J Electr Eng Technol.2015; 10(4): 1815-1821
http://dx.doi.org/10.5370/JEET.2015.10.4.1815

ISSN(Print) 1975-0102
ISSN(Online) 2093-7423

Performance Improvement Using an Automation System for Segmentation of Multiple Parametric Features Based on Human Footprint

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Abstract – Rapid increase in population growth has made the mankind to delve in appropriate identification of individuals through biometrics. Foot Print Recognition System is a new challenging area involved in the Personal recognition that is easy to capture and distinctive. Foot Print has its own dimensions, different in many ways and can be distinguished from one another. The main objective is to provide a novel efficient automated system Segmentation using Foot Print based on structural relations among the features in order to overcome the existing manual method. This system comprises of various statistical computations of various foot print parameters for identifying the factors like Instep-Foot Index, Ball-Foot Index, Heel- Index, Toe- Index etc. The input is naked footprint and the output result to an efficient segmentation system thereby leading to time complexity.

Keywords: Human footprint, Multiple features, Preprocessing, Segmentation, Gaussian filter, Cropping, Region growing

1. Introduction

Biometric is mainly used for personal recognition based on the different characteristic of every individual nature of humans. It is broadly classified into two main category (i) High accuracy-oriented and (ii) Human friendly. High accuracy oriented in for infinite number of people namely finger print and iris where as the later one refers to a finite no. of people in a group such as co-workers or family. Therefore for a small group identification can be performed efficiently in biometric recognition using Footprint which is a challenging method now. Palm print, face, retina, voice, signature, keystroke, ear, gait and automatic face recognition [1] also plays an methods under specific conclusion [2].

There are several other biometric systems existing today but there is always a need for a new technology and this system will be of apt use for certain special areas of application. This FPRS can be worked in two ways:

1. Static mode: where the user will have to stand and his foot image will be captured by the sensors.
2. Dynamic mode: The walk over mode, where the user can walk without any halt and the sensor will detect the footprint.

In today's world, identity of individuals plays an important role in all fields. It helps to differentiate one person from another. Biometrics can be defined as a stream which deals with the identification or differentiation of individuals through their physical characteristics or traits. Among the various organs studied in biometrics, footprint is considered to be efficient because it differs from person to person and also spoofing is difficult.

2. Related Work

Weidong Wang et al [3] verified the concept of Footprint Heavy Pressure Surface Pick-up and Description. The distribution of footprint heavy pressure surface reflects the behaviour feature and the physiological feature of the human body. It is mentioned that footprint heavy pressure surface pick-up and description is the foundation of footprint biological feature identification.

Sean W. Yip, B.S. et al [4] analyzed the measurement of force distribution beneath the feet. The performance of the postural control system may be helpful in identifying the persons with an increased risk of falling. Foot position and orientation can also be extracted from force distribution without the need for manually tracing footprints.

LIU Guozhong et al [5] have proposed measurement system for 3-D foot shapes under different loads. A measurement system for 3-D foot shapes under different loads is described, which can automatically extract foot parameters such as Foot Length, Ball Width, Heel Width, Ball Girth, Toe Height, Instep Height, Arch Height, Ankle Height, Arch Curve and Footprint. The information on how the feet shape changes with loads is important for shoe designing, plantar stresses analysis and orthopaedic

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Received: February 16, 2014; Accepted: January 19, 2015

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treatment.

Rong Wang et al [6] designed toe shaped recognition algorithm based on fuzzy neural networks. The characters of footprint shape, a toe shape description method, based on geometric characteristic values of toe image is proposed. Corner detection is carried out on toe region and the characteristic points which can describe the toe shape are confirmed by the edge of toe image.

Jaeseok Yun et al [7] proposed a biometric user identification method based on user's gait. They divided obtainable features from user's gait into two categories: (i) walking pattern, and (ii) stepping pattern (dynamic footprints). This paper considers an approach of identifying user with dynamic footprints.

