Multiple Faces Authentication in Video Security System

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Abstract

Face recognition for security camera is currently far from practical and many problems need to be solved before it can approach the capability of the human perception system. The task is challenging as the overall similarity of all human faces accompanied by large differences between face images of the same person due to image capture variations such as changes in lighting, view point, head pose, and facial expression. Moreover, the differences between images of the same face due to these nuisance variations can be much greater than those between images of different faces. Face recognition on still images is the first step for this study and try to examine the ability to identify and label the elements of a scene. The main objective of this paper is to specify an object especially faces using the image segmentation and object recognition approaches.

Keywords: face detection, image recognition, image segmentation

1. Introduction

User identification schemes based on passwords, secret codes or identification cards have been widely used for security purpose many years ago. Authentication process is becoming a regular routine in our lives. If anyone knows the password, the person can gain access to the resources. If the scheme used in a system is based both on a card and a password, the intruder would need to apply more effort to gain entry to the system, and with more advanced technologies. By using with biometric information for authentication becomes popular. It is the most secure and convenient authentication tool. It cannot be borrowed, stolen or forgotten, and produce a fraudulent copy one is practically impossible. Biometrics measures each person's unique physical or behavioral characteristics to recognize or authenticate their identity.

Technologies that use biometrics have the potential for application to the identification and verification of individuals for authentication to secured areas. A lot of biometric techniques are being developed based on different features and algorithms. This includes recognition of voice, fingerprints, hand shape, retinal scans, handwritten signatures, etc. Among them automated face recognition is also another alternative for noninvasive verification and identification of people.Most current face recognition systems only work well on controlled still images with images taken under very constrained conditions. Compared to still images, recognition using CCTV images is much more difficult due to the considerably worse quality of images. In addition, real-time recognition imposes time limits on the processing that can be done on each image. For surveillance applications, a potentially useful ability is the automatic inference on identity from face images. Smart camera can be used in many various applications e.g. in the quality control, object classification, static and dynamic event recognition, emergency situation recognition,Optical Character Recognition (OCR), face recognition and more.

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2. Face Detection Methods

In some cases, face images stored in the data bases are already normalized. There is a standard image input format, so there is no need for a detection step. However, the conventional input images of computer vision systems are not that suitable. They can contain many items or faces. In thesecases face detection is mandatory. Face detection methods can be classified as the following:

1. Knowledge-based methods: Ruled-based methods that encode our knowledge of human faces.^
2. Feature-invariant methods: Algorithms that try to find invariant features of a face despite its angle or position.^
3. Template matching methods: These algorithms compare input images with stored patterns of faces or features.^
4. Appearance-based methods: A template matching method whose pattern database is learnt from a set of training images.
5.

3. Face Recognition Methods

Face recognition uses the spatial geometry of distinguishing features of the face. It is a form of computer vision that uses the face to identify or to authenticate a person. The current face recognition techniques can be classified into four main categories based on the way these represent the face:

1. Appearance based, which uses holistic texture features.
2. Model-based, which employs shape and texture of the face, along with the 3D depth information.
3. Template-based face recognition.
4. Techniques using neural networks.

Appearance based face recognition

The faces are stored as two-dimensional intensity matrices. Each image is represented in a high vector space, i.e. a point in a high-dimensional vector space. In order to identify the different faces, an efficient and effective representation (feature space) is derived, depending on the application of interest. Given a test image, the similarity between the stored prototypes and the test image is then carried in the feature space. This technique is further classified into Linear (subspace) Analysis and Nonlinear (manifold) Analysis.

Linear (Subspace) Analysis

Principle Component Analysis(PCA), ICA and LDA are classical linear subspace analysis techniques used in face recognition. Each classifier has its own representation of high-dimensional face vector spaces called basis vectors. For each case, the basis vectors are formed according to some statistical considerations. After forming the basis vectors from the face database, faces are then projected onto the basis vectors to get a feature vector. The matching score between the projected test image and the projected training images is calculated. This matching score is inversely proportional to the distance between the projected test image and the projected training images. The larger the matching score, the better the match is.

