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Evaluation of Video Analytics For Face Detection and Recognition

[1]Dr. T. Senthil Kumar
[1]Associate Professor, Department of Computer Science and Engineering, Amrita Vishwa Vidyapeetham, Coimbatore -641112, TemilNadu, India.
drtsk111@gmail.com
[2]S. Saivenkateswaran
[2]M. Tech second year, Computer Vision & Image Processing, Amrita Vishwa Vidyapeetham, Coimbatore-641112, TamilNadu, India.
prvns3934@gmail.com

Abstract

Face Detection and Recognition is presenting a challenging approach in the field of computer vision and Image processing [www.cosy.sbg.ac.at]. To localize and to extract the particular face region in the image or video, Face Detection is used as the first step for Face Recognition systems [www.idsia.ch] [1]. Face detection and recognition has several applications. They are content based image or video retrieval, video coding, video conferencing, crowd analysis, intelligent human computer interfaces [iasir.net][1]. Still many researches are going on because it is very tough to find the exact face of a person if we need to match the face region in the database that makes face detection a tough problem in computer vision [iasir.net].This paper analyzes how Face Detection and Recognition approaches can be used for a wide variety of applications like smart buildings, driver recognition during accidents.

Index Terms: Face Detection, Face Recognition, Feature Extraction, Feature Based Approaches, Image and video based approaches.

Introduction

Face Recognition is a current research area in computer vision field. There are several applications like image processing, pattern recognition, computer vision, neural networks, neuroscience and other surveillance applications [irdindia.in] [2]. Face Detection is the first step in Face Recognition which has many image appearance as follows:

Pose condition: Pose condition of a face (all orientations) will change depend on the camera and some features may become partially or fully occluded [vision.ucsd.edu].

Occlusion: Faces may be occluded by other objects partially or fully.

Image conditions: when the image is captured, lighting and camera characteristics are some of the factors which affect the appearance of a face.

F. Lecumberry has proposed that there are many closely related problems of Face Detection and Recognition. Detection part tells you the image or video contains face or not [3]. Second step is Face recognition. Kumar Rath, Subrat and Siddharth Swarup Rautaray suggested that the Face recognition tells whether the detected face is similar to the target face image or not. Face recognition includes feature extraction and matching for recognizing the face whether the person is same or not. Matching will be done by checking the image features in the database [4].

Face Recognition Systems

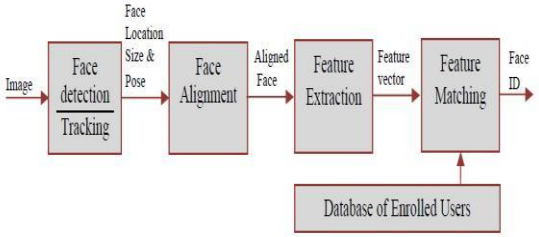


Figure: Face Recognition System

In usual, face recognition systems are set to be three steps. Among them, detection is the first part which detects the particular face in an image or video. Detection may include face edge detection and other pre-processing steps, either for simple or cluttered scene. Feature extraction denotes the acquirement of the image features from the image such as texture, statistical features, etc. Face recognition is represented to perform classification to the above image features.

In Face Recognition systems, the evaluation of the system and benchmarking of the algorithm is very decisive. Previous work on the evaluations provides how the evaluation of recognition algorithms and systems can be performed very effectively. For face recognition system (1) large dataset is needed to train images for detecting face in an image or video, (2) After face detection feature (face) should be clearly visible for extracting features, (3) scoring should be done which reflects the system requirement changes that results from errors in recognition; (4) system reject error behaviour should be studied, (5) the accuracy, samples, speed and hardware, and human interface are extremely required for the face recognition.

For face recognition, a standard database containing face images (frontal, non-frontal) such as FERET program, both to supply a sufficient number of images to allow testing these algorithms. Other face databases are FRT which embrace MIT face database (about 2952 face images), UMD face database (about 7100 face images),

USC face database (100 face images) UMIST face database(about 2100 face images) [2].

Statistical Approach For Recognition Algorithm

Normally, in image face region is represented as high dimensional pixel arrays. Each image is viewed as a vector in d-dimensional space in statistical approach. The dimensionality of data specification is too high. The goal is to choose and apply the correct statistical tool for extraction. Many of the statistical methods are not used as a separate one. The methods are modified or extended in order to get better results compared to previous results.

