Implementation of Contactless Finger Knuckle Identification System

Kyi Pyar Zaw, Aung Soe Khaing

Abstract— **This paper presents an emerging biometric identifier, namely finger knuckle-print (FKP), for personal identification. The texture pattern produced by the finger knuckle bending is highly unique and makes the surface a distinctive biometric identifier. This paper deals with recognition of the system, which involves the finger knuckle extraction and recognition of the knuckle surface by using artificial neural network. Biometrics authentication is an effective method for automatically recognizing a person's identity. Recently, it has been found that the finger knuckle print (FKP), which refers to the inherent skin patterns of the outer surface around the phalangeal joint of one's finger, has high capability to discriminate different individuals, making it an emerging biometric identifier. In this paper, the finger knuckle prints are extracted using edge detection applied for dimensionality reduction. Different edge detection methods, to detect edges in knuckle image, are employed in this system. Artificial neural network play a major role for classifying the knuckle surface.**

Index Terms—**Finger Knuckle Print, Artificial neural network, Edge detection, Feature extraction, Identification**

I. Introduction

The finger-back surface, also known as dorsum of hand, can be highly useful in user identification and has not yet attracted the attention of researchers. The contact free imaging of the finger back surface is highly convenient to users. The skin pattern on the finger-knuckle is highly rich in texture due to skin folds and creases, and hence, can be considered as a biometric identifier. Further, advantages of using Finger Knuckle Print (FKP) include rich in texture features, easily accessible, contact-less image acquisition, invariant to emotions and other behavioural aspects such as tiredness, stable features and acceptability in the society [1].

Knuckle identification is one of the most important biometric technologies that have drawn a substantial amount of attentions and interests recently. Fingerprints have long been used in the identification of individuals because of the well-known fact that each person has a unique fingerprint Finger Knuckle prints are one of the recent recognition system, as everyone on Earth appears to have a unique set of finger knuckle prints at any given time.

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Knuckle print classification and recognition systems will be a challenging task for hackers as it involves unique identification method, incorporating techniques like Neural Networks. Usually Biometric recognition can be used in Identification mode and Verification mode. In identification mode, the biometric system identifies a person from the entire enrolled population by searching a database for a match based solely on the biometric. This is sometimes called "one-to-many" matching. In Verification mode, where the biometric system authenticates a person's claimed identity from their previously enrolled pattern. This is also called "one-to-one" matching. In this paper, the efforts are focused on developing an automated method to extract knuckle surface and geometrical features from the finger back surface and investigate its performance for a potential biometric system [2].

Biometrics authentication includes fingerprint, iris, voice and face. Every trait has its own pros and cons. There exist various challenges depending on the trait such as pose and illumination for face, occlusion and cooperative for iris etc [3].

A very strong authentication system is needed in today's world. The texture pattern produced by the finger knuckle bending is highly unique. The finger geometry features can be simultaneously acquired from the same image, at the same time and integrated to further improve the user identification accuracy of such system [1].

The proposed authentication system deals with the database of 'n' number of images i.e a system is designed for one-to-many identification. A system uses just a webcam or smart phone as a part of hardware [2].

The system is divided into two main modules, namely: Registration and Identification.

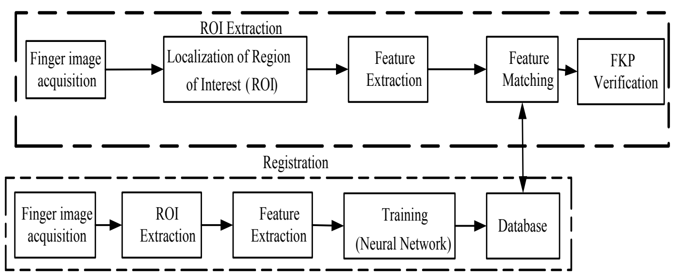

Fig. 1. Block Diagram of Proposed System

The system can be precisely understood by looking at the system block diagram shown in Fig. 1. Proposed work is focusing on the development of an automated method for extracting finger knuckle print and knuckle features from the finger back surface and using it for personal identification purpose.

