Automatic Aging Simulation of the Human Face

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Abstract

An automatic simulation of the face aging system is developed. This system can predict how old the person is and then simulate the face appearance will be carried out based on this predicted age. Eigen face approach is used for both age prediction and age simulation systems. Especially, simulation of the age progression is performed. In Eigen face, face images are decomposed into a set of characteristic feature images called Eigen faces. The age prediction and face simulation systems are carried out by projecting a new face image into this face space and comparing its position in the face space with those of known faces. After that the best matched face in the face database is examined by the Eigen face representation of face. This approach is a simple and powerful means for performing automatic age simulation for facial images.

Keywords - feature extraction, age prediction, age simulation

1. Introduction

Age prediction is concerned with the use of a training set to train a model that can estimate the age of the facial images. Among the first to research age prediction were, Kwon and Vitoria Lobo who proposed a method to classify input face images into one of the following three age groups: babies, young adults and senior adults [1]. Their study was based on geometric ratios and skin wrinkle analysis. Their method was tested on a database of only 47 high resolution face images containing babies, young and middle aged adults. They reported 100% classification accuracy on these data. Hayashi focused their study on facial wrinkles for the estimation of age and gender [2]. Skin regions were first extracted from the face images, followed histogram equalization to enhance wrinkles. Then, a special Hough transform, DTHT (Digital Template Hough Transform) was used to extract both the shorter and longer wrinkles on the face. Their experiments were not very successful on the age classification task though, achieving only 27% accuracy of age estimation and 83% on gender classification. It is important to note that they did not mention the size or source of their test to generate their accuracy values. Hayashi also noted the difficulty of extracting wrinkles from females' ages between 20 and 30 due to presence of makeup [2].

Lanitis empirically studied the significance of different facial parts for automatic age estimation [3]. The algorithm is based on statistical face models. Lanitis claims that introduction of the hairline has a negative effect on the results [3].His study was limited to subject ranging from 0 to 35 years old, and contained 330 images, of which only 80 were used for testing purposes. Evidently, faces with more wrinkles weren't used, leaving in doubt his ability to estimate the age of subjects older than 35 years. Some researchers have focused on particular age groups only, while others use an extremely wide classification range. Primarily, due to the lack of a good database, a global age

prediction function, covering an extensive range of ages has yet to be developed.

J . R . Scolar and P . Navarreto [4] proposed an face recognition algorithm based on Eigen space. J . Yang and et al.[5] introduced the a new approach to appearance-based face representation and recognition. Most of the research in this area is very limited by the size and quality of the database used.

In this research, age dependent face recognition system based on the diagonal PCA (Principal Component Analysis) method is developed. First, the age of the input individual is predicted and then face recognition is performed with corresponding age group in face database. Finally, the record of the matched person is appeared as output.

Age changes cause major variations in the appearance of human faces. Due to many lifestyle factors, it is difficult to precisely predict how individuals may look with advancing years or how they looked with “retreating years”. The desire aged face is simulated from the input face image base on the PCA (Principal Component Analysis) method.

This system provides the personal identification and recognition for security system. It will be provided the searching of the missing children and wanted persons. By considering the individual age groups, the processing time and complexities will reduce in the face recognition and identification. The proposed system can be applied to predict the current facial appearance of children missing for several years and suspected terrorists. It will become a valuable and routine forensic tool used by criminal investigators.

2. Preprocessing

Image enhancing stage is performed to obtain the specific result for acquired image. Face region extraction, noise filtering, resizing image, histogram equalization and image adjusting processes are included in enchaining step.

Rectangle tool is applied for face region extraction. Neighboring pixel approximation method and median filtering method are used for resizing of the required size of face image and noise filtering, respectively.

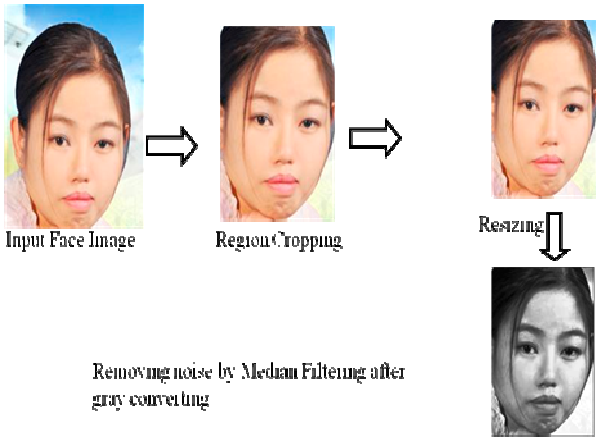

Figure. 1 Image Enhancing

3. Feature Extraction

The fast and accurate facial features extraction algorithm is developed. Features extraction- deals with extracting features that are basic for differentiating one class of object from another. The extracted features of each face in database can be expressed in column matrix show in Figure 2.