Nonlinear (Manifold) Analysis

The nonlinear manifold is more complicated than linear models. Actually, linear subspace analysis is an approximation of this nonlinear manifold. Direct nonlinear manifold modeling schemes are explored to learn this nonlinear manifold. In what follows, Kernel Principal Component Analysis (KPCA) is introduced as an example of nonlinear analysis.

Model-based face recognition

This approach uses a model of the face to perform recognition. The model is formed from prior knowledge of facial features. A recent technique developed by Wiskott and *et al.* is the elastic bunch graph matching technique. Also, Cootesand *et al.*, by integrating both shape and texture, developed a new technique called the 2D morphable face model, which measures face variations. A more advanced 3D morphable face model has also been explored to capture the true 3D structure of the human face surface.The model-based approach usually involves three steps:

1. Developing the face model.
2. Fitting the model to the given facial image.
3. Using the parameters of the fitted model as the feature vector to calculate the similarity betweenthe query face and prototype faces from the database and perform the recognition.

Template-based face recognition

Template matching involves the use of pixel intensity information, either as original gray-level or processed to highlight specific aspects of the data. The template can either be the entire face or regions corresponding to general feature locations, such as the eyes or the mouth. Cross correlation of test images with all training images is used to identify the best match. The template matching strategy was based on earlier work, except that they automatically detected and used feature-based templates of mouth, eyes and nose, in addition to the whole face image.

4. Process Flow of Face Recognition

A complete biometric recognition system comprises both hardware and software; the hardware collects the data, and the software interprets the data and evaluates acceptability and accessibility. An important difference with other biometric solutions is that faces can be captured from some distance away, with for example surveillance cameras. A facial recognition system is a computer application for automatically identifying or verifying a person from a digital image or a video frame from a video source. One of the ways to do this is by comparing selected facial features from the image and a facial database. The architecture of the object recognition system is shown in Figure 1.

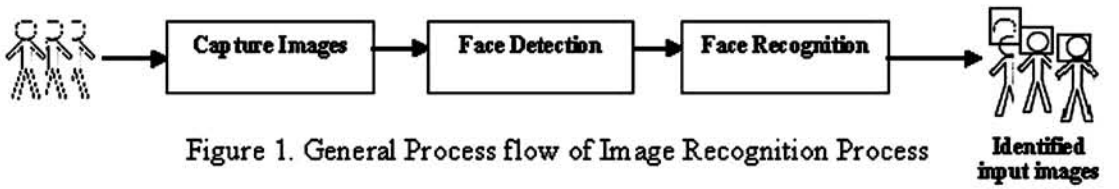

Figure 1. General Process flow of Image Recognition Process

5. Methodology

The Viola-Jones face detector

The Viola–Jones object detection framework is the first object detection framework to provide competitive object detection rates in real-time proposed in 2001 by Paul Viola and Michael Jones. There are three main steps of this face detectionframework.

1. "Integral Image" which allows the features used by our detector to be computedvery quickly.
2. "AdaBoost learning algorithm" is a simple and efficient classifier which is built to select a small number of critical visual features from a very large set ofpotential features.
3. "Cascade" which allows backgroundregions of the image to be quickly discarded while spending more computation on promising face-likeregions.

The simple features used are reminiscent of Haar basis functions which have been used by Papageorgiou et al. (1998). There are three kinds of features they are a two-rectangle feature, a three-rectangle feature and a four-rectangle feature as shown in Figure 2.Each feature results in a single value which is calculated by subtracting the sum of the white rectangle(s) from the sum of the black rectangle(s).

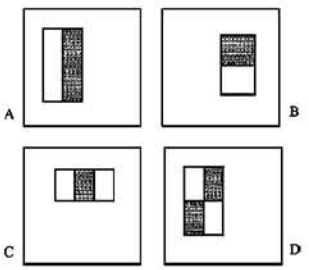

Figure 2. Example rectangle features shown relative to the enclosing detection window. The sums of the pixels which lie within the white rectangles are subtracted from the sum of pixels in the grey rectangles. Two-rectangle features are shown in (A) and (B). Figure(C) shows a three-rectangle feature, and (D) a four-rectangle feature.

