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A Review on Fingerprint Image Enhancement Algorithms

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Abstract: Biometric is one of the important security systems. A lot of biometrics is available in market like using fingerprint, palm, face, iris, ear, texture, signature, leg and ECG signal. All these types are unique ones, out of these finger print based biometric systems are available with low cost and gets accurate results. It has unique features. Drawback of this fingerprint device is low quality input image due to the poor sensor. But, to get accurate result the manufactures are required high quality fingerprint image. To overcome this problem one may go for enhancement operation. In this paper presents survey on past 20 years papers to learn the algorithms to improve the quality of the fingerprint image.

Keywords: image enhancement, spatial domain and frequency domain.

1. Introduction:

Image enhancement is the concept to improve quality of image or remove noises present in the images. In this paper present the enhancement on fingerprint image. Enhancements techniques are implemented under two domains 1. Spatial domain, 2. Frequency domain. In case of spatial domain enhancement operations are applied on each pixel and other side the image is filtered in frequency domain. In this paper describe various fingerprint enhancement techniques. The fingerprint are having 11 patterns namely simple arch, tented arch, ulnar loop, Radial loop, concentric whorl, spiral whorl, press, whorl, imploding, whorl, composite whorl, peacocks eye, variant patterns. All these are having minutiae and ridges. To extract features' of these patterns may required different techniques.

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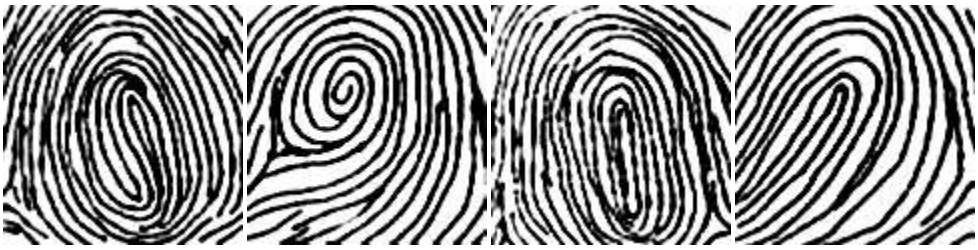
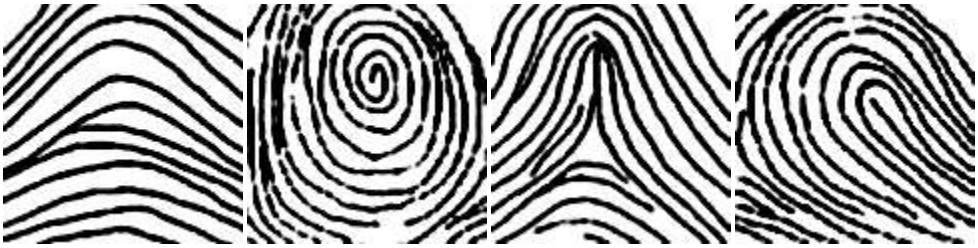
1.1.*Types of fingerprints :*

Fingerprint is an individual one. A fingerprint will remain unchanged during an individual lifetime. All fingerprints categorized in to 3 types 1.Arches 2.Loops 3.whorls. Further divided many types each. [51] 60-65% population has loops,30-35% has whorls and 5% has arches according to Bertillon systems.



(a) (b) (c) (d)



(e) (f) (g) (h)

(i) (j) (k)

Fig 1.1. a. ulnar loop, b. radial loop, c. concentric whorl, d. spiral whorl, e. press whorl, f. imploding whorl, g. composite whorl, h. peacocks eye, i. variant, j. simple arch, k. tented arch

1.2.Characteristics of fingerprint :

Characteristics are used to analyze the nature of fingerprint and utilize for identification. Characteristics are 1.ridge

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ending 2. Bifurcation 3.Short ridge 4.Encolsure (lake) 5.Hook (spur) 6.Dot 7.Bridge 8.Delta 9. Cross over 10.Eye 11.Specialty 12.Core.

Minutiae applied to the specific fingerprint to analyze it. In following chapters describe the different enhancement techniques for extracting features of an image and compare all these techniques.

