Face Recognition

Applications

- Law enforcement (mug shot identification)
- Verification for personal identification (driver's licenses, passports, etc.)
- Surveillance of crowd behavior
- Security applications
- US Visit program
- FACE IS A PASSIVE BIOMETRIC
  - Does not need cooperation

- Bill Gates was photographed by the Albuquerque, New Mexico police in 1977.

Data Collection – Controlled

- Environment must be well controlled
- Mug Shot approach
  - frontal + profile photographs
  - uniform background
  - identical poses
  - similar illumination
- Faces can be cropped, size and position normalized, minimum background

Data Collection - Uncontrolled

- Example: Security Camera
- more than 1 face can appear
- lighting conditions vary
- facial expressions
- different scale
- position, orientation can vary
- Glasses, Facial Hair, Face Covering
- Face Recognition is a Complex Problem

Data Collection - Uncontrolled

- **inhardfocus.com/2008/06/race-rec-face-rec.html**
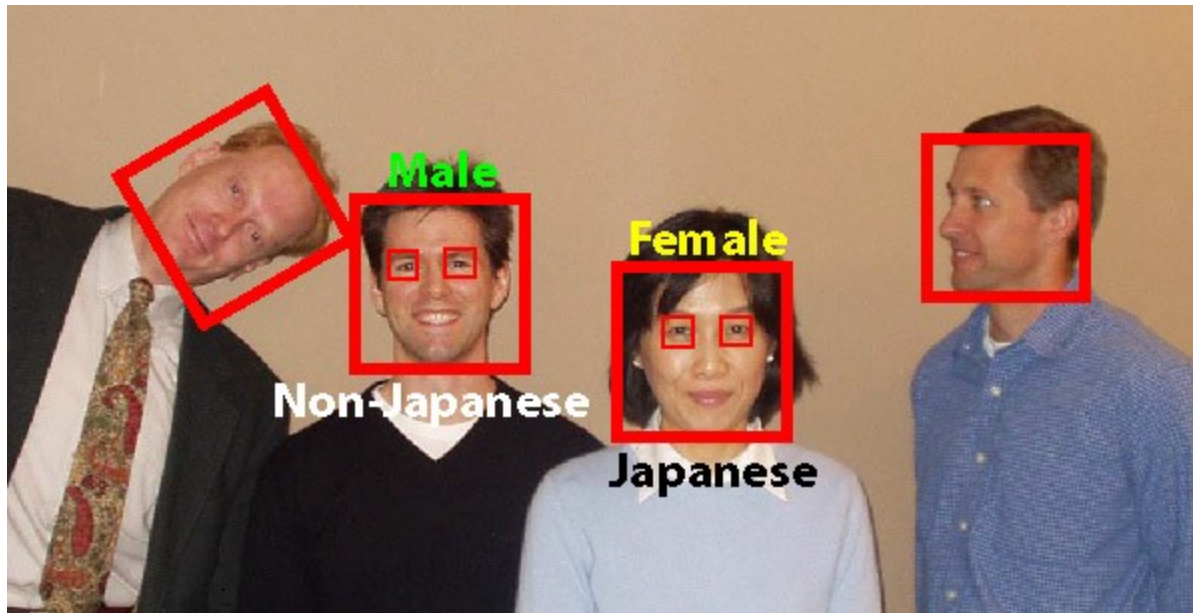
Approaches

