Face Recognition

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Step 1: Face Detection
- Different Color Spaces
  - RGB
  - YCbCr
  - HSI
  - UCS (Perceptually uniform color system)
- Histogram-based Approaches
  - Skin color distribution model
  - Hair color distribution model
- Morphological Operations

Step 2: Feature Extraction
- Edge Detectors
- Wavelet and wavelet packets
- Discrete Cosine transformation
- Gabor filters
- Several Important Statistics: Moments
- Shape/color features
- Fuzzified features

Step 3: Face Recognition
- Classification Techniques
  - PCA (Principal Component Analysis)
    - Kernel PCA
    - GA-PCA
    - Incremental PCA
  - LDA (Linear Discriminant Analysis)
  - ICA (Independent Component Analysis)
  - Locality Preserving Projections (LPP)
  - SVMs (Support Vector Machines)
  - NN (Neural Network)
    - RBF (Radial Basis Function) NN
    - SOM (Self-Organizing Map)

Step 3: Face Recognition (Cont.)
- Statistical Modeling
  - Bayes classifier
- Distance/Similarity Measures
  - Euclidean Distance
  - Bhattacharrya Distance
  - Manhattan Distance

Common Face Databases
- FERET: Face Recognition Technology
  http://rvl1.ecn.purdue.edu/~aleix/aleix_face_DB.html
- Yale B
- CMU PIE: Carnegie Mellon University
  Pose, Illumination, and Expression
Face Detection: Commonly Used Techniques

- Technique 1: Finding Faces in images with controlled background: Remove the background will always give the face boundaries.

- Technique 2: Finding Faces by Color: Use the typical skin color to find face segments. However, it doesn’t work with all kinds of skin colors, and is not very robust under varying lighting conditions.

Face color distributions are normally modeled as Gaussian mixtures.

Face Detection: Commonly Used Techniques (Cont.)

- Technique 3: Finding Faces by Motion: Frame differencing, Thresholding, Noise removal, and Add up pixels on each line in the motion image.

- Technique 4: Finding Faces using the Mixture of the Above: Motion analysis can be further combined with heuristics or color information to get an initial guess at the location of a face.

Typical Heuristics Used in Face Detection

- For face detection, we know that the head is located on top of the body, and that a human normally walks upright and so on. The following heuristics capture some of this prior knowledge:
  1. If there is a large moving object in the image, there may be a human present.
  2. If the movement in the upper part of the moving object is larger than a threshold, this may be the top of the human, thus a face.

Face Detection: Commonly Used Techniques (Cont.)

- Technique 5: Finding Faces in Unconstrained Scenes
  - Template Matching Methods:
    - Several standard patterns stored to describe the face as a whole or the facial features separately.
  - Appearance-Based Methods:
    - The models (or templates) are learned from a set of training images which capture the representative variability of facial appearance.

Feature Extraction

- Edge Detectors
- Wavelet and wavelet packets
- Discrete Cosine transformation
- Wavelet Gabor filters
- Several Important Statistics: Moments
- Shape/color features
- Fuzzified features
Feature Extraction: Face Space

- The face space is usually computed by a principal components analysis or linear discriminant analysis (Fisher’s Linear Discriminant) of the face database.

- Both analyses are classical methods for multivariate analysis.

- They can form eigenfaces or fisher faces.

Some examples of eigenfaces (the number indicates the principal component number, ordered according to eigenvalues)

Feature Extraction: Gabor Wavelet-based Features

- Gabor wavelet filters are multi-scale and selective to specific directional changes in the image.

- They can therefore be used to obtain invariance to scale change and to investigate the effect of locally oriented image features.

- In addition, they achieve a certain amount of localized normalization for illumination.

(b) The Gabor wavelet responses at 3 spatial frequencies and 4 orientations (0, 45, 90, 135).

Gabor Wavelet-based Features (Cont.)

It can be seen that at lower frequencies, faces are smoothed to a larger extent resulting in less sensitivity to small translations in the image-plane and greater correlation between nearby images in a sequence.

However, using excessively low frequencies results in loss of relevant spatial structure as can be seen in the first row of (c).
Gabor wavelets are complex, consisting of an odd and even kernel. The Gabor-filtered image can be decomposed into magnitude and phase components. (c) shows the magnitude responses for the same image.

In order to investigate the effect of the local intensity normalization performed by Gabor wavelets, the magnitude responses at the different orientations are superimposed. Figure (a) shows normalized intensity image. Figure (b) shows the superimposed magnitude image.