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II. System Architecture

The system is divided into modules as registration and identification. In registration module a new user is registered. The registration process initially starts with the filling of basic information and an image of knuckle is captured using smart phone. The acquired image is stored in database and a pre-processing technique is applied to it. After the lighter image is obtained, neural points of the image are calculated and stored in a database with which registration process is put to an end.

Authentication is a process where a registered user goes for authentication. Initial steps of image acquisition, pre-processing and feature extraction are same. Further, this image is matched with the images stored in database. Artificial neural network plays a major role over here. Based on matching result calculated in percentage the decision of whether to grant an access or to deny it is made.

III. FKP Identification Algorithm

There have been several promising efforts in the literature to exploit finger knuckle image pattern images for the automated personal identification. This paper deals with recognition of the system, which involves the finger knuckle extraction and recognition of the knuckle surface by using artificial neural network. Biometrics authentication is an effective method for automatically recognizing a person's identity.

There are many different approaches and algorithms in implementing for finger knuckle print identification system. In this work, the process for FKP identification system can be divided into the following different stages:

- Image acquisition
- Feature extraction
- Database Establishment
- Creating and training the neural network
- Identification

In this system, there are two main parts: registration and Identification.

Feature extraction system is implemented by using Edge Detection Method and principle component analysis algorithm.

A. Finger Image Acquisition

The backside of finger is to be acquired using web cam or smart phone or digital camera. An acquisition system has been developed for the collection of finger-back images. A very user-friendly imaging system is constructed. This imaging system uses a web camera focused against a white background under uniform illumination. The camera has been set and fixed at a suitable distance from the imaging surface.

B. Pre-processing for Feature Extraction

Each of these images requires localization of region of interest for the feature extraction. The region of interest is the region having maximum knuckle creases. An ROI can be cropped from the original image for reliable feature extraction and matching. This gives segmented finger knuckle image.

C. Knuckle Feature Extraction

The knuckle image mainly consists of curved lines and creases. Knuckle curved lines and creases are to be detected. Knuckle features are then extracted. Fig. 2 is the flowchart of detail process for feature extraction. In feature extraction, first the target vector is created. Target vector is n x n matrix with diagonal values are one and all others are zeros. The purpose of feature extraction is to extract the significant features of images.

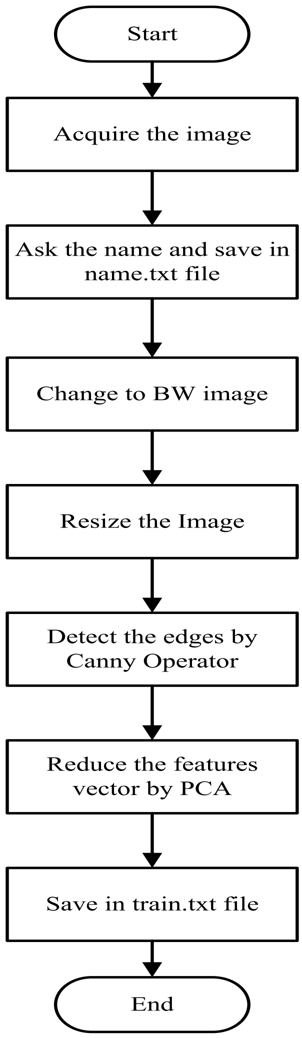

Fig. 2 Flowchart of Feature Extraction

Firstly the number of features that want to take for each image is defined because the number of features that have to train must equal for all images. In this work, the feature should be 100 at least. The images are load to MATLAB. The region of interested image is cropped. The ROI images are normalized to 100 x 80 pixels format files. This size is the normal for enough detail while keeping the processing time low.

Then they are changed to binary (black and white) format since edge detection can be done on binary (black and white) or grey scale images. The edges of binary images are detected by using different mask operators such canny, sobel, prewitt or Roberts edge operator. The Canny edge detector is widely used in computer vision to locate sharp intensity changes and

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to find object boundaries in an image. The Canny edge detector classifies a pixel as an edge if the gradient magnitude of the pixel is larger than those of pixels at both its sides in the direction of maximum intensity change [5].

