

**MODIFIED GABOR FILTRATION AND EDGE BASED CONVOLUTION IN
NEURAL NETWORK**

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Abstract:- Reliability and accuracy of the features extracted from fingerprints are essential for the performance of any fingerprint comparison algorithm. Image Enhancement as a pre-processing step allows extracting features more accurately by enhancing the quality of the fingerprint signal. Our proposed work is based on three stages such as: feature extraction, convolution process and filtration. The edge based convolution is done with filtration using Laplace Gabor filter to reduce the noise level of latent fingerprints. We present a complete evaluation of the different parameters involved in this process and show edge detection results on several real images through our proposed scheme.

Keywords- Fingerprint, Filtration, Convolution, Feature extraction, neural network

1. INTRODUCTION

Biometric confirmation systems confirm a person's claimed identity from behavioural traits (signature, voice, keystrokes and gait) or physiological traits (face, iris, and ear, DNA, eye). Biometric is the science and technology used for measuring and analysing data. Biometric system is of two types Uni-modal and multi-modal biometric system. Biometric system trusts on the evidence of single source of information for authentication of a person. Human have used fingerprints for personal identification for many centuries and the similar correctness using fingerprints has been shown to be very high [1]. A fingerprint is the design of ridges and valleys on the surface of a sensitive, the formation of which is resolute during the first seven months of fetal advance. Fingerprints of identical doubles are dissimilar and so are the prints on each finger of the same person. Automated Fingerprint Identification Systems have been positively used in forensics and law enforcement applications to reliably identify an individual. Fingerprint matching situations generally fall into one of the following two categories: (i) Ten print search and (ii) Latent search.

A majority (60%) of crime laboratories in the United States reported analyzing latent fingerprints recovered from crime scenes, and a total of 271,000 latent prints were processed by public forensic crime laboratories in 2009 alone². During January 2017, FBI's Integrated Automated Fingerprint Identification System (IAFIS), which maintains the largest criminal fingerprint database in the world, conducted 17,758 latent "feature" searches (latent features were manually marked by latent examiners), and an additional 4,160 latent "image" searches [2] (latent features were automatically extracted by IAFIS). Compared to rolled and slap prints (or reference prints), which are acquired under supervision, latent prints are lifted after being unintentionally deposited by a subject, e.g., at crime scenes, typically resulting in poor quality in terms of ridge clarity and large background noise. Unlike reference prints, the action of depositing finger mark on a surface is not repeatable if latent prints are found to be of poor quality. National Institute of Standards & Technology (NIST) periodically conducts technology evaluations of fingerprint recognition algorithms, both for rolled (or slap) and latent prints. In NIST's most recent evaluation of rolled and slap prints, FpVTE 2012, the best performing Automated Fingerprint Identification System (AFIS) achieved a false negative identification rate (FNIR) of 1.9% for single index fingers, at a false positive identification rate (FPIR) of 0.1% using 30,000 search subjects (10,000 subjects with mates and 20,000 subjects with no mates) [2]. For latent prints, the most recent evaluation is the NIST ELFT-EFS where the best performing automated latent recognition system could only achieve a rank-1 identification rate of 67.2% in searching 1,114 latents against a background containing 100,000 reference prints [3].

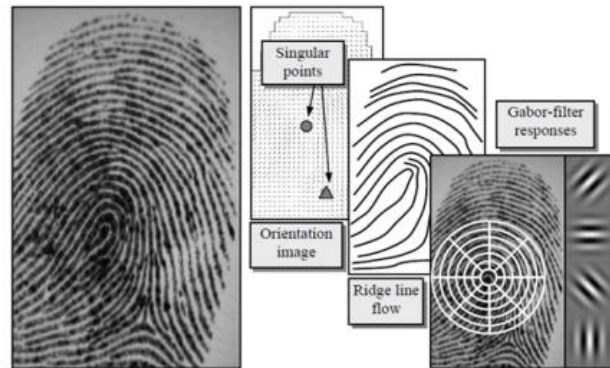


Figure-1 Convolution based filtration of latent fingerprints

Methods to perform image segmentation for shot boundary detection in the context of video/audio/image databases by examining the images stream have also been developed by many researchers. The tasks related to geometric feature extraction such as edge detection have received very little attention in so far as the direct processing of digital video is concerned. These tasks are important in many applications, e.g., object detection and tracking, in addition to the fact that the extraction of geometric features is needed to generate content descriptors for images and videos. Many works in compressed domain edge feature extraction only provided certain coarse interpretation of statistical features, which tend to ignore important low-level features such as edges, corners, or fine textures [4]. There have been some preliminary edge extraction methods based on the classification of DCT coefficients. Some coarse edges can be extracted out directly from transform coefficients.

