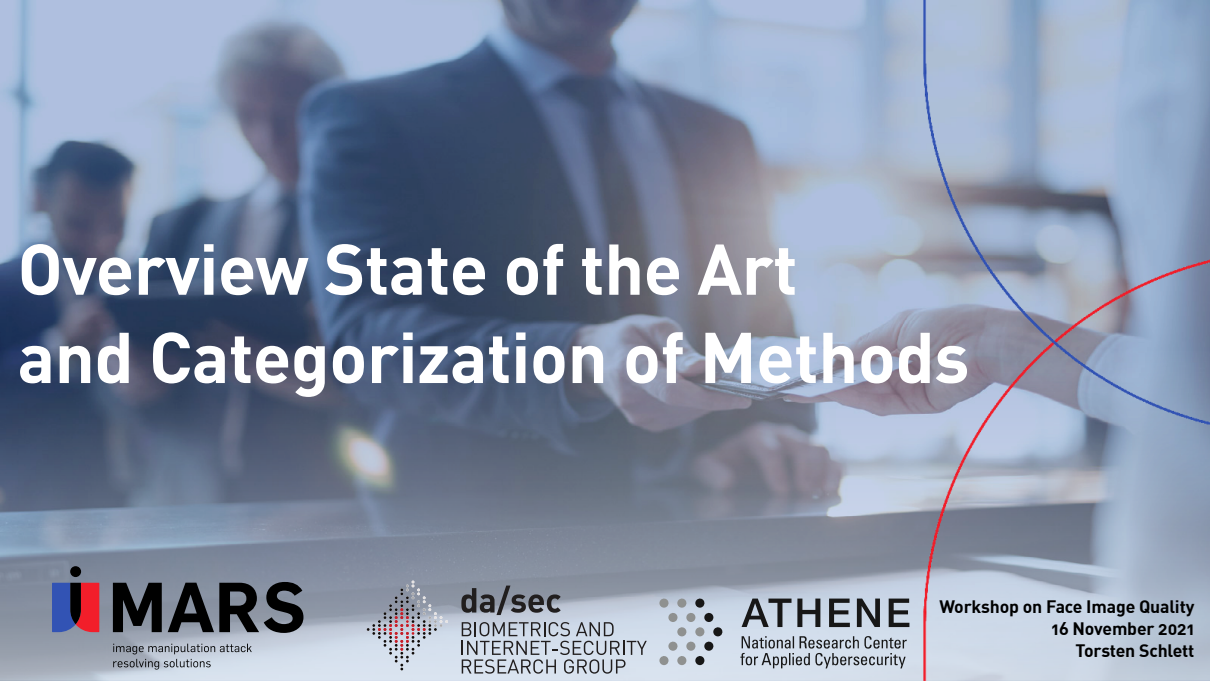
Overview State of the Art and Categorization of Methods



iMARS
image manipulation attack resolving solutions

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BIOMETRICS AND INTERNET-SECURITY RESEARCH GROUP

ATHENE
National Research Center for Applied Cybersecurity

Workshop on Face Image Quality
16 November 2021
Torsten Schlett

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Agenda

Introduction

Factor-specific categories

Aspect categories

State of the Art

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Introduction

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The iMARS project

“image Manipulation Attack Resolving Solutions”

- Funded with 6.988.521, 25€ by the EU as part of Horizon 2020.
- Officially started 1. September 2020, planned end date is 31. August 2024.
- 24 partner organizations (industry, academia, end users).
- Image morphing/manipulation attack detection and document verification.
- **Also involves FIQA (Face Image Quality Assessment) research.**

See the final slide for links with further information.

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Survey paper

“Face Image Quality Assessment: A Literature Survey”

Torsten Schlett, Christian Rathgeb, Olaf Henniger, Javier Galbally, Julian Fierrez, Christoph Busch

- Introductory material
- **Categorization**
  $\rightarrow$ That's what this presentation is about.
- Dataset list
- Evaluation (ERC)
- Open issues and challenges

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FIQA vs. (general) IQA

	FIQA	IQA
Image content:	Face images 	 General images
Assesses:	Biometric utility 	 Perceptual quality
Common input:	Usually no-reference	Full/Reduced/No-reference
"Reverse usage":	Not always general enough (modern FIQA is specialized)	Can be used as FIQA (with limited potential)

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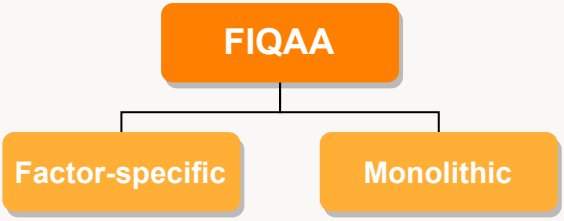
Taxonomy - Factor-specific vs. Monolithic



Interpretable (often actionable) factors, which could help an operator to avoid face image deficiencies in a re-capture attempt.

