Fuzzy-cellular neural network for face recognition
HCI Authentication

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Fuzzy-cellular neural network for face recognition HCI Authentication

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Abstract. Because of the rapid development of mobile devices technology, ease of use and interact with humans. May have found a mobile device most uses in our communications. Mobile devices can carry large amounts of personal and sensitive data, but often left not guaranteed (pin) locks are inconvenient to use and thus have seen low adoption while biometrics is more convenient and less susceptible to fraud and manipulation. Were propose in this paper authentication technique for using a mobile face recognition based on cellular neural networks [1] and fuzzy rules control. The good speed and get recognition rate from applied the proposed system in Android system. The images obtained in real time for 60 persons each person has 20 to 60 different shot face images (about 3600 images), were the results for (FAR =0), (FRR =1.66%), (FER =1.66) and accuracy =98.34. Keyword: HCI, HCI authentication, Face recognition, Cellular neural network, Fuzzy.

1.Introduction
Because of the great sophistication of computer technology, Human Computer Interaction (HCI) techniques have become an important component of our lives HCI Interested in the understanding between persons and the Machine [2]. Because of the increased use or spread of mobile devices, interaction between humans and computers has increased Such technologies include PDAs, handheld communicators, pocket music players, two-way pagers, cameras, watches smart, GPS units, medical and work devices, and smartphones.

Mobile devices are rapidly evolving technologies capable of give many services through a wide domain of apps through multiple networks such as the Internet (e.g. e-mail, online banking), amusement (e.g. photos and video games) and the Participation of data (via Bluetooth, laptops/ computers). The increase of functionalities presented by mobile devices enables persons to storage increasing amounts of broad ranging kinds of data from business to personal and sensitive data. and mobile users worry of their devices being missing or stolen. there are a types of security threats that can affect mobile devices. We divide these mobile threats into various types: application threats such as (Malware, Spyware, Privacy Threats and Vulnerable Applications), web threats such as (Phishing Scams, Drive-By Downloads, Browser exploits), network threats such as (Network exploits and Wi-Fi Sniffing) Physical Threats as smartphones are small and carry
with us almost anywhere, it is important to provide security [2]. The loss or theft of a device is one of the most prevalent mobile threats. The loss of a valuable mobile device was not as important as personal and sensitive information.

Biometrics technologies indicate to recognize individuals depended on their distinguishing biological or behavioral traits. These traits include face, speech, fingerprints, gait, hand-vein, retina, iris, palm-print, ear, and signature. Biometric security systems supply suitability and high stability to persons, it is needless to remember passwords or have physical tokens. Using face recognition for mobile authentication, their acceptable authentication execution and a reliable and user-friendly way are in high requesting for mobile devices. Some of the previous work in face recognition: Fast Face Recognition Based on Wavelet Transform on PCA [4] and using “Prabujeet Kaurl” User Authentication in Social Networking Sites using Face Recognition [5] and N.Rajkumar S.Vijayakumar C.Murukesh applied new face recognition method dependent on 2D Level 2 Wavelet decomposition, PCA with singular value decomposition, and Bayesian Classifier is suggested. The results were accurate (PCA, ICA and KPCA 77, 77 and 87) [6] in 2016 the Naveen S, Shihana Fathima R and Dr. R S Moni used features employed a form the whole face as well as the eye and nose expected to Local binary pattern (LBP) and Binarized Statistical Image Features (BSIF) are utilized to extract the texture features of the face for recognition and the results (BSIF Accuracy =84.90) and (LBP Accuracy = 47.84) [7]. In this paper we suggest co-authentication system, face recognition and using cellular neural network with fuzzy rules control.

