From Appearance Matching to Feature Invariant Matching Face Recognition: Comparisons between PCA and SIFT

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Abstract

From important of Face recognition we found many of techniques and method applies to this type of discipline, from this methods we have SIFT and PCA. In this paper we compared between SIFT and PCA in terms of their accuracy and running time. Testing done using Yale database based on 3 fold cross validation. The result shows the superiority of the SIFT technique over the PCA.

1 Introduction

Face recognition is one of the important field in identification and surveillance application,[1] these application range from static to a dynamic, uncontrolled face identification in messy background. Face recognition system have many challenges that must overcome to get better performance and most of these challenging falls under how to recognize the faces under different condition related to around environmental when capture image such as: illumination, pose, occlusions, facial expression, and aging affect. Therefore, we find that many research proceeding in this field [2], but not all of these methods provide a completely performance, every technique have cons and pros. From these methods we have a gigantic approach principle component Analysis (PCA) and scale invariant feature transform (SIFT).

Face recognition may be verification or identification process, the difference between them that the verification compares the captured face image with one stored image in the database but identification compare inputted image to a number of face image stored on the database, In this paper use the second one for our objective that compare between PCA and SIFT depend on known face data base using 3 fold cross validation which can be used to compare the performance of different modeling. There are many surveying done for face recognition methods and algorithm with different purposes [1][2][3][4][5][6].

This paper propose a new comparison approach based on 3 fold cross validation and on different parameter taken that showing pros and cons of gigantic face recognition PCA and SIFT. The reminder of this paper is structured as follows: In section 1 Discuss a literature review about important related face recognition methods, section 2 mentions for theoretical background, then section 3 and 4 discuss our experiments and conclusions.

2 Literature Review

Face recognition start early at 1960's but it still a modern topic [1], there are different and diverse technique supposed that make the research a very challenge task this is due to human face itself are variant characteristic [2], face exposed to different condition

that must take into account when propose new algorithm and from these condition illumination, occlusion, pose, aging.. etc. There are several attempts to surveying face recognition methods, every effort classify these algorithm from the viewpoint of authors to natural of face recognition methods, one of these classification depend on if we have a single image or a database of image to compare it with a captured image (identification or verification) [4], other classification depend on it application commercial, surveillance, and law enforcement [7]. But the more apportionment on face recognition is dividing on natural of algorithm itself for example: Knowledge-based methods, Feature-invariant methods, Template matching methods, Appearance-based methods as Yan, Kriegman and Ahuja presented a classifications that accepted in 2002[3].

In this paper am classify face recognition method depend on how robustness for more general challenging problem that meet face recognition, and because the PCA is returned to appearance approach and SIFT is returned to feature invariant I will discuss the two type in following two paragraph then list most challenging condition and how most researchers beard these problem.

2.1 Appearance based method

In this method we have training images that used as a template to recognize inputted image, then apply statistical analysis or machine learning to find the characteristic of the faces, describe these characteristic by a distribution model or discriminate function, and the reduction made for efficiency computation such as PCA.

2.2 Feature invariant methods

Methods from these types try to find invariant feature in spite of rotation or pose such as SIFT.

2.3 Face recognition challenge

There are many efforts in face recognition but still have failure in some algorithm, in the following paragraphs we review some common method robustness for these challenges:

2.3.1 Pose

Figure 1 show faces with different pose[8], many algorithms such as eigenspace using PCA, Fisher discriminate analysis, Independent component analysis, PCA kernel, and many paper take comparison of them [9][10][11][12], these algorithm dependent in frontal view of image and doesn't robust again pose , to avoid this problem transformation approach proposed to transform the face from unknown pose into frontal view, this approach may be image level transformation or feature level transformation, For example 3D spring based wired face model (SBM) is image level and elastic graph matching (EGM) is feature level transformation, both transformation based get a better recognition than without transformation [13].

Figure 1: faces with different pose

Other way trying to solve problem used component based recognition by finding three facial regions (eye, mouth, and nose) then apply good classification method such as Support Vector Machine (SVM), 2-D Hidden Markov Model (HDD)[14].

Huang et al. (2000) proposed pose invariant face recognition using novel neural network by extending eigenspace method. They used eigenspace to extract the feature then used neural network for recognition purposes [15].

In 2009 Xiaozheng and Yongsheng make a good reviewing for face recognition crosswise pose [6].

2.3.2 Illumination

The most problem faced researcher which decreased the performance of their algorithms[2], such as normal face recognition such as eigenface based PCA,

LDA...Etc. So intensified efforts to solve the illumination challenge which led to the diversity of these method.

