Face Recognition a Review

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Abstract— Face recognition is a very popular topic in research application of pattern recognition and computer vision. In recent years face recognition has received substantial attention from both research communities and the market, but still remained very challenging in real applications. A lot of face recognition algorithms, along with their modifications, have been developed during the past decades. Real-world face recognition systems require careful balancing of three concerns: computational cost, robustness, and discriminative power. The Objective is to implement, test and compare performance of the various 'Pattern Classification Algorithms' on different facial features and to come up with a quantitative analysis of effectiveness of Algorithms in different scenarios. This paper provides a holistic approach towards the technology, various application, standard and challenges that are faced in face recognition.

Keywords—Feature extraction, Face detection, Face recognition.

I. INTRODUCTION

Face recognition is a highly active area of research with a wide variety of real-world applications, and in recent years a clearly defined face-recognition pipeline has emerged. Face recognition systems are an important field in computer vision and are currently used to monitor for dangerous persons and track criminals. A face recognition system uses a database of images and compares another image against those to and a match, if one exists. This face recognition pipeline has four main stages: detection, or finding where the faces are in an image; representation or feature description transforms the aligned faces into some representation emphasising certain aspects; and classification, which determines whether a certain face matches a target face or a model [1]. Good face representations are those which minimise intra-person dissimilarities (i.e., the differences between face images of the same person due to variations of illumination, pose) whilst enlarging the margin between different people. This is a critical issue, as variations of pose, illumination, age, and expression can be larger than variations of identity in the original face images.It is widely applied in artificial intelligence, video surveillance, identity authentication, human-machine interaction and so on. There are several challenges in face recognition like different poses, expression, background and illumination conditions to name a few, because of which the task become difficult.

Overall aim of our work is the production of face recognition systems for surveillance applications, which imposes extra constraints upon the design of both the descriptor and classification stage [1]. Specifically:

1. The system should be robust to variations in lighting, pose, image quality, and age.
2. Execution time should be fast: The face representation must be fast to extract, and the classifier must also be fast.
3. Extraction and matching must be automatic: There should be no need for hand labelling (of, for example, facial features).
4. The solution must be scalable: In particular, adding new faces to the database should not require re-training.
5. The system should not rely on external data: Systems which require a large set of ''negative faces'' (that is, faces which are guaranteed to not appear as a target) are impractical for surveillance purposes. We can never be 100% sure that a particular person will not appear in the surveillance domain.
6. The system should be able to work with just one gallery image: Within a surveillance context, sometimes very limited information is available about targets.

Stages of Face Recognition

(1) Face detection
(2) Feature extraction
(3) Facial recognition

I.I FACE DETECTION

As one of the most important external features of people, face plays an extremely important role in interpersonal communication. Face detection, as a critical aspect of automatic face recognition system, is in the spotlight [2]. The purpose of face detection is to determine whether the image judge exists human faces, and if exists, then return to the face's spatial location and separate them from the background.

I.I.I APPROACHES FOR FACE DETECTION

- *Knowledge-based methods*:

  These are rule-based methods. They try to capture our knowledge of faces, and translate them into a set of rules. It's easy to guess some simple rules. A face usually has two symmetric eyes, and the eye area is darker than the cheeks [3]. Facial features could be the distance between eyes or the colour intensity difference between the eye area and the lower zone.

- *Feature invariant approaches*:
  Algorithms that try to find invariant features of a face despite its angle or position. The idea is to overcome the limits of our instinctive knowledge of faces.

- *Template matching*:

  Template matching methods try to define a face as a function. We try to find a standard template of all the faces. Several standard patterns stored to describe the face as a whole or the facial features separately. Different features can be defined independently.

- *Appearance*-based methods:

  Appearance-based methods rely on techniques from statistical analysis and machine learning to find the relevant characteristics of face images. Some appearance-based methods work in a probabilistic network. An image or feature vector is a random variable with some probability of belonging to a face or not. The models are learned from a set of training images that capture the representative variability of faces.

I.II FEATURE EXTRACTION

Feature extraction process can be defined as the procedure of extracting relevant information from a face image. This information must be valuable to the later step of identifying the subject with an acceptable error rate. The feature extraction process must be efficient in terms of computing time and memory usage [3]. A feature extraction algorithm extracts features from the data. It creates those new features based on transformations or combinations of the original data.

I.III FACE RECOGNITION

Face recognition is an evolving area, changing and improving constantly. Many research areas affect face recognition - computer vision, optics, pattern recognition, neural networks, machine learning.

I.III.I DIFFERENT APPROACHES FOR FACE RECOGNITION

- *Geometric/Template Based approaches:*

  The template based methods compare the input image with a set of templates. The set of templates can be constructed using statistical tools like Support Vector Machines (SVM), Principal Component Analysis (PCA), Linear Discriminant Analysis (LDA), Independent Component Analysis (ICA), Kernel Methods etc.

