Face Recognition using the LCS algorithm

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Abstract: Today, the topic of human identification based on physical characteristics is a necessity in various fields. As a biometric system, a facial recognition system is fundamentally a pattern recognition system that identifies a person based on specific physiological or behavioral feature vectors. The feature vector is typically stored in a database upon extraction. The main objective of this research is to study and assess the effect of selecting the proper image attributes using the Cuckoo search algorithm. Thus, the selection of an optimal subset, given the large size of the feature vector dimensions to expedite the facial recognition algorithm is essential and substantial. Initially, by using the existing database, image characteristics are extracted and selected as a binary optimal subset of facial features using the Cuckoo algorithm. This subset of optimal features are evaluated by classifying nearest neighbor and neural networks. By calculating the accuracy of this classification, it is clear that the proposed method is of higher accuracy compared to previous methods in facial recognition based on the selection of significant features by the proposed algorithm.

Keywords: Facial Recognition, Cuckoo Algorithm, Feature Extraction, Feature Selection

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1. Introduction

The identification of humans from one another is based on a series of characteristics that are unique to each individual and differ from person to person. Today, identifying individuals based on physical features is a necessity in various fields. In this regard, recent advancements in the field of imaging technology have given way to the development of biometric systems. These systems are able to extract required identification data and compare them with reference data to show if the claimed identity is matched. Various identifiers are used for identification including fingers, hands, feet, face, eyes, ears, teeth, veins, sounds, signature and typing style, walking style, etc. Identification is an act that humans carry out routinely and daily in their lives with high precision. The ever-increasing public access to computers, mobile phones and smart systems has given significant attention to automated processors on images including identification, human-computer interaction, and multimedia management. Researches and developments on facial recognition is also underway for the same reason.

Over time, facial recognition techniques have been developed and pursue different goals based on the type of facial recognition application. In some applications, being online is of higher importance and identification speed is prioritized whereas in other cases the accuracy of identification is more important. In general, these techniques aim to increase the speed and accuracy of identification.

Facial recognition has advantages over other biometric systems such as finger print recognition. Along with the naturalness and inextensibility of this method, the most significant advantage of facial recognition is that the face can be covered at any distance. From six biometric characteristics presented by Heimeyer, facial features have the highest compatibility in MRTD (Machine Readable Travel Documents) systems. Facial recognition has played a vital role in photographic devices, memory storage containing high amounts of images, and increased security as one of the most powerful biometric technologies.

2. History of facial recognition systems

Today, the need for systems that protect privacy without losing individuals' identities is vital. Although in the world today, passwords are used for ATMs, computers, various software, internet accessibility etc. but with technological advancements, biometric methods including fingerprints, iris scans, handwriting, facial recognition etc. are introduced to enhance security. In these methods

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such as fingerprints or handwriting, direct individual cooperation is required (touching the sensor correctly), while the facial recognition system can be applied without individuals' cooperation [1]. In previous FRT based systems, static and controlled images were utilized for facial recognition which included a wide range of technical challenges regarding image processing, pattern analysis, and pattern detection. The use of static images or videos for this method created challenges in terms of image quality, background clutter (issues in algorithm classification), image variety from a particular person, matching criteria and image nature.

Taking video images from a particular scene, identifying or approving the identity of one of more people on the scene using a stored face database is a possibility. Existing information such as race, age, gender, facial expression and speech are included in automated facial recognition which limit the search (increased recognition) [2].

The upgraded solution consists of dividing faces from cluttered scenes, extracting features from facial areas, recognition and subsequent verification. Regarding identification issues, the system input is an unknown face, and the system extracts the individual's identity from a database and then the verification system attempts to confirm or reject the face in question. [3]

Understanding and processing images is an important and typical part of human perception, while developing a similar computer system is still under research. The first facial recognition researches were carried out in 1954 with a psychological viewpoint by Taguir, in 1964 with an engineering viewpoint by Bledsoe, in 1972 with a sentimental viewpoint by Darwin and in 1988 with a profile-based biometric viewpoint by Galton.

Automated facial recognition research began in 1970 and has been a major research field by neuroscientists (understanding the face as a dedicated process, a general process or local features analysis) and engineers over the past 47 years.

Pattern categorization methods in the 1970s included measured features such as the distance between significant facial points and facial characteristics. Throughout the 1980s, facial recognition studies remained largely obscured. In the early 1990s, research in the FRT area significantly increased and many theories presented by researchers were replaced by small sets of images based on mathematical and engineering theories. Limited data was formulated for facial recognition and two dimensional images were extracted from three dimensional objects. Light, brightness, and angles are significant image based issues regarding this extraction.

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During the past 15 years, further research has focused on facial feature extraction methods such as eyes, mouth etc. for automated facial recognition. During this period, facial recognition classification methods including the comprehensive appearance method (eigenfaces) and feature-based graph matching (Fisherfaces) have been more successful.

The feature-based method is less sensitive to changes in light in comparison with the comprehensive method but did not determine the exact location of the face. Nevertheless, the feature extraction method is not reliable and not accurate enough such that many techniques for determining the position of the eye did not function correctly when assuming geometric and textured models for the eye when the eye is closed. [4]

The static images issue has inherent advantages and disadvantages. In applications such as driving licenses, considering the controlled nature of the image acquisition method, the segmentation issue is relatively simple. However, in locations such as the airport, a static image of a particular facial scene may include serious challenges for the classification algorithm. On the other hand, if a video sequence is available, the segmentation of an individual on the move can easily be performed using motion as a sign. Small sizes and lower quality of captured facial images from videos can significantly solve identification issues. Therefore, during the past 5 to 8 years, considerable research has focused on video based facial recognition. In 1995, a review article on FORT was presented by Chellappa. At that time, video based facial recognition was in its infancy. During the past 8 years, more attention has been paid to facial recognition in terms of technical advancements. Many of the facial recognition business systems are still available.

