Palmprint Spectral Biometric Authentication System by using ASD FieldSpec 4 Spectroradiometer

Anita G. Khandizod
Dept. of CS & IT,
Dr. B. A. M. University.
Aurangabad, India

Ratndeep. R. Deshmukh
Dept. of CS & IT,
Dr. B. A. M. University.
Aurangabad, India

Stephen G. Karungaru
Institute of Advanced Science & Technology,
The University of Tokushima,
Tokushima, Japan

Soumya Banerjee
Birla Institute of Technology
Extension Center, Deoghar

Vandana L. Jadhav Patil
Deogiri College
Aurangabad, India

ABSTRACT
Biometric spoofing is a method of fooling a biometric identification management system, where an artificial object is presented to the biometric scanner that imitates the unique biological properties of a person which the system is designed to measure, so that the system will not be able to distinguish the artifact from the real biological target. Therefor existing biometric technology can be enhanced with a spectroscopy method. In this paper ASD field Spec 4 Spectroradiometer device is used to overcome this problem. In this paper preprocessing including smoothing like Moving Average, Savitzky-Golay, Median Filter, and then some descriptive statistical operation carried on preprocessed palmprint data. Recognition rate of the system was calculated by using correlation coefficient and the recognition rate of the proposed system is 77.56 %.

General Terms
Pattern Recognition, Biometric

Keywords
Spectra ASD FieldSpec 4; Hyperspectral palm-print; Derivatives, smoothing

1. INTRODUCTION
Plamprint is a unique, low resolution, high accuracy and user-friendliness, reliable, more acceptable when data capture, could provide more information than fingerprint, workers or elder people may not provide clear fingerprint but could provide clear palmprint so palmprint having these advantages as compare to other biometric characteristics.

In the past decades, numerous palmprint recognition systems and algorithm have been proposed and developed successfully but the recognition accuracy and anti-spoof capability is limited in some cases[1], because most of the previous work used the white light, multispectral and hyperspectral images as the illumination source. Hyperspectral imaging has attracted substantial research attention as it can obtain large discriminative information in a short time [2], current biometric system provide images for person authentication, Impression of the Palmprint images can be left on the surface by sweat or secretion from glands presents in palmprint region or can be used transferring ink to copy the palmprint features, many times palmprint sensors accepted artificial palmprint therefor the accuracy is limited. Thousands of palmprint that leaves everywhere in one's daily life can be recovered and molded into artificial palmprint for fooling. Palmprint recognition system, many times palmprint sensors accepted artificial palmprint therefor the accuracy is limited. This problem is solved by ASD Fieldspec4 spectroradiometer, in order to increase the accuracy and prevent spoofing attack. Researchers face challenges when collecting spectral reflectance measurements of lab and field, ASD (Analytical Spectral Devices) Spectroradiometer is the study of interaction between the physiochemical characteristics and spectral signature characteristics of object [3]. ASD FieldSpec 4 spectroradiometer find out more information and the best spectroradiometer in the FieldSpec line according to the needs. ASD spectroradiometer have been used in detection, identification, verification and quantification of object. The aim of this work is to provide the spectral signature of palmprint smethods to increase the performance of the existing palmprint system. This device consists of three separate detectors: UV/VNIR range (300-1000), for the SWIR1 range (1,000–1,800 nm) and the SWIR2 range (1,800–2,500 nm).

Table 1. Technical Specification of the ASD Fieldspec 4 Spectroradiometer [4]

Spectral Range	350-2500 nm
Spectral resolution	3 nm @ 700 nm 10 nm @ 1400/2100 nm
Sampling Rate	0.2 sec per spectrum
Weight	5.44 kg
Bands	2151
Maximum Radiance	VNIR 2X Solar, SWIR 10X Solar
Computer	Windows 7, 64 bit laptop
Wavelength Accuracy	0.5 nm
Wavelength Reproducibility	0.1 nm
Scanning Time	100 milliseconds
Stray Light Specification	VNIR 0.02%, SWIR 1 and 2 0.01 %

Fiber optic cable connected to the spectrometer having 10 cm distance from palmprint area, manipulated by using pistol grip at a 45 o angle to the palmprint target area.

