Semi Automatic Approach to Face Recognition from Facial Expression

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Abstract

Face recognition (FR) is a very challenging problem and up to date, there is no technique that provides a robust solution to all situations and applications that face recognition may encounter. This paper proposes a face recognition system which considers a grey scale image from frontal side. Face recognition and facial expression recognition are carried out using maximum likelihood. Facial appearance matching is improved by facial expression matching. We present semiautomatic approach to face recognition from facial expressions. The goal of the work presented here in, is to develop face recognition techniques by using statistical analysis for preprocessing step and a probabilistic model for classification step. In our current implementation, the face is divided into 16 facial feature points by using bounding box.

Keywords: Face recognition (FR)

1. Introduction

Face recognition is one of the biometric identification by scanning a person's face and matching it against a library of known faces. Though people are good at face identification, recognizing human face automatically by computer is very difficult. Face recognition is not only one of the most challenging computer vision problems but also has many commercial and law enforcement applications [1]. Face recognition has been widely applied in security system, credit-card verification, and criminal identifications, teleconferences and so on. Face recognition is influenced by many complications, such as the differences of facial expression, the light directions of imaging, and the variety of posture, size and angle. Even to the same people, the images taken in different surroundings may be dissimilar. Facial Feature extraction has become an important issue in recognition of human faces [4].

In recent years, several face recognition systems have been presented by many researches with large variations concerning preprocessing, feature extraction, inter pattern representation and of course classification. The numerous presented systems show different capabilities and strengths in aspects of recognition performance [10]. The face recognition problem is usually approached into one of two ways [5]:

Face recognition (identification)

Given a probe face-image and a gallery of class-labeled faces, find the correct class-label for the probe image. In other words; "Who am I?"

Face verification (authentication)

Given a class-labeled probe face-image, decide if the probe image has a correct class-label. In other words; "Confirm that I'm a person X"

A typical face recognition system includes the following steps: (1) extract human face area from images, i.e. detect and locate face; (2) find a suitable representation of the face region; (3) classify the representations. In my research, after the facial features are extracted, the classification of the face can be performed using the distance of these features [2]. Facial expression is one of the most powerful, natural, and immediate mean for human beings to communicate their emotions and intentions. Current approaches to facial expression analysis typically attempt to recognize a small set of prototypic emotion [11]. Six basic expression classes i.e. joy, surprise, anger, sadness, fear and disgust, defined by Ekman [3], often used.

It is very difficult to recognize the expression in very low intensity. In most real world interactions, the facial feature changes are caused by both talking and expression changes. More accurate results will be achieved if the system can detect talking in a higher level and only performs the expression recognition procedure for the images only content expression changes [8]. The goal in most face recognition approaches is to find a similarity measure invariant to illumination changes, head pose and facial expressions, so that images of faces can be successfully matched in spite of these sources of variation [10]. On the other hand, the goal of expression recognition is to find a model for non-rigid patterns of facial expression, so that expressions can be classified in spite of a wide range of variation.

Although there has been a great deal of research on the subject of facial motion analysis from image sequences, face recognition research has been focused on still images.

Face recognition approaches on still images can be broadly grouped into geometric and template matching techniques. In the first case, geometric characteristics of faces to be matched, such as distances between facial features, are compared. The feature based approach searches the image for a set of facial features and group them into face candidates based on their geometrical relationship [2]. Most approach for the classification of expressions from image sequences are based on neural networks, rule-based models, template base-methods using the maximum-distance classification, gabor wavelets, statistical models using discriminant function analysis, or probabilistic models such as hidden Markov Models [9]. Face recognition systems can achieve high recognition rate for good quality, frontal view, constant lighting and only subtle expression or expressionless face images [6].

In this paper, we propose a “Statistical Approach” in which face models jointly capture information about facial appearance and expression patterns so that recognition of faces and facial expression recognition cooperate so that the similarity measure used for face recognition benefits from facial expression.

2. System Architecture for Face and Facial Expression Recognition

In order to perceive and recognize human faces, we must extract the prominent characteristics on the face.

