Face Processing for Security: a Short Review

Ion Marqués   Manuel Graña

Computational Intelligence Group, Universidad del Pais Vasco

CISIS'10

Outline

Outline

Face Detection.

- Most face recognition applications require face detection.

Face Detection process

1. Determine the presence of a face.

2. Locate the face.

Face Detection.

- Most face recognition applications require face detection.

Face Detection process

1. Determine the presence of a face.

2. Locate the face.

Knowledge-based Methods.

- Capture our knowledge of faces and translate into a set of rules.
- Very difficult to introduce noise and uncertainty robustness.

Example:

- We use face color as a feature to build rules.
- But: Illumination changes face color

Figure: Skin color changes due to illumination variations

Knowledge-based Methods.

- Capture our knowledge of faces and translate into a set of rules.
- Very difficult to introduce noise and uncertainty robustness.

Example:

- We use face color as a feature to build rules.
- But: Illumination changes face color

Figure: Skin color changes due to illumination variations

Knowledge-based Methods.

- Capture our knowledge of faces and translate into a set of rules.
- Very difficult to introduce noise and uncertainty robustness.

Example:

- We use face color as a feature to build rules.
- But: Illumination changes face color

Figure: Skin color changes due to illumination variations

Template Matching Methods.

- A face model is built (e.g. whole face 2D model based on silhouette).
- Face candidates are matched with the models.
- Pose variations are a problem –> Deformable and 3D templates

Example:

- Build eye and mouth templates.
- Once mouth and eyes are located, face-region is easily obtained.
- Problem: Eye and/or mouth occlusion.

Template Matching Methods.

- A face model is built (e.g. whole face 2D model based on silhouette).
- Face candidates are matched with the models.
- Pose variations are a problem –> Deformable and 3D templates

Example:

- Build eye and mouth templates.
- Once mouth and eyes are located, face-region is easily obtained.
- Problem: Eye and/or mouth occlusion.

Template Matching Methods.

- A face model is built (e.g. whole face 2D model based on silhouette).
- Face candidates are matched with the models.
- Pose variations are a problem –> Deformable and 3D templates

Example:

- Build eye and mouth templates.
- Once mouth and eyes are located, face-region is easily obtained.
- Problem: Eye and/or mouth occlusion.

Appearance-Based Methods.

- Statistic analysis and machine learning tools to extract features.
- Examples include eigenface methods, SVMs, Neural Networks, Hidden Markov Models.
- Commonly used along other methods (e.g. PCA to extract face features and build face template).

Example, Viola-Jones algorithm:

- Uses AdaBoost machine learning algorithm to select features and train classifiers.
- Builds a cascade of classifiers.

Appearance-Based Methods.

- Statistic analysis and machine learning tools to extract features.
- Examples include eigenface methods, SVMs, Neural Networks, Hidden Markov Models.
- Commonly used along other methods (e.g. PCA to extract face features and build face template).

Example, Viola-Jones algorithm:

- Uses AdaBoost machine learning algorithm to select features and train classifiers.
- Builds a cascade of classifiers.

Appearance-Based Methods.

- Statistic analysis and machine learning tools to extract features.
- Examples include eigenface methods, SVMs, Neural Networks, Hidden Markov Models.
- Commonly used along other methods (e.g. PCA to extract face features and build face template).

Example, Viola-Jones algorithm:

- Uses AdaBoost machine learning algorithm to select features and train classifiers.
- Builds a cascade of classifiers.

Appearance-Based Methods.

- Statistic analysis and machine learning tools to extract features.
- Examples include eigenface methods, SVMs, Neural Networks, Hidden Markov Models.
- Commonly used along other methods (e.g. PCA to extract face features and build face template).

Example, Viola-Jones algorithm:

- Uses AdaBoost machine learning algorithm to select features and train classifiers.
- Builds a cascade of classifiers.

Face Detection Example.

Face detection video example

- Crowded public place.
- Risk of criminal activities.
- Need of video surveillance system.
- Face detection and storing software for video surveillance

Face Tracking.

- Once face is detected, the challenge is to track the face along video frames

- Face tracking is a motion estimation problem.

- Usually a face-area (e.g. a rectangle) is defined, and features or color space used to track it.

Face Tracking.

- Once face is detected, the challenge is to track the face along video frames
- Face tracking is a motion estimation problem.
- Usually a face-area (e.g. a rectangle) is defined, and features or color space used to track it.

Face Tracking.

- Once face is detected, the challenge is to track the face along video frames
- Face tracking is a motion estimation problem.
- Usually a face-area (e.g. a rectangle) is defined, and features or color space used to track it.

Face Tracking Example.

