Improved The Image Enhancement Using Filtering and Wavelet Transformation Methodologies

Ram Kumar[1], Manoj Eknath Patil[2]

[1]Research Scholar (Ph.D), [2]Research Guide

[1,2]Department of Computer Science & Engineering,Dr. A.P.J Abdul Kalam University, Indore, India

[1]hr.coet@gmail.com, [2]mepatil@gmail.com

Abstract: *The use of a person's fingerprints as a method of identification is both one of the earliest methods and one of the most common methods used today. The process of recognising a person's fingerprints can be broken down into two primary groups: image-based and minutiae-based. An approach to fingerprint identification that is based on photographs is provided in this piece of research. After finding the central point and finishing the pre-processing of the image, the next step is feature extraction, which can be done with the help of a variety of different methods, including the Fast Fourier Transform (FFT), the Discrete Cosine Transform (DCT), the Discrete Wavelet Transform (DWT), and the Gabor Filter. This list is comprised of the mean energy, the standard deviation, and the Shannon entropy. In this study, a comparison of all four transforms reveals that the DCT and DFT are more effective than the DWT and the Gabor filter.*

Keywords: Image Enhancement, Wavelet Transformation, Discrete Cosine Transform (DCT),

I. INTRODUCTION

Over the past few years, a lot more research has been done on fingerprint recognition [1]. Still, it is hard to make a fingerprint identification method that works well and quickly. Two of the most important ways to identify fingerprints are through small details and images [2], [3]. When the quality of the fingerprint picture is improved through pre-treatment, image-based techniques become easier to use and show that they work. A fingerprint's image structure is made up of ridges, furrows, and the places where all of these features meet. Approaches that are based on small details focus mostly on cross points, while methods that are based on pictures focus mostly on how a fingerprint picture is put together. Because the method is based on small details, it doesn't matter how good the fingerprint picture is and can find a different number of cross points. In the past few years, there has been a lot of research on the fingerprint feature [4–10]. Yang [4] used tessellated invariant moments as fingerprint verification characteristics. In [6], the Gabor filter method is used to pull out the direction energy. The fingerprint picture was broken up into eight sub bands using a method described in [7] that was based on directional filter banks. Then, for each block, the direction of the energy distribution was found. Li et al. [8] came up with a way to check a fingerprint. It uses directional filter banks and Hu invariant moments to pull out the fingerprint feature. [8] Tico et al. [9] used wavelet decomposition to pull out features, and then they used the l2-norm of each high frequency sub band (detail sub band) as the fingerprint's features. Wavelet and the Fourier-Mellin Transform (WFMT) is a model that was made to solve problems caused by changes in position and orientation angle as well as changes in shape [10]. After the fingerprint image was cropped, Lee and Wan [11] divided it into eight-by-eight blocks that didn't overlap and used Gabor filters to take a sample from each block. The wavelet methods that came before [9] did not take into account the need to improve the fingerprint image before extracting its features. We were inspired by research that had been done before [11], so we came up with an image-based technique that uses wavelet modification. With our technology, the fingerprint image can be made better. The region of interest (ROI) is also broken up into pieces that don't overlap. One way to explain it is as follows:

（i） Improve Image of Fingerprint.

(ii) Discover the point of comparison and set up a 128 ROI around it.

(iii) Divide the ROI into 16x16 blocks that don't overlap, and use wavelet to separate each block. The fingerprint image can be used to get the wavelet domain feature vector.

(iv) Use the Euclidian distance measure to match features.

