Mathematical Modeling for Face Recognition System

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ABSTARCT

Face recognition system is a desktop application which is used to recognize human faces without human intervention in a video frame, an image or video file. It is an imminent issue in various domains. Due to wide range of increase in crime it can play a significant role in crime management and law enforcement. In this paper, Eigenfaces method is used for face recognition to improve its performance we have introduced key-frame concept by using color histogram. In the recognition process, an eigenface is created for the given face image, and the Euclidian distances between this eigenface and the pre stored eigenfaces are calculated. The eigenface with the least Euclidian distance is the one the person resembles the most. This technique is the first successful method in face recognition area.

General terms:

PCA, Eigenfaces, Color histogram.

Key Words:

Face recognition system, eigenfaces, key-frame, color histogram.

1. INTRODUCTION

Face Recognition in a motionless image or a video frame is a coming up issue in various fields such as biometrics, image processing, and pattern recognition. In addition to face recognition system there are various applications in law enforcement, crime management. The concept first came into existence in the year 1960 which was a semi automated system.

Face recognition is one of the significant issues in rising technology. Due to enhancement in surveillance cameras for the various security purposes and monitoring crime, there is a need of development of algorithms which are more appropriate for handling the kind of images captured by these cameras.

1.1 FACE RECOGNITION:

Face recognition system is similar to other biometric system. The basic idea behind it is that every human has unique face.

Face Recognition system is an automatic tool which is used in computer to recognize faces in a still image or video clips.

It automatically identify the face from the input data, compares it with the image database present in the system. There are two categories of face recognition as shown below:
1. Face verification.
2. Face Identification.

1.1.1 Face Verification:

Face verification is a 1:1 match that compares a face image against a template face images, whose identity is being claimed. [2]

1.1.2 Face Identification:

Face identification is a 1: N problem that compares a query face image against all image templates in a face database to determine the identity of the query face. [2]

2. RELATED WORK:

The face recognition has various techniques. The following study is done on success rate of various techniques with respect to number of images in training set.

The principal component analysis is the first technique was invented in 1901 by Karl Pearson. The success rate of it is 79.65% with 400 images in training set. [3] Next was the Principal component analysis with relevant component analysis has success rate of 92.34% with 400 images in

training set [3]. The Independent component analysis has two functions. The success rate of tanh function is 69.40% with 170 images in training set and has success rate with Gauss function is 81.33% with 40 images in training set [4]. Hidden markov model has success rate of 84% with 200 images in training set [5]. But the success rate was 100% with ORL database [6]. Active shape model has the success rate of 78.12% to 82.05% with 100 images in training set [7], [8]. The Wavelet transform has success rate of 80% to 91% with 100 images in training set [9]. The support vector machines has success rate of 85% to 92.1% [10], [11]. The neural networks was proposed in 2007 by Bhuiyan et al. has success rate of 97.3% [12]. Finally Eigenface method was proposed by Sirovich and Kirby. It was the first most accurate method for face recognition. The concept first came into existence in the year 1991. The success rate is 92% to 100% with 70 images in training set [13].

Table 1. Literature Survey

Method	Number of images in the training set	Success rate	Reference
Principal Component Analysis	400	79.65%	[3]
Principal Component Analysis + Relevant Component Analysis	400	92.34%	[3]
	170	tanh function 69.40%	[4]
Independent Component Analysis	40	Gauss function 81.35%	[4]
Hidden Markov Model	200	84%	[5]
Active Shape Model	100	78.12-92.05%	[7],[8]
Wavelet Transform	100	80-91%	[9]
Support Vector Machines	-	85-92.1%	[10],[11]
Neural Networks	-	93.7%	[12]
Eigenfaces Method	70	92-100%	[13]

3. System Design:

Face authentication and face identification are challenging problems. The fact that in the recent past, there have been more and more commercial, military and institutional applications makes the face recognition systems a popular subject.

The face recognition system is a system which will detect the human face in a video. The video is first converted into frames then the face recognition is done on each frame. The identified face will be transformed into eigenfaces. This eigenface will be matched with the pre stored eigenfaces by finding the euclidian distance between them. The eigenface with least euclidian distance is the one with whom the identified face resembles or the match is not fount. But a minute drawback of this technique is that the system is slow to identify the faces in video as it track the face and matches the tracked face with pre stored images in each frame of video which will take time if the motion in a video is slow for instance in a video a news reporter is delivering news will have least motion and in frame only one face will be recognized frequently in each frame which unnecessarily consumes time as the system will recognize the same face multiple times.

So as to overcome this drawback of traditional system, we are introducing a method of PCA with eigenfaces only on the key frames i.e the frames that have drastic change than the preceding frame in video. As the algorithm is applied only on key frames the time required to track and match all the faces in a video file will be very less than the previously established approach.

The strategy of the Eigenfaces method consists of extracting the characteristic features on the face and representing the face in question as a linear combination of the so called 'eigenfaces' obtained from the feature extraction process. The principal components of the faces in the training set are calculated. Recognition is achieved using the projection of the face into the space formed by the eigenfaces. A comparison on the basis of the Euclidian distance of the eigenvectors of the eigenfaces and the eigenface of the image under question is made. If this distance is small enough, the person is identified. On the other hand, if the distance is too large, the image is regarded as one that belongs to an individual for which the system has to be trained.

