Face Recognition Using Active Appearance Models (Edwards et al, 1998)

Overview

- New framework for interpretation of face images & image sequences using **Active Appearance Model (AAM)**

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Objective

- To develop **full, photo-realistic model-based** approach to face recognition
  - **model-based**: formulating a model to interpret face images and representing them by a set of parameters
  - **full**: using all information given in the image
  - **photo-realistic**: able to match directly between the image and model-synthesized example

Problem Statement

- Apply developed approach to face images and image sequences, and show that:
  - **Images**: Good recognition performance for personal identification and expression recognition
  - **Image Sequences**: Stable estimate of personal identification

Background

- Eigenface (Turk & Pentland, 1991)
  - Utilizing only appearance information of a face
  - Not robust to expression, pose variations
  - Synthesizing new views of a face from a set of example views
  - Not able to generalize to unseen images
- Active Shape Model (ASM) (Cootes et al)
  - Using shape & local appearance information
  - Still not using full information given

Overall Diagram
AAM Modeling

1. Alignment
   Align all the sets of points into a common coordinate frame
   \[ \begin{bmatrix} x_1, y_1, \ldots, x_n, y_n \end{bmatrix} \]

2. PCA
   \[ x = \mu + P s \]
   \[ g = \mu + P b \]

3. PCA
   \[ x = \mu + P s \]
   \[ g = \mu + P b \]

4. Combine & PCA
   Combine two vectors with weights & PCA
   \[ b = Q c \]

AAM Search

Task: Find a set of **AAM parameters** that best matches a new image based on the AAM model generated by the training set

Optimization Problem
- Same for any new images: global solution
- How to solve?
  - 1. Find the relationship between image error and parameter changes
  - 2. Using the relationship, adjust parameters to reduce the error until it converges

Feature Selection

- **Linear Discriminant Analysis (LDA)**
  - Objective
    - Find the most discriminative feature (ID vs non-ID)
  - Assumption
    - Within-class variation is similar for each person
    - Covariance matrix provides good overall estimate
  - Task
    - Apply LDA to sets of parameters from training data
  - Result
    - Discriminant parameters

Conclusion

- Utilize shape and whole appearance information
  - succeed to use all the information
- Apply LDA to AAM parameters
  - succeed to decouple ID parameters and non-ID parameters
- Use a specific intra-class scatter matrix from image sequences
  - improve the stability of ID recognition
- Provide a basis for scene interpretation of face images

Experiment

- **Database**
  - 400 face images
  - with expression, pose, illumination variations
  - 200 training, 200 test
- **Images**
  - Identity: Equal performance with hand work
  - Expression: Lower recognition rate than human
- **Image Sequences**
  - Stable Estimate of identification