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A Holistic Security Progress in Palmprint Recognition System: Forthcoming Techniques

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Abstract

A Biometric System is an ensured authenticated security system which accesses the precious data in the digital world with the human physical characteristics. Palmprint Recognition System is one the highly accepted biometric system due to its easy acquisition and reliability. The notion of this research work is to survey the last decade research works and evolution of Palmprint Recognition System where the researchers are used the various feature extraction techniques to extract the palmprint features for authentication process and various classifier algorithms to classify the authorized persons for identification process. At ultimately, this survey reveals the most optimized feature extraction approaches and classification algorithms to direct the future research works toward theses methodologies to attain the efficient Biometric Authentication and Identification System for achieving the 100% accuracy and efficient of information security in the digital world.

Keywords: Biometric system, Palmprint Recognition System, feature extraction techniques, classifier algorithms, Biometric Authentication and Identification System.

I. INTRODUCTION

Biometric Authentication and Identification System (BAIS) is the secure and access control applications through which a person's identity is authenticated by using biological data or by scanning some body parts to prevent identity fraud, to tighten the access control of digital information and persons verification in Airports, Schools, private cars, Laptop, shopping Malls, public transports, blood banks, election and refugee registration. Biometric Authentication and Identification system is an emerging and ever changing field of biometric technology whenever a security protocol is required. Biometric authentication and Identification systems rely on a specific data about unique biological traits to implement the authentication and identification process efficiently [1].

Biometric Authentication and Identification system has two key modes: Authentication mode and Identification mode to perform one-to-many and one-to-one comparisons of a captured biometric trait with a specific template stored in a biometric database. The block diagram of the Biometric Authentication and Identification System is shown in Figure.1.

Biometric Authentication and Identification System is using various biometric traits which are become more active in research side over the last few decades. There are several biometric traits in biometric technology: Fingerprint, Facial, Iris, Retina, Hand geometry, Palmprint, Voice, Key stroke, and DNA. Amid the various Biometric traits, Determine which biometric trait is most optimized one in biometric technology to achieve the most effective information and access control security in low cost with more accuracy by measuring and comparing essential characteristics of various Biometric traits. Figure.2, shows several biometric traits used in Biometric Authentication and Identification System.

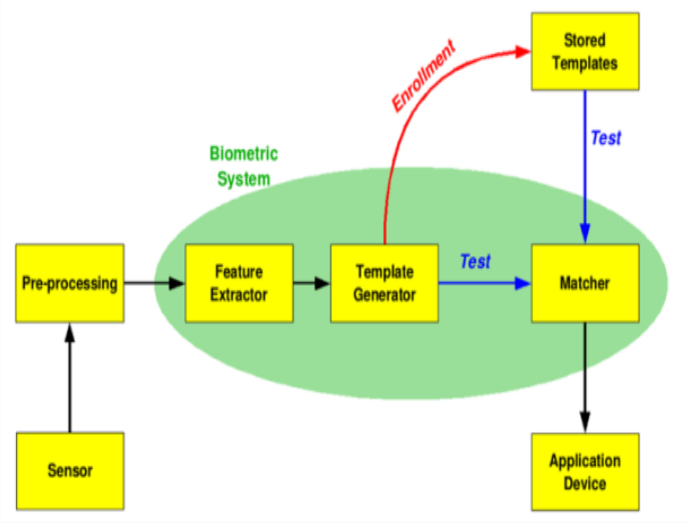


Fig.1. Block Diagram of Biometric Authentication and Identification system

The characteristics of various biometric traits are measured by defining Uniqueness, Permanence, Universality, Measurability, Comparability, Collect ability, Invasiveness, Performance, processing speed, Accuracy, Cost Factor, Ease of use and Circumvention [2].

