ISSN: 2349- 5197
Impact Factor (PIF): 2.138

INTERNATIONAL JOURNAL OF RESEARCH SCIENCE & MANAGEMENT

GABOR FILTER FOR FINGERPRINT RECOGNITION: A REVIEW

P. P. Dadhich[1*], S. Borse[2]
[1*]M.E.Student Department of Electronics and TelecommunicationL.K.G.N Sapkal College of Engineering, Nashik
[2]Assistant Professor, Department of Electronics and Telecommunication L.K.G.N Sapkal College of Engineering, Nashik
Correspondence Author: dadhich.pankaj@gmail.com

Keywords: Biometrics, Feature extraction, Fingerprint, Gabor,minutiae, Recognition.

Abstract
Many researchers continue to experiment with Gabor filter in area of biometrics identification which also includes fingerprint recognition. Gabor filters have been widely used for feature extraction in fingerprint identification. This paper attempts to present a survey of fingerprint recognition methods that employ various Gabor filter based approaches in feature extraction.

Introduction
The use of fingerprints for personal identification has a very long history. Fingerprints have been used as a method for person identification since 7000 BC, which proves the method is time tested. The formation is initiated and mainly depends on the conditions of the embryonic development, and the darker ridge pattern formed remains unchanged throughout the entire life i.e. immutability [1].A fingerprint image consistsof a quasi-periodic structure with ridges (darker regions) and valleys (lighter regions). These local characteristics of fingerprint structure (i.e. ridge endings and ridge bifurcations) are called minutiae. These minutiae provide fingerprints the property of uniqueness. The probability of a fingerprint with 36 minutiae points will share 12 minutiae points with another arbitrarily chosen fingerprint with 36 minutiae points is 6.10×10^{-8}[2]. Both the immutability and the uniqueness properties make fingerprint matching as one of the most reliable and trusted techniques of person identification.
Many different approaches have been used in area of fingerprint recognition.These can be broadly classified as minutiae based and image based [3]. AutomaticFingerprint recognition owes its induction to minutiae based approach. But these minutiae based approach requires extensive preprocessing to extract features. Noisy fingerprint image results in false minutiae being extracted. Thus an additional stage is required for purification. Thus image based approaches are now preferred over the minutiae based approach as they can be directly applied to grayscale image. Usually no additional preprocessing is needed.But it requires an efficient algorithm for core point detection as image based approaches have limitations in tracking variation in position, orientation and scale of image.
Gabor filter has not only found its application in both these approaches but also been in wide application in new hybrid approach, which combines preprocessing and feature extraction using Gabor filter [16] or application of Gabor to enhanced image resulted after use of preprocessing algorithm.
A reference point is selected and the area around the reference point is treated as the area of interest for extracting the minutiae features as there are maximum variations are around the reference point and these variations decrease away from the areareference point.
Gabor filters can be seen as a filter bank that can represent the local frequencies. Gabor filters were introduced to image processing by [9], mainly due to effectiveness in detecting discontinuity in an image or part of it. This has allowed use of Gabor filter in edge detection and feature extraction by identifying continuity.
This literature survey is organized as follows: Section II discusses specialty and use of Gabor Filter in finger print recognition, Section III various methods proposed by different authors are presented in terms of advancement to existing ones and different versions of Gabor filter implemented for feature extraction and fingerprint recognition. Section IV is a table of comparison of different categories of fingerprint recognition that use Gabor filter.

Usefulness of GABOR filter in fingerprint recognition
Fingerprints have structured local ridge orientation and ridge frequency. Thus, the enhancement algorithmtakes advantage of this regularity of spatial structure by applying Gabor filters. These filters are tuned to match the local ridge orientation and ridgefrequency.Based this, the Gabor filter is applied to each pixel location in the image. Thefilter enhances the ridges oriented in the direction of the local orientation, and decreases anything with different orientation. Hence, the filter increases the contrast between the foreground ridges and the background, while effectively reducingnoise. As shown in fig.2.1, Gabor filter based algorithms don't require any preprocessing steps.

ISSN: 2349- 5197
Impact Factor (PIF): 2.138

INTERNATIONAL JOURNAL OF RESEARCH SCIENCE & MANAGEMENT

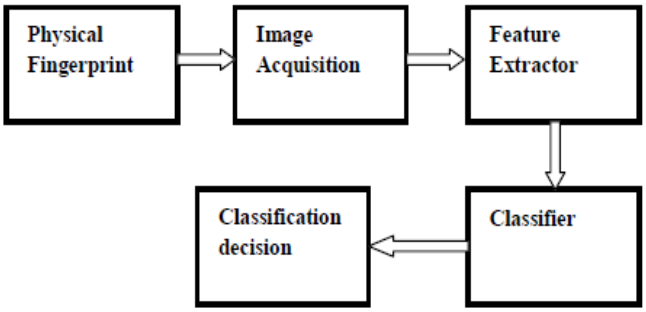

Fig.2.1Block diagram of Fingerprint Recognition system

Fingerprint enhancement methods based on the Gabor filter have been widely used for fingerprint classification [6] and fingerprint matching [7, 8]. Gabor filterscan be effectively tuned to specific frequency and orientation values as they are bandpass filters that haveboth frequency-selective and orientation-selective properties [4].