Many researchers have discussed about the convolutional based filtration process for enhancement of latent fingerprint. Some of them are discussed in this section:

Shao and Han et al. (2012) [5] use the nonnegative matrix factorization (NMF) to initialize the fingerprint orientation field instead of the gradient-based approach, which obtains more robust results.

Feng and Jain et al. (2013) [6] propose a method based on dictionary learning for estimating the orientation field of latent fingerprints. Also, we have proposed some methods for orientation field estimation, for example, Wu and Guo et al. (2013) [7] propose a SVM-based method for fingerprint and palmprint orientation field estimation.

AnushSankaran et al., 2013 [8] defined as Clarity of a latent impression is defined as the discernibility of fingerprint features while quality was defined as the amount of features causal towards matching. Automated estimation of clarity and quality at local regions in a latent fingerprint is a study challenge and had received limited attention in the literature.

Daniel Peralta et al., 2015 [9] Fingerprint recognition had found a reliable application for verification or identification of 32 people in biometrics. Worldwide, fingerprints can be viewed as respected traits due to several 33 perceptions observed by the experts; such as the distinctiveness and the permanence on 34 humans and the performance in real applications. Among the main stages of fingerprint 35 recognition, the automatic matching phase has established much attention from the early 36 years up to nowadays. This paper was devoted to review and categorize the vast number 37 of fingerprint matching methods proposed in the specialized literature. In particular, they 38 focus on local minutiae-based matching algorithms, which provide good performance with 39 an excellent trade-off between efficacy and efficiency.

Emanuela Marasco et al., 2014 [10] numerous issues related to the exposure of fingerprint recognition systems to attacks had been high-lighted in the biometrics nonfiction. One such susceptibility comprises the use of artificial fingers, where materials such as playdoh, silicone, and gel were decorated with fingerprint ridges. Researchers had demonstrated that some commercial fingerprint recognition systems can be misled when these artificial fingers are placed on the sensor, i.e., the system successfully processes the resulting fingerprint images thereby agreeing an adversary to spoof the fingerprints of another individual. Though, at the same time, several countermeasures that separate between live fingerprints and spoof artefacts had been studied. While some of these anti-spoofing schemes were hardware-based, several software-based approaches had been proposed as well. In this paper, they review the works and present the state-of-the-art in fingerprint anti-spoofing.

Contextual Filtering by Maltoni et al. They state that it may be "the most widely used technique for fingerprint image enhancement" [8]. In contrast to most other approaches, contextual filtering is especially tuned to fingerprint image

enhancement and focusses on its specific characteristics. Based on estimations for local orientation and ridge frequency appropriately parametrized Gabor filters are applied locally. With the usage of Gabor-Filters again the underlying assumption is that the signal of a fingerprint is locally similar to an oriented cosine. Several extensions to Contextual filtering are proposed which modify one or more working steps, e.g. using the frequency domain for estimation of local orientation and ridge distance.

Buades et al proposed a decomposition of the signal of the fingerprint image into two components [9]. Local Total Variation is used as a measure for sensibility regarding smoothing operations. This measure can be used to determine the so-called cartoon component which represents the very low frequency component which is less sensible to smoothing. The texture part shall contain a clearly visible fingerprint signal.

