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Modified PCA with Genetic Algorithm for Age Invariant Face Recognition

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Abstract*:* Security systems based on traditional techniques are more prone to be attacked by hackers and, such major attacks exposed weakness in most sophisticated security systems. A number of supervision agencies are now more motivated to improve security based on body or behavioral uniqueness, often called biometrics. Face recognition is non-intrusive since it is based on images recorded by a distant camera and can be very effective even if the user is not aware of the existence of the face recognition system. Automatic face recognition is a challenging problem in the field of Pattern Recognition and image processing due to its varying nature. It has wide range of applications such as law enforcement, national identity, banking, and logical access control. In this research paper a modification of an existing technique (PCA) will be discussed to improve the efficiency of face recognition. In Principal Component Analysis (PCA) Technique face images are represented as vectors by concatenating the pixels of the image line-by-line. A mean face is calculated by computing the average of each vector. A difference vector is also computed for each user to qualify the differences to the mean face. Than a covariance matrix of the difference vectors is computed. As a final step, principal axes are obtained by Eigen decomposition of covariance matrix. First N eigenvectors presenting the highest Eigen values will be retained and represents the most significant features of face images. Finally, each user model is represented as a linear combination (weighted sum) of coefficients corresponding to each Eigen faces. PCA is performed only for training the system, due to which this method results to be very fast when testing new face images. Due to this property PCA is selected for this work as modification will take place during training phase.

Keywords: AFR, PCA, Face Recognition, Genetic Algorithm, Age Invariant.

I. INTRODUCTION

Face recognition is one of the most important biometric which seems to be a good compromise between actuality and social reception and balances security along with well privacy. Also it has a variety of potential applications in information security, law enforcement, and access controls. More efforts have been devoted to face recognition because of the availability of commodity cameras and deployment opportunities in many security scenarios. However, face recognition is susceptible to a variety of factors encountered in practice, such as pose and lighting variations, expression variations, age variations, and facial occlusions.

Pose Variation: Pose variation is one of the major sources of performance degradation in face recognition. The face is a 3D object that appears different depending on which direction the face is imaged. Thus, it is possible that images taken at two different viewpoints of the same subject (intra-user variation) may appear more different than two images taken from the same view point for two different subjects (inter-user variation).

Lighting Variation: It has been shown that the difference in face images of the same person due to severe lighting variation can be more significant than the difference in face images of different persons. Since the face is a 3D object, different lighting sources can generate various illumination conditions and shadings. A lot of studies has been done to develop invariant facial features that are robust against lighting variations, and to learn and compensate for the lighting variations using prior knowledge of lighting sources based on training data. These methods provide visually enhanced face images after lighting normalization and show improved recognition accuracy of up to 100%.

Occlusion: Face images often appear occluded by other objects or by the face itself (i.e., self-occlusion), especially in surveillance videos. Most of the commercial face recognition engines reject an input image when the eyes cannot be detected. Local feature based methods are proposed to overcome the occlusion problem.

Expression: Facial expression is an internal variation that causes large intra-class variation. There are some local feature based approaches and 3D model based approaches designed to handle the expression problem. On the other hand, the recognition of facial expressions is an active research area in human computer interaction and communications.

Age Variation: The effect of aging on face recognition performance has not been substantially studied. There are a number of reasons that explain the lack of studies on aging effects:

- Ageing is one of the most critical factors degrading face recognition performance.

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- Template update can be used as an easy work-around for aging variation.
- There has been no public domain database for studying aging until recently.

Aging related changes on the face appear in a number of different ways:
(i) Wrinkles and speckles,
(ii) weight loss and gain, and
(iii) Change in shape of face primitives (e.g., sagged eyes, cheeks, or mouth).

All these aging related variations degrade face recognition performance. These variations could be learned and artificially introduced or removed in a face image to improve face recognition performance. Even though it is possible to update the template images as the subject ages, template updating is not always possible in cases of missing child, screening, and multiple enrolment problems where subjects are either not available or purposely trying to hide their identity. Therefore, facial aging has become an important research problem in face recognition. In this work a modified PCA based recognition has been proposed for template update to overcome the global variations from age variation.

II. RELATED WORK

From literature it is found that human face recognition is an ongoing area of research since last five decades. Most of the work has been carried out by using statistical features, geometrical features, color, facial expression, pose and aging. Most of the face recognition studies that have addressed the aging problem are focused on age estimation or age simulation. Designing an appropriate feature representation and an effective matching framework for age invariant face recognition still remains an open problem. The algorithms used by many researchers for face recognition are PCA, LDA, Eigen space-based adaptive (EP), Elastic bunch graph matching, 3-D morph able model, kernel method and so on. It is also found that the most of the work which was focused on aging used the PCA algorithm [26].