In this paper RS3 software are used to collect the hyperspectral signatures of palmprint and View Specpro software are used for post processing spectra files that were stored using ASD instrument. MATLAB-12 was used in the programming environment, FSF (Field Spectroscopy Facility) pre and post processing toolbox is also used and it can be freely downloaded.

2. HUMAN SKIN REFLECTENCE

Light reflected from the skin, there are two reflection components: a specular reflection component and diffuse reflection component. The specular reflection occurs at the surface [5], in which light from a single incoming direction (incident ray) is reflected into a single outgoing direction (reflected ray) and make the same angle with respect to the normal surface, thus the angle of incidence equals the angle of reflection (Qi = Qr). Incident light travels through the skin and hitting physiological particles. In diffuse reflection light from a surface such that an incident ray is reflected at many directions. This carries information about the skin color of person's and his/her biological spectral signature. Blood has hemoglobin, bilirubin, Beta-carotene, melanin in the epidermis absorbs blue light at ~ 470 nm; hemoglobin absorbs green and red light at ~ 525 nm, ~ 640 nm, and papillary dermis absorbs near infrared light at 850nm.

3. METHODOLOGY

A step wise detailed methodology adopted for the present research work is shown in figure. 3. The process of collecting spectral reflectance of palmprint and analysis involved the following steps.

3.1 ASD Field Spec 4 Spectroradiometer

Over 25 years ago the ASD develop the science of field and lab spectroscopy and world's most trusted field and lab spectrometers. These instruments are also used for many remote sensing applications including crop, plant, vegetation climate, snow, soil analysis. ASD Field Spec 4 spectroradiometer can measure radiant energy (radiance and irradiance) [6].

3.2 Spectrometer Warm-Up

It is recommended that warm up the ASD Fieldspec 4 before use, depending upon the environment the warm up time will change. For radiometric work one hour is recommended and for reflectance measurements only 15 minutes is needed. The reason for warm up the instrument is that the three spectrometer detectors i.e. VNIR silicon photodiode, SWIR1 and SWIR2 detectors consists of InGaAs

3.3 Optimization

Optimization adjust the sensitivity of the instrument, according the specific illumination conditions at the time of spectral measurement, one minute time needed for optimization of the ASD Fieldspec 4 [7]. Therefore it is necessary to optimize the detectors regularly to decrease the detectors saturation level.

3.4 Dark Current

The amount of electrical current which is produced by electrons inside the ASD is always added to incoming photons of light, this signal generate a false data called dark current. Dark current stabilized the incoming current, during every optimization dark current is collected automatically; it is stored in the memory and applied for each and every spectral measurement.

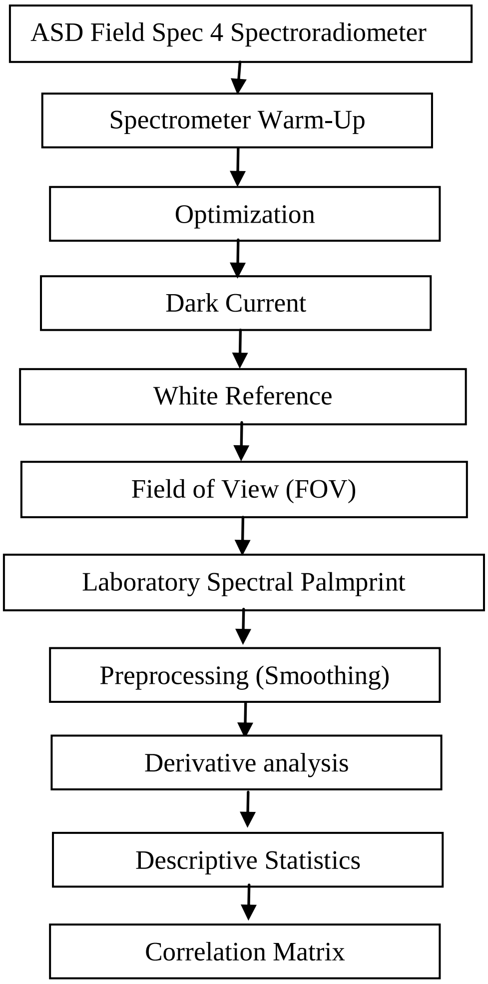

Fig. 1 Flow chart showing the methodology for Generation of palmprint Spectral Signature

3.5 White Reference

This is the calibration or reference panel which gives the 100 percent reflectance of incident illumination to calibrate the target reflectance. White reference is also called as 'baseline' [8]. When collect spectral data in lab or field, take white reference every 10 to 15 minutes for better reflectance spectra.