- *Piecemeal/Wholistic approaches;*

  The relation between the features or the relation of a feature with the whole face is not taken into account. Many early researchers followed this approach, trying to deduce the most relevant features. Some approaches tried to use the eye, a combination of features, and so on. Some Hidden Markov Model (HMM) methods also fall in this category.

- *Appearance-based/Model-based approaches;*

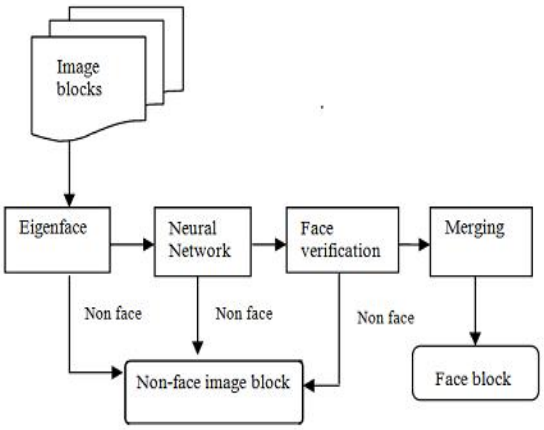
  Appearance-based methods represent a face in terms of several raw intensity images. An image is considered as a high-dimensional vector. Then statistical techniques are usually used to derive a feature space from the image distribution. The sample image is compared to the training set. On the other hand, the model-based approach tries to model a human face. The new sample is fitted to the model, and the parameters of the fitted model used to recognize the image.

Face detection was included as an unavoidable pre-processing step for face recognition and as an issue by itself, because it presents its own difficulties and challenges, sometimes quite different from face recognition. We have soon recognized that the amount of published information is unmanageable for a short term effort, such as required of a PFC, so in agreement with the supervisor we have stopped at

a reasonable time, having reviewed most conventional face detection and face recognition approaches, leaving advanced issues, such as video face recognition or expression invariances, for the future work in the framework of a doctoral research [3].

II. FACE DETECTION USING EIGENFACE AND NEURAL NETWORK

In this paper, we propose a hierarchical face detection system which cascades the eigenface algorithm, the neural network, and a simple face verification scheme [4]. The eigenface algorithm is used to search the candidates of the face regions. Then these candidates are examined by a neural network. The template based face verification method is used to confirm each face region from the output of the neural network. The face regions of different images which were taken in dissimilar conditions, e.g. light, background, and face to camera distance, may cause varied appearances of faces.



$$\psi = \frac{1}{M}\sum_{n=1}^{M} I_n$$

And the mean-adjusted image can be defined as

Φn= In-ψ, for n= 1, 2, …M.

Let C denote the covariance matrix and be defined as

$$C = \frac{1}{M}\sum_{n=1}^{M} \Phi_n \Phi_n^T$$

The neural network with the back-propagation algorithm is adopted as the second part of our face detection system. The projection weights of the face and non-face blocks are computed and used as the positive and negative training vectors of the neural network, respectively. In our system, the neural network consists of a hidden layer with nine hidden nodes. We design a simple face verification method to remove these false detection blocks. The main idea of the verification scheme is to consider the distribution of the edge points from the general facial features.

RESULT: The neural network is combined with the eigenface algorithm and a template based face verification method. According to the experimental results, our system produces a high detection rate with a small number of false detection

III. FACE DETECTION USING SCS-PCA

One of the most significant features of human face's surface is skin colour, for the colour image, skin colour is the relatively concentrated; stable region in the image. It's better to distinguish human face from background regions by the skin colour**.** In this paper, a new face detection algorithm is introduced, which combined the skin colour segmentation and the Principal Component Analysis (PCA), named SCS-PCA [5].

Skin color segmentation mainly refers to two aspects content color space and skin color model.

Color Space

Skin color has its own characteristics, which can form the different expression in the different color space. Therefore, it makes the computer has different the skin color identification ability and treatment effect in different color space. The main color space has RGB, CMY/CMYK, YCbCr, HIS (HSV), YIQ, and YUV and so on. This paper will describe the skin color model with YCbCr color space, because the YCbCr space has the similar composition principle with humanity's visual perception process.

The conversion formula from the RGB space to the YCbCr space [5] is as follows:-

$$\begin{bmatrix} Y \\ Cb \\ Cr \\ 1 \end{bmatrix} = \begin{bmatrix} 0.2990 & 0.5870 & 0.1140 & 0 \\ -0.1687 & -0.3313 & -0.5000 & 128 \\ 0.5000 & -0.4187 & -0.0813 & 128 \\ 0 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \\ 1 \end{bmatrix}$$

Skin color model is one model that it needs to use the algebra (analysis) or look-up table forms to express which pixel's color belongs to the skin color, or express the similar degree between pixel's color and skin color. This paper will use skin color Gaussian model, which is not simply binary skin color location, but by computing pixel's probability value, constituting continual data information, then obtain a skin color probability chart, confirm the color according to the numerical magnitude.

