Personal identification system based on multi biometric depending on cuckoo search algorithm

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Abstract. In modern devices, many personal identification systems are used using various biometrics to confirm the identity of an individual and identify him for several purposes. Some of these essential biometrics are used in this paper to help identify a person while attaining social distance because of the widespread epidemics. The features of the face, eyes, nose, and finally, the features of the mouth are used in this article. The work begins by detecting the parts of multibiometric from the input images using Viola-Jones face detection algorithm with a modification to it then segment them. After that, various initial treatment processes begin which helps clarify them to facilitate subsequent operations. Also, a Histogram of oriented gradient method (HOG) is used to extract the significant features of those image segments. The extracted features from these segments are entered into the developed cuckoo search algorithm (DCSA), the best image segment within the used dataset is searched for similar in terms of characteristics to the entered image segment. The work has also been developed so that the system is executed on two cores using parallel processing technology to utilize the processor as much as possible and reduce the time it takes to implement the system and identify the person concerned. A high identification rate has been reached, reaching 99.25%, and overall speed up 1.40323 sec relative to serial execution.

Keywords: Multi biometric, Cuckoo Search Optimization Algorithm, Preprocessing, Viola-Jones Face Detection Algorithm, HOG, DCSA, Parallel Processing.

1. Introduction.
The emergence of some epidemic diseases such as the recently introduced Corona disease, which is transmitted rapidly through contact, has led to a reduction in the use of systems and techniques that are used to confirm the identity and which require touching the associated devices. Such as the use of fingerprints, palm prints, or even the use of live signatures, as these techniques were rapid methods of spreading diseases among people. Also, the need for social distancing has led most people to carry out their activities, work, and lessons through computer services and the Internet, which has increased the need for institutions and official departments to confirm the identity of the people who communicate with them. Therefore, experts have recently resorted to advocating the development and use of personal identification techniques that reduce contact between people by focusing on safer biometrics that have strong characteristics to distinguish people at the same time.

Multibiometric Systems mean systems that rely on multiple biometric characteristics are systems that use more than one physiological or behavioral characteristic for the same person[1], and the most striking biometric solution is facial identification[2].
In [3] the authors suggested a mapping technique for using deep convolutional neural recognition (DCNNs) networks consists of the proposed architecture for two branches of DCNNs to map the high and low-resolution face images, [4] build a deep neural network for deeply encoding the face regions, also [5],[6] built an application for facial recognition for a Convolutional Neural Networks Biometric Network-Based, while [2] a facial classification strategy was proposed using the support vector machine algorithm,[7] Propose a multi-biometric face recognition technique to extract deep features from various facial regions using multiple convolutional neural networks (CNNs). A system that uses KELM to identify normalized face images is proposed in [8] to compensate for the effects of light variations. In this paper, the clearest multi-biometric for digital camera capture, the simplest availability and the most accurate and recognizable for individuals were adopted. Where the work relied on using the characteristics of the face, eyes, nose, and mouth separately using modified Viola-Jones face detection algorithm, as these characteristics express the person clearly. Where the algorithm (Histogram of oriented gradient algorithm) is used in the process of extracting important characteristics, reducing the dimensions, and developing an algorithm (Cuckoo Search Algorithm CSA) one of the metaheuristic algorithms, to make the algorithm better in the process of searching for the ideal solution and reaching the desired goal. Also proposed an algorithm for the execution of work on 2 cores to achieve optimum utilization of the processor inside the computer and achieve a high speed of execution. So that the work aims to achieve the identification of people by using multiple biometric features with a high recognition rate and short execution time.

2. Traditional cuckoo search optimization algorithm:
It is an intelligent algorithm that is considered one of the metaheuristic algorithms for optimization and random searching, first introduced in 2009[9] that simulates the behavior of one of the cuckoo bird family types in finding the nest and raising the young. Where this bird searches for a suitable nest randomly from the nests of other birds to lay its eggs in it so that the owner of the nest does not suspect the host, and each egg from the original nest represents a solution, while the cuckoo’s egg represents a new solution[10].

3. Proposed work:
3.1. Creating dataset:
In the first stage of the system’s work, the original dataset is created, which consists of 180 diverse natural images for a large group of people. The number of models varies for each person, as some people have some changes in taking pictures, for example changing the state of the mouth (silence, laughing, taking out the tongue, changing movement The mouth is in a different direction.) Also, some changes may occur to the type and shape of the covering over the head. It may also change at times from the shape of the eyes by adding different medical glasses, as well as other changes such as the background and the distance from the camera. For this purpose, a smartphone camera is used, Also some standard datasets are used, some pictures can be seen in Figure 1.
3.2. Preprocessing:

To facilitate smooth implementation of the algorithm steps, the input images are preprocessed at this stage. These preprocessed include unifying the input image sizes for all images into a single size, then converting it from (RGB) color space images to gray-level color space images.

