# CONTOURLET BASED FINGER PRINT MATCHING

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**ABSTRACT**

This paper describes a novel approach to finger print matching using a new mathematical transform: the contourlet transform. Contourlet improves traditional wavelet based approaches by incorporating a directional component. It finds a direct discrete-space construction and is therefore computationally efficient. In this paper, 2-D spectrum is divided into fine slices using iterated directional filter bank (DFB), directional energy distributions for each block from the decomposed subband outputs is then computed. Only dominant directional energy components are employed as elements of the input feature vector, which serves to reduce noise and improve computational efficiency. The proposed algorithm captures both local and global details in a fingerprint as a compact fixed length FingerCode. The fingerprint matching is based on the Euclidean distance between the two corresponding FingerCodes and hence is extremely fast. The method significantly reduces the memory cost and processing time associated with verification, primarily because of the efficient DFB structure and the exploitation of directional specific information.

**Index Terms –** *Biometrics, directional energy, directional filter bank (DFB), Contourlet, feature extraction, fingerprints, matching, verification*

## INTRODUCTION

Different types of wavelets have been used as tools to solve problems in signal analysis, image analysis, medical diagnostics, boundary value problems, geophysical signal processing, statistical analysis, pattern recognition and many others. Though wavelet based techniques have proven their worth in number of fields the major drawback associated with them is their inability to capture geometry of two dimensional edges. In particular, natural images containing smooth curves as edges cannot be efficiently captured by the wavelet transform.
Contourlet, a new geometrical image transform, can efficiently handle the intrinsic geometrical structure containing contours [1], [2]. It uses a structure similar to that of curvelets [3] [4], a double filter bank structure, by combining the Laplacian pyramid with a directional filter bank [2].
In this paper, we employ contourlet transform for fingerprint matching. The finger-print biometrics employs broadly two techniques: minutiae based matching and holistic approach. Minutia based matching techniques use discriminatory minutia points like ridge endings or bifurcations as feature points for the classifiers [5]-[7]. The disadvantage attached with minutia based approaches is inaccuracies of minutia points' detection, particularly with small size finger print sensors. Finger print matching also suffers from difficulties with respect to alignment of minutia patterns from input and template fingerprints.
Holistic approaches try to overcome or complement minutiae-based approaches by directly extracting features from fingerprint as a whole [8], [9]. The methods, using filtering or transforms extract a compact fixed size feature vector.
In this paper, we propose a new image based fingerprint matching method. The proposed method incorporates directionality as a prominent feature component and represents the fingerprint in terms of directional energies. A reference point is established manually. The area with a certain radius around the detected reference point is then used as a region of interest (ROI) for feature extraction. Fingerprint features are extracted from the ROI using contourlet transform, which effectively decomposes the image into several directional subband outputs. From the decomposed subband output, directional energy values are calculated for each block, only the dominant ones are retained. The rest of the directional energies are set to zero, effectively treating them as noise.

Contourlet transform is explained next. Details related to the feature vector generation and finger print matching process are given in subsequent sections. Finally the conclusion is drawn.

## CONTOURLET TRANSFORM

The Contourlet transform is a new geometrical transform recently developed by Minh N. Do and Martin Vetterli [11], [12] This geometrical transform has shown promising results, compared to wavelet transform, in approximating images containing textures and oscillatory patterns. Fingerprints consist of oscillatory patterns, and contourlet transform is therefore considered to be a suitable option for fingerprint classification and matching. Figure 1 gives the flowgraph of the transform, consisting of two stages; the subband decomposition and directional decomposition. Laplacian pyramids are used for subband decomposition while directional filter banks are used for directional decomposition. A detailed review of the Contourlet transform and its implementation can be found in a number of texts like [11] and [12].

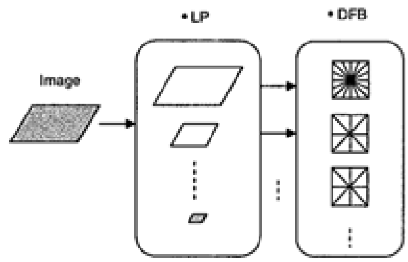


**Fig-1:- A Flowgraph of Contourlet Transform**

## FEATURE VECTOR GENERATION

A fingerprint consists of a series of ridges that flow parallel to the locally dominant direction and occasionally make local singularities like a core or delta point. Because of this strong directional information fingerprints posses, the contourlet transform is thought to be a good candidate for fingerprint feature extraction. In the first stage of feature extraction, the ROI is manually selected from an input fingerprint image and a square area of 128 x 128 pixels around the reference point is utilized for computing contourlet transform coefficients. The point of maximum curvature of the ridges that are upwardly convex is used as the reference point. The fingerprint image is further decomposed into directional subblocks through contourlet transform. Figure-2 depicts the process of reference point and ROI selection and subsequent contourlet decomposition. The respective energy in each subblock is computed as in [10]. Let $f_\Theta(x,y)$ be a coefficient in Θ directional subblock in the contourlet transformed image. The energy of the coefficient is computed through:

$$E_{k\theta} = \sum_{x,y \in S_{k\theta}} \left| f_{k\theta} - \overline{f}_{k\theta} \right| \tag{1}$$

where $\overline{f}_{k\theta}$ is the mean value of Θ directional subblock.