Wei Jia et al [8] utilize a system to identify the new born babies using the foot image. This is implemented in the hospital maternity ward where the babies are swapped or changed. Here a coordinate system is defined to align the images, and a region of interest (ROI) is cropped. In recognition stage, four orientation feature-based approaches, Ordinal Code, BOCV, Competitive Code, and Robust Line Orientation Code, are exploited for recognition. This kind of approach can take high resolution photographs and then can be used for preprocessing and identification with a high accuracy.

V. D. Ambeth Kumar and M. Ramakrishnan [9] has implemented a new approach for FPRS using wavelet and Fuzzy Neural Network. The transformation of the footprint image is done by the wavelet to detect the edge and then according to the statistical distribution disciplinarians of different toe images the membership functions are constructed, keeping the angle and length as parameters. These obtained values are used as single judgement factor. The input to the neural network is given by computing the distance vector between the four model vectors and the comprehensive judgement vector. However only few features are taken into consideration for this recognition.

3. Proposed Work

Personal authentication is a critical issue for hospitals, birth centers and other institutions where multiple births occur and has not been well studied in the past. In this, a novel automated online newborn personal authentication system is proposed based on footprint recognition. Compared with traditional offline footprint scheme, the proposed automated system can capture digital footprint images with high quality. Besides low quality image, newborn offline footprint has drawbacks. Traditionally footprint images and their parameters are taken manually thereby it is a difficult task to form the database. This results in time consuming and also lacks in the performance measure.

Fig. 1, shows the working module consists of basically the input image which is a normal dirty footprint image which are either scanned or photographed. They are converted into grayscale images i.e., binary images that indicate black (0) and white (1) for showing the image impression. In order to perform morphological operations, regions are marked using the morphological marker. Then the connected components of a particular feature such as a toe are noted and a particular value is found using the 'bwarea.bin' function indicating the area of its presence. This is done by involving the creation of binary files that are required for execution of the morphological operation.

For example, a toe to be noted as an important distinguishing feature then its length height, depthness etc. are marked to a fixed level and its area is determined. Each of the above components of the toe is configured and its features are marked and separated. This is preceded by using a SVM (Support Vector Machine) which aids in developing, identifying and differentiating the evolving footprint over time. Here, 4 to 5 features of a selected component are recorded in a small database and trained using Supervised Neural Networks. The network contains more than 1 and less than 3 hidden layers that help in producing a relatively perfect match or mismatch when executed with proper conditions. This improves the accuracy and also minimizes the execution time. Various griming images are taken for different features and preprocessed generally and the test results given the performance in the identification of an individuals.

The various mathematical factors used during the process includes

ballfootindex=(maximumfootwidth/overallfootwidth) *100
ballheelindex = (maximumfootwidth/heelwidth)*100
instepfootindex= (minimumfootwidth/overallfootwidth) *100
heelindex = (heelwidth/heellength)*100
toeindex = (toewidth/toelength)*100
toeballindex = (toewidth/maximumfootwidth)*100

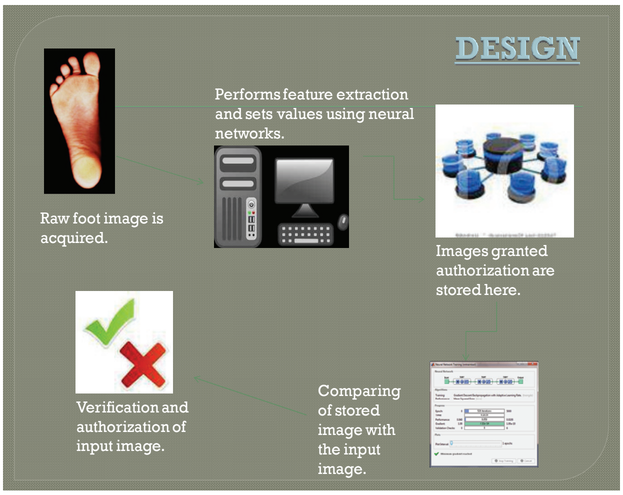


Fig. 1. System Structure

The FPRS system shown constitutes 4 modules namely Modules:

1. Image Acquisition.
2. Image Preprocessing.
3. Image Segmentation.
4. Image Recognition

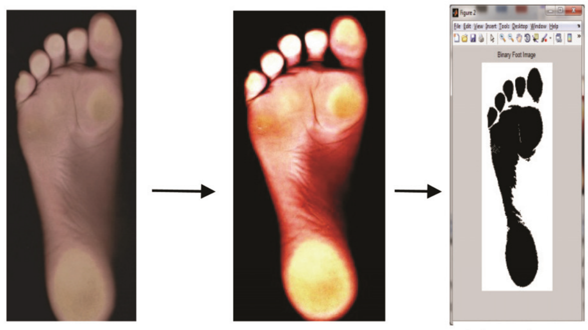
3.1 Image acquisition

A raw image file contains processed data obtained from the image sensor of either a digital camera or image scanner. These raw files are not yet processed and therefore not perfect to be printed or edited. Normally, the image is processed where exact adjustments can be made before it is converted to a "positive" file format such as '.jpeg'' for storage, printing, or for further manipulation. The purpose of raw image format is to save with minimum loss of information, data obtained from the sensor, and the conditions surrounding the captured image. In this, a minimum of 50 left and right foot images from various individuals of both genders are obtained. It includes 35 males and 15 females.

Fig. 3 shows a Canon MG3170 flat-bed scanner for acquiring the image. The foot image is saved using JPEG format in a size range that varies from a minimum of 550×190 pixels to 1024×768 pixels as per the cropping proportion of execution code.

Fig. 3. Image Acquisition

Fig. 4. Raw Foot-Image



Original Scanned image from a Cannon MG3170 Flat-Bed

Edited scanned image using Adobe Photoshop CS5.1 Extended Edition

Binary image (grayscale) of the preprocessed image

Fig. 5. Steps of image preprocessing process

Fig. 4 Shows a sample of footprint image obtained from the scanner.

3.2 Image preprocessing

Image Preprocessing is the technique of enhancing and improving the quality of data images prior to computational processing. It involves removing low-frequency background noise, equalizing the intensity of the individual particles images, removing shadows and masking portions of images. After this 'Image Filtering' is performed is to reduce the noise present in the image. For this 'Gaussian filtering' is used which are characterized by narrow bandwidths, Sharp cutoffs, and low overshoots. First the image is captured and then imported to work for better enhancements using the 'Adobe Photoshop CS5.1 Extended Edition' editor. This stage plays a vital role where changes have been done to RGB range and threshold areas of the image. Due to this, the vibrancy areas of the image are increased to produce a better quality image after the preprocessing stage.

Fig. 5 gives simple example of the working process of the Image Preprocessing.

3.3 Image segmentation

Image segmentation is the process of dividing digital image into multiple segments or parts (sets of pixels). The goal is to simplify change the representation of an image into a more understandable and easier image to analyze. This is used to locate objects and boundaries like lines, curves, etc. in images. Therefore it is the method of appointing a label to every pixel in an image such that pixels with the same label share certain or similar visual characteristics.

For example, the 'region growing' segmentation is used to segment the MR image of brain tumor. Region growing is a procedure that groups pixels or sub regions into larger regions. The result is a set of segments that collectively cover the entire image or a set of points in the form of contours. Similarly in footprint, the connected components of a particular feature such as toe, heel, ball region, and joint region are noted and a particular value is found using the 'bwarea.bin' function denoting the area of its presence. The scanned and preprocessed image is then broken down into parts.

3.4 Image recognition

Image Recognition refers to the process where an input image is fed into a recognizing engine and compared with a set of test images. The process needs a minimum of one input image, a database containing a set of authorized images and a test /sample image for comparison. Here recognition method is implied and applied in such a way that it aids in performing and supporting the authentication process. Before the image recognition is initiated, image segmentation must be done.

For this, an automation system is developed which focuses on image segmentation. The output of the system gives the exact value for the various features namely.

a). Foot Length
b). Maximum Foot Width
c). Minimum Foot Width
d). Toe-Length
e). Toe-Width
f). Heel-Length
g). Heel-Width

These features are the vital parts of the segmented image of the raw-foot which are further used to improvise the 6 factors that help in determining the perimeter and area values to be stored in the database.