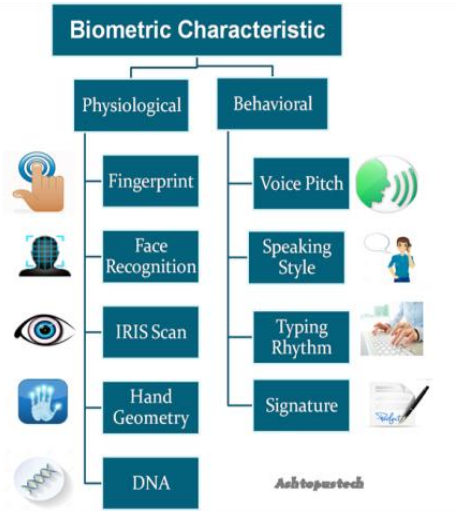


Fig.2. various biometric traits in biometric technology

Table – 1, Table - 2, Table - 3, shows the comparison of essential characteristics of the biometric traits. It has been proved that the Finger Print and Palmprint biometric trait technologies provide high accuracy, uniqueness, permanence, performance and low cost factor compared to others [3]. Nevertheless, Palmprint is found to be better than Finger print biometric technology due to its rich feature values in low resolution, stability, size, deformable and uniqueness. Palmprint Recognition System is used in civil applications, law enforcement and many such applications where access control is essential.

Table 1: Comparison of essential characteristics in various biometric technologies. (L – Low, M – Medium, H – High)

Biometric Traits	Uniqueness	Permanence	Comparability	Collect ability	Invasiveness
Iris	H	H	M	H	M
Retinal	H	H	M	M	H
Finger Print	H	H	M	M	M
Palm Print	H	H	M	M	M
Hand geometry	M	L	M	H	M
Face	M	M	L	H	L
Ear	M	M	L	M	L
X-rayed teeth	L	L	L	M	H
DNA	H	H	L	L	H
Voice	L	L	L	M	L
Signature	H	L	M	H	M
Typing Rhythm	L	L	L	M	M

Table 2: Comparison of essential characteristics in various biometric technologies. (L – Low, M – Medium, H – High)

Biometric Traits	Circumvention	Safety concern	Accuracy	Stability	Cost Factor
Iris	L	H	H	H	H
Retinal	L	H	H	H	H
Finger Print	M	M	M	H	L
Palm Print	M	M	M	M	L
Hand geometry	M	M	M	M	H
Face	H	M	L	M	M
Ear	L	L	L	M	M
X-rayed teeth	H	L	L	L	H
DNA	L	H	H	H	H
Voice	H	H	L	M	L
Signature	H	H	M	M	M
Typing Rhythm	M	L	L	L	M

Table 3: Comparison of essential characteristics in various biometric technologies. (L – Low, M – Medium, H – High)

Biometric Traits	Popularity	Ease of Use	Acceptability	Performance
Iris	M	M	M	H
Retinal	L	L	L	H
Finger Print	H	H	H	M
Palm Print	L	M	H	M
Hand geometry	L	H	M	M
Face	H	H	H	L
Ear	L	H	M	L
X-rayed teeth	L	H	L	L
DNA	H	L	H	H
Voice	H	H	H	L
Signature	H	H	H	M
Typing Rhythm	L	L	L	L

II. PALMPRINT RECOGNITION SYSTEM

Palmprint recognition system exploits the palm of a person for authentication and identification. The general system architecture of a Palmprint Recognition System is shown in Figure 3.

A. Palmprint image acquisition

Palmprint images can be acquired by offline and online methods. In offline, the palm painted with ink is placed a paper and scanned, which contains creases, ridges and Minutiae. Due to its slow process, online method is offered for real time applications. The sample offline palmprint image is shown in Figure 4.

In online method, Researchers utilize low resolution grayscale palm image (such as 75 or 150 ppi) and high resolution grayscale palm image (such as 450 or 500 ppi) as shown in Figure.5(b) and Figure.6(c) to extract the principal lines, wrinkles and more discriminate feature like ridges, singular points and minutiae are obtained by CCD (Charge Coupled Device) based palmprint scanner, which is shown in Figure 5(a). Digital and video cameras causes low quality recognition problem due to its uncontrolled environment with illumination variations and distortions. Multispectral Palmprint Recognition System, 3D Palmprint Recognition System and Latent Palmprint Recognition System are novel Palmprint Recognition Systems that have been recently developed for obtaining lot of vital and robust feature information by using more sensor techniques to acquire exclusive palmprint images such as multispectral palmprint images and 3D-palmprint images.