Recently, significant research efforts have focused on modelling, tracking, identifying and integrating systems for video based facial recognition. A new set of data has been presented and recognition methods have been evaluated using this data. It is not an exaggeration to state that facial recognition has turned into an active application in pattern detection, image analysis and understanding. [5]

In 2001, Charles Nelson carried out psychological and experimental methods for facial recognition on newborns and attempted to estimate newborns' future appearances. [6]

Previously mentioned methods produce a descriptive vector by combining rows and columns of images, and then use a map (linear-nonlinear) and decrease the dimensions of an appropriate space to express faces. Subsequently, the tensor algebra method was introduced as tensor faces by Vasilesko et al. in 2003 following Pentland's name.

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In 2007, Javad Naghi et al. studied facial recognition using MATLAB and neural networks which resulted in increased processing speed and facial recognition with fewer computations. [7]

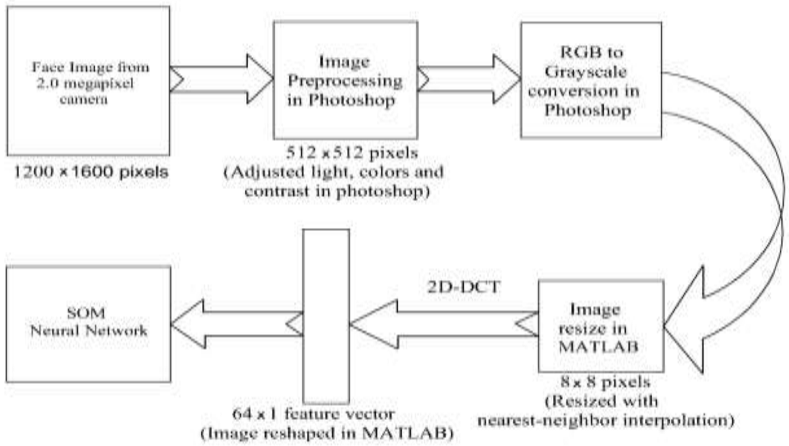

Figure 1: using MATLAB for faster processing [7]

In recent years, suitable problem solving tools i.e. evolutionary algorithms such as genetic algorithms (GA), particle swarm optimization (PSO) and imperialist competitive algorithms (ICA) have been utilized in pattern recognition and feature selection. In 2016, Pratib Sakhi, Sunny Behal and Pritbala Singh improved facial recognition algorithms as compared to principle component analysis (PCA) and linear discriminant analysis (LDA) using genetic algorithms. [8].

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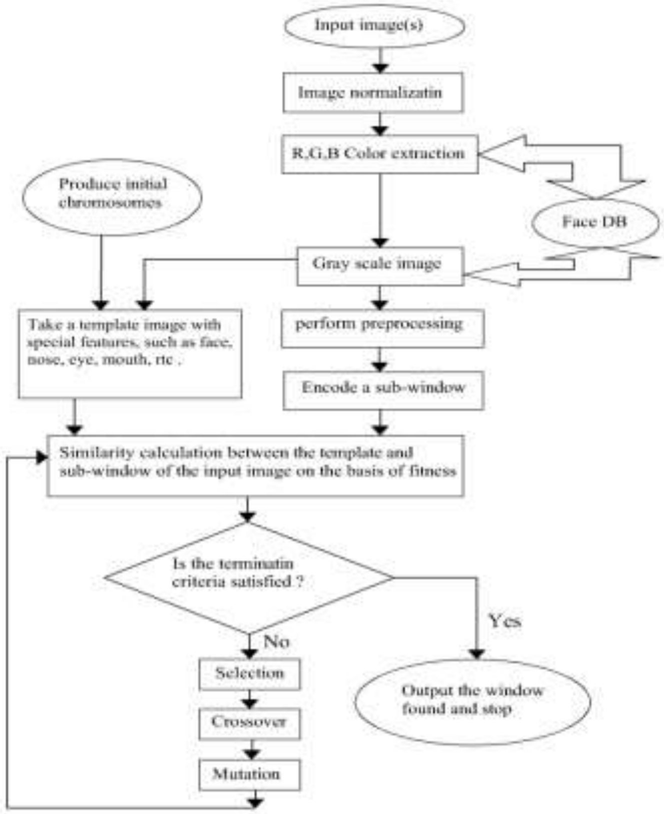

Figure 2: improved facial recognition using genetic algorithm [8]

In 2017, even with vast advancements in facial recognition, shifts in lighting was still a challenging issue. Gianni Hu et al. utilized the LNFF method to prevent facial changes in different lighting. This method is based on information from the variable database (in terms of appearance and brightness) and is intended to produce frontal images. [9]