Fig. 6 displays the various measurements of each of the above mentioned factors:
where,

1 →represents the 'footlength'
2 →represents the 'maximumfootwidth'
3 →represents the 'minimumfootwidth'
4 →represents the 'toelength'
5 →represents the 'toewidth'

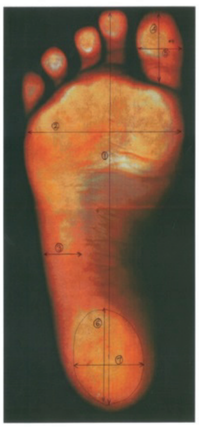


Fig. 6. Measurement of each factor

6 →represents the 'heellength'
7 →represents the 'heelwidth'

1. Foot Length: This is the maximum distance from the tip of the heel to the tip of the big toe or of another toe, whichever protrudes the farthest.
2. Maximum Foot Width: This indicates the maximum width at the ball, across the heads of first and fifth metatarsal bones of the foot.
3. Minimum Foot Width: Represents the minimum foot width, usually across the arch of the foot.
4. Toe-Length: The maximum length of the big toe measured from the outermost tip to the ball line.
5. Toe-Width: The maximum width of the big toe.
6. Heel-Length: The maximum length of the heel portion along the central line of the footprint. An outline is marked encircling the heel area as observed visually before measuring.
7. Heel-Width: The maximum width of the heel measured across the encircled area.

Using these features, that include main areas of the foot such as toe, heel, joint, and the ball regions, 6 various factors are developed to obtain the perfect values for the foot parameters. To determine the values of these factors a set of formulas are applied to each factor. They are

1. Ball Foot Index
2. Ball Heel Index
3. Instep Foot Index
4. Heel Index
5. Toe Index
6. Toe Ball Index

The basic Formulas used to determine values for the above 6 factors are :

a) ballfootindex= (maximumfootwidth/overallfootwidth) *100
b) ballheelindex = (maximumfootwidth/heelwidth)*100
c) instepfootindex=(minimumfootwidth/overallfootwidth) *100
d) heelindex = (heelwidth/heellength)*100
e) toeindex = (toewidth/toelength)*100
f) toeballindex = (toewidth/maximumfootwidth)*100

4. Experimental Results and Analysis

In our method, simple and an effective image segmentation process is done using the bwarea.bin function present as an in-built function in MATLAB 7.7 software tool.

Fig. 7 shows the image of user1.jpg. This right foot image in the input for the automation system where it generates the value of different features and parametric factors from the image as given in Table 1:

Fig. 7. User1.jpg

Table 1. Different types of parameters for single person

Parameters	Values
toeparameter	812.3747
toelength	146.1297
heelparameter	1.1573e+003
heellength	297.3102
jointparameter	577.2620
jointwidth	126.8258
ballparameter	474.1493
maximumfootwidth	190.5722
ballfootindex	48.2172
ballheelindex	97.4586
instepfootindex	49.4745
heelindex	65.7702
toeindex	86.7899
toeballindex	66.5500

Table 2. Find the parameter for individual persons

Person Name	toe parameter	toe length	heel parameter	heel length	joint parameter	joint width	ball parameter	maximum foot width
User 1	793.7056	192.6477	1.1558e+003	296.0953	5463087	123.6818	613.9483	188.569
User 2	398.7523	135.4960	651.9483	265.8020	288.7107	72.9110	1.0140e+003	342.6603
User 3	656.3919	136.2125	1.2150e+003	302.0882	0	131.7775	397.1198	109.9474
User 4	703.6224	167.1137	355.3970	101.8243	6155635	119.0650	569.9066	185.7247
User 5	710.7351	133.3058	1.4440e+003	309.7392	5770782	128.6147	384.4335	102.5432
User 6	591.3209	142.1974	1.2597e+003	306.6984	5105513	102.6997	262.6102	89.0127
User 7	422.5685	125.8916	1.3825e+003	256.2231	2782254	69.5673	218.8528	218.8528
User 0	012.3747	146.1297	1.1573e+003	297.3102	577.2620	126.8258	474.1493	19057 22

The process of image acquisition is performed by obtaining the various right & left images of men & women. The Canon MG3170 flat-bed scanner is the equipment used as the device for capturing the raw foot-image.

