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A Review on Enhancement of Latent Fingerprint Images by Multi-scale patch based Sparse Representation & Hazy Images by Image Dehazing and Transmission Map Refinement

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ABSTRACT: Image enhancement plays an important role in image processing. As the name indicates it focuses on enhancing the quality of the image. This paper gives a review or survey on various enhancement techniques used for enhancement of latent fingerprint images and hazy images. Latent fingerprints or simply latent can be considered as cardinal evidence for identifying and convicting criminals. The amount of information available for identification from latent is often limited due to their poor quality, unclear ridge structure and occlusion with complex background or even other latent prints. Latent fingerprint identification is of critical importance in criminal investigation. Latent fingerprint images are usually of poor quality with unclear ridge structure and various over- lapping patterns. Prior to feature extraction, fingerprint enhancement is necessary to suppress various noises and improve the clarity of ridge structures in latent finger- prints. A latent fingerprint enhancement combines the total variation model and multi-scale patch-based sparse representation. The total variation model is applied to decompose the latent fingerprint into cartoon and texture components. The cartoon components are the non fingerprint patterns as the structured noises can be removed. A multi-scale patch-based sparse representation method is used for the enhancement of the texture component. Dictionaries are constructed with a set of Gabor elementary functions to capture the characteristics of fingerprint ridge structure and multi-scale patch- based sparse representation is iteratively applied to reconstruct high-quality finger-print image. it removes the over- lapping structured noises and also restore and enhance the corrupted ridge structures. This method is greatly reduced the noise rates in the specified latent finger-print images and improves the global ridge structure significantly. Dehazing is the method used to enhance the hazy images. This paper also focuses on different transmission map refinement techniques. Dehazing plays a dominant role in many image processing applications. The visibility of outdoor images is often degraded due to the presence of haze, fog, sandstorms, and so on. Poor visibility caused by atmospheric phenomena causes' failure in image processing applications. Haze removal also known as dehazing refers to different methods that aim to reduce or remove the image degradation that have occurred while the digital image was being obtained.

KEYWORDS: Latent fingerprint, sparse representation, Gabor transform function, multi-scale patch, De-hazing, Dark Channel Prior, Colour Attenuation Prior.

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I. INTRODUCTION

Image enhancement is a pre-processing step which is used to improve the quality of the image by removing blur and noise. Latent fingerprints are the finger skin impressions left at the crime scene by accident. Usually, such impressions are not directly visible to human eyes unless some physical or chemical techniques are used to process and enhance. Latent fingerprint have been used as an important evidence to identify criminals in law enforcement agencies for more than a century. Before introduction of automated fingerprint identification system (AFIS), latent fingerprints were manually matched against previously enrolled full (rolled or plain) fingerprints by latent examiners to find the suspects. The emergence of AFIS significantly improved the speed of fingerprint identification and made the latent identification against a large fingerprint database feasible. After over thirty years of development, tremendous advances have been made on developing AFIS for full print to full print matching. However, compared to the rolled and plain fingerprints, latent finger- prints are usually of low image quality, caused by unclear ridge structure, uneven image contrast, and various overlap- ping patterns such as lines, printed letters, handwritings or even other fingerprints, etc. . First, the minutiae features in the same fingerprint marked by different latent examiners or by the same examiner but at different times may not be same, which results in making different matching decisions on the same latent-exemplar pair . Then minutiae features in latent fingerprints are manually marked while the minutiae features in enrolled fingerprints are automatically extracted. Thus, manually marking minutiae features is not the best solution for latent fingerprint identification. Latent fingerprints need an enhancement which removes various overlapping patterns, connects broken ridges and separates joined ridges.