The operation of Canny Edge Detector is following:

- Smooth image with a Gaussian

$$S = G_\sigma * I \quad G_\sigma = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{x^2+y^2}{2\sigma^2}} \tag{1}$$

- Compute the Gradient magnitude

$$\nabla S = \left[\frac{\partial}{\partial x} S \quad \frac{\partial}{\partial y} S\right]^T = \left[S_x \quad S_y\right]^T \tag{2}$$

- Thin edges by applying non-maxima suppression to the gradient magnitude

$$\left|\nabla S\right| = \sqrt{S_x^2 + S_y^2} \quad \theta = \tan^{-1}\frac{S_y}{S_x} \tag{3}$$

- Detect edges by double thresholding

The outputs of canny edge detector are reduced to numbers of features that predefined by using principal component analysis (PCA) techniques. They are saved in hard disk.

Principal Components Analysis (PCA) Method is following [6]:

- Step 1: Get 2D image data
- Step 2: Subtract the mean

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \tag{4}$$

- Step 3: Calculate the covariance matrix

$$\mathrm{cov}(x, y) = \frac{\sum_{i=1}^{n} (x_i - x)(y_i - y)}{(n-1)} \tag{5}$$

- Step 4: Calculate the eigenvectors and eigenvalues of the covariance matrix
- Step 5: Final Data = Row Feature Vector x Row Zero Mean Data

D. Database Establishment

In order to evaluate the proposed FKP identification, an FKP database is to be established by collecting finger back images of various persons. The FKP images are collected from 5 persons. Four images, left index finger, the left middle finger, the right index finger and the right middle finger are taken for each person. Therefore 20 images are collected. The features of collected FKP images are extracted by using feature extraction method described in above section. These features are trained in neural network. The trained data for each person are saved by specific name.

E. Creation of Neural Network and Training

At the beginning, the initial weights are chosen randomly and then the training or learning begins. There are two approaches to training; supervised and unsupervised. In supervised training, both the inputs and the outputs are provided. The network then processes the inputs and compares its resulting outputs against the desired outputs. Errors are then propagated back through the system, causing the system to adjust the weights, which control the network. There are many laws (algorithms) used to implement the adaptive feedback required to adjust the weights during training. The most common technique is known as back-propagation.

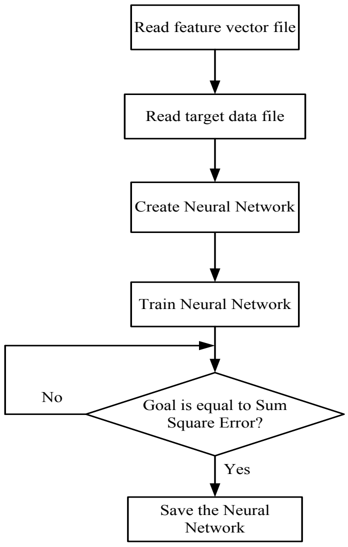

Fig. 3 Flowchart of Neural Network Creation and Training

In this portion, the back propagation Neural Network is created and trained by using data file and target file. After getting the goal of sum square error, the created neural network is saved in MATLAB memory to identify the various finger knuckle print images. Where new function creates the new perceptron neural network, with parameters of minimum and maximum range of input data and n is the number of output neurons. In this system, the network requires the ten input neurons which is the same as the number of features of each FKP and returns the network object.

After creating the network, the weights and biases of the network are also initialized to be ready for training. The goal is assigned to 0.5. The neural network has to be trained by adjusting weight and bias of network until the performance reaches to goal.

1) Neural Network: Basically, an artificial neural network is a system. A system is a structure that receives an input, process the data, and provides an output. Here the normalized value is given as input. ANN is the most commonly used, as it is very simple to implement and effective. In this work, we will deal with Back Propagation ANNs.

Back Propagation ANNs contain one or more layers each of which are linked to the next layer. The first layer is called the "input layer" which meets the initial input (e.g. pixels from a letter) and so does the last one "output layer" which usually holds the input's identifier (e.g. name of the input letter). The layers between input and output layers are called "hidden layer(s)" which only propagate the previous layer's outputs to the next layer and [back] propagates the following layer's error to the previous layer. Once an input is presented

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to the neural network, and a corresponding desired or target response is set at the output, an error is composed from the difference of the desired response and the real system output. The error information is fed back to the system which makes all adjustments to their parameters in a systematic fashion (commonly known as the learning rule). This process is repeated until the desired output is acceptable [4].