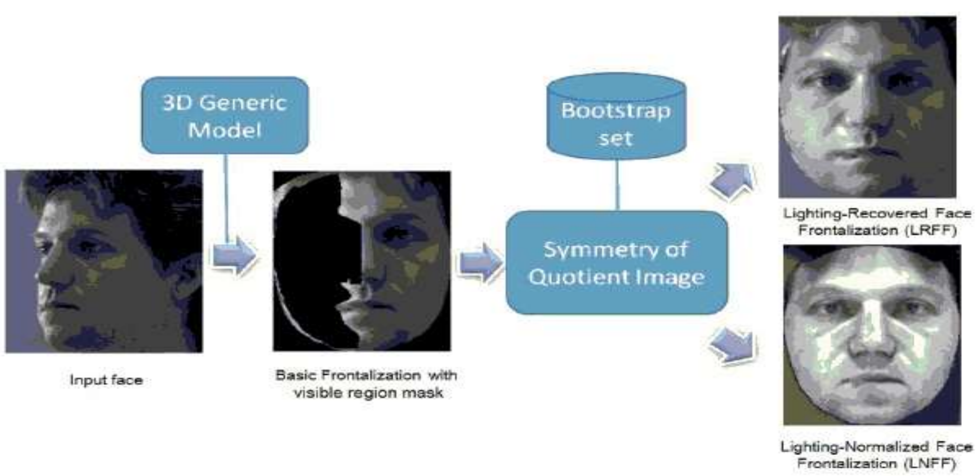

Figure 3: reducing the effect of light on facial images using LNFF [9]

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Subsequently, Chian Lewah, Chao Wangha and Xiao Yang Ying solved the problem of identifying colored faces in 2017 by extracting color information and nonlinear features. The key to this is to extract comprehensive color information and efficient troubleshooting features. In this paper, a new nonlinear feature extraction approach for color facial recognition named dual iterative core analysis (DMDA) has been proposed. [10]

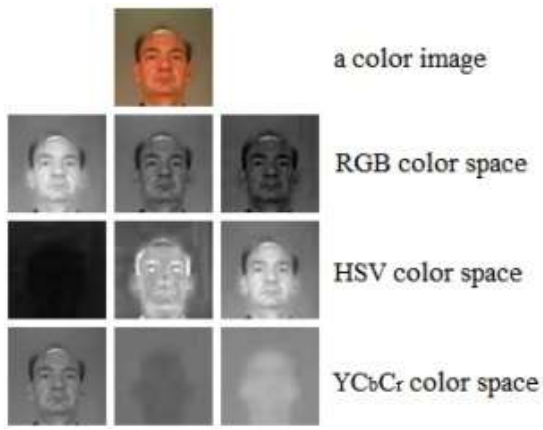

Figure 4: color information extraction for facial recognition

In 2017, Ramirez Donoso, Caesar San Martin, Gabrielle Hermosaulus, utilized long wavelength infrared (LWIR) bands for facial recognition through thermal multidimensional imaging, which created new concepts for facial recognition. This method consists of a feature vector for each individual which is a type of unique thermal effect that depends on the heat release of the individual's skin and its temperature. [11]

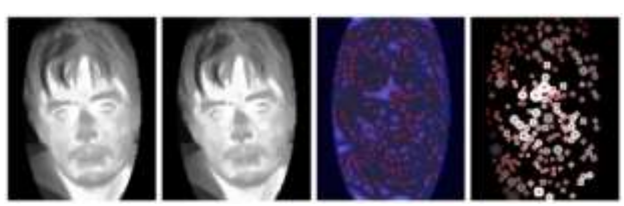

Figure 5: facial recognition using thermal imaging

In 2017, Lingradora et al. were able to significantly reduce the complexity and response time by presenting their new facial recognition method based on Gabor Kernel. In this method, the (PSO-GSA) search algorithm is used to optimize the single-Gabor parameters in order to optimize the

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gravitational-hybrid particles. In addition, this method is compatible with optimization filters and can increase efficiency. [12]

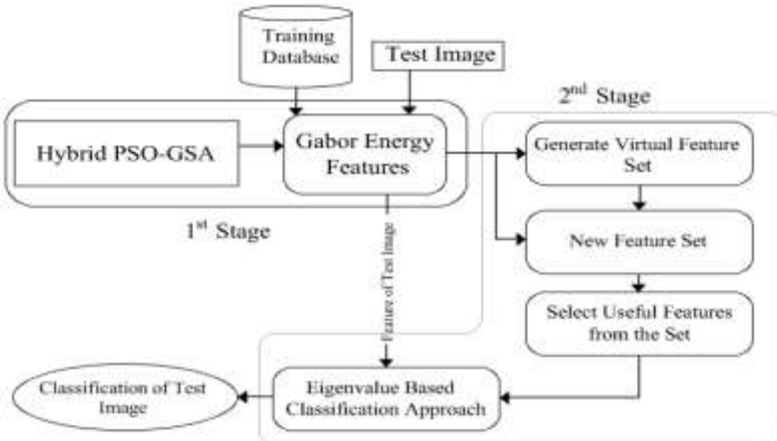

Figure 6: facial recognition based on Gabor Kernel

Chingching Ding et al. presented a paper in 2017 in which they identify a person's unusual facial traits (PIFR) and manage identification challenges. [13]

The table below compares facial recognition systems from 2001 to 2017.

