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A Comparitive Rugoscopic Analysis for Accurate Feature Extraction

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ABSTRACT

Biometrics is an interesting pattern recognition research area comprising of various modalities. The neoteric security issues such as hacking and theft have put tokens, codes and pins in jeopardy. The biometric systems and modalities have emerged as a ray of hope and have proved to be a diacatholicon for authenticity. Fingerprints are one such modality which has proved its uniqueness and consistency over a period of time with a gargantuan number of users. This paper focuses on the pre-processing stages of a fingerprint processing. Thinning algorithms such as Guo-Hall's, Stentiford and Hall's are used and compared analytically. The texture features such as Energy, Entropy and Correlation coefficient have been obtained to bolster the use of thinning. The simulations are performed and results have been procured.

Keywords: Fingerprint, Texture features, Thinning.

1. INTRODUCTION

Biometrics is the praxis of using biological data in the most effective form to authenticate an individual and is considered as the most intriguing pattern recognition research area in recent times. It encompasses automated methods of recognizing an individual based on computed biotic and comportmented characteristics. The birth of an individual vouchsafes ineradicable traits and idiosyncratic characteristics which befits a biometric system. Due to the colossal advantages, large number of modalities has been introduced. Amongst the various modalities, fingerprints are the oldest and widely used. The prints on the finger are formed during the early embryonic development. The distinct motifs formed in the finger are caused by the continuous folding of the fingers and are known as volar pads [3]. Based on the alignment of pads formed, the patterns are classified into a basic whorl, arch or a loop. The ridges appear as a whorl, when the volar pads are conspicuous and forms explicit convolutions. But if the ridges appear when the volar pads are unconcealed, the pattern formed would be a loop. The arrangement of ridges is called as a loop when the volar pads are yet to be saturated. The rudimentary ridge patterns are shown in Figure 1.

Loops are ridge patterns which enter from one side, make a rise and egresses on the same side from where it entered. A circular formation of the ridges is called as a Whorl. An arch is a pattern when ridges

Figure 1: Basic Ridge Patterns

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enter from one side, surges up in the center and exits on the other side of the finger. Apart from the basic ridge patterns, there are other subdivided patterns which occur such as a tented arch, ulnar loop, radial loop, double loop and center pocket loops. Concentric, spiral, imploding and composite whorls are a few sub patterns which are formed from the basic whorl pattern. Fingerprints have been used for over one hundred years and are well accepted as an extraordinary recognition technology. Other modalities such as Facial recognition, palm prints, Iris scans, voice recognition, DNA, signature, hand geometry and gait recognition [1] are also employed in many fields.

The extraordinary feature of a fingerprint is determined by a pivotal component called the minutiae [7, 8]. Each minutiae may occur at different positions which vary from finger to finger. These minutiae points play a significant role in the post processing stages like the fingerprint matching. The various classifications of minutiae are dots, bridge, enclosures, and trifurcations [9]. Fingerprint applications ranges from forensic departments for criminal investigations [2] to attendance systems and various other security systems. The preprocessing steps are vital for all fingerprints to avoid noise, ambiguity and to ensure better enhancement and clarity [4], [20]. A fingerprint with good quality is that which is clear and free from noise, a medium quality and a poor quality fingerprint would consist of relative amount of noise, scars and dirt [10]. But however good the quality of the fingerprint is, it should go through the process of preprocessing for accurate plotting of minutiae. Preprocessing involves binarization and thinning of the ridges in a fingerprint. Before a fingerprint image enters this preprocessing stage, it is checked for its type, whether it is a RGB or a grayscale image. The RGB image is otherwise called as a true color image [11]. A gray scale image consists of 256 values. If the given input image is a RGB image, it is first converted to its grayscale image and then sent for the preprocessing channel. Binarization of the grayscale image involves converting an image with 256 values to a corresponding image having only 0's and 1's, where 0 represents the ridges and 1 is for furrows or valleys [17, 18]. Binary images are easy to store and manipulate, as each pixel is converted to a single valued pixel. A binary image is obtained by comparing each pixel value of a grayscale image with a threshold value. In a binarized image, the ridges of the fingerprint are usually thick which makes it difficult for plotting of minutiae [16, 17]. Thinning is the vital process which helps to trim the width of each ridge in a fingerprint to a one pixel value [6], [20]. A minutiae point is better extracted in a perfectly thinned image rather than in a binarized image [12, 13]. Skeletonization is a form of thinning where the pixels on the boundary of the image are removed but the continuity is preserved.