- **Face Recognition: Representation and Classification**

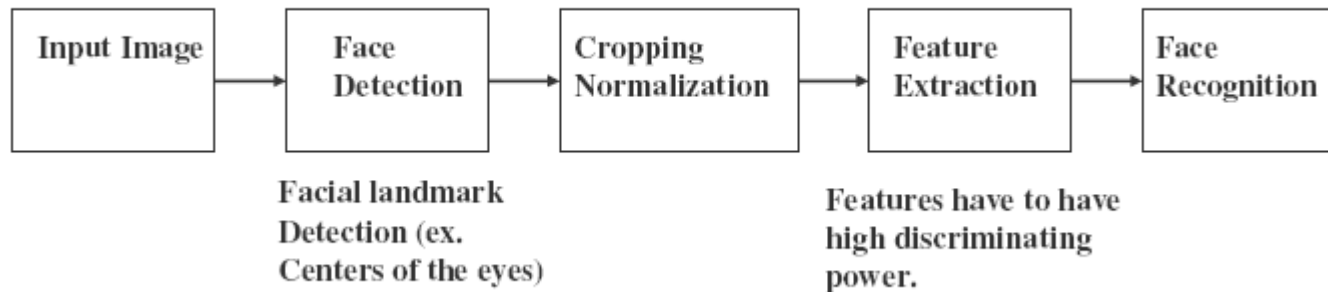| Criteria	Variations
Sensing modality	2-D intensity image, color image, infrared image, 3-D range image, combination of them
Viewing angle	Frontal views, profile views, general views, or a combination of them
Temporal component	Static images, time-varying image sequence (may facilitate face tracking, expression identification, etc.)
Computational tools	programmed knowledge rules, statistical decision rules, neural networks, genetic algorithms, etc.

Modalities

- Optical Camera
- Infra Red Camera

Face Biometric

- Macro Elements: mouth, eyes, nose, ears, lips, cheek bones, forehead
- Micro Elements: distance between features, size of features
- Heat Radiation
- Both Geometric and Statistical features derived
- Humans can identify each other easily but difficult to automate

Image Processing

| Input Image | → | Face Detection | → | Cropping Normalization | → | Feature Extraction | → | Face Recognition |

Facial landmark Detection (ex. Centers of the eyes)

Features have to have high discriminating power.

- Cropping and Normalisation
  - facial region extraction (minimizes influence of other factors not related to face
  - spatial normalization, which aligns the centres of the eyes and fixes the number of pixels between the eyes via rotation and scaling information
  - Intensity normalization

Performance Evaluation

- Measured using standard databases and objective performance statistics

- The face recognition vendor test (FRVT) in 2002 reported:

  - under normal indoor illumination, the state-of-the-art face recognition system achieve 90% verification rate at a false accept 1%;

  - under outdoor conditions, the best vendor can get 50% verification rate at a false accept rate 1%;

- Illumination and pose are still challenging areas

Face Detection

- Earlier methods: correlation or template matching techniques, matched filters, Skin detection

- Recent methods are data-driven learning-based techniques
  - Statistical modeling (estimation of face to non-face patterns, then apply pattern classifier)
  - Neural network-based learning (learn to discriminate face – nonface patterns using training samples and the network structure)

Face Recognition

- Low Dimensional representation for good data representation

- Enhanced discrimination abilities
  - High separability between patterns

- Approach – Manually Defined Features
  - Geometric features such as distance and angles between geometric points: (ex. eye corners, mouth extremities, nostrils, chin top, etc.)
  - For profiles: a set of characteristic points.
  - Locations of points can be extracted automatically

Approaches

- Manually Defined Features – Problems
  - Automatic extraction is not reliable
  - The number of features is small(low dimension)
  - The reliability of each feature is difficult to estimate
- Automatic Derived Features
  - Non-Statistical (Neural Networks)
  - Statistical (Eigenfaces)

Face Representation Methods

- **Representation Method**
  - Principle Component Analysis
  - Gabor Wavelets
    - Pattern recognition technique but can be computationally intensive
- **Recognition Methods**
  - Graph Matching
  - Bayes Classifier
    - (**Bayes classifier** minimises the probability of mis-classification)

Local Feature Analysis

- ## Based on Macro Elements

1. Separation of face from background
2. Reference points are detected used the change in shading around features.
3. Anchor points are tied in triangles.
4. Angles are measured from each of anchor points.
5. 672-bit template is generated.
6. Change in lighting conditions or orientation leads to new templates.
7. Live scan undergoes the same processing. High percentage score results in match.