Table 1: facial recognition models comparison

Year	Title	Author	Technology used	Advantages	Disadvantages
2001	The Development and Neural Bases of Face Recognition	Charles A. Nelson	psychology and experimental methods	facial recognition for newborns	facial recognition inability for adults
2007	A MATLAB based Face Recognition System using Image Processing and Neural Networks	Jawad Nagi, Syed Khaleel Ahmed, Farrukh Nagi	neural networks	high processing speed and ability, low computational requirements	inefficient in self-organizing
2016	Face Recognition System Using Genetic Algorithm	Pratibha Sukhija, Sunny Behal , Pritpal Singh	Genetic Algorithm	improved recognition algorithm compared to PCA-LDA algorithms	low accuracy

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2017	Lighting-aware face frontalization for unconstrained face recognition	Weihong Deng, Jiani Hu , Zhongjun Wu , Jun Guo	LRFF	improved production of images exposed to light, independent of database	does not work in intense light
2017	Dual multi-kernel discriminant analysis for color face recognition	Qian Liua, , Chao Wanga, Xiao-yuan Jing	linear method	facial recognition in color images, high processing speed	inefficiencies in black and white images
2017	Reduced isothermal feature set for long wave infrared (LWIR) face recognition	Ramiro Donoso , Cesar San Martín , Gabriel Hermosilla	multidimensional images and infrared bands	recognition of thermal images via isothermal attributes, low-cost, does not require external source for reflection	undesirable changes due to changes in ambient temperature, individuals' metabolic processes and sensitivity to cameras
2017	An evolutionary single Gabor kernel based filter approach to face recognition	Dora, Lingraj Sanjay Agrawal, Rutuparna Panda , Ajith Abraham	PSO-GSA search algorithm	reduced complexity and response time	Requires optimized filters for improved design and performance
2017	Pose-invariant face recognition with homography-based normalization	Changxing Ding, Dacheng Tao	PFIR invariable facial recognition homography	facial recognition with variable gestures and lighting	requires a precise 3D face model, high computational cost

3. Facial recognition system

Facial recognition is the system's first step, and reliability in this section has a major impact on performance and the use of the automated facial recognition system. If an image or video clip is inputted to an ideal facial recognition system, it should be able to search and recognize faces regardless of position, size, scale, angle, direction, age and state. Additionally, recognition should take place regardless of external lighting conditions and image/video content.

A facial recognition system can be involved as a biometric system in both "face detection" and "face recognition" modes. Face detection is a one-to-one matching operation that compares the questioned face with the recorded identity-proven face image. The applications of this mode include identity authentication regarding immigration and e-passport matters.

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Facial recognition is a one-to-many matching process where the questioned face is compared to several selected faces. In some applications of this mode, only one similar face is required to be found. For example, in a monitoring system or watch list it is required to find more than just similar faces. In such applications, by defining a level of reliability, all facial images with similarity scores above the defined level are reported. Facial recognition can take place using skin color (for faces in color images and video clips), motion (for faces in videos), head and face shape, facial expression, accessories such as spectacles, hats etc. or a combination of these parameters. Based on such parameters, facial recognition applications can be categorized into "scenarios where users cooperate with the system" and "scenarios where users do not cooperate with the system".

In this case, the recorded image or video clip of a scene is compared using a database of faces and additional information (such as age, gender, etc. to reduce search dimensions and enhance recognition authenticity) to identify and then confirm the identity of one of more persons on the recorded scene.

However, the most successful facial recognition algorithm is one that only utilizes the facial appearance and when an input image is scanned using a subpage in all locations and scales. Categorizing the template in this subpage as faces or non-faces takes place through educational data and using statistical learning methods for facial identification.

3-1. The process of the facial recognition system

Facial recognition is a visual issue in the statistical field in which a face is identified as a 3D object in various conditions of light, orientation, mode and other parameters. In general, a facial recognition system consists of four modules; face-localization, normalization, feature extraction and matching, as shown in figure 7.

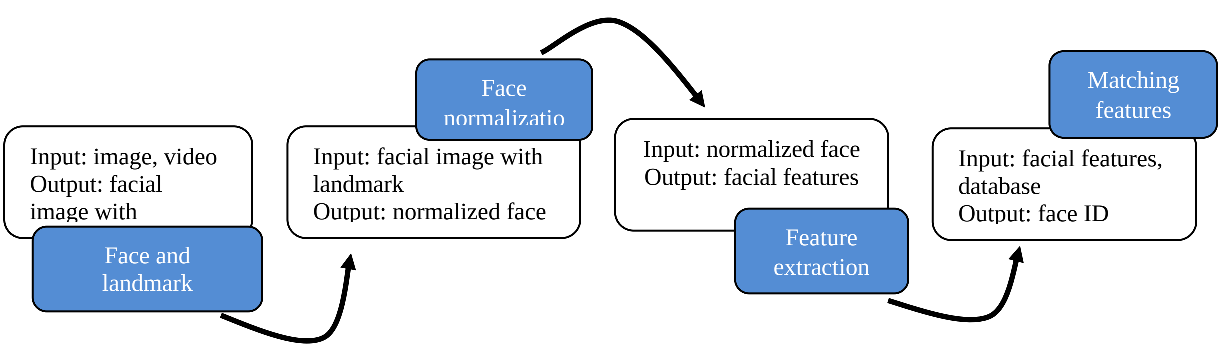

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Figure 7: the process of the facial recognition system

3-2. Features of facial recognition systems

Facial recognition systems are popular among users. The reason for this is that the user can generally be unaware of the system and there is no need for direct interaction with the system. For example, for retina analysis, the user must be placed behind the eye examination machine to carry out the analysis. This is not the case with facial recognition where at any moment, even without the user's awareness, cameras can take pictures.

