Footprint Recognition using Modified Sequential Haar Energy Transform (MSHET)

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Abstract

Footprint identification is the measurement of footprint features for recognizing the identity of a user. Footprint is universal, easy to capture and does not change much across time. Footprint biometric system does not require specialized acquisition devices. Footprint image of a left leg is captured for hundred people in different angles. No special lighting is used in this setup. The foot image is positioned and cropped according to the key points.

Sequential modified Haar transform is applied to the resized footprint image to obtain Modified Haar Energy (MHE) feature. The sequential modified Haar wavelet can map integer-valued signals onto integer-valued signals abandoning the property of perfect reconstruction. The MHE feature is compared with the feature vectors stored in database using Euclidean Distance. The accuracy of the MHE feature and Haar energy feature under different decomposition levels and combinations are compared. Above 92.375% percent accuracy can be achieved using proposed MHE feature.

Keywords: *Foot print, Sequential Haar Transform network, Heel Shape, Information Security*

1. Introduction

A lot of automated biometrics based identification and verification systems have been developed [1]. The biometrics features derived from fingerprints [2], faces [2], irises, retinas, a speaker's voice, and perhaps a variety of other characteristics. The systems are now used in a wide range of environments, such as law enforcement, social welfare, banking, and various security applications.

Some systems for personal identification use fundamental biometric features derived from fingerprints and irises. To acquire the feature, subjects must input their biometrics to a sensor. Signatures [3] and speakers' voices [4] are also features useful for verification; however, obtaining these features requires the subjects' cooperation. The main problem in automatic personal identification is how to verify the sampled feature against the registered feature with high reliability. Practical methods for automated biometrics based identification have not yet been developed for use with unconstrained subjects. Problem in automatic personal identification is how to verify the sampled feature against the registered feature with high reliability. Practical methods for automated biometrics based identification have not yet been developed for use with unconstrained subjects. A high recognition rate by verifying raw footprints directly is difficult to obtain, because people stand in various positions with different distances and angles between the two feet. To achieve robustness in matching an input pair of footprints with those of registered footprints, the input pair of footprints must be normalized in position and direction. Such normalization might remove useful information for recognition, so geometric information of the footprint prior to normalization into an evaluation function for personal recognition decision is included. In this paper, we propose a footprint-based personal recognition method and test its reliability. Footprint texture features are usually extracted using transform-based method such as Fourier Transform [5] and Discrete Cosine Transform [6]. Besides that, Wavelet Transform [7] is also used to extract the texture features of the footprint. In this work, a Sequential modified Haar Wavelet is proposed to find the Modified Haar Energy (MHE) feature. Fig 1,2 shows the proposed footprint identification using Sequential modified Haar Transform.

