ATHENE
National Research Center
for Applied Cybersecurity

Selection of a suitable data set for training a face image quality assessment algorithm

Olaf Henniger

ATHENE is a research center
of the Fraunhofer-Gesellschaft
with the participation of

Fraunhofer SIT

Fraunhofer IGD

TECHNISCHE UNIVERSITÄT DARMSTADT

h_da
HOCHSCHULE DARMSTADT
UNIVERSITY OF APPLIED SCIENCES

Problem statement

- Given: Plenty of face image data sets, collected for different purposes
  - https://www.face-rec.org/databases/
  - http://interstellarengine.com/ai/dataset-face-recognition.html
- Wanted: Data set for training a face image quality assessment algorithm
  - Input: Any image on which a face is detected (whether captured at an e-gate, entry/exit system or in the wild)
  - Output: Degree to which the input image supports automated recognition against ICAO-compliant reference face images (as in ISO/IEC WD 29794-5)

Requirements on training data for supervised learning

- To be labelled with target values
- More than one face image per subject
  - To allow mated comparisons
- At least one ICAO-compliant reference face image per subject
  - To quantify the degree to which the face image supports automated recognition against ICAO-compliant reference face images
- Coverage of wide ranges of image properties and potential quality issues
  - Capture-related such as non-uniform illumination, under- or over-exposure, motion blur
  - Subject-related such as pose, facial expression
- As large as needed, but still manageable

Considered face image data sets

- Color FERET Version 2
  - Scanned analog photos from 7 viewpoints
- Face Recognition Grand Challenge (FRGC) 2.0
  - Frontal face images, 2 lighting conditions, 2 facial expressions
- NIST Special Database 32 – Multiple Encounter Dataset II (MEDS-II)
  - 2 viewpoints, varying lighting conditions
- Multi-PIE
  - 15 viewpoints, 19 illumination conditions, 6 facial expressions
- VGGFace2
  - Hundreds of images per subject downloaded from the Internet, largely captured under unconstrained conditions (in the wild)

Example: Influence of head pose on comparison score

[Color FERET Version 2 data set]

Reference							
Probe							
Dissimilarity score [ArcFace]	0.890	0.651	0.601	0.568	0.572	0.599	0.862

Example: Influence of image size on comparison score

[Color FERET Version 2 data set]

Reference			
Probe			
Size	512 x 768	256 x 384	128 x 192
Dissimilarity score [ArcFace]	0.568	0.534	0.548

- Not the larger the better.

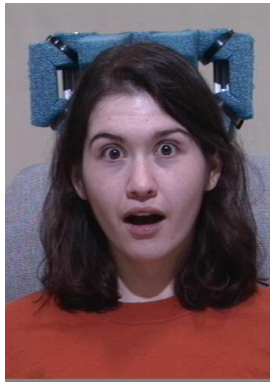
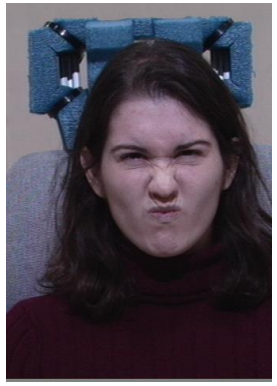
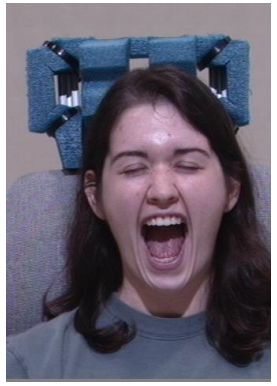
Example: Influence of illumination on comparison score

[Multi-PIE data set]

Reference					
Probe					
Dissimilarity score [ArcFace]	0.586	0.577	0.556	0.472	0.538

Example: Influence of facial expression on comparison score

[Multi-PIE data set]

Reference						
Probe						
Dissimilarity score [ArcFace]	0.472	0.528	0.611	0.676	0.817	0.826

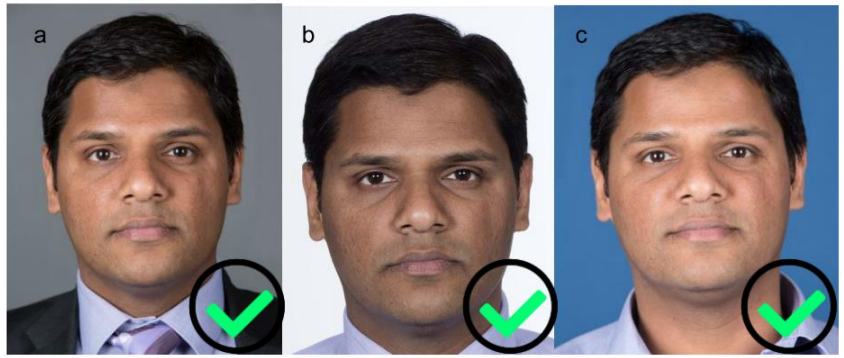
Properties of the considered face image data sets

	ICAO compliance	Varying head pose	Varying image size	Varying illumination	Varying facial expression	Other quality issues
Color FERET Version 2	👍	👍	👍			
FRGC 2.0	👍			👍	👍	
MEDS-II	👎	👍	👍	👍		👍
Multi-PIE	👍	👍		👍	👍	
VGGFace2	👎	👍	👍	👍	👍	👍