3.6 Field of View (FOV)

It is very necessary to define the field of view appropriately before collecting the spectral signature of palmprint. Field of view is defined as the solid angle through which light incident on input target and will enter the spectroradiometer [9]. FOV represents the geometric feature of the palmprint. The FOV is circular and will be 1, 8, 25 (bare fibre) degrees, for lab measurement 1 and 8 degree and for field measurement 25 degree FOV are used. Figure 6 shows the FOV geometry in which tangent of α and δα the angle of the instrument's FOV, gives the Diameter D.

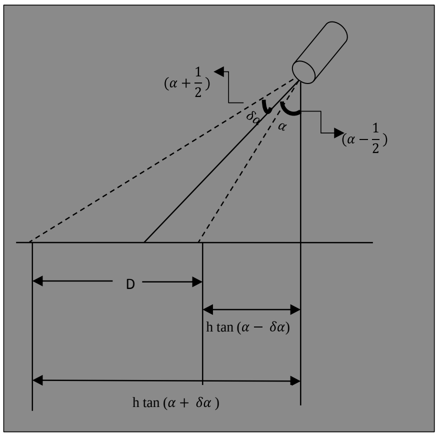

Fig.2 Geometry of Field of View (FOV)

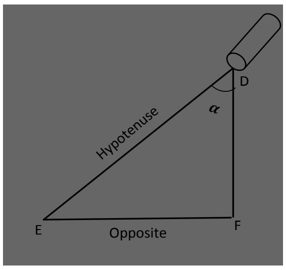

Fig.3 Angle (α) calculation of Field of View (FOV)

From figure 7 the angle (α) is calculated as fallows.

Cos α= Adjacent (H) /Hypotenuse (1)

See table I Adjacent or height = 5 and hypotenuse =5.5 therefor, Cos α = 5/5.5= 0.9090

Cos-1 (0.9090) = 24.63

α = 24°

To estimate the area covered from certain height:

D = H ((tan (α+δα) - (tan (α- δα)) (2)

Where,

H= height of the spectrometer

α = Angular FOV of the spectrometer

D= Diameter

r= Radius of the FOV with area

r= D/2

A= πr2 (3)

A= Area Sampled

For example to establish the area sample with H =5 cm, α = 24°, FOV= 1°, δα= ½ (one half of the FOV)

D = 0.1045 cm2, r = 0.0522 cm2, A = 0.0085 cm2

The area sample from height 5 cm is 0.0085 cm2

For lab measurement 10 cm height for 1 degree FOV and 15 cm height 8 degree FOV was suitable to capture spectral signature of palmprint. Table I and II gives summary of the diameter of 1 and 8 degree FOV.

Table 2. Calculations at different angle of diameter for varying height for 1° FOV

Height	Hypotenuse	Diameter	Area (1°)	Angle
5	5.5	0.1045	0.0085	24
6	7.7	0.1686	0.0223	38
7	9	0.2023	0.032	39
8	10	0.2136	0.0358	36
9	12.5	0.2934	0.0675	43
10	14.5	0.361	0.1023	46
11	15	0.3476	0.0948	42
12	16	0.3684	0.1065	41
13	17.2	0.3861	0.1169	40
14	19.2	0.4564	0.1635	43
15	21	0.5055	0.2005	44

Table 3. Calculations at different angle of diameter for varying height for 8° FOV

Height	Hypotenuse	Diameter	Area (8°)	Angle
5	5.5	0.839	0.5525	24
6	6.5	0.9912	0.7712	23
7	7.4	1.096	0.9429	19
8	8.8	1.1832	1.0989	25
9	10	1.5597	21.9095	26
10	11.1	1.733	2.3575	26
11	12.9	2.0977	3.4542	31
12	13.8	2.1972	3.7898	29
13	15.5	2.5903	5.2668	33
14	17	2.8557	6.4016	34
15	18.6	3.2144	8.1111	36