The aging pattern of an individual depends on a variety of different factors that are difficult to model in a computational framework. But humans are quite good at matching faces across age progression [7]. This may mean that irrespective of the exact manner in which a person ages, there is a coherency in the way facial appearance changes with age. This motivates us to capture and utilize this coherency to recognize age-separated faces. Specifically, we analyze the coherency of the drifts in various facial features to verify whether two age-separated images belong to the same individual or not [12]. We use approach to match the facial features across two images in order to evaluate the displacement. Since facial features are not specific to human faces, it does not always locate all the facial features. Also appearance changes like weight gain/loss will affect the facial features. For different image pairs, different number of features at different locations may be extracted. Moreover, since the displacement of features depend on the underlying facial muscle structure; this information may be used to obtain a better measure of drift coherency. Also, measures to capture textural variations with aging may be useful for matching age-separated images in adults [26].

III. GENETIC ALGORITHM

A genetic algorithm [10] is a heuristic technique used to solve optimization problems. Optimization problems attempt to find the best solution for a given problem that has several parameters with associated constraints. The most basic tools for solving optimization problems are complete enumeration of all possible choices, calculus, and linear optimization techniques using the simplex algorithm. The steps that are performed in Genetic Algorithm for optimization of database are as follows.

1. **Create Initial Population** - The GA selects an initial chromosome population of a specified size randomly. In other words, it fills in the input variables randomly with acceptable values. A full set of input variables is a chromosome, and it makes as many of these as you specify. For example, if the user has requested 20 population members in the problem definition, they are created by assigning random values to genes, based on the range set when the genes were defined. This provides an initial group of 20 population members for generation 0.
2. **Decode the Chromosome** - The GA then evaluates the 'fitness' of each chromosome by finding out how well it meets the fitness function. That is, how optimal an answer does this set of input values produce?
3. **Order the Chromosomes** - At the beginning of each generation, the population members are evaluated and then ordered according to their fitness.
4. **Choose Which Chromosomes will Mate** - In order for crossover to occur, we must pair two population members so that genes can be exchanged. Mate selection is carried out using evolutionary principles. That is, members with the best fitness are given a higher likelihood of mating, which increases the chances of superior offspring. Mate selection is accomplished by using a "graduated" roulette wheel.
5. **Perform Crossover** - Once a member of the population and its mate have been chosen, it must be determined which genes will be exchanged. This is done by randomly selecting two "cut points" in the string of genes. Genes in between the two cut points will be swapped between the population member and its selected mate.
6. **Store Offspring** - Each member of the original population will be given a chance to mate according to the "roulette" selection outlined above. This will result in a new population which is the same size as the original population.
7. **Mutate Selected Chromosomes** - After the new population has been created, randomly selected members of the population will undergo mutation based on the settings made by the user. For a random mutation, the GA randomly selects the population members to undergo mutation according to a specified

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mutation probability. The GA then randomly selects the genes which will be mutated according to the specified probability. Next, each gene selected will be calculated; it is either added to or subtracted from the original gene. The new value of the gene is checked to make sure that it does not go outside the specified range.

8. **Replace parts of population with superior mutations and superior prior generation members –** The fitness for each member will be recalculated after all the genes have been mutated. The population members are then ordered according to their fitness. The best members of the old population may be added to the new population in some algorithms, unless the best members of the old population are not as good as the worst members of the new population. A genetic algorithm that keeps one or more of the best members from each generation is said to incorporate "elitism". This keeps the best members of the population from getting worse from one generation to the next, and insures that the fitness of the best member can only improve or stay the same. It also gives the "elite", highest-fitness individual's further opportunities to produce offspring in subsequent generations.
9. **Create new generation -** Once this has been done, the population is ready to create another generation. The population will cycle through generations until the Exit Condition is met.

IV. PRINCIPAL COMPONENT ANALYSIS

Principal component analysis (PCA) was invented in 1901 by Karl Pearson. PCA is a variable reduction procedure and useful when obtained data have some redundancy. This will result into reduction of variables into smaller number of variables which are called Principal Components which will account for the most of the variance in the observed variable. It is a useful statistical technique that is used in fields such as face recognition and image compression, and is a common technique for finding patterns in data of high dimension. It is a dimensionality-reduction technique that is often used to transform a high-dimensional dataset into a smaller-dimensional subspace prior to running a machine learning algorithm on the data. It is a way of identifying patterns in data, and expressing the data in such a way as to highlight their similarities and differences. Since patterns in data can be hard to find in data of high dimension, where the luxury of graphical representation is not available, PCA is a powerful tool for analysing data. The major advantage of PCA [15] is using it in Eigen face approach which helps in reducing the size of the database for recognition of a test images. The images are stored as their feature vectors in the database which are found out projecting each and every trained image to the set of Eigen faces obtained. PCA is applied on Eigen face approach to reduce the dimensionality of a large data set.