Also, it can be noted for its availability. This means that it still functions when no specific biological property (such as an eye in a blind person or a disabled person's fingerprint) exists. Another example of the face's higher reliability is in comparison with identification through odor which the user can deliberately or inadvertently cover using perfume. In the case of the iris, which can be traced from meters away, the user may use sunglasses or advanced lenses to cover, but again this issue is of less importance in facial recognition where the operation is not disrupted. (In a more general case, in a database training sample, a person can be in different states such as with sunglasses, beard, moustache etc. but the system will not be disrupted). This system will not remain constant as with fingerprints such that the shape, size, and facial areas such as skin will change in time though this issue can be resolved by sampling at certain intervals.

Another advantage of this system is its potential to counter fraud. Under normal circumstances and in daily life, a person can easily change appearance using makeup and may not be identified by other people. This is not the case when attempting to deceive a device. However, this does not mean that the device can definitely identify anyone who has changed their appearance but the error rate is much lower compared to that of an individual. One of the disadvantages of this system, in contrast to the fingerprint template that is fully recognizable, is its lack of uniqueness. This does not mean that two different individuals are 100% similar since there are still slight differences (such as with twins or father and son). The issue of the inability to accurately identify all facial patterns decreases the performance of this criterion compared to other methods. Consequently, due

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to the constraints described and the highest degree of compatibility among all criteria, facial recognition is one of the most applicable, popular and up-to-date identification systems available.

3-3. Issues concerning facial recognition systems

Overall, there are many issues and challenges regarding facial recognition systems. For example, there may be a need for facial recognition where an image has been recorded with a low quality camera or in an environment with lack of appropriate lighting which has been transferred via the internet. A suitable facial recognition system should have total response capability for these matters.

3-3-1. Lighting issues in facial recognition

As shown in figure 8, even the same images may seem different due to changes in light and different optical conditions may affect the difference between two individuals in recognition.

Figure 8: an example of the lighting issue

To solve the lighting issue, the following solutions are proposed:

- Exploratory views
- Class-based views
- Image comparison views
- Model based views

3-3-2. Issues of different image angles in facial recognition

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This issue is illustrated in figure 9 where the same images are presented in different angles. When images have different angles, facial recognition becomes an arduous task. In order to solve this issue, the following solutions are proposed:

- Multiple views based on multiple images
- Image comparison views
- Combined views
- Model based views

Figure 9: example of the different angles issue

In more realistic circumstances, there may be a combination of the mentioned issues.

3-4. Face based facial recognition methods

By utilizing methods based on facial appearance, facial recognition is considered as a matter categorized under the scanned subpage to one of the face and non-face classes. In appearance based methods, assuming that different facial expressions are in different conditions, the difficulty of modelling three dimensional structures of faces is avoided to a great extent. The face/non-face categorization can be taught through a set of examples that include faces (under various conditions) and examples of non-faces.

Figure 10: top ten images of faces and bottom ten images of non-faces

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Classifications are highly operational since the pixels of a face image are heavily interdependent while this is not the case in non-face images. Nevertheless, vast changes in facial appearance, lighting and various facial expressions have greatly complicated face/non-face borders. Furthermore, changes in face direction adds to this complexity. Since the speed of a resolution is of great importance, a strict nonlinear classification is required to deal with this complexity. Since 1920, many studies have taken place regarding the development of such complex structures and many improvements have been made. For example, a facial recognition system has been proposed based on the analysis of the main axes (PCA) or on the basis of a specific facial display.

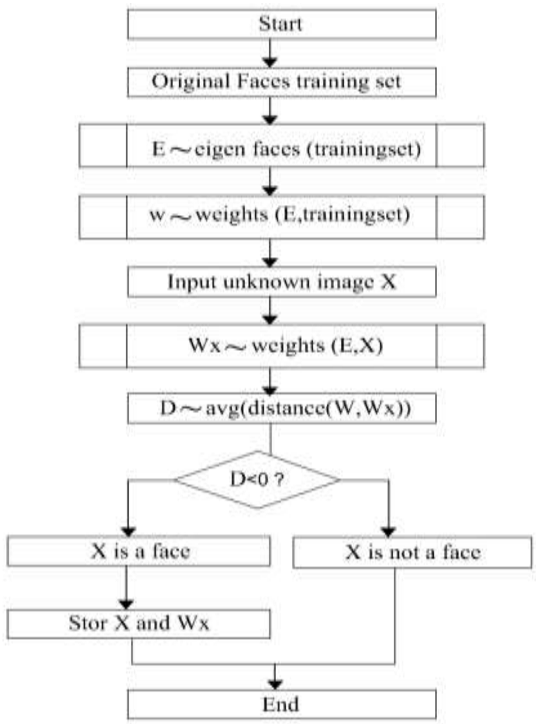

Figure 11: facial recognition based on main axis analysis (PCA)

Since only likelihood is considered in the PCA subcategory base version, other likelihood studies are considered in the orthogonal complementary domain. By utilizing such system, likelihood in the image space (community of two sub frames) is modeled using the multiplication of two estimates and provides a more accurate estimate for facial recognition. In another method, first the space image is split into several face and non-face clusters, and then each cluster is decomposed into the PCA subclass and empty substrate. Finally, the Bayesian estimate is applied to obtain useful statistical characteristics. An example of other methods is the use of connected neural networks. Using a slider window, the input image is examined after passing a pre-processing step.

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As another solution, a nonlinear backup vector device can be modified to distinguish and categorize facial patterns and non-facial patterns, or a sparse network learning structure of windows can be utilized for facial recognition. In these systems, a bootstrap algorithm is used repetitively to accumulate face images from non-face images.

