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Analysis of techniques and approaches to palm print: Review

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Abstract

For over 15 years, palmprint identification technology has been developed and tested on a range of image resolutions (high and low). This study demonstrates the numerous varieties of palmprints and the difficulties associated with the palmprint recognition method. Furthermore, we go over the step-by-step process of developing a palmprint biometrics system, starting with image acquisition, preprocessing, feature extraction, and matching, as well as a summary of palmprint databases and their characterizations, as well as some palmprint recognition techniques and research works related to palmprint biometrics purposes. This paper focuses on comparing the types of systems in terms of deep learning, machine learning, and systems that require learning.

Keywords: Palmprint, Image, Identification, Biometrics, Techniques, Deep Learning, Machine Learning
2010 MSC: 62P10, 68U10

1 Introduction

For over 15 years, the palm print identification technology has been developed and tested on a range of image resolutions (high and low). Biometric solutions for palmprint recognition and security systems have recently gained popularity [16]. Whereas the biometric technique is still in its infancy but is showing promise, Sir William Herschel utilized handprint recognition for the first time in 1858, when he registered the prints of Indian government officials under his command and matched them to new samples taken on paydays to ensure identity [47]. In comparison to other biometrics traits (physiological or behavioral), the palm print modality played the most important role in increasing the security of Parson's authentication (identification and verification), and it is an active research topic that has piqued the interest of biometrics researchers [40]. And palm print recognition systems analyze picture data from a photograph of a person's palm and match it to a previously documented record for that individual using scanning equipment or a camera-based application, as well as accompanying software [4]. Palm prints, like fingerprints, contain comparable information. Palm scanners, like fingerprint scanners, enlarge the details in a picture of a human palm's pattern of elevated areas (referred to as "ridges") and branches (referred to as "bifurcations"), as well as other features such as scars, wrinkles, and texture [19]. These three techniques are based on visible light, heat emission analysis, and pressure analysis, respectively. Palm scanners can be contactless or require users to touch their hands to the screen. Palm prints and fingerprints are commonly combined to increase the accuracy of identification [44]. Because a handprint covers a larger region of skin, it has a greater number of distinguishable traits, making false positives practically impossible and willful fabrication far more difficult [34]. When fingerprints are not available in other

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circumstances, such as criminal investigations, a complete or partial palm print may be obtained. A palmprint is a tiny region of the palm's surface that includes additional information that may be used to identify a person [50]. It also includes a unique characteristic (uniqueness means that no two people have the same feature) and is called permanence since it does not change over time. As a result, palmprints are a dependable and secure modality when compared to other palmprint categories such as fingerprints and faces. It contains a plethora of palmprint-related features [54]. Several of these traits are associated with the minutiae aspect of the fingerprint line, which includes ridge bifurcation and termination. Additionally, it has various elements, including geometry, delta points, principal lines, and wrinkles. Each of these traits is extracted using a unique process [22]. Additionally, multiple resolution devices (low or high) can capture this characteristic, which is one of the advantages of palm printing in that the device used to capture the palm picture has no side effects. Another advantage is that, in comparison to other systems, it has a small area with a lot of information to extract, as well as a high acceptance rate [1].

2 Problem Domain

The biometric system has three primary challenges: accuracy, scalability, and usability [17]. Numerous strategies have been proposed to improve the accuracy of biometric systems, including merging multiple biometric characteristics for the introduction of what is referred to as a multimodal biometric system [29]. The following figure 1 shows the three main problems faced by recognition systems of palmprints.