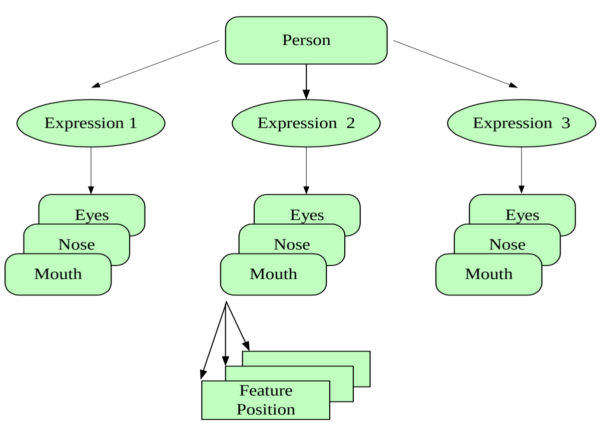

Figure 1. System Design of Face Recognition and Facial Expression

3. Overview of Semi-automatic Process of Face Ratio Computation

The semiautomatic process can be divided into three major steps. The first stage is feature detection. The second includes the computation of Euclidean distances and ratio. The final stage is statistical computation and output the results.

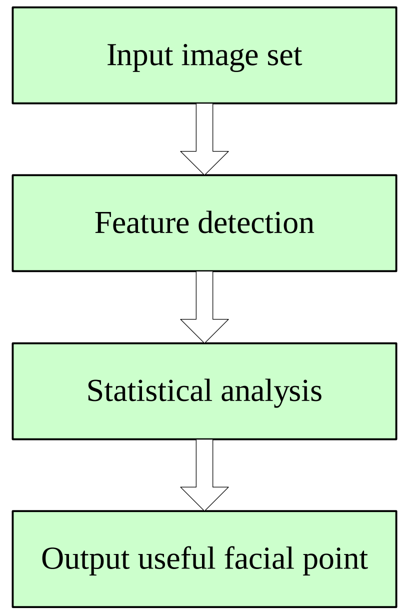

Figure 2. The semiautomatic process of face ratio computation

There are some limitations in our system.

- Attempt to recognize face image from data collected with a high resolution frontal faces (face region greater than or about 200x200 pixels.
- We will use some manual preprocessing

4. Head Pose Detection

There are 3 head pose classes.

Frontal or near frontal view

In this view, both eyes and lip corners are visible.

Side View or profile

In this view, at least one eye or one corner of the mouth becomes self occluded because of the head turn.

Others

All other reasons cause more facial features to not be detected such as the back of the head, occluded face, and face with extreme tilt angles.

Table 1. The definition and examples of the 3 head pose classes: (1) frontal or near frontal view (2) side view or profile (3) other such as back of the head or occluded faces.

Poses	Frontal (Near frontal)	Side view (Profile)	Others
Definitions	Both eyes and lip corners are visible	One eye or one lip corner is occluded	Not enough facial feature

5. Datasets of Facial Images

To develop the face recognition system, we construct our own face database from some staff from UCSY. We select only the frontal images. Slight face rotation is allowed. The angle of acquisition is not known exactly but it varies between 25° and 45°, and some facial expression. To ensure that the location of the features can be detected precisely, we have some limited constraint such as not wearing glasses, without beards, etc. This constraint is very typical in face recognition. All images in research should be taken under good lighting conditions. The files are all in JPEG format, approximately 256x256 pixels.

Figure 3. Example images used in our research

We use only the gray-scale images. If the input images are chromatic, we need to change them to gray-scale images.

6. Image Pre-processing

Pre-processing steps are biologically motivated and serve the purpose of data reduction, removal of redundancies, and speed-up of parameter searches. The key to the recognition is feature extraction and it reduces redundant information which is not concern as the attributes of the face. In our research, we choose only 16 feature points.

6. 1. Locating the Face Area

Firstly, we locate the general area of face from the whole image. According to the prior knowledge of human faces, the face area can be matched by the normalized as shown in Fig. In fact, the sub-image and model used to math is relatively small, so as to make it robust to the change of scale and rotation of the image and accelerate the matching of face model.

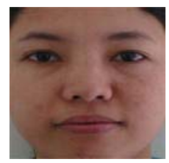

Figure 4. Normalize face

6.2. The Feature Point on Human Face

Applying human visual property in the recognition of faces, people can identify face from very far distance, even the details are vague. Human face is made up of eyes, nose and mouth and chin etc. There are differences in shape, size and structure of those organs, so the faces differ in thousands of ways, and we can describe them with the shape and structure of the organs so as to recognize them. One common method is to extract the shape of the eyes, nose and mouth and then distinguish the faces by distance and scale of those organs.

We can tell the characteristics of the organ easily by locating the feature points from a face image. If we normalized the characteristics which have the properties of scale, translation and rotation invariance, we can normalize the face in the database through pretreatment, so as to extend the range of database, reduce the storage and recognize the faces more effectively.

