Scattering Wavelet Transform Based Palm print Biometric recognition

Submitted by

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Introduction

Recent developments in the identification methods using palm prints have shown that the palm of the hand contains more features than a fingerprint and is easier to acquire compared to most other biometric signals. Wavelet decomposition is the predominant mathematical tool used [3] for extracting these features. In this project, we implement a basic identification system using palm print images and Scattering convolutional networks. The scattering coeffecients of an image are invariant to small translations and rotations and are therefore ideal for operation on images acquired without many constraints on the acquisition method.

Scattering Convolutional Networks

A conventional convolutional neural network uses feature filters for convolution at each stage. In a scattering convolutional network (SCN) however, these feature filters are replaced by wavelets. At each stage, the image from the previous stage is taken and convolved with an averaging filter and a scaled and dilated wavelet. Directional complex Morlet wavelets are used in these networks. The scattering coefficients are the images which are obtained when the output of a layer is convolved with the averaging filter, which in this case is just a circularly symmetric Gaussian. The output image at the mth layer is given by [1]:

$$f = |x \star \psi_{\lambda_1}| \star \psi_{\lambda_2}| \cdots | \star \psi_{\lambda_m} \tag{1}$$

The scattering coefficients from this layer are obtained by the following modulus averaging operation [1]:

$$|f| \star \phi \tag{2}$$

The ψ_{λ_i} represents the Morlet wavelet for a particular rotation and scale pair. For example, if we resolve into 8 angles and 4 scales, there are a total of 32 different wavelets and ψ_{λ_i} represents one of them. So the modulus convolution chain in (1) corresponds to a specific path in the SCN. The averaging operation brings about a loss of all the high frequency information in the previous image but this information is obtained for the next layer on further modulus convolution with the dilated and rotated Morlet wavelet function. This averaging operation that results in the scattering coefficient is also responsible for making the coefficient invariant to localized translations and rotations [2]. A two layer deep SCN is implemented in this project and the resulting scattering coefficients are used to perform identification.

There are two steps in the implementation process. Firstly, palm print images of several persons are acquired and the scattering coefficients of these images are computed and stored in a database. Then, one of the persons whose palm print was taken can be identified from among the ones in the database that was built earlier. This is similar to the way a fingerprint is used to secure a mobile phone.

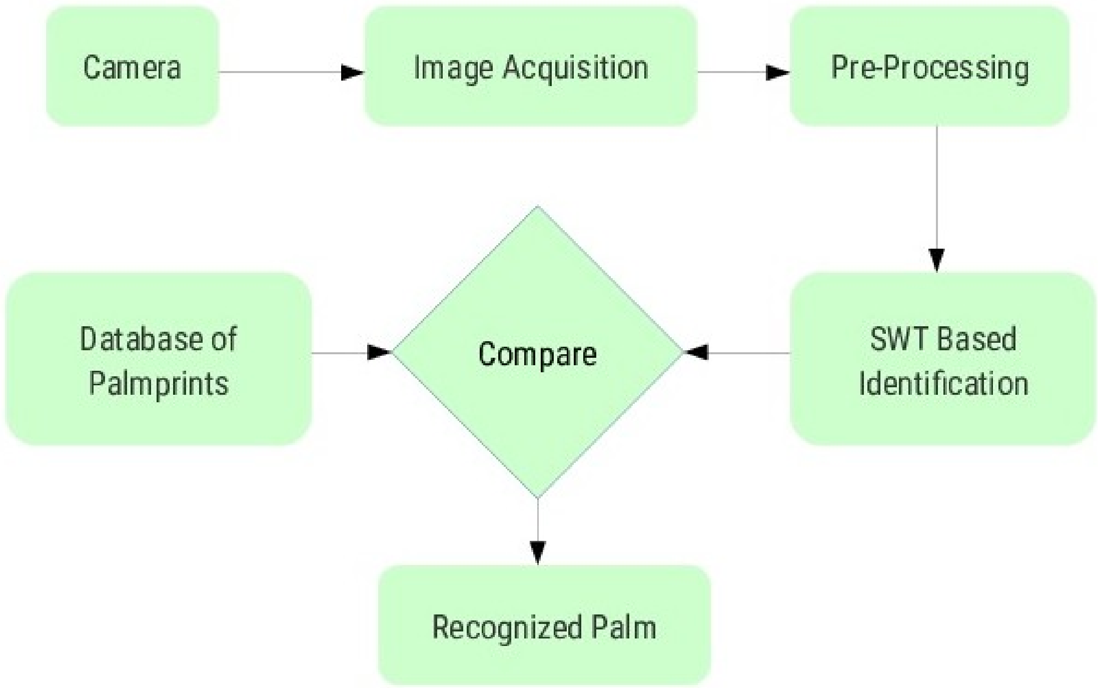


Figure 1: Palm print biometric recognition system.