One of these efforts done by Adini, Moses,and Ulman (1997) which try to extract illumination invariant feature from image whether using edge map or image derivatives using 2D Gabor filter based on their claim that can be found horizontal feature that doesn't affect by illumination, their result confirmed that these rough algorithm not robust for illumination condition, but find horizontal feature such as eyes mouth improve their methods[16]. J-H.Lai, P.Yuen, and G-C.Feng take up the same approach to find feature invariant illumination by building spectroface which apply wavelet transform to remove the effect of facial expression then by using holistic Fourier to extract invariant feature not against only illumination but with scale, transformation, and rotation feature, and the result gives a high accuracy with less time [17].

Other researchers transform the image into another basic representation with illumination variability and from these researches:

Face recognition under varying illumination based on a 2D face shape model done by Xie and Lam in 2004, this paper depend on histogram concepts, apply the block based histogram equalization and compare it with original image using histogram equalization to knowing light category of image which the authors divide the light into 65 category, then make reconstruction for image using 2D face shape model. Authors results showing improves on PCA method when this method apply [18].

Illumination invariant feature extraction and mutual-information-based local matching for face recognition under illumination variation and occlusion approved by A.Nabatchian, E.Abdel-Raheem, and M.Ahmadi, the authors provide simple and good idea for illumination invariant and have a good accuracy, they assume that the image is a product of light and reflectance, which can be thought as low and high frequency so illumination can be separated. The approach as following: firstly apply logarithmic function on two part of image (light and reflectance) to compress the range of bright pixel values, and expand the range of dark. After that they assume that the illumination found on low frequency so they can apply high pass filter, the output after making a filter is illumination invariant and can be used for usual recognition methods such as PCA or LDA [19].

Georghiades and Belhumeur (2001) make a model of illumination variation using ordinary appearance based method but with a little number of training database as shown in [20], other work done on 3D image as Huang, Heisele, and Blanz doing, they take three image for the same face and build new image using 3D Morphable Models, then apply component based recognition in [21]. The following figure showing different light condition in the same face [22].

Figure 2: show different light condition in a face

2.3.3 Occlusion

Different way to solve problem; From Ohio University H.Jia and A.Martinez (2009) provide a reconstruction method to solve occlusion problem by represents the visible pixels of the test image as a linear combination of the visible pixels in the training images [23].the same persons in the same university provide another method using support vector machine in [24]. From USA to Turkey Kepenekci et al. provides Gabor wavelet to extract feature that doesn't occluded then use these feature for comparisons purposes, they used single image as training with higher recognition rate rise than 95% [25]. Figure 3 explain occlusion in faces [24].

Figure 3: Occluded Faces

2.3.4 Scale and Rotation

In [26] authors find invariant feature for rotation through break down the inputted image into two dimensional wavelet then use PCA to reduce the dimensionality of feature vector. Radial Basis Function used to tell if it face and in which orientation. In another way Henry,Shumeet and Takeo use neural network to find feature invariant against rotation for any angel [27].

SIFT algorithm is a major algorithm that proven they robustness against scale and rotation especially in object recognition [28]. From important of this algorithm many research use it as rough for face recognition, and other work done to enhancement this method; Mohamed Aly(2006) use a direct SIFT fro face recognition [29], but Cong and Xudong submit two enhance method called Volume-SIFT (VSIFT) and Partial-Descriptor-SIFT (PDSIFT) for face recognition based on the original SIFT algorithm, VSIFT eliminates unreliable keypoint, and PDSIFT to decrease the size of descriptor vector, also authors in (2011) provide another enhanced in matching approach in SIFT as in [30].

In [31] another adaptation done on basic SIFT called fixed SIFT (FSIFT) Janez , Vitomir and Nikola(2010) compute the descriptor at a fixed predefined image locations learned during the training stage. This approach make enhancement on illumination variability. This paper [32] use rough sift but the enhancement in the approach done on classify the image into sub regions used k mean cluster trying to found more specific person feature. Yan and Rahul provide PCA-SIFT method which the same of sift in simple difference that instead of using histogram they used PCA for gradient patch, the paper result prove that PCA-SIFT are more robust to image deformation and more compact than ordinary SIFT [33].

Finally, Dniz, et al. (2011) provide a paper robust against occlusion, pose and illumination based on histogram of oriented gradient (HOGs), authors justify they approach by the following statements "The three main contributions of this work are: First, in order to compensate for errors in facial feature detection due to occlusions, pose and illumination changes, we propose to extract HOG descriptors from a regular grid. Second, fusion of HOG descriptors at different scales allows to capture important structure for face recognition. Third, we identify the necessity of performing dimensionality reduction to remove noise and make the classification process less prone to overfitting" [34].