Once the ridge orientation and ridge frequency information has been determined, these parameters are used to construct the even-symmetric Gabor filter. A twodimensionalGabor filter consists of a sinusoidal plane wave of a particular orientationand frequency, modulated by a Gaussian envelope [4].

Gabor filters are used due to their frequency-selective and orientation-selective properties which allow the filter to be tuned to give higher response toridges for specific orientation and frequency in the fingerprint image and low response for other orientations. This preserves the ridge structure and simultaneously reduces.

The even-symmetric Gabor filter is the real part of the Gabor function, whichis given by a cosine wave modulated by a Gaussian (Fig.2.2). An evensymmetricGabor filter in the spatial domain is defined as [5]:

$$G(x, y; \theta, f) = \exp\left\{-\frac{1}{2}\left[\frac{x_\theta^2}{\sigma_x^2} + \frac{y_\theta^2}{\sigma_y^2}\right]\right\}\cos(2\pi f x_\theta), \qquad 1.1$$

$$x_\theta = x\cos\theta + y\sin\theta, \qquad 1.2$$

$$y_\theta = -x\sin\theta + y\cos\theta, \qquad 1.3$$

where μ is the orientation of the Gabor filter, f is the frequency of the cosinewave, σ_x and σ_y are the standard deviations of the Gaussian envelope along thex and y axes, respectively, and x_θ and y_θ define the x and y axes of the filter coordinate frame, respectively.

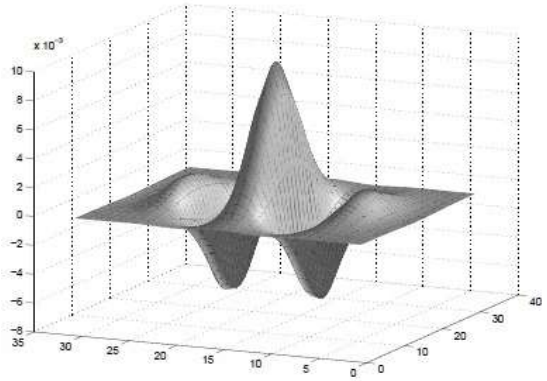

Fig.2.2 An even-symmetric Gabor filter in the spatial domain.

The Gabor filter is applied to the fingerprint image by spatially convolvingthe image with the filter. The convolution of a pixel (*i; j*) in the image requires the corresponding orientation value *O*(*i; j*) and ridge frequency value *F*(*i; j*) ofthat pixel. Hence, the application of the Gabor filter *G* to obtain the enhancedimage *E* is performed as follows:

ISSN: 2349- 5197
Impact Factor (PIF): 2.138

INTERNATIONAL JOURNAL OF RESEARCH SCIENCE & MANAGEMENT

$$E(i,j)=\sum_{u=-\frac{w_x}{2}}^{\frac{w_x}{2}}\sum_{v=-\frac{w_y}{2}}^{\frac{w_y}{2}} G\big(u,v;O(i,j),F(i,j)\big)N \qquad 1.4$$

where,O is the orientation image, F is the ridge frequency image, N is thenormalized fingerprint image, and $w_x$and $w_y$are the width and height of theGabor filter mask, respectively.

Algorithms in fingerprint recognition using GABOR filter

The method proposed in [11]filters each block using a Gabor filter with 'm' different directions. In method proposed, it uses 8 filters. Filter response is larger, if one of the blocks has high quality (i.e., strong ridge direction. In poor-quality blocks or background blocks, the 'm' filter responses are similar. The standard deviation of the filter responses is then used to determine the quality of each block. A quality index 'QI' of the whole image is finally computed as the percentage of foreground blocks and images are accepted or rejected based on QI. An example of quality estimation using Gabor filters is shown in Fig. 3.1 for two fingerprints of different quality.

(a) (b)

Fig. 3.1. Estimation of fingerprint quality using Gabor filters. Panel (a) is the input fingerprint images. Panel (b) is the block wise values of the standard deviation of m filter responses (eight in this example) with a different direction. Blocks with a brighter color indicate higher standard deviation value and, thus, higher quality.