2. METHODOLOGY

The main objective of the proposed method is to precisely enhance the fingerprint to achieve superior performance in many computer vision tasks from low-level image processing to high-level semantic understanding. Fig. 2 demonstrates the general architecture for the proposed framework. The proposed framework is sub divided into three stages: feature extraction, convolution process and filtration

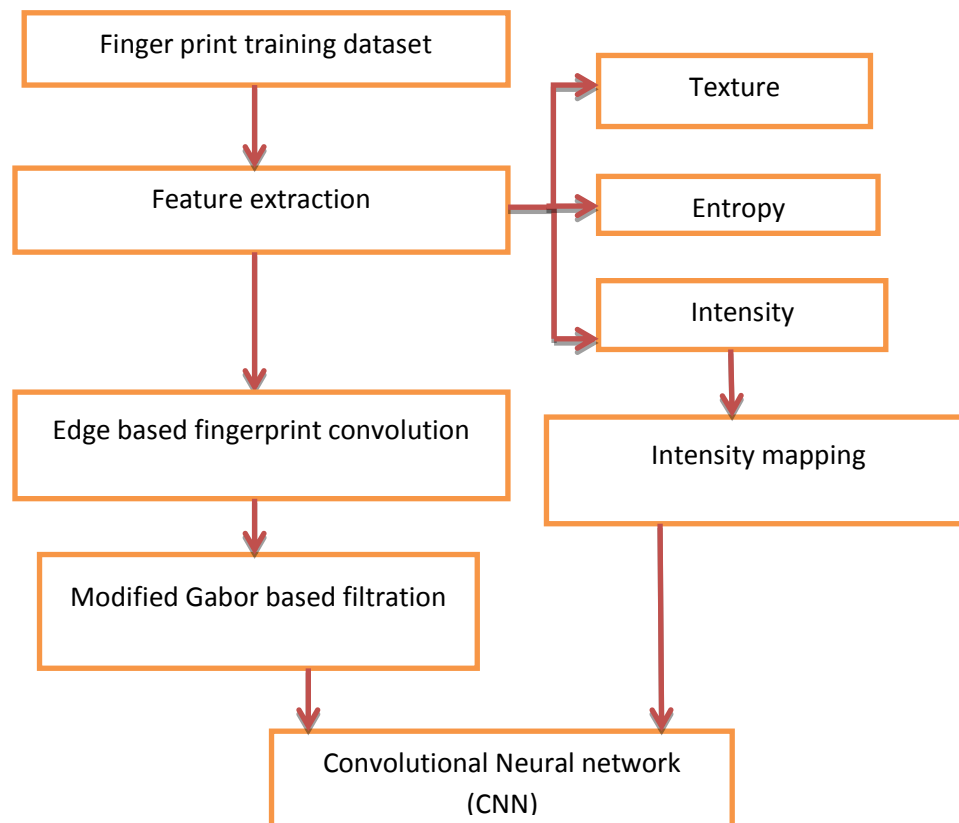


Figure2 system architecture of proposed system

Feature extraction:

Reference prints are typically of higher quality compared to latents, so it is easier to get reliable minutiae from them. For this reason, we extract only one minutiae template, but we still extract the texture template. The reference print minutiae are extracted by a COTS tenprint AFIS rather than the proposed minutiae extractor for latents. The ridge flow is extracted by

Short Time Fourier Transform (STFT) . A reference print minutiae template, similar to latents, includes (i) ridge flow, (ii) minutiae set and (iii) minutiae descriptors. For computational efficiency, each nonoverlapping block of $sb \times sb$ pixels is considered to define a single virtual minutia. Since the latent texture template considers two virtual minutiae, we expect that at least one of them will be in correspondence with the reference print virtual minutia in the true mate. The features are extracted based on texture, entropy and intensity.

Intensity mapping:

In order to preserve more details and contrast in rich texture areas and compress luminance in weak texture areas, we propose an adaptive intensity-mapped method, which adjusts the intensity value according to each pixel's contextual texture consistency. This function, here defined as:

$$\beta = \frac{Ir + G(Ii)}{Ii + G(Ii)}$$

where β denote intensity value for the pixel , β are global and local parameters for intensity contrast respectively. The adaptation factor $G(Ii)$ is determined by the contextual texture consistency . In our method for each pixel, and it is a local variable given by the contextual texture consistency in the homogenous region of one pixel.