2. THINNING ALGORITHMS

Guo – Hall's algorithm [6], [20] is an iterative process executed over each pixel of the fingerprint. This algorithm is applied on a block of pixels in a chosen matrix. The 8-connectivity and 4-connectivity are used to resolve connectivity problems. C (P_1) is given as the distinct number of 1's in p1's 8-neighborhood. N(p_1) provides an end-point check, and preserves the endpoints while deleting many redundant pixels in the middle of the curve.

Table 1
Guo-Hall's Algorithm

```
While deletion of points do
    for every pixels p(i,j) do
        if    (a) C(p1) is equal to 1;
              (b) N(p1) is either 2 or 3;
              (c) Apply one of the following:
              1. ((i-1,j) V (i-1,j+1) V (i+1,j+1)) v (i,j+1) = 0 in odd iterations
              2. ((i+1,j) V (i+1,j-1) V (i-1,j-1)) ^ (i,j-1) = 0 in even iterations
                 Delete pixel p(i,j)
        end if
end for
end
```

The Stentiford's algorithm [21, 22, 23] is a parallel thinning algorithm that thins the ridges of the fingerprint and at the same time preserves the connectivity of the image by forming accurate curves as in the original image. A set of four templates is used to find the deletability of pixels, where cp (i,j) represents the center pixel, and L,B and R(Img) represents the left, bottom and right of the image to be processed.

The connectivity number finds the number of objects connected with any pixel at a given point of time [15, 16]. The connectivity Number is given by:

$$C_N = \Sigma_{k \in S} * N_K - (N_K * N_{K+1} * N_{K+2}) \quad (1)$$

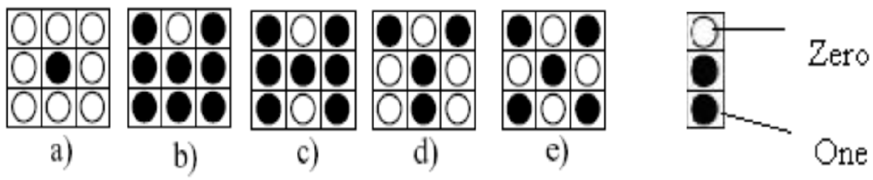

Figure 2: Connectivity Pattern

The Connectivity Numbers (C_N) for Figure 2: a) $C_N = 0$, b) $C_N = 1$, c) $C_N = 2$, d) $C_N = 3$, e) $C_N = 4$.

Table 2
Stentiford's Algorithm

```
Find p (i,j) = T1
    if ((cp (i,j) != 1) && (C_N==1)) Then Delete p(i,j)
        if (i,j) == T1 repeat steps 1 & 2.
        else if (i,j) == T2, T3 and T4 repeat steps 1 to 3.
          T2 == L (Img), moving from bottom to top and from left to right.
          T3 == B (Img) moving from right to left and from bottom to top.
          T4 == R (Img), moving from top to bottom and right to left.
                Set white the pixels marked for deletion.
          end if
        end if
    end
```

The Hall's algorithm [6], [18] is a parallel thinning algorithm that is partially serialized into two distinct sub-iterations. The Hall's algorithm checks for the deletability of the pixel at the initial stage, and then the ridges are thinned pixel by pixel.

Table 3
Hall's Algorithm

```
For all pixels p(i,j) do
    Determine deletability of pixel
    if (1< B(p) < 7) & (A(p) = = 1) then p(i,j) = deletable
        end if
    end for
        for all pixels p(i,j) do
    if ((i-1,j) = (i+1,j) =1 and (i,j+1) is deletable) & ((i,j+1) = (i,j-1) = 1
    and (i+1,j) is deletable) & ((i,j+1),(i+1,j+1),(i+1,j) are deletable
        then Do not Delete p(i,j)
    end if
    end for
end
```

It has been observed that Guo-Hall's algorithm and Stentiford's algorithm gave a thinned image, whereas the Hall's algorithm produced a skeletonized image. The curves have been preserved better in the Stentiford's when compared to the ridges in Guo-Hall's Thinning.

3. TEXTURE FEATURE ANALYSIS

Texture features of a fingerprint help in adding relevant and adequate information for a given fingerprint image. Three texture features like the Entropy, Correlation coefficient and Energy has been computed to show the effect of thinning on fingerprints. Entropy is classified as a statistical measure of randomness that can be used to characterize the texture of an input image [14]. Entropy [11] is defined as:

$$\text{-sum}\,(p.*\log^2(p)) \tag{2}$$

In the above equation, p refers to the value obtained after the normalization of the image. The Correlation Coefficient is computed in two steps: The first is to remove the noise in an image by applying a 2-D median filter [14]. The second step is to apply the correlation coefficient function [11] to the filtered image. The correlation coefficient for an image is given by

$$\frac{r = \Sigma_m \Sigma_n (A_{mn} - \bar{A})(B_{mn} - \bar{B})}{\sqrt{(\Sigma_m \Sigma_n (A_{mn} - \bar{A})^2)(\Sigma_m \Sigma_n (B_{mn} - \bar{B})^2)}} \tag{3}$$

Where A and B are the mean values of A and B.

