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A Review on: Image Filtering Techniques for Fingerprint Recognition

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ABSTRACT

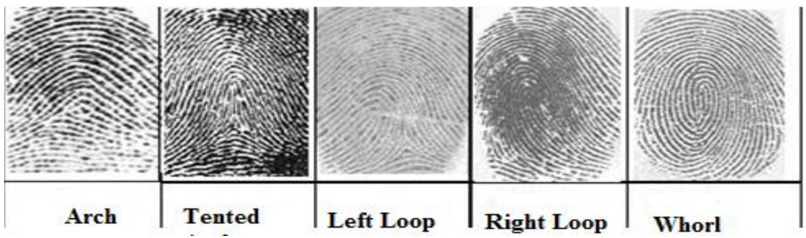
Fingerprint recognition is one of the most eminent methods in Biometrics, and it is mainly used biometric solution for authentication on computerized systems. Images are often corrupted by random variations like intensity, illumination, or have poor contrast and they cannot be used directly .Filtering is a technique to transform pixel intensity values to reveal certain image characteristics like enhancement, smoothing, template matching etc. This paper illustrates various image filtering techniques. We focused on spatial filtering techniques like Mean and Order-Statistics filters and various types under these filters which are used in fingerprint recognition.

Keywords: Biometrics, Fingerprint Recognition, Filters, Order-Statistics

I. INTRODUCTION

The use of Biometric Fingerprints for identification has been employed in law of enforcement for about a century. A much broader application of fingerprints is for identity management , access control ,personal authentication, for instance to access a computer, a network, a bank-machine, a car, or a home [3]. The palms and soles on our skin shows a serial pattern of ridges and valleys. These ridges and valleys on the finger, called friction ridges help the hand to hold the substances by increasing friction and improving the tangible sensing of exterior textures. The "Friction Ridge Patterns" describes the nature and origin of these characteristics. Another important use of friction ridges is person identification. The models of friction ridges in each and every finger is unique and unchallengeable, enabling its use as a mark of identity. In fact, even identical twins can be differentiated based on their fingerprints. Superficial injuries such as cuts and bruises on the finger surface alter the pattern in the damaged region only temporarily and the ridge structure reappears after the injury heals. [7]

Fingerprints can be used in two types of systems for establishing the identity of a person verification and identification system. Fingerprint is an impression formed through deposit of minute ridges and valleys when a finger touches a surface. These ridges and valleys present are permanent and do not change throughout lifetime if an injury or mutilation happens they reappear within a short period. The five commonly found fingerprint ridge patterns are arch, tented arch, left loop, right loop and whorl. [1].



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Fingerprint has proved to be a very reliable human identification and verification index and has enjoyed superiority over other biometrics such as ear, nose, iris, voice, face, gait and signature. The uniqueness of the ridges and valleys makes it immutable and therefore serves a strong mark for identity.[4]. One of the world's largest fingerprint recognition systems is the Integrated Automated Fingerprint Identification System, maintained by the FBI in the US since 1999. A fingerprint recognition system can be used for both verification and identification. In verification, the system compares an input fingerprint to the "enrolled" fingerprint of a specific user to determine if they are from the same finger (1:1 match). In identification, the system compares an input fingerprint with the prints of all enrolled users in the database to determine if the person is already known under a duplicate or false identity (1:Nmatch). Detecting multiple enrollments, in which the same person obtains multiple credentials such as a passport under different names, requires the negative identification functionality of fingerprints. So fingerprint identification has become vital in many areas and this can be done more perfectly by using different image filtering techniques.

