



PCA+ SVM a method for Video based face Recognition

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Abstract: Video face recognition (VFR) has received quit attention in past years. Lots of research and studies has been made in the past to achieve efficient and accurate results. Many methods which are found though are successful in giving accurate results are either expensive or time consuming. It seen through experimental results that when standard algorithm PCA (Principal Component Analysis) and SVM (Support Vector Machines) applied individually for Video based face recognition gives accurate and efficient result. Also PCA+SVM when applied to the still face recognition achieve high accuracy but this method is never applied to VFR. Over here an effort is made to improve face recognition accuracy of videos by applying PCA+SVM method and to prove method is efficient, accuracy results are compared with existing algorithms, Nearest Neighbour (NN) and Multi-joint Sparse Representation (MJSR) Algorithm.

Keywords: MJSR, NN, PCA, Video Face Recognition, SVM.

I. Introduction and Related Works

Video based face recognition is an active area of research in recent years. Number of methods is proposed to achieve high accuracy for VFR's. Though interesting VFR's are known for opportunities and challenges it presents. If the method used fails to identify faces accurately the accuracy of face recognition falls down drastically. Though Face recognition is studied widely but most of the research is done in still based face recognition than in case of VFR. Also existing methods in VFR achieves good accuracy results but at the expense of money, time and human efforts.

Principal Component Analysis (PCA) is a standard feature extraction based algorithm extensively used for face recognition. It is mainly used for identifying and extracting main features and matching them during the process of face recognition. It's been seen in [6] [8] and [9] that PCA is mostly used in still based face recognition and achieves up to 99% of accuracy. But very few methods make use of PCA in VFR. One of such method is given in [6] which uses PCA as feature extractor along with a classification algorithm and achieves good results of accuracy. Support Vector Machine (SVM) is also a standard algorithm for classification. It is known to achieve accurate results for feature classification phase of face recognition. [7] Shows how in combination with a feature extraction algorithm SVM delivers correct results of accuracy for VFR. PCA+ SVM is used for still based face recognition in [5] and achieves recognition accuracy up to 99%, but this combination is never been used for VFR till now. Over here an attempt is made to use PCA+SVM method for VFR. [3] And table 1 shows a detailed reasoning so as to why PCA+ SVM is to be used and how it is better than rest of the method used for video based recognition.

Table 1 Comparison between different face recognition methods

Method Name	Pros	Cons	Accuracy
Still images based PCA + SVM [5]	-robust and consistency of results across different parameter setup -One of the best recognition rates -Fast and guaranteed about performance	-increase in complexity	90-97%
Video-Image based: Sparse Representation Based Classification and Multi-task joint sparse representation [1]	-Fairly fast and robust -excels at rejecting unknown identities -achieves one of the best precision rate	-fails to recognize users in case of multiple users in single frame -makes use of ℓ^1 - minimization which is computationally expensive	85%
Video- Video based: 3 types: 1. feature extraction based e.g. PCA with some algo for classification[6] SVM as classifier for feature extracted by some algo[7]	- Use multi-frames (video sequences) of the input video to obtain discriminant features. - Does not impose any environmental restrictions -work well for face localization in uncluttered background	- Assumes prior face detection - Threshold decision for feature classification can be difficult.	86-92%
2. Based on distribution of faces in video e.g. Probabilistic Appearance Manifolds.[11]	-Captures pose changes -effective with clean data (not noisy) -Generates good result without occlusion. -computational phase is dramatically reduced	- sensitive to illumination -produces unbalanced cluster -time consuming -complicated	84-90%

3. Dynamic change of face in videos e.g. Adaptive HMM[10]	-temporal characteristic of video is considered. -The subject used for recognition is updated continues. -Demonstrated good empirical results	-Needs lots of positive and negative results -Difficult to decide threshold for updating. -Complex and very expensive.	80-89%
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PCA+SVM is video-video feature extraction based face recognition. It is a 2-way recognition method where PCA is used for extracting facial features or eigenfaces and SVM is used to classify the features in to classes to help recognition.