2. Cellular Neural Network (CNN) Background

Standard CNNs, known as Chua-Yang models contains of a rectangular ZxF orders of identical-cells, describing by the states and outputs equations:

$$\frac{dx_i}{dt} = -x_{ij} + \sum_{j \in N_i} A(i,j;k,l)y_{jkl} + \sum_{k \in N_i} B(i,j;k,l)u_{kl}$$

Where \((u_{kl})\) inputs, \((x_{ij})\) the states, and \((y_{jkl})\) the cell output in position \((i,j)\), the \(k\) and \(l\) denoting a generics cell belongs to the neighborhood \(N(i,j)\) of the cell at position \((i,j)\). The matrices set and threshold \(\{A, B\}\), that contain the neural (or nonlinear) network weights, and call the cloning-template and defining the network processes execution. There are many advantages and disadvantages to the CNN model. The CNN model additional cells or neurons can be added to the network to extend the network. It can also perform tasks that a linear program cannot. When an element of the neural network fails, it can continue without any problem because of its parallel paradigm. Another advantage of the CNN model is that neural network can learn by adjusting its coupling strengths and does not need to be reprogrammed. It can also be implemented in any application without any problem [8].

3. Face Recognition Background

There are three steps for face recognition: Face Detection, Features Extraction, and Face Recognize 'Figure (1)' shows Face recognize steps. [9]

![Figure 1. Steps for face recognition: Face Detection, Features Extraction, and Face Recognize](image-url)
3.1. Face Detection
Face detection as a first stage for face recognitions the major function of this stage is to determine whether human faces show in a given picture. There are many face detection algorithm as Local Binary Pattern (LBP), features whereas Support Vector Machine (SVM), classifier is used with Histogram of Oriented Gradients (HOG).

3.2. Features extraction
The second step of face recognition is Process of extracting important information from a face picture. Features as (eyes, nose and mouth) [10].

3.3. Face match
Feature matching is the actual recognition operation. The feature vector features acquired from the features extraction is matched to person face picture register and stored in a database [11].

4. Chaos system
The Henon map is a prototypical two dimentional invertible repeat map with chaotic solutions suggest by the French astronomer Michel Henon [12]

\[ Wn + 1 = 1 + aWn2 + bTn \]
\[ Tn + 1 = wn \]

The second equation above can be written as \( Tn = Wn-1 \), the Henon map can be written in terms of a single variable with two time delays [13] :

\[ Wn+1 = 1 + aWn2 + bWn − 1 \]

5. The proposed Modified CNN With Chaos System (HCNN)
In this stage, the Modified Chaotic CNN was used to find optimal face recognition between face features in database and current entered face features. The proposed modifications are in two locations in CNN, the first modification in the outputs of CNN by adding Henon results to (CNN) for improving the making a decision. Second modification was used Henon chaos system in the learning feeding of the CNN in order to increase the learning speed and get acceptable results in stable case by avoiding angle deviation of face image. Also, to optimization the speeding of the learning and detection of case to find the optimal matching for two images face in face recognition system. Figure (2) shows the modification of CNN cells by adding Henon chaos system. The proposed modified CNN equation will be:

\[ \frac{dx}{dt} = -x_{ij} + \sum_{j \in N_i} A(i,j,k,l) + ch \cdot ykl + ch + \sum_{k \in N_i} B(i,j,k,l) ukl \]

Where the chaos is \( ch \) and:

\[ ch = Wn + 1 + aWn2 + bTn \]
6. The Proposed System

The main aim of the proposed system is to design the authentication system for (HCI), to get high-level identity management processes and a system that is easy and safe to use. The user can be authorize or rejected within a few seconds. The propose system is consists two main stages. First is the face recognition using (PCA) and second face recognition using Henon Cellular Neural Network (HCNN). This stage consists from three steps and named as: face-detection, features extraction, face recognitions and classifications. The flowchart of a face recognition proposed system is presented in Figure (3). The input images obtained from image acquisition devices e.g. Using a camera 2-megapixel and image size (256 * 256) might not be suitable for recognition due to noise or illumination conditions. first step preprocessing to remove noise and fix the illumination, in this stage using Canny edge detection, Canny edge was a multi-stage algorithm that can discover edges with noise at the same time. The two steps preprocessor and the edge detection were merged into one stage when using canny. The next stage-features extraction- includes obtaining important face features from the data. These features are face areas, difference, corner or measurement, (e.g. eyes spacing, Size and shape of nose and mouth) at this stage we were able to extract 70 secondary and primary advantage using the algorithm principal component analysis (PCA). The next is to classify and match features based on the stored face features in database. Second stage in proposed system is the modified cellular neural network by using chaos for face recognition. This modification (as shown in Figure 2) to the CNN is to increase the learning speed and accuracy of the recognition operation. These two steps of face recognition using (HCNN) work parallel to the image of the face, where the image enters the proposed system in parallel. One enters the system of face recognition and the other enters into the modified (HCNN) and the results goes to the fuzzy rules control and calculated the process where (HCNN) accelerate and corresponding improvement in decision-making. The Algorithm of proposed system is shows in algorithm (1):