Additionally, the selection of face feature points is crucial to the face recognition. We should extract the feature points which represent the most important characteristics on the face and can be extracted easily. The number of feature points should take enough information and not be too many. If the database has different postures of each people to be recognized, the property of angle invariance of the geometry characteristic is very important.

In our research, after estimating the head pose, the facial features are extracted only for the face in frontal view or near frontal view. We observe that most facial feature changes that are caused by an expression are in the area of eyes, brows and mouth.

We select 16 feature points from gray-scale image. Fig. 1 shows their locations. The points are all in the middle of the rectangle sides., including 8 from eyes, 2 from nose and 6 from the mouth as shown in figure( ).

In feature detection step, feature location must be extracted precisely before we can measure the distances and their ratio among different facial points. We might identify each point by hand.

To detect the main components of frontal face including the eyes, the nose and both the upper and lower lips, we set up a semiautomatic approach. To improve the detection accuracy, the semiautomatic process needs some constraint working environment. We examine human facial images by measuring the Euclidean distances among different feature points.

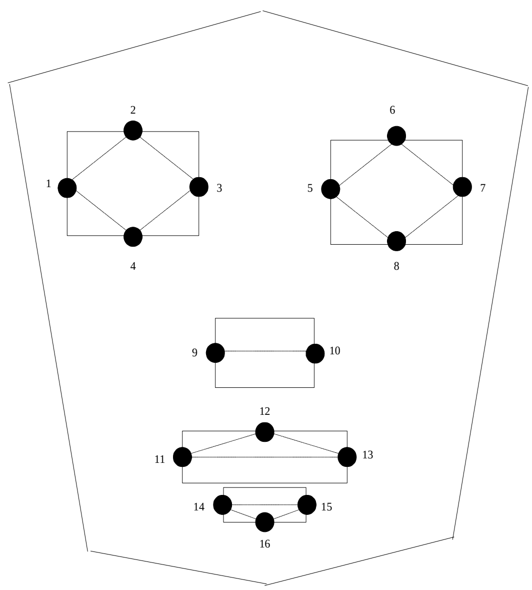

Figure 5. Feature points use in facial ratio computation

Algorithms:

Step 1: we find the center of feature point

Step 2: we translate each feature point with center points.

Step 3: We normalization about the size

Step 4: We normalization about the angle.

Finally we calculate the mean and standard deviation of each face image in different facial appearance and facial matching.

7. Modeling Facial Appearance (Statistical Computation)

Consider $P_1,P_2,P_3,\ldots,P_{16}$ be sixteen feature points from a face image. Then we can find the center(C) between the feature points in x-y co-ordinate by the following equation.

$$C = \frac{P_1 + P_2}{2}$$

7.1 Translation

Translation is to change a point with co-ordinates (P_1, P_2, ..., P_{16}) to a new location. We can compute the new positions of the sixteen feature points from the new center point (C) as the following.

$$P_i' = P_i - C$$

where i = 1,2,3,…,16.

7.2 Normalize about size of image

We can solve the normalize face from the following equation

$$Pi'' = \frac{Pi'}{D_{17}}$$

Where D_{17} is the distance between feature point P_1 and P_7.

7.3 Euclidean distance

Let us consider feature point P_1 is in (x_1,y_1) and P_2 in (x_2,y_2). We can get the Euclidean distance D_{17} from the following equation

$$D_{17} = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

7.4 Rotation

To rotate a point about another arbitrary point in space requires three transformations. The first translates the arbitrary point to the origin, the second performs the rotation and the third translates the point back to its original position.

The rotation of angle θ is measured in clockwise direction when looking at the origin from a point on the +Z axis. The transformation affect only the values of X and Y co-ordinate. In this paper, we can use the normalization angle by using point P_1 and P_7. we can get θ by using point P_1 and P_7 , where P_1 point is in co-ordinate (x_1 , y_1) and P_2 point is in (x_2 , y_2) , we get tan θ from the following equation