3.3. Detect the segments of the multibiometric for each facial image:

Here at this stage, the multibiometric segments are identified and cut from the original image separately and stored in a special matrix, which is done by using a detection algorithm based on the Viola-Jones face detection algorithm[11]. Besides, a special programmatic section was used to modify the algorithm, whereby the nose area is used to obtain the mouth area easily. After the nose is determined, the square of dimensions by which the nose was defined is shifted downwards to easily identify the mouth without making mistakes with a small amount of enlargement of those dimensions, this is because the nose area is stronger in the detection process with this algorithm, that will help to get the segments correctly while not allowing false possibilities or segments that are out of place. Whenever the square of the nose contour is shifted by the length of the nose of the person (the length of the vertical side of the square) while expanding the square by the width of the nose of the person (the length of the horizontal side of the square) to show us the square that correctly defines the mouth area of the person. The mechanism of action is thus shown in Figure 2. The method of detecting and segmenting an image from the images entered into the device is shown in figure 3.

Figure 2. Defining the mouth area by shifting and enlarging the square that determines the nose
3.4. Feature extraction:

The Feature extraction process was carried out using the Histogram of oriented gradient (HOG) method to obtain the best characteristics and features of each segment of multibiometric that belong to one of the images in the dataset. In most systems for recognizing objects or people, a strong set of extracted properties is relied upon. This method relies on studying edge descriptors based on gradation[12]. It uses a gradient of local intensity or distribution in the direction of the edge to describe an object's appearance. So effectively, HOG features will be resolving the issues of classification and identification systems[13]. First of all, HOG is calculated, usually by convolution, by finding the horizontal gradients and vertical gradients in the image. For both the horizontal direction and vertical direction, use the (One_Dimention) point discrete derivative mask for, which is (-1,0,1) in the horizontal direction and (-1,0,1) in the vertical direction. The value of the gradient can be calculated according to the value of each pixel in the image using the equation:

\[ G = \sqrt{g_y^2 + g_x^2} \]  

(1)

It is also possible to measure the angle of the gradient for each pixel of the image by using the equation:

\[ \theta = \arctan\left(\frac{g_y}{g_x}\right) \]  

(2)

Where \( g_y \) represents the result of the convolution in the vertical direction, while \( g_x \) represents the result of the convolution in the horizontal direction[14].

3.5. Developing Cuckoo search Algorithm (DCSA):

The process of extracting the previously mentioned traits was applied to each of the biometric segments that were segmented from all the images, whether in the dataset or entered into the system, which were later used as inputs to the cuckoo search algorithm, and this represents a hybridization of the algorithm so that it deals with the extracted properties and not with the images and segments directly. The goal of the basic search optimized cuckoo algorithm is to replace the bad (solution) individuals with the good individuals in the nest. This is done by using the fitness function [10],[15]. Therefore, the algorithm has been developed to suit the work in searching for the optimal solution, which represents the best match of the properties of the biometric segments with the corresponding segments in the dataset. Therefore, the Euclidean distance equation was used as a function of fitness for all individuals or solutions available in each generation which is can be defined as the following equation:[16][17]

\[ D(x,y) = \sqrt{(x_1 - y_1)^2 + (x_2 - y_2)^2} \]  

(3)
Where $D$ is the distance between $x$ which has $(x_1, x_2)$ coordinates, and $y$ which has $(y_1, y_2)$ point. Thus, the pseudo-code of the DCSA algorithm can be written as follows in figure 4[18][19], where: $s$ is the solution(egg), $m$ is the nests, $pr$ the probability of egg laid by a cuckoo is discovered by host bird with $pr \in [0, 1]$, $D$ is the fitness value which calculated by equation 3.