Next sections give detailed idea about how the PCA+SVM method works and details the experimental results by comparing existing algorithm such as NN and MJSR with PCA+SVM based on video clip from a movie.

II. PCA+ SVM METHOD

As mentioned earlier, PCA+SVM is a 2-way face recognition method with PCA used for feature extraction and SVM used for classification. For better understanding the mathematics involved with PCA and SVM algorithm is discussed over here. Also, the dataset in the form of movie clips are used to show the features extracted by PCA and classification results of SVM [4].

A. Principal Component Analysis

PCA is most used and cited method for face recognition. It is an algorithm which extracts principal components of multi-dimensional data to reduce dimensionality [2].

Given: T a 2D matrix of p 1D images each of M×N pixels. Show how PCA is used for feature extraction.

Input: Training image dataset T = [Ti, Ti₂, ..., Ti_p]_{MN × p}

Output: Vector Data Set Y.

Solution:

Step 1: Compute the mean image vector m: contains common features of all face vectors

$$m = \frac{1}{p} \sum_{i=0}^p T_i \quad (1)$$

Step 2: Compute normalized face vectors for each face vector

$$\sum_{i=0}^M A_i = \sum_{i=0}^M T_i - m \quad (2)$$

Step 3: Compute Co-variance matrix

$$C = AA^T \quad (3)$$

Where A is set of normalized face vectors given as A = [A₁, A₂, ... A_M] and is MN×P dimension matrix and A^T is a P×MNmatrix.

Therefore, C will be MN× MN matrixes which will be require very high computations and memory.

Thus PCA uses dimensionality principal so now L will be given by

$$L = A^T A \quad (4)$$

And its dimension will be P× P which is greatly reduced without loss of information.

Step 4: Compute eigenvalue [$\lambda_1, \lambda_2, \dots, \lambda_k$] and eigenvectors or eigenfaces [$\Omega_1, \Omega_2, \dots, \Omega_k$] where k>M always.

λ is a eigenvalue if it satisfies following equation

$$\det(\lambda I_n - L) = 0 \quad (5)$$

By solving above equation if we get two eigenvalues λ_1 and λ_2 the eigenvectors for them can be found by using equation

$$\text{Matrix } (\lambda I_n - L) v = 0 \quad (6)$$

If V1 & V2 are two eigenvectors extracted and stored in matrix V then eigen-face Y of co-variance matrix C can be given as

Therefore

$$Y = V * A \quad \text{is required matrix.} \quad (7)$$



Fig. 1 Mean face and Eigenface extracted using PCA

B. Support Vector Machine

Support Vector Machines (SVM) belongs to kernel methods which map data from an original space into a higher dimensional feature space using non-linear mapping. SVM separates p-dimensional data using p-1 dimensional

decision surface (hyper plane) in such a way that maximizes the margin of the data sets. The margin is defined as the minimal distance of sample of decision surface. The distance of decision surface from the nearest appearance of individual data sets should be largest possible.

Given: the input data set D as $\{(\mathbf{x}^{(i)}, y^{(i)}); \mathbf{x}^{(i)} \in \mathbb{R}^n; y^{(i)} \in \{+1, -1\}; i \in \{1, \dots, N\}\}$ find Hyper plane to classify most of the data or learn classifier $f(x)$.

Input: Data set $\mathbf{x}^{(i)}$ where $i = 1, \dots, N$ and Data set : $y^{(i)} \in \{-1, +1\}$.

Output: classifier y

Step1: Construct classifier

First, compute matrix H as

$$H_{ij} = y^{(i)} y^{(j)} k(\mathbf{x}^{(i)}, \mathbf{x}^{(j)}) \quad (8)$$

For each corresponding value in data input data set where $K(\mathbf{x}, \mathbf{x}')$ is a kernel function.