3-5. Facial features extraction methods

In recent years, various methods have been assessed for extracting vital and effective features for facial recognition. These methods are divided into three main categories.

Appearance features: these include the axis of facial components such as eyes, nose, rings, tissues and various areas of the face. There are many limitations in extracting these features from images.

Algebraic features: each image can be considered as a matrix such that various algebraic and mathematical transformations may be applied. Algebraic properties are the result of a process and generally indicate the intrinsic properties of an image. Basic component analysis (PCA conversion) is one of the important operations carried out on the image matrix. This conversion is one of the significant methods for extracting algebraic properties of the face image, which is based on the specific covariance matrix vectors. The matrix-specific vectors express the algebraic distribution of the matrix and geometric constants which can be used to extract image features. Other algebraic methods include SVD parsing. It is clear that the analysis of single matrix values is one of the most effective methods for matrix image feature extraction. Single parsing is also used in noise signal compression and processing.

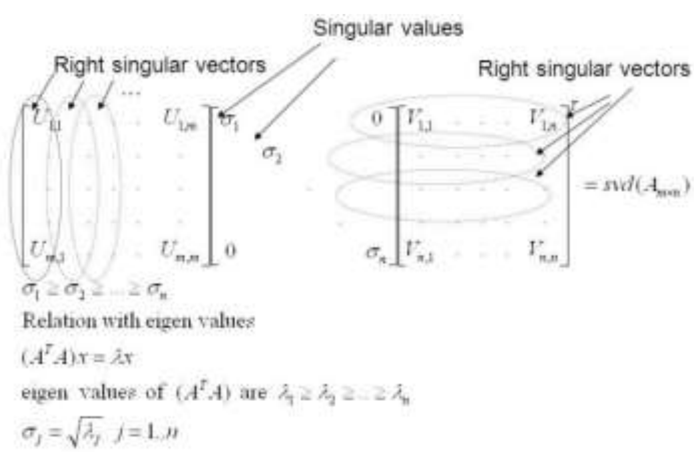

Figure 12: facial features extraction using SVD (Singular Value Decomposition)

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Image statistical features: considering that images are two dimensional and by regarding image points as statistical data, statistical features can be used to describe images. In this method, features that are capable enough to describe the image are used. Such information is both rich and stable. One of the most important statistical methods is the use of top level self- dependence method. Extracted image features are considered as vectors. If the extracted vectors are great in dimension, these dimensions must be decreased to improve classification and separation of classes.

3-6. Heuristic based facial recognition methods

The development of the science of optimization is based on the desire of humans to achieve perfection. Humans want to visualize and achieve the best. But since humans are not able to fully understand all the conditions governing the best, in most cases, instead of the ideal answer or absolute optimality, they will be content with a satisfying answer. For this reason, several approaches have been proposed for designing acceptable quality responses under acceptable time constraints. Algorithms that can guarantee appropriate responses at a certain distance from optimal responses which are called approximate algorithms. There are other algorithms that guarantee a near optimal response which are called probability algorithms. Apart from these two categories, it is possible to adopt algorithms that have no guarantee in providing responses, but based on the evidence and records of their results, they have, on average, the highest quality/time contrast for solving issues under consideration. These algorithms are called heuristic algorithms. Heuristics include criteria, methods, or principles for deciding between multiple choices and the most effective choices to achieve desired goals. In general, three categories of heuristic algorithms can be distinguished:

- Algorithms that focus on the structural features and structures of responses and use them to define constructive algorithms and local searches.
- Algorithms that focus on the heuristic guidance of a constructive algorithm and can overcome sensitive conditions (such as avoiding the local optimum). These algorithms are called metaheuristic algorithms.
- Algorithms that focus on a combination of a heuristic concept or framework with types of mathematical programming (typically accurate methods).

Type one heuristics can function very well (sometimes optimal). However, they may have issues when it comes to low quality responses. As previously mentioned, one of the major issues that

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these algorithms face is falling into local optimizations without a chance of avoidance. To improve these algorithms, a new wave of approaches were introduced in the mid-seventies. These approaches include algorithms that explicitly or implicitly manage search variations (when there are signs of poor search areas) and search intensification (with the aim of finding the best response in the area under consideration). These are metaheuristic algorithms. These algorithms include prohibited search, genetic algorithms, annealing simulation, particle swarm algorithm, ant colony algorithm, firefly algorithm, colonial competitive algorithm, harmonic search algorithm, cuckoo optimization algorithm etc.

Following the colonial competitive algorithm, a new method called the cuckoo optimization algorithm, which has the potential of finding the optimal overall points has been formed. This algorithm is one the newest and most powerful evolutionary optimization methods introduced so far. The cuckoo algorithm is inspired by the cuckoo bird's way of life which was developed by Xin-she Yang and Suash Deb in 2009. The cuckoo algorithm is based on a type of cuckoo's lifestyle. This algorithm has been developed by Levy with a simple random isotropic variable. The cuckoo algorithm was later explored in more detail by Ramin Rajabiun in 2011. In order to become familiarized, it is best to get acquainted with the lifestyle and behavior of this bird. All 9000 bird species in the world have the same method of motherhood where they lay eggs. Birds do not give birth to their offspring, they lay eggs, and nurture their chicks once they're born. The larger the eggs, the less likely it is that a female bird can hold more than one egg at a given time since larger eggs will require more energy and cause difficulties in flying. On the other hand, since eggs are a rich source of protein for other predators, birds need to provide a safe place for chicks to be born and bred. Finding a safe haven for chicks and raising them until they are independent is an important issue that each bird has cleverly solved. They have incorporated a type of sophisticated and artistically engineered method. Nesting diversity and architecture are unique among all creatures. Most birds create their nests in separate, unidentified, and inert vegetation to prevent identification by predators. Some of them hide their nests so skillfully that even humans, with all their visual equipment, are not able to observe and identify them. Meanwhile, some birds have freed themselves from the trouble of nesting and parenting, and have instead, utilized shrewd methods. These birds deemed "brood parasites", never nest for themselves, and instead, place their eggs in the nest of other bird species while waiting for these birds to tend to their eggs alongside their own.