The input image is subjected to level 5 Daubechies wavelet decomposition [14], [20]. The Shannon entropy is used with a threshold method called Balance Sparsity-norm to find the energy retained in the image after decomposition.

It has been deduced that the values obtained after the thinning process is better than the values acquired before thinning. When the noise is reduced and the quality of the image is good and consistent throughout, the value of the texture features such as entropy and correlation coefficient is said to reduce, which is inversely proportional to the increase in energy retained in an image. This signifies that thinning is a mandatory process that revolutionizes a fingerprint quality.

4. RESULTS

Fingerprint images are taken from biometrics.idealtest.org and the simulations are carried out using MATLAB. The variations in texture features have been shown in the below two tables. Three fingerprint images were taken for observation to elucidate that texture values obtained after thinning proved to be better.

Table 4
Before Thinning

Images	*Before Thinning*		
	En	*CC*	*Er*
Fp1	4.92	0.98	96.12
Fp2	4.24	0.98	97.20
Fp3	4.67	0.99	96.60

Table 5
After Thinning

Images	*After Thinning*								
	Guo – Hall's			*Stentiford's*			*Hall's*		
	En	*CC*	*Er*	*En*	*CC*	*Er*	*En*	*CC*	*Er*
Fp1	3.78	0.88	99.96	2.42	0.81	99.97	3.92	0.86	98.76
Fp2	3.84	0.86	99.95	2.37	0.78	99.98	3.99	0.90	97.98
Fp3	3.95	0.88	99.93	2.40	0.80	99.99	4.15	0.98	96.85

Tables IV and V shows the variations in the values of texture features observed before and after the thinning process. Fp1, Fp2 and Fp3 are the raw fingerprint images taken without the thinning process implemented on them. The terms En, CC and Er, stands for Entropy, Correlation Coefficient and Energy respectively. Table V shows the thinning methods Guo-Hall's, Stentiford's and Hall's applied on the three fingerprint images. The values show the increase in the quality of the image after thinning.

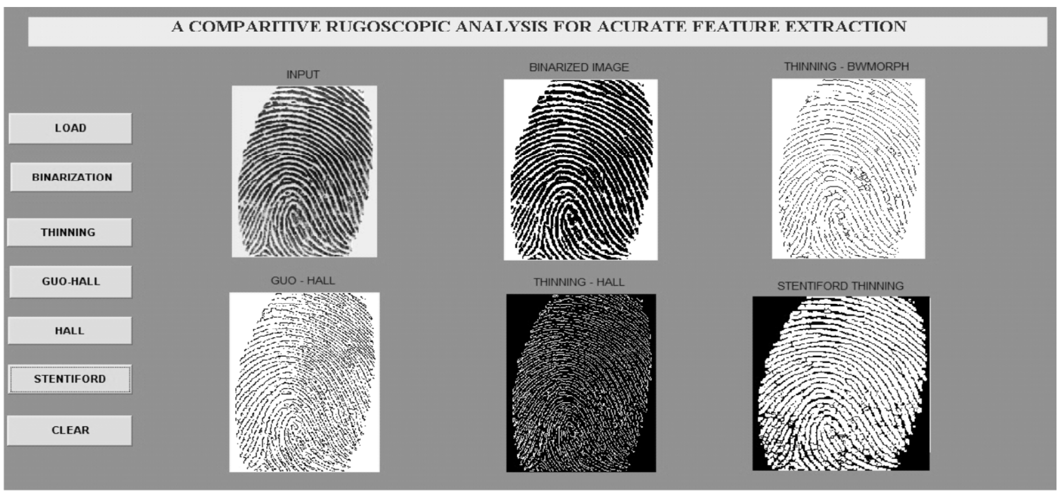

Figure 3: Comparison of Thinning using the three Algorithms

The morphological operation 'thin' is applied to the binarized fingerprint image before using the three algorithms for thinning. This operation of thinning is done infinitely till there occurs no change in the fingerprint image. Figure 3 shows the fingerprint being processed with the thinning algorithms along with the morphological thinning operation. The neighborhood operation is carried out on the binarized image to effectuate the thinning process. The results obtained after thinning significantly stipulate that it is an imperative process for a good quality image. It is deduced that both Guo-Hall's and Stentiford's algorithm gave thinned images. The former was seen to be faster but the latter produced better curves as in the original image. The Hall's algorithm skeletonized the ridges of the fingerprint. The texture feature values were more effective in Stentiford's algorithm with more retained energy in the image.

