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TEXTURE BASED FINGER PRINT IDENTIFICATION

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Abstract

In recent days , many digital finger print image based identification applications are used widely for human identity . Finger print features like minutiae (ridge lines, bifurcation, ridge ending) delta point, core point, texture patterns of ridges and valleys etc., are used for finger print identification. Reliable finger print identification system uses the finger print features to provide higher accuracy . Many finger print identification systems have been proposed based on minutiae , ridge lines. But these systems performance are not effective as compared to texture based methods. In this article , significance of feature extraction techniques , various texture based finger print identification methods are investigated and analysed . Limitations of minutiae, , and based identification systems are discussed. Also how effective the texture based identification systems are discussed. A comparative analysis of experimental results of various methods of finger print identification is done. This paper is concluded with the finding of appropriate method of texture based feature extraction for effective identity authentication.

Keywords : Finger print feature, Texture feature, feature extraction, ridges, finger print recognition.

1. Introduction

Unique texture patterns of ridges and valleys present in human finger print makes every finger print unique .This feature is one of the most dominant features because other features of finger print can be replicated . For example , in minutiae feature extraction number of minutiae extracted for same finger will vary at different extraction process .So the identification system cannot differentiate the original and fake finger print. It makes the finger print identification system ineffective. Thus Texture patterns of finger print are used for effective human identification.

2. Feature and its classification

A feature is a function of one or more measurements which specifies some quantifiable property of an object, and is computed as if it quantifies some significant characteristics of the object. Three common visual features are color , texture and shape.

Features can be classified as follows:

a) General features*:* These are application independent features for example color, texture, and shape. Also, according to the abstraction level, they can be further divided into three types:

(i) Pixel-level features: Features that are calculated at each pixel, for example: color, location.
(ii) Local features: Features that are calculated over the results of subdivision of the image band on image segmentation or edge detection.
(iii)Global features: Features that are calculated over the whole image or just some regular sub-area of an image.

(a) Global structure (b) Local Structure

Fig 1 . Global and Local features of finger print

b) Domain-specific features: These are application dependent features such as human faces, fingerprints, and various conceptual features. These features are generally a synthesis of low-level features for a specific domain. Also, all features can be widely classified into high-level features and low-level features. Low-level features can be extracted directly from the original images, and high-level feature extraction is based on low-level features. Low level features are discussed under color feature. Color is one of the important feature that makes possible the recognition of images by humans. It is a property which is dependent on the reflection of light to the eye and also the processing of that information by the brain. We generally use color to tell the difference between some objects, places, and the time of day. Basically, colors are defined in three dimensional color spaces. There are color three models: *RGB* (Red, Green, and Blue), *HSB* (Hue, Saturation, and Brightness) and *HSV* (Hue, Saturation, and Value). Among these, the last two are dependent on the human perception of hue, saturation, and brightness .First color space is specified and once the color space is specified, color feature can be extracted from images or regions. There are a number of important color features that have been proposed in the literatures, including color histogram, color moments(CM) , color coherence vector (CCV) and color correlogram *etc.*

3. Feature extraction and techniques

Feature extraction or selection is a process of extracting meaningful feature subset from original sets by some rules. It is an important step in pattern classification, pattern recognition, data mining, machine learning etc. Extraction of ideal features gives the intrinsic content of the images as complete as possible. Low level feature extraction techniques based on color, texture and shape. To extract efficient and productive features is still a challenging problem.

Main advantages of feature extraction

1. To reduce the complexity of space and the time of machine training .
2. To achieve dimensionality reduction

3. To Reduce computational time .

Feature extraction techniques

Feature extraction techniques are used to represent pattern with minimal loss of important information. These can be divided into following four categories:

i. Non transformed structural characteristics:

It includes moments, model parameters , and power and phase information.

ii. Transformed structural characteristics

It includes frequency spectra and subspace mapping methods.

iii. Structural descriptions

It includes parsing techniques, formal languages and their grammars, and string matching techniques.

iv. Graph descriptors

It includes semantic networks, attributed graphs and relational graphs .Some important methods are Gray Level Histogram and Gray Level Coherence Vector , Discrete Wavelet Frame ,Gabor Transform, Fourier Descriptor, Hu Moment Invariants, Color Moments, Local Color Histogram, Average RGB, Co-occurrence, Geometric Moment and Global Color Histogram etc.,