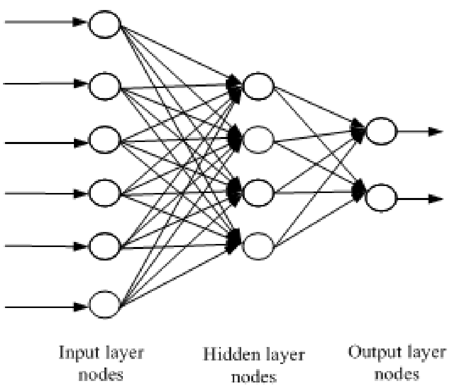

Fig. 4 Multilayer Feedforward ANN Architecture

Short characterization of feedforward networks:

- Typically, activation is fed forward from input to output through ‘hidden layers’, though much other architecture exists.
- Mathematically, they implement static input-output mappings.
- Most popular supervised training algorithm: backpropagation algorithm
- Have proven useful in many practical applications as approximators of nonlinear functions and as pattern classificators.

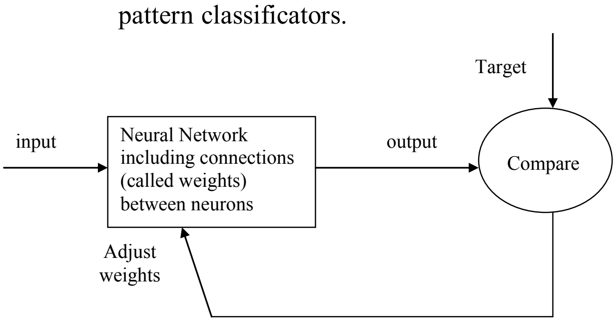

Fig. 5 Training in Neural Network

Neural networks are composed of simple elements operating in parallel. These elements are inspired by biological nervous systems. As in nature, the network function is determined largely by adjusting the values of the connections (weights) between elements. Typically, neural networks are adjusted, or trained, so that a particular input leads to a specific target output. Fig. 5 illustrates such a situation. There, the network is adjusted, based on a comparison of the output and the target, until the network output matches the target. Typically, many such input/target pairs are needed, in this supervised learning, to train a network.

F. Identification

Identification is the final application portion of the system it is used to identify the name of the user. The saved neural network is loaded first, then the input feature vector is extracted from the user input image file. It is put into the neural network and the neural network will identify this features. The result is displayed with output box. Fig. 6 shows the flow chart for identification of system.

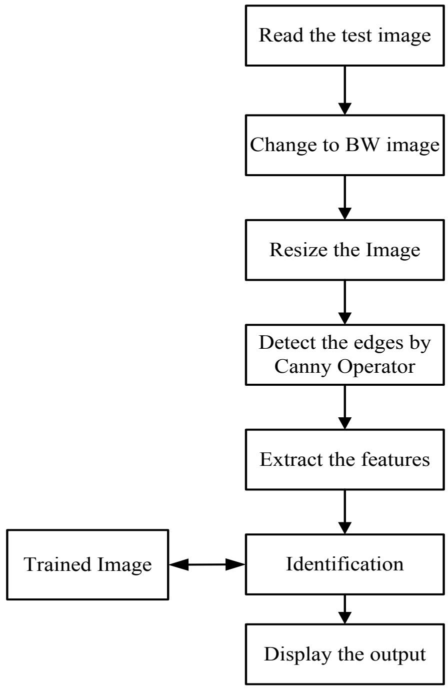

Fig. 6 Flowchart of Identification System

IV. Simulation Results

Use In the first portion, photos of various persons’ FKP images are collected and saved in data set, such as user1, user2, ect. Some of these photos are shown in Fig. 7. For each person, there are 4 different photos are collected and saved in train files.