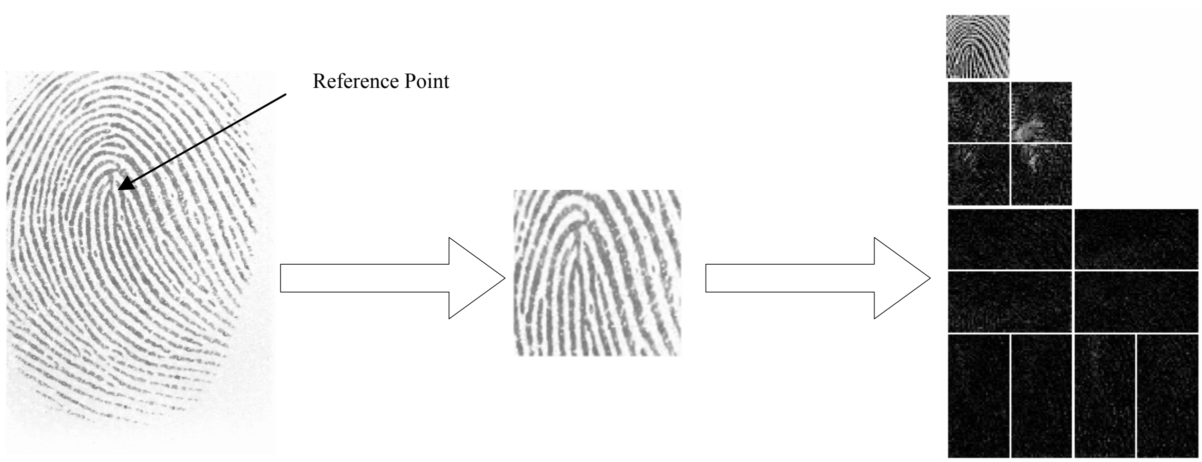


**Fig-2:- Finger Decomposition using Contourlet Transform, from left the first figure shows the original image, the second ones shows the cropped image and third gives the Contourlet decomposed image.**

Now the feature value can be computed by:-

$$F_\theta = \begin{cases} [F_{\max} \times \widehat{E_\theta}] & if \quad \widehat{E_\theta} > Th_{en} \\ 0 & otherwise \end{cases}$$

Where $\widehat{E_\theta}$ is average normalized energy of all subbands and $Th_{en}$ denotes the threshold energy value (between 0 and 1) selected empirically (for instance in our case we selected it to be 0.14 signifying that the subbands with energies less than 14% is considered as noise and thus discarded). $F_{\max}$ is a positive integer normalization constant defined in [10] and taken to 255.

The dominant directional energy is extracted by comparing the energy of each subband with a preset threshold. We tested the proposed algorithm at the small database of fingerprint images downloadable from [11]. It consists of 10 fingerprint images of the same person taken with some rotational changes. The results are impressive as with minimal processing time, the images were matched. The energies for the same directional sub-blocks were found to be less than threshold for the most of the images belonging to same person.

**FINGERPRINT MATCHING**

Matching of the fingerprint image is performed based on the minimum Euclidean distance classifier between the input feature vector and the template feature vector. The normalized Euclidean distance between the input and the template feature vectors is given by:-

$$\hat{d} = \min \sqrt{\sum_\theta d_\theta}$$

$$where$$

$$d_\theta = \begin{cases} v_\theta - t_\theta & if\ v_\theta \neq 0\, and\ t_\theta \neq 0 \\ 0 & otherwise \end{cases}$$

Where $v_\theta$ denotes the $\theta$-direction feature vector coefficient for the input image and $t_\theta$ denotes $\theta$-direction feature vector coefficient for the template image.

**CONCLUSION**

We have proposed a new image based fingerprint feature extraction and matching method without the need to detect minutiae. In the proposed method, a reference point is established for the fingerprint. Certain area around the detected reference point is used as ROI for feature extraction. The fingerprint features are extracted based on the ratios of the directional energy values in each block. The method uses the controurlet transform to obtain the normalized energies and the feature vector is generated by taking only the dominant directional components. Fingerprint matching is performed based on finding the normalized Euclidean distance between the input and the template feature vectors. Experimental results validate the effectiveness of the proposed method in extracting fingerprint features and achieving good performance. To improve the verification accuracy, further study is needed with larger database of fingerprint images and on combining the minutiae information with the directional energy features.

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