DRIVERS FOR DEVELOPMENT AND USE OF FACE IMAGE QUALITY ASSESSMENT ALGORITHMS

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NIST/EAB/DHS OBIM WORKSHOP
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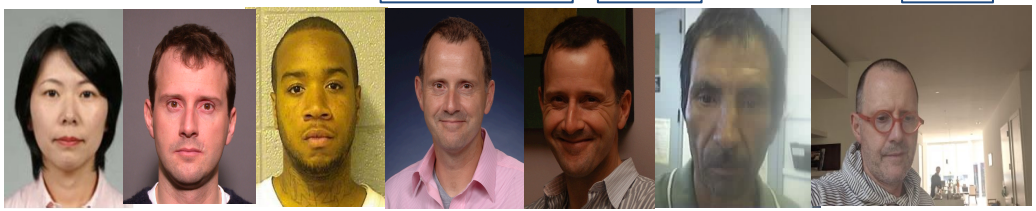
Good, bad, wild, ugly, and lots beyond

ISO, ICAO or Mugshot | Profile Professional | Profile Amateur | Poor Camera | Selfie Off-axis



SUBJECT COOPERATION

NO COOPERATION

Photo-journalism | Amateur photographer, Flickr | Covert capture | Public Video | No control | No signal

Why the push for face quality assessment?

Backdrop

- Increased reliance on face recognition
- Increased use globally, with interchange
- Collection is remote from recognition
  - Physically, temporally, and organizationally
- Increasingly relaxed capture envelope
  - Speed tradeoff
- Better recognition algorithms, yes, but
  - Fail with pose, noise, demographics
  - Fail with large N and high thresholds
- Unlike fingerprint + iris, many face cameras are “dumb”, unware of the face itself
- Many photos deviate from ISO/ICAO
  - Subject appearance
  - Poor imaging
- Human “forensic” adjudication errors
- New opportunities for image manipulation