5. CONCLUSION

The simulations are performed successfully by binarizing, thinning the fingerprint images. The success of any fingerprint recognition strongly relies on the quality of the final output of the fingerprint image. Experimental results showed that the thinning algorithms played a remarkable role on the quality of fingerprints. The Guo-Hall's algorithm was faster and helped maintain the connectivity of the ridges in the fingerprint. On the other hand, the Stentiford's algorithm fosters thinned ridges with spectacular curves that most accurately mirror the original image. The Hall's algorithm produced skeletonized ridges of the given fingerprint. Inorder to obtain results with better performance, an improvement in image binarization, staircase removal along with minutiae extraction and matching could be introduced with more noise such as scars and cuts. The texture features could be more extensively studied as a future work.

REFERENCES

[1] Ross A A, Nandakumar K, Anil K Jain: Handbook of multibiometrics. In : Springer

[2] FBI, http://www.fbi.gov/aboutus/cjis/fingerprints_biometrics/biometric-center-of-excellence/modalities/fingerprint, Jan 2014.

[3] Forensic Science, www.all-about-forensic-science, Jan 2014.

[4] Mario D and Maltoni D: Direct Gray-Scale Minutiae Detection in Fingerprints. In: IEEE Transactions on Pattern Analysis and Machine Intelligence, 1997, 19(1), pp. 27-39.

[5] Huang P, Chang C Y and Chen C C: Implementation of an Automatic Fingerprint Identification System. 1998.

[6] Khanyile N P, Tapamo J R and Dube E: A Comparative Study of Fingerprint Thinning Algorithms. 2011.

[7] Patil N, Kulkarni G and Patil D: Fingerprint recognition for Library management. In: International journal of computation Engineering and Management, 2013 Jan, 16(1).

[8] Maltoni D, Maio D, Jain A K, Prabhakar S: Handbook of fingerprint recognition. In: Springer 2003, 2009.

[9] Mali K and Bhattacharya S: Various aspects of Minutiae as a fingerprint feature. In: International journal of computer science & Engineering Technology (IJCSET), 2002.

[10] Maltoni D and Maio D: Fingerprint analysis and representation. In: IEEE transactions on pattern analysis and machine intelligence, 1997, 19(1), PP.27-39.

[11] Types of Images, www.mathworks.in, Jan 2014.

[12] Prabhakar S, Anil K Jain and Pankathi S: Learning fingerprint minutiae location and type. In: Journal of pattern recognition, 2003, 36(8),PP.1847-57.

[13] Maddala S and Tangellapally S R: Implementation and evaluation of NIST Biometric Image software for Fingerprint recognition, thesis 2010.

[14] Saha M, Chaki J and Parekh R: Fingerprint Recognition using Texture Features. In: The International Journal of Science and Research, 2013, 2 (12).

[15] Raymond T: Fingerprint Image enhancement and minutiae extraction. In: Ph.d thesis, School of Computer Science and software engineering, University of Western Australia, 2003, PP 21-56.

[16] Stoney D A: Distribution of epidermal ridge minutiae. In: American journal of physical anthropology, 2005, 77(33), PP. 367 – 376.

[17] Grace Hannah J, Dr. Gladis D: Dactyloscopy and comparison of Algorithms for Efficacious Minutiae Extraction. In: The International Conference on Advance Research in Engineering & Technology (ICA^{R}ET), 2014, Vol.1 Part-B, 4th Edition, PP. 52-57.

[18] Grace Hannah J and Dr. Gladis D: A Juxtapose of Algorithms for Effective Thinning Integrated with Minutiae Extraction in Fingerprints. In: The International Conference on Communication and Computing (ICC), 2014, Published by Elsevier Pvt. Ltd, PP. 8-15.

[19] Grace Hannah J and Dr. Gladis D: Thinning Algorithms with Texture Features for Effective Dermatoglyphic Analysis. In: The International Conference on Innovations in Contemporary IT Research (ICITR), 2015, Vol II, PP. 58.

[20] Grace Hannah J and Dr. Gladis D: Lophoscopy with Thinning Algorithms for Inimitable Fingerprint Processing. In: The International Conference on Information and Convergence Technology for Smart Society (ICICTS), 2015, 1(1), PP. 254-260.

[21] Alberto Martin and Sabri Tosunaglu: Image Processing Techniques for machine vision.

[22] F.W.M. Stentiford and R.G.Mortimer: New Heuristics for Binary Thinning. In: IEEE Transcations, 1993.

[23] Issac O. Avazi Omeiza: An Investigation of Problem of Thinning in Fingerprint Processing. In: The Nigerian Journal of Technological Development, Vol 9(1) 2012.