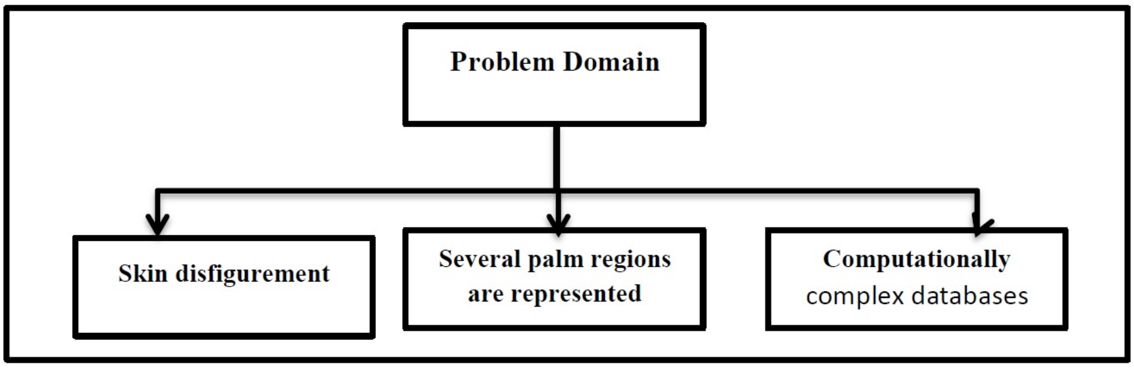


Figure 1: three main problems faced by recognition systems of palmprints [4].

To summarize these three problems, we will review them in the following Table 1:

Table 1: Domain Problem

NO	Refers	Domain	Description
1	[14]	Skin disfigurement	The palm features several bigger joints than the tip of the finger. As a result, the distortion between different impressions of the palm is uncommon. It's also more important than a distortion of fingerprints.
2	[23]	Several palm regions are represented	Palmprints from different places have varying degrees of quality and originality.
3	[31]	Databases that are computationally	Databases aren't always preserved in the same coordinate system during palmprint operations. The minutiae matching algorithms should try all possible spins. Because palmprints contain a greater number of minutiae than fingerprints, matching algorithms that are more convenient for fingerprints are less effective in matching palmprints.

3 Kind of Palmprints

Palmprint is divided into three categories [42], which are detailed below Latent:

- **Latent [16]:** It is thought to be a palm surface that is unseen or sightless. When skin friction ridges, it unintentionally leaves palm impressions on a surface, whether visible or not at proof time. Electronic, physical, and chemical processing are some of the approaches that can be used to display the fractional or whole palm. The eccrine gland, blood, oil, paint, and ink can also be used to generate the latent palmprint. It can detect deficiency, deformity, overlap, or any other type of combination.

- **Patent [28]:** They are visible and can form as a result of the transfer of an unusual item onto the palm's surface. There is no need for augmentation in the patent palmprint, as it is required in the first type, which is mostly shot.

- **Plastic [46]:** Plastic palmprint is the friction ridge impression from palm skins on an article or instrument that keeps the texture of the palm and the shape of the ridges. This type is visible and does not require improvement; it can be photographed and improved, similar to a non-plastic impression, and coated with a finger's natural secretion. Because the matter type is rarely obtainable at the murder scene, this form of palm is rarely possible, see figure 2.

Figure 2 is a summary of the three types of Palmprint Type

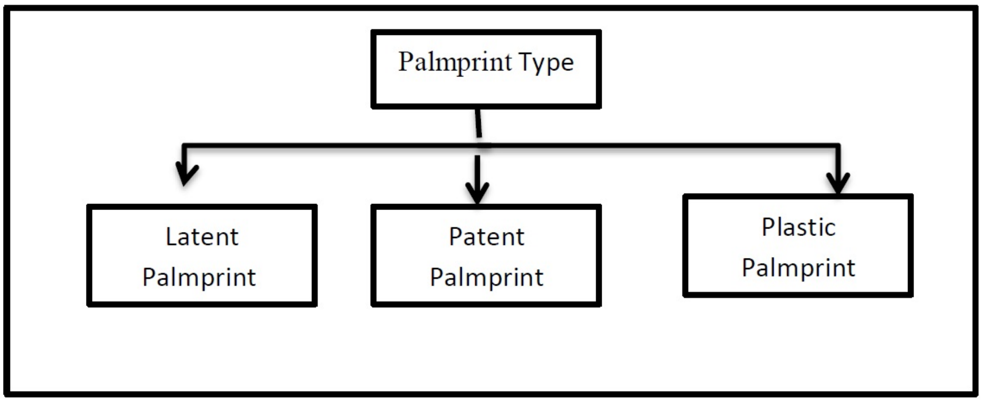


Figure 2: Three Categories of Palmprint Type [42]

