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IMAGE ENHANCEMENT USING DIFFERENT FORMS OF HEX-GABOR FILTER: A COMPARATIVE ANALYSIS

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ABSTRACT
An Integrated Automatic Fingerprint Detection Service (IAFDS) is used to analyze fingerprint image enhancement. Fingerprint images are typically improved by reducing unknown fact ration to identify good and clear fingerprints and Integrated Automatic Fingerprint Detection Service (IAFIS) is mainly to get accurate results. All images having some noisy data which are enhanced by using a filtering method which aims to improve output image with the components of spatial frequency, pixel directions of input image. An experimental description is useful improve fingerprint images using Gabor Filter (GF) is presented in this paper. Domain lattices are fixed in the certain limit range of spatial frequency and window Hanning are fixed. By adjusting all the given parameters of the proposed transformation function in the specified range, substantial improvement of contrast of masses is achieved along with the suppressing of background tissues. In this paper, we approach different filters with Hex-Gabor Filter (HBF) to enhance the fingerprint image to execute the two major operations which are preprocessing in image enhancement and interpolation method. It is because of these reasons numerous specialists have examined the chance of utilizing a hexagonal structure to speak to advanced pictures. Wavelet likewise have its own preferred position and joining wavelet and handling of pictures in Hexagonal structure, that additionally will give better execution, on the grounds that hexagonal wavelet incorporates the benefits of the hexagonal matrix alongside the wavelets. Using proposed HBF method, sigma value is 2/pi can be obtained and the value of sigma meaning is proven. An experimental findings demonstrate that the HBF increases the representation of the fingerprint better than other methods of filtering and removing features.

Keywords: *Fingerprints, Gabor filter, Hex-Gabor filter, IAFIS, interpolation, sigma value.*

I. Introduction:

Biometrics offers highly flexible applications for defense operations for identity management. Biometrics delivers reliable authentication, transparency, User friendly and time saving method which is useful for company for document entry, identification and other security issues such as passwords [1]. Now-a-days fingerprints are one of the important security traits which are widely used by personal recognition systems. An IAFDS is essential method to find optimal solution fingerprint recognition. Today, fingerprints are one of the biometric traits that are most widely used by personal recognition systems. The introduction of fingerprint recognition is one of the essential tasks of the IAFIS. One of the five 2D lattice forms is the hexagonal lattice or triangular lattice. An equilateral triangle is created by three nearby points. The four orientations of such a triangle are by far the most common in images. By seeing the

triangle as an arrow, they can easily be pointed to as pointing up, down, to the left or to the right; however, they may also be assumed to point in two oblique directions in either instance. By far the most frequent is two orientations of an image of the lattice. With triangles pointing up and down, they can simply be referred to as "hexagonal lattice with horizontal rows" (as in the diagram below and "hexagonal lattice with vertical rows" with triangles pointing left and right. They vary at an angle of 30°. In determining the output image, the multiple parameters of the Filter bank play a major role. Gabor's filters select the scale, phase, orientation and frequency of the output signal. The image characteristics are determined by using a suitable Gaussian filter for each pixel with an adaptively selected dimension, direction, frequency and phase. For the option of the necessary kernel size, an image property called phase divergence is used. For each pixel at the chosen size of the filter, characteristic features related to the shift in light, texture and location are removed.

The characteristics of two distinct fingerprint images are contrasted by the fingerprint recognition system. The filter comparison with hex-Gabor filter is based on the characteristics of edge detection, scaling, patterns and designs of fingerprints [3]. Arch, loop and whorl are three simple patterns which are available in given fingerprints [4]. Fingerprints are given as input to recognition devices which extracts an enhanced output image by comparing with some filters. The output of fingerprint image is enhanced from the old one of stored images and recognize by individuals by comparing the given information [5]. Biometric refers to an individual's automatic recognition by using certain physiological or behavioral characteristics identified with the individual. Personal identification is the association of an identity with a single individual [6]. It plays a vital role in our culture, in which hundreds of thousands of organizations in financial markets, health care, electronic commerce, telecommunications, government, etc., raise questions about an individual's identity millions of times every day. Hexagonal matrix of pixels can be spoken to on the current rectangular screens for demonstrating and preparing reason, which is more appropriate for PC vision demonstrating. Controlling information tested on one grid to create information inspected on an alternate cross section is named as resampling. In this methodology, the first information is tested on a square grid while the ideal picture is to be tested on a hexagonal grid (Figure.1)