The interleaved ridge and valley flows of fingerprint form a sinusoidal-shaped plane wave with well-defined frequency. and orientation in a local neighborhood. A number of methods were proposed to take advantage of this information to enhance the poor quality of fingerprints. The visibility of outdoor images is often degraded due to the presence of haze, fog, sandstorms, and so on. Visibility restoration refers to different methods that aim to enhance the visibility of an image and dehazing is an example of visibility restoration method. Visibility restoration aims to reduce or remove the degradation that has occurred while the digital image was being obtained. Haze removal or dehazing is highly required in computer vision applications and in computational photography. Removing the haze layer from the input hazy image can significantly increase the visibility of the scene. The haze free image is basically visually pleasing in nature. Many vision algorithms suffer from low- contrast scene radiance. Haze or fog the atmospheric particles give the scene depth information. In image processing area haze removal is one of the challenging problem or task as because the haze is de- pendent on unknown depth. For a single input hazy image the haze removal problem is under constrained problem. It is main degradation of outdoor images and weakening of both color and contract images. The bad weather conditions may demeans the quality of the images of outdoor scene. This Problem is used for a photographer to capture the images. These results are used for changing color and blurring images. These atmospheric conditions are used to blur the captured scene. The air is added some misted particles. Which are scattered around the reflected light is also scattered. These scattered events mainly classified into two types such as at- attenuation and air light. Haze removal methods are classified into two types: Image segmentation and Image restoration. Image segmentation is a process of segregation of digital images into multiple segments. Image restoration is the process of taking a corrupted image.

II. RELATED WORK

Latent fingerprint images are usually of poor quality with unclear ridge structure and various overlapping patterns so it's necessary to enhance such images. Gabor filtering is widely used for fingerprint enhancement. In this method, the local ridge orientation and frequency are first estimated at each pixel based on a local neighborhood. Then a Gabor filter is tuned to the local orientation and frequency and applied on the image pixel to suppress the undesired noise and improve the clarity of ridge structure. This method requires reliable estimation of local ridge orientation and frequency, which is challenging for poor quality fingerprint. Another interesting technique based on Short Time Fourier Transform (STFT) analysis was proposed to perform contextual filtering in the Fourier domain for fingerprint enhancement. The traditional 1D (one dimensional) time-frequency analysis is extended to 2D fingerprint images for short (time/space) frequency analysis. The probabilistic estimates of the fore-ground region mask, ridge orientation and frequency are simultaneously computed from STFT analysis.

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Fingerprint Images	Description
Patent Prints	• Visible Prints that occur when a substance on the skin of a finger comes in contact with the smooth surface of another object. • Eg: Blood on his hands.
Plastic Prints	• Visible, impressed prints that occur when a finger touches a soft, malleable surfaces. • Fingerprints that are freshly painted or coated or those that contain wax, gum, blood etc. held and then retain the finger ridge impressions.
Latent Prints	• Fingerprint impressions secreted in a surface or an object are invisible to the naked eye. • it derives from sweat pores found in ridges of fingers. • When the finger touch other body parts, moisture, oil and grease to the ridges. • Techniques provide for identification of these types of prints are lasers, powders and various light sources.

III. PROPOSED METHOD

A. Image Decomposition and Reconstruction Techniques

A Proliferation of literature for Multi-scale patch based sparse representation of Latent Fingerprint enhancement. Here highlight some of the key contributions.

In [1] the Biometric recognition Systems are the automatic recognition systems which uses the physical characteristics of a person like finger print, hand geometry, face , voice and iris. These systems overcomes the drawbacks of the traditional computer based security systems which are used at the places like ATM, passport, payroll, drivers licenses, credit cards, access control, smart cards, PIN, government offices and network security. The biometric recognition systems have been proved to be accurate and very effective in various applications. The biometric features can be easily acquired and measured for the processing only in the presence of a person. Hence these systems are proved highly confidential computer based security systems. Fingerprints have been widely used for reliable human identification in forensics and law enforcement applications for over a century. Law enforcement agencies routinely collect records of all apprehended criminals in two forms: rolled and plain. Rolled fingerprints are obtained by rolling a finger from nail to nail to capture the complete ridge details on a finger while plain fingerprints are captured by pressing down a finger on the at surface of a fingerprint card.

In [2] Image decomposition and restoration for blurred im- ages are the significant challenges in image Processing. Using bilateral filter, image is decomposed into two meaningful components. One is the cartoon component which is often called as geometrical part or sketchy approximation. Other is the texture component which is often called as oscillating part or small scale special pattern. Image restoration for blurred images with or without missing pixels can be performed using median filter and conservative filter. Median filter is a non- linear digital filter which is often used to remove noise. It preserves the edges while removing noise. Conservative filter is also a non-linear smoothing filter. It ensures that the value of the output pixel is within the bounds of its neighbors. Image decomposition and restoration are the two important problems in image processing. In image decomposition, image is decomposed into two meaningful parts.