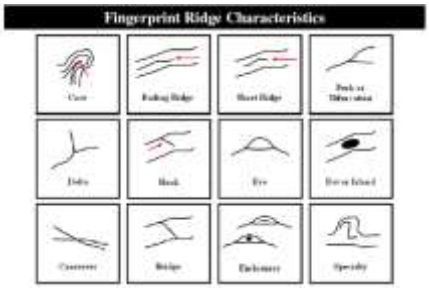

Fig 1.2.1: Fingerprint characteristics

Fig 1.2.2: Fingerprint Analysis

2. Literature survey:

[1] ju cheng yang et.al proposed algorithm by short time fourier transform (STFT) based sytem. It works under two domains spatial domain and frequency domain. This technique is used to filter multi spectral noises in the fingerprint image. By using this algorithm may extract the intrinsic properties of finger like region mask, local ridge orientation and local ridge frequency and also developed wavelet and fourier mellin transform.[2] chao hang wu et.al proposed algorithm to remove impulse noise by using combination of two filter namely anistropic filter and directional median filter. In This algorithm first applied anistropic filter on fingerprint image to remove Gaussian noise and then the filtered image follows directional median filter for eliminating impulse noise. This is also useful to extract the features local orientation and global features. [3] eun-kyung yun et.al developed an image

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enhancement algorithm with adaptive filters. The adaptive filter will be used to differentiate vallys and ridges clearly. The proposed algorithm to identify ROI of different pattern fingerprint images adaptively and also mentioned wavelet scalar quantization menthod [4] jianwei yang et.al proposed modern Gabor filter (MGF) . it overcomes drawbacks of traditional Gabor filter (TGF). In TGF method local orientation in practice doesnot consist of an ideal digital sinusoidal plain wave in some images or regions and the following problem has overcome with MGF. The MGF advantages are preserving fingerprint image structure and achieving image enhancement consistency. It reduces FRR of a fingerprint matcher by approximately 2% and FAR of 0.01% [5] marius tico et.al proposed direction low pass filter to remove false minutiae and detect thinned binary image of the fingerprint. It is useful to identify the ridge direction and succeed to remove most of the ridge breaks. As a result may obtain binary ridge image. The proposed algorithm is able to detect and cancel false minutiae associated with spikes, holes, ladder structure, and spurs. [6] jie zhou et.al proposed hierarchical scheme for the implementation for gradient based images. The proposed algoritm estimate local orientations around this region for lower resolution level until the consistency is below a certain level. The result exactly gets as averaged square gradient algorithm. The proposed algorithm also provides segment the ridges adaptively. [7] anil k jain et.al proposed Gabor filter to capture both local and global details in fingerprint as a compact fixed length finger codes. This proposed algorithm matches based on Euclidian distance between two corresponding finger codes and it is exactly fast. It is able to achieve verification with accuracy. Even the system performance better than a state of art minutiae based systems. In case of performance requirement of the application system does not demand a very low false acceptance rate. [8] ching tang hsieh et.al develop a novel algorithm which can improve the clarity and continuity of ridge structures based on the multi resolution analysis of global texture and local orientation by the wavelet transform. It consists normalization, wavelet decomposition, global texture filtering, local directional compensation and wavelet reconstruction for wavelet decomposition. It may extract eight co-efficient while global texture and local orientation in case the combination of daubechies and haar wavelet with quadrature mirror filter. This proposed method improve the quality the situations of blur region and broken ridge. [9] yuliang he et.al proposed a novel image enhancement algorithm based on orientation fields. The proposed algorithm deals with the problem of point pattern matching in finger print recognization by changing the points to the polar co-ordinate system and compare point sets. This algorithm estimates the orientation and gets binarization thinning resulted output image. [10] frenado Alonso et.al proposes a new algorithm for image enhancement. The proposed algorithm has following steps local orientation, spatial coherens, Gabor features', pixel intensity, power spectru, combination of local feautures. The proposed algorithm works on gradient of the gray level images, ridge frequency and power spectrum [11] lin hong and anil k jain et.al proposed a algorithm with Gabor filter. The algorithm consists normalization, orientation estimation, region mask estimation finally the resultant fingerprint image applied to the Gabor filter to remove the noise and increases the contrast. [12] b.g.sherlock et.al done fingerprint image enhancement by directional fourier filtering algorithm. In this proposed algorithm fingerprints are first smoothed using a directional filters whose