Contradictory to directly applying Gabor filter to image the image, [11-15] usepreprocessing for enhancement, which is based on the convolution of the image with Gabor filters tuned to the local ridge orientation and frequency. As shown in Fig. 3.2 the image is first segmented, and then normalized for specified mean and variance. Local orientation and ridge frequency for each pixel is calculated before applying Gabor filter for each of these pixels in the image. This enhances the ridges oriented in the direction of local orientation and increases contrast and results in reduction in background noise. Thismethod uses run length coding before feature extraction and is fast in terms to feature extraction and cost effective compared to computational thinning process.

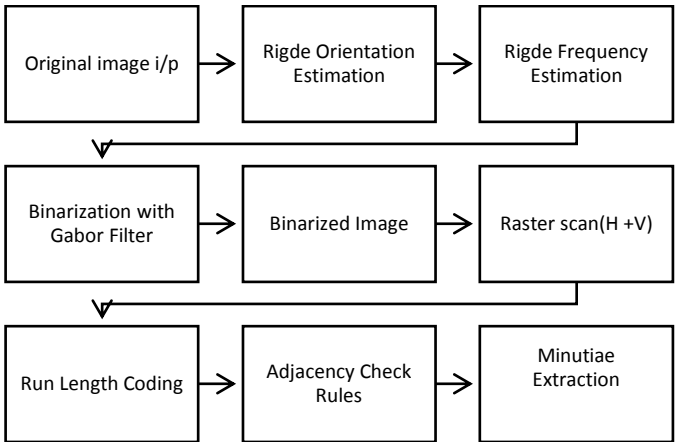

Fig. 3.2.Block diagram of proposed minutiae extraction algorithm using run-length encoding

A new approach was proposed in[16] based on minutia extraction using Gabor phase. It differs from many existing in sense that this approach uses the transform domain of the fingerprint image. The convolution of image Gabor filter, results in a complex

ISSN: 2349- 5197
Impact Factor (PIF): 2.138

INTERNATIONAL JOURNAL OF RESEARCH SCIENCE & MANAGEMENT

image. This complex image is then transformed into the amplitude and phase part. Extraction of minutiae features is done directly from the Gabor phase field

Image enhancement can be donein the spatial or frequency domain. In [21] Gabor filter was used for frequency domain of ridges; band pass filter was also applied to capture negative frequencyresponseas intensity values to change abruptlyfrom white to black at the pores. They applied wavelettransforms which is a high localized property in both frequency and spatial domains. Hence they used Mexican hat wavelet transforms. In [22], the idea to use frequency domain was taken forward by applying Fast Fourier transform to gray scale image and then applying Log- Gabor filter. Image enhancement is done in frequency domain and finally inverse transform is applied to FFT image. The implementation resulted in maximum variations in original and enhanced image. This increased number of termination and reduced number of bifurcations due to un-smoothing and noisiness.

Method proposed in [17] uses Gabor filter to capture both local and global details via core point detection. This is done in a finger print by implementing compact fixed length Finger code. Euclidean distance used on small database resulted in fast computation and accuracy to 98.2%.

Elmir et.al.[19] used Gabor filter based feature extraction proposed in [18,10], but instead of using support vector machine (SVM) for identification, they use spike neural network (SNN). Also comparison between SVM, SNN and Radial Basic Functional (RBF) neural network is also presented, which shows the efficiency of SNN over SVM and RBF in terms speed and accuracy especially for online applications.

Comparison

Major categories are compared based on the characteristics given in the paper and tabulated in Table 1

Technique → / Parameter ↓	Minutiae Extraction	Gabor Filter Based	Hybrid
Reliability	Difficult to Extract minutiae in low quality image	Reliable	More Reliable
Limiting Factors	Quality of Image	Accurate reference point is required	Depends
Accuracy	High	Less Accurate	High
Time Delay	High	Low	High
Computational Complexity	High	Low	High
Preprocessing	High	Not Applicable	High
Data Size	Not suitable for large databases	Suitable for large databases	Not suitable for large databases
Matching Techniques	Sophisticated	Simple	Sophisticated
Applications	Suitable for forensic applications	Suitable for civilian applications	Suitable for Forensic applications

Table 1. Comparison of finger print recognition approaches.

Conclusion

Fingerprint remains an important and challenging research area Image processing and continues to interest thus attracts researchers even after many years of research. The applications in judicial and forensic field needs highly sophisticated systems with no margin for error, while for office and personal safety and security needs speed is most important criteria. The papers reviewed has covered both types of systems, these are categorized as minutiae based, image based and hybrid. Thus we have reviewed performance of Gabor Filter for feature extraction in fingerprint images. Gabor mainly requires reference point detection for feature extraction and can perform well even for low quality images, but methods reviewed were also where preprocessing is done to facilitate effective and speedy extraction and thereby enhancing the over all system of fingerprint recognition. Not all papers can be compared due to use of different databases; it can be future work to test these different methods on standard databases.