Integral image

Rectangle features can be computed very rapidly using an intermediate representation for the image which we call the integral image. The integral image at location x, y contains the sum of the pixels above and to the left of x, y, inclusive:

$$h(x,f,p,\theta) = \begin{cases} 1 & \text{if } pf(x) < p\theta \\ 0 & \text{otherwise} \end{cases} \quad ii(x,y) = \sum_{x' \le x, y' \le y} i(x',y')$$

Where ii (x, y) is the integral image and i (x, y) is the original image.

AdaBoost learning algorithm

The second step is constructing a classifier in order to select a small number of important features using AdaBoost learning algorithm. AdaBoost is a machine learning boosting algorithm capable of constructing a strong classifier through a weighted combination of weak classifiers. A weak classifier is calculated by the following equation:

Where x is a 24*24 pixel sub-window of an image, f is the applied feature, p indicates the direction of the inequality, and θ is a threshold that decides whether x should be classified as a positive (a face) or a negative (a non-face).The final strong classifier is obtained after applying the Adaboost algorithm.

Cascaded classifier

The cascaded classifier is used to determine whether a given sub-window classifier is definitely not a face or maybe a face. The cascaded classifier is composed of stages in which each consists of a strong classifier. The concept is illustrated with two stages in Figure3.

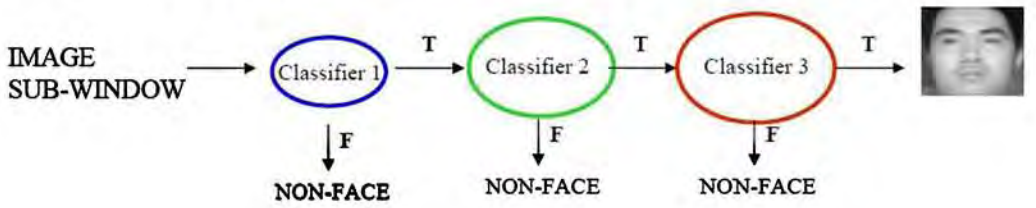

Figure 3. Schematic diagram of the face detection cascade

A series of classifiers are applied to every sub-window. The initial classifier eliminates a large number of negative examples with very little processing. Subsequent layers eliminate additional negatives but require additional computation. After several stages of processing the numbers of sub-windows have been reduced radically.This algorithm is implemented in OpenCV as cvHaarDetectObjects ().

Principle component analysis (PCA)

PCA method has been widely used in applications such as Facerecognition and image compression. PCA is a common technique for finding patterns in data, and expressing the data as eigenvector to highlight the similarities and differences between different data. The following steps summarize the PCA process.

1. Let {D1,D2,...DM} be the training data set. The average Avg is defined by:

$$Avg = \frac{1}{M}\sum_{I=1}^{M} D_I$$

2. Each element in the training data set differs fromAvg by the vector $Yi=Di-Avg$. The covariance matrix Cov is obtained as:

$$Cov = \frac{1}{M}\sum_{I=1}^{M} Y_I . Y_i^T$$

3. Choose M' significant eigenvectors of*Cov* as *EK's*, and compute the weight vectors W_{ik} for each element in the training data set, where k varies from 1 to M'.

$$W_{ik} = E_k^T(D_i - Avg)$$

6. Distance Measure

Themostpopulardistancemeasureis Euclideandistance.Let $i = (x_{i1}, x_{i2}, \ldots, x_{ip})$ and $j = (x_{j1}, x_{j2}, \ldots, x_{jp})$ between objectsdescribedby p numerical attributes.TheEuclideandistancebetweenobjects i and j isdefinedas

$$d(i,j) = \sqrt{(x_{i1} - x_{j1})^2 + (x_{i2} - x_{j2})^2 \ldots (x_{ip} - x_{jp})^2}$$

Implementation of face recognition process

The prototype was developed for face detection and recognition. This system can detect the faces; extract features recognize the identity of the face. The process flow of the face recognition system was as shown in Figure 4.