Eigenfaces ("Ones own face")

- Appearance Based Approach
- Input is 2D greyscale image
- Image seen as High Dimensional Vector(number of pixels)
- Each image is decomposed in terms of other basis vectors (eigenvectors)

$$\mathbf{f} = \sum_{k=1}^{N} w_k \mathbf{e}_k$$

- Where N is the image dimension, $\mathbf{e}_k$ is the k-th eigenface.
- Template consists of weights, w_k
- The features of input image and database templates are compared using nearest neighbor rule (ex. 1-NN = Euclidean distance).

Neural Network: Detection

- **Training Set:** N face images with identified macro features are fed into network + other random images.
- Other faces are entered with no identified macro features.
- The unidentified faces are re-entered into system with identified features.

The parts of ANN: (a) face detection and framing; (b) ANN input level; (c) Receptive fields; (d) Hidden units; (e) Output.
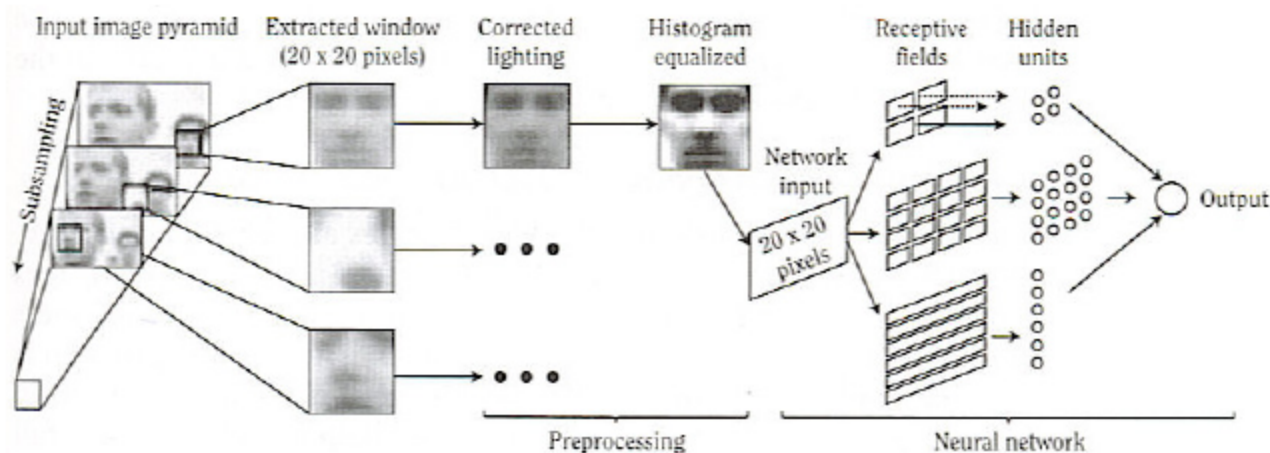
Representation and Recognition

- **Principle Component Analysis (PCA) derives an orthogonal projection** basis that leads directly to dimensionality reduction and feature selection. Eigenfaces = eigenvectors related to the largest eigenvalues. PCA is optimal criterion for dimensionality reduction, but **does not always provide good discrimination.**

Face: Pros and Cons

Pros:

- Used for manual inspection: driver license, passport. Wide public acceptance for this biometric identifier.
- The least intrusive from sampling point of view, requiring no contact.
- Face recognition can be used (at least in theory) for screening of unwanted individuals in a crowd, in real time.
- It is a good biometric identifier for small-scale verification applications.

Cons:

- For robust identification, face needs to be well lighted by controlled source.
- Currently it performs poor in outdoor protocol.
- Disguise is an obvious circumvention method. Disguised person is not identified.
- There is some criminal association with face identifiers since it has been used by law enforcement agencies ("mug-shots").
- Privacy concerns.