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Since the cuckoo habitat has to provide local food sources (especially insects) for laying eggs, the main concern for brood parasites is the host habitat. Cuckoos are found in a wide range of habitats. Most species inhabit forests, especially in the ever-warmer rainforest. In addition to forest, some cuckoo species choose a wider range of habitats that include arid and desert regions. Immigrant species with cuckoo-friendly temperature select a wide range of habitats (from canebrake to areas devoid of trees) to take full advantage of host birds. Most cuckoo species are non-immigrants but there are several species that have seasonal migrations. There are also species that have periodic migration in their habitat domain. Immigration may take place during the day as with channel-billed cuckoos, or during the night as with yellow-billed cuckoos. For cuckoos that live in highlands, access to food is a requirement in order to migrate to tropical regions in the winter. Long-tailed Koel cuckoos live and lay eggs in New Zealand and migrate to Polynesia, Micronesia and Melanesia during the winter. Yellow-billed and Black-billed species that live and procreate in North America, travel non-stop for about 4000 kilometers over the Caribbean Sea. Other long-term migrations include Lesser cuckoos that fly from India to Kenya (about 3000 kilometers) over the Indian Ocean. In Africa, there are 10 types of cuckoo-polarized intra-continental migrations, which they spend seasons when they are not procreating in the continent's tropical areas and migrate to the north and south areas of the continent (with dry and arid pastures) to lay eggs. There are about 56 old and 3 new brood parasite cuckoo species that place their eggs in the nests of other birds. These are compulsory brood parasites since this is the only way they can procreate.

Cuckoo chicks grow out of eggs earlier than host chicks and develop at a faster rate. In most cases, cuckoo chicks throw host eggs or host chicks out of the nest. This is completely instinctive since cuckoo birds do not have the opportunity to learn such behavior. The cuckoo chick forces the host bird to prepare its food and demands food on a regular basis. The cuckoo bird declares its need for food to the host bird by opening its mouth. A chick's open mouth is an indication of hunger for the mother. Female cuckoos are highly skilled in the production of eggs similar to that of host birds. This is a matter of natural selection. Although, some birds are able to identify such eggs and throw them out of the nest. Parasitoid cuckoos are divided into groups and each group specializes on a particular host bird. It has been proved that each expert group of cuckoos is genetically different from other groups. The expertise on the host is improving and evolving for the need of duplicating the eggs of the host bird.

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Facial recognition systems have been studied by researchers for many years and many algorithms have been presented. In these systems, with increased images databases, issues such as memory deficiencies and low processing speed arise. To overcome such issues, in recent years, several investigations have been proposed in the field of feature selection, which include cuckoo search algorithms (COA), ant colony optimization (ACO), genetic algorithm (GA), particle swarm optimization (PSO), and imperialist competitive algorithm (ICA). These algorithms utilize repeated replication and the experience of previous iterations to achieve optimal response [14].

There are three hypothesis to form the mathematical model of the cuckoo algorithm (CA). The first hypothesis of the host nest is constant. The second hypothesis is that each one randomly selects an egg at a time in a host nest. In the third hypothesis, the best nest with high quality eggs is transferred to subsequent generations.

The current search domain for the cuckoo X_i (t) for i = 1, 2. . . . (N), in time (t) is presented as $X_i = \left(x_i^1, x_i^2, \dots, x_i^d\right)$ for the d-dimension. Thus, the next solution for X_i (t + 1) in time t+1 can be presented as:

$$X_i(t+1) = X_i(t) + \alpha \oplus Levy\ (\lambda) \quad (1)$$

Where the magnitude of step α will create problems in the search dimension, 0 < α, will typically be 1, ⊕ is the input sign, and the Levy (λ) parameter is a random variable with approximation $Levy \sim u = t^{-\lambda}$ and$1 < \lambda < 3$. Other methods of calculating the Levy parameter include the Mantegna algorithm as shown below: [15]

$$Levy = \frac{u}{|v|^{1/(\lambda-1)}} \quad (2)$$

The distribution of all these variables forms a large dimensional space called the Levy space. Since parameters such as the number of cuckoos, the probability of release, the maximum number of eggs laid by cuckoos in a lifetime are initialized by the user, the longevity parameter t (tMAX as maximum longevity) in the d-dimensional for the cuckoo algorithm in time is as follows:

$$x_i^d(t=1) = rand \times (Upper^d - Lower^d) + Lower^d \quad (3)$$

Here, $Lower^d$ and $Upper^d$ are minimum and maximum dimensional searches in feature d, where u and v are normal distribution.

The quasi-code of the Cuckoo algorithm (CS), with randomization i in the search dimension $X_i(t=1) = \left(x_i^1, x_i^2, \dots, x_i^d\right)$ in the d-dimension for i= 1, 2 . . . (N) is as follows.