4 System Model

It means (Detection, Recognition, and Identification) and these are the types of techniques through which human identities are formed. It's all quite simple until you put it into practice: detection, categorization, recognition, and identification. Then you learn there are significant practical and subjective issues that make them tough to use, identify, or examine [20]. The next table 2 shows the difference between the three terms:

5 Procedures of the Palm print recognition system

There are four steps in a standard palm print recognition system and These are the general basic steps of detection [33, 39]:

- Palm print image acquisition
- Preprocessing especially in ROI location
- Feature extraction
- Matching

The palm print image acquisition technique is used to gather palm print pictures. Preprocessing is used to segment a section of the palm print picture for feature extraction. Feature extraction derives valuable characteristics from a preprocessed palm print [37]. A database stores registered templates, and a matcher examines the characteristics of two palm prints, as seen in Figure 3.

Table 2: System Type Techniques [18, 20]

NO	Name	Description	Figure
1	Detection	The capacity to determine whether or not there is some 'thing' vs. nothing.	
2	Recognition	The capacity to determine the nature of an object (person, animal, car, etc.)	
3	Identification	The capacity to distinguish one person from another.	

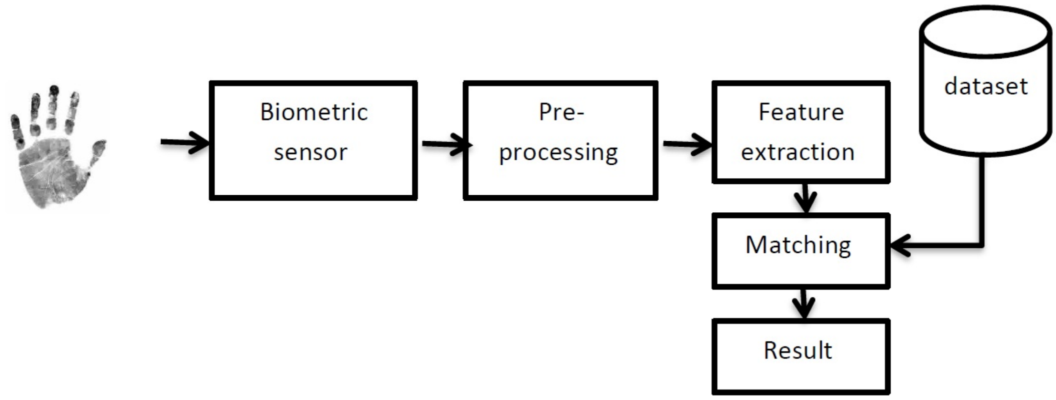


Figure 3: four steps in a standard palm print recognition system [37]

There are two steps to the process: training (enrollment) and testing (Recognition) [13]. During the training phase (enrollment), a biometric sensor or reader collects each palm to produce a digital picture. This image is utilized as training data and then preprocessed to eliminate unwanted data, noise, and reflection. Preprocessing is used to enhance the sharpness of the image and to extract regions of interest (ROI). The preprocessed output is transmitted to the feature extraction step for each training data set, where the feature data may be extracted and recorded in the database [18]. The testing stage (recognition) is identical to the training stage, except for the inclusion of phases for matching training and testing features. The outcome is either a match or a non-match, or a recognized or unrecognized sequence [11]. It can be summarized in the following table 3, which shows the nature of the work of each step:

5.1 Feature Extraction

Palmprint features are known to exist on several levels, and various degrees of characteristics are seen in various types of palmprints. palmprint photographs The low-resolution palmprint pictures, which have a resolution of around 100 pixels per inch (PPI), are texture-based images with dark lines as the most prominent and visible parts [8]. Among them are the top three widest and deepest. The longest lines are referred to as "major lines," while the remainder are referred to as "wrinkles" [12]. As a result, the primary lines, wrinkles, and creases become visible. Texture and color