Convolution Filtering:

Modified Gabor filter is applied here for filtration process whereas the laplace is applied to make the filtration process more effective. The Gabor filter is a linear filter which impulse response is defined by a harmonic function multiplied by a Gaussian function. This filter can be used to detect line endings and edge borders over multiple scales and with different orientations.

While operators that focus on global information are essential to describing a variety of physical systems, operators that focus on local information are essential to analyzing physical signals. For example, linear, timeinvariant (or shift-invariant) systems are usually analyzed with Fourier or Laplace transforms which are global operations

$$G(x,y,\theta,\mu,\beta) = \exp\left(-\frac{x^2 + \beta^2 y^2}{2\mu^2}\right) \exp\left(i\left(2\pi\frac{x}{\beta} + \theta\right)\right)$$

$$G(s) = \int_0^\infty e^{-x^2 \beta^2 y^2} f(t) dt. \int_0^\infty e^{2\pi x / \beta} f(t) dt$$

To detect the edges of the eyes, the parameters of Gabor wavelet are set as follows: $x=1$, $y=4$, $\beta=2\pi$, $pmax=\pi/2$ and $\mu=2$. In this experiment, Gabor wavelet with horizontal orientation is selected because it produces discriminative Gabor features better than other orientation. The parameter r represents the scale of the filter. The greater value of r is set, the size of filter is becomes small. The parameter μ is a standard deviation of the Gaussian function along the x and y -axes. By using this parameter, the width of the filter can be changed and it can increase or decrease the thickness of the edge

Network architecture:

FCN is used to map raw fingerprint to minutia-score map with a fixed stride. Minutia-score map is the output of the network, and each point is a minutia-like score corresponding to the raw fingerprints. In our practice, three pretrained models are used to initialize the former convolutional layers, including ZF model , VGG model and deep residual model . Remaining layers consists of a classification layer and a location regression layer. The network model learnt on the combination of all the features is able to provide a better quality distribution of fingerprints, rather than using individual features.

3. PERFORMANCE ANALYSIS

The enhanced images obtained using all the approaches stated above were analyzed and compared based on the following parameters: (i) Entropy, (ii) RMS Contrast, and (iii) Moment. The result values obtained by carrying out the subjective analysis of the outputs

Entropy is the measure of disorder or more specifically predictability. It denotes information about the texture of an image.

Contrast is the difference in visual properties that distinguishes an object from other objects and the background of the image. Contrast is determined by calculating the difference in the color and brightness of the object and other objects within the same field of view in the image. Since the human optical system is more sensitive to contrast than absolute luminance.

Table-1 Analysis of different filters in terms of its entropy, moment and contrast level

Method	Entropy	RMS contrast	Moment
Gabor wavelet filtration	0.50	0.35	0.11
Log gaborfiltration	0.82	0.33	0.15
Laplace gaborfiltration (proposed)	0.96	0.56	0.10
Wiener filter	0.42	0.37	0.12