In [3], the representative algorithms for fingerprint orientation field estimation. Local estimation approaches compute a local ridge orientation using only the neighborhood pixels around. Gradient, silt-based and local Fourier analysis are three most representative methods. Gradient based approaches compute local orientation by summarizing gradients of local neighborhood. Silt-based methods choose the direction with smallest intensity variation as the local orientation.

Local Fourier analysis applies Fourier transform on a local image patch and analyzes in the frequency domain to find out the local orientation. All the three kinds of methods mentioned above consider small local area have different scaled pixels for computing a local orientation and thus are sensitive to image noise. To deal with this problem, a number of regularization techniques have been proposed. The simplest approach is to apply low-pass filtering on the initial orientation field [2], considering the fact that orientation

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field is smooth in most area. Another regularization technique is MRF-based. The orientation if field is modeled as Markov Random Field and optimized using graph cut [4] or loopy belief propagation [3] to minimize the energy function. Different from the local estimation approaches; global parametric models attempt to solve this problem using general functions, such as polynomials [8] and Fourier series [2]. Some models require singular points as input, while detection of singular points relies on accurate orientation field.

Model	Description
• Short Time Fourier Transform (STFT) Analysis	• Fingerprint image divided into overlapping windows. • Fourier spectrum of small region is analyzed and probabilistic estimates the ridge frequency and orientation
• Frequency and Spatial Domain Filtering	• Compute DFT, Normalization, Local orientation estimation, Local frequency estimation, Region mask estimation and Filtering.
• Fourier Transform & Histogram Equalization	• FT used to decompose an image into sine and cosine components. • Histogram Equalization increases the global contrast of images.
• Wavelet and Filtering	• Enhance the fingerprint images by reducing noises and threshold values by DWT.
• Principle Component Analysis (PCA)	• Apply Local Pixel Grouping (LPG) and PCA on blur image and apply wavelet for Thresholding.

Model	Description
• Discrete Wavelet Decomposition (DWT)	• Decompose an image into different sub bands. • High frequency sub band interpolated and its coefficients are corrected by using high frequency sub bands by Stationary Wavelet Transform (SWT).
• Fast Fourier Transform (FFT)	• Uses the contextual information to the local ridges to connect or separate ridges based on spatial filtering. • Filter is separable to radial and angular domains.
• Laplacian Pyramid	• Decomposing images into band pass images and perform contrast of each images. • Individual images are enhanced in contract and detailed manner.
• Gabor Filter	• Apply Normalization and Compute local ridge orientation, local ridge frequency for enhance the image.

Figure2.1 Image reconstruction techniques

In [5] integrate information from different scale orientation fields to improve the orientation estimation accuracy. Small scale orientation field provides accurate information in the high-quality areas and around singularities, while large scale orientation field is more robust against image noise. Initial orientation fields of different scales are corrected by looking up different orientation dictionaries of corresponding scales. The task is then formulated as a multi-layer MRF inference problem.ti-scale Dictionaries: Construct dictionaries of orientation patches from a set of high-quality fingerprints from NIST SD27.

Sparse representation methods can be categorized into two general groups: naive sample based sparse representation and dictionary learning based sparse representation. However, on the basis of the availability of labels of atoms, sparse representation and learning methods can be coarsely divided into three groups: supervised learning, semi-supervised learning, and unsupervised learning methods.