Opaque assessments/quality scores, which cannot be immediately interpreted with respect to some concrete separable factor.

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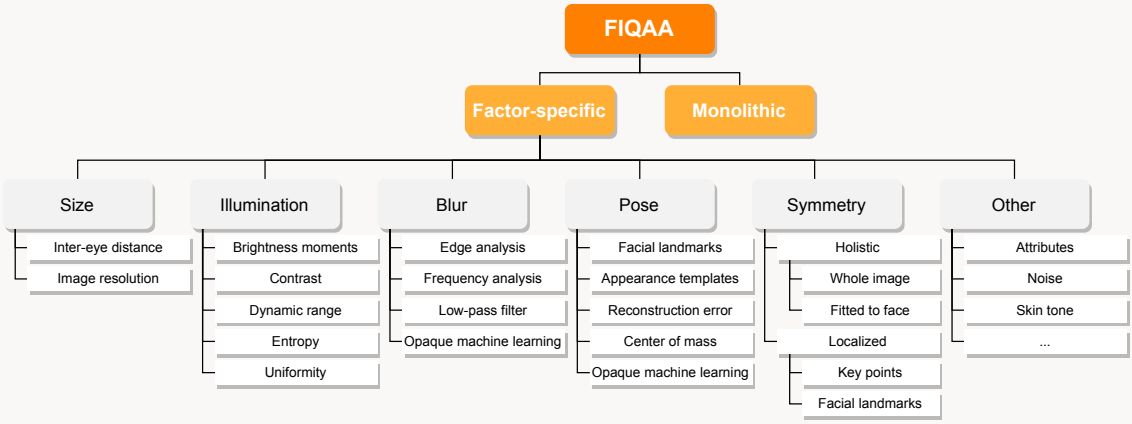
Taxonomy - Overview



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Factor-specific categories

Factor-specific FIQA - Size

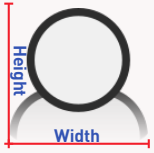

Image resolution
Implementations differ only
in the way width/height are used.

Inter-Eye Distance (IED)
Relies on landmark detection.
ISO/IEC 39794-5: Distance between the eye centers.

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Factor-specific FIQA - Illumination

Brightness moments
Mean / Variance / Skewness / Kurtosis.

Contrast
E. g. as standard deviation or Michelson contrast.

Dynamic range
E. g. smallest value range used by $\geq 95\%$ of all pixels.

Entropy
E. g. as $-\sum h(i) log_2(h(i))$ with normalized histogram h.

Uniformity
E. g. via landmark-local histogram comparisons.

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Factor-specific FIQA - Blur

Edge analysis
E. g. mean of the gradient image.

Frequency analysis
Involves transformation into the frequency domain.

Low-pass filter
Input compared against artificially blurred version.

Opaque machine learning
A few deep learning approaches aimed to assess blur.

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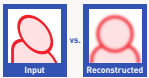
Factor-specific FIQA - Pose

Facial landmarks
Pose angles are estimated based on facial landmark positions.

Appearance templates
Models based on training images for specific poses.



Reconstruction error
Reconstruct the input as a frontal image and check the error.

Center of mass
Selected pixel center of mass deviation from image center.

Opaque machine learning
E. g. binary frontal/non-frontal classification.

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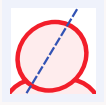
Factor-specific FIQA - Symmetry

Holistic - Whole image
Comparison of fixed left/right halves.



Holistic - Fitted to face
Left/right halves are fitted to the face.

Localized - Key points
E. g. via SIFT (Scale Invariant Feature Transform) points.

Localized - Facial landmarks
E. g. symmetry of lines defined by landmark pairs.

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Factor-specific FIQA - Other

Attributes
E. g. with/without glasses.

Noise
E. g. model trained on different synthetic noise types and levels.

Skin tone
E. g. $[-30°, +30°]$ hue and $[5\%, 95\%]$ saturation.

(More)
Ink mark detection, crease detection, background uniformity, . . .

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Aspect categories

Aspect - Overview

Aspects in addition to the factor-specific/monolithic categorization:

- **Capture-/Subject-related**
  - Per factor.
  - More on the following slides.
- **Video-frame context**
  - Still FIQA, only the surrounding context differs.
- **Deep learning**
  - Either used or not used.
- **Fusion**
  - More on the following slides.
- **Data**
  - More on the following slides.

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Aspect - Capture-/Subject-related

- **Capture-related**: FIQA is influenced by circumstances external to the capture subject, such as the used sensor (e.g. camera focus, resolution) or the illumination setup.
- **Subject-related**: FIQA is influenced by the subject, e.g. pose, expression, or movement.