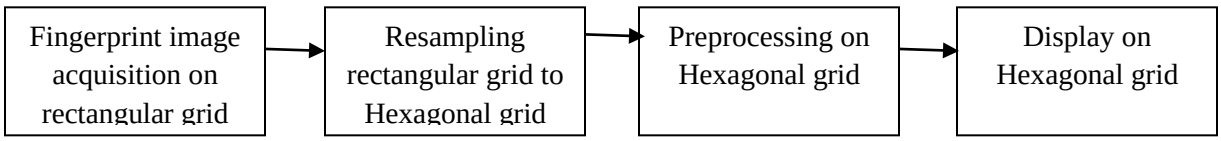


Figure 1: Visualization of Resampling Hexagonal grid image

Passwords and ID cards have historically been used to modulate entry to limited networks. In these schemes, however, protection can be quickly broken when a password is revealed to an unauthorized person or a card is stolen by an impostor [7]. In addition, basic passwords are easy to guess and it can be challenging to remember difficult passwords. At around seven months of fetal development, fingerprints are entirely developed and finger ridge configurations do not alter in an individual's life, even due to injuries such as bruises and fingertip cuts [8]. Image restoration is processed by an interpolation method which is a routine operation for image transformations. All the transformation of image

processing includes rotation, registering, scaling and preprocessing. Both low pass and high pass filters are used to boost edge detection and preprocessing technique [9].

To boost the given image and encourages interpolation by bringing kernal pixel position as on. A given Hex-Gabor filter is much more efficient than a unipolar narrow filter at higher resolution in edge enhancement and texture (high pass filter is also known as a Gaussian wave filer). Directional pixel distances and orthogonal path filtering are essential, but unequal kernels of lattice also important [10].

II. Related works

The review of different research papers that led to image enhancement using Gabor filters is discussed in this literature survey.

For fingerprint image enhancement, Cartesian Gottschlich [11] suggested curved Gabor filters. Standard Gabor filtering has been updated so that curved structures in noisy images can be enhanced. The suggested methodology increases the quality of the fingerprint, smoothens the image without producing objects. To obtain a robust estimation for noisy images, two orientation field estimation methods are combined. Using local orientation values, which are used for measuring local ridge frequency, curved regions are built. For enhancement of the input images, previously calculated orientations and ridge frequencies are used.

The technique recommended fingerprint improvement using STFT analysis [12]. A well-known method used to analyze non-stationary signals is the Short Time Fourier Transform (STFT). This approach considers all the features of the input image, such as the mask of the foreground area, the direction of the local ridge and the frequency of the local ridge. To compete against conventional Fourier domain filtering methods, the algorithm requires less memory. The approach proposed is more stable and there is an average gain of 24 percent.

Gray-scale handwritten words for pictures to derive characteristics from the terms using GF [13]. Set n Gabor was used by them Filters to remove these focused components from the word picture on the gray scale. The outputs that are filtered The binary images of the extracted parts that are used for the extracted parts are then processed to obtain a Calculation of single and binary attributes. Sections are derived from the picture of the word by Using answers from a Gabor filter bank.

Enhancement of fingerprint images suggested using Mehter's built technique. The combination of block filtering, histogram equalization and high pass filtering methods is the Mehter technique. Using histogram equalization and high pass filter increases the contrast of the fingerprint graphic, and this improves the ridges. It also strengthens the structures that give each ridge an accurate directional element. Median filter use in block filtering corrects the incorrect path of the block [14].

Using unsupervised hierarchical function learning, Mihir Sahasrabudhe [15] Next the study carried out by different individuals for image enhancement is here, researchers are answered, indicated that on the use of Adaptive Histogram provides stronger outcomes Equalization, but the image's presence is still not free, Of the washed out form. The contrast and sharpness are insufficient. The context information is also fogged, as is the aircraft. It is evident from the above brief literature review that enough work has already been performed for improving fingerprint images.

III. Filters Comparison

A. Gabor Filter

Dennis Gabor initially invented the Gabor filter, and we used it for 2D images (CT images). Due to its optimal localization properties in both the spatial and frequency domains, the Gabor function has been recognized as a very useful tool in computer vision and image processing, especially for texture analysis. The image presentation based on the Gabor function is an exceptional local and multi-scale decomposition in terms of lagoons that are placed in space and frequency domains simultaneously (and optimally). The Fourier transform of the impulse response of a GF is the convolution of the Fourier transform of the harmonic function and the Fourier transform of the GF according to the given theorem of convolution.