Principal Component Analysis (PCA)

Principal Component Analysis (PCA) is one of the most used statistical method among all other methods [www.ucc.ie]. PCA takes a large number of correlated variables and transform this data into a smaller number of uncorrelated variables while running maximum variation. However, PCA was not widely used before development of computers. The development of PCA were made by Hotelling and Girshick [5]. From that, principal components is found which has a linear combination of spontaneous variables (correlated variable to uncorrelated variables) [etd.lsu.edu]. The common assumptions are (1) linearity frames, (2) the assumption of large variances have the brief information that the data has a high signal to Noise Ratio. Sometimes it may be an incorrect assumption, (3) the principal components are orthogonal. The greatest variance of projection of the data lies in the first co-ordinate.

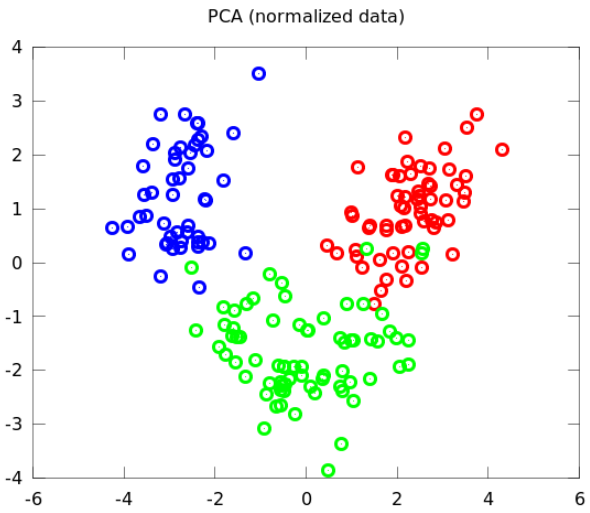


Figure: Normalized data after applying PCA

Discrete Cosine Transform (DCT)

DCT gives a set of data values at different frequencies in terms of a sum of cosine functions. DCT has a strong energy compaction compared with other transformation

functions [ijeit.com]. It can be used to transform images, with an effective dimensionality reduction. DCT have been widely used for data compression. There are two major compression techniques named as lossy compression and lossless compression. Mostly DCT is used in JPEG standard. This standard used in the form of lossy image compression that centres on the DCT. The part of compression occurs during the part of a technique called quantization. It is based on Fourier Discrete Transform (using only real numbers). It is computationally easy to implement. The DCT has a set of ***basis functions*** known as input array (8*8) can be computer and stored which has more efficient.

The process

1. The image has to be separated into 8×8 pixels.
2. The second step is to apply DCT from left to right, top to bottom.
3. Each block is compressed through quantization in the third step.
4. After reducing the space, the image is reconstructed through decompression by using Inverse Discrete Cosine Transform.

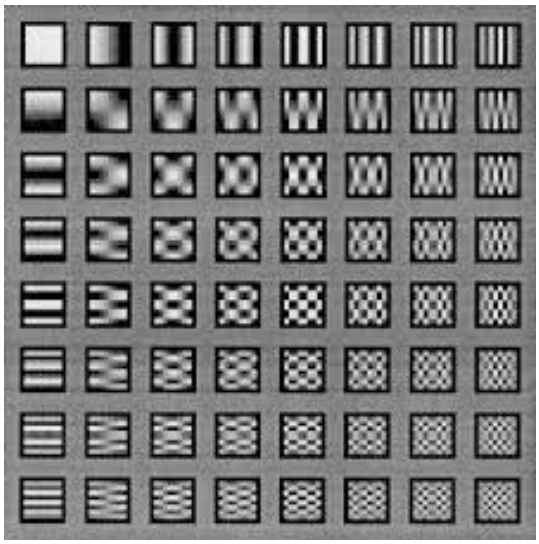


Figure shows the DCT working in an image. DCT has high energy compaction which is ability to pack input data into as few coefficients as possible. In this image first (0, 0) is known as DC components and remaining (0, 1) to (7, 7) are AC components. Their frequency is non-zero in one or both directions.