3.7 Laboratory Spectral Palmprint data collection

In order to control the lighting, palmprint database collection was carried out in dark room laboratories. The spectral signature of palmprint database from 50 individuals was built in Geospatial technology research laboratory, Dr. Babasaheb Ambedkar Marathwada University. The age distribution was from 20 to 40 years old. Database was collected by 1 and 8 degrees of FOV. In each degree the subject was asked to provide around 10 spectral signature of each of his/her left and right palms, so the total database contains 2000 reflectance spectra (350nm ~ 2500nm) of palmprint

Fig.4 Laboratory experimental measurement setup of palmprint Spectra

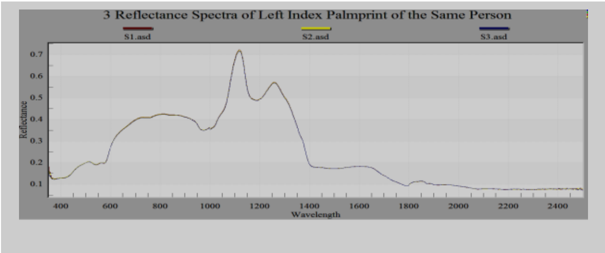

Fig.5 *(a) Same Person Palmprint Spectra*

As can be observed in fig 5 (a) shows the three reflectance spectra of palmprint look identical because it comes from an object of the same Plamprint pattern, fig.5 (b) show reflectance spectra of five different persons, having variation among different individuals as there are variation in palmprint pattern, physiological characteristics. Thus, reflectance spectra of the palmprint check the authentication of the person during verification process of biometric.

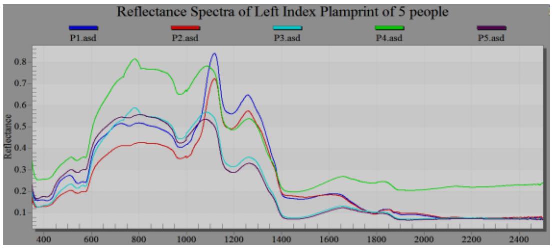

Fig.5 *(b) Variation among different Persons Palmprint Reflectance*

3.8 Pretreatment of palmprint spectral data

Preprocessing plays significant role in biometrics, it includes smoothing, first and second order derivatives of palmprint spectral signature.

3.8.1 Smoothing

Smoothing preprocessing technique is applied on collected database, smoothing helps to remove noise from spectral signature without reducing the number of variables [10]. In smoothing Moving Average, Savitzky-Golay, Median Filter smoothing techniques are used. Fig 10 shows the raw reflectance spectra and filtered reflectance spectra, the moving average smoothing technique gives good result as compare to other smoothing technique.

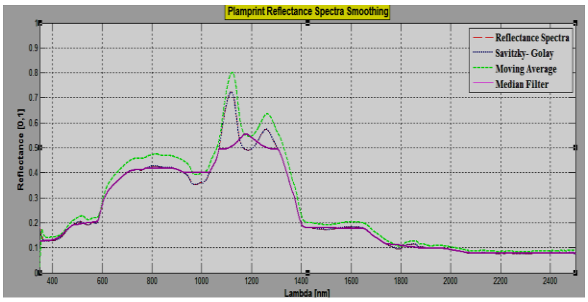

Fig.6 Plamprint Reflectance Spectra Smoothing

3.8.2 Derivatives

First and second derivatives are useful especially separating out peaks of overlapping bands [11]. As compare to the reflectance spectra of palmprint the first and the second derivatives may swing with greater amplitude, reflectance spectra of palmprint changes from positive slope to negative slope as show in fig.11 (a) and (b). First and second derivative spectra can be a good noise filter. The formula used to estimate the first derivative is

$d\alpha/d\lambda = [\alpha(\lambda + \Delta\lambda) - \alpha(\lambda - \Delta\lambda)] / 2\Delta\lambda$ (5)

From the first derivative the second derivative was calculated and the formula is

$d^2s/d\lambda^2 |_j = d/d\lambda (ds/d\lambda) |_j \approx s(\lambda_i) - 2s(\lambda_j) + s(\lambda_k) / (\Delta\lambda)^2$ (6), Where $\Delta\lambda = \lambda_k - \lambda_j = \lambda_j - \lambda_i$, $\lambda_k > \lambda_j > \lambda_i$