For the filtering of a one-dimensional signal, the Gabor transform was originally developed. "The resemblance between the Gabor transform and "simple" primary visual cortex cells was shown by Daugman. A GF kernel is a function of both the Fourier and the Gaussian basis components. The filter becomes susceptible to particular image components with spatial frequency and orientation because of the Fourier base. The Gaussian is necessary for the filter to be spatially localized. In this respect, the convolution is identical to the windowed Fourier transform with the Gabor filter. The Daugman's formula has a special structure and is difficult to measure Equation 1:

$$G = \exp(-\pi[(x - x_0)^2 a^2 + (y - y_0)^2 b^2]) \exp(-i2\pi(u(x - x_0) + v(y - y_0)) \quad (1)$$

Where (x0; y0) are the center positions of the convolution window, the chosen spatial frequency determining vector is (u; v) in Equation 2.

$$hg(x,y) = a(x,y)\, b(x,y) \quad (2)$$

The Gabor Filters have received considerable attention because these filters can approximate the characteristics of certain cells in some mammals' visual cortex. Furthermore, these filtration has been shown to have optimal location properties in both the spatial and frequency domains and are therefore well suited to problems with texture segmentation. In many applications, Gabor filters have been used, such as texture segmentation, target detection, fractal dimension control, document processing, edge detection, recognition of the retina, image coding and representation of images. As a sinusoidal plane of specific frequency and direction, modulated by a Gaussian envelope, a texture feature can be seen.

B. Half pixel shift based approach for Hex-Gabor with hexagonal lattice

Reconstruction of images by interpolation is a standard task of image processing during any image transformation. Image registration, preprocessing, scaling and edge detection are provided in certain transformations. Image acquisition system hexagonally laid from an interest of the Human Vision system which are substantially interested in hexagonal sampling has recently been seen. They still have a hexagonal sampling method of topological results and properties of geometric representation with signal acquisition.

To convert entities in the discrete domain in order to reapply the continuous domain results, one must always be confident that they are expressed with adequate accuracy. Usually, actual signals are purely limited in amplitude and quantization is not a concern. A proper construction in implementations relies more on the sampling theorem. A reliable and aliasing-free construction of Gabor filters can be rendered in the frequency domain by following the sampling theorem. A new technique for the design of recursive implementations of the Gabor filters was suggested. For image processing and feature extraction, Gabor filters have attractive properties: Spatial domain and spatial frequency are selected in Orientation, frequency space which are having a certain theoretical limit in giving resolution. Therefore, in recent years, they have been commonly used in these areas.

These filters are characterized in the human visual region of simplified cell which are proved in cortex place. In the visual cortex of a cat, Hubel and Wiesel found the spatial frequency of a Gaussian wave in sinusoidal wave which are shown in experimental results. The two fields focused on the performance study of hexagonal image processing in this work are image compression and denoising. In addition to compression and denoising, this analysis also involves simulation of the pseudo hexagonal pixel image and the technique of image hiding as an extension of the pseudo hexagonal pixel image. Because no hardware is available for the retrieval of hexagonal images, it is important to translate images from traditional images to process images in the hexagonal domain. Alternate pixel suppression methods are used during this work to simulate the hexagonal sampled grid. For image enhancement and interpolation, we have used a Gabor filer.

C. True Square lattice responses on Hex-Gabor filter

Image pre-processing is performed by the interpolation method while transferring all images to restoration method. Image restoration process includes preprocessing technique, scaling, frame correction and edge detection in all kinds of transformations. To enhance the image, low and high pass filters are used. When we bring kernels on and add image pixel positions, it boosts the image and encourages interpolation as well. A modulated wave filter is more efficient than a unipolar narrow filter at higher resolution in edge enhancement and texture. Isotropic kernels are sufficient in normal lattices, but directional and the orthogonal direction filtering is critical for unequal pixel distances. This illustrates the reason for merging the filter-banks' answers. Therefore, three Hex-Gabor kernel orientations are designed by adding 0', 60', and 120' answers, and the resulting kernel are obtained. Visual error was observed by rendering maximal signal value (2/pi) as picture free. Window Hanning is useful to note small values as corrections which are provided by the kernel.