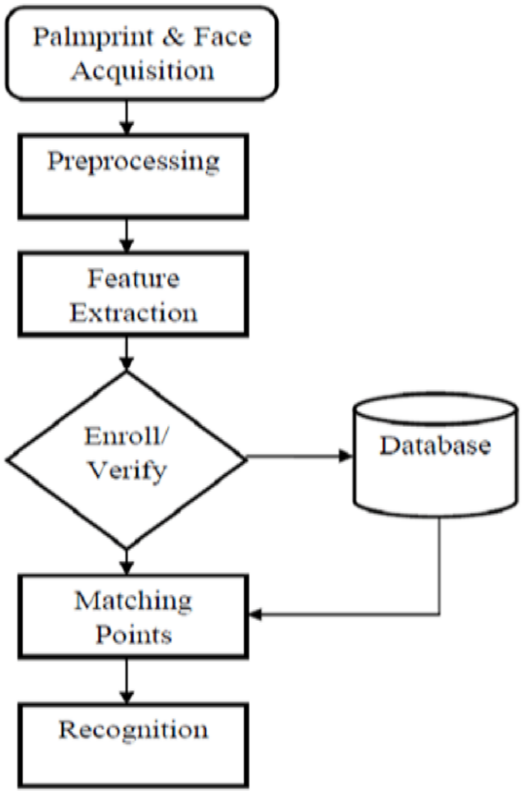


Fig.3. Architecture of Palmprint Recognition System

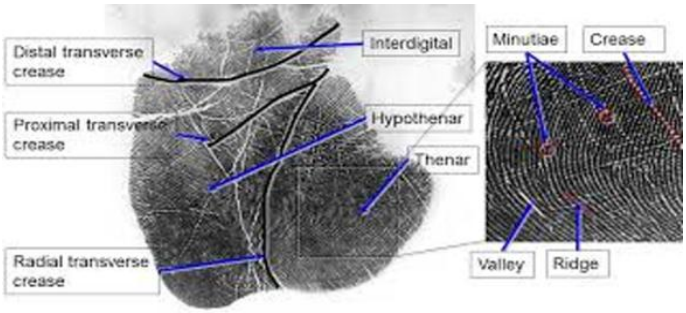


Fig.4. Offline Palmprint Image

- **Multispectral Palmprint Recognition System**

Multispectral Palmprint Recognition System uses the Multispectral and infrared spectral palmprint images that have palm vein information and different spectral wavelengths features to increase the accuracy of palmprint recognition in higher level [4].

- **3D-Palmprint Recognition System**

3D-Palmprint Recognition System uses 3D structural and depth information on palm surface that fetches distinct discriminative features for personal authentication and it's hard to be mocked [5]. Figure 6(b) shows 3D-palmprint image.

- **Latent Palmprint Recognition**

Latent palmprint Recognition System uses latent palmprint images that use as a vital crime scene mark for suspect and victim identification in forensic applications and law enforcement. Figure 6(a) shows the latent palmprint image which has minutiae feature [6].

- **Standard Palmprint Database**

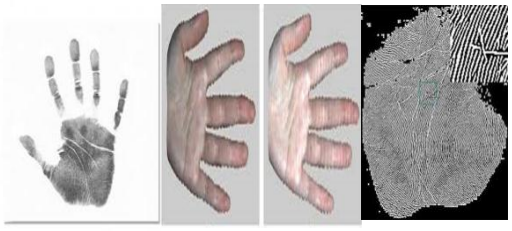
Most of the researchers are interested to use the standard available database of 2D- and 3D-palmprint images, because of easy available and accessible.

- **CASIA 2D-palmprint image database**

This contains 5502 eight bit gray-level JPEG image files of both left and right palm captured from 312 subjects using a CMOS camera. Figure 7(a) shows the 2D-palmprint images in CASIA database.

(a) (b)

Fig. 5(a). CCD palmprint scanner, **5(b)** online palmprint image

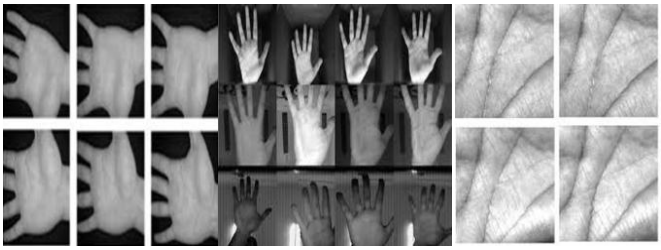


(a) (b) (c)

Fig. 6(a). (a) Latent palmprint image, 2pt 3D-palmprint image, **6(c)** High-resolution palmprint image

- **CASIA Multi-spectral palmprint database**

This contains 7,200 eight bit gray-level JPEG image files of both left and right palm captured from 100 different people in two separate sessions by using a self-designed multiple spectral imaging devices. In each session, there are three samples which contain six palm images are captured at the same time with six different electromagnetic spectrums. Wavelengths of the illuminator corresponding to the six spectrums are 460nm, 630nm, 700nm, 850nm, 940nm and white light respectively.