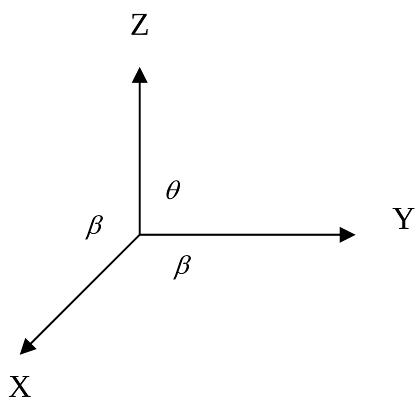

Figure 6. View angle in a plane

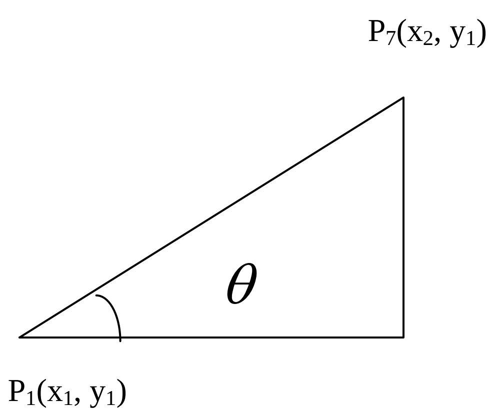

Figure 7. Angle between Feature Point P1 and P7

$$\tan\theta = \frac{y_2 - y_1}{x_2 - x_1}$$

In my research, rotation of a point about the Z-co-ordinate axis by an angle θ is achieved by using the transformation

$$\begin{pmatrix} x''' \\ y''' \end{pmatrix} = \begin{pmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix}$$

We will solve the above step by step again and again for one person, who face is a little changes and finally we can calculate the mean and standard deviation of that person.

In this case, why we use point P_1 and P_7?

For finding angle we use P_1 and P_7. This is because sometimes P_1 and P_7 may not be on the horizontal line; the face may not be parallel to the horizontal axis. We can find such face in the following figure. Finally we-can find the mean ($\bar{x}$) and standard deviation (σ) for each image in different facial appearance. For finding σ we will use the following equation.

$$\sigma = \sqrt{\frac{\sum_{i=1}^{N} (x_i - \bar{x})}{N}}$$

where N=1,2,3,…,16

A_1	A_2	•••	μ_A	σ_A
$P_1'''(x,y)$				
$P_2'''(x,y)$				
- - -				
$P_{16}'''(x,y)$				

Where A1, A2,….are images in different facial appearance from one person. Where μ_A and σ_A is the mean and standard deviation for each person.

Initially we compute Euclidean distance to all feature vectors in the gallery and rank them accordingly. We determine how well we can do with a single feature location. In this case we choose the feature vector (of all the extracted feature vectors in the current test image) which is close to (in Euclidean distance) some feature vector in the gallery and assign this test image the class label of that feature vector.

Figure 8. Getting x and y co-ordinate from one feature point

8. Classification (Modeling Facial Appearance and Expressions)

Consider the face recognition problem where $\rho \in \{1,2,3,\ldots,P\}$ represent ρ-th person in a database of P people and f is the portion of the observed image used for face recognition. Face recognition get in a maximum likelihood setup,

$$\rho^{*} = avg \max_{\rho = 1,2,\ldots,P} P(f / \rho),$$

by using the model that maximizes the likelihood probability of the observed image.

We will use a hidden, discrete variable $\ell = 1,2,\ldots,N$ to index the facial expressions and the likelihood probability of the image f given the identity class ρ is computed from

$$P(f / \rho) = \sum_{\ell=1}^{N} P(f / \ell, \rho) P(\ell / \rho)$$

In the proposed frame work, faces are modeled as a set of regions containing sub-sets of facial features. This model is built under the consideration that the facial features can be accurately located.

We assume the facial feature regions $\{ r_i, i = 1,2,.., R\}$ to be independent for given person and facial expression, and compute the likelihood probability of the observed image from:

$$P(f / \ell, \rho) = \prod_{k=1}^{R} P(r_k / \ell, \rho)$$

Finally, we calculate the likelihood probability $P(r_k / \ell, \rho)$ of a region based on the position x_{ki} and appearance v_{ki} of its F_k facial feature as:

$$P(r_k / \ell, \rho) = P(v_{k1},\ldots,v_{kFk} / x_{k1},\ldots,x_{kFk}, \ell, \rho) \, P(x_{k1},\ldots,x_{kFk} / \ell, \rho)$$

And then, we model the position of the facial features in a region $P(x_{k1},\ldots,x_{kFk} / \ell, \rho)$ jointly with a multidimensional Gaussian distribution.

We will model the appearance of each facial feature with a multidimensional Gaussian distribution.

9. Conclusion

Face recognition is a very interesting research topic. It is very challenging to develop a system that can perform in real time and in real world because of low image resolution, low expression intensity and the full rage of head motion. Our research includes translation, small rotation and illumination changes. Our goal is to show that statistical features such as standard deviation provide an excellent basic for face classification if an appropriate distance is used. Correct calculation of statistical analysis might facilitate the useful feature point for face recognition. We construct a Probabilistic model for classification step.

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