Any of Hex-Gabor features are described as follows: (i) filters are only collecting pixel values of two dimensional base in intra-routed. Pixel values are analyzed by Hex-Gabor filter only, but not for conventional Gabor filter which are Hex domain with different axes recognizes lines. (ii) Directions of inter pixels which are neighboring to another pixel in normal lattice are often considered by Hex-Gabor filter. (iii) The sigma value of 2/pi is isotropic as well as nonlinear kernel. This allowed filtering that would strengthen the edges of the image and preserve smooth data in every normal lattice. (iv) It is possible to use all the rectangular and square grid lattice to obtain optimal results for hexagonal image processing. This indicates the value in the orthogonal directions of considering materials. (v) Always hexagonal lattice values are changed from standard rectangular lattice which are shows suitable compensated. In this paper also explain how this sigma collection by the eye visualizes finer information. The kernel is not unipolar for sigma values longer than 2/pi. (vi) The sigma value is changed to 2/pi

which lost isotropy of Hex-Gabor filter and also loss quality of kernel filtering in the given condition. To illustrate this kernel, by assigning signal values are 1,2,3… n/pi, the forms of the kernels (vii) By altering small variations after 2 pi sigma value. (viii) It produces a continuous image surface that enables interpolation while using kernels for image enhancement. In addition, of Gaussian filter value as compact fact, in the addition of kernel value for the given function.

D. Gabor filter response on rectangular lattice

During the acquisition of, the images from the rectangular lattice to the hexagonal lattice, a substantial reduction of image quality was found. Therefore, before processing the file, selection of the appropriate interpolation technique is necessary. Reconstruction of images by interpolation is a standard task of image processing during any image transformation. Considerable interest in hexagonal sampling has been seen recently. They also have improved topological and geometrical characteristics, leading to a more effective two-dimensional representation of the signal Images are normally built from different band-limited. One of the special, popular and accurate types of verification procedures is the detection and acknowledgment of persons using fingerprints as biometric authentication. The paper proposes a fingerprint verification method using a matching algorithm based on the filter bank. The algorithm uses the Gabor filter bank to obtain fingerprint characteristics. For identification and recognition of a person, these characteristics are then compared. The Euclidian distance is used to compare the query image feature vector with the fingerprint database feature vector. Two sets of FVC2000 and DBIT databases are used to assess the algorithm's performance and efficiency. The experimental results indicate that the algorithm's average efficiency for FVC2000 and DBIT fingerprint databases is 82.95 percent and 89.68 percent respectively.

It is substantiated that all the properties of the classic Gabor filter are present in the developed method. This greatly extends the Gabor filter's functionality. Experimental filtration samples have been presented. Based on the comparison of the filtered Filter bank, the convenience of using the new filter is justified. Consideration is given to applying hex-Gabor filtering for images by introducing a two-dimensional hex-Gabor filter. It is substantiated that in the developed method, all the characteristics of the classic Gabor filter are present. This extends the functionality of the Gabor filter greatly. Experimental samples for filtration have been presented. The convenience of using a new filter is justified based on the comparison of the filtered filter bank. By introducing a two-dimensional hex-Gabor filter, consideration is given to applying hex-Gabor filtering for images.

E. Gabor filter response on hexagonal lattice with Hanning window

The quality of the input fingerprint images relies on the performance of a fingerprint recognition system. Several studies on improving fingerprint images for fingerprint recognition have been investigated. The adaptive filtering method based on GF is the representative enhancement GF. However, owing to the large mask size of GF, this technique is computationally costly. We propose a HGF in this paper, which is suitable for rapid spatial implementation. The HGF is a modified filter that preserves a GF's frequency property and decreases the GF's mask size. The HGF not only reduces the processing time by approximately 41 percent compared to the GF, but also improves the fingerprint image, which is as reliable as the GF. This is characterized by Equation 3.

$$h_k = 0.54 - 0.46\cos\left(\frac{2\pi k}{N-1}\right), \qquad 0 \le k \le N \tag{3}$$

IV Hexagonal Resampling Techniques

Threre are two unique sorts of portrayal of hexagonal cross section, for example, alternate pixel suppressal strategy and half-pixel shift technique. Hexagonal network picture dependent on substitute pixel suppressal technique can be gotten from the traditional picture by then again smothering lines and sections of the existing rectangular framework and sub examining it. The wide range of various pixels of the rectangular framework which don't have any correspondence with the hexagonal partners are smothered to zero. While handling this sub examined picture the stifled pixels are not considered in calculation. The sub examined hexagonal network is appeared in Figure. 2.