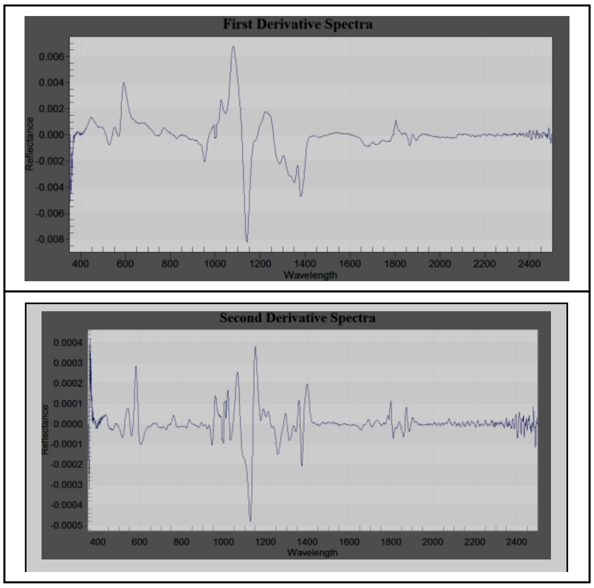

Fig.6 Plamprint reflectance spectra and its respective derivative spectra

3.9 Statistical analysis for the identification of Palmprint Reflectance Spectra

In the present study descriptive statistics like mean, standard deviation, RMS, Skewness, Kurtosis, Median, they describe the distribution and relationship among variables. Descriptive statistics for given palmprint spectral signature data are listed in table no V. The mean value for person 7 (p 7) are with 5110.6 relatively low, positive kurtosis and skewness indicate few high values with asymmetrical distribution. In this paper correlation coefficient matrix is used which is statistical technique, show whether and how strongly pairs of variables are related.

Table 4. Descriptive Statistics of palmprint spectral signature

P	Mean	Std Deviation	RMS	Skew ness	Kurt osis	Median
P1	10145.4	9049.8	13593.7	0.95	-0.24	6906.1
P 2	8674.3	9375.4	12771	1.5	1.47	4143.2
P 3	8981.1	8312	12235.9	1.49	1.58	-5624.5
P 4	6595.2	6275.6	9102.9	1.23	0.58	3685.7
P 5	11079.4	10668.9	15379.4	0.99	-0.25	-7198.7

The correlation coefficient of table V highlights diagonal 1.00 values, which shows relationship between people. There are some negative correlations are also found which indicate inverse relationship between person and the value 0.00 indicates that there is no relation between persons. To test the algorithm the total dataset consist of 1000 coming from 25 individuals including 1 and 8 degree and left and right palm print having 10 samples each was considered. For each set, 5 samples were taken as training samples and 5 samples for test. To determine the effectiveness of the proposed method, there is need to examine the recognition rate (R). R can be defined as

$$R = \frac{\text{No of test samples correctly classified}}{\text{Total number of test samples selected}}$$

By using correlation coefficient, the recognition rate for proposed system is 77.56 %.

Table 5. Correlation matrix of palmprint spectral signature

Person	P-1	P-2	P-3	P-4	P-5	P-6	P-7
P-1	1.00						
P-2	0.91	1.00					
P-3	0.91	1.00	1.00				
P-4	0.96	-0.99	0.99	1.00			
P-5	-0.06	0.27	-0.21	0.12	1.00		
P-6	0.00	-0.31	0.24	0.16	0.99	1.00	
P-7	-0.45	-0.53	-0.52	-0.51	-0.27	-0.27	1.00

4. CONCLUSION

Existing biometrics technologies enhances by using palmprint spectroscopic method in order to prevent spoofing, palmprint spectral signature vary from person to person, and makes spoofing a very difficult task. In this paper database of palmprint spectra signature was developed, to remove noise three types of smoothing techniques are used like Moving Average, Savitzky-Golay, Median Filter. Then derivatives spectra analysis was experimented and the result useful to identify that 1150 nm were consistent in discriminating palmprint spectral signature, descriptive statistical analysis and Correlation coefficient could be used for discriminating palmprint spectral signature those belonging to the same or different persons. The recognition rate of proposed system is 77.56 %. In future feature extraction method like 2D2 PCA and SVM classifier will be used to improvement the recognition rate of the system.

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