**Algorithm (1) the proposed system Steps.**

**Input**: face image  
**Output**: ratio of identification  
Steps 1: initial camera  
Step2: capture image  
Step3: face detection (using canny filter)  
1: Smoothing removing noise by Gaussian filter with formula  
\[ g(m,n) = G_\sigma(m,n)*f(m,n) \]  
Where  
\[ G_\sigma = \frac{1}{\sqrt{2\pi\sigma^2}}e^{\exp(-\frac{m^2+n^2}{2\sigma^2})} \]
2: Compute gradient of $g(m, n)$ using any of the gradient operators with formula

$$M(n,n)=\sqrt{g_m^2(m,n) + g_n^2(m,n)}$$

And

$$\partial(m,n) = \tan^{-1}\left[\frac{g_n(m,n)}{g_m(m,n)}\right]$$

3: Threshold $M$ with formula

$$M_{T(m,n)} = \begin{cases} M(m,n) & \text{if } M(m,n) > T \\ 0 & \text{otherwise} \end{cases}$$

4: Suppress non-maxima pixels in the edges in MT

Step 4: features extraction using algorithm (PCA).

1: convert face image $(i*j)$ to vector $(v)$

2: find average by using Equation

$$AV = \frac{1}{M} \sum_{k=1}^{m} I_{n,k}$$

3: find differential distance by using Equation

$$U = I_{n} - AV$$

4: Find the covariance matrix by using Equation

$$SC = \frac{1}{M} \sum_{k=1}^{m} U_{n,k} U_{n,k}$$

5: selected highest eigenvalue

Step 5: Applying (HCNN) modify on result step 2

Step 6: applied Fuzzy rule control on result step 4 and step 5

Step 7: checking stage if ratio accepts then open screen and services

Else Not authentication

Step 8: end
After the matching operation the output will be a ratio for both HCNN and PCA face identification ratios. These values entered into fuzzy control the first step is to convert the matching value (x) into a group of fuzzy variables. This done by giving values to each of a group of membership functions. The values for each membership function f(x) are determined by the original value x and the shape of the membership. Now divide the corresponding ratios into the fuzzifier variables, where the percentages are between (1...45) low and Symbolizes them (LO), (40...70) medium and Symbolizes them (ME) and (60....90) high and Symbolizes them (HI). The proposed fuzzy rules used in this proposed system are:

If HCNN= LO and PCA=LO then flags=0
If HCNN=LO and PCA= ME then flags=0
If HCNN=ME and PCA=LO then flags=0
If HCNN= ME and PCA=ME then flags=1
If HCNN= ME PCA=HI then flags=1
If HCNN=HI and PCA=LO then flags=0
If HCNN=HI and FEPCA= ME then flags=1
If HCNN=HI and FEPCA=HI then flags=1

The Calculation Defuzzification is convert truth values into output from the following equation (6). The algorithm (2) shows steps of fuzzy control and decision making. [14]

\[
U = \frac{\sum_{i=1}^{N} u_i f_i}{\sum_{i=1}^{N} f_i}
\]

Algorithm (2): fuzzy control and decision making stage

| Input: (HCNN) ratio and (PCA) identifier ratio and similarity user face |
| Output: flag value |

Step1: start
Step2: check the similarity of user if no similarity then go to end authentication and display error message
Step3: converting a ratio of (HCNN) and (PCA ratio) into a fuzzy input using:
   - If ratio <= 45 then LO
   - Else If 45 <= ratio <= 70 then ME
   - Else If 70 <= ratio <= 90 then HI
Step4: applied fuzzy rule
Step5: convert truth values into output using Defuzzification operation
Step6: get flags results from step4 and step5
Step7: Compute decision based on the flag:
   - If flag =1 then
     - Accept the authentication and open the services and the screen
   - Else If flag =0 then
     - Shows message authentication Error
Step7: End.