Fig. 7 FKP Image

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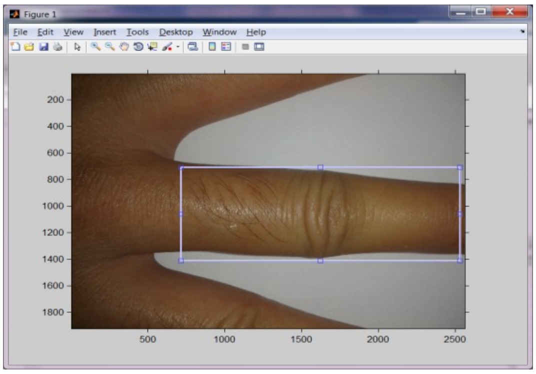
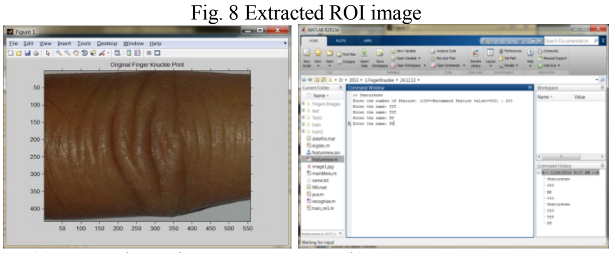
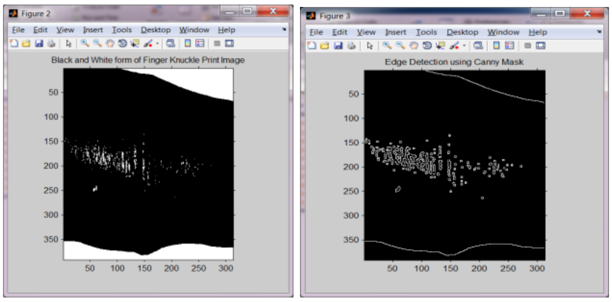


Fig. 8 Extracted ROI image



(a) Cropped FKP image (b) Enter User's name



(c) Binary Image (d) Edge Detected Image

Fig. 9 Feature Extraction (Left middle finger of user TZT)

In the second part, the ROI is cropped and the images are changed to binary image as shown in Fig. 9. To get the equal size of feature vector for each image, the figures should be the same size.

In the feature extraction parts, the edge between black and white spaces are chosen and detected by edge operator. Canny edge operation is selected for this purpose and the edge detected image is shown in Fig. 9. The edge features are large to input to the Neural Network. Therefore they are reduced by PCA method to get the most relevant features from the vector. The extracted features are saved in train.txt file and which is applied to the input of the Neural Networks.

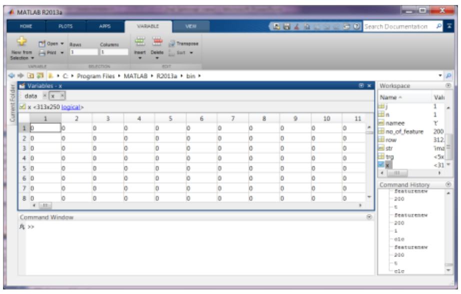


Fig. 10 Extracted feature data (313*250)

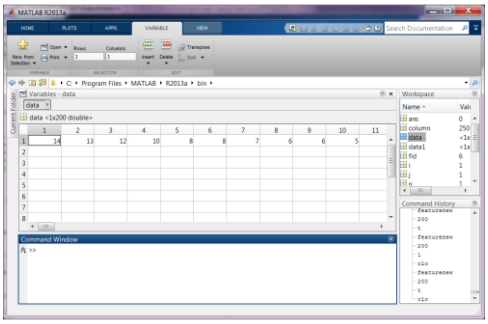
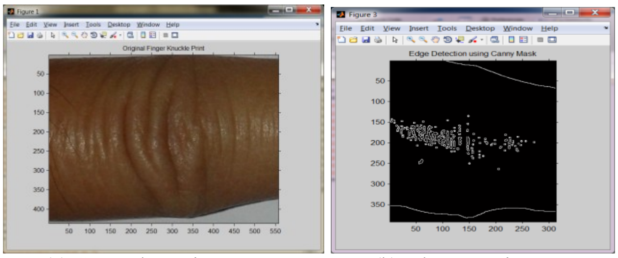
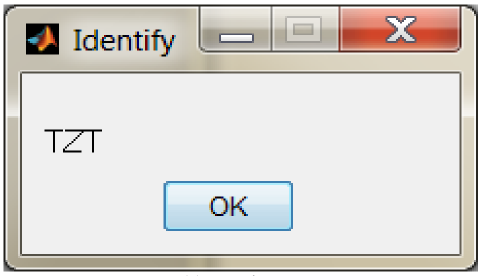