Image filtering is useful for many applications, including smoothing, sharpening, removing noise, and edge detection etc., A filter is defined by a kernel, which is a small array applied to each pixel and its neighbors within an image. In most applications, the center of the kernel is aligned with the current pixel, and is a square with an odd number (3, 5, 7, etc.) of elements in each dimension. The process used to apply filters to an image is known as CONVOLUTION, and may be applied in either the spatial or frequency domain. Within the spatial domain, the first part of the convolution process multiplies the elements of the kernel by the matching pixel values when the kernel is centered over a pixel. The elements of the resulting array (which is the same size as the kernel) are averaged, and the original pixel value is replaced with this result. The CONVOL function performs this convolution process for an entire image. The CONVOL function is different for different filtering techniques and each technique is used to remove different noises present in the image which reduces the image quality. In this paper we are focusing on spatial filtering techniques like Mean filter and different types in Mean filtering like Arithmetic Mean, Geometric mean ,Harmonic mean and Contrahormonic mean, Order-Statistics filtering like Median, Max and Min and Alpha-Trimmed Mean filtering.

1.1 Mean Filter

Basic idea is to replace each pixel intensity value with a new value taken over a neighborhood of fixed size. The size of the filter controls degree of smoothing.

1.1.1 Arithmetic Mean Filter:

It is a simple Sliding-Window spatial filter that replaces the central value in the window with the average (Mean) of all the pixel values in the window. The window is usually a square but can be any shape. Arithmetic Mean method is defined as the average of intensity values in a m×n region is replaced with the pixel position m=n.[2]

The average represents the new pixel value.

$$F(i, j) = 1/m \times n \sum p_{\epsilon m} \sum q_{\epsilon n} f(p, q)$$

The normalization factor mn preserves the range of values of the original image.

Arithmetic Mean Filtering is a simple and easy method for smoothing images. It reduces the amount of intensity variations between one pixel and the next.

1.1.2 Geometric Mean Filter

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In this method, the color value of each pixel is replaced with the geometric mean of color values of the pixels in a surrounding region. A larger region (filter size) yields a stronger filter effect with the drawback of some blurring. The geometric mean filter is better at removing Gaussian type noise and preserving edge features than the arithmetic mean filter, and is defined as: The n^{th} root of the product of *n* pixels x1,x2,…xn.

$$G=n\sqrt{x1.x2\ldots xn}$$

Geometric Mean Filtering is an efficient method for removing Gaussian noise and preserving edge features than arithmetic mean filter.

1.1.2 Harmonic Mean Filter

The harmonic mean is a larger region (filter size) yields a stronger filter effect with the drawback of some blurring. It is defined as the ratio of number of pixels (n) to the sum of reciprocals of the pixel values x1,x2,...xn.

$$F=n / (1/x1+x2+...+xn)$$

The harmonic mean filter is better at removing Gaussian type noise and preserving edge features.

1.1.3 Contra Harmonic Mean Filter

The contra harmonic mean filtering operation yields a restored image based on the expression:

$$\hat{x}(f,g) = \sum_{(p,q)\epsilon\, ab} y(p,q)^{R+1} / \sum_{(p,q)\epsilon\, z_{ab}} y(p,q)^{R}$$

where R is called the order of the filter. This filter is well suited for reducing or virtually eliminating the effects of salt-and-pepper noise. For positive values of R, the filter eliminates pepper noise. For negative values of R it eliminates salt noise. It cannot do both simultaneously. Contra-harmonic filter reduces to the arithmetic mean filter if R = 0, and to the harmonic mean filter if R = - 1

The Contra-Harmonic Mean Filter is member of a set of nonlinear mean filters which are better at removing Gaussian type noise and removing positive outliers.

1.2. Order-Statistics Filters

Order-Statistics filters are nonlinear spatial filters whose response is based on ordering (ranking) the pixels contained in the image area encompassed by the filter. The ranking of the filter at any point shows its response. Ordering of pixels of an image is performed using sliding window technique. In which pixel by pixel operation is done by using a filtering technique. Where the local statistics obtained from the neighborhood of the center pixel gives a lot of information about its expected value. Ordering of pixels refers that they are sorted. The local statistics obtained from the neighborhood of the center pixel gives a lot of information about its expected value. If the neighborhood data are ordered ,then ordered statistic information is obtained. If this ordered statistic vector is applied to a finite impulse response(FIR)filter, then the entire scheme becomes an ordered statistics(OS) filter. These filters are differentiated based on how they choose the values in the ordered list. [20]