II. Related Work

A fingerprint is an illustration of the edges and valleys that may be found on the surface of a fingertip. Fingerprints are used to identify individuals. Each person's fingerprints are absolutely one-of-a-kind and unrepeatable. The edge properties of the surrounding area and the linkages between them are what determine the singularity of a fingerprint [3]. There are many distinguishing features of neighbourhood margins, including but not limited to islands, short edges, walled-in sections, and others that have been uncovered. The information on these characteristics of the neighbouring edge is not communicated in an accurate manner. Because of the nature of fingerprints and the conditions under which they are imprinted, the vast majority of them are only seldom visible in fingerprints. This is because they are so dependent on the nature of fingerprints and the conditions under which they are imprinted. A single bent segment is what's referred to as an edge, and the space that exists between two edges that are near to one another is what's referred to as a valley. The minutiae, which are the neighbourhood discontinuities in the edge stream design, are the source of the highlights that are employed for differentiating proof. It is only possible to create a minutiae pattern using two different kinds of points: edge endpoints and bifurcations. Edge endpoints are the focuses where the edge bends, but bifurcations are the sites where an edge splits from a single path to two paths like a Y-intersection. Bifurcations are also known as Y-intersections. In most cases, a unique mark for a respectable grade will have between 40 and 100 minutiae. When there is a lot of background noise or when the person's skin is in bad condition, the quality of the photographs taken of a person's fingerprint can degrade, which can be problematic for law enforcement purposes. As a direct consequence of this, an advancement strategy is required for the upgrade.

H. Wang et al[1] Large losses can be caused by GIS mechanical issues. Vibration signal detection was employed for GIS monitoring and problem identification. This study uses a custom-built testing setup to investigate GIS vibration. Vibration characteristics and mechanical defects can be studied using a fingerprint extraction method. We discovered that the GIS vibrated at a frequency of 100 Hz after examining vibration signal spectra. Wavelet transformation was used to derive the mechanical vibration fingerprint. As a result, the in-service GIS circuit breakers and arresters shook. Vibration acoustic fingerprints of the aberrant signal differed from conventional ones due to its wide frequency range and substantial harmonic components. GIS mechanical defects can be discovered by comparing frequency spectra and vibration signatures.

B. Samira et al[2] Biometric templates pose security and privacy issues in authentication and integrity verification systems. Encryption, template transformation, and watermark reinforcement algorithms have been presented. Biometrics-based watermarking reinforcement uses watermarking and feature modification. Our innovative biometric watermarking approach has two degrees of protection. Watermarking is used to check fingerprint integrity during transmission or storage. Cancellable transformations prevent the saved biometric template from being registered.

M. Nazarkevych et al[3] Developing fingerprint biometric security. There are several ways to process images. The Ateb-Gabor filter is a new idea that has been offered. To create this new filter, the Gabor function was incorporated (exponential and periodic cosine). Expansion and periodic Ateb cosine functions are combined into one. The transformation of Ateb-wavelet Gabor is investigated. Filtering of fingerprints makes use of both traditional and cutting-edge technologies. The effectiveness of a new filter has been demonstrated. In this case, it's an Adafruit fingerprint scanner coupled with a wxWidgets-based physical model. There is a Python script that it generates. We wrote code in PyCharm.

Patrick J. Van Fleet, et al[4] Two members of the Coiflet filter family, including the Daubechies formulation, are outlined below as a point of reference. Biorthogonal spline filter pairs will also be constructed as part of this research. Cohen-Daubechies-Feauveau biorthogonal filters are used by both the FBI and the JPEG2000 Image Compression Standard Committee to compress digitised fingerprint photographs.

III. Proposed methodology

In contrast to the frequency domain, the spatial domain has been the subject of a significant amount of research and development with regard to the improvement of images. In contrast to that, here is what the frequency domain looks like. Working in the frequency domain is the primary focus of our investigation because, in contrast to working[15] in the spatial domain, it is much simpler to notice the effects of filters when working in the frequency domain. For this reason, we have chosen to centre our investigation on this aspect of the problem. As a direct consequence of this, we will be directing the majority of our efforts in that direction. In addition, after conducting research on the numerous transformations that can be used in the frequency domain, we were interested in locating the one that was superior to the others and produced an improved image of the highest possible quality. This was something that we wanted to discover as soon as possible. This was the aim that we wanted to achieve. Due to the fact that we are analysing fingerprints, a straightforward modification made it possible for us to extract highly detailed information. We were able to adapt the findings of our research to the development of fingerprint authentication[16] and identification systems with the assistance of the minute points that were generated as a consequence of thinning and binarization.