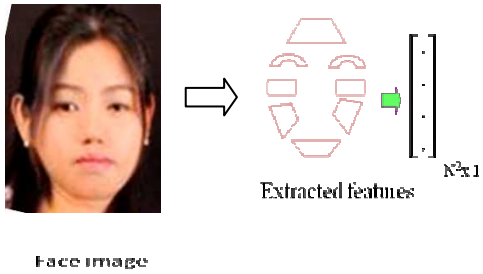

Figure. 2 Feature Extraction

$$\text{M face images} \quad \left\{ \begin{bmatrix} \cdot \\ F_1 \\ \cdot \\ \cdot \end{bmatrix} \begin{bmatrix} \cdot \\ F_2 \\ \cdot \\ \cdot \end{bmatrix} \cdots \begin{bmatrix} \cdot \\ \cdot \\ \cdot \\ \cdot \end{bmatrix} \right\}_{N^2 \times M}$$

$$\text{Mean Face} = \Psi = \sum_{i=1}^{M} F_i$$

$$A = \left\{ \begin{bmatrix} \cdot \\ \Psi F_1 \\ \cdot \\ \cdot \end{bmatrix} \begin{bmatrix} \cdot \\ \Psi F_2 \\ \cdot \\ \cdot \end{bmatrix} \cdots \begin{bmatrix} \cdot \\ \Psi F_M \\ \cdot \\ \cdot \end{bmatrix} \right\}_{N^2 \times M}$$

The fundamental matrix A and it mean feature are computed for each age group. The matrix Ω can be described as

$$\Omega = \left\{ \begin{bmatrix} \cdot \\ A_1 \\ \cdot \\ \cdot \end{bmatrix} \begin{bmatrix} \cdot \\ A_2 \\ \cdot \\ \cdot \end{bmatrix} \cdots \begin{bmatrix} \cdot \\ A_M \\ \cdot \\ \cdot \end{bmatrix} \right\}_{N^2 \times M}$$

And then the age group that gives the minimum Euclidean distance will be assumed as the age of the input image.

4. Proposed System

In this research, automatic simulation of the face aging system is developed. Three different research activity around human aging: age invariant face feature, age estimation and simulating aging process. The flow chart of the proposed system overview is shown in Figure 3. Figure 3 described the overview of the proposed system. Image enchaining stage is performed for acquired image.

Face region extraction, noise filtering, resizing image and histogram equalization process are included in enchaining step. Eigen faces for each age group are stored in Database. The minimum different is computed among the input face and mean faces of all age groups for predict age. Finally, in age progression stage, the simulated face is produced by the mean structure of the desire age groups.

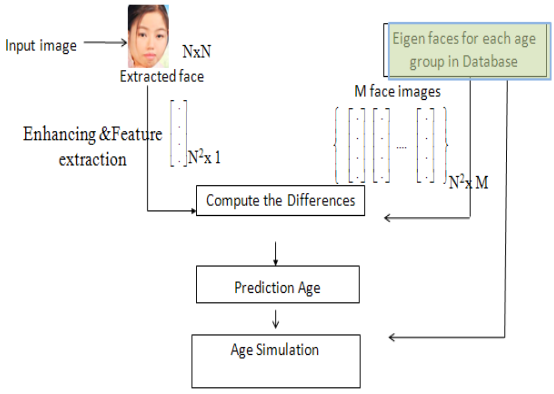

Figure. 3 System Flow Diagram

4.1. Approach to Age Prediction System

Eigen faces for each age groups are stored in Database. The minimum different is computed among the input face and mean faces of all age groups for predicting age. High-Level Functioning Principle of the Eigenface-Based Age Prediction Algorithm is shown in Figure 4. The processing steps for creating the face database are as following:

1. Acquire an initial set of face images (the training set).
2. Calculate the Eigenfaces from the training set, keeping only the M Eigenfaces that correspond to the highest Eigenvalues. These M images define the face space.
3. Calculate the corresponding location or distribution in M-dimensional weight space for each known individual, by projecting the face images(from the training set) onto the “face space”.