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orientation matched to the local ridge orientation. Threshold then yield the enhancement image by FFT. [13] sharat chikkerur et.al develop an algorithm by STFT transform. It is a well known technique in image processing to analyze non-stationary signals. Here extend to 2-D fingerprint image. It estimates all the intrinsic properties of the fingerprint such as the foreground region mask, local ridge orientation and frequency. The advantaged of the proposed algorithm: the enhancement utilizes the full contextual information and it has reduced space requirements compared to more popular fourier domain filtering techniques. [14] Josef strom bartunek et.al proposed algorithm gives improvement to an adaptive fingerprint image enhancement method.i.e based on contextual filtering. The author updates the blocks preprocessing, local analysis and non-linear dynamic range adjustment method is used. The author introduced a new method is successive mean quantization transform (SMQT). This method is a combination of curved Gabor filter with adaptive filter. It is extended pyramid decomposition approach. It raises the improvement on three out of four FVC2004 databases. [15]Mustafa khalafa et.al proposed a novel fingerprint image algorithm by develop mahtre technique. This proposed algorithm is a combination of histogram equalization(HE), high pass filter and median filter. This method is enable to increase fingerprint contracts and enhance ridges and furious structures to get accurate direction of ridge. Median filter correct wrong block direction and removes the noise. The enhanced mehtre technique produce a fine image quality comparing with exiting mehtre. [16] baartunek et.al proposed several improvements to an adaptive fingerprint enhancement method that is based on contextual filtering. The term adaptive means the parameters of the image are automatically adjusted based on the input fingerprint image. The key processing blocks are modernized by additional new processing stages. So, as to yield a original enhancement system, first non-linear processing block adjusted the dynamic range of the image then a new update to previously derived global fingerprint analysis is conducted to aid the fundamental spatial frequency estimation of the fingerprint image. [17] Ghafoor et.al develops fingerprint enhancement approach which is depends on local adaptive contextual filtering. The enhancement technique has processing both spatial domain and frequency domain. The image filtering in frequency domain and then local directional filtering in spatial domain. Here the Gabors are inspired by multi channel processing visual information in the biological model of human visual system. The proposed algorithm gives better result. [18] amit v.malwade et.al compares three similar methods based on contextual filtering. These methods are depending on locally estimation features such as fingerprint ridge frequency orientation and curvature. These features are used to perform matched techniques. The processed algorithm has median filter to filter the data outliers and then a radial frequency histogram to calculate from the magnitude of the median filtered image. The fundamental frequency of the fingerprint has assumed located at the point where the radial frequency histogram obtains its maximum value. The radial frequency histogram is here to smooth in order to reduce the impact of spurious noise. The proposed algorithm extracts more robust features from low quality fingerprint image. It can obtain greater accuracy by the addition of non minutiae information. [19] anil k jain et.al fingerprint image enhancement algorithm and reported to achieve good performance. They acquired fingerprint features by the procedure of

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preprocessing, binarization, thinning and extract minutiae. These methods have claimed robust. The drawback binarization may lose some significant information stored in original gray level image. [20] lin hong et.al employed gabor filter in fingerprint image enhancement and claimed that it can achieve good performance. Because Gabor filter have both frequency selective and orientation selective properties. It may have optimal joint resolution in both spatial and frequency domains. [21] s.green berg et.al applied anisotropic filters to enhance the fingerprint images. It is well known that wave shape features. It analyses topographic characteristics by mathematical method can enhance or reconstruct the fingerprint image. Disadvantage of this proposed method is time consumed filter. [22] d.maio & x.jang et.al used a Gaussian shape mask or low pass filter to filter selected selection in every tracing step. Selection by local dominant orientation. [23] tianzi jiang et.al proposed a new algorithm to improve the quality of fingerprint image on gray images. The algorithm has normalization and filters to increase contrast. The resultant output image more contrasted than other techniques. This proposed system clearly differentiates ridges and valleys present in the image. [24] yiwang et.al develops enhanced gradient based algorithm for estimation of fingerprint orientation fields. The proposed algorithm coarse estimates the fingerprint estimation fields. It gives best estimation is then selected form the least noise affected neighborhood according to some reliability measures. [25] iwasokum Gabriel babatunde et.al propose finger print matching algorithm using minutiae singular point networks. The proposed method has different format such as smooth, extract minutiae, ridge segmentation, orientation and frequency estimation, filtering, thinning for binarization. The steps are interchanged. This system will give noise less image and extracts minutiae.[26] devarasan ezhilmaran et.al implement the intuitionistic type II fuzzy set algorithm for contrast enhancement of fingerprint images. The proposed technique is more effective. Especially very useful for forensic science operations. It offered better result with good quality, less noise, low blur if compared with non-fuzzy and fuzzy techniques. [27] neearaj kamboj et.al proposed algorithm helpful to analyze discretized fingerprint texture. The proposed algorithm has two stages and uses two modes such as spatial, frequency domain. In first stage decomposing input image in to four sub bands by 2-D DWT. Compensated image was produced by adaptively obtaining the compensation co-efficient for each subband based on the referred Gaussian template. In second stage apply F.T to overcome the drawbacks of spatial domain method. It removed image background and the blurred region of fingerprint image. [28] bharat yadav et.al develop a novel fuzzy based image enhancement algorithm. He develops fuzzy inference system to get better fingerprint images. The proposed techniques connect the break ridges and remove the spurious noise. [29] a.yesu raja et.al implements an effective noise reduction scheme for the improvement of fingerprint ride enhancement algorithm. The proposed algorithm developed by inverse VST and Gabor based ridge enhancement. This system overcomes the drawbacks of variance stabilizing transformation, fuzzy filter and curvlet transform. The proposed method extracts the ridge curves present in the image. [30] Tamin r.randolph et.al proposed a Novel algorithm for fingerprint image enhancement using a binary angular representation. It allows directional information to be displayed visually in the subbands. Moreover, its reconstruction process is well behaved and allows subband