WAVELET TRANSFORM

In order to obtain an improved fingerprint image, a bank of Gabor filters is applied to the ridge-and-valley pixels that were generated from the normalised input fingerprint picture. These pixels were used to generate a ridge-and-valley pattern. This is done so that a more accurate image of the fingerprint can be obtained.

$$\Psi_{a,b}(x) = 2^{-a/2}\Psi(2^{-a} - b)$$

An example of wavelet-based signal processing is provided by the wavelet-based wavelet transformation mentioned below: In terms of rows and columns, y is the final outcome of the one-dimensional wavelet transformation. High-pass and low-pass filters H and G are used in the first step of image deconstruction as shown in the chart below. This is done in order to achieve the intended

$$Wf(x)(a,b) = |a|^{-1/2} \int_R f(x)\Psi(\frac{x-b}{a})dx$$

result.

The subbands denoted by and cA are two instances of subbands that contain low frequencies. The h-j-cD, v-j-cD, and d-j-cD subbands are high frequency subbands that are included in the j-level decomposition. These subbands are responsible[18] for conveying information regarding edges and singularities in the horizontal, vertical, and diagonal directions of the picture, respectively.

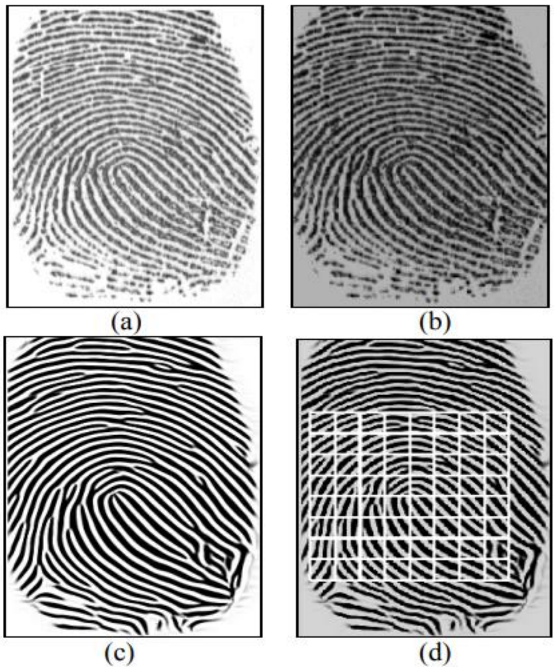

Figure 1. (a) It's the original fingerprint image, (b) Rescaled photograph, (c) better fingerprint recognition, (d) ROI.

The First Steps in The Preconstruction Of The Fingerprint Image

Before attempting to extract the feature of the fingerprint, it is very necessary to first improve the picture of the fingerprint. This is done to ensure that the quality of the fingerprint image does not have a negative impact on the performance of the method for recognising fingerprints. Specifically, this is done so that there is no risk of a false positive. To enhance the look of fingerprint photos, we make use of Hong's boosting approach, which was created specifically for that purpose [19]. The following outline offers a description of Hong's algorithm, including an explanation of its most significant steps.

(i) **Normalization:** The input fingerprint image is normalised using a mean and variance that has been previously determined in order to minimise the effects of sensor noise and changes in finger pressure. (Both the mean and the variance have been assigned a value of 100.)

(ii) **Local frequency estimation:** It is possible to generate a local frequency image by combining an estimated orientation image with each block of normalised fingerprint data (the fingerprint image is broken into 1616 blocks).

(iii) **Region mask estimation**: When deciding whether the block can be recovered or not, the region mask is consulted to make this determination.

(iv) **A bank of Gabor filters** is used to improve the fingerprint image by applying ridge-and-valley pixels derived from the normalised input fingerprint picture. It's done this way in order to get a better impression of your fingerprint.