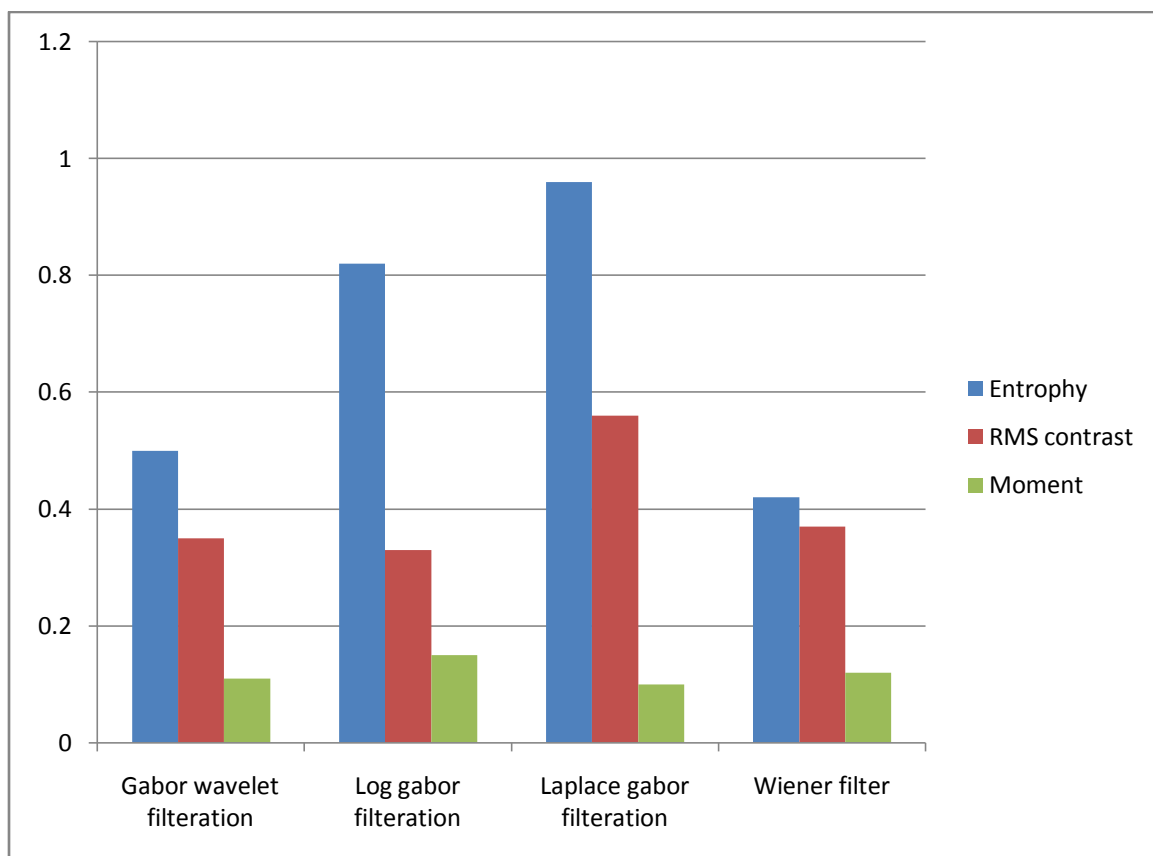


Figure 3- Comparison between existing and proposed filter

Table-2 Analysis of accuracy between different filters

Method	Number of matches (out of 50)	Percentage of match (accuracy)
Gabor wavelet filtration	26	64%
Log gabor filtration	34	76%
Laplace gabor filtration (proposed)	45	95%
Wiener filter	37	81.4%