Next, Use quadratic solver to solve the optimization problem.

$$\alpha = \arg\min_{\alpha} \left(\frac{1}{2} \alpha^T H \alpha - \sum_{i=1}^N \alpha_i y^{(i)} \right) \quad (9)$$

$$\alpha = \text{Where} \begin{cases} 0 \leq \alpha_i \leq C \\ \sum_{i=1}^N \alpha_i y^{(i)} = 0 \end{cases}$$

Lastly compute b by

$$\text{Index} = \{i | \alpha_i > 0\} \quad (10)$$

$$N_{\text{index}} = |\text{index}| \quad (11)$$

$$b = \frac{1}{N_{\text{index}}} \sum_{i \in \text{index}} (y^{(i)} - \sum_{i \in \text{index}} \alpha_i y^{(i)} K(\mathbf{x}^{(i)}, \mathbf{x}^{(i)})) \quad (12)$$

Step 2: Classification phase

Compute value of y

$$y = \text{sign} \left(\sum_{i=1}^N \alpha_i y^{(i)} K(\mathbf{x}^{(i)}, \mathbf{x}) + b \right) \quad (13)$$

And apply to x

$$= \begin{cases} \text{if } y = +1 \text{ then } \mathbf{x} \text{ belong class } \{+1\} \\ \text{if } y = -1 \text{ then } \mathbf{x} \text{ belong class } \{-1\} \end{cases}$$

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1.png



2.png



3.png



4.png

Fig. 2 Classes formed by SVM

III. Experimental Result

The main experimental results here are of face recognition accuracy for different movie clips of varying or same duration compared for different algorithms. There are 3 clips in .avi format with duration ranging in between 1 to 2 minutes. The face recognition algorithm with which the proposed method is compared is NN (Nearest Neighbour), MJSR (Multi-joint Sparse representation the existing method), and PCA+SVM (Proposed method). The result for NN and MJSR are taken from paper [1]. Table 2 shows comparison between all 3 methods. Also graph in fig 3. Clearly shows on an avg PCA+SVM achieve maximum result than the other 2 algorithms. It can be seen that PCA+SVM achieves 11% more accuracy than NN and 9% more accuracy than MJSR algorithm.

Table 2. Clip-wise accuracy compared using NN, MJSR and PCA+SVM

Clip	Duration (in seconds)	Accuracy (In Percentage)		
		NN	MJSR	PCA+ SVM
C_1	159	73.33	76.19	89.05
C_2	150	80.90	93.75	92.01
C_3	145	87.50	82.08	95.33

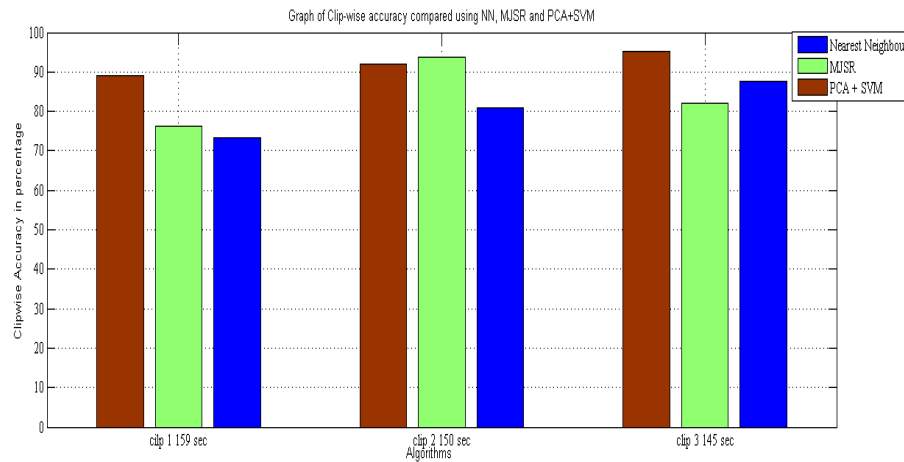


Fig 3 Clip-wise accuracy compared using NN, MJSR and PCA+SVM

IV. Conclusion

VFR is challenging field but along with challenges it also presents many opportunities. PCA+SVM when applied to still base face recognition achieved high results. Therefore, an attempt is made over here to use this combination in case Video face recognition. It is seen through experimental results that PCA+SVM method achieves up to 95% accuracy even in case of VFR and it is relatively simple and cheaper method than the existing methods.

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