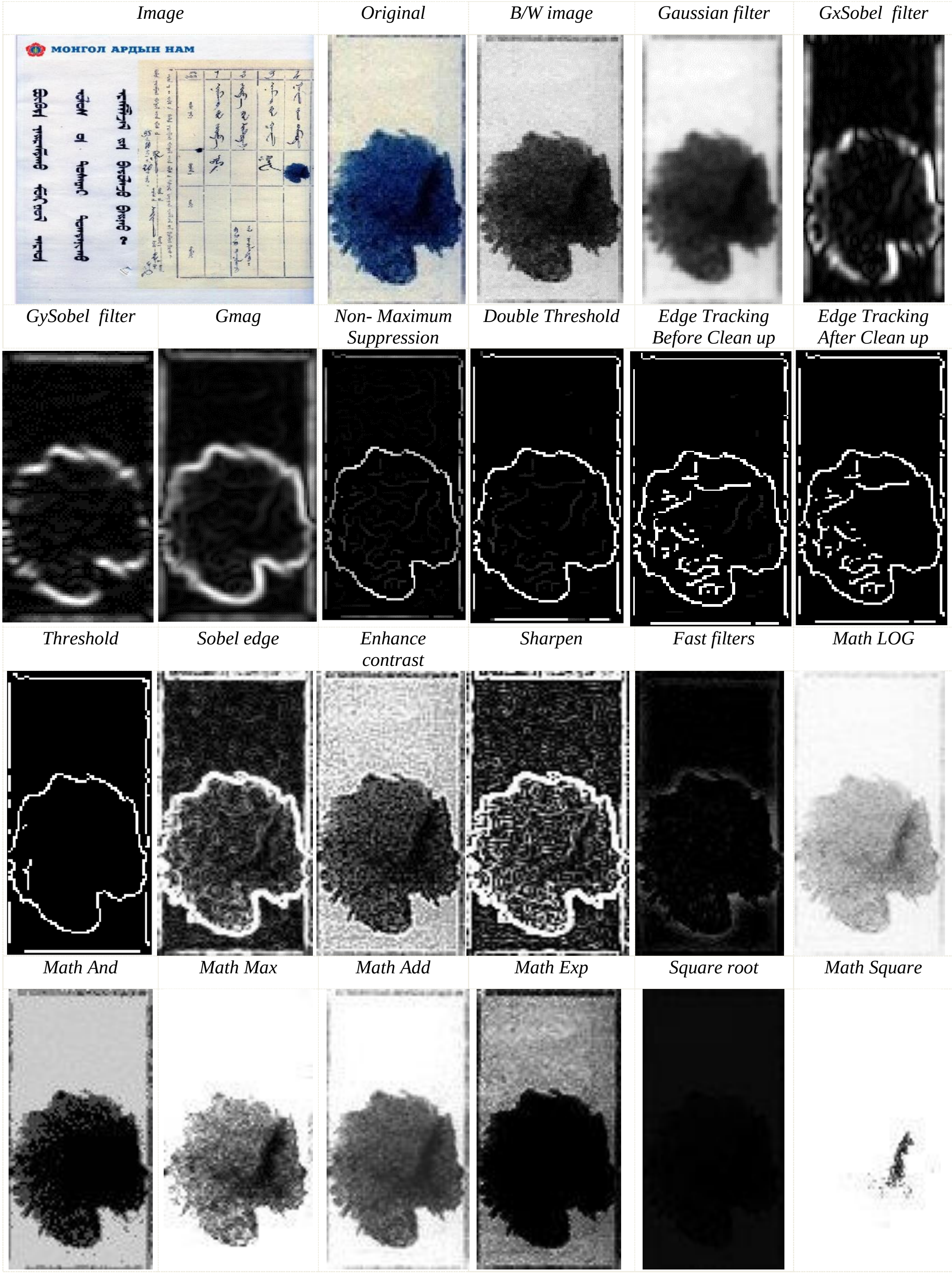

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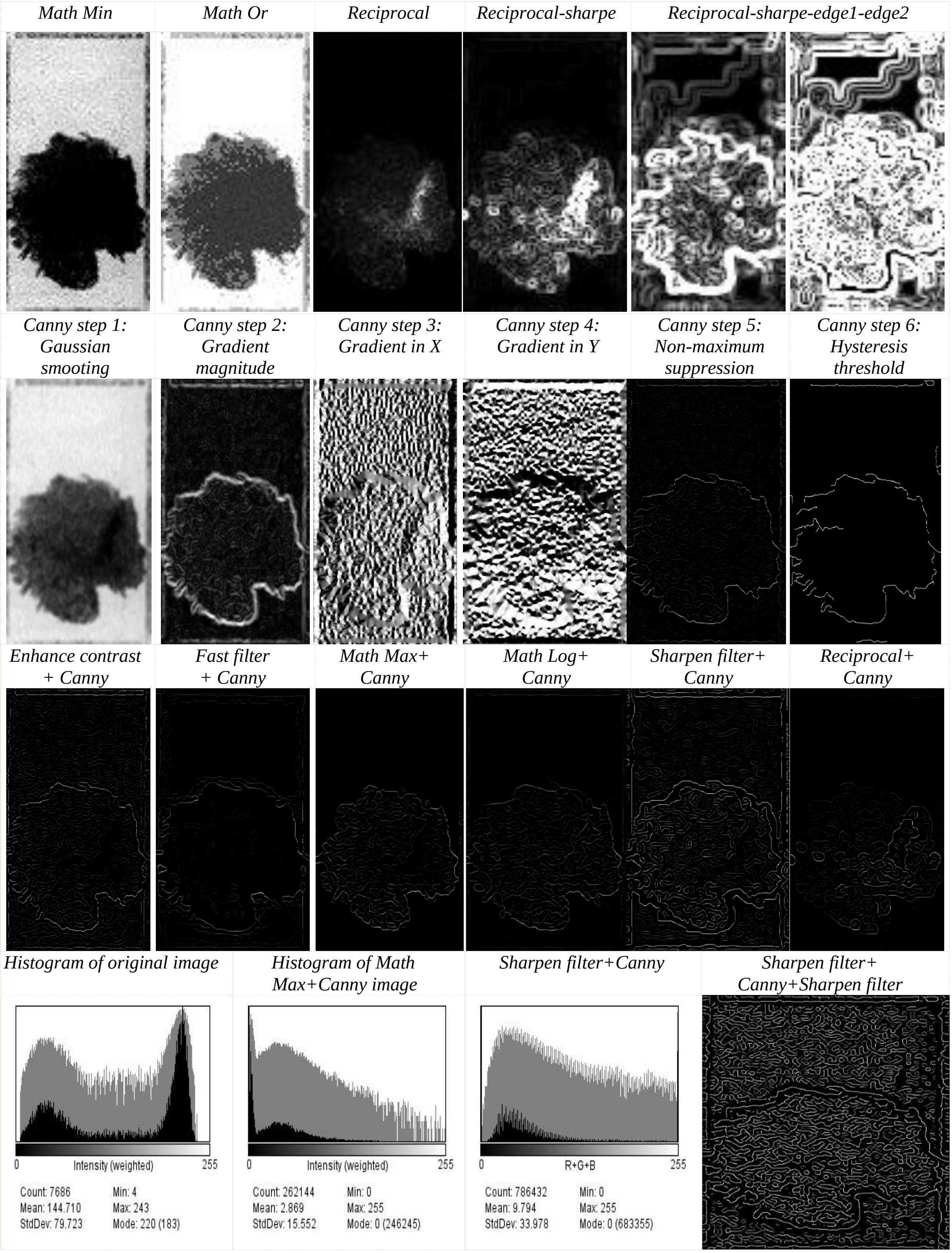


Fig 2: Enhancement, Filters, Math operation, Sobel and Canny edge detect methods some result images

So far, we have seen a model for diffusing still images to remove noise or texture, and a model for sharpening the edges of a diffused image, both focusing on speed and efficiency rather than the quality of results. We have also seen a comparison of a couple of other variationally models for different textured images *(figure 2)*. All models displayed varying degrees of success, performing well with some images and poorly with others. In practice, the Gaussian filters are blurred images and remove noise detail much more but not increase radius 2.5. Sharpen technique is increased improve the clearness enhancement image and lightning edges. Also, we the trained basic definitions of binary mathematical morphology. Mathematical Log, And, Or, Min, Max, Exp, Square root, Square and Reciprocal operators experiment results gave the brightest and darkest points much more increased in the history of fingerprint images. In practice, this assumption is improved edges for fingerprint images of poor quality, which greatly convenient the applicability of Sobel and Canny edge detection techniques. These techniques also combined Sharpen and Gaussian filtering techniques gave the good result and much more noise reduced. Also, we show an example of some fingerprint images histogram *(figure 2)*.