Table 3: summarized of General Step of Palmprint

RE	Name of step	Description
[55]	Image Acquisition	It is the first phase of any biometric system, and it involves the employment of devices to capture the palm image and analyze it. Some palmprint images are available for free use at some institutions, referred to as standard databases, such as the PolyU database, CASIA, and IIT New Delhi, all of which are available for educational purposes and may be obtained by contacting the proprietors. There are two methods for obtaining a palmprint image: the classic "ink" method and the use of technologies such as a CCD-based palmprint scanner and a digital camera to transform the image into digital form. They're photographing palm prints with a digital camera. The photos are acquired using multiple light sources from different directions, and the CCD-based palmprint scanner is dependent on the lens, camera, and light sources.
[30]	Pre-processing	Preprocessing is the second and most critical phase of any biometrics system's development (identification or verification), and it is used to remove noise and increase the quality of the palm picture. Palmprint preprocessing is a technique for extracting the most critical portion of the palm surface that contains the most information. This region is also referred to as the Region of Interest (ROI), which is defined as a rectangular area on the palm.
[8]	Feature Extraction	The feature extraction procedure is carried out on the picture's output from the preprocessing step, which is a fixed-size image. After that, extract palm characteristics such as main lines, wrinkles, and minutiae, each of which is associated with a certain resolution.
[53]	Matching	The matching stage involves comparing the obtained feature to the database template.

are the most noticeable aspects of low resolution. Palm print photographs The palmprint's ridges, on the other hand, are not visible in low-resolution palmprint photos but are visible in high-resolution palmprint images (approximately 500 PPI) [31]. In high-resolution palmprint images, the ridge patterns (direction and densities), valleys, folds, and tiny points are often generated by the ridges. Additionally, certain local elements of the palmprint, such as pores, may be identified only in photographs with a resolution of at least 500 PPI, if not 1000 PPI. As a consequence, we classify palmprint characteristics into three distinct groups [48]. The following table 4 summarizes the most well-known features in a palmprint and how they may be extracted, as well as the optimal technique to apply to this sort of feature.

Table 4: Fameas Features in Palmprint

NO	Refers	Features based	Features extraction	Technique best to used
1	[10]	Straight lines Texture	Directional projection algorithm	Euclidian distance Energy
2	[25]	Texture and feature points	Deepened on system	Energy different and Hausdorff distance
3	[15]	Lines and textures	Stack filter and 2D Gabor	Humming distance
4	[26]	Textures Lines	LPQ	Multiple techniques can be applied
5	[32]	Lines feature Features	Sobel operator and morphology	Correlation function and BPNN
6	[24]	Features vector	Multi-scale wavelet	Euclidean distance and NND rules
7	[35]	Texture	Gabor transformation and ICA	BPNN
8	[9]	Orientation features	Six Gabor filter on diff direction	Humming distance
9	[7]	Discriminant DCT features	Improve FisherPalm method	Neural network

5.2 Palmprint Techniques Approach

The Region of Interest (ROI) in a palmprint image is critical for extraction. There are numerous features to detect in this tiny region. There are a variety of approaches for detecting this characteristic, depending on the sort of feature you wish to extract. This section discusses four groups of approaches: line-based, statistical-based, texture-based, and subspace-based techniques. There are many techniques utilized, but classifying them is challenging because some of them use many image processing methods, as indicated in table 5:

Table 5: Fames Approach in Palmprint

RE	Approach	Description	Methods
[35]	Texture-based	This feature extraction approach was used to extract textural characteristics from palmprint photographs. Palmprint has a large number of texture characteristics that may be extracted, and it is a very rich modality with numerous texture features. This texture feature can be extracted in different ways in both local and global features, and we can create a feature vector in palmprint by extracting texture information from the palmprint image and storing it as a feature vector.	• Gabor filter • Laws mask Texture-based • Discrete Fourier transform • Discrete cosine transform Wavelets • LBP and 2DLPP
[5]	Statistical based	Statistical techniques are classified into two categories: local statistical approaches and global statistical approaches. Both of these methods are used to palmprint photos in order to extract statistical information. The local statistical approach works by transforming an image to a different domain, dividing it into several blocks or regions, and then calculating local statistical features from each region, such as mean, variance, and standard deviation, which are used as feature points in the palmprint feature vector. In the case of global statistical approaches that convert images and calculate global features such as moments, centers of gravity, and density.	• Mean and standard deviation • Zernike moments • Hu Invariant Moments • the center of gravity, density, spatial dis passivity, and energy • L1-norm energy, Variance
[36]	Subspace-based	The subspace-based technique, also known as the appearance-based approach, entails using subspace analysis to locate low-dimensional objects in high-dimensional input space.	• Principal component analysis(PCA) • Linear discriminant analysis(LDA) • Concurrent subspaces analysis (CSA) • Multiline discriminant analysis (MDA)
[3]	Line-based	This technique extracts palmprint lines, which are one of the most essential aspects of palm prints. These lines, especially principal lines and wrinkle lines, are employed as a unique feature of palmprint images that are used in biometrics systems to recognize people. Also, this methodology focuses on the orientation of palmprint lines, principal lines, and wrinkle lines as well as edge points, where numerous edge detection methods, such as Canny, Prewitt, and others, are employed.	• Line Matching • Line-based • Line Detection • Crease Detection • Morphological Operators

5.3 System Type

The popular techniques for data mining are classification, cluster analysis, association rules, sequential pattern discovery, regression, and prediction. Algorithms are classified into two major groups [6]. As shown in figure 4:

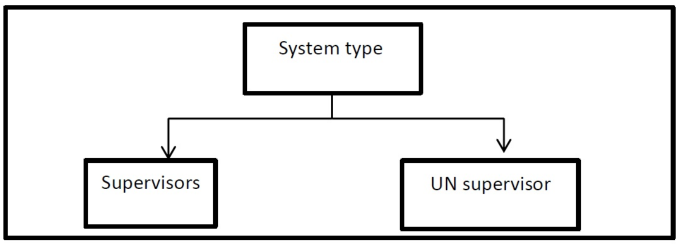


Figure 4: system type [6]

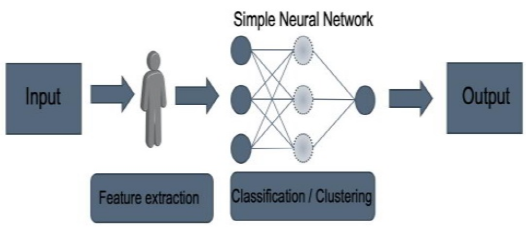
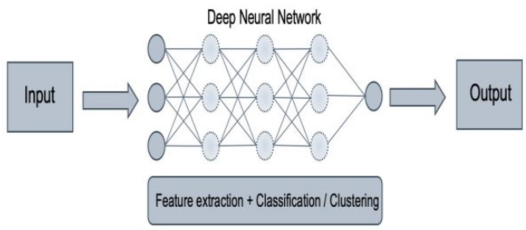
Table 6: summary of supervisor vs. un supervisor [6]

Name mode	Classification	Clustering	Complexity	Labeled data
supervisor	✓	☒	☒	✓
un supervisor	☒	✓	✓	☒

5.4 Technical learning

To appreciate the difference between machine learning and deep learning, the simplest method is to recognize that deep learning equals machine learning [49]. Deep learning is a significant achievement in the field of machine learning. It employs a programmable neural network, which enables robots to make accurate decisions without the assistance of humans. The terms "artificial intelligence," "machine learning," and "deep learning" are frequently used interchangeably [41]. In the table 7, the difference between the two types will be explained.

Table 7: Machine learning vs. deep learning [2, 43].