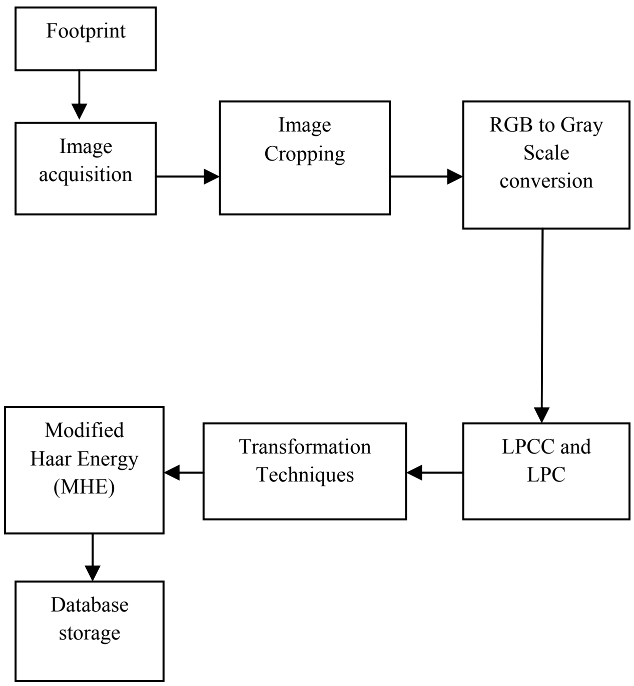

Fig. 1 Footprint identification using Sequential Modified Haar Wavelet

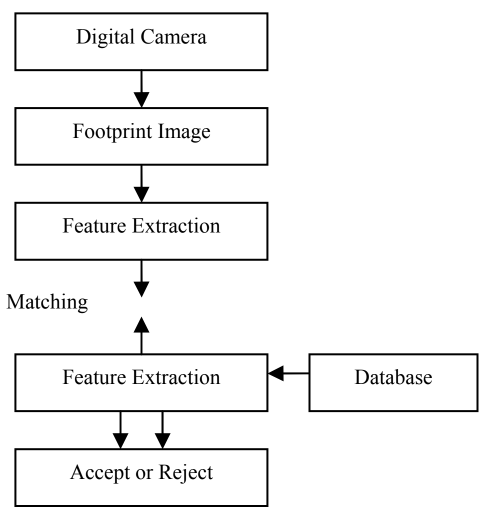

Fig. 2 Footprint identification using Feature Extraction

In this work, hundred images of left leg of 100 people are acquired using a digital camera. The foot image is aligned according to the keypoints and it is cropped. The energy features of the footprint are extracted using Sequential modified Haar Wavelet. The Modified Haar Energy (MHE) is represented using feature vector and compared using Euclidean Distance with the threshold values stored in the database. Fig 2 shows the process of footprint identification using feature extraction. The footprint image captured using digital camera is extracted for its features. The already existing features of footprint images stored in database are compared. Then, the footprint image is accepted or rejected based on the comparison.

2. Proposed Method

To obtain a footprint image, from digital camera. Method for acquiring the footprints are described in the next section. This section, we describe a normalization procedure and a recognition method.

2.1 Normalization

2.1.1. Image Acquisition

Hundred left leg images from 100 different individuals are captured using a Canon PowerShot A420 digital camera. The image is taken without any special lighting condition. The foot must be closed while acquiring the foot image. Dark intensity backgrounds, such as black and dark blue are used in this work. The foot image is saved using JPEG format in 1024 x 768 pixels.

Fig. 3 Foot image

2.1.2. Image Cropping

After acquiring the foot image, the next step is to crop the image. Cropping can be done by keypoints determination and extracting the image.

The foot image is cropped to extract the heel shape as the intensity is highest in the heel portion. Fig. 4 shows the extracted footprint image using the proposed method.

Fig. 4 Footprint image

2.1.3. Conversion to Grayscale format

The footprint image is acquired in RGB format. It is converted into grayscale intensity format before image enhancement. Fig. 5 shows the footprint image in grayscale format.

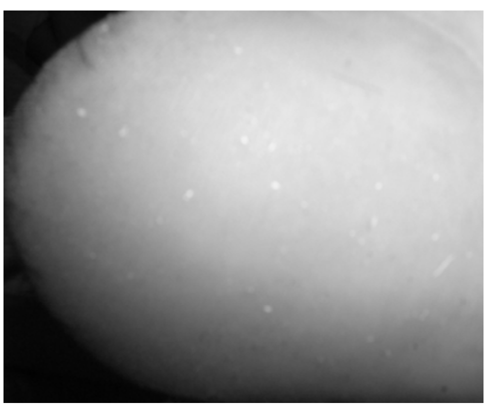

Fig. 5 Footprint image in Grayscale Intensity format

2.1.4. LPCC and LPC

The Grayscale image is further enhanced by converting to a matrix format of 256 X 256 pixels. Also the matrix so formed is separated into odd and even matrices to be used in the transformation technique.

2.1.5. Transformation Techniques

Footprint texture features are usually extracted using transform-based method such as Fourier Transform [5] and Discrete Cosine Transform [6]. While using Discrete Cosine Transform, some of the points are missed leading to an inaccurate inference. Also Fourier Transform involves floating-valued signals to integer-valued signals, thus less accuracy. Besides that, Wavelet Transform [7] is also used to extract the texture features of the footprint. In this work, a Sequential modified Haar Wavelet is proposed to find the Modified Haar Energy (MHE) feature.

The Haar wavelet coefficients are represented using decimal numbers. It required eight bytes for storing each of the Haar coefficients. The division of the subtraction results in y-axis operation will also reduce the difference between two adjacent pixels. Due to these reasons, sequential Haar wavelet that maps an integer-valued pixel onto another Integer-valued pixel is suggested. Sequential Haar coefficient requires only two bytes to store each of the extracted coefficients. The cancellation of the division in subtraction results avoids the usage of decimal numbers while preserving the difference between two adjacent pixels.