Linear Discriminant Analysis

Even though PCA is the good technique, But LDA is an important method for extracting features [6]. This is used in classification methods. From discriminant analysis, most discriminant features low dimensional space can be mapped by high dimensional samples. Samples are projected in feature space will be formed as maximum between-class scatter and the minimum-within class scatter simultaneously. The drawback of LDA is that it may have small sample size problem. This kind of

problem arises whenever the dimensionality of the sample are smaller. The execution of Linear Discriminant Analysis has computational complexity [6].

Suppose we have $x_1 \ldots x_m$ in m samples belonging to class c, each class has m_k elements. The objective function of LDA is,

$$a_{opt} = \text{argmax} \frac{a^T S_b a}{a^T S_t a}$$

Gabor Wavelets

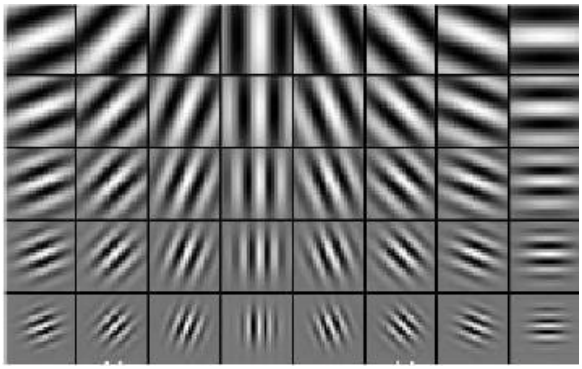


Figure: Gabor wavelets

Kin-Man Lam proposed that Gabor wavelets are used in object detection, recognition and tracking for extracting local features. To extract global features in image or video is computationally drastic. Daugman proposed that these filters are local spatial band pass filters for concerted resolution of information in 2d Spatial and Fourier domains [2]. Gabor function is,

$$\Psi_i(\vec{x}) = \frac{\|\vec{k_i}\|^2}{\sigma^2} e^{\frac{\|\vec{k_i}\|^2 \|\vec{x}\|^2}{2\sigma^2}} \left[e^{j\vec{k_i}\vec{x}} - e^{-\frac{\sigma^2}{2}} \right]$$

Kernel PCA

Kernel functions for performing nonlinear PCA were first introduced by Scholkopf et [7]. It is an extension of Principal Component Analysis using techniques of kernel methods. The basic methodology of kernel PCA is to apply a non-linear mapping to the input ($\Psi(x) : R^N \rightarrow R^L$) and solve a linear PCA in the resulting feature subspace. In this,

$$K(x_i, x_j) = (\Psi(x_i) \cdot \Psi(x_j))$$

Assuming the projection of the data has been centred, the resulting Eigen problem is,

$\lambda V = C_x V$

The selection of optimal kernel is a problem. Typical Gaussian kernels are,

$$K(x,y) = \exp\left(-\frac{||x-y||^2}{2\sigma^2}\right)$$

Face Detection and Recognition Techniques

Template Matching Method

Template matching methods are based on convolution, normalized Cross-correlation, Sum of Squared Difference, sum of absolute difference etc. Matching the detected features by using Sum of absolute difference will perform well at variation in illumination, poses but it is affected by variation in clutter background. Sum of Squared Difference is sensitive to noise and illumination changes. Convolution technique for template matching method gives that the speed increases and computational time decreases but it is slower compare to other methods. The perfect matching of extracted face with the target image is indicated by Cross-correlation coefficient values. This approach is good for face if the sensed image do not have any rotation or scaling. Template matching method will not be good for all the cases because it is rotation-dependent, scale-dependent, and computationally expensive [8].

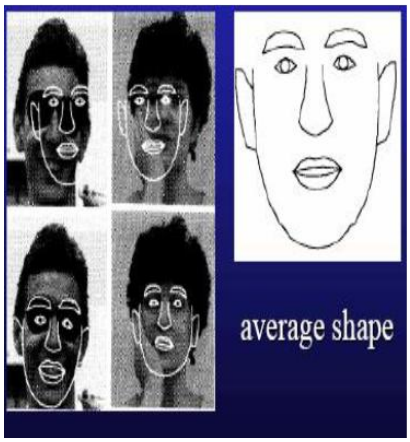


Figure: Template Matching Methods

Geometric Feature Based Methods

This approach is the earlier approach to the face detection and recognition. In this system, facial features are detected first and other geometric characteristic are gathered in a feature vector used to represent the face. For taking facial features first we have to fix the landmark for finding feature vector, as well as pairs of landmarks tracking results are extracted, and normalized. Landmark is initialized and tracked by *Elastic Bunch Graph*. To recognize a face, feature vector of test image and as same as face image in database is compared. Between these vectors, a minimum distance criterion is used to determine the identity of the face.