(a) (b) (c)

Fig. 7 (a) 2D-palmprint images in CASIA database, **7(b)** Touchless palmprint images in IIT Delhi database, **7(c)** 2D-ROI palmprint images in POLYU database.

- **IIT Delhi Touchless 2D-palmprint Database**

This contains touchless 2D-palmprint BMP images files of both left and right palm collected from the 235 subjects. Figure 7(b) shows the sample touchless palmprint images in IIT, Delhi. In each subject, there are seven 800 × 600 pixels images are acquired in varying hand pose variations.

- **PolyU 2D-ROI Palmprint Database**

This comprises 8000 segmented and normalized BMP image files of both left and right palm from 400 volunteer in two separate sessions. In each session, 5 images were captured. Figure 7(c) shows the PolyU 2D- palmprint database images.

- **PolyU Multispectral Palmprint Database**

This contains 6000 images of both left and right palm captured from 250 different people in two separate sessions. In each session, there are 6 samples were collected.

B. Pre-processing

Pre-processing is used to suppress unwanted distortions, enhance some image features and segment the center Region of Interest (ROI) of acquired good quality or low quality palmprint images. The pre-processing steps are shown in Figure 8(a), 8(b), 8(c) which involves converting the gray-level image into binary, segmenting and extracting the region of interest. Cropped 2D-palmprint Region of Interest image is used for feature extraction.

Most of the ROI extraction algorithms make use of the key points between fingers to set up a coordinate system. In key point extraction, the valley points are taken as orientation from index finger, middle finger, ring finger, little finger to found the center portion of palm image and then a circular or a squared portion of defined size is cropped. Key point detection step has several implementations including tangent-based, bisector-based and finger-based.

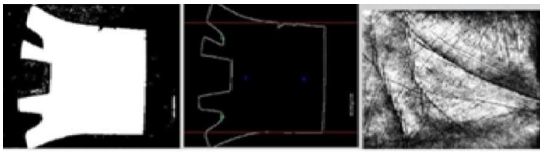
- **The Tangent-Based Approach**

This consider two boundaries, which shows in Figure 9(a), one from point finger and middle finger, other from ring finger and last finger as two convex curves and computes the tangent of these two curves. The two intersections are considered as two key points for establishing the coordinate system and depend on a very short boundary around the bottom of fingers.

- **Bisector-based approach**

This constructs a line using two points, the center of gravity of a finger boundary and the midpoint of its start and end points. The intersection of the line and the finger boundary is considered a key point, which processes are shown in Figure 10(b) and 10(c).

After obtaining the coordinate systems, the central parts of palm prints are cropped in square, circular and half elliptical region is easier for handling translation and rotation variation. Palmprint ROI image is enhanced using a high-frequency emphasis filter and histogram equalization to expose the ROI region obviously.



(a) (b) (c)

Fig.8 (a) Binary Palm Image, **8(b)** Edge of Image, **8(c)** Region of Interest.

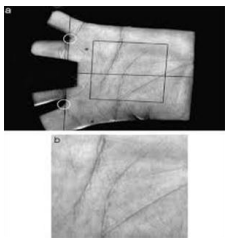


Fig. 9(a). Key point and coordinate system, **9(b).** 2D-palmprint ROI

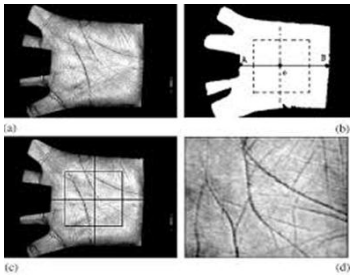


Fig. 10(a). Gray-level 2D palmprint image, **10(b)** and **10(c).** Bisector based ROI Extraction, **10(d).** 2D-palmprint ROI.

C. Feature Extraction

Transforming the input data into the set of features to make the authentication and identification process of individual and stored in database which can be done by existing feature extraction algorithms. Feature extraction algorithms are classified as follows: line-, subspace-, statistic-, coding-based approaches.

- **Line based approach**

This approach uses palm lines as set of features by using edge detection methods. Compute first order derivative and second order derivatives of the palm images to identify the magnitude, edge points and its directions. The weighted sum of local directional magnitude acts as a feature value [7].