For every image of the detail coefficients, the image is further divided into 4 x 4 blocks. The Modified Haar Energy for each of the block is calculated using (1).

$$MHE_{i,j,k}=\sum_{p=1}^{P}\sum_{q=1}^{Q}(C_{p,q})^2 \text{ -------}\rightarrow \quad (1)$$

where i is the level of decomposition, j is Horizontal, Vertical or Diagonal details, k is the block number from 1 to 16, P x Q is the size of the block. The MHE energy feature for every detail coefficients are arranged as in (2).

$$MHE_{i,j}=[MHE_{i,j,1},MHE_{i,j,2},\ldots\ldots,HE_{i,j,16}]\text{---}\rightarrow \quad (2)$$

2.1.6. Storing

Lastly, the Modified Haar Energy (MHE) or the threshold value of the footprint image is stored in the database for future references.

2.2. Recognition Method

Recognition Method is also called as ***Testing***. The normalization procedure removes the geometric information of input footprint (raw image). In Testing, normalization is done for the footprint image and then it is compared with the one stored in the database.

2.3. Experiments & Results

For experiment we took image samples of 100 different persons in 10 different angles using a digital camera. We used the block to get the conclusion.

2.3.1. Training

We took image samples of 100 different people and cropped heel portion to find the, MHE of all blocks. We took a number of MHE out of which we select the minimum.

Let MHE_1,MHE_2, MHE_3 …………….etc be the Modified Haar Energy for n blocks.
Using the formula,

MHE=Minimum (MHE_1,………….)

For each person, the MHE is found in this way.

$VPerson_1$= Minimum(MHE_1……………..)
$VPerson_2$= Minimum(MHE_2……………..)
…..
$VPerson_{100}$= Minimum(MHE_{100}…………)

These are stored in the database.

2.3.2. Testing

The footprint to be tested was taken in 10 different angles and heel part was cropped so as to get the MHE of the heel shape using:

MHE=minimum (MHE_1,………)

This test MHE was compared with the MHE of different persons stored in the database.

Result=$Test_{MHE}$-$VPerson_{i\ MHE}$

Where i=1 to 100

If result is 0, the person with same footprint is found. That person is the master of the test footprint sample.

Comparison with other methods:

The accuracy of Recognition of Footprint images using Sequential Modified Haar Transform is compared with the other methods for recognition. The following table shows the comparison of accuracy of recognition for Sequential Modified Haar Transform with Discrete Cosine Transform and Fourier Transform

TABLE 1: COMPARISION OF ACCURACY (PERFORMANCE) OF THE PROPOSED METHOD WITH OTHER WAVELET BASED METHOD

Transform Types	Recognition Accuracy (%)	Computation time in ms (Recognition)
DCT [Ref.6]	**83.64**	**142**
FT [Ref.5]	**87.43**	**128**
SHT [Proposed]	**92.375**	**118**

The corresponding graph for the accuracy rate of recognition footprints using above mentioned techniques in as follows

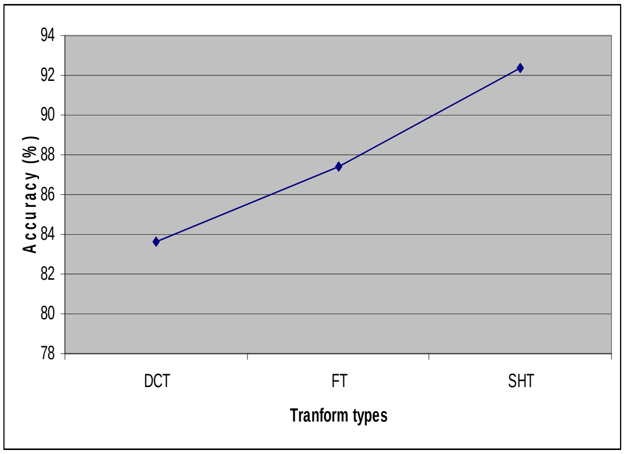

Fig.6 Comparison of existing transforms (DCT, FT) Accuracy in % with proposed one (SMHET)

3. Conclusion

The heel portion of the leg is cropped as it is having more intensity at this portion. This cropping is done using built-in function. The heel portion is divided into blocks using Sequential Modified Haar Transform. Minimum MHE is selected from all the calculated MHEs. Comparing the MHE of test image with all person's MHEs. If both MHEs match then the master of the footprint is found. This is an efficient method as it is more accurate. A high accuracy rate of 92.375% is achieved using Sequential Modified Haar Transform. This accuracy rate can be improved further by using **Pressure sensing mat.**

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