Machine learning	**Deep learning**
Definition: Machine learning (ML) is a type of artificial intelligence (AI) that enables software programs to improve their prediction accuracy without explicitly stating that they should. Machine learning algorithms anticipate new output values using past data as input. Recommendation engines usually make use of machine learning. There are several applications, including fraud detection, spam filtering, malware threat detection, business process automation (BPA), and predictive maintenance.	**Definition:** In deep learning, artificial neural networks are utilized to perform difficult computations on massive amounts of data. It's a form of machine learning that's inspired by the structure and function of the human brain. Machines are trained using example-based deep learning algorithms. Deep learning is widely applied in a variety of areas, including healthcare, e-commerce, entertainment, and advertising.
Example: (Linear Discriminant Analysis -LDA), (Support Vector Machines SVM), k-nearest neighbors –KNN)	**Example:** (Convolutional Neural Network-CNN), Long Short Term Memory Networks (LSTMs), Restricted Boltzmann Machines (RBMs).
Work: Machine learning is a subset of artificial intelligence (AI) that teaches computers to think like people do, through the process of learning from and improving on prior experiences. It works by analyzing data and recognizing patterns with minimal human intervention, and machine learning is capable of automating nearly any task that can be completed using a data-defined pattern or set of rules. This enables firms to automate formerly manual processes such as customer service call answering, bookkeeping, and resume screening.	**Work:** While deep learning algorithms make use of self-learning representations, they also make use of artificial neural networks (ANNs) that replicate the way the brain processes information. Throughout the training phase, algorithms use unknown components in the input distribution to extract features, arrange objects, and identify significant data patterns. This occurs on numerous layers, with algorithms used to construct the models, similar to how robots are trained for self-learning. Deep learning models employ a variety of algorithms. While no network is perfect, certain algorithms are more suited to particular tasks than others. To choose the best, a full comprehension of all primary algorithms is required.
	

6 Data in palmprint

There are various standard palmprint databases available online for research purposes, some of which are shown in table 8 along with their descriptions.

7 Comparing previse study

In this section, we highlight the most important studies that researchers used as sources for their research on the subject of palm print and studies within the last five years, which will be clarified in the following table 9:

8 Conclusion

The paper offers a review of palmprint recognition technology. It emphasized the palmprint recognition process step by step, beginning with the collection of palmprint data during the acquisition stage, followed by the removal of unwanted data and noise using an enhancement technique during the preprocessing stage, which results in a Region

Table 8: Fames Data in Palmprint

NO	Refers	Name	year	Details
1	[56]	CASIA Multi-Spectral Palmprint Image Database	2008	It has an 8-bit gray level and contains 7,200 palms from 100 participants, each with 72 samples and a 768×576 pixel image.
2	[57]	CASIA Palmprint Image Database	2005	It's an 8-bit grayscale image with 5505 palms taken from 312 participants with a 640×480 pixel resolution.
3	[58]	PolyU Multispectral Palmprint database	2001	It is a collection of color photographs of 6,000 palms obtained from 250 people, each with 24 samples.
4	[59]	PolyU palmprint database 1.0	2011	It's a grayscale image with 600 palms obtained from 100 participants, each with 6 samples, and a 384×284 pixel image size.
5	[59]	PolyU palmprint database 2.0	2014	It's a grayscale image with 7752 palms obtained from 386 participants, each with 20 samples, and a 384×284 pixel image size.
6	[60]	KVKR-Palmprint Database	2015	It is a color photograph of 900 palms obtained from 150 participants, each with 6 samples, and has a 640×480 pixel image size.
7	[61]	IIT Delhi Touchless Palmprint Database	2008	It is a bitmap image with 3290 palms obtained from 235 participants. Each subject has 14 samples with image sizes ranging from 150×150 to 800×600 pixels.
8	[62]	National Palm Print System	2019	The NPPS repository has about 15 million distinct palm print identities and over 29 million individual palm prints associated with those identities, all of which can be used as investigative leads.
9	[63]	COEP Palm Print Database	2021	It consists of eight distinct photos of a single individual's palm. The collection contains 1344 photos of 168 individuals. The database was compiled over the course of a year. The photos are labeled with the IMG person number suffix (image number). For example, jpg IMG 001(1). The jpg file corresponds to the first individual and his/her first photograph. The photographs were taken with a digital camera. The photos have a resolution of 1600×1200 pixels. The "Rajiv Gandhi Science and Technology Commission" is funding the initiative.
10	[64]	The Tsinghua Palmprint Database	2016	This collection comprises 1,280 palmprint photos of 80 people (two palms per subject and eight impressions per palm), which were collected using a Hisign commercial palmprint scanner. All palmprint photos are 2040×2040 pixels at a resolution of 500 pixels per inch. THUPALMLAB's uni-impression subset is not publicly accessible.