Do {

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Take the Levy flight for ith cuckoo, and evaluate the fitness f_i for X_i

Then choose a nest 'j' randomly from all the nests, evaluate the fitness f_j for X_j

if ($f_i > f_j$),

Then replace X_i with X_j for minimization problem, or replace X_j with X_i for maximization problem.

End

D. Then the worst nests are abandoned with a probability (pa) and the new one is built

E. t = t + 1.

} while ($t < (t_{MAX} + 1)$) or stop the criterion reached.

4. Upgraded cuckoo algorithm (LCS)

The main objective of this research is to study the advanced search learning algorithm (LCS) in order to compensate speed and memory deficiencies by reducing sampling size and search dimensions from "search patterns" and "learning for face recognition". The search pattern, which is a cognizant global search method, is inspired by the lifestyle of the cuckoo bird. As with other evolutionary algorithms, the COA starts with a primitive population consisting of birds. These bird population has a number of eggs that will be hosted in the nests of host birds. The eggs that are similar to the host eggs will have a greater chance of growing and turning into adult cuckoos while other eggs are identified and eradicated by the host bird (pa∈ [0, 1]). The number of grown eggs is an indication of the suitability of nests in that area and the largest number of saved eggs which is the parameter that the COA intends to optimize. [16, 17]

The cuckoo search algorithm (CS) is a search learning algorithm, which typically uses Levy distribution to explore the search space and seeks to distribute it. The aim of this research is to carry out a cuckoo search without utilizing Levy distribution. Cuckoo's standard search algorithm for controlling step size in the iterative process is devoid of a mechanical algorithm that can control the algorithm to reach minimum or maximum global values. Here, the goal is to add a step size commensurate with the nest in the search space at the current time. [17]

Since the parameter α is a constant, it is ignored at this stage. Therefore, in the cuckoo matched algorithm, the step size is given below:

$$step_i(t+1) = \left(\frac{1}{t}\right)^{\left|\left(best f_i(t) / \left(best f(t) - worst f(t)\right)\right)\right|} \quad (4)$$

In this formula, best f (t) is the best value at cuckoo search time t and worst f (t) is the worst value at time t.

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The step size is initially high, but the number of generations increases, its size decreases. This suggests that once the algorithm reaches a desirable global solution, the size of the step is very small. Equation (4) shows that step size is consistent with nature. Hence, the LCS search algorithm is modeled as follows:

$$X_i(t+1) = X_i(t) + randn \times step_i(t+1) \quad (5)$$

This equation offers an entirely new search space for the LCS algorithm. Another benefit of this method is that no initial parameters have been defined. This algorithm is faster than the cuckoo search algorithm (CS), and if the step size is considered to be commensurate with the best global process, equation (5) is modeled as follows:

$$X_i(t+1) = X_i(t) + randn \times step_i(t+1) \times \left(X_i(t) - X_{gbest}\right) \quad (6)$$

X_{gbest} is the best global solution between all x_i values for i=1, 2, . . .N at time t. Here equations (4) and (6) are optimized for higher processing speed.

For the quasi-code of the cuckoo search learning algorithm (LCS), the number of host nests (N) for i= 1, 2 . . . N and d-dimension at the objective function f (x) is set randomly. The objective function of the host nests f (x_i) for i = 1, 2 … N are set initially at t=1.

Do {

Find the bestf and worstf of the current generation among the host nests.

Calculate the step size using Eq. (4).

Then calculate the new position of Cuckoo nests using Eq. (6).

Evaluate the objective function of the host nests f (X_i) for i = 1, 2. . . N.

Then chose a nest among N (say j) randomly.

If (f_i> f_j)

Then replace X_i with X_j for minimization problem, or replace X_j with X_i for maximization problem.

End

F. Then the worst nests are abandoned with a probability (pa) and new one is built.

G. t = t + 1.

} while (t ⇐ t_{MAX}) or End criterion not satisfied.

Results are evaluated and the best solution with relevant ranking is reported.

5. Conclusion

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In this paper, a complete report of the background and changes made to identify faces from non-faces in images is presented. There are three stages in facial recognition (FR); face normalization and extraction, features selection and recognition. Facial features extraction methods are divided into three general categories. Appearance features consisting of facial features such as eyes, nose, rings, tissues and areas of the face. Algebraic features, where each image can be considered as a matrix so algebraic and mathematical operations can be applied. These features are the result of such process and generally indicate intrinsic properties of an image. The statistical properties of an image can be obtained from statistical data points to describe the image since the image is two dimensional and its points are considered statistical data.

A new method for selecting a subset of facial features using the cuckoo algorithm is proposed. Using a matrix from the output of this algorithm on face images and transforming them into a feature vector, the dataset of the cuckoo algorithm is prepared. This dataset is considered the input of the cuckoo algorithm which includes the sample, features, and class labels for each image. Also, in the cuckoo search algorithm (CS), there is no mechanical algorithm to control the algorithm to achieve minimum or maximum global values. In this proposed search learning algorithm (LCS), the focus is on the selection of features. Once the algorithm achieves a desirable global solution, the step size is very small. The algorithm is improved due to its evolutionary nature and the iterations are reduced. Thus, by minimizing the feature dimensions and preserving a set of specific and key features, processing speed is accelerated and the amount of occupied space is reduced. Results indicate that the proposed method has higher accuracy compared to other methods.

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