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modifications to be mode while enabling good quality reconstruction. [31] chih-jen lee et.al propose Gabor filter based image enhancement algorithm. The proposed algorithm developed a fast and robust approach to fingerprint recognition. It develops simple preprocessing process. It extracts local and global features such as core point detection, local ridge orientation, fingerprint classifier and reconition. [32] hong et.al have explained an enhancement algorithm based on the minutiae extraction. It is one of the fastest fingerprint enhancement methods. Which can improve the clarity of ridges and vally of fingerprint images based on frequency domain filtering and ridge orientation. The improved goodness index and verification accuracy evaluates this method as an efficient one. Here the Gabor filter is applied to each pixel in the image. [33] mohammed shaker M.A et.al proposed a new algorithm for enhancement using adaptive pre-processing of data and k-means segmentation. It improves exiting methods based on contextual filtering. Adaptive system implies the parameters of this method are automatically adjusted. It extends the work of global and local levels. The proposed method combines and updates existing processing blocks. In this method k-means used it for segmentation [34] zhang et.al propose an efficient fingerprint image enhancement algorithm with Gabor filter. This Gabor filter filtered the noise in both domains such as spatial, frequency domains. This algorithm is to connect the broken ridges. [35] Yang et.al proposed a novel filter method for fingerprint image enhancement.MGF in order to overcome draw backs of TGF. It improves the quality as compared with TGF. [36] kim et.al proposed a novel fingerprint image enhancement algorithm on the basis of image normalization and Gabor filter. This proposed method is effectively extracts the features of intrinsic properties like local ridge histogram, local directional estimation. The algorithm identifies the minutiae adaptively. [37] Khan et.al proposed a directional filter to provide the output in the form of bidirectional images. Bidirectional subband has provided filter in each subband individually. The median filter should apply to the fingerprint image before given to proposed method. It is used to remove non-uniform illumination. [38] jun-tao et.al proposed an image enhancement algorithm as a combination of both edge filter and Gabor filter. In edge filtering the algorithm enhances edges and segments the images in to several blocks. Then using multilevel block size method is used to extract the orientation fields from the segmented image. Finally Gabor filter used to enhance the fingerprint image. [39] d.bennet et.al proposed a novel algorithm as a combination of single vector decomposition (SVD) and discrete wavelet transform(DWT). The proposed algorithm is used to remove the noises and illumination sources and DWT is a purpose to extract the minutiae and estimate direction of filed. The SVD will maintain gray level intensity values are around a minutiae point. Maintain the local information. It provides accurate result in minutiae region. [40] yanga et.al propos a novel two stage enhancement scheme in both spatial and frequency domains. He proposed combinations of Gabor and STFT filter. It works as a ridge compensation filter in the image to use the context information of local ridge to connect or separate ridges. The broken ridges will be connected. Merge ridges will separate efficiently. [41] l.g.babatunde et.al modified some of the sub models of an existing algorithm for the fingerprint image enhancement. It consists

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of different models for fingerprint image segmentation, normalization, ridge orientation estimation, ridge frequency estimation, Gabor filtering, binarization and thinning. [42] bhavin patel et.al develop the fast discrete curvlet transform and compared the result with discrete wavelet transform(DWT), curvlet transforms. The discrete curvelet transform extracts the edge based features more efficiently than DWT. [43] avenash kumar et.al develops a simple and efficient road map to process fingerprint images in frequency domin. In this proposed method uses combination of histogram equalization (HE) and fast fourier transform(FFT). First applied the HE to derive ridge frequency and then followed the FFT. This method is used for fingerprint feature extraction. This is also evaluated by the k-nearest nighbour classifier. [44] r.sivaranjani et.al develops Gabor based fingerprint image enhancement techniques. He compare the error measurements like PSNR & MSE of Gabor, modified Gabor filter(MGF), Log-Gabor filter. This paper proves the MGF get better result compared with other techniques. [45] nisha gupta et.al proposed a fingerprint recongnition system using hybrid of STFT, INLM with Rayleigh CLAHE algorithm. The algorithm Interference normalized least mean square with ray leigh contrast limited adaptive HE. It amplification of noise by clipping the histogram at a predefined value before calculated CDF. It equally redistributes the part of the histogram above a clip limit among all the histogram.[46] ghazal et.al proposed an algorithm combination of both median filter and FFT. The proposed algorithm used to extract the features and evaluated by k-nearest neighbor classifier. It also removes the noise to enhance the image. [47] rama reddy et.al develops an image enhancement algorithm with hierarchical markov random fields. It extracts features such as directional fields, minutiae and singular points reliably using hierarchical markov random fields. Split the image into overlapping patterns and enhance all locally normalized through adaptive filters. Introduce FAGE &SAGE ability to reduce false minutiae data in noise images. [48] reshma rajan et.al develops a novel algorithm using combination of histogram equalization (HE) and Frangi filter. It maintains the histogram levels at a vein. This algorithm is used to extract the features of fingerprint vein for authentication [49] r.d.raut et.al presents new approach for personal authentication using finger knuckle surface for feature estimation. This method removes noise and also enhances the FKP image. That improves accuracy of the system. The proposed technique has accuracy of 88.99% and EER of 10.01%. [50] anoop T R et.al presents FFT enhancement for ridge discontinuity analysis and use of scars along with ridge discontinuity and minutiae density for alteration. The scar is detected by adaptive average filtering and threshold. It is suitable for all types of alteration such as. Obliteration, distortion and initialization.