of Interest (ROI), which is a critical component of the palmprint image, and finally, by extracting the feature from the ROI of the palmprint image during the practicing stage. The following stage is matching, which entails comparing the input palm photographs to a template saved during the enrollment process. Additionally, the research focuses on palmprint varieties and the difficulties inherent in their detection. Finally, some study has been done on palmprint recognition techniques and palmprint databases, as well as their characterization and the scientific paper used a method of comparison between deep learning, machine learning, and types of systems. Previous studies shed light on the last five years of deep learning.

Table 9: Comparing Previse Study

RE	Author	Year	Contribution	Limitation	Database	Result
[21]	S. Kaushik and R. Singh	2016	A hybrid solution was presented by integrating 2D-LPF, PCA, and Gabor filter methods. The suggested technique improves accuracy while reducing complexity in palm print identification. but also demonstrates a technique for decreasing the complexity associated with palm print recognition systems based on PCA.	Evaluation of a tiny database with a maximum of twenty users. Each user has five palm samples, and the suggested system's algorithm performs well on a small collection of palmprint photos, but has not been tested on a larger dataset.	Not define the name	Accuracy= 99.0
[51]	A. Younesi and M. Amirani	2017	A new approach to personal identification based on palmprints was shown. This was accomplished by first extracting the ROI of the acquired palmprint and then sending it to the Gabor filter bank, which consists of four filters. We extracted textural information from phases using the BSIF technique. The final BSIF code is created by linearly concatenating the four BSIF codes with equal weights. After obtaining the normalized histogram of the BSIF code, six characteristics were extracted from it. Finally, people were identified using the KNN classifier.	The proposed system does not use any deep learning techniques but uses the traditional way.	Polytechnic University (PolyU) palmprint database	Accuracy=99.27 in dataset 1 And Accuracy=99.81 in dataset 2
[52]	L. Zhang. Et al	2018	PalmRCNN, a DCNN-based system, has been proposed as the first DCNN research in the field of contactless palmprint/palm vein recognition. At the feature extraction step, we utilized a modified Inception ResNet v1 to extract deeper valuable traits that can subsequently be used for identification or verification. We train an SVM classifier for identification using feature vectors obtained by a modified Inception ResNet v1 network. For verification, we employ the Euclidean distance between the feature vectors of the two palms under study.	The data set used not a stander data set to evaluate the result.	benchmark datasets	Accuracy=100 Error=2.74
[38]	H. Shao. Et al	2019	A suggested transfer autoencoder is proposed for cross-domain palmprint recognition. The transfer autoencoder is composed of two convolutional autoencoders and one discriminator. Convolutional autoencoders build on the basis of linear autoencoders by including convolutional layers and pooling layers. By optimizing the reconstruction loss, discriminative low-dimensional features are retrieved and information loss is minimized. The discriminator acts as a link between the source and target domains, allowing for the extraction of the same feature distribution in both.	Work on part of the palm, not the whole palm	Multispectral palmprint database	Accuracy= 99.90
[45]	A. Verma and P. Tiwari	2020	By utilizing KNN, scientists created a simple and effective method for improving the precision of the palmprint's orientation attribute.	In the proposed system, the definition, the outcome, and the dataset utilized are omitted.	collected data	Accuracy= Not definition
[27]	M. Manoj and S. Arulselv	2021	Proposed Because biometric properties of people fluctuate depending on the person and are difficult to guess, the biometric security system has improved the security of systems or applications. Print identification is one of the most common biometric system approaches. Matching is also done with machine learning classifiers. Palm prints are matched using a KNN classifier in this proposed method.	The suggested system is intended to define, rather than to demonstrate, the system's output.	collected data	Accuracy= Not definition

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