Eigen Face [2] Approach is adequate and efficient method to be used in face recognition due to its simplicity, speed and learning capability. Eigen faces are a set of Eigen vectors used in the Computer Vision problem of human face recognition. They refer to an appearance based approach to face recognition that seeks to capture the variation in a collection of face images and use this information to encode and compare images of individual faces in a systematic manner. The Eigen faces are Principal Components of a distribution of faces, or equivalently, the Eigen vectors of the covariance matrix of the set of the face images, where an image with N by N pixels is considered a point in N^2 dimensional space. Previous work on face recognition ignored the issue of face stimulus, assuming that predefined measurement were relevant and sufficient. This suggests that coding and decoding of face images may give information of face images emphasizing the significance of features. These features may or may not be related to facial features such as eyes, nose, lips and hairs. We want to extract the relevant information in a face image, encode it efficiently and compare one face encoding with a database of faces encoded similarly. A simple approach to extracting the information content in an image of a face is to somehow capture the variation in a collection of face images. We wish to find Principal Components of the distribution of faces, or the Eigen vectors of the covariance matrix of the set of face images. Each image location contributes to each Eigen vector, so that we can display the Eigen vector as a sort of face. Each face image can be represented exactly in terms of linear combination of the Eigen faces. The number of possible Eigen faces is equal to the number of face image in the training set. The faces can also be approximated by using best Eigen face, those that have the largest Eigen values, and which therefore account for most variance between the set of face images. The primary reason for using fewer Eigen faces is computational efficiency.

V. METHODOLOGY

The proposed model consists of two major stages of processing the image. The two phases are verification phase and updation phase. Verification phase is some what existing technology where the image are acquired from a live camera or taken from some other source. After acquiring the image pre-processing is done for removal of noise. This pre-processed image is then used by feature extraction phase followed by a verification phase. These phases will be discussed in next section. The updation phase is the key of proposed model where the database is periodically updated on the basis of existing information and current information using genetic algorithm. Figure 1 shows the basic block diagram of proposed methodology of age invariant face recognition. The whole diagram is divided into two blocks. The verification block situated at right side and the updation block on the left side.

Training: In PCA Technique face images are represented as vectors by concatenating the pixels of the image line-by-line. A mean face is calculated by computing the average of each vector. A difference vector is also computed for each user to qualify the differences to the mean face. Than a covariance matrix of the difference vectors is computed. As a final step, principal axes are obtained by Eigen decomposition of covariance matrix.

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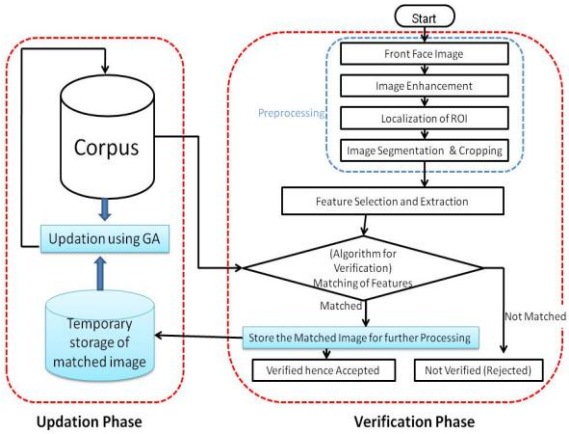

Figure 1: flow diagram showing the proposed methodology.

First N eigenvectors presenting the highest Eigen values will be retained and represents the most significant features of face images. Finally, each user model is represented as a linear combination (weighted sum) of coefficients corresponding to each Eigen faces. PCA is performed only for training the system, due to which this method results to be very fast when testing new face images. Due to this property PCA is selected for this work as modification will take place during training phase.

A. VERIFICATION PHASE: Let's discuss the verification phase first. In The current scenario a trained database is used for verification purpose. It starts with acquiring a front face image from a live video. This module will continuously monitor the live video for any human face and will get a still image as soon a front face appears. This still image is then pre-processed i.e. image enhancement, localization of region of interest, image segmentation and cropping. After pre-processing Eigen vectors are calculated from the given image. PCA is going to be used for this work therefore in feature extraction phase Eigen vectors are identified. These Eigen vectors are then compared with the vectors available in database for verification. A difference vector is calculated for user data available in database with test image, and if difference vector is less than threshold value then the test image is accepted (verified) else rejected. For the proposed model the verified test images (Eigen vectors) along with associated information are stored in a temporary database for further processing.