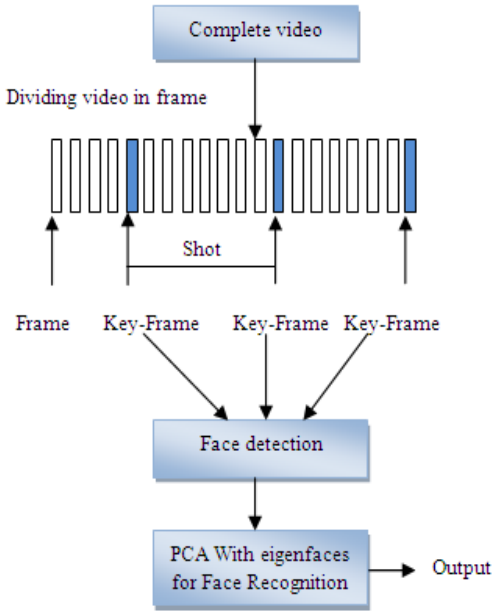

Fig 1: System Design

4. Eigenfaces Method

The basis of the eigenfaces method is the Principal Component Analysis (PCA). Eigenfaces and PCA have been used by Sirovich and Kirby to represent the face images efficiently [14]. They have started with a group of original face images, and calculated the best vector system for image compression. Then Turk and Pentland applied the Eigenfaces to face recognition problem [15]. The Principal Component Analysis is a method of projection to a subspace and is broadly used in pattern recognition. An objective of PCA is the replacement of correlated vectors of large dimensions with the uncorrelated vectors of smaller dimensions. Another objective is to calculate a basis for the data set. Main

advantages of the PCA are its low sensitivity to noise, the reduction of the requirements of the memory and the capacity, and the increase in the efficiency due to the operation in a space of smaller dimensions.

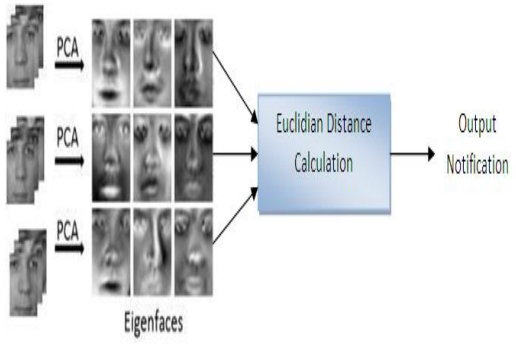

Fig 2: General strategy for Eigenface.

5. Key-frames:

A video frame is a solo picture or motionless shot that is shown as fraction of a larger video. Key-frame is the frame that can represent the content of a section of a video. The key frames are the frames which has drastic change than the previous frame. In proposed system, the key-frame extraction is done with the help of color histogram.

The algorithm of color histogram is given below:

1. Set'd' as threshold and initialize the algorithm.
2. Select the first frame and set it as a key frame.
3. If no frame is captured go to 6.
4. Start the comparison of current captured frame with the selected key frame.
5. Calculate the difference between them
   a. If the *d* > difference then select the current frame as next key frame.
   b. If the *d* < difference then go to c.
   c. Go to next frame.
6. End.

7. Mathematical Model:

A mathematical model is a description of a system using mathematical concepts and language. A model may help to explain a system and to study effects of different components of a system to predict the behavior of system.

The mathematical modeling for our system is as follows

S= {∑, F, δ, C}
S = Face Recognition.
∑ = set of input symbols = {Video File, image, character information}
F = set of output symbol = {Match Found then notification to user, Not Found}
δ = 1. Start
2. Read training set of $N * N$ images
3. Resize image dimensions to $N^2 * 1$
4. Select training set of $N^2 * M$
Dimensions, M: number of sample images

5. Find average face, subtract from the faces in the training set, create matrix A

$$\Psi = \frac{1}{M} \sum_{i=1}^{M} \Gamma i$$

Where,
Ψ= average image,
M= number of images, and
Γi= image vector.

Φi = Γi – Ψ
Where, i = 1, 2, 3, …, M.

A = [Φ1, Φ2, Φ3…ΦM]
6. Calculate covariance matrix: AA'

$$C = A^T * A$$

7. Calculate eigenvectors of the c covariance matrix.
8. Calculate eigenfaces = No. of training images –no. of classes (total number of people) of eigenvectors.
9. Create reduced eigenface space-
The selected set of eigenvectors are multiplied by the A matrix to create a reduced eigenface
10. Calculate eigenface of image in question.
11. Calculate Euclidian distances between the image and the eigenfaces.
12. Find the minimum Euclidian distance.
13. Output: image with the minimum Euclidian distance or image unrecognizable

C = {The system will not process the audio data, Eigenfaces will generate the grayscale images, The algorithm will run only on key frames.}

8. CONCLUSION

We have proposed Face recognition using PCA Eigenfaces. The system aims to find solutions for a robust method for face recognition from videos, reducing the time requirements for face recognition with introduction of PCA Eigenfaces on key frames.

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