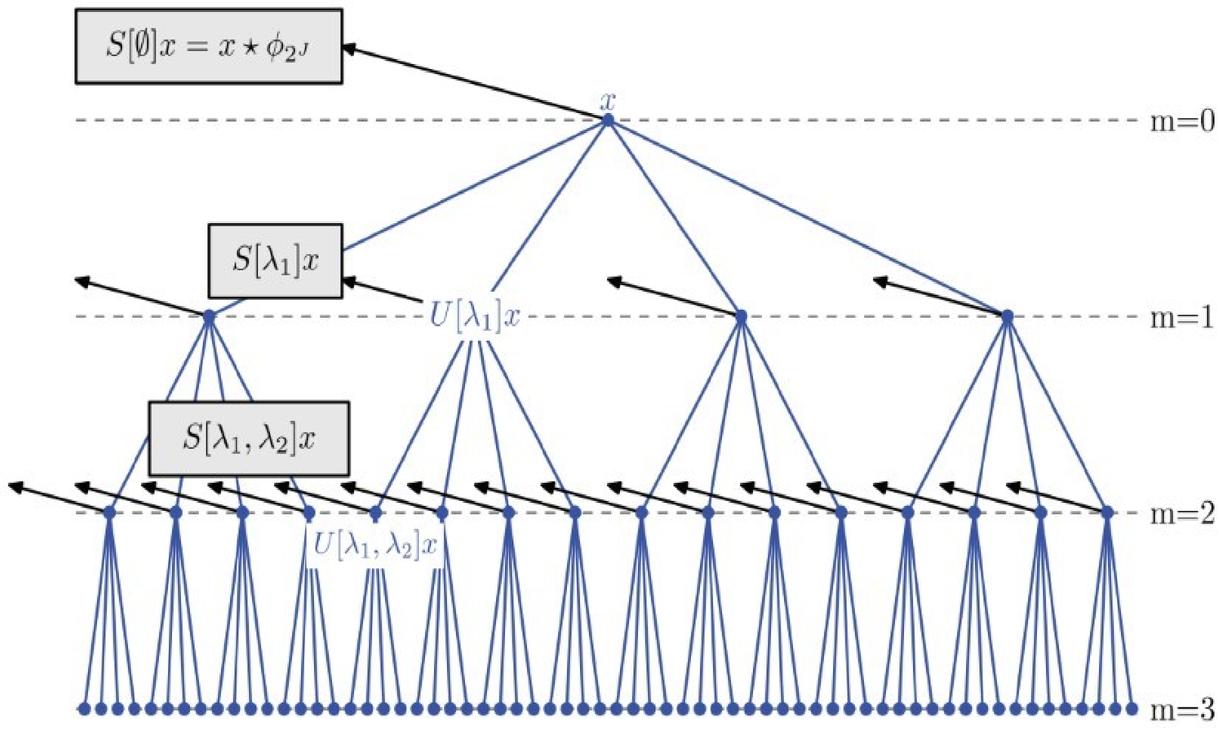
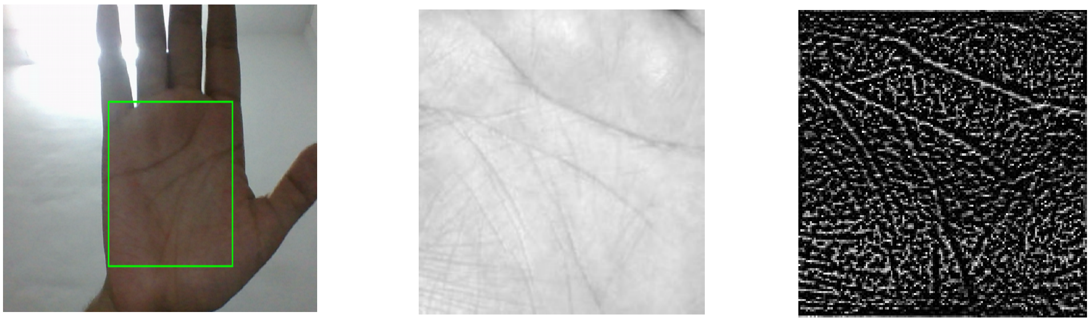


Figure 2: Scattering Convolutional network.