1.2.1 Median filter

Median filter is a Sliding-window spatial filter. It replaces the center value in the window with the median of all the pixel values in the window. In order to perform median filtering in a neighborhood of a pixel [i,j]:

- Sort the pixels into ascending order by gray level.
- Select the value of the middle pixel as the new value for pixel [i, j]

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The best-known order-statistics filter is the median filter; it replaces the value of a pixel by the median of the gray levels in the neighborhood of that pixel:

$$\hat{x}(a,b) = \underset{(p,q)\epsilon Z_{ab}}{\text{median}} \{y(p,q)\}$$

The original value of the pixel is included in the computation of the median.[6] Median filters are quite popular because, for certain types of random noise, they provide excellent noise-reduction capabilities, with considerably less blurring than linear smoothing filters of similar size. Median filters are particularly effective in the presence of both bipolar and unipolar impulse noise. Median filter is popularly known for "Edge – Preserving" as it theoretically preserves step edges without blurring. This method works efficiently in removing salt & pepper noise in preserving image details.[5]

1.2.2 Max and Min Filters

The "Max - Min" filter blurs the image by replacing each pixel with the difference of the highest pixel and the lowest pixel (with respect to intensity) within the specified window size. The maximum and minimum filters are shift-invariant. Whereas the minimum filter replaces the central pixel with the darkest one in the running window, the maximum filter replaces it with the lightest one.[20]

$$\hat{x}(a,b) = \max_{(p,q)\epsilon Z_{ab}} \{y(p,q)\}$$

This filter is useful for finding the brightest points in an image. Also, because pepper noise has very low values, it is reduced by this filter as a result of the max selection process in the subimage area S. The Min filter represents the 0th percentile.[6]

$$\hat{x}(a,b) = \min_{(p,q)\epsilon Z_{xy}} \{y(p,q)\}$$

1.2.3 Mid Point Filters

In the midpoint method, the color value of each pixel is replaced with the average of maximum and minimum (i.e. the midpoint) of color values of the pixels in a surrounding region. A larger region (filter size) yields a stronger effect. The midpoint filter is typically used to filter images containing short tailed noise such as Gaussian and uniform type noise. The midpoint filter is the average of the maximum and minimum within the window.[20]

Ordered set $\Rightarrow f_1 \leq f_2 \leq \cdots \leq f_{N^2}$

Mid Point= $\frac{(f_1 + f_{N^2})}{2}$

Good for random Gaussian and uniform noise.

$$\hat{x}(a,b) = \frac{1}{2}\left[\max_{(p,q)\epsilon Z_{ab}} \{y(p,q)\} + \min_{(p,q)\epsilon Z_{ab}} \{y(p,q)\}\right]$$

1.2.4 Alpha-Trimmed Mean Filter

The alpha-trimmed mean filter is based on order statistics and varies between a median and a **mean filter**. It is used when an image contains both Gaussian and salt and pepper noise. First we have to sort the neighborhood pixels into ascending order, discard a given number (alpha) from each end of the list.Output pixel is the mean of the remaining pixel values .[6]

Alpha = 0 gives a mean filter

Alpha = $(b^2 - 1)/2$ gives a median filter

We can delete the b/2 lowest and b/2 highest grey levels.

So $y_r(p,q)$ represents the remaining $mn - b$ pixels.

$$\hat{x}(a,b) = \frac{1}{mn - b} \sum_{(p,q)\epsilon Z_{ab}} y_r(p,q)$$

II. CONCLUSION

Fingerprint recognition is one of the most oldest and most common forms of biometric identifications .In this paper, we have discussed different filtering techniques and also coded which technique is useful for efficient removal of specific noise such as Mean filter is for smoothing images, Geometric Mean for removal of Gaussian noise ,Harmonic &Contra harmonic for removing positive outliers and Max and Min filter for salt and pepper noise etc., These mentioned methods conclude that the fingerprint is fast and accurate for more reliable and secure system. Future research work can be carried out to improve the quality of the image by implementing an image enhancement method along with a matching filtering technique.

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