B. UPDATION PHASE: The complexity of this phase is much higher than the verification phase. It is basically responsible for time to time updation of Eigen vectors and hence database so to replace the unused outdated data with fresh information. This phase will came into existence periodically like at night or once in a weak, or even once in a year which depends on the frequency of verification of a single user. In this updation phase the concept of genetic algorithm has been adapted. As already discussed the images which are verified successfully are stored in a temporary database. These stored images are clubbed with associated data from corpus and then genetic algorithm is applied to optimize the Eigen vectors for better acceptance ration. In general the acceptance ratio reduces with time as face of human changes over time. The proposed idea is basically to maintain and increase (in certain cases) the acceptance ratio. Figure 2 describes the detail of updation phase where genetic algorithm is applied for optimizing the Eigen vectors.

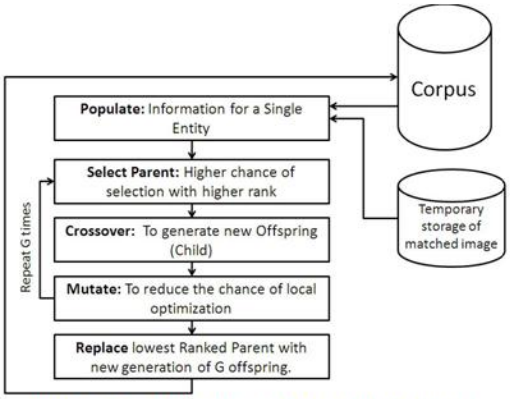

FIGURE 4: DETAIL EXPLANATION OF UPDATION PHASE

A genetic algorithm is a heuristic technique used to solve optimization problems. Optimization problems attempt to find the best solution(s) for a given problem that has several parameters (goals or resources) with associated constraints. In the proposed idea following steps of genetic algorithms are used:

- ✓ **Start** Generate random population of n chromosomes (suitable solutions for the problem). In this phase the Eigen values of an object are selected from both database i.e. the corpus and the temporary database. Each object will have a number of Eigen vectors already stored in corpus as well as some new values will also be available in temporary data base.
- ✓ **Fitness** Evaluate the fitness f(x) of each chromosome x in the population. In the proposed model the fitness number will be directly proportional to difference vector to mean value. The fitness number will be high for an image whose difference vector value is less as compared to difference vector of other images for the same object.

Repeat until a threshold value is obtained

- ✓ **Selection** Select two parent chromosomes from a population according to their fitness (the better fitness, the bigger chance to be selected).
- ✓ **Crossover** the parents to form new offspring (children). If no crossover was performed, offspring is the exact copy of parents. This step is not required in the proposed model.
- ✓ **Mutation** Mutate new offspring at selected position(s) in chromosome. The Eigen vectors will be changed by calculating the average displacement of all selected Eigen values.
- ✓ **Accepting** Generate new population by placing new offspring. The new mutated Eigen values will replace the existing Eigen values whose fitness value is lowest for a particular object.
- ✓ Return the best solution in current population. Current corpus data will be replaced with new data sets obtained after performing the above iteration.

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After applying genetic algorithm database is updated periodically with recent face images which will surely decrease the false rejection rate. All hypertext links and section bookmarks will be removed from papers during the processing of papers for publication. If you need to refer to an Internet email address or URL your paper, you must type out the address or URL fully in Regular font.

VI. CONCLUSION

Face recognition is a challenging problem in the field of image analysis and computer vision that has received a great deal of attention over the last few years because of its many applications in various domains. Research has been conducted vigorously in this area for the past five decades or so, and though huge progress has been made, encouraging results have been obtained and current face recognition systems have reached a certain degree of maturity when operating under constrained conditions; however, they are far from achieving the ideal of being able to perform adequately in all the various situations that are commonly encountered by applications utilizing these techniques in practical life.

In the proposed work sufficiently optimized data-base for human face images will be obtained, that will be able to recognize a person effectively irrespective of age. Proposed algorithm will use optimized database at any stage of age therefore it gives acceptable results. As this algorithm will optimize the database periodically the complexity of algorithm will not affect the existing algorithm during verification process. In the proposed work, a thorough mathematical analysis will be performed for the recognition of face from front face feature extraction and a well optimized database. In order to achieve the target of age invariant face recognition this model with Genetic Algorithm will surely increase the acceptance ratio. This algorithm can be extended to other systems in which objects vary with time like signature in banking application.

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BIOGRAPHIES

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Dr. Sanjay Kumar received his Ph.D. in Computer Science & Engineering from Ravishankar Shukla University, Raipur in 2005. Presently working as Reader, School of Studies in Computer Science & IT at Pt. Ravishankar Shukla University, Raipur. He has more than seventeen years long experience in the field of teaching and research. His research area includes advanced networking, parallel computing and image process. He has delivered a lot of expert lectures, chaired number of conferences and inducted with various professional bodies. His research work has been published in many national and international journals and conferences.