3 Theoretical Background

Any face recognition systems have common steps which explained in the following block diagram[1]:

Figure 4: Block Diagram

In this paper we don't need face detection which is the process of find the face in the image or video sequence; we apply the PCA and SIFT on known database that contains faces only for feature extraction then make a face recognition for identification purposes. To apply these algorithms which depend on feature extraction we should firstly perceive what are the PCA and Sift.

3.1 Principle Component Analysis (PCA) [28]

It's a statistical method that objected to reduce the dimensionality space of variables without losing of the data. PCA used in many application and from these applicant it used in face recognition, the scenario of PCA working that we get a database of faces image, build the eigenspace by putting all the image into a one large image, find the mean of every face and subtract it from large image, this step called the normalization stage. Then find the covariance matrix and calculate the eigenvalues and eigenvectors from the matrix, to choose best eigenvalues we should sort them in descending according the eigenvectors. Finally we make projection to eigenspace.

3.2 Scale Invariant Feature Transform (SIFT) [28]

SIFT is a well-known method for object recognition devolved by David Lowe extracted as final document in 2004. SIFT discriminate that it invariant to image scaling and rotation, and robustness for illumination and 2D camera view point. It used in many applications mainly for object recognition. Mohammad Ali apply sift method for face recognition [29] and in 2009 Cong and Jiang apply two improvement on sift for face recognition [30]. Sift has four step to identify the feature in the image which is a vector of 128 dimension, first step search about all scale and location using difference of Gaussian function after make blurring by Gaussian filter in image this step called scale space extrema detection and in it decide if the keypoint is interest or not by search for a minimum or maximum value with 26 neighbor related for any pixel (keypoint). Finally find keypoint descriptor that created from local image gradients and this feature based on orientation histogram.

3.3 Matching methods

PCA and SIFT use nearest neighbor for matching purposes but in different strategy, PCA use it as a direct declaration between two features:

$$D(F1, F2) = \sqrt{\sum_i (F1_i - F2_i)}$$

, but sift find the closest neighbor and comparing it to the second closest neighbor and so on if the second larger than the first by specified ratio then it considered a correct match. In sift implementation by David Lowe for object recognition purposes use 0.6 to eliminate all matches that greater than this distance ration.

4 Experiments and Results

In this section we discuss the code used in comparisons, database, and our result.

4.1 Experiments environments

We use Matlab as working environments, SIFT code available in David Lowe website [35], and PCA get from [36].

4.2 Database

In this paper we used Yale faces database. The Yale Face database contains 165 grayscale images in GIF format of 15 individuals. There are 11 images per subject, one per different facial expression or configuration: center-light, w/glasses, happy, left-light, w/no glasses, normal, right-light, sad, sleepy, surprised, and wink [22].

Figure 5: Sample of Database

4.3 Approach

We classify the database based on 3 fold cross validation. For each of 3 fold, we randomly assign the data into 3 fold d0, d1, d2 two of them assigned as training and the rest as test, and then try this process 3 times so can the testing faces changed. Since we use Yale database training fold have 110 faces but test have 55 faces.

In SIFT method, we extract the feature which called descriptor for all training image, because it have different length we store it as a linked list. Then extract feature from test data set and apply SIFT matching algorithm, apply process 3 times for different test and training set.

In PCA method, we extract the feature from training and testing image which is the projection of faces into eigenface, we assume that number of feature vector is 100. Then apply matching algorithm as explained in section 3.

4.4 Result

We compare between SIFT and PCA in terms of recognition rate and running times. Recognition rate: number of recognized image to number of testing image and the running time is run time for all testing image to the number of testing image. The following table showing recognition rate for 3 fold and final result which is the average between them:

Table 1: Recognition Rate

Fold	SIFT	PCA
1st	89.06	65.1
2nd	85.4	67.9
3ed	86.5	73.5
Average	86.98	68.83

Table 2 showing running time (in minute):

Table 2: Recognition Rate

SIFT	PCA
1.09	10.9

From table 1 we clearly show the superiority of the SIFT technique over the PCA, we have nearly 87% recognition rate instead of 69%, but the two method also have less recognition rate than the paper listed in a literature and this is due to two reasons: firstly Yale databases have a faces with illumination and poseetc. another reasons using 3 fold cross validation which randomly choice the testing and training faces.

On the other hand, the running time is very important in many applications which is the sift take a long time to make a good recognition rate but the PCA have less time with acceptable recognition rate.

4.5 Conclusion

In this paper we show that SIFT have a higher performance rate than PCA method, but to what utmost degree can apply the SIFT in real system. Suppose we have a two important scenario: Jorge stolen a gold shop, and the police search about the stolen person, let the camera capture Jorge face, in this time the police need to knowing the person in their database without concern about the time, so in this type of system can use sift. Nevertheless Jorge needs to enter into his house; in this type of system SIFT is too slow to being used. So we conclude that the SIFT has a higher performance but not in real time for all application.

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