Feature Extraction using Minutiae Algorithm

The details of local ridge characteristics are critical to the identification of fingerprints. Because of this, it is critical to accurately label the smallest details and eliminate any erroneous ones. As a result of factors including skin variations and scars, as well as wetness and inappropriate contact with scanning tools, fingerprints can be corrupted and degraded. This necessitates the application of picture enhancing techniques prior to the extraction of minute features. [20] Miniature points are used to illustrate discontinuities, and they can take on a number of shapes:Ridge Ending: ridge ends at this point suddenly.

(i) Point where a ridge splits into two or more separate ones.
(ii) This type of ridge is known as "Ridge Dots."
(iii) Ridge Islands are the name given to the small islands that can be found in the space between two separate ridges.
(iv) Ponds and lakes: these are the empty spaces that can be found between the ridges..
(v) **Bridges:** These are the little ridges that connect the larger ridges that are adjacent. An image segmentation algorithm is necessary to discern between the noisy backgrounds and the foreground in order to obtain high precision when working with minute points. Calculations for image enhancement necessitate preserving the original ridge flow model without making any modifications. The methodologies for the extraction of the minute details can be broadly divided into two categories: [21]

Conclusion

The work could benefit from more enhancements, which will be discussed in greater depth below. When applied to latent fingerprints of poor quality, the results of painting and Exemplar are not favourable since these techniques complete the image using the information that is already available in the image. This causes the results of these techniques to be unfavourable. In addition, when the latent is weak, there is a very limited amount of present information available. In addition, the scope of the work that is being asked is restricted so that it only includes images in black and white. In the not too distant future, work may be done on photographs that contain colour. As a direct consequence of this, the conclusion of a latent that is of low quality continues to be a challenging task. There is opportunity for further enhancement in the pre-processing stage of the recommended algorithm, notably in the form of automatic segmentation and ROI formation.

Reference

[1]. H. Wang, J. Yang, X. wang, F. Li, W. Liu and H. Liang, "Feature Fingerprint Extraction and Abnormity Diagnosis Method of the Vibration on the GIS," 2020 IEEE International Conference on High Voltage Engineering and Application (ICHVE), 2020, pp. 1-4, doi: 10.1109/ICHVE49031.2020.9279652.
[2]. B. Samira, R. H. Lamia and E. B. A. Najoua, "Biometric Template Security Using Watermarking Reinforcement Based Cancellable Transformation," 2021 International Conference on Cyberworlds (CW), 2021, pp. 270-277, doi: 10.1109/CW52790.2021.00052.
[3]. M. Nazarkevych, M. Kipish, Y. Voznyi, Y. Sydorenko, M. Podavalkina and O. Shevchuk, "Fingerprint Recognition Device is Built on the Method of Filtering Ateb-Gabor," 2019 IEEE International Scientific-Practical Conference Problems of Infocommunications, Science and Technology (PIC S&T), 2019, pp. 179-182, doi: 10.1109/PICST47496.2019.9061509.
[4]. Patrick J. Van Fleet, "FILTER CONSTRUCTION IN THE FOURIER DOMAIN," in Discrete Wavelet Transformations: An Elementary Approach with Applications , Wiley, 2019, pp.365-426, doi: 10.1002/9781119555414.ch9.