Important feature Extraction Methods and its limitations

S.No	Methods	Description	Advantages	Limitations
1.	K-Means clustering method used. (Fixed no. of features are used)	Cluster's centroid.(Set of gray values forms a cluster) and WCS(within-cluster sums) In this method ,clusters are formed using image pixel values by dividing the image. Euclidean distance calculation is done	* No sensitivity to image rotation. Features remain same even after rotating the image *Simple to implement. *Good feature extraction *Gives unique features	*Difficult to form and decide number ofclusters . *To solve sensitivity problem ,histogram should be used
2	WPT(Wavelet packet tree) decomposition method . (No fixed no of features)	Haar scaling low pass approximation parameter and haar wavelet high pass details parameter are computed .	*Efficient feature extraction using histogram instead of image. *Gives unique features	*Difficult to select number of levels of decomposition * Sensitive to rotation of images

3	Local Binary Pattern Method (No fixed no of features)	LBP feature extraction is done (Here image is represented as 1-d Array of pixels)	*Excellent feature extraction using histogram instead of image. *Gives unique features	*Sensitive to rotation of images * To solve sensitivity problem ,histogramshouldbe used
4	Minutiae based method (No fixed no of features)	No.of Bifurcations, No.of Ridge ending are used. Euclidean distance is computed for allbifurcations and ridge endingis computed. Crossing numbers are computed	*Efficient *No Sensitiveto rotation of images *Gives unique features	Resizing of image is needed here to reduce no.of bifurcations and ridge ending
5	Improved method of feature extraction		*Minutiae extracted directly from gray level images. *No binarization and Thinning are required	

6	Improved Minutiae extraction method by Anil Jain *et al*	Pre-processing, binarization, thinning and extracting minutiae.	Good performance. *Robust Meod	*Binarization may lose some significant information of images. * Binarization and thinning are time consuming.
7	Improved Extraction method proposed by D. Maio*et al* X. Jiang *et al* [3]	* Gaussian-shape mask or low pass filter is used in pre-processing *Extracts minutiae directly from gray-level fingerprint images. * Analysis of topographic surface patterns in a gray-level fingerprint image	*No Binarization and thinning. *No loss of information *Not time consuming. * Efficiency *Robustness	*Diffcult in processing end points

8	Improved Extraction method proposed byTianzi Jiang	* Gabor filter, to enhance fingerprint images in poor quality *Gaussian-shape mask filter for good quality fingerprint images to get higher processing speed. * Computation of the orientation field to correctly trace the ridgelines	Good performance in both robustness and efficiency	Tracing the ridgelines is difficult

4. Texture Feature

Texture is one of the useful characterization for a wide variety of images. It is generally believed that for recognition and interpretation, human visual systems use texture. In general, it is said that color is usually a pixel property whereas texture can only be calculated from a group of pixels. There are a large number of techniques that have been proposed to extract texture features. They can be broadly classified into two types based on the domain from which the texture feature is extracted. Those are spatial texture feature extraction methods and spectral texture feature extraction methods. In case of spatial texture feature extraction methods, texture features are generally extracted by calculating the pixel statistics or by finding the local pixel structures in original image domain. Whereas in case of spectral texture feature extraction method, firstly an image is transformed into frequency domain and then feature is calculated from the transformed image. Both of these features have their own advantages and disadvantages .

- Spectral texture features are a desirable choice for images or regions with sufficient size. Whereas, for small images or regions, especially when the regions are irregular, spatial features are considered.
- Among texture features, Spatial features usually have semantic meaning understandable by humans and can be extracted from any shape without any lose of information.But, it is difficult to have sufficient number of spatial features for image representation, and also spatial features are sensitive to noise.

- When the regions are irregular, spatial features are a desirable choice. Whereas, Spectral texture features are more robust, and also take less computation because convolution in spatial domain is implemented as product in frequency domain which is done using Fast Fourier Transform.
- When images or regions are of sufficient size, spectral texture features are a better choice .