![Figure 4. DCSA Algorithm Pseudo Code](image)

3.6. **Parallel Processing Method:**
Parallel processing implies faster execution of the program by breaking the main program into several components and running simultaneously as each component operates on a separate processor or kernel[20][21]. The program is divided into two separate parts, so that each part is executed on a different core in the processor, to implement this method I used: (Intel ® Core TM i5-7200U, CPU @ 2.50GHZ 2.70GHZ) computer, Windows10 Processor OS. figure 5 represents a system execution by using two cores(kernels) which are called workers in MATLAB programming language.
Figure 5. Flowchart of the Parallel Processing Method

Start

Master

Read Input Images

Preprocessing Images

Dataset

Worker 1

Face Detection
Feature Extraction
Implement DCSA algorithm and Keep the best solution(sol1)

Mouth Detection
Feature Extraction
Implement DCSA algorithm and Keep the best solution(sol2)

Worker 2

Eyes Detection
Feature Extraction
Implement DCSA algorithm and Keep the best solution(sol3)

Nose Detection
Feature Extraction
Implement DCSA algorithm and Keep the best solution(sol4)

If [[sol1 or sol2] = (sol3 or sol4)]

Master

End

Result

Figure 5. Flowchart of the Parallel Processing Method
Where the Master responsible for:

a. It provides the possibility of choosing the method used in the implementation and works to prepare the work environment as a whole in the case of parallel implementation.
b. Calling the necessary functions for parallel execution.
c. Process the input image as preliminary processing and then pass it on to the workers later.
d. Open parallel environment.
e. Preparing the workers and giving each worker his data and functions that it will work on.
f. Close the parallel environment.
g. Collecting and arranging the results and examining the solutions obtained to find the best.
h. Output results.

While the worker will responsible for:

a. Receive the data the worker needs from the master, including the target image that he wants to identify.
b. Implementation of the feature extracting method and developed cuckoo algorithm and searching for the best solution for two types of the biometric segment.
c. Return the best solutions to the master.

4. Measures Used To Calculate System Results:

To calculate the results obtained after implementing the developed algorithm and applying the aforementioned work steps, a set of important measures are used. These measures are divided into two main types, one that calculates the results of the system’s accuracy in identifying people through its biometric characteristics and the success of the proposed algorithm for that purpose. As for the second type, it is concerned with measuring the speed and efficiency obtained from the implementation of the proposed algorithm in identifying people after implementing it in a parallel manner. The first type includes two measures, so The following measures can be used to calculate the identification results:

1) Identification Rate IR = \( \frac{\text{Number of sample correctly identified}}{\text{Total number of images}} \) * 100

Which represents the percentage of the number of people who have been identified in the system successfully, and the higher the value of this scale, the stronger the system will be in identifying people.

2) Wrong Identification Rate (WIR) = \( \frac{\text{Number of images identified error}}{\text{Total number of images}} \) * 100

Which represents the percentage of the number of people who have been not identified in the system, and the lower value of this scale, the stronger the system will be in identifying people.

As for the second type, as seen in the following two equations, the measure of the increasing speed and the measure of the increase in the efficiency was used to prove the efficiency and performance of the system.

1) Speed Up = \( \frac{\text{The execution time of serial execution (one core) in second}}{\text{The execution time on n cores (in second)}} \)

This scale represents the acceleration factor of the system when we use parallel processing, which helps increase the execution speed of the intelligent system and depends on the execution time spent. Whenever the output value of this equation is greater than 1, the system is considered to be better in terms of execution speed.
2) Speed up Efficiency = \frac{\text{Speed Up}}{c} \quad (7)

The measure of increased efficiency depends on the scale of the acceleration factor, and that \( c \) represents the number of cores used in the execution. In terms of speed-up efficiency, the greater value of the output for this equation, the system is considered better.

5. Results and Analysis.

Practical experiments were conducted and the system was tested in identifying images of people in two ways (parallel execution and sequential execution). The input images were identified by finding the best solutions in recognizing the face, eyes, nose, and mouth, which represent the multibiometric for each image of a person. The result is calculated in favor of the image of the optimal solution that emerged from the implementation of the algorithm of cuckoos developed four times each time for a specific type of multibiometric and the detection of the solution closest to it. If the solutions returned from the four algorithms (DCSA algorithm for face identification, DCSA algorithm for mouth identification, DCSA algorithm for nose identification, DCSA algorithm for eyes identification) do not match, then the facial recognition solution with the mouth recognition solution is considered and must match with the nose recognition solution with the eye recognition dependent solution. This is because the biometric characteristics of the face and the nose are stronger than the biometric characteristics of the eyes and mouth. This is due to the possibility that the person will wear eyeglasses, use colored lenses, or make some striking movements of the mouth that cause the inability to recognize them.