7. Experimental Results
In this section, experimental results of the proposed methodology are presented. The algorithm has been implemented using android studio 2.2.2. figure (4) shows android studio. The database utilized for face recognition (the images were obtained in real time) comprises and content a 20 to 60 different shot face
images for each person (from 60 persons). The acquisition system for face image is samsung S5 device mobile. The recognition execution is calculate by means of FAR, FRR, FTE, and RR or accuracy. The FAR is the percent mistake of a system that accepts imposter as actual users while FRR is the percent mistake of a system that rejects real person as imposter FER. The Failure to Enroll average is the number of persons who fail in their tried at register and RR or accuracy is the recognition rate. These equations explain below, also calculate time detection and time match. Tables (1), (2) and (3) show results.

$$\text{FRR} = \frac{\text{Number of rejected of an authorized person}}{\text{Total number of attempts}} \times 100 \quad (7)$$

$$\text{FAR} = \frac{\text{Number of acceptance of an unauthorized person}}{\text{Total number of attempts}} \times 100 \quad (8)$$

$$\text{FER} = \frac{\text{Number of acceptance of an unauthorized person}}{\text{Total number of attempts}} \times 100 \quad (9)$$

The recognition rate RR=100$$\frac{\text{FER}+\text{FRR}}{2}$$ (10)

**Figure 4.** (a) shows android studio (b) shows genymotion

|               | PCA       | CNN       | PCA&CNN  |
|---------------|-----------|-----------|----------|
| FAR           | 0/20=0    | 0/20=0    | 0/20=0   |
| FRR           | 3/20=15%  | 2/20=10%  | 1/20=5%  |
| FER           | 2/20=10%  | 2/20=10%  | 1/20=5%  |
| ACCURACY      | 87        | 90        | 95       |

Table 1. Results for 20 Persons Face Recognition
Table 2. Results for 60 Persons Face Recognition

|               | PCA            | CNN            | PCA&CNN       |
|---------------|----------------|----------------|---------------|
| FAR           | 1/60=1.6%      | 0/60=0         | 0/60=0        |
| FRR           | 5/60=8.3%      | 3/60=5%        | 1/60=1.66%    |
| FER           | 4/60=6.66%     | 3/60=5%        | 1/60=1.66%    |
| ACCURACY      | 92.5           | 95             | 98.34         |

Table 3. The Proposed System Results and Time Computing.

| Class | Original image | Gaussian Smoothing | Canny Filter | Feature extraction | Detection time(HCNN) | Matching time |
|-------|----------------|--------------------|--------------|--------------------|----------------------|---------------|
| 1     | ![Image 1](image1.png) | ![Image 2](image2.png) | ![Image 3](image3.png) | ![Image 4](image4.png) | 690 ms              | 263 ms        |
| 2     | ![Image 5](image5.png) | ![Image 6](image6.png) | ![Image 7](image7.png) | ![Image 8](image8.png) | 699 ms              | 180 ms        |
| 3     | ![Image 9](image9.png) | ![Image 10](image10.png) | ![Image 11](image11.png) | ![Image 12](image12.png) | 768 ms              | 290 ms        |

8. Discussion

The proposed HCI Secure Authentication Technique that was developed to protect the users from threats and concerns related to the safety of their personal information. From the results, we obtained that the proposed system is very fast (about 0.0800 sec it's less than one second) in the process of detecting and face recognition. Also according to the results obtained through the implementation of the system on 60 people and each person (20 to 60) different situations, we note that the high speed of recognition with good performance. Where 2 images were rejected out of 6000 images due to high deviation of the image of the face. The use of the CNN of recognition led increasing speed of recognition of the system and according to
the results in the tables we notice the matching speed of 140 to 310 millisecond and the speed of detection was 500 to 900 milliseconds (Depending on lighting conditions and angle of face) less than one second. By integrating CNN with Henon and running in parallel with PCA we notice an increased speed learning algorithm and gave it the best results.

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