5. Texture Feature extraction methods

Fingerprint image in high quality shows a regular texture and has clearly wave-shape surfaces alternate between ridges and valleys. These features are extracted and used in finger print recognition. Texture feature extraction simplifies the finger print classification. For texture based finger print identification, effective extraction of texture features is very essential. Most famous texture feature extraction methods used for finger print recognition are described below

a) Gray Level Co-occurrence Matrix:

Gray Level Co-occurrence Matrix (GLCM) is one of the well accepted representation for the texture in images. It generally incorporate a count of the number of times a given feature (for example, a given gray level) exists in a particular spatial relation to another given feature. GLCM is one of the most popular texture analysis methods, estimate various image properties related to second-order statistics. The process involved is as follows:

1. First of all, co-occurrence matrices for the images in the database and also the query image are computed. For each image, four matrices will be generated.
2. Next step is to build up a 4×4 features from the previous co-occurrence matrices. Four main features used in feature extraction are energy, entropy, contrast and homogeneity.

Advantages : Intitutive, Compact , Robust

Disadvantages : High Computation, Not Cost effective, Not enough to describe all textures.

b) *Steerable Pyramid:* This pyramid splits recursively an image into a set of oriented sub-bands and a low pass residual. The image is decomposed into some decimated low pass sub bands and a set of undecimated directional sub bands. It is a linear multi-orientation, multi-scale image decomposition that contributes to a useful front-end. The basis functions of the steerable pyramid are Kth-order directional derivative operators (K chosen randomly), which occur in different sizes and have K+1 orientation. They span a rotation-invariant subspace , as directional derivatives and they are designed and sampled in such a way that the whole transform forms a tight frame .

Advantages : Supports any number of orientation.

Disadvantages : Sub-bands undecimated hence more computation and storage.

c)*Contourlet Transform:* This is basically a combination of a Directional Filter Bank (DFB) and a Laplacian pyramid (LP) . Laplacian pyramid provides the multiscale decompositions and Directional filter bank provides multidirectional decompositions. Contourlet transform is considered as a double filter bank structure. It is usually implemented by the pyramidal directional filter bank (PDFB) which divides images into directional sub bands at different scales. The LP is decomposition of original image into a hierarchy of images such that each level corresponds to a different band of image frequencies. The contourlet transform contributes to a sparse representation for two-dimensional piecewise smooth signals that resemble images .

Advantages : Multi resolution, Multi orientation , Robust.
Disadvantages: Need rotation, normalization .
d) *Gabor Wavelet Transform:* This transform basically dilates and rotates the two dimensional Gabor function. Then the image is convolved with each of the obtained Gabor functions. Gabor filter is typically developed to sample the entire frequency domain of an image by characterizing its center frequency and orientation parameters. In this, the image is filtered with a bank of either Gabor filters or Gabor wavelets of various preferred spatial frequencies as well as orientations. Each of the wavelet encapsulates energy at a specific frequency and direction that provide a localized frequency as a feature vector. However, texture features can also be extracted from this group of energy distributions. Let $I(x,y)$ be the input image then the gabor wavelet transform convolves $I(x,y)$ with a set of Gabor filters of different spatial frequencies as well as orientations. The two-dimensional Gabor function $g(x,y)$ is defined as :

$$g(x,y) = \frac{1}{2\pi\sigma_x\sigma_y}\exp\left[-\frac{1}{2}\left(\frac{x^2}{\sigma_x^2}+\frac{y^2}{\sigma_y^2}\right)+2\pi jW_x\right]$$

where W is the center frequency, $sx$and $sy$are the scaling parameters of the filter (the standard deviations of the Gaussian envelopes) and θ determines the orientation of the filter.
Advantages:
Multi scale, multi orientation, Robust
Disadvantages:
Need rotation, Normalisation , Losing
of spectral information due to incomplete cover of spectrum plane.

Conclusion:

Texture feature of finger print is unique and cannot be duplicated as such as original finger print. But Minutiae features in original finger print can be created in fake finger print as same as in original one. Since texture patterns of original finger print are unique, stable and can not be imitated in fake finger print , texture based method ensures security and reliability of the finger print identification systems. Though many methods are available for texture feature extraction , each method has its own merits and demerits in extraction process. Based on the application , a suitable texture feature extraction method can be chosen to achieve good performance in finger print identification systems.

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