Face tracking video example

- This example belongs to a commercial solution.
- Illustrates the tracking capabilities of their system.
- Tracks (and recognizes) faces along a *The Office* TV seres episode.
- Face location (and recognition) software for Tracking example video

Outline

Template Matching Methods.

- A face model is built and matched.
- 3D models build from 3D scans show promising results.
- Usually normal cameras are used: Pose variations are the biggest challenge.

Example:

- Adaptive appearance models for face recognition.
- This video shows an AAM over a moving face.

Template Matching Methods.

- A face model is built and matched.
- 3D models build from 3D scans show promising results.
- Usually normal cameras are used: Pose variations are the biggest challenge.

Example:

- Adaptive appearance models for face recognition.
- This video shows an AAM over a moving face.

Template Matching Methods.

- A face model is built and matched.
- 3D models build from 3D scans show promising results.
- Usually normal cameras are used: Pose variations are the biggest challenge.

Example:

- Adaptive appearance models for face recognition.
- This video shows an AAM over a moving face.

Template Matching Methods.

- A face model is built and matched.
- 3D models build from 3D scans show promising results.
- Usually normal cameras are used: Pose variations are the biggest challenge.

Example:

- Adaptive appearance models for face recognition.
- This <u>video</u> shows an AAM over a moving face.

Statistical Learning for Recognition Algorithms.

- Statistical tools used to define a low-dimensional face space.
- The goal: Patterns belonging to different classes occupy disjoint and compacted regions in the feature space.
- So, we can draw a separation line, curve, plane, etc. between faces belonging to different classes.

Examples:

- Principal Component Analysis, Linear Discriminant Analysis, Locality Preserving Projections, Independent Component Analysis.
- Other tools like bayesian networks, regression algorithms, generative models.

Statistical Learning for Recognition Algorithms.

- Statistical tools used to define a low-dimensional face space.
- The goal: Patterns belonging to different classes occupy disjoint and compacted regions in the feature space.
- So, we can draw a separation line, curve, plane, etc. between faces belonging to different classes.

Examples:

- Principal Component Analysis, Linear Discriminant Analysis, Locality Preserving Projections, Independent Component Analysis.
- Other tools like bayesian networks, regression algorithms, generative models.

Statistical Learning for Recognition Algorithms.

- Statistical tools used to define a low-dimensional face space.
- The goal: Patterns belonging to different classes occupy disjoint and compacted regions in the feature space.
- So, we can draw a separation line, curve, plane, etc. between faces belonging to different classes.

Examples:

- Principal Component Analysis, Linear Discriminant Analysis, Locality Preserving Projections, Independent Component Analysis.
- Other tools like bayesian networks, regression algorithms, generative models.

Statistical Learning for Recognition Algorithms.

- Statistical tools used to define a low-dimensional face space.
- The goal: Patterns belonging to different classes occupy disjoint and compacted regions in the feature space.
- So, we can draw a separation line, curve, plane, etc. between faces belonging to different classes.

Examples:

- Principal Component Analysis, Linear Discriminant Analysis, Locality Preserving Projections, Independent Component Analysis.
- Other tools like bayesian networks, regression algorithms, generative models.

Neural Network Approaches.

- Artificial Neural Networks ease classifier building task.
- Some successful approaches use ANNs for feature extraction as well, combined with statistical tools

Examples:

- ANN combined with Gabor filters: Feature extraction pre-process. Resulting Gabor-images are input for a ANN.
- ANN with Hidden Markov Models: ANNs perform dimensionality reduction. The output is processed by a 2D-HMM.

Neural Network Approaches.

- Artificial Neural Networks ease classifier building task.
- Some successful approaches use ANNs for feature extraction as well, combined with statistical tools

Examples:

- ANN combined with Gabor filters: Feature extraction pre-process. Resulting Gabor-images are input for a ANN.

- ANN with Hidden Markov Models: ANNs perform dimensionality reduction. The output is processed by a 2D-HMM.

Neural Network Approaches.

- Artificial Neural Networks ease classifier building task.
- Some successful approaches use ANNs for feature extraction as well, combined with statistical tools

Examples:

- ANN combined with Gabor filters: Feature extraction pre-process. Resulting Gabor-images are input for a ANN.
- ANN with Hidden Markov Models: ANNs perform dimensionality reduction. The output is processed by a 2D-HMM.

Classifiers for Face Recognition.

- Once features are selected, the last step is to classify the image.

- Many different classifiers have been used. Sometimes two or more are combined.

- Used combining methods include Fuzzy integrals, Logistic regression, Boosting techniques, Class set reduction, etc.

Classifiers for Face Recognition.

- Once features are selected, the last step is to classify the image.