Knowledge Based Method

In Knowledge based method, the methods for Face Detection have been developed and derived based on the rules from the researcher's knowledge. The features of a face and their relationships were described. For example, two eyes that are similar to each other, nose, mouth and ears in face. These features relationship can be extracted first, and face candidates are identified by their relative distances. Verification process is applied to reduce the false detection. Knowledge based method is difficult in translating human knowledge into rules. Many false positives are there if rules are very general. Detecting different poses of face is difficult [vision.ucsd.edu].

Feature Based Method

Feature based method uses Color, Texture; facial features such as nose, mouth, eyebrows, eyes, and hair etc., the edge detectors are used to detect the features because edges are invariant to illumination. A statistical model will be defined based on the extracted features for describing their relationships and to verify the face existence. Feature-based methods are scale-independent, rotation-independent, and fast. Feature-based method works well under varying illumination condition its performance degrades if the image features are corrupted with occlusion and noise [9].

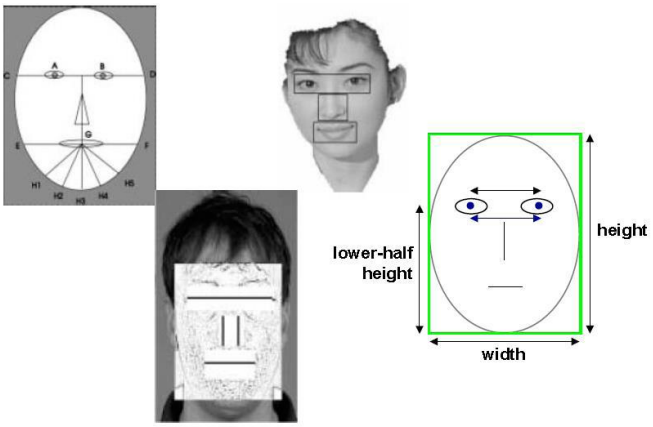


Figure: Feature based methods.

Correlation Based Methods

Correlation based methods are based on the computation of *Normalized Cross Correlation* (NCC) coefficient [1]. The initial process corresponds to the location of significant facial features (eyes, nose, and mouth) can be determined [ijsetr.org]. Brunelli and poggio have used a set of templates for detecting a person's eyes in an image by considering maximum absolute values of the Normalized Correlation Coefficient at each point in target image. For obtaining scale variations different scales are used. The problems coming up with the scale variations can be reduced by hierarchical correlation. The templates for the test image facial feature are compared with the template facial feature which is stored in database, giving result through Normalized Cross Correlation. Beymer has extended the correlation based on a view

based approach for recognizing faces under varying orientation with respect to the axis perpendicular to the image plane. This approach is highly computational expensive and complexity, and it is too sensitive to lighting conditions.

Appearance-Based Methods

Appearance-based methods statistical techniques and machine learning for finding the similar characteristics of face or non-face in an image. Discriminant functions from the learned characteristics that are apparently used for Face Detection. Computation efficiency and detection efficiency can be done by Dimensionality Reduction.

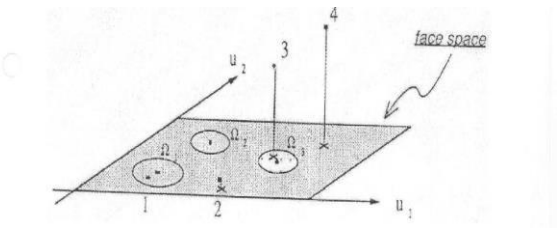
Eigen Faces

A lot of the previous works on automated Face Recognition has discarded for some issues like background and other challenges [11]. Face images has particularly focused on features such as head outline, eyes, nose, mouth etc., in computer recognition. Eigen Faces is a most simple approach for extracting features contained in image of a face is to capture various collections of images. In mathematical terms, the system is to find principal components, or covariance matrix's Eigen vector and the linear combination of the Eigen vectors which is called Eigen faces. Largest Eigen values are best Eigen faces. Sirovich and Kirby (1990) were motivated Eigen Faces purely represent faces using Principal Component analysis. These authors have performed reconstruction of huge set face images by storage of few amount of collection of each face's weights.

