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Palm Print Recognition Using Intelligent Techniques: A review

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ABSTRACT

Hand or Palm print recognition systems are one of the efficient people recognition and authentication systems that provide high-security levels by approving the entering and exiting of people such as employees in the work field or companies. The basis for using palmprints lies in the fact that no two individuals have exactly the same palmprint pattern, moreover palmprints remain more or less stablethroughout the lifetime and are easily obtainable using standard imaging techniques. Palm print recognition systems process picture data from a photograph of a person's palm and compare it to a record for that person using a scanning device or camera-based application. There are numerous ways to obtain a palmprint image, including digital scanners. Researchers have taken palmprint photographs using video cameras, CCD-based scanners, and tripods. A CCD-based scanner may be used to take a high resolution image of a palmprint. A palm image can also be perfectly aligned with the user's hand thanks to the pegs on the CCD-based scanner The palmprint has a variety of natural ompositions that are rich in identifying characteristics like wrinkles, ridges, major lines, single, and minute points. Because of these, a palmprint is a distinctive biometric that is trustworthy for identifying humans As Artificial Intelligence (AI) methods and applications improved, the improvement of computer techniques and the usage of techniques increased in all fields including people recognition field. Many intelligent techniques are used to recognize people such as neural networks, the Genetic Algorithm, Particle Swarm Algorithm, and Deep Learning all these techniques are used and have almost the same recognition accuracy.

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1. INTRODUCTION

The fingerprint is a biological pattern that is unique for each person and there is no two prints are alike even for the identical twins. This pattern is used all over the world to recognize people because the fingerprints depend not only on the DNA but it depends on different environmental factors in the uterus before the person is born [1], [2]. Palm or hand recognition is one of the major steps of, the Biometric technique which is one of the most efficient and successful Identification recognition techniques. Simply it identifies the body or the behavior patterns that can recognize the person [3], [4]. Biometric techniques is a very powerful method in security systems over the world, the palm recognition can play a significant role in police investigations of criminal actions because it can give a certain decision about the identity of the person who commits the criminal action [5]. Many personal authentication systems are developed depending on the palm print which uses the major lines, wrinkles, and the salient on the palm of the person all these will produce a unique and stable structure that will not change during a lifetime [6]. These systems used a camera or scanner with their software that will process the produced images to compare them with the datasets that are saved in the system, palm prints are the same as fingerprints. The palm recognition system will use some methods to improve the palm

edges or other distinctive areas, such as thermo- methods, visual methods and other types of methods Fig. 1 shows the specific areas and their labels on the palm [7].

Passwords now are not enough to authenticate the identity of people because they can be lost, forgotten, or even stolen [8], so the research started to find other methods that have more security and accuracy using the biometrics methods [9], [10]. The limits of this research is to identify people through their palmprint

2. PALM RECOGNITION

The idea of palm recognition for people's identification is suggested for the first time in 1858 by Sir William Herschel who works in India for people who cannot write their names, instead they press their hands in ink to print a hand shape on the contract back as some kind of IDs [11]. At the end of 1994, the first Automated Fingerprint Identification System (AFIS) appeared to print the palm of the hand [12], during the period from 2002 to 2004 the Federal Bureau of Investigation (FBI) could develop the national services of palm prints that improve the ability of the law forces to identify the criminals and decrease the time of solving crimes and improve the accuracy of the identification using Integrated Automated Fingerprint Identification System (IAFIS) [13]. Now Australia has the biggest palm prints library in the world where the National Automated Fingerprint Identification System has 4.8 million prints, this system is compatible with the National Standards of American National Standards Institute (ANSI)/ National Institute of Standards and Technology(NIST) for data exchange that will make the process of exchanging the prints datasets with the Interpol or the FBI when there is a necessary [14].

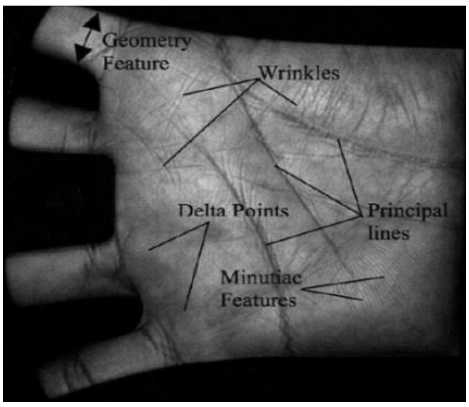

Fig. 1. The palm wrinkles, principal lines, and other features

3. THE PALM PRINT RECOGNITION PROCESS

Palm print is one of the biometric measurements that contains the FingerPrints, Face Pictures, Iris and Voice recognition, the process of Palm recognition starts with scanning the palm by using a special type of scanners which will make a prototype of the print as a type of personal authentication [15] Fig. 2 shows this process.