The preprocess procedure is followed by enhancing the raw foot-image and followed by image segmentation. The feature extraction technique is done in image segmentation. Table 2 and Table 3: gives the total of 7 factors obtained after segmentation for different individual's persons.

Table 3: Find the factors for individual person

Person	Ball foot index	Ball Heel Index	instep foot index	heel index	toe index	toe ball index
User 1	41.4273	81.0950	51.0849	78.5319	64.2010	65.5895
User 2	94.2930	630.2685	630.2685	20.4541	53.8105	21.2779
User 3	28.9281	47.9586	60.3189	75.8900	96.7441	119.8550
User 4	42.1578	208.9328	20.177	87.2994	71.2479	64.1083
User 5	25.8456	41.2982	62.5829	80.1640	96.4810	125.4249
User 6	24.5443	37.9767	64.6298	76.4229	72.2233	115.3764
User 7	22.3387	33.1183	67.4512	87.7607	55.2597	93.4156
User 8	48.2172	97.4586	49.4745	65.7702	86.7899	66.5500

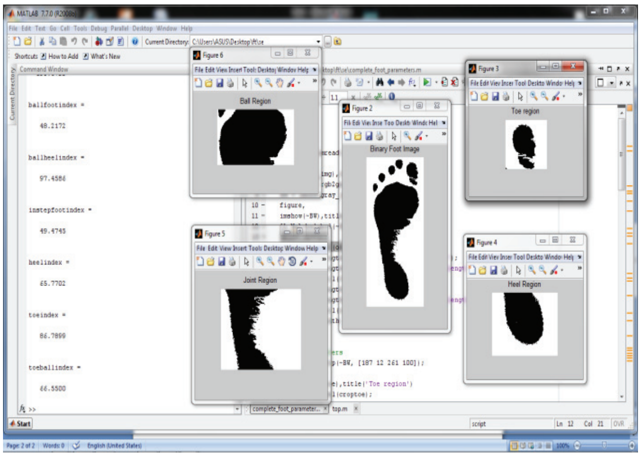


Fig. 8. Other Sample Parameters

Fig. 8 represents the sample output screen shot.

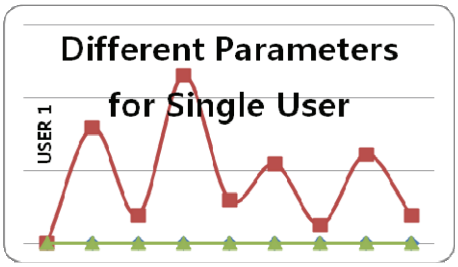


Fig. 9. Different Parameters for User 1

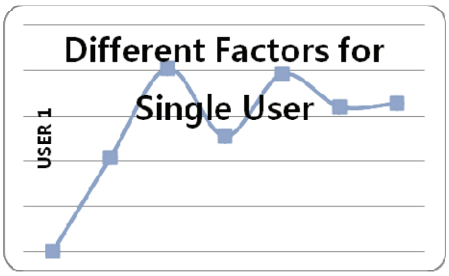


Fig. 10. Different Factors for User 1

Fig. 9 gives the 7 parametric feature values of single person from the automated system which clearly indicates that each feature has different combination of values for single person.

Fig. 10 depicts the results of the automation system of different factors for single person. It was found that the performance has improved in the automatic segmentation process after testing its respective features.

5. Conclusion

We have developed an automation system for the recognition of individual using footprint based on the segmentation features of the foot. This system is superior to the previously separated manual method (Suneel, 1980). In this proposed method, the factors are divided using the statistical formulas and the corresponding values are stored in the database.

This can be extended further for the human recognition by taking the features as one of the injects to train through ANN (Artificial Neural Network) for various level.

Acknowledgements

We the members of this project, acknowledge our sincere gratitude for the excellent support extended to us by the management for providing all the required facilities. Our sincere thanks go to our respectful guide who has extended his support throughout the entire project with his valuable suggestions and guidance

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