Calculating Eigen Faces

Let an image which contains face I(x, y) be a 2D N by N array of intensity values [4],

1. Obtain the training face images $I_1, I_2, \ldots I_M$
2. After obtaining training sets represent each img I_i as vector Γ_i
3. The mean face vector Ψ has to be computed.
4. Mean face is to be subtracted from the training samples: $\Phi_i = \Gamma_i - \Psi$
5. From the mean and the input samples compute the covariance matrix C:
6. Where $A = [\Phi 1\ \Phi_2 \ldots\ldots \Phi_M]$ $(N^2 \times M)$
7. Compute the eigenvectors u_i of AA^T.



Experiments have been done with sixteen subjects, three orientations and three sizes. The challenges faced are the input image has been taken in three lighting conditions with six different resolutions. 2,592 Total number of images for training data sets.

Problems

The problems faced during training are; (1) similar background is required for training all sample face images, (2) limited lighting conditions, (3) scale need to be similar because different scales decreases performance quickly with changes to the head size, (4) different orientations.

Viola Jones Face detection Algorithm

In Face Recognition systems, Face detection and localization from images is the first step to detect the face. Improvement in Face Detection would lead to benefit of many applications. Viola and Jones proposed a method with which the face are detected accurately within an image. This method can be applied to different environment for different applications to accurately detect facial features. By dividing the area under detection, false positives are removed and the speed of detection is consequently increased due to the decrease in area examined for detection. Although there are many algorithms for Face Detection, each has its own pros and cons. These algorithms includes usage of flesh tones, contours, neural networks or filters. These algorithms are computationally expensive. Variations of shape and pigmentation will be there within a human face.

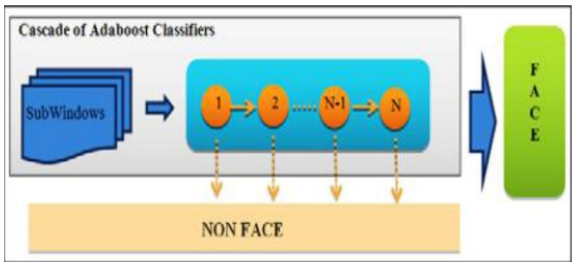


Figure: Viola jones working principle

Viola and Jones developed by using an algorithm called Haar Classifiers, to rapidly detect an object. AdaBoost classifier cascades works based on Haar-like features and

not on pixel values. To detect human facial features, requires to train the Haar classifier first. AdaBoost algorithm and Haar feature algorithms are used to implement for training images in the initial stage. Training the classifiers, two sets of samples are required. One image set contains a scene that does not having the object. This set of images are negative images. The other set of images, the positive images. It contains more similar properties of the object. The object within the positive images is located by the name of the image, height and width of the object, the upper left pixel. Separate classifiers were trained for each and every object which is going to detect in the frame. The object will be detected by the facial features once the classifiers were trained [13].

Neural Networks Methods

Neural Networks are the computing system which has a number of highly interconnected elements that process of dynamic state response by their external inputs. Neural Networks are commonly organized in layers that are containing an *active function* made up of a number of interconnected *nodes*. Input layer is used to present patterns to the network. This can communicate to one or more hidden layers through weighted connections [14].

Lowrence et.al has been proposed a hybrid neural network technique that is the combination of Local Image Sampling, (input –templates) *Self Organizing Maps* (SOM) and a CNN. SOM organizes a set of features which represents a robust representation of image samples [11]. These features from SOM then fed into the convolutional neural networks. Probabilistic Decision Based Neural Network was also introduced for face detection and recognition [www.cse.iitm.ac.in].