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Because of the sparse constraint, sparse representation methods can be divided into two communities: structure constraint based sparse representation and sparse constraint based sparse representation. (1) In the greedy strategy approximation for solving sparse representation problem, the target task is mainly to solve the sparse representation method with l0-norm minimization. Because of the fact that this problem is an NP-hard problem, the greedy strategy provides an approximate solution to alleviate this difficulty. The greedy strategy searches for the best local optimal solution in each iteration. For the sparse representation method, the greedy strategy approximation only chooses the most k appropriate samples, which are called k-sparsity, to approximate the measurement vector. In the constrained optimization strategy, the core idea is to explore a suitable way to transform a non-differentiable optimization problem into a differentiable optimization problem by replacing the l1-norm minimization term, which is convex but non smooth, with a differentiable optimization term, which is convex and smooth. More specifically, the con- strained optimization strategy substitutes the l1-norm minimization term with an equal constraint condition on the original unconstrained problem. (3) Proximal algorithms can be treated as a powerful tool for solving non smooth, constrained, large-scale, or distributed versions of the optimization problem. (4) The general framework of the homotopy algorithm is to iteratively trace the final desired solution starting from the initial point to the optimal point by successively adjusting the homotopy parameter. In [7] the main challenging problem for latent fingerprint enhancement is to remove various types of image noises while reliably restoring the corrupted regions and enhancing the ridge clarity and details. Sparse representation on redundant dictionary is a promising method for image reconstruction especially from the noisy image. As a powerful statistical image modeling technique, sparse representation has been success- fully used in various image processing and recognition applications. A latent fingerprint enhancement algorithm via multistage patch based sparse representation, which consists of two main stages. First, the TV model is used to decompose latent image into cartoon and texture components. The cartoon component with most of the irrelevant contents is discarded, while the texture component contains the weak latent fingerprint and is extracted for further enhancement. Second, instead of using Gabor filtering, a set of Gabor elementary functions with various parameters are used to build the basis atoms of dictionary and the texture component is reconstructed via sparse representation for latent fingerprint enhancement.

B. Image Dehazing

Haze is an atmospheric phenomenon where dust, smoke and other dry particles obscure the clarity of the sky. The process of removing haze from image is called dehazing Aim of dehazing is to Increase the visibility of the scene and correct the colour shift caused by the atmospheric light. Dehazing Techniques are basically classified into types: Single image dehazing & multiple image dehazing.

B.1 Multiple Image Dehazing

In this haze removal, two or more images or multiple images of the same scene are taken

MULTIPLE IMAGE BASED DEHAZING	
METHODS	**FEATURES**
METHOD BASED ON DIFFERENT WEATHER CONDITION	• Two or more images of the same scene are taken. • The basic idea is to take the differences of two or more images of the similar scene
METHOD BASED ON POLARIZATION	• In this method two or more images of the same scene are taken with different polarization filters. • The basic idea is to take multiple images of the same scene that have different degrees of polarization.
METHOD BASED ON DEPTH MAP	• This method uses depth information for haze removal. • User interaction is required to align 3D model with the scene.

Fig2.2 Multiple image base dehazing

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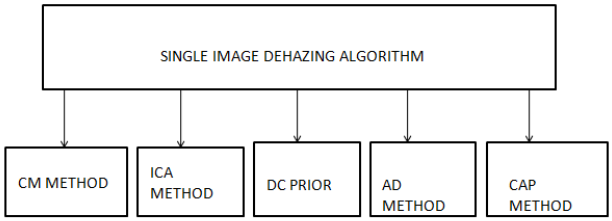
2.2.2 Single Image Dehazing

This method requires only a single input image. This method relies upon statistical assumptions or the nature of the scene and recovers the scene information based on the prior infor- mation from a single image.



SINGLE IMAGE DEHAZING METHODS	
METHODS	**FEATURES**
Contrast Maximization Method	• **Contrast maximization is a method that enhances the contrast.** • **The resultant images have larger saturation values because this method does not physically improve the brightness but it just enhances the visibility.**
Independent Component Analysis	• **ICA is a statistical method to separate two additive components from a signal.** • **This approach is physically valid and can produce good results, but may be unreliable because it does not work well for dense haze.**
Anisotropic diffusion	• **Anisotropic diffusion is a technique that reduces haze without removing image parts such as edges, lines or other details that are essential for the understanding of the image.** • **Its flexibility permits to combine smoothing properties with image enhancement qualities.**

Fig2.3 Single image Dehazing methods

C. Prior Based Dehazing

Prior is something that you know beforehand. The prior information of images can be used in image processing problems to enhance the results. Two main priors used in image dehazing are