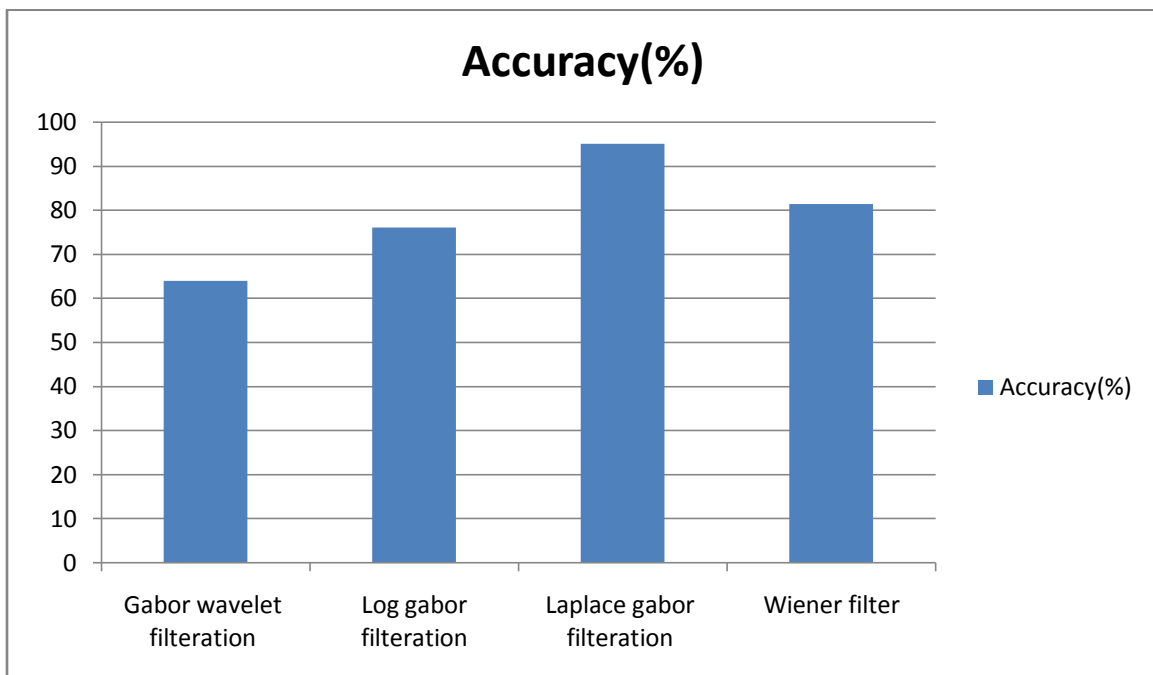


Figure 4- Comparison of accuracy

4. Conclusion

As we can see that the proposed method has superior advantage in inference speed which can make the matching time much more efficient, especially when having larger scale of fingerprints. The convolution filtering makes to find effective filtration process and to find latent fingerprints. Moreover the accuracy level of the proposed method is more while comparing with existing filters. forThemethod proposed in this study would be applicable in the domain of forensics and would help improve the accuracy and time required for matching fingerprints.

Reference

- [1]Feng, Jianjiang, Jie Zhou, and Anubhav K. Jain."Orientation field estimation for latent fingerprint enhancement." Pattern Analysis and Machine Intelligence, IEEE Transactions on 35.4 (2013): 925-940
- [2] C. Watson, G. Fiumara, E. Tabassi, S. L. Cheng, P. Flanagan, and W. Salamon, "Fingerprint vendor technology evaluation: Evaluation of fingerprint matching algorithms," NISTIR 8034, 2012.

- [3] M. D. Indovina, V. Dvornychenko, R. A. Hicklin, and G. I. Kiebusinski, "Evaluation of latent fingerprint technologies: Extended feature sets (evaluation 2)," Technical Report NISTIR 7859, NIST, 2012.
- [4] Mohamed S M, Nyongesa H O. Automatic fingerprint classification system using fuzzy neural techniques[C]//Fuzzy Systems, 2002. FUZZ-IEEE'02. Proceedings of the 2002 IEEE International Conference on. IEEE, 2002, 1: 358-362
- [5] Shao G, Han C, Guo T, et al. An NMF-Based Method for the Fingerprint Orientation Field Estimation[M]//Computer and Information Science 2012. Springer Berlin Heidelberg, 2012: 93-104
- [6] Feng J, Zhou J, Jain A K. Orientation field estimation for latent fingerprint enhancement[J]. Pattern Analysis and Machine Intelligence, IEEE Transactions on, 2013, 35(4): 925-940.
- [7] Wu Y, Zhao T, Wang S, et al. A SVM-based method for the estimation of fingerprint and palmprint orientation[C]//Intelligent Control and Information Processing 14 (ICICIP), 2013 Fourth International Conference on. IEEE, 2013: 343-348.
- [8] Sankaran, Anush, Mayank Vatsa, and Rajdeep Singh. "Automated clarity and quality assessment for latent fingerprints." Biometrics: Theory, Applications and Systems (BTAS), 2013 IEEE Sixth International Conference on. IEEE, 2013
- [9] Peralta, Daniel, et al. "A survey on fingerprint minutiae based local matching for verification and identification: Taxonomy and experimental evaluation." Information Sciences 315 (2015): 67-87.
- [10] Marasco, Emanuela, and Arun Ross. "A survey on antispooofing schemes for fingerprint recognition systems." ACM Computing Surveys (CSUR) 47.2 (2015): 28.
- [11] D. Maltoni, D. Maio, A. K. Jain, and S. Prabhakar, Handbook of fingerprint recognition. springer, 2009.
- [12] A. Buades, T. M. Le, J.-M. Morel, and L. A. Vese, "Fast cartoon+ texture image filters," Image Processing, IEEE Transactions on, vol. 19, no. 8, pp. 1978–1986, 2010.