Training Feed Forward Networks

This algorithm is presented for nonlinear least squares. This is incorporated to train feed forward neural networks into back propagation algorithm. This is ANN where the units' connections do not for a *directed cycle* [pediaview.com]. There are two perceptron, ***Single Layer Perceptron.*** It consists of a one layer of output nodes. The inputs are directly fed via series of weights to the output nodes. Normally a perceptron can be generated activated and deactivated values. For creating the threshold value lies between 1and -1. More perceptron can result output as 0 thresholds for quick train. Perceptron may be trained learning algorithm which is called ***delta rule*** [www.idsia.ch]**.** Delta rule calculates the error from calculated output to sample output data, and uses this for creating adjustments for updating the weights. It is implemented in the form of *gradient descent*. ***Multi-Layer Perceptron*** consists of several layers of computational units; all neuron in one layer has been connected directly to the subsequent layer neurons. The most popular Multi- layer networks technique is back propagation. The drawback is, the network fails to capture true statistical process creating the data [www.idsia.ch].

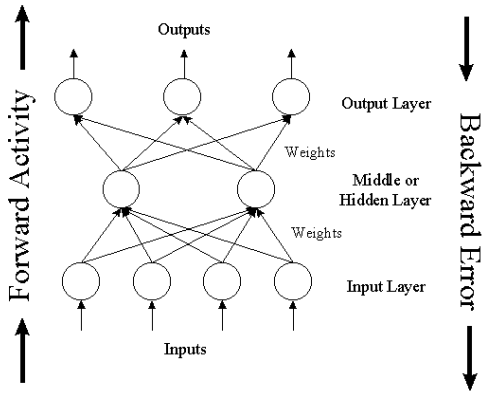


Figure: Feed Forward Neural Network

Transformation Invariance in Pattern Recognition
Statistical modelling or regression, the amount of data is a critical factor which affects the performance in pattern recognition. If the amount of data is unlimited, even optimal solution will be given by trivial algorithm. In practical case, by introducing prior knowledge given limited data, satisfactory performance needs sophisticated methods to organize the problem.

Performance Evaluation

Techniques used	Strength	Limitations
Wavelet Based Dominant Features	Extracting much information and very fast	This method is not sensitive in illumination Condition
Histograms Based Accurate Face Recognition	Simple technique	For Face Recognition histograms are not better tools and it is not fixed for different illumination conditions.
Principal Component Analysis	Fast and Accurate	Not giving correct result because of linear data if missing values are present
Kernel PCA	Fast extraction and execution, use iny real time applications	Time and memory consumption is low.
Sub window Extraction Algorithm	Recognition rate is high	Computationally expensive and time Consuming
Eigen faces and ANN	This method will collect more information	Some mismatch may occur because Eigen face is very hard to give good

		result for different head orientations.
Back Propagation Neural Networks (BPNN) with PCA [14]	Combining of PCA with BPNN, nonlinear images can be recognized easily with high recognition rate. [14]	Its accuracy rate will be affected by huge amount of data.
Face Detection in color images	Simple and fast, less memory consumption	Detecting skinny part as a part of face.
Face Recognition using Decision Tree Based LBP	Result is accurate	Incorporate weights for different kind of facial regions.
Simple Face Detection by Edges	This method efficiently removes background.	False acceptance rate will be presented.
Gabor Filters with Neural Network Based Face Recognition	It is a hybrid network than BPNN which takes few iteration to train images and time for recognizing faces is less [14].	Still false recognition problem occurs. 16% from the evaluation.
Artificial Neural Networks Based Robust Face Recognition	Computationally fast. For storing pictures and comparing is less time.	Decrease Recognition Rete.
Face Detection and Recognition using adaboost and PCA Algorithm [14]	It is fast and simple. Accuracy rate is high. This is used in Real Time Face Detection and Recognition Applications	PCA doesn't reduce dimensions if the link between two variables are very weak. [14]

Conclusion

This paper discusses the survey about the different approaches and techniques for face recognition. Even though Face Detection and Recognition is a challenging problem in the field of Computer Vision and many applications are received and has been done because of its various domains and applications [irdindia.in]. Researches have been conducted more and more for accurately detecting face and recognizing face in the past few years. The human face is difficult to identify, but with a configuration principle of facial features the target face can be identified. The ultimate goal of researchers in this area is to enable an automatic system to detect and recognize the particular person's face using some computer vision algorithms.

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