Fig. 2. Palm Print scanning process using scanner

The recognition process is summarized into four steps: [16] firstly the data preprocessing of a stored dataset or make a new dataset by scanning palm prints, secondly: Image processing by denoising it or removing

the unnecessary parts and keeping the most important parts for the recognition process, thirdly: Features extraction such as the principle lines, density map and other details, fourthly: matching the stored data with the new scanned data to do the recognition process. Fig. 3 shows Palm Recognition Process. Accepted/rejected after matching.

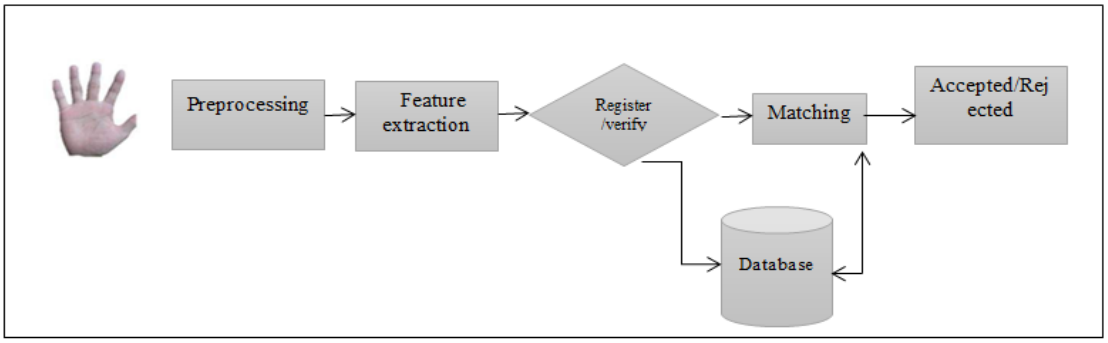

Fig. 3. Palm Print recognition process.

4. THE INTELLIGENT METHODS USED IN PALM PRINT RECOGNITION

There are many intelligent techniques that could recognize people from their palm prints with different levels of accuracy.

4.1. Artificial Neural Network (ANN)

In spite of the fast and big development of computing techniques but sometimes it cannot solve some complex problems, the research starts to go towards a new path in Artificial Intelligent (AI) applications and build knowledge-based systems. These systems simulate the mechanism of the natural system in living beings such as humans. These mechanisms like learning, conclusion, adapting, and perception, from this idea the Artificial Neural network (ANN) starts to develop, these networks simulate the biological neural networks in humans begins which is a nonlinear system [17]. The ANN has the ability to classify or analyze the data without any need to have any knowledge of the mathematical relationship among them [18]. The ANN can be described in general as a network with a number of layers starting from the input layer ending with the output layer with or without a hidden layer or layers in between them depending on the type of the network. Each layer has consisted of a number of neurons that are connected together, increasing the number of neurons or the number of the hidden layer will enable the network to solve more complex problems, but the training time will be increased too. ANN is used in solving problems in different fields such as: Engineering, Medicine, Prediction, Optimization, Statistical Patterns, Financial risk management, and some other fields [19], [20].

4.2. Deep Learning (DL)

Deep Learning (DL) is a field of knowledge that study in the theories and algorithms that can learn by themselves in a way that simulates the function of the human brain, which is one of the Artificial Intelligent fields that gives computers the ability to deal with very complex problems, this type of learning can extract new features by itself [21]. Research starts to study the behavior of the human brain to simulate its function using computing methods not biological methods, lately DL is used in different systems and applications to identify people using biometric information. To learn DL network a huge number of patterns should be used to train this type of network to achieve good results, after the network can recognize all the patterns in the training data it can recognize almost any similar pattern that is not in the training set. There are some types of DL networks that developed to recognize different biometric patterns such as finger prints, the training steps are: preprocessing step, features extraction step, and data matching [22], [23]. One of the DL networks is Convolutional Neural Networks (CNN) which is one of the ANN that was introduced for the first time by Yann André LeCun in 1998, the network simulates the biological neural cells in the human brain this network is one of the computer vision solutions [24]. Many biometric applications used this type of networks because its ability of extract knowledge from a huge dataset besides that is has the ability to connect the inputs to the hidden layer which will increase the speed of learning. This type of networks consisted of: convolution layer, pooling layer and fully connected layer Fig. 4 shows these layers in CNN [25], [26].