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3. Comparison of different algorithms:

Table 1: Comparison of enhancement algorithms

S.No	Author Name	year	Enhancement Technique / Algorithm	Measuring Parameters	Domain	Advantage / Algorithm Purpose
1	Ju cheng yang,dong sun park	2008	Short time fourier transform (STFT)	LMS, EWC	Spatial and frequency	To eliminate multi-spectral noise, estimate the intrinsic properties
2	Chaohong, Zhi Xin shi	2004	Combination of Anisotropic filter and directional filter	--	Spatial	To filter the impulse noise and estimate the local orientation and global feautures
3	Eun-kyung ,sungbae cho	2006	Adaptive filter	Wavelet scalar qunitzation	Frequency	To estimate the direction of ridge orientation
4	Jianwei yang	2003	Modified Gabor filter	FAR,FRR	Spatial and frequency	Preserving fingerprint structure and achieving image enhancement consistency. It reduced FRR,FAR
5	Marius Tico	2000	Directional filter	--	Spatial	Able to detect and cancel false minutiae associated with spikes,holes,bridges and spur. It removes most of the ridge breaks.
6	Jie zhou	2004	Hierarchical scheme of Gradiant	Threshold	Frequency	It estimates the local orientation around the region even in lower resolution. Result provides exactly averaged square gradient
7	Anil k jain	2000	Gabor filter	Euclidean distance, length of finger	Spatial and frequency	It is extremely fast and achieves accurate verification. Best

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				code		result for minutiae based algorithm
8	Ching tang hsieh	2003	Wavelet transform and quadrature mirror filter	--	Frequency	Improve the clarity, continuity of ridge structures and situations of blur region and broken ridge.
9	Yuliang	2003	Adaptive orientation field	Point pattern matching	Spatial	Deals with problem of point pattern matching in fingerprint reorganization by changing the points to the polar co-ordinate system & compare pointset
10	Frenado Alonso	2007	Spatial coherence with Gabor	Global feautures	Spatial and frequency	It estimate accurately the global features like direction field and power spectrum
11	Lin hong	1998	Gabor filter	Region mask and orientation	Frequency	The algorithm estimates local orientation and region mask
12	b.g.sherlock	1994	Combination of directional with FFT	--	Spatial and frequency	It get good quality noise less image
13	Sharat chikkerur	2007	STFT	--	Frequency	To analyze the non-stationary signals. It utilizes the full contextual information and reduced space requirement compared to Fourier transform
14	Joesf strom bartunek	2011	Curved Gabor filter and successive mean quantization transform(SMQT)	--	Frequency	It act as a contextual filtering. It perform nonlinear contrast enhancement operation.
15	Mustafa khalafa	2011	Mehtre	--	Spatial and	To increase the contrast and

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					frequency	enhance the ridges as well as furious structures. It removes noise.
16	Baartunek	2013	Extended adaptive filter	--	Frequency	It is used as a contextual filtering and adjust primary frequency based on the global analysis
17	Ghafoor	2014	DCT with direction filter	--	Spatial and frequency	It is also used for contextual filtering. It represents better enhanced image compared with extended adaptive filter.
18	Amit v. malwade	2015	Median filter , DCT, and adaptive filters	Radial frequency histogram & fundamental frequency	Frequency	It is used to smooth the fingerprint image and extracts robust features of low quality image.
19	Anil k jain	1997	binarization	--	Spatial	To enhance the fingerprint image.
20	Lin hong	1998	Gabor filter	--	Frequency & spatial	Enhance the image by remove the break point
21	s.green berg	2000	Anisotropic filter	--	Spatial	It analyze topographic characteristics by mathematical method can enhance
22	d.maio	1997	Gaussian with low pass filter	--	Spatial	It enhance the image and select the local dominant orientation
23	Tianzi jiang	2002	Wavelet	--	Frequency	It enhances the gray scale image. It represents ridges and valleys clearly
24	Yiwang	2007	Modern Gradient method	--	Spatial	It gives best estimation of orientation fields from the least noise affected