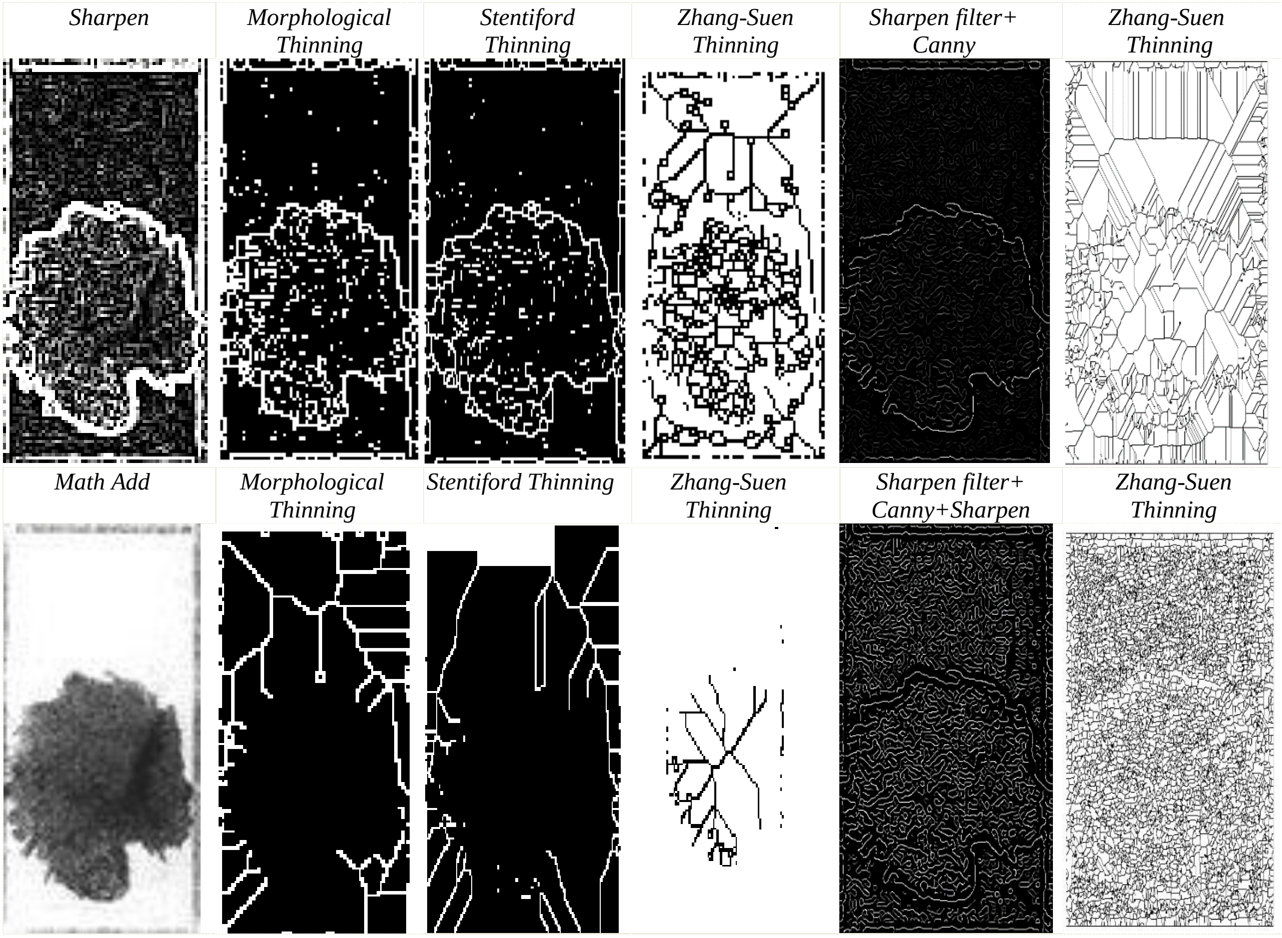


Fig 3: Thinning algorithms some result images

The following *(figure 3*) shows the thinned image resulting from the application of a hybrid implementation based on the merging of the above algorithms in the following order: Stentiford's pre-processing scheme feeding images into Zhang-Suen's basic algorithm, with Holt's staircase removal algorithm as a post-processor. The Stentiford method tends to produce lines that follow curves well, resulting in vectors that most accurately reflect the original image. The Zhang-Suen method tends to be better at extracting straight lines from a raster, so may result in more desirable vectors from an original image which comprises mainly straight lines [13, 28]. Thinning algorithm is a Morphological operation that is used to remove selected foreground pixels from binary images but not gave the good result in history fingerprint images.

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The enhancement, Sharpen techniques, Canny edge detection, Gaussian filter and Zhang-Suen thinning methods combined gave the good result and much more reduced noise, increased edges, gave the lightning and enhanced fingerprint image.

## V. CONCLUSION

History documents fingerprint, generally of not good quality, are collected under controlled conditions from a known subject using ink on paper or digitally with a live scan device. The history document fingerprint images are often small, unclear, distorted, smudged, or contain few features; can overlap with other prints or appear on complex backgrounds, and can contain artifacts from the collection process and we need to enhancement old fingerprint image. History fingerprint image is possible to develop an enhancement algorithm that exploits these visual clues to improve the clarity of ridge structures in corrupted and enhancement. We trained an enhancement algorithm which can adaptively enhance the ridge and furrow structures, a computationally efficient filtering the Gaussian and Fast filtering technique, Mathematical Log, And, Or, Min, Max, Exp, Square root, Square and Reciprocal operators, Canny and Sobel edge detection methods, enhancement Sharpen techniques and Morphological, Zhang-Suen and Stentiford thinning methods and combined their methods and some experiment results in fingerprint images. Mathematical operators experiment results gave the brightest and darkest points much more increased in the history of fingerprint images. The morphological and Stentiford thinning methods not gave the good result of our experiments history fingerprint images. The enhancement, Sharpen techniques, Canny edge detection, Gaussian filter and Zhang-Suen morphological thinning methods combined gave the good result and much more reduced noise, increased edges, gave the lightning and enhanced fingerprint image. The techniques based on direct grayscale enhancement perform better than approaches which require Gaussian filtering techniques and Zhang-Suen morphological thinning as all steps. Also, this technique will be able to improve the latent image quality and to reduce the errors during the matching process.