Table 1 shows the most important results obtained from implementing the system on 180 images. We note from the results of the table that the strongest biometric characteristics are the facial and nose characteristics due to the lack of their changes even with changing the headcover sometimes, where the face and nose biometric identification ratio was 100%. It also appears that the IR of biometric for the eyes is 98.6% which is stronger than the biometric for the mouth that the IR of it is 98.4%, that is because the addition of glass glasses does not affect the results to a large extent as it affects moving the mouth or opening and closing it. Also, notice that the use of two cores to implement the system is much faster 1.40323 times compares to serial execution, as well as the efficiency of the system has achieved high efficiency estimated at 0.701615, which is considered to be very good even though the parallel execution needs to do a lot of additional executive operations that are not needed by the sequential execution. Figure 5 shows the implementation of the system as an example and the results with the data information of the person. Table 2 demonstrates a comparison of the recognition results using previously used algorithms with the proposed algorithm DCSA.
Table 1. Results of the system execution

| No. | Type of Multibiometric | Type of Execution          | IR | WIR | Speed Up times (in seconds) | Speed Up Efficiency |
|-----|------------------------|----------------------------|----|-----|-----------------------------|---------------------|
| 1   | Face                   | Serial Execution           | 100| 0.0 | 1                           | 1                   |
| 2   | Nose                   | Serial Execution           | 100| 0.0 | 1                           | 1                   |
| 3   | Eyes                   | Serial Execution           | 98.6| 1.4| 1                           | 1                   |
| 4   | Mouth                  | Serial Execution           | 98.4| 1.6| 1                           | 1                   |
| 5   | Face                   | Parallel Execution Using 2 cores | 100| 0.0 | 1.40323                    | 0.701615            |
| 6   | Nose                   | Parallel Execution Using 2 cores | 100| 0.0 | 1.40323                    | 0.701615            |
| 7   | Eyes                   | Parallel Execution Using 2 cores | 98.6| 1.4| 1.40323                    | 0.701615            |
| 8   | Mouth                  | Parallel Execution Using 2 cores | 98.4| 1.6| 1.40323                    | 0.701615            |
|     | Total                  |                            | 99.25| 0.75 | 1.40323                    | 0.701615            |

Figure 6. Example of system execution
Table 2. A comparison between Algorithms (among works)

| No. | Algorithm                                      | Biometric Type   | Recognition Rate        |
|-----|-----------------------------------------------|------------------|-------------------------|
| 1   | Two-Branch Deep Convolutional Neural Network Architecture[3] | Face             | 80.8% to 98.8%          |
| 2   | deep neural networks [4]                      | Face             | 98.52%                  |
| 3   | Convolutional Neural Networks [5]             | Face             | 98.75%                  |
| 4   | Convolutional Neural Network (CNN)[6]         | Face             | 98.75                   |
| 5   | support vector machine[2]                     | Face             | 94% to 99%              |
| 6   | deep learning[7]                              | Face, Nose, Eyes, Mouth | 93.77% to 97.94       |
| 7   | light variations [8]                          | Face             | 98.89%                  |
| 8   | Proposed Algorithm (DCSA)                     | Face, Nose, Eyes, Mouth | 99.25                  |

6. Conclusion and future work.

The adoption of the developed cuckoo search algorithm along with the trait extraction algorithm used in the Persons identification system has proven its worth in reducing the possible solutions and reaching the optimal solution at a high speed. Also, the adoption of multiple biometrics has given power in identifying people while achieving social distancing, so a person who relies on this type of system does not need to touch devices for this purpose. Although the camera used to take pictures is a non-fixed camera, so the total IR reached 99.25, which is an excellent value in personal identification ratio. This can be seen by observing the outcome of identification obtained in Table 1, and the comparison made with other algorithms shown in Table 2. The great results that have been achieved give high confidence in using the system with established verification systems in institutions and official departments. Also, the use of parallel execution has given importance to this kind of exploitation of available computer capabilities, which helps in developing systems specialized in identifying people quickly where the speed up reached 1.40323 times compares to serial execution and the Speed Up Efficiency 0.701615 which is high.

As future work, we can develop the work to include another type of biometric in addition to the one used in the research. Also, additional other algorithms can be used in the trait extraction process to reduce the possibility of error such as PCA, LDA, etc. Also, with the increase in the number of dataset images, more than two cores can be used in the execution of the system to increase the utilization of the processor and ensure the utilization of the time spent.

Some limitations may appear in this algorithm, which is not identifying a specific area of the biometric areas used by the method, and this may be due to the lack of clarity of the taken image or to the rapid movement of the person during the capture, which distorts the image completely, or to some external environmental influences that affect the clarity of the image such as the presence of blur on the lens or taking the photo in a relatively dark place, etc., which negatively affects the identification results.
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