Face recognition: The problems, the challenges and the proposals

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Outline

- Introduction
- The problems
- Face recognition scenarios
- Face recognition proposals
- Conclusions
Acknowledgements

- Alberto Albiol
- Josep Vilà
- Emiliano Acosta
- Luis Lorente

Face recognition

Wen-Yi Zhao: The Advances in Face Processing -- Face Recognition – ICIP 2003
### Typical applications

<table>
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<tr>
<th>Areas</th>
<th>Specific Applications</th>
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| Entertainment                 | Video Game/Virtual Reality/Training Programs  
Human-Computer-Interaction/Human-Robotics                                        |
| Smart Cards                   | Drivers’ Licenses/Passports/Voter Registrations/Entitlement Programs  
Welfare Fraud/Passports/Voter Registration                                        |
| Information Security          | TV Parental control/Desktop Logon/Personal Device (Cell phone etc) Logon/Database Security/ Medical Records/Internet Access |
| Law Enforcement & Surveillance| Advanced Video Surveillance/CCTV Control  
Shoplifting/Drug Trafficking/Portal Control                                          |

There are other things than security applications !!!

- Video indexing
- Content access

- **Shot segmentation**
  - Analysis of color, shape and motion
  - Object tracking
  - Speech recognition
  - Speaker identification
  - etc..

- **Database**
  - Shots
  - Shot
  - Shot
  - Shot
  - Shot
  - Shot
Face recognition scenarios

The problems

Face detection

Face detection goes first!!!
Face detection / recognition

- Segmentation
  - Temporal segmentation
  - Key frame extraction
- Detection
  - Region segmentation
  - Region identification
- Recognition
  - Normalization
  - Feature extraction
  - Distance definition

Face detection techniques

- Feature-based
  - Low-level analysis
    - Edges
    - Color
    - Motion
    - Constellation analysis
  - Feature analysis
- Image-based
  - Linear subspace methods
  - Neural networks
  - Statistical approaches
Face detection results (1)

Linear subspace methods (as an example)

Face detection results (2)

Skin detection + segmentation + region merging (as an example)
Face detection FOR recognition

Wen-Yi Zhao: The Advances in Face Processing
ICIP 2003

Which is a correct detect FOR face recognition?

Face normalization (1)

Frontal faces
Face normalization (2)

Morphing

- "Candide" model simplified
- Standard model through training images.
- Texture mapping

More problems: pose

FacePix database
More problems: illumination

FacePix database

More problems: illuminants

Different camera calibration and illumination conditions

http://www.ee.oulu.fi/research/imag/color/pbfd.html
More problems: the data base
(to compare results among different techniques)

- FERET
- XM2VTS
- CMU PIE Database
- AT&T
- Oulu Physics Database
- Yale Face Database
- Yale B Database
- MIT Database
- UPC data base
- Others

Face recognition scenarios

The challenges
Face recognition – *easy* scenarios

Problem *almost* solved

Face recognition – *solvable* scenarios

Work is needed!!!
Face recognition – difficult scenarios

A LOT of work is needed!!!

Face recognition – very difficult scenarios

A LOT of work is needed during MANY years !!!
Face recognition approaches - 1

- Geometric
- Linear subspace
- Template matching
- Neural networks
- Deformable templates

Face recognition approaches - 2

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<th>Approach</th>
<th>Representative Works</th>
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<td>Hybrid LFA</td>
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<td>Local &amp; global feature method</td>
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<td>Face region and components</td>
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Principal component analysis

Training images

Normalization → PCA → Eigenfaces

Projection → training image coefficients

Test image

Normalization → Projection → Comparison

Eigenfaces → training image coefficients

Identified image

\[ d(\tilde{x}, \tilde{y}) = \sqrt{\sum_{i=1}^{N} (\tilde{y}_i - \tilde{x}_i)^2 / \lambda_i} \]

Eigenfaces – manual normalization

Originals

Shape

Normalized

Eigenfaces

Reconstruction

Identified image

\[ \hat{y} = \sum_{i} c_i \hat{x}_i \]
Self eigenfaces – PCA

Eigenfaces "Rosa"
(automatically normalized)

Principal component analysis

\[ \Sigma_x = E[(\tilde{x}_i - \bar{x})(\tilde{x}_i - \bar{x})^T] \]
\[ \approx \frac{1}{N} \sum_{i=1}^{N} (\tilde{x}_i - \bar{x})(\tilde{x}_i - \bar{x})^T \]
\[ = \frac{1}{N} \bar{M}_x \bar{M}_x^T \]

\[ \Sigma_x \bar{A}_i = \lambda_i \bar{A}_i \]

Computational problem with \( \bar{A}_i \)

\[ \bar{M}_x = \frac{1}{\bar{U} \tilde{A}^2 \bar{V}^T} \]

The columns of \( \bar{U}, \bar{V} \) are the eigenvectors of \( XX^T \)
Face unknown - recognition

Test image

Reconstruction error < threshold → Unknown = Julio

Can face recognition be helped?

• Face detection + face recognition
• Video-based FR
• Multimodal-based FR
• Use of color information
Face detection + face recognition

Video sequence → Face detection → Still image Face recognition → Combine Opinion

Person m model

Decision

Reject

Accept

Faces detected and recognized automatically

92% success in a news sequence
Face detection + recognition results (2)

Faces detected and recognized automatically
92% success in a news sequence

Video based face recognition

- Good frames can be selected
- Video provides temporal continuity
  - reuse of recognition information
- Video allows tracking of images
  - facial expressions
  - and pose variations can be compensated for
- Motion, gait and other features can help
- Depth information is also useful
Video based face recognition (compressed sequences)

B - frame  I - frame  P - frame

In case of compressed sequences, adequate frame must be used

Multimodal based face recognition (1)

• Fusion of different information
  - audio, text, close-captions, color, etc.

If there is information, USE IT
Multimodal based face recognition (2)

Video sequence → Video preprocessing → Multimodal recognition → Recognized person

Audio information → Other information

Multimodal based face recognition (3)
(a possible model)

Video sequence → Face model
Images → Face model

Audio expert → Audio opinion → Post-classifier → Accept / reject

Speaker model

Many different classifiers can be used Bayesian, MSE, etc.

Multimodal information brings up to 5% of recognition improvement
Practically all works on face recognition have been done only with the luminance information. Why not to use the color for face recognition?
Use of color – Y u v

Use of color - HSV
Use of color - training stage

Use of color - test stage
Importance of color: Results

Test  With luminance  With color

4% of improvement

Any other help for face recognition?

YES!

The human visual system
The human visual system - 1

If the HVS can do it, a computer can do it

The human visual system - 2

If the HVS can do it, a computer can do it
The human visual system - 3

Prof. Eric H. Chudler, Dept. of Anesthesiology
University of Washington

The human visual system - 4
Is there any hope for face recognition?

Strong need of cooperative research between

- Computer vision
- Signal Processing
- Psychophysics
- Neurosciences

Conclusions

- Yes there is hope for face recognition
  - Human Visual System
  - Need cooperative work
    - Computer vision, signal processing
    - Psychophysics, Neurosciences

- Multimodal information
- Face detection + face recognition
- Video-based FR
- Use of color information
Many thanks for your attention !!!

Hvala na pažnji!!!