The expression of skin color distribution two-dimensional Gaussian function is:

$$P(C_b, C_r) = \exp\left[-0.5(x-M)^T C^{-1}(x-M)\right]$$

Where: x for the sample pixel in the YCbCr color space's value, M is the skin colour's sample mean in the YCbCr color space, C is the skin color similarity model's covariance matrix,

M and C are obtained through the statistical computation to the massive skin color sample.

$$\begin{cases} x = [Cb, Cr]T; M = E(x) \\ C = E((x-M)(x-M)T) \end{cases}$$

Face detection algorithm based on feature subspace is mapped face image to one certain feature space, and then distinction between the face mode and non-face mode according to the distribution law in feature subspace. The commonly used algorithm is Principal Component Analysis (PCA), also known as eigen-face method.

SCA-PCA Algorithm process utilize skin color segmentation do the rough detection got the candidate face region, magnified the threshold value appropriate to avoid missing detection in the course of rough detect and allow a certain degree of false detection, then to regard candidate face region as the input, through the PCA method to find out the feature face space, and use eigen-face Vector to expression each sample in the face database, towards a new sample work out the space distance between it and the face database.

RESULT: In this paper, through in-depth study and analysis skin color segmentation and feature face algorithm these two kinds of face detection method, the novel face detection method was introduced, which integrates these two kinds of classifier face detection. The experiment results show that the method mentioned in this paper reduces the false detecting rate increases the detection rate at the same time.

IV. FACE A NOVEL FACE RECOGNITION APPORACH USING NORMALIZEDUNMATCHED POINTS MEASURE

Here propose a new powerful measure called Normalized Unmatched Points (NUP) to compare gray images and discriminate facial images. NUP works by counting the number of unmatched pixels between two images after they have been suitably pre-processed.

Face recognition is an intricate visual pattern recognition problem which can be operated in these modes:-

a. Face verification that compares a query face image against a template face image whose identity is being claimed.
b. Face identification that compares a query face image against all the template images in the database to determine the identity of the query face.
c. Watch list that compares a query face image only to a list of suspect.

Huttenlocher and Rucklidhe et al [8] proposed the Hausdroff Distance (HD) and Partial Hausdorff Distance (PHD) measures to compare images. Hausdroff distance makes it suitable for face recognition because such distortions occurs frequently in facial images and are usually caused due to slight variation in pose and facial expressions.

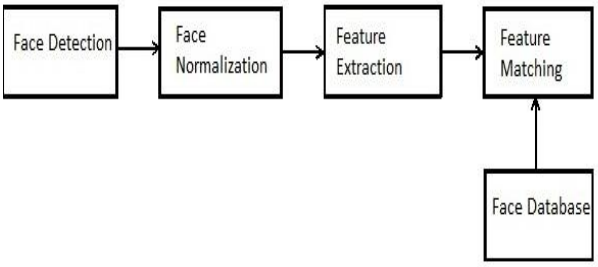


Fig. 2 Face Recognition System

The face recognition approach based on NUP measure is different from existing Hausdroff distance based methods as it works on gt-transformed images that are obtained from gray images rather than edges images. Thus, this approach can achieve the appearance based comparison of faces. An algorithm is also presented to efficiently compute the NUP measure.

Let A= {a1, a2, a3, ..., am} and B= {b1, b2, b3, ..., bn} be two set of points then, undirected Hausdroff distance [8] between A and B is defined as:

$$HD(A, B = HD(B, A) = \max\left(hd(A, B), hd(B, A)\right)$$

Here hd(A,B) is the directed Hausdroff distance defined by:

$$hd(A, B) = \max_{a \epsilon A} \min_{b \epsilon B} \|a - b\|$$

RESULT: Normalized Unmatched Points (NUP) has been proposed to compare gray facial images. This approach can achieve the appearance based comparison of faces. The NUP measure is computationally inexpensive and provides good performance levels.

V. CONCLUSION

Face recognition is still a very challenging topic after decades of exploration. A number of typical algorithms are presented, being categorized into appearance-based and model-based schemes. We conclude with the fact that our integrated approach to the detection, recognition and learning of human faces can be modelled to the detection and recognition of any generic object. Our detections and recognition results, independently, are extremely competitive to the best detection and recognition results published. Face recognition is a technology just reaching sufficient maturity for it to experience a rapid growth in its practical applications.

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