- **Subspace based approach (Appearance based approach)**

This approach makes use of Principal Component Analysis (PCA), Linear Discriminant Analysis (LDA) and Independent Component Analysis (IDA) to reduce the dimensionality of input data without loss of information with low noise sensitivity and memory capacity. The spatial coefficients are considered as the feature used for matching. This approach does not need any prior knowledge of the palmprints [9].

- **Statistical based approach**

In local statistical approach, image is divided into several regions such as mean and variance of each region. In global statistical approach, feature is applied on the whole palmprint image and evaluates moments, center of gravity and density [12].

- **Coding approach**

This approach reduces the input data size by using single Gabor filter to extract the local phase information of palmprint. This approach has very low memory requirement and fast matching speed [14].

- **Fusion approach**

Fusion is a promising approach that may increase the accuracy of biometric system.

- **Unimodal hybrid feature extraction approach**

This approach is blooming too hastily in the biometric field to improve the recognition accuracy or facilitate recognition speed in less cost by conjoining of two or more feature extraction approaches on one of the biometric traits [18].

- **Multimodal biometric traits approach**

This approach is reconnoitring magnificently to attain the distinctive identification of authorized person by the fusion of two or more biometric traits techniques [25]. Figure11 shows the architecture of multimodal biometric traits recognition system.

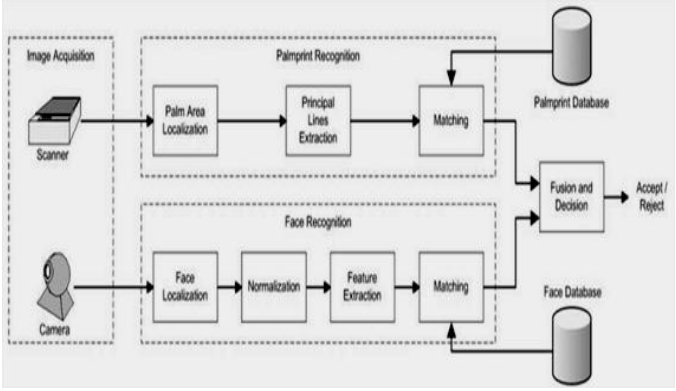


Fig.11. Architecture of Multimodal Biometric traits recognition system.

D. Classification

Classification gets more attention of researchers to perform the identification process in palmprint recognition system. If classification performs identification, then one-to-many matching on individuals with all templates of database, otherwise one-to-one matching on individuals with only the template he/she claims to be, which is done for verification. Verification or identification is evaluated by using distance measure methods. Most used metric functions are L1 measure, L2 measure, Euclidean Distance, Hamming distance, Cosine Distance functions. Distance measures metric functions are not give 100% accuracy and consume more time for computation and recognition. To optimize the identification performance in terms of speed and accuracy, researchers explore the machine learning and deep learning algorithms based on the prior knowledge of palmprints, which is possible to model complex patterns and reduce the prediction problems. In supervised learning, machine learning model learns from the past input data and makes future prediction as output. Unsupervised learning model draws inferences from datasets consisting of input data without labeled responses. Unsupervised classifiers are K-Nearest Neighbor, Naïve Bayes; supervised classifiers are Probabilistic Neural Network, Back propagation Neural Network, Modular Neural Network, Support Vector Machine. Moreover, Machine learning algorithms are complex to implement, takes more processing time to learn or train a large amount of data and not afford much more expected accuracy of recognition rate compare than Deep learning classifier algorithms [27]. In deep learning, a convolution neural network (CNN or ConvNet) is a class of deep neural networks, most commonly applied to analyzing visual imagery for acquiring super-human accuracy (100%) of recognition rate compares than any other classifiers.

III. DISCUSSION

Palmprint recognition system is considered the most reliable biometric recognition technique due to its low cost, user friendliness, high speed and accuracy. In this paper, Table 4, 5 6, 7, 8, 9 and 10 affords a holistic analysis of various feature extraction approaches and classifier techniques of palmprint recognition system in the last decades. Table-5, shows appearance based feature extraction technique has proven to be efficient than other existing feature extraction techniques.