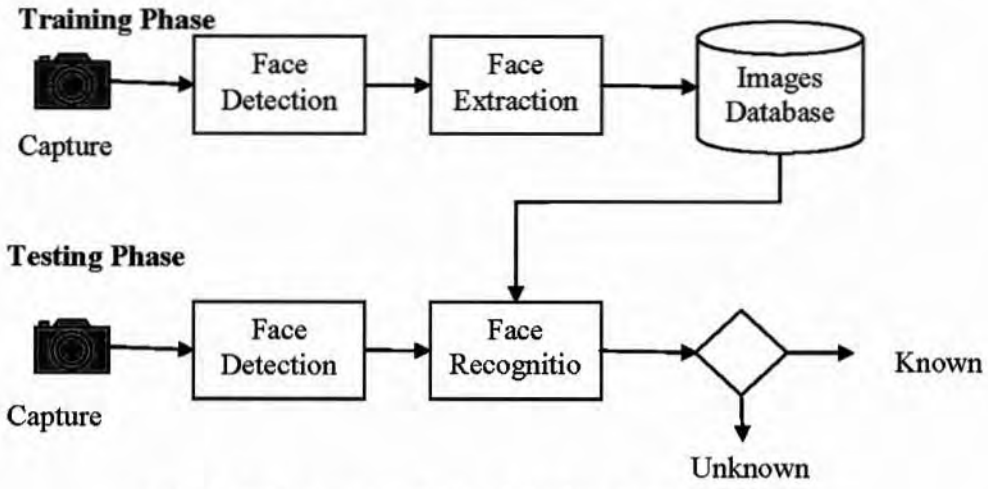

Figure4. The process flow of the face recognition

For the training phase, input may be either photo or video stream. The image was detected by Viola–Jones face detection algorithm to extract face. The extracted face and their respective name were stored in image database for further use as shown in Figure 5. For the testing phase, after the unknown image was entering to the system, faces were detected and extracted. The extracted faces are recognized by PCA algorithm by comparing with existing image database to decide whether known or unknown faces.

(a) (b)

Figure 5.(a) Training phase, (b) Testing phase

7. Evaluations

Face detection is the first step of the face recognition system. The performance of the entire face recognition system is influenced by the reliability of the face detection. Evaluation was emphasized on face detection. The tests were performed using images which are randomly chosen in various pose, lighting with same dimension. The images include a group photos with three, four, five and six and above group of peoples. The face recognition algorithm shows 97% accuracy for three people's images detection, 90% accuracy for four people group images, 68% accuracy for five people's images and 76% accuracy for six and above people in the test images. The face detection algorithms can be applied to images or video frames. The algorithm cannot recognize the 60~90 degree angle face. The algorithm can recognize 98% if there is only one face or people in the image that was frontal view. This is the essential for the small skill authentication system.

Table 1. Average accuracy for face detection for each image group

Test ID	Average Accuracy
Test 1	97%
Test 2	90%
Test 3	68%
Test 4	74%

Test 1Face detection result for images with three people in each.

Test 2 Face recognition result for images with four people in each.

Test 3 Face recognition result for images with five people in each.

Test 4 Face recognition result for images with six and above people in each.

Face recognition algorithms' results depend completely on the face images collected for creating the training set. Training sets are especially sensitive to the following properties of the face images: Lightning on the face (direction/intensity), Face expression (sad, angry, wink, etc) and make-up, Position of the face (rotation or tile), Image quality. To recognize and identify the input faces more efficiently, it is important to get more efficient training set.

Because of the experiments were conducted using recognition under various lighting, scale and orientation, the result may vary. One issue to consider is a significantly different background will adversely affect recognition, as the algorithm cannot distinguish between face and background. The size of the face may also play a major role in the recognition rate. The detection algorithm gives an idea of the face size, but may not always be correct. The main issues associated with the human face detection problem are as follows:

- We need to consider in lighting conditions.
- There have different facial expressions.
- The particular position of an individual face.
- The background images and colors.

To reduce those problems, we need to go future study to fine appropriate algorithms to get better recognition.When a high level of security is needed, authentication factors with biometrics techniques are recommended.The developed system was not suitable where number of people is large. It is convenient to use user accounts in an operating system for members of an office or a family where number of people is small.

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