- Dark channel prior
- Colour Attenuation prior

Dark Channel Prior

The dark channel prior [9] is based on the statistics of outdoor haze-free images. In most of the non-sky patches, at least one color channel (RGB) has very low intensity at some pixels (called dark pixels). These dark pixels provide the estimation of haze transmission. This approach is physically valid and work well in dense haze. When the scene objects are similar to the air light then it is invalid. The dark channel prior [9] is based on the statistics of haze-free outdoor images. In case of local regions which do not cover the sky, it is very often that some pixels (called dark pixels) have very low intensity in at least one color (rgb) channel. In the haze image, the intensity of these dark pixels in that channel is mainly contributed by the airlight. Therefore, these dark pixels can directly provide accurate estimation of the hazes transmission. By combining a haze imaging model and a soft matting interpolation method, a

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high quality haze-free image can be recovered and produce a good depth map (up to a scale).

Colour Attenuation Prior

Colour attenuation prior [11] is based on the difference between the brightness and the saturation of the pixels within the hazy image.Repairs transmission map and restores visi- bility. Colour attenuation prior is based on the difference between the brightness and the saturation of the pixels within the hazy image. By creating a linear model for modelling the scene depth of the hazy image under this novel prior and learning the parameters of the model by using a supervised learning method, the depth information can be well recovered. The need of feature selection is to select most sensitive features which make changes in image quality. To detect or remove the haze from a single image is a challenging task in computer vision, because little information about the scene structure is available. In spite of this, the human brain can quickly identify the hazy area from the nat- ural scenery without any additional information. The bright- ness and the saturation of pixels in a hazy image vary sharply along with the change of the haze concentration. A natural scene is to show how the brightness and the saturation of pixels vary within a hazy image. In a haze-free region, the saturation of the scene is pretty high, the brightness is moderate and the difference between the brightness and the saturation is close to zero.

Colour Attenuation Prior Based Dehazing by Edge Preservation and Attenuation

Colour attenuation prior[11] based dehazing gives a better dehazing results and enhances the contrast of the image very well compared to other prior based dehazing techniques and this dehazing technique can be enhanced by adding a edge attenuation operation so a better dehazing result can be obtained.

D. Transmission Map Refinement

Transmission map refinement is an important step in most of the image dehazing methods.Refining of transmission map results gives better dehazing results. Various filters have been used for transmission map refinement and a comparitive study of those filters is given below.

TRANSMISSION MAP REFINEMENT		
	FEATURES	DISADVANTAGE
GAUSSIAN FILTER	Transmission maps obtained using a small local patch tend to have colour textures, and thus, the Gaussian filter can improve the accuracy of the transmission maps	The Gaussian filter is not very effective in sharpening a blurry transmission map due to its low pass characteristic,
BILATERAL FILTER	The bilateral filter is a widely used edge preserving smoothing filter	Bilateral filter is not very effective in terms of the quantitative performance
SOFT MATTING	Transmission map manages to capture the sharp edge discontinuities and outline the profile of the objects by soft matting refinement.	Computationally expensive
CROSS BILATERAL FILTER	Preserve edge information.	Gradient reversal artifacts
GUIDED FILTER	The guided filter is a fast and non-approximate linear-time algorithm, which can perform as an edge preserving smoothing operator like the bilateral filter, but does not suffer from the gradient reverse artifact.	

Fig2.4 Transmission map Refinement

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IV. CONCLUSION

Latent fingerprint enhancement includes image decomposition and fingerprint reconstruction. Enhancement removes noises and improves the clarity of ridge structures and it also restores and enhances the corrupted fingerprint ridge structures. Dehazing algorithms is very useful for many computer vision applications. It is found that most of the existing researchers have neglected many issues; i.e. technique accurate for different kind of circumstances. Poor visibility caused by atmospheric phenomena in turn causes failure in computer vision applications, such as outdoor object recognition systems, obstacle detection systems, video surveillance systems, and intelligent transportation systems. In order to solve this problem, visibility restoration techniques have been developed and play a key role in many computer vision applications that operate in various weather conditions.

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