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						neighborhood.
25	Iwasokun Gabriel babatunde	2015	Improve the novel algorithm	--	Spatial	It enhances the fingerprint image by smoothing and binarization
26	Devarasan exhilmaran	2015	Intuitionistic type II fuzzy set	--	Spatial	Offered better result with good quality,less noise, low blur
27	Neeraj kamboj	2015	Combination of F.T and HE	--	Spatial and frequency	The background and the blurred region of fingerprint images were also removed
28	Bharati yadav	2015	Fuzzy	--	Frequency	To connect the break ridges and removes spurious noise
29	a.yesh raja	2015	Combination of variance stability transform and Gabor filter	--	Frequency	It will identify the curves and enhance the image
30	Tami r.randolph	2001	Binary angular representation	--	Frequency	It provide the capability to perform region target suppression of artifacts and pattern feature enhancement
31	Chih-jen lee	1999	Gabor filter	--	Frequency	To extracts the local as well as Global features.
32	Hong	1998	Minutiae based Gabor filter	--	Frequency	To improve the clarity of ridges and valleys of fingerprint image. It is one of the fastest enhancement methods.
33	Mohammed shaker	2013	Adaptive filter with K-means	--	Frequency	It is used to enhance all types of quality fingerprint images.
34	Zhang	2002	Gabor filter with change the algorithm steps	--	Frequency	It is also used to extract the global properties and also enhance the image
35	Yang	2003	MGF	--	Frequency	It reduces the FAR

						& FRR
36	Kim	2002	Combination of normalization and Gabor filter	--	Frequency	It is one of the adaptive filter to enhance the image
37	Khan	2005	Direction filter	--	Spatial	To remove the non-uniform illumination.
38	Jun tao	2009	Combination of both edge filter and Gabor filter	--	Spatial	To identify the edges and enhanced the segment images
39	d.bennet	2011	Combination of SVD & DWT	--	Frequency	It removes the noise, illumination and maintain gray values around the minutiae
40	Yanga	2013	Combination of both ridge compensation filter and Gabor filter	--	Spatial and frequency	It connect the broken ridges and separate merge ridges
41	l.g.babatunde	2012	Modified sub models of existing basic algorithm	--	Frequency	It is used to enhanced the fingerprint image by Gabor filter
42	Bhavin patel	2015	Combination of DWT and discrete curve let trans -form	--	frequency	It extracts the fingerprint edges.
43	Avenash kumar	2015	Combination of both HE & FFT	--	Frequency	Feature extraction evaluated by k-nearest neighbor classifier
44	r.sivaranjani	2015	Gabor,MGF,Log - gabor	PSNR, MSE	Frequency	He proves MGF gives better enhance image if compared with Gabor and Log-gabor
45	Nisha gupta	2015	Combination of both STFT and adaptive HE	--	frequency	It equally redistributes the part of the histogram and amplify the noise by clipping a histogram at a predefined value
46	Ghazal	2009	Combination of Median filter &	--	frequency	It is used to extract the ridges and

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			FFT			remove the scars in the image
47	Rama reddy	2011	Hierarchical markov random fields	--	Frequency	It extracts the features such as directional field, minutiae, singular points and enhance the image
48	Reshma rajan	2014	HE with Frangi filter	--	Frequency	It extracts the features of finger vein
49	r.d.raut	2014	Kekres wavelet transform(KWT)	--	Frequency	It gives great potential to be used for spectral feature extraction of knuckle print

4. Conclusion:

This paper presents survey on fingerprint image enhancement technique. In this paper descried all the spatial and frequency domain techniques related to fingerprint biometric authentication system. It covers lot of algorithms which are very famous such as Gabor, Log-Gabor, MGF, HE, SVD, DWT and median filter. All the above discussed algorithms are follows unique techniques and all are used to obtain enhance image by extract the orientation fields, direction, histogram, remove unwanted scars and breaks, represent ridges and valleys clearly. Our feature work develop a novel algorithm using combination of modified Gabor filter (MGF), Median filter and directional filter to enhance the fingerprint image

References:

[1] ju cheng yang, dong sun part, “A fingerprint verification algorithm using tessellated invariant moment features”, neurocomputing, 3 march-2008.

[2]chaohong wu, zhixin shi, venu govindaraju, “fingerprint image enhancement methods using bidirectional median filter”, The international society for optical engineering, 18 feb 2004

[3] Eun-kyung yun, sung-bae cho, “Adaptive fingerprint image enhancement with fingerprint image quality analysis”, Elsevier/image and vision computing,2006 101-110.