Fig. 11 Feature Data after reducing by PCA Method



(a) Cropped FKP image (b) Edge Detection

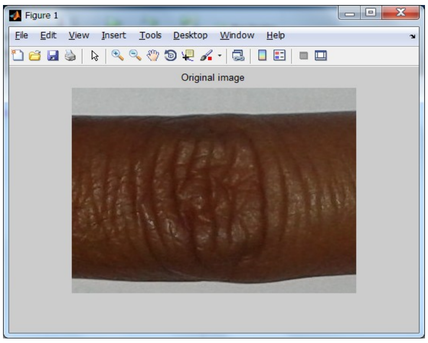


(c) Result Box

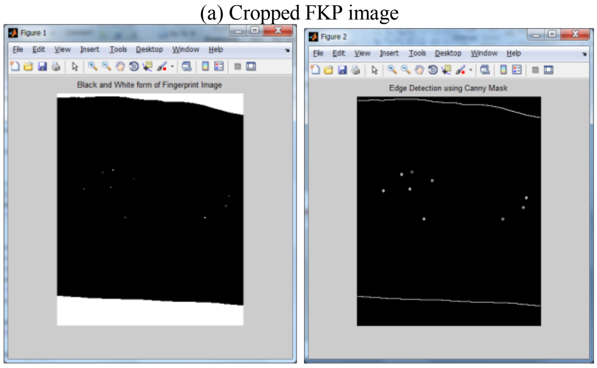
Fig. 12 Testing for user TZT's Left Middle Finger Image

In identification step, the user has to input the image for testing. Then the system will simulate and will show the identified person as shown in Fig. 12.

When FKP images of unknown persons are used to classify, all of them are resulted as unknown person as described in Fig. 13.



(a) Cropped FKP image



(b) Binary Image (c) Edge Detected Image

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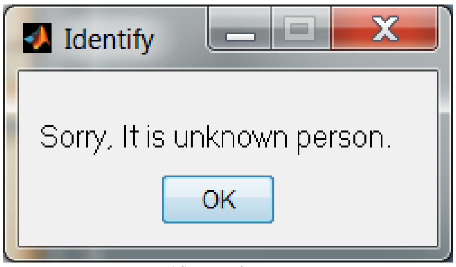

(d) Result Box

Fig. 13 Testing for unknown User's Finger Image

The extracted feature is 250 and the training time is 20.23s for 754 epochs with the performance error of 0.01. When 4 FKP images are trained, the time taken is only 2.2s for 367epochs with the performance error of 0.01. There are 20 FKP images are used in train data set, all of them can be classified after the Neural Network has trained. When 4 unknown fingerprints are used to classify, all of them are resulted as unknown fingerprint. The system can conclude that 100% correct for well trained fingerprint images. In feature vector extraction, the type of edge mask is one of the important roles in this system. The higher the feature extracted values, the better the accuracy with minimum time taken. The best extracted feature value is 300 and the minimum recommend value is100.

V. Conclusions

This system proposes contactless, cost effective and user friendly finger knuckle surface based biometric identifier for personal identification. Unlike other work, this approach uses single knuckle print image and no need to collect the large amount of knuckle images. It is efficient approach as it requires less computation and processing time. The developed system automatically extracts the knuckle texture and simultaneously acquires finger geometry features to reliably authenticate the users. Describe the finger knuckle feature extraction algorithm by using edge detection methods. How to create database by using neural network is also presented. Simulation results of feature extraction and identification system are illustrated. Based on the above methods, these methods need two images: test image and train image. Firstly, crop the test image and train image. The cropped images are changed to black and white image since edge detection can be done on black and white. Then the image has to be resized as the input images must be the same size. The feature extraction method is employed to extract the features. Canny Edge Detection method has been proposed under the feature extraction. After finishing feature extraction, the numbers of features are reduced by using the PCA method to compress the data of high dimension. For the train image, the extracted features are trained by using Neural Network. The features of test image and train image are compared by using Neural Network. Then the output will be displayed the user name or unknown.

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