## REFERENCES

[1] Letian Cao & Yazhou Wang, (2016): Fingerprint image enhancement and minutiae extraction algorithm, Master thesis, Linnaeus University, Sweden, pp 1-2 S.
[2] Balaji & N. Venkatram, (2008): Filtering of noise in fingerprint images. International Journal of Systems and Technologies, Vol. 1, No.1, pp 87-94
[3] Vincenzo Conti, Giovanni Pilato, Salvatore Vitabile, Fillippo Sorbello, (2002): Verification of Ink-on-paper Fingerprints by Using Image Processing Techniques and a New Matching Operator, http://www.researchgate.com/publication/2529861, pp 1-7
[4] Ganbold Ganchimeg (2015): History Document Image Background Noise and Removal Methods. International Journal of Knowledge Content Development & Technology, Vol.5, №2, December, pp 11-24
[5] R. Kausalya & A. Ramya, (2014): Latent Fingerprint Images Enhancement Techniques. International Journal of Advanced Research in Computer and Communication Engineering, Vol.3, Issue 2, February, pp 5671-5674
[6] C. Champod, C. Lennard, P. Margot, and M. Stoilovic (2016). Fingerprints and Other Ridge Skin Impressions, Boca Raton, FL: CRC Press, 2nd edition, pp 428
[7] Christian Neusius, Jan Olszewski (1994): A Noniterative Thinning Algorithm.ACM Transactions on Mathematical Software (TOMS), Vol. 20, Issue 1, March, pp 5-20
[8] P. Subashini & S. Jansi, (2011): Optimal Thinning Algorithm for detection of FCD in MRI Images. International Journal of Scientific & Engineering Research Volume 2, Issue 9, September, pp 1-7
[9] P. C. K. Kwok, (1989): Customizing Thinning Algorithms, Processing of IEEE International conference of Image Processing Applications, pp. 633-637
[10] Ritter G., X., & Wilson, J., N., (2001): Handbook of Computer Vision Algorithms in Image Algebra, second edition, CRC Press LLC, Boca Raton, London New York, Washington, D.C
[11] Serra J (1982): Image Analysis and Mathematical Morphology, Academic press, London
[12] Sonka, M., Hlavac, V., Boyle, R (1998): Image Processing, Analysis, and Machine Vision. 2nd Edition, Pws. Pub. Co., 1998.
[13] Zhang and Suen (1984): A Fast-Parallel Algorithm for Thinning Digital Patterns. Image processing and Computer Vision, Volume 27, Number 3, March, pp 236-239
[14] Alberto Martin and Sabri Tosunoglu (1986), Image Processing techniques for Machine Vision, pp 1-9
[15] Louisa Lam, Seong-Whan Lee (1992): A Survey of Thinning Methodologies, IEEE transactions on pattern analysis and machine intelligence, Vol.14, No.9, September
[16] Gonzalez (2002): Digital Image Processing, 2nd Edition, pp 282-359
[17] Sarah Bal & Anmol Kalra, (2014): Biometrics-Fingerprint Recognition. International Journal of Information & Computation Technology, Volume 4, Number 1, pp 1097-1102
[18] K. Sapthagiri & P. Sravya, (2015): Finger print recognition system using ridge thinning method, International Journal of Science, Engineering and Technology Research (IJSETR), Volume 4, Issue 5, May, pp 1302-1307

ISSN: 2350-0328

International Journal of AdvancedResearch in Science, Engineering and Technology

Vol. 6, Issue 3 , March 2019

[19] L. Hong, A. K. Jain, S. Pankanti and R. Bolle (1996): Fingerprint Enhancement: In Proceedings of the first IEEEWACV, pp 202-207, Sarasota, FL

[20] K. Jain, L. Hong, and R. Bolle, (1997): On-line fingerprint verification. IEEE Transactions on Pattern Analysis and Machine Intelligence, 19(4), pp. 302–314

[21] L. Coetzee, E. C. Botha (1993): Fingerprint recognition in low quality images. Pattern recognition, Vol.26, No.10, 1993, pp.1441-1460

[22] Gjjgj Z. M. Kovacs-Vajna (2000): A fingerprint verification system based on triangular matching and dynamic time warping. IEEE transaction on pattern analysis and machine intelligence, Vol.22, No.11, November, pp.1266-1276

[23] A.A. Paulino, A. K. Jain, F. Jianjiang, (2010); Latent Fingerprint Matching. Fusion of Manually Marked and Derived Minutiae, In Proc. 23rd SIBGRAPI Conference on Graphics, Patterns and Images (SIBGRAPI), pp.63- 70

[24] Grace T. Bartoo, Yongmin Kim, Robert M. Haralick, David Nochlin, and Shuzo Mark Sumi (1988), SPIE Vol. 914, Medical Imaging II, pp 466-475

[25] Robert Fisher, Simon Perkins, Ashley Walker and Erik Wolfart (2000): Hypermedia Image Processing Reference, Copyright © 2000

[26] Ganbold Ganchimeg (2016): Digital Image Processing Techniques for Object Detection and Shape Matching. Conference on Mongolian Information Technology, MMT 2016, pp 167-172, Mongolia, 06/05/2016

[27] John Canny (1986): A Computational Approach to Edge Detection. IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. PAMI-8, No. 6, November, pp 679-698, doi: 10.1109/TPAMI.1986.4767851

[28] Haralick, R.M., Stenberg, S., and Zhuang, X., (1987): Image Analysis Using Mathematical Morphology, Part I, IEEE Trans. of Pattern Analysis and Machine Intelligence, Vol. PAMI-9, No. 4, July, pp 532-550

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