[4]jianwei yang, lifeng liu, tianzi jiang, yong fan,”A modified Gabor filter design method for fingerprint image enhancement, jan 2003 1805-1817

[5]Marius tico, pauli kuosmame, “An algorithm for fingerprint image postprocessing”, IEEE transaction, 2000, 0-7803-6514

[6]jiezhou, jinwei gu, “A model based method for the computation of fingerprints orientation field”, IEEE transactions on image processing, VOL.3, NO.6, june-2004

[7]anil k jain, salil prabhakar,lin jong, sharath pankanti, “Filter bank based

fingerprint matching", IEEE transactions on image processing, VOL.9,NO.5, may-2000

[8]ching-tang hsieh,Eugene lai, you-chuang wang, "An effective algorithm for fingerprint image enhancement based on wavelet transform", the journal of the pattern recognition society, 2003 303-312.

[9]yuliang he, jie tian, xiping luo, tanghui zhang, "Image enhancement and minutiae matching in fingerprint verification", Elsevier/pattern recognition letters, 2003.

[10]frenando Alonso-fernandez,Julian fierrez, "A comparative study of fingerprint image quality estimation methods", IEEE transactions on information forensics and security,VOL.2,NO.4, December-2007.

[11]lin hong,yifei wan, anil k jain, "fingerprint image enhancement: algorithm and performance evaluation", IEEE transaction on pattern analysis and machine intelligence, September -1998.

[12]b.g.sherlock, d.m.monro, k.millard, "fingerprint enhancement by directional fourier filtering, IEEE transactions on image signal processing, VOL-141, NO.2, April-1994.

[13]sharat chikkerur, Alexander n.cartwright, venu govindaraju, "fingerprint enhancement using STFT analysis", the journal of the pattern recognition society, 2007

[14]Josef strom bartunek, mikael nilsson, benny sallberg, ingvar classon, "Adaptive fingerprint image enhancement with emphasis on preprocessing of data", IEEE, 2011

[15] Mustafa khalafa,zaid amin abduljabar, huda ameerzeki, "fingerprint image enhancement by develop mahtre technique",ACIJ,VOL.2,NO.6, November-2011.

[16] Josef Ström Bartunek, Mikael Nilsson, Benny Sällberg and Ingvar Claesson, "Adaptive Fingerprint Image Enhancement With Emphasis on Preprocessing of Data", IEEE Transactions on Image Processing, Vol. 22, No. 2, February 2013

[17] Mubeen Ghafoor, Imtiaz A. Taj, Waqas Ahmad, Noman M. Jafri, "Efficient 2-fold Contextual Filtering approach for Fingerprint Enhancement *",* IET Image Process, 2014, Vol. 8, lss. 7, pp. 417-425.

[18]amit v.malwade, Dr.r.d.raut, Dr.v.v.takare, "a survey on enhancement techniques to improve the accuracy in fingerprint matching", international journal of advanced research in computer science and software engineering, VOL.5,NO.4, april-2015.

[19] Anil Jain, Lin Hong, Ruud Bolle, "On-line Fingerprint Verification," IEEE Trans. Pattern Anal. Mach. Intell. 19, pp.302-314, April 1997.

[20] Lin Hong, Yifei Wan, Anil Jain, "Fingerprint Image Enhancement: Algorithm and Performance Evaluation", IEEETrans. Pattern Anal. Mach. Intell. Vol. 20, No.8 pp.777-789, Aug. 1998.

[21] Shlomo Greenberg, Mayer Aladjem, Daniel Kogan , Itshak Dimitrov, "Fingerprint Image Enhancement Using Filtering Techniques," 15th *Int.* Conf. on Pattern Recognition, Barcelona, September 3-8, IEEE Computer Society Press-2000.

[22] D. Maio, D. Maltoni, "Direct Gray-scale Minutiae Detection in Fingerprints," IEEE Trans. Pattern Anal. Mach.Intell.19, pp.27-39, 1997.

[23] jianwei yang, lifeng liu, tianzi jiang, "A improved method for extraction of fingerprint features", the international society for optical eningeering, july-2002.

[24]yiwang, jiankun hu, fengling han, "enhanced gradient based algorithm for the estimation of fingerprint orientation fields", ELSEVIER/ applied mathematics and computation, 2007.

[25]iwasokun Gabriel babatunde, "fingerprint matching using minutiae singular point network",international journal of signal processing, image processing and pattern recognition,VOL.8, NO-2,2015.

[26]devarasan ezhilmaran, manicham adhiyaman, "contrast enhancement of fingerprint images using intuitionistic type II fuzzy set",sjst, april-2015.