Key: 👍 Fulfilled 👎 Partially fulfilled

Selection of ICAO-compliant reference face images

- Essential ICAO portrait quality requirements (yes/no criteria)
  - Number of faces: only one single face
  - Image file colour: The image shall be captured in colour.
  - Inter-eye distance: ≥ 90 pixels
  - Background colour: grey, light blue or white
  - Background texture: no texture
  - Background contrast: The boundary between head and background should be clearly identifiable.
  - Exposure values: Lighting shall be equally distributed on the face.
  - Contrast: appropriate brightness and good contrast between face, hair and background
  - Dynamic range: at least 50 % of intensity variation in the facial region
  - Noise: high signal-to-noise ratio
  - Head pose orientation: fully frontal
  - Facial expression: neutral
  - Eyes: The eye-visibility zone shall be visible and unobscured.

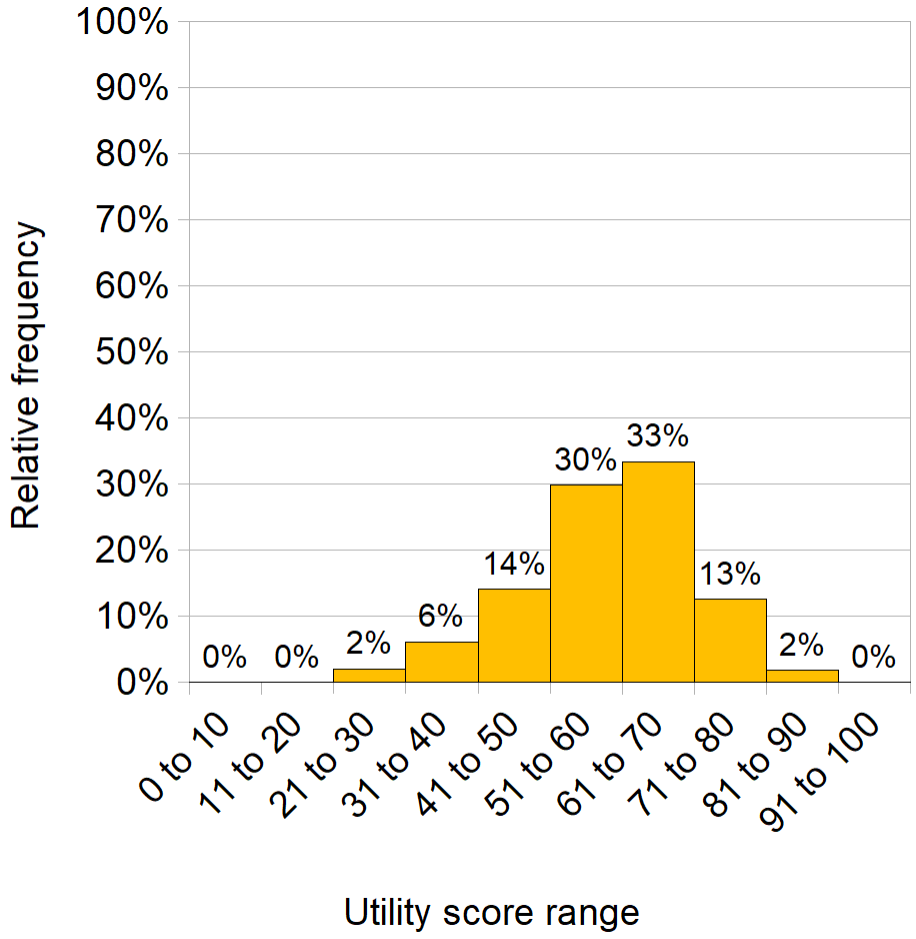


Composed face image training data set

Data set	Number of ICAO-compliant reference images	Number of probe images
Color FERET Version 2	13	784
FRGC 2.0	44	947
MEDS-II	2	20
Multi-PIE	36	7,073
VGGFace2	25	9,830
Total	120	18,654

Utility score distribution of composed training data set

- Utility
  - Degree to which a biometric sample supports biometric recognition performance [ISO/IEC 2382-37]
  - ≈ Normalized difference between the means of mated and non-mated comparison scores for a sample, calibrated to the range from 0 to 100
    - Here: using ArcFace dissimilarity scores between each probe and each ICAO-compliant reference image
  - Target labels for supervised training of a face image quality assessment algorithm



Summary

- To quantify the degree to which an input image supports automated recognition against ICAO-compliant reference face images,
  at least one ICAO-compliant reference face image per subject is needed
- To cover wide ranges of potential quality issues,
  images should be selected from multiple face image data sets
- List of face images in our composed data set available for re-use

Fraunhofer
IGD

Dr. Olaf Henniger

Competence Center for Smart Living & Biometric Technologies
Fraunhofer Institute for Computer Graphics Research IGD

Fraunhoferstrasse 5 · 64283 Darmstadt · Germany
Phone +49 6151 155-526 · Fax -480
olaf.henniger@igd.fraunhofer.de