References

1. A. K. Jain, R. Bolle and S. Pankanti.Eds. Biometrics-Personal Identification in Networked Society.Kluwer Academic Publishers. 1999.
2. SharathPankanti, SalilPrabhakar, and Anil K. Jain. On the individualit of fingerprints. IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 24, no. 8, pp. 1010–1025, 2002.
3. VidyadeviBiradar and HandeSarojadeviImage Analysis Techniques for Fingerprint Recognition, International Journal Of Computational Engineering Research (Sept.,2015), 606-615
4. Daugman, J. G. Uncertainty relation for resolution in space, spatial frequency,and orientation optimized by two-dimensional visual cortical filters.Journal of the Optical Society of America (A) 2, 7 (July 1985), 1160–1169.
5. Jain, A. K., and Farrokhnia, F. Unsupervised texture segmentationusing Gabor filters. Pattern Recognition 24, 12 (1991), 167–186.
6. Jain, A. K., Prabhakar, S., and Hong, L. A multichannel approachto fingerprint classification. IEEE Transactions on Pattern Analysis andMachine Intelligence 21, 4 (1999), 348–359.
7. Prabhakar, S., Wang, J., Jain, A. K., Pankanti, S., and BolleR. Minutiae verification and classification for fingerprint matching. In Proc. 15th International Conference Pattern Recognition (ICPR) (September 2000), vol. 1, pp. 25–29.
8. Ross, A., Jain, A., and Reisman, J. A hybrid fingerprint matcher.Pattern Recognition 36, 7 (July 2003), 1661–1673.
9. H. Knutsson, "Filtering and reconstruction in image processing," Ph.D.dissertation, Linköping Univ., Sweden, 1982.
10. J. Daugman, "Complete discrete 2-D Gabor transforms by neural networks for image analysis and compression," IEEE Trans. Acoust.,Speech, Signal Process., vol. 36, no. 7, pp. 1169–1179, Jul. 1988.
11. L. Shen, A.Kot, and W. Koo, "Quality measures of fingerprint images,"in Proc. Audio Video-Based Person Authentication, 2001, pp. 266–271.
12. S. Klein, A. M. Bazen, and R. Veldhuis, "Fingerprint image segmentation based on hidden markov models", in 13th Annual workshop in Circuits, Systems and Signal Processing, 2002.
13. F. Alonso-Fernandez, J. Fierrez-Aguilar, and J. Ortega-Garcia, "An enhanced gabor filter-based segmentation algorithm for fingerprint recognition systems", in proc. 4th International Symposium on Image and Signal Processing and Analysis(ISPA 2005), pp. 239–244.
14. X. Chen, J. Tian, J. Cheng, and X. Yang, "Segmentation of fingerprint images using linear classifier", EURASIP Journal on Applied Signal Processing, vol. 4, 2004, pp. 480–494.
15. E. Zhu, J. Yin, C. Hu, and G. Zhang, "A systematic method for fingerprint ridge orientation estimation and image segmentation",Pattern Recognition, vol. 39(8), 2006, 1452–1472.
16. X. Gao, X. Chen, J. Cao, Z. Deng, C. Liu and J. feng, "A Novel Method Of Fingerprint Minutiae Extraction Based On Gabor Phase", In Proc. IEEE International Conference on Image Processing, 2010, pp. 3077-3080.
17. Ms.Prajakta M. Mudegaonkar and Prof.Ramesh P. Adgaonkar"A Novel Approach to Fingerprint Identification Using Gabor Filter-Bank"ACEEEInt. J. on Network Security, Vol. 02, No. 03, July 2011, pp. 10-14
18. DhruvBatra, GirishSinghal and SantanuChaudhury: Gabor Filter based Fingerprint Classification using Support Vector Machines, IEEE INDIA ANNUAL CONFERENCE 2004, INDICON 2004
19. YoussefElmir , ZakariaElberrichi , RédaAdjoudj Mohamed Benyettou "Personal Identification By Fingerprints Based On Gabor Filters" Unpublished.
20. Anil K. Jain, Yi Chen, and MeltemDemirkus, Pores and Ridges: High-Resolution Fingerprint Matching Using Level 3 Features, IEEE Transactions onPattern Analysis and Machine Intelligence, Vol. 29, No.1, January 2007.
21. Mrs.K.Kanagalakshmi&Dr.E.Chandra "Frequency Domain Enhancement AlgorithmBased on Log –GaborFilter in FFT Domain"Global Journal of Computer Science and TechnologyVolume 12 Issue 7 Version 1.0 April 2012