- Many different classifiers have been used. Sometimes two or more are combined.

- Used combining methods include Fuzzy integrals, Logistic regression, Boosting techniques, Class set reduction, etc.

Classifiers for Face Recognition.

- Once features are selected, the last step is to classify the image.
- Many different classifiers have been used. Sometimes two or more are combined.
- Used combining methods include Fuzzy integrals, Logistic regression, Boosting techniques, Class set reduction, etc.

Outline

Security Applications
in Information Security

- Access security (OS access, data base access control).
- Data privacy (e.g. medical records).
- User authentication (trading, on-line banking, OS log in authentication).

Security Applications
Access Management and Biometrics

- Secure access authentication (restricted facilities).
- Permission based systems.
- Access log or audit trails.
- Person identification (national IDs, Passports, voter registration, driver licenses).

Security Applications
Law Enforcement

- Automatic Identity verification (border controls).
- Video surveillance.
- Suspect tracking.
- Simulated aging.
- Forensic face reconstruction.

Security Applications
Personal Security

- Home video surveillance systems.
- Expression interpretation (driver monitoring systems).
- Electronic device use restriction (e.g. children's safety).

Actual Use of Face Processing

Building access control:

- Visitor tracking and suspect detection system.
- Used face detection and recognition over a video surveillance system.
- This <u>video</u> shows the system working.

Airport passenger control:

- Border control and suspect detection: Travelers undergo a face scan process.
- The implementation of the system in UK is covered by BBC on <u>this video</u> .

Actual Use of Face Processing

Building access control:

- Visitor tracking and suspect detection system.
- Used face detection and recognition over a video surveillance system.
- This <u>video</u> shows the system working.

Airport passenger control:

- Border control and suspect detection: Travelers undergo a face scan process.
- The implementation of the system in UK is covered by BBC on <u>this video</u> .

Actual Use of Face Processing

Portable suspect identification system:

- Brockton (MA, USA) police get iPhone based system to identify suspects through facial recognition in the field.
- This video shows the implementation of the system.

Actual Use of Face Processing

Portable suspect identification system:

- Brockton (MA, USA) police get iPhone based system to identify suspects through facial recognition in the field.
- This video shows the implementation of the system.

Outline

Problems To Overcome

- Due to uncontrolled image retrieval: Illumination changes, feature occlusion, aging, expression changes, pose variations, different scales.

Figure: Variations: Normal image, expression change, pose variation, scale/illumination variation, aging/occlusion.

- Due to limitations of cameras: Low-quality images, low frame-rate videos, noise, only 2D information.
- Other issues to consider:
  - Right to personal privacy.
  - Personal data protection.

Problems To Overcome

- Due to uncontrolled image retrieval: Illumination changes, feature occlusion, aging, expression changes, pose variations, different scales.

Figure: Variations: Normal image, expression change, pose variation, scale/illumination variation, aging/occlusion.

- Due to limitations of cameras: Low-quality images, low frame-rate videos, noise, only 2D information.
- Other issues to consider:
  - Right to personal privacy.
  - Personal data protection.

Problems To Overcome

- Due to uncontrolled image retrieval: Illumination changes, feature occlusion, aging, expression changes, pose variations, different scales.

Figure: Variations: Normal image, expression change, pose variation, scale/illumination variation, aging/occlusion.

- Due to limitations of cameras: Low-quality images, low frame-rate videos, noise, only 2D information.
- Other issues to consider:
    - Right to personal privacy.
    - Personal data protection.

Future Of Face Processing

- New image capturing devices: 3D images, multispectral data, infrared images.

- New computational approaches: lattice computing, etc.

- Discoveries in neuroscience lead to novel face processing methods.

- Many new application in other areas: Medicine, leisure, advertising.

Future Of Face Processing

- New image capturing devices: 3D images, multispectral data, infrared images.
- New computational approaches: lattice computing, etc.
- Discoveries in neuroscience lead to novel face processing methods.
- Many new application in other areas: Medicine, leisure, advertising.

Future Of Face Processing

- New image capturing devices: 3D images, multispectral data, infrared images.
- New computational approaches: lattice computing, etc.
- Discoveries in neuroscience lead to novel face processing methods.
- Many new application in other areas: Medicine, leisure, advertising.

Future Of Face Processing

- New image capturing devices: 3D images, multispectral data, infrared images.
- New computational approaches: lattice computing, etc.
- Discoveries in neuroscience lead to novel face processing methods.
- Many new application in other areas: Medicine, leisure, advertising.

Face Processing for Security: a Short Review

Ion Marqués   Manuel Graña

Computational Intelligence Group, Universidad del Pais Vasco

CISIS'10