[27]neeraj kamboj, veena rani, "design and implementation of fingerprint biometrics based on discritized fingerprint texture description",international journal of innovative research in computer and communication engineering", VOL.3,ISSUE.6, june-2015.

[28]bharati yadav, ramnivas giri, "fingerprint recognition using fuzzy based image enhancement", international journal of innovative research in science,engingeering and technology, VOL.4,ISSUE.12, December-2015

[29]a.yesu raja, s.arumuga perumal, "An effective noise reduction scheme for the improvement of fingerprint ridge enhancement", journal of harmonized research in engineering,2015.

[30] tami r.randolph, mark j.t.simth, "fingerprint image enhancement using a biangular representation", IEEE,2001.

[31] Chih-jen lee andsheng-de wang, "A gabor filter based approach to fingerprint recognition", IEEE – 1999

[32] L. Hong, Y. Wan, A. Jain, "Fingerprint Image Enhancement: Algorithm and Performance Evaluation", IEEE Trans. Pattern Analysis Machine Intelligence, Vol. 20, no.8, pp.777-789, 1998.

[33] mohammed shaker M.A, nithin M.V, "Fingerprint image enhancement using adaptive preprocessing of data and k-means segmentation", IJSR – 2013.

[34] Yigang Zhang, Yuhua Jiao, Juncao Li, Xiamu Niu, "A Fingerprint Enhancement Algorithm using a Federated Filte"r,HIT,China,2002.

[35] J. Yang, L. Liu, T. Jiang, Yong Fan, "An improved method for extraction of fingerprint features" In: Proc.2nd ICIG, SPIE, Vol. 4875, no.1, pp. 552558, 2003.

[36] Byung-Gyu Kim, Han-Ju Kim and Dong-Jo Park, "New Enhancement Algorithm for Fingerprint Images", IEEE proceedings,Vol.4651,no.2,pp. 1051-1055, 2002

[37] Mohd. A. U. Khan, M. Khalid Khan, M.Aurangzeb Khan, "Fingerprint Image Enhancement Using Decimation-Free Directional Filter Bank", Information Technology Journal, Vol. 4, no. 1,pp.16-20, 2005.

[38] Xue Jun-tao, Liu Jie Liu Zheng-guang, "An enhancement algorithm for low quality finger-print image based on edge filter and Gabor filter", Proc. Of SPIE, Vol. 7383,2009.

[39] D.Bennet and Dr. S. Arumuga Perumal, "Fingerprint:DWT, SVD Based Enhancement and Significant Contrast for Ridges and Valleys Using Fuzzy Measures", JCSE, Vol. 6, no.1, pp.36-42,2011

[40] Jucheng Yang, Naixue Xiong and Athanasios V.Vasilakos, "Two Stage Enhancemet Scheme for Low-Quality fingerprint images by learning from images",IEEE Transactions on Human Machine System, Vol.43,no.2,March,2013.

ISSN2454-9940
www.ijsem.org
Vol 13, Issuse.1 Jan 2022

[41] I.G. Babatunde, A. O.Charles, A. B.Kayode and O.Olatubosun, "Fingerprint Image Enhancement:Segmentation to Thinning",IJACSA,Vol.3,no.1,pp.15-24,2012.

[42]bhavani patel, miss shivangi malli, " a survey on fingerprint image quality improvements using hybrid approaches", JETIR,VOL-2,ISSUE.12,dec-2015.

[43]avenash kumar,tahseen a.jillani, "a simple and efficient road map to process fingerprint images in frequency domain",international journal of computer applications,feb-2015

[44]r.sivaranjani, " gabor filter based fingerprint enhancement technique", VOL.3,NO.4,april-2015.

[45]nisha gupta,anshul kumar, "fingerprint recognition using hybrid STFT,INLM with Rayleigh CLAHE", IJARCSSE,July-2015

[46]ghazali sulong, tanzila saba, amjad rahman,saprudin, "A new scars removal technique of fingerprint images", ICIC-BME- 2009,

[47]ramareddy, anoop m, namboodri, " Fingerprint enhancement using hierarchical markov random fields", IEEE-2011.

[48]reshma rajan, indu m.g, "A novel finger vein feature extraction technique for authentication", AICERA-2014

[49]r.d.raut, sujata kulakarani, nehan,gharat, "Biometric authentication using kekre's wavelet transform", international conference on electronic systems, signal processing and compating technologies-2014

[50] anoop t r, mini m.g, "Detection of fingerprint alteration using scars, minutiae density and ridge discontinuities", international journal of scientific and engineering research,vol-4,No-8,august-2013.

[51] http://shs2.westport.k12.ct.us/forensics/04-fingerprints/classification.htm