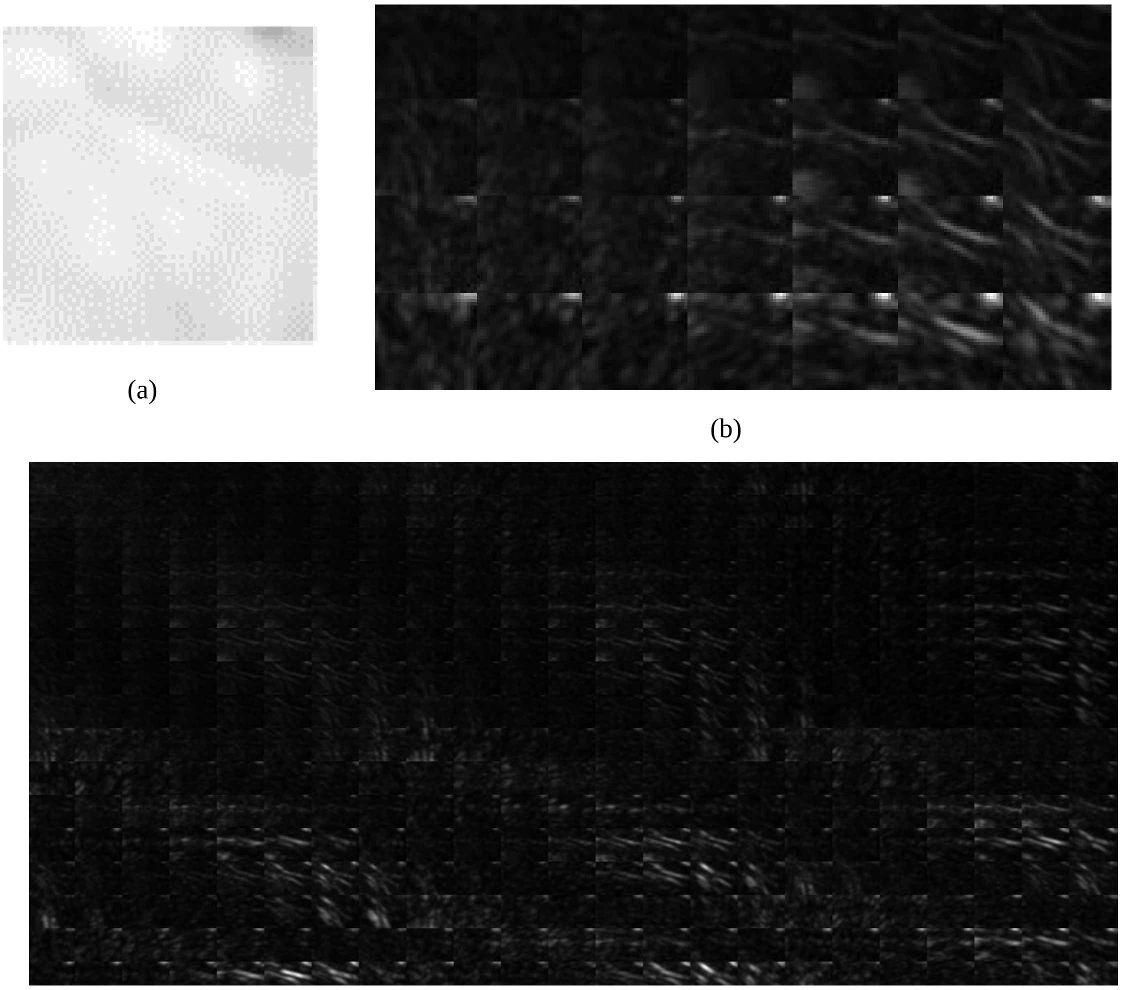
Acquisition and Pre-Processing

In the acquisition process, the region of interest is directly extracted from the camera image as shown in Fig. 3(a) The resulting image in Fig. 3(b) is then processed to enhance the ridges in the acquired palm image. The resulting image is shown in Fig. 3(c). Enhancement of the palm print image extracts out fine and subtle features from the raw image. Pre-processing of an image enhances the accuracy while matching with a large number of other palm prints in a database. False Acceptance Rate (FAR) and False Rejection Rate (FRR) factors show tremendous improvement if the image, whose features needs to be extracted, is pre-processed properly.



(a) (b) (c)

Figure 3: Image Acquisition and Preprocessing. (a) Acquiring the ROI. (b) Extracted Palm print. (c) Preprocessed image using Monogenic wavelets.



(a) (b)

Figure 4: Scattering coefficients. (a) Level 0. (b) Level 1. (c) Level 2.

The technique used here for enhancing the image is based on phase congruency. Phase congruency was developed by Peter Kovesi to extract out the features based on edge detection. Phase Congruency highlights a single response on thin edges of a palm print. It is invariant to illumination and its value always lies in the range 0 to 1, where a higher value indicates a more distinctive and crucial feature.

Phase Congruency around point x, is given as follows:

$$PC(x) = \frac{E(x)}{\sum_n A_n} \tag{3}$$

Where, numerator denotes the local energy of signal and the denominator denotes the summation of the amplitudes of its Fourier Components.

Identification

A new image of the palm of a person in the database is taken and its scattering coefficients are computed. This set of scattering coefficients is compared with each of the scattering coefficient sets in the database and the one with the least Euclidean distance is identified to be the right person.

References

[1] J. Bruna and S. Mallat, "Invariant Scattering Convolution Networks," in *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol. 35, no. 8, pp. 1872-1886, Aug. 2013.

[2] L. Sifre and S. Mallat, "Rotation, Scaling and Deformation Invariant Scattering for Texture Discrimination," *2013 IEEE Conference on Computer Vision and Pattern Recognition*, Portland, OR, 2013, pp. 1233-1240.

[3] Saranraj S, Padmapriya V, Sudharsan S, Piruthiha D and Venkateswaran N, "Palm print biometric recognition based on Scattering Wavelet Transform," *2016 International Conference on Wireless Communications, Signal Processing and Networking (WiSPNET)*, Chennai, 2016, pp. 490-495.