Table 4: A survey of line based Feature Extraction Approach

Feature Extraction	Classifier	Ref	Rec_ Rate	Year
Geometrical shape features	SVM and Neural Network	[8]	89% and 90%	2014
geometrical features and principal lines as texture feature	k-means clustering and BP-ANN	[20]	95.65% and 93.47%	2015

Table 5: A survey of subspace or appearance based Feature Extraction Approach

Feature Extraction	Classifier	Ref	Rec_ Rate	Year
2DPCA	Nearest neighbor and cosine distance	[9]	99.14%	2009
Fourier Transform		[10]	95.48%	2002
PCA	Euclidian Distance	[11]	97.53%	2014
PCA	Euclidean distance and Backpropagation Neural Network	[37]	96.67% and 93.33%	2016
PCA and DWT	Euclidean Distance	[38]	85% and 95%	2016
Wavelet based Kernel PCA	SVM	[39]	99.65%	2008

Table 6: A survey of statistical Feature Extraction Approach

Feature Extraction	Classifier	Ref	Rec_ Rate	Year
Gray Level Co-occurrence Matrix (GLCM)	SVM multi-classification and binary classification	[12]	75.2% and 87.5%	2011
Haralick features from GLCM	matching-score level	[13]	98.91%	2012

Table 7: A survey of coding based Feature Extraction Approach

Feature Extraction	Classifier	Ref	Rec_ Rate	Year
2-D Gabor filter	SVM	[14]	98.15%	2016
Square Gabor Filter and circle Gabor filter	Normalized hamming Distance	[15]	FFR=3.8% and FFR=1.2%	2009
Two elliptical Gabor filters with different orientations	normalized hamming distance	[16]	98.53%	2013
Log Gabor filter and comparison with ICA	Neural Network	[17]	92.50% and 83.33%	2012

Table 8: A survey of hybrid Feature Extraction Approach in unimodal palmprint Recognition System

Feature Extraction	Classifier	Ref	Rec_ Rate	Year
Use Gabor Filter then PCA	KNN	[18]	98.12%	2018
kernel principal component analysis and modified finite radon transform	Local Mean *K*-Nearest Centroid Neighbor	[19]	100%	2015
Fusion of Discrete Wavelet transform(DWT), Canny Edge Detector, Gaussian Filter, Principle Component Analysis(PCA)	Euclidean Distance	[20]	99%	2015
using Hybrid Wavelet Transform of DCT and Walsh, PCA, EHD (Edge Histogram Descriptor)	Euclidean Distance	[21]	95%	2015
DWT+ DCT and QPCA (PIDDQ)	Euclidean Distance	[22]	99%	2012
Local feature SIFT and texture feature GLCM and PCA	KNN	[23]	EER-0.217%	2017
Gabor and Wide Principal Line Image (WPLI)	Dissimilarity Distance(DD)	[24]	99.86%	2016

Table 9: A survey of multimodal biometric traits Feature Extraction Approach

Feature Extraction	Classifier	Ref	Rec_ Rate	Year
Multiple features like texture (Gabor), line and appearance (PCA) for palm print, fingerprint images	KNN	[25]	98.82%	2012
PCA for Ear and Iris recognition	Euclidean Distance	[26]	EER=1.4%	2013

Table 10: A Survey of Deep Learning Classification and Feature Extraction Approach

Feature Extraction	Classifier	Ref	Rec_ Rate	Year
LBP and Minutiae Extraction for fingerprint, Canny edge detection algorithm for palmprint	CNN	[27]	100%	2017
CNN	Multi-class SVM	[28]	100%	2018
CNN		[29]	100%	2018
CNN-F	CNN	[30]	99.95%	2017
DCNN-(PalmRCNN)	------	[31]	100%	2018

From the Table-8, Hybrid feature extraction approach in unimodal palmprint recognition system offers more recognition rate than the multimodal biometric traits feature extraction approach due to its high expensive, lot of memory storage spaces leads poor performance.

In Table-10, the classification process obtained 100% accuracy in convolutional neural network (CNN, or ConvNet) algorithm, which provides fast, super-human accuracy for image classification with less computational power.

F. Conclusion

From the analysis of the past decades research works in palmprint recognition system, it is recommended to propose Hybrid feature extraction approach of unimodal palmprint recognition system for recognition process to extract the distinctive features of genuine persons' palmprint images and deep learning classifier algorithms for verification process to achieve 100% accurate verification for acquiring the well-set secure to access the authorized person's e-information and possessions from hacking and third-party intrudes problems . Yet, it needs some pace to enhance its main characteristic of security and vulnerability.

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