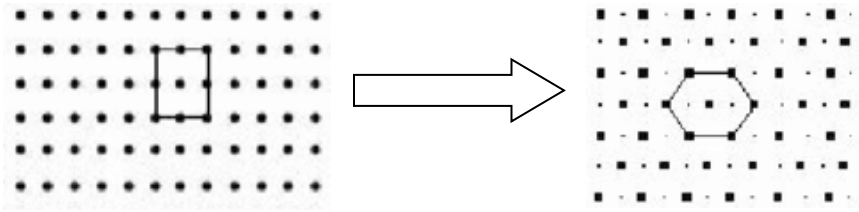


Figure 2: Rectangular grid to Hexagonal grid using alternate pixel suppression techinique

The hexagonal framework got above by sub inspecting the rectangular lattice picture comprises of less pixels contrasted with rectangular tested picture which will influence the nature of the picture. Here, we consider hexagonal lattice dependent on half-pixel move strategy [8]. For each odd line , discover the midpoint between two adjoining pixels by basic direct introduction (i.e., mid = (left + right)/2). Dispose of the left and right, keeping just the mid qualities. This gives us a hexagonal planning from a standard square or rectangular framework.

Table I HGF Response Efficiency Analysis Of Rectangular And Hexagonal Lattices

	True square lattice on HGF	Gabor filter response on rectangular lattice	HGF lattice with Hanning window
Image 1	56.85	59.63	68.54
Image 2	55.36	59.82	69.71

It was observed from the study that the processed images with these sigma values are of higher quality and the findings are plotted in Table .1 for $\sigma = 1.5$. Table.1 demonstrates the efficiency relation of the Hex-Gabor response of the images on true square and rectangular lattices with a Hanning window on true square lattice and Gabor response.

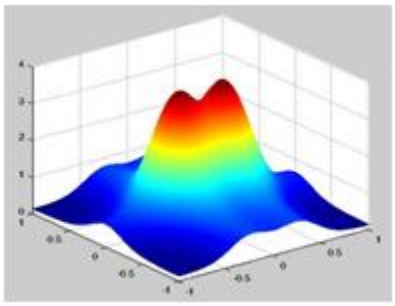
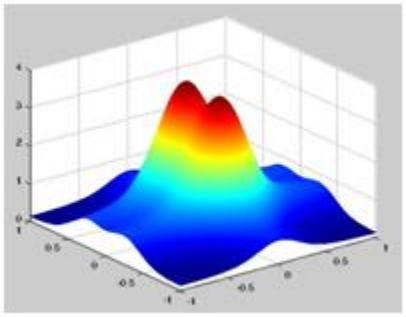


Fig 3 (a) Half pixel shift based hex lattice



F**ig 3 (b)** True square lattice in Hex-Gabor

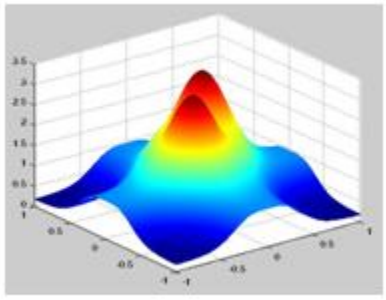


Fig 3 (C) Gabor filter response on rectangular lattice

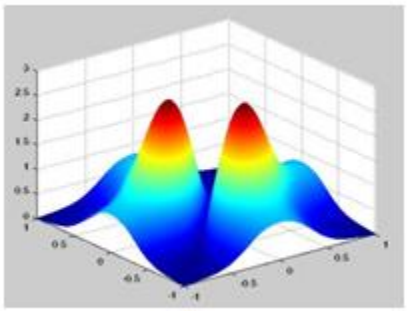


Fig3(d) Gabor filter response on hexagonal lattice with Hanning window

It is observed from the findings that the images from Figure 3(a) to (d) is free from spurious coloring with the influence of the window and the texture characteristics of the image are quite simply relative to the original image.

V . Conclusion

The study of the practical application of the Gabor filter in computer vision tasks was discussed in this article. It calculated the different parameters of the formula for the filter. An experimental description is useful improve fingerprint images using Gabor filter is presented in this paper approach from the comparative analysis. In re-sampling and interpolation, we have suggested implementing Hex-Gabor filtering on the hexagonal lattice. The advantages of hex Gabor filters were stated for filtering, edge detection and registration purposes in an earlier paper. In this article, the sigma 'parameter from 0.5 to 3 is found to fulfill much of the criteria for image interpolation according to the findings obtained in the previous section. We may get enhanced with a special value of sigma for reflected images. Using the proposed Hex-Gabor method, sigma=2/pi can be obtained and the meaning of this sigma value is proven. The experimental findings demonstrate that the Gabor filter increases the representation of the fingerprint better than other methods of filtering and removing features. In this wok, the wavelet put together picture pressure is performed with respect to both square just as hexagonal examined pictures and the

presentation is looked at utilizing Mean Square Error (MSE) and Peak Signal to Noise Ratio (PSNR). Gabor channel is utilized for the introduction of hexagonally sampled images. Compression on hexagonal area gives better outcomes contrasted with compression on rectangular space.

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