Human Recognition Based On Facial Profile

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CmpE 58Z – Term Project

Outline
• Face Recognition and Facial Profile
• Different Experimental Approaches
• Profile vs. Profile Identification Approaches
  • Landmark-based
  • Appearance-based
  • 3D-model based
  • Contour-based
  • Ear-based
• Proposal

Face as a Biometric Modality

• Face: widely used modality
  • Non-intrusive
  • passive
  • non-cooperative

• Different Application Areas
  • identification
  • human-computer interaction

Challenges in Face Recognition

• High identification performance with near-frontal images

• Challenges in real-life scenarios:
  • Illumination variations
  • Expression variations
  • Pose variations

Recent studies present, however +/- 90 degrees usually not included

Facial Profile

• Pose extrema: +/- 90 degrees

• Why profile?
  • Complementary structure of the face: good information for identification
  • Low computational cost, Fast matching
  • Less discriminative power, however easy analysis

• Different application areas:
  • Driver recognition
  • Door-entrance control
  • Non-cooperative identification (passport control)

Different Experimental Approaches

• Frontal vs. Profile
  • Gallery Set: Frontal images
  • Probe Set: Profile images

• Profile vs. Profile
  • Gallery Set: Profile images
  • Probe Set: Profile images
Profile vs. Profile Approaches

- Landmark-based Approaches
- Appearance-based Approaches
- 3D model-based Approaches
- Contour-based Approaches
- Ear-based Approaches

Landmark-based Methods

- 1970’s - late 1990’s
- Fiducial points extracted from the profile
- Nose tip, nose bottom, forehead, mouth...
- Harmon et al.
  - 17 fiducial points
  - Feature vector
  - Euclidean distance
- Wu et al.
  - 6 landmark points
  - 24 features

Landmark-based Methods

- Campos
  - 8 landmark points
  - Curvature Scale Space
- Dariush
  - 9 landmark points
  - Change of value’s sign
- Liposck and Loncaric
  - 12 landmark points
  - Scale-space filtering
  - 21 distance features

Appearance-based Methods

- Facial profile image is used as the direct input to classification system
- Texture information can be utilized to improve performance
  - However, texture is sensitive to illumination conditions
  - Workarounds must be developed for uncontrolled illumination

Appearance-based Methods

- Filter-based approaches fall under this category
  - Haar features (Gentile et al.)
  - Gabor features (not yet implemented)
  - Angular radial transform (not yet implemented)
  - Steerable pyramid (not yet implemented)
  - ...
Appearance-based Methods

- According to the selected kernel, rotation and scale invariance can be achieved
- Filtering with the selected kernel may yield discriminative information about the facial profile

3D-model based Methods

- Facial surface is a 3D surface
- 3D-models can be used to aid 2D face recognition
- Compare 2D planar profiles & 3D face models
  - Project the 3D model for a given pose
  - Obtain the corresponding facial profile
  - Hausdorff distance between the probe and gallery profiles
- Face is not perfectly symmetric
- Face is almost never at yaw of perfect 90°
- Distance between the camera and the object

Contour-based Methods

Profile based approach by Yu et al.

- 4 fiducials are used
  - F: forehead point
  - N: nose tip
  - B: nose bottom
  - C: chin point
- Comparison of probe profile(with 4 fiducials) with profiles in database those are categorized into k clusters → preselection with k-means clustering
- Matching technique:
  - 4 fiducials are located on x-y coordinate
  - All candidates are compared with probe using "variation form"
  - Closest x,y values(fiducials) is the match

Matching technique:

\[
R_{x,y} = \begin{cases} 
1, & R_{x,y} \leq \alpha \leq \beta \\
R_{x,y} > \beta, & R_{x,y} < \beta
\end{cases}
\]

Profile based approach by Bhanu et al.

- Profile extraction using Canny edge detection and heuristics rules
- Scale-space filtering is applied to facial profile as 1D function
- Points with large curvature values are found tracked down to lower scales for better accuracy
- Dynamic time warping is applied to find optimal alignment between located points
- Algorithm doesn't need to extract predetermined fiducials; handles missing & extra points
- Matching technique: Euclidian distance

Dominant-point based approach by Gao et al.

- Doesn't rely on any specific edge detector
- Dynamic two-strip algorithm is used to detect dominant points that point with high curvatures
- Dense representation: 50 points
- Matching technique: Modified Hausdorff distance, very sensitive to outlier points

Histogram representation of profile (by Pan et al.)

Facial profile curve is represented as histogram with appropriate rotation

Matching technique: Histogram metric approaches

- Profile alignment approaches
  1. Tangent-based normalization
  2. 2D ICP
  3. Simulated annealing
- Similarity approaches
  1. X-square distance
  2. Kullback-Leibler distance
  3. Bhattacharyya distance
  4. PDF Ln forms

Contour-based Methods

Ear-based Approaches

Advantages
- Robustness (lighting and pose variations)
- Invariance (time, expressions)
- Reliability (like iris and fingerprint)
- Two ears of a person are alike

Disadvantages
- Occlusions (hair, earrings)
Ear-based Approaches

Using Scale Invariant Feature Transform (SIFT) descriptor for feature extraction

- Ear skin color model is formed by Gaussian mixture model (GMM), pixels are segmented based on their colors using vector quantization, color slice regions are generated.
- K-L divergence is used for keeping color slice regions that gives high probability matching for SIFT.
- SIFT keypoints are extracted and an augmented vector of extracted SIFT features are created for matching.
- Euclidian Distance method and nearest neighbour approach is used for verification.

Proposal

- Different Modalities:
  - Modality #1: Contour-based Approach
  - Modality #2: Ear-based Approach
- Comparison of Different Modalities
- Fusion of Modalities

CMU Multi-PIE Database

- 250 subjects, 4 sessions
  - Sessions differ by time/expression
  - Each session contains 2/3 sub-sessions
- 15 different camera positions/angles
- For every camera position, 20 different illumination conditions

Experimental Subset of the Db

- Experiment:
  - Profile images: both gallery and probe
    - Pose Variations: only profile images
  - No illumination/expression variations to be considered
    - 4 scans per subject (only first session images)
  - Modality comparisons & fusion
    - Session #1 includes ear occlusions
- 250 Subjects