[5]. Santosh, N.K., Barpanda, S.S. Wavelet and PCA-based glaucoma classification through novel methodological enhanced retinal images. *Machine Vision and Applications* **33,** 11 (2022). https://doi.org/10.1007/s00138-021-01263-w
[6]. Romualdo, L.C.S., Vieira, M.A.C., Schiabel, H. *et al.* Mammographic Image Denoising and Enhancement Using the Anscombe Transformation, Adaptive Wiener Filtering, and the Modulation Transfer Function. *J Digit Imaging* **26,** 183–197 (2013). https://doi.org/10.1007/s10278-012-9507-1
[7]. Bedi, A.K., Sunkaria, R.K. Ultrasound speckle reduction using adaptive wavelet thresholding. *Multidim Syst Sign Process* **33,** 275–300 (2022). https://doi.org/10.1007/s11045-021-00799-4
[8]. Sudhakar Ilango, S., Seenivasagam, V. & Madhumitha, R. Hybrid two-dimensional dual tree—biorthogonal wavelet transform and discrete wavelet transform with fuzzy inference filter for robust remote sensing image compression. *Cluster Comput* **22,** 13473–13486 (2019). https://doi.org/10.1007/s10586-018-1982-9
[9]. Prabu, M., Shanker, N.R., Celine Kavida, A. *et al.* Geometric distortion and mixed pixel elimination via TDYWT image enhancement for precise spatial measurement to avoid land survey error modeling. *Soft Comput* **24,** 14687–14705 (2020). https://doi.org/10.1007/s00500-020-04814-x
[10]. Provenzi, E., Caselles, V. A Wavelet Perspective on Variational Perceptually-Inspired Color Enhancement. *Int J Comput Vis* **106,** 153–171 (2014). https://doi.org/10.1007/s11263-013-0651-y
[11]. Almutiry, O., Iqbal, K., Hussain, S. *et al.* Underwater images contrast enhancement and its challenges: a survey. *Multimed Tools Appl* (2021). https://doi.org/10.1007/s11042-021-10626-4
[12]. Jamil, U., Khalid, S., Akram, M.U. *et al.* Melanocytic and nevus lesion detection from diseased dermoscopic images using fuzzy and wavelet techniques. *Soft Comput* **22,** 1577–1593 (2018). https://doi.org/10.1007/s00500-017-2947-2
[13]. Gebremeskel, G.B. A critical analysis of the multi-focus image fusion using discrete wavelet transform and computer vision. *Soft Comput* **26,** 5209–5225 (2022). https://doi.org/10.1007/s00500-022-06998-w
[14]. Dubey, A.K., Jain, V. An accurate recognition of facial expression by extended wavelet deep convolutional neural network. *Multimed Tools Appl* (2022). https://doi.org/10.1007/s11042-022-12871-7
[15]. Hachicha, S., Sayahi, I., Elkefi, A. *et al.* GPU-Based Blind Watermarking Scheme for 3D Multiresolution Meshes Using Unlifted Butterfly Wavelet Transformation. *Circuits Syst Signal Process* **39,** 1533–1560 (2020). https://doi.org/10.1007/s00034-019-01220-z
[16]. Yousefi, H., Taghavi Kani, A., Mahmoudzadeh Kani, I. *et al.* Wavelet-based iterative data enhancement for implementation in purification of modal frequency for extremely noisy ambient vibration tests in Shiraz-Iran. *Front. Struct. Civ. Eng.* **14,** 446–472 (2020). https://doi.org/10.1007/s11709-019-0605-8
[17]. da Silva Amorim, L., Ferreira, F.M.F., Guimarães, J.R. *et al.* Automatic segmentation of blood vessels in retinal images using 2D Gabor wavelet and sub-image thresholding resulting from image partition. *Res. Biomed. Eng.* **35,** 241–249 (2019). https://doi.org/10.1007/s42600-019-00028-9.
[18]. "A New Satellite Image Enhancement Method Using Wavelet Transformation and Morphological Filtering." International Journal of Science and Research (IJSR), vol. 5, no. 4, 5 Apr. 2016, pp. 2059–2063, 10.21275/v5i4.nov163046.
[19]. Narayana Tinnaluri, Venkata Surya, and Anil Kumar. "Thermal Image Enhancement and Analysis Techniques of Image Processing Using Wavelet Transformation." SSRN Electronic Journal, 2018, 10.2139/ssrn.3478148.

[20]. Baranitharan, K., and S. Srinivasa Rao Madane. "Clustering Approach for Colour Image Enhancement Using Stationary Wavelet Transformation." International Journal of Computer Applications, vol. 118, no. 25, 28 May 2015, pp. 5–8, 10.5120/20960-3495.
[21]. Suryanarayana, Gunnam, and Ravindra Dhuli. "Image Resolution Enhancement Using Wavelet Domain Transformation and Sparse Signal Representation." Procedia Computer Science, vol. 92, 2016, pp. 311–316, 10.1016/j.procs.2016.07.361.