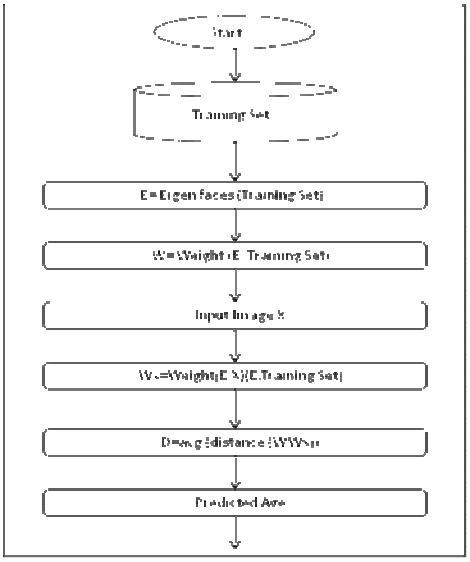

Figure. 4 High-Level Functioning Principle of the Eigenface-Based Age Prediction Algorithm

These operations can also be performed occasionally to update or recalculate the Eigenfaces as new faces are encountered. Having initialized the system, the following steps are then used to predict new face images:

1. Calculate a set of weights based on the input image and the M Eigenfaces by projecting the input image onto each of the
2. Classify the weight pattern to predict the age.
3. (Optional) Update the Eigenfaces and/or weight patterns.

In the age prediction task, the age of the subject is predicted based on the minimum Euclidean distance between the face space and each face class.

4.2. Approach to Age Simulation System

Facial age simulation involves the reconstruction of a given facial image by simulating aging effects to reflect how an individual might look in the future or the past. In this section, we describe how to synthesize aged portraits with the aid of the age prediction function discussed in above. We combine the aging function and a method to transfer wrinkle information between subjects to make an individual in an image appear older or younger.

In age progression stage, the simulated face is produced by the mean structure of the desire age groups. Within a given database, all weight vectors of the persons within the same age group are averaged together.

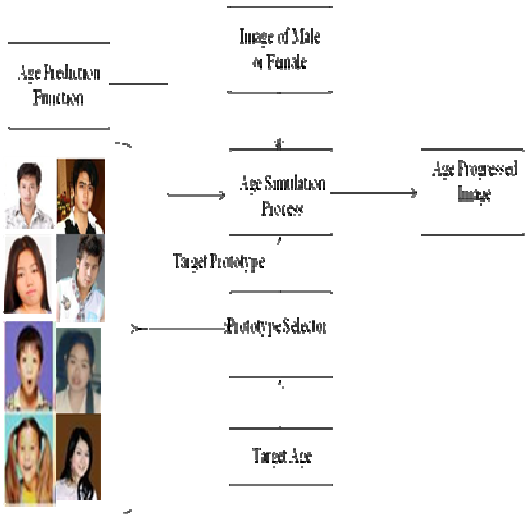

Figure. 5 System Flow Diagram of Age Simulation

5. Experiments and Results

A range of an age estimation result is 15 to 70 years old, and divided into 10 classes with 5 years old range. If the class of the estimation result contains the real age of the subject, the result is considered as correct. The accuracy rate is about 95 percent. Since one of our research targets is to test our system and compare it with human being, we took opinions of thirty people for 150 images selected from all ranges randomly. It is interesting to see how much far or close our system to human being is. The prediction result is shown in figure 6.

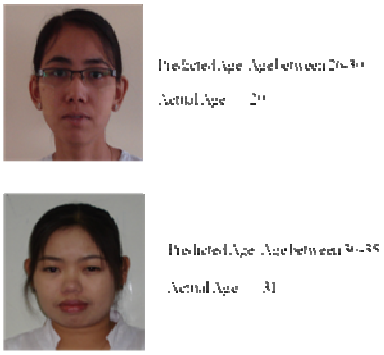

Figure. 6 Prediction Results

6. Conclusion

The age prediction system for a very wide range is introduced. The age prediction errors were due to the poor quality images, the lighting condition, and the large variation of pose and so on. So, the age of the persons can only be predicted within a range of five years. This system limits the prototypes from 15 years to 60 years in age because the face undergoes major changes in shape before the age of 15 years. The accuracy of the system can be analyzed by the variation on the range of the age groups. This research highlights some of the problems and challenges in the field of forensic face recognition. This approach is a simple and powerful means for performing automatic age simulation for facial images.

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