Per factor-specific category:

- **Size**: Subject-r. (subject to camera distance) & Capture-r. (camera resolution).
- **Illumination**: Capture-r. (lighting), but also Subject-r. (e.g. lighter/darker facial hair).
- **Pose**: Predominantly Subject-related.
- **Blur**: Subject-r. (movement) & Capture-r. (focus).
- **Symmetry**: Considers illumination & (often) pose.

(**Monolithic**: By definition a mixture.)

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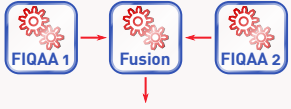
Aspect - Fusion

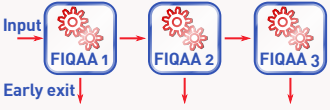
Explicit

E. g. weighted sum with manually set weights.



Trained

E. g. using neural networks or random forests.



Cascade

Can exit early, which can reduce computational workload.

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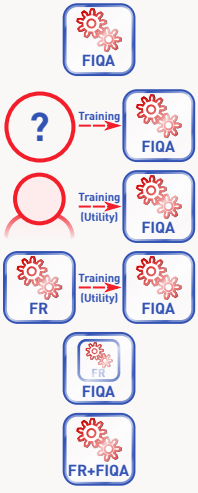
Aspect - Data



Hand-crafted
No training required. E. g. image resolution FIQAAs.

Utility-agnostic training
Trained, but not on utility data. E. g. landmark-based pose.

Human utility ground truth
Trained on utility assessments from humans.

FR-based ground truth
Trained on FR-derived scores.

FR-based inference
Utilize FR models during inference.

FR-integration
FR and FIQA trained in a single model.

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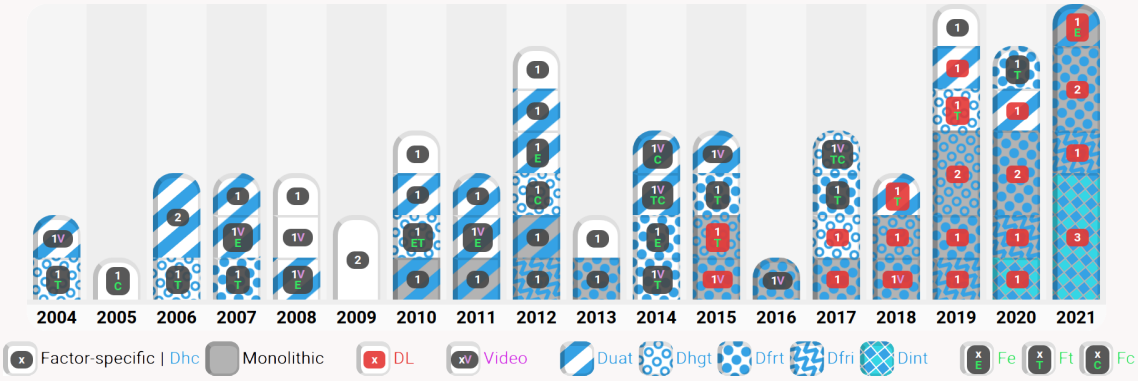
State of the Art

Timeline



Dhc	Hand-crafted	**Dfrt**	FR-based GT training	**Fe**	Explicit fusion
Duat	Utility-agnostic training	**Dfri**	FR-based inference	**Ft**	Trained fusion
Dhgt	Human GT training	**Dint**	FR-integration	**Fc**	Cascade fusion

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Concrete State of the Art

Approaches with dedicated presentations in the workshop:

- **FaceQnet v0 & v1**: FR-based training
  v0: "FaceQnet: Quality Assessment for Face Recognition based on Deep Learning" (2019)
  v1: "Biometric Quality: Review and Application to Face Recognition with FaceQnet" (2020)
- **PCNet**: FR-based training
  "Inducing Predictive Uncertainty Estimation for Face Recognition" (2020)
- **SDD-FIQA**: FR-based training
  "SDD-FIQA: Unsupervised Face Image Quality Assessment with Similarity Distribution Distance" (2021)
- **MagFace**: FR-integration
  "MagFace: A Universal Representation for Face Recognition and Quality Assessment" (2021)

Some other modern approaches:

- **SER-FIQ**: FR-inference
  "SER-FIQ: Unsupervised Estimation of Face Image Quality Based on Stochastic Embedding Robustness" (2020)
- **LightQNet**: FR-based training
  "LightQNet: Lightweight Deep Face Quality Assessment for Risk-Controlled Face Recognition" (2021)

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Thank you!

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"Face Image Quality Assessment: A Literature Survey" preprint:
https://arxiv.org/abs/2009.01103

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