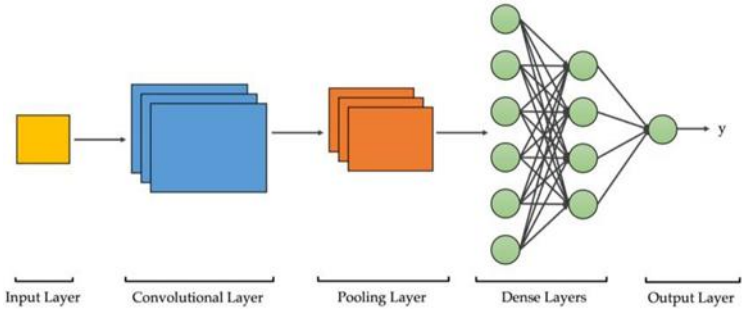

Fig. 4. Convolutional Neural Networks

4.3. Genetic Algorithm (GA)

GA is one of the methods that are used in AI that was suggested by John Holland and his colleagues in Michigan University labs, this algorithm is inspired by the evolution theory which is studying genes and how they will be passed from parents to children [27], [28]. This algorithm starts with finding an initial solution to the problem and then selects new solutions from a number of different solutions by some crossovers and mutations that lead to produce new members or solutions all that is done to reach the best one. This algorithm is used to improve biometric systems such as the palm print systems in the last few years [29]–[31].

4.4. Fuzzy Logic

In 1965 Lotfi A. Zadeh published a scientific paper known as "Fuzzy Sets" a set that has no clear boundaries that simulate human thinking in decisions that takes all the possibilities by using the patterns of approximate values instead of exact values, this type of logic represents the real values of the variables by numbers lies in the range [0,1] which differs from the Boolean logic that gives the values either 0 or 1 [32]–[34], Fig. 5 shows the difference between the Fuzzy logic and the Boolean logic.

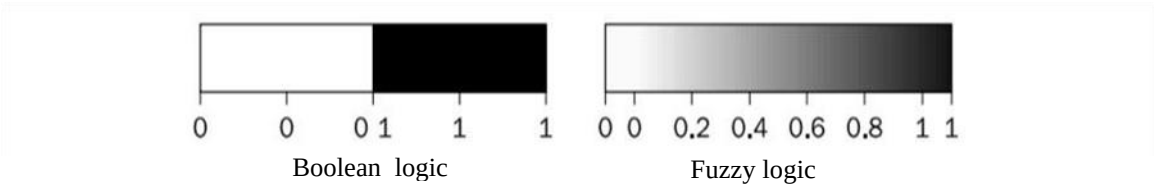

Fig. 5: The Difference Between Fuzzy logic and Boolean logic

This type of logic deals with the problem depending the incertainty and indeterminacy concepts, it represented the variables by using linguistic terms such as: long, short, big, small, poor, and so on. These terms are vague, not specific and the determination of their accuracy of them is rational; instead of describing them by using the 0 and 1 numbers a range of numbers from 0 to 1 is given. Although this type of logic is not easy but it is considered as a positive logic that the researchers are looking to. This type of logic is used in designing expert systems that can make creative decisions that are most suitable to the situation. This helps the human mind opening that makes the human has better description to himself and the world and gives new ideas to solve problems by finding the best solutions. Fuzzy logic has different applications in different fields such as weather prediction, climate prediction, traffic prediction, and airways applications [35]–[37].

4.5. Swarm Intelligence Algorithms

Swarms Intelligence earned popularity in the AL field since its starts in the eighties of the twenty century which has been studied by a high number of researchers to use it in distributed problems that simulate the idea of the groups behavior of living beings in the natural, as an example of these algorithms the Particle Optimization Algorithm [38]–[40]. This algorithm is based on the behavior of the colonies such as the ant colony, bee colony, whale swarms, and fish swarms. All these are examples of swarms optimization algorithms, the particle represents any member in the swarm such as the whale, fish, ant or bee in these examples each particle depends on the group intelligence or its own intelligence (e.g.: if any member could reach the right path or the goal so all the group will follow this member to the right path. Each member of the group has two important features (speed and location) so all the particles communicate with each other to update their speeds and locations according to the information collected from all the particle groups. One of the specifications of this algorithm is the ability to work without any central guide or leader and no supervision, the particle can

prevent collisions among them and they can synchronize their speeds together in the swarm [41]–[43]. In the last years the Particle Swarms Optimization (PSO) algorithm shows significant development by using it in different applications and achieve very good results in a short time, many methods are founded to improve and enhance this algorithm using nontraditional methods to solve complex problems that classic methods could not solve such as the signal routing, training ANN and could be used in the computer movies to move the creatures in a normal way by local interaction among them [44], [45].

5. LITERATURE REVIEW

There are many works in the literature that used AI to recognize people using Palm Print techniques. In 2018, Lin Zhang and others proposed a new method for palm print recognition. By building a deep convolutional network based on Deep Convolutional Neural Networks (DCNN) where it learns high-level features through extensive sampling training by a deep architecture and the Support Vector Machine (SVM) classifier that takes feature vectors extracted by the modified Inception_ResNet_v1 network as samples. This proposal was called (PalmRCNN). The system was tested on a total of (12000 database) palm print images, and the results showed a classification accuracy of 95.48% [46].

In 2018, Zhou J and others presented a new method using the (Siamese network)to identify the end-to-end palm print, after that the convolutional features are extracted using Geometry Group-16 (VGG-16) networks. The upper network was able to directly calculate the similarity of two inputs based on their characteristics. When compared to other modern works, the proposed technology produced good results. This system was tested on 2078 palm print images from a standard database (CASIAM). The results showed that the accuracy of identification reached 99.33% [47].

In 2018 Tarawneh *et al.* used CNN to recognize the palm image and to extract the feature from the image, the pre-trained networks (Alex Net, VGG-16, and VGG-19) are used with SVM as a classifier. This technique gives 95% as the accuracy on PolyU database [48].

In 2019 Genovese A *et al.* suggested PalmNet to recognize the palm print. This network is a CNN that classifies the data without any supervision using a Gabor filter with PCA and NN-1 classifier depending on the Euclidean distance. This system was trained using 600 images from PolyU database, the classification accuracy was 95% [49].

In 2019, Weiyong Gong and others presented a new method to identify the palm print by using the Convolutional Neural Networks (CNN). The neural network has the ability to directly input the image and then get the classification result. The proposal is called structure Alexnet.The ReLU activation function was used to improve speed and accuracy. This activation function makes the network converge at a faster speed with high computational efficiency. The proposed technique gave good results by comparing it with the rest of the modern works. This system was tested on a standard database set (PolyU Multi-Specraldatabase) for a palm print image. The results showed that the classification accuracy reached 99.99% [50]

In 2020 S. Zhao and B. Zhang suggested a new method for palm recognition by using Joint Constrained Least-Square Regression (JCLSR) with CNN to solve the problem of classifying a small number of samples by using local deep learning with different corrections to the palm image. The experiments are done on palm print with Multispectral, then tested on 2601 images of palms from two standard datasets (TongjiT and IITDT). This system can classify the image with 98.17% and 97.85% for each dataset respectively [51].

In 2020, John P. *et al.* propose a new work that uses a convolutional neural network and a Gabor filter based on a genetic algorithm. Gabor filters are used to capture scale and orientation features. The network parameters are set adaptively based on the function of the genetic algorithm and the central frequency, adjusting the size of the filter according to the input data set. The experimental results that were tested on a standard database consisting of two groups (PolyU and CASIA) showed a classification accuracy of 99.2% and 99.77%, respectively [52].

In 2020 Yingyi Zhang *et al.* presented a study of fingerprint verification on smartphones, using multi-brand smartphones. An extensive palm print data set was collected, including 16,000 palm images from 200 people, which is the largest in this field. A verification system was proposed based on Deep Convolutional Neural Networks (DCNN) called DeepMPV. The experiments conducted on the fingerprint verification indicate that the proposed model, DeepMPV, is superior to all its competitors. This proposed system was tested on the standard database (CASIA IIT-D PolyU II TCD MPD). The results showed a classification accuracy of 98.11%, 99.19%, 99.97%, 99.81%, and 98.06%, respectively [53].

In 2021, Lian Wu and others proposed a new exploratory method to identify the palm print by extracting three types of features, which are the most important ones for the components of the palm print image. Those features are texture type, gradient type, and orientation type. These three features are then combined to perform palm print matching. The system was tested on three palm print databases (CASIA, IITD, and GPDS). The

results clearly show that the proposed method outperforms the previous fingerprint descriptors. The results also showed classification accuracy of 88%, 88% and 87%, respectively [54]

In 2022 M. Rajeshwari *et al.* introduced new palm recognition method using the palm texture and shape features, these features were extracted using two methods; the first is the Gray Level Co-occurrence Matrix (GLCM) to extract the texture features, and the second to extract the shape features using Laplacian of Gaussian to detect edges of the image with Euclidean distance to measure the accuracy of matching. This method was tested using PolyU database which has 74% accuracy with GLCM method and 80% using the shape method [55]. Table 1 shows the summary of all the previous works and the used dataset with the achieved accuracy.

In the table below many algorithms and techniques are presented that use AI to classify or match the Palm print beside the features extraction methods that are applied to different datasets of palm prints. The major factor to compare these methods is classification accuracy, many factors affect the accuracy such as (image quality, scanner problems, and palm injuries) all that and other factors affect the accuracy of classification besides the features extraction method and the classifiers types. Based on that we could say that "Palmprint Recognition Based on Convolutional Neural Network-Alexnet" is the best one that classifies the images with accuracy equals to 99.99% .

Table 1. A summary of published approaches for Palmprint Recognition

No.	Authors	Year	Methods	Dataset	Recognition Accuracy
1	Lin Zhang *et al.*	2018	Palmprint and Palmvein Recognition Based on DCNN and A New Large-Scale Contactless Palmvein Dataset	(12000) palm print images	95.48%
2	Zhou J *et al.*	2018	Siamese network	CASIAM	99.33%
3	Tarawneh *et al.*	2018	Pre-trained Convolutional Neural Networks CNNs to extract features and then (SVM) used for classification	PolyU	95.5 %
4	Genovese *et al.*	2019	PalmNet–GaborPCA	PolyU	95%
5	Weiyong Gong *et al.*	2019	Palmprint Recognition Based on Convolutional Neural Network-Alexnet	PolyU	99.99%
6	S. Zhao and B. Zhang	2020	Joint Constrained Least-Square Regression (JCLSR)	TongjiT IITDT	98.17% 97.85%
7	John P. *et al.*	2020	Genetic Algorithm Based Gabor CNN For Palmprint Recognition	PolyU CASIA CASIA	99.2% 99.77% 98.11%
8	Yingyi Zhang *et al.*	2020	Towards Palmprint Verification On smartphones	IIT-D PolyU II TCD MPD	99.19% 99.97% 99.81% 98.06%
9	Lian Wu *et al.*	2021	Triple-Type Feature Extraction for Palmprint Recognition	CASIA IITD GPDS	88% 88% 87%
10	M. Rajeshwari *et al.*	2022	Palm Print Recognition Using Texture and Shape Features	PolyU GLCM	74% 80%

6. CONCLUSION

The palm recognition system is a developed system that can be used in many fields of work and institutions to identify people. This work viewed the methods and techniques that used in recognition using Artificial Intelligent techniques based on the previous research in the literature the process of recognition is briefly done by four steps; the first step is the data preprocessing, the second is the processing, the third is the features extraction the fourth and the last is the recognition or matching the input data with the saved data in the system. With the fast development of palm recognition applications new methods of recognition should be suggested for improvement that will push the researchers to invent new methods by hybridizing intelligent methods to reach better results.

future work : MasterCard is currently experimenting with new technology that allows people to make payments through a face, finger or palm print, and on Tuesday the company launched a program for retailers to offer biometric payment methods such as facial recognition and fingerprint scanning. Users will be able to authenticate payments by showing their face or fingerprint instead of swiping a payment card. The software has already launched in five stores in Brazil and the company says it plans to roll it out globally later. About 1.4 billion people are expected to use facial recognition technology to authenticate payments by 2025

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