Support Vector Machines for Off-Line Signature Verification and Identification using Contourlet Transform

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Abstract

In this paper, we propose new offline signature Identification and Verification based on the contourlet coefficient as the feature extractor and Support Vector Machine (SVM) as the classifier. In projected method, first signature image is normalized based on size. After pre-processing, contourlet coefficients are computed on particular scale and direction using contourlet transform in feature extraction. After feature extraction, all extracted coefficients are feed to a layer of SVM classifiers as feature vector. The number of SVM classifiers is equal to the number of classes. Each SVM classifier determines if the input image belongs to the resultant class or not. Proposed methodology implemented using MATLAB R2009a software tool. The research is on standard GPDS960 English signature database, based on this experiment, we achieve a 94% identification rate.

Keywords: Signature Identification and Verification, Contourlet transform, Support Vector Machine.

1. Introduction

The person identification system based on biometric measurement like fingerprints, voice, retina and signature is very active area of research [1]. The signatures are one of the most well-liked and consistent biometric features. There are two main do research fields in this area are: signature verification and signature identification. A signature verification system decides whether the signature is genuine or forger. A Signature identification system identifies the owner of the signature [2]. There are two key methods of signature verification. One is an on-line method to measure the sequential data such as handwriting and pen pressure with a special input device. Another is an off-line method that uses an optical scanner to obtain handwriting data written on paper [3]-[4]. In this paper, we make use of the global features, the Curvature and the orientation and use the contourlet transform as feature extractors. Support vector machine evaluates the performance of the proposed method.

This paper is arranged as follow. In section 2, we know more about the wavelet, curvelet and contourlet transforms. In section 3, we explain our proposed method which included the preprocessing, feature extraction and classification stages. The experimental results are given in section 4. Section 5 presents the conclusion.

2. Related Work

2-D wavelet is decomposing the image into subbands with different frequency and orientation. It does not capture directional information. Cand'es & donoho [5] introduced multiresolution transform, curvelet, which is capture the intrinsic geometrical structures such as smooth and silky contours in natural images multiscale transform with frame elements indexed by location, curvature and orientation parameters, and have time frequency localization properties of wavelets but also shows a very high degree of directionality and anisotropy [6].

Curvelets are representing a smooth and silky contour with smaller number of coefficients compared with wavelets (Fig.1).
The curvelet transform is implemented by decomposing the image into a sequence of disjoint scales. Each scale is analyzed by means of a local ridgelet transform. So, curvelet transform is based on multiscale ridgelet transform joint together with a spatial bandpass filtering operation at dissimilar scales [7],[8],[15].

![Wavelet and Curvelet](image)

**Fig. 1.** a) Wavelet b) Curvelet decomposition

The contourlet transform is presented by Do and Vetterli [9]. Contourlets not only hold the main feature of wavelets are namely multiscale and time-frequency localization, but also grips a high degree of directionality and anisotropy. The main difference between contourlets and other multiscale directional systems is that the contourlet transform allows for different and flexible number of directions at each scale, at the same time as achieving almost critical sampling [10]. It is implemented by decomposing the image into multiscale with Laplacian Pyramid decomposition (LPD) and then decomposing subbands at each scale into directional parts with Directional Filter Bank decomposition (DFBD)[10]-[14].

![Contourlet Transform](image)

**Fig. 2.** An implementation of contourlet transform using laplacian pyramid decomposition and directional filter bank decomposition

In contourlet transform, LP is first used to decompose images into multi-scale, followed by DFB to decompose subbands at each scale into directional parts. This is implemented iteratively with applying PDFB on the coarse scale of image, as is shown in Fig. 2.

3. Proposed Method

3.1 Preprocessing

Each signature is scanned into a gray level image and use smooth borders function on these Grayscale images. This function provides Smooth the borders to Grayscale images and avoid border effect. At least, the signature images are converted to standard size 352*352 as shown in Fig 3.

![Signature Images](image)

**Fig. 3.** preprocessing steps (a) before preprocessing. (b) after preprocessing

3.2 Feature extraction

Feature extraction is very important phase in offline signature recognition system. Compared with feature extraction from the entire characters in identification, feature selection after direction decomposition is more reflect the structure composition of characters. Contourlet not only inherits the main qualities of wavelet transform, such as multi-scale and time-frequency information, but also capture direction characteristics. It holds the geometrical formation of images, and implement a true sparse representation of images. Handwritten signature possesses plentiful direction characteristics; so contourlet transform take hold of the structural features of images effectively, which is in favor of the correct identification. The signature image is decomposed into a low pass sub band and 8 band pass directional sub bands. The multi-scale inherent of contourlet transform [14] enables it to effectively exploit the real image edges that are localized in both location and direction.

For the creation of feature vector of the signature, first in each direction of four different scales we find out in which scale the maximum value occurs and then increase the counter corresponding to pair <scale, direction> in the feature matrix. This procedure in addition, these eight directions is produced by dividing of 180 degrees to 8 sub degrees. In contourlet transform the number of directional sub bands at each level is set to 2^n where n is a positive integer number. For example, if we prefer to decompose an image into four levels using n= (1, 2, 3, 4) then we get 2, 4, 8, and 16 sub bands as shown in Figure 4.
Figure 4 shows the directional decomposition is computed with the detailed image, by with, if we made more pyramidal decompositions we produce at least a half more information of the above level as redundancies. One example of the contourlet transform of the signature image is shown in Fig. 5. The directions supported by the first DFB are 8, and those supported by the second DFT are 4. From the simulation result, we can find that the image will be expanded since the high frequency components are not downsampled, so the contourlet transform is a redundant transform.

3.3. Classification

After the feature extraction stage, superiority of features extracted is quantified calculate the accuracy of the classifier. Classification is the final step of signature identification. For classification of signature classes, a layer of SVM classifier has used. An SVM is a classifier derived from statistical learning theory.

The number of SVM classifiers in the classification layer is equal to number of signature classes. Vapnik introduced the beginning of SVM in late of 1970’s. SVM, based on a solid mathematical foundation, which attempt resolve a universal problem of classification. The basic proposal of SVM is deceptively simple. Given a set of vectors in Rn, labeled +1 or -1 that is separable by a hyper plane, SVM finds the hyper plane with the maximal margin. In this mode, the kernel of SVM classifier is a one order polynomial classifier. Occasionally, more complicated kernels such as higher order polynomial, MLP and Radial Basis Functions (RBF) are used.

Fundamentally, SVM is a binary classifier, i.e. SVM is classifying two classes. As a result, for classification of N classes, N SVM classifiers are needed. For signature identification, number of SVM classifiers is equal with number of signers. A SVM classifier is used per class that classifier output is -1 or +1. When all classifier outputs except only one classifier are -1, the class of input signature will be the corresponding class of classifier that generates +1. When the output of all classifiers are -1 or two or more classifier outputs are +1, the input signature will not belong to any known class. The main advantages of SVM when used for image classification problems are: (1) capability to work with high-dimensional data and (2) high generalization performance without the required to add a-priori knowledge, still when the dimension of the input space is very high.

4. Experimental Results

For testing the performance of our proposed method, we use GPDS960 signature database contains data from 960 individuals classes with 24 genuine signatures for each individual, plus 30 forgeries of his/her signature. The signatures are in “bmp” format, in black and white and 300 dpi. We test 20 classes of signatures; our training data set include 480 genuine images. While our test data set include 480 genuine and 600 forgery images. All experiments in this section use a contourlet transform with “9-7” pyramid filters and 4 decomposition level. Table I shows rates of verification for first experiment on English signature database.

For given selected 10 classes we have achieved final FAR 0 % for the system and final FRR is 50 % in the classification mode. In the signature identification mode we have achieved final accuracy of 94%.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Class Number</th>
<th>FRR (%)</th>
<th>FAR (%)</th>
<th>Rate of Identification (%)</th>
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<td>93.3333</td>
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5. Conclusion

We proposed offline English signature verification based on contourlet transform using SVM as classifier. We used GPDS960 signature database which is used by Ghandali, S., and Moghaddam M.E. [16], they used DWT transform and SVM classifier. They reported 93% for recognition rate. But our method could identify signatures with 94% true rate on same dataset. We used contourlet transform of signature image as feature extraction and SVM as classifier.

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References


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