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Fingerprint Segmentation: A Review

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Abstract : Image segmentation is a technique by which a digital image is divided into various smaller regions called Image segments. This helps to reduce the complexity of the image to make further processing of the image simpler. Biometrics is a technique used to identify or verify the identity of a person using physiological and behavioral characteristics. Among the biometric technologies, fingerprint is the most widely used biometrics. A fingerprint is an impression left on any object by the friction ridges of a human finger. Human fingerprints are unique, difficult to alter, and durable over the life period. They are used in mobile, institutions, shopping malls and police station to identify a person. This paper gives a detailed review of various segmentation techniques of fingerprint.

***Index Terms* – biometrics, fingerprint, segmentation, image, thresholding.**

I. INTRODUCTION

Biometrics is the measurement and analysis of individual person's unique physical and behavioral characteristics. The technology is mainly used for identification and verification. The most widely used biometrics are fingerprint, face, iris, etc. Fingerprint is an impression made by the ridges on the ends of the fingers and thumbs. Fingerprints are most widely used biometrics for personal identification, because the fingerprints of every human being is unique and does not alter with age or growth. Fingerprint Image segmentation is the process of dividing the fingerprint image into regions. Before processing the input fingerprint image, it is necessary to separate foreground region from background image. The segmentation process improves the accuracy of the feature extraction method and reduces the processing time. Thresholding is an important technique applied in image segmentation applications. Image segmentation by thresholding is a simple powerful widely used technique for segmenting images having light objects on dark background. The basic idea of thresholding is to choose an optimal gray-level threshold value for separating area of interest in an image from the background based on their gray-level distribution. Thresholding method converts a multilevel image into a binary image and selects proper threshold to divide image into several regions and separate objects from background. It is useful in discriminating foreground from the background. By choosing an appropriate threshold value, the gray level image is converted into binary image by changing all pixels below some threshold to zero and all pixels about that threshold to one. The resulting binary image must contain required information about the shape and position of the objects of interest. The advantage of obtaining a binary image is that it reduces the complexity of the data and simplifies the process of recognition and classification. Otsu method is of type global thresholding in which threshold value depends only on gray value of the image.

II. FINGERPRINT SEGMENTATION TECHNIQUES

i. **Directional Image Method:** The directional image is a transformed image in which each pixel of the image indicates the direction of the gray level uniformity [1] as shown in Fig.1 It represents the local orientation.

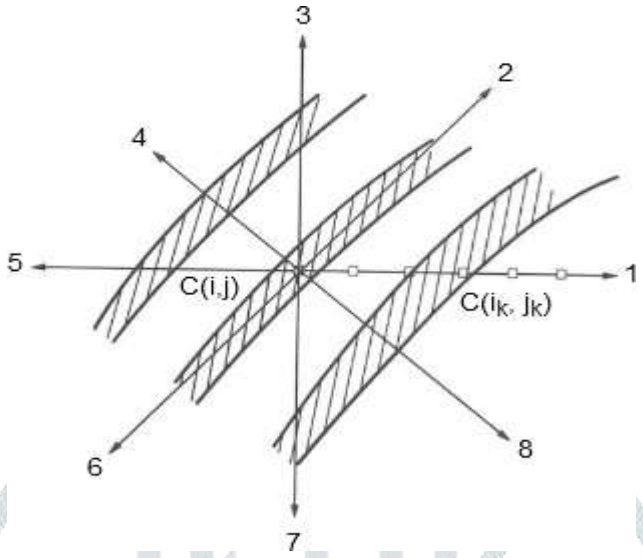

Fig. 1 : Directional Image of the fingerprint ridge.

ii. **Composite Method:** This method estimates the histogram of orientation along with the gray scale variance of each block [2].

iii. **Coherence Mean Variance (CMV):** There are three features that contain useful details for image segmentation [3]. They are Coherence, local Mean and local Variance. The features are averages by Gaussian window so that the output contains both local features and average features. The coherence is a measure which represents how the gradients are pointing in the same direction.

iv. **Ridge Score:** The dominant ridge score is the ratio of the number of pixels with the dominant gradient orientation, after quantization to 8 orientations, with regard to all the pixels in an image window [4].

v. **Harris Corner:** The Harris corner points are used to discriminate the fin- gerprint foreground from background image [5]. The strength of the Harris point is higher in the foreground region than in the background region.

vi. Boundary Values: From the fingerprint image, the blocks containing the boundary of fingerprint image are located and gray level values are computed for these blocks [6]. Using the threshold value, the blocks are considered as either foreground block or background block.

vii. Convex Hull: In convex hull method of fingerprint segmentation, the gray level of each pixel is normalized to interval [0,1]. The Image is binarized based on the value of mean [7]. A median filter is applied and edges of binary image are detected using edge detection, The ROI is extracted as a polygon using polygon convex hull algorithm.

viii. Morphological Operations: The fingerprint image is divided into blocks and enhancement operation is performed using adaptive histogram equalization followed by Gaussian filtering to remove unwanted noise [8]. Gradient value is computed using Sobel operator and standard deviation is calculated for gradient value. Then morphological operations such as dilation, erosion and opening are applied to remove noise from binary image.

ix. Thresholding: Otsu method is global thresholding[9] selection method, which is based on the interclass variance maximization. The Otsu method requires evaluating a gray level histogram before running. However, because of the one-dimensional in which the gray-level information is considered, it does not give better segmentation result. Otsu method was one of the better threshold selection methods for real world images with regard to shape and uniformity measures. But this method does not work well with non-uniform illumination. There are three types of thresholding algorithms such as Global thresholding [10], Local thresholding and Adaptive thresholding.

x. Gradient of Orientation: The fingerprint image is segmented into ridge regions and non-ridge regions [8]. Then ridge regions are segmented based on the value of the estimated ridge orientation. The ridge regions of correct value of orientation are considered as foreground block and the remaining incorrect orientation regions are taken as background block. The fingerprint ridge orientation is estimated using gradient based method.

xi. Watershed Algorithm: It is a region-based segmentation approach which is based on gray scale morphology [11]. The watershed algorithm searches for regions with high intensity that divides neighbourhood local minima. The tool used for watershed segmentation is distance transform in which the distance from the pixel to its nearest nonzero pixel is considered.

xii. Block Features: The fingerprint segmentation uses three block features namely the block clusters degree, the block mean information, and the block variance. The block clusters degree measures how the ridge pixels of finger- print are clustering. The block mean information is the difference of local block mean and global image mean. The block variance is calculated from mean value.

xiii. Directional Total-Variation Model: This method combines directional information with the total variation and decomposes the fingerprint image into two layers: cartoon and texture [12]. The cartoon layer consists of unwanted components whereas the texture layer contains useful information.

xiv. Adaptive Directional Total Variation Method: The total variation model is suitable for multi scale image decomposition and feature selection [13], but it is difficult to compute due to non-differentiability and non-linearity of the fidelity term and the total variation term. The two spatially changing parameters of the model, orientation and scale are adaptively selected according to the textural orientation and background noise level.

xv. Laplacian of Gaussian (LoG): The fingerprint image is normalized and LoG filter is applied [14]. Again the resultant image is normalized and converted into binary image using LoG edge detection technique. The gradient value is calculated in the y direction of the image and morphological operations are applied to remove the noise.

xvi. Global Variation Method: This method decomposes the fingerprint image into three components such as Cartoon, Texture and Noise [15]. After decomposition, the foreground region is separated from the non-zero coeffi- cients in the texture image by means of morphological processing. The cartoon part contains the homogeneous regions corresponding to lower frequency.

III. CONCLUSION

Biometrics is the most suitable method for identifying and authenticating individual person in a fast and reliable way through unique biological characteristics. They are used in various applications such as law enforcement, healthcare, military, border control and commercial applications. Fingerprint is the most widely used and widely acceptable biometric system. Before processing the fingerprint for matching, segmentation operation is performed. Image segmentation is a branch of digital image processing in which an image is partitioned into different parts according to their properties and features. The primary goal of image segmentation is to simplify the image for further easier analysis. The various segmentation techniques for fingerprint are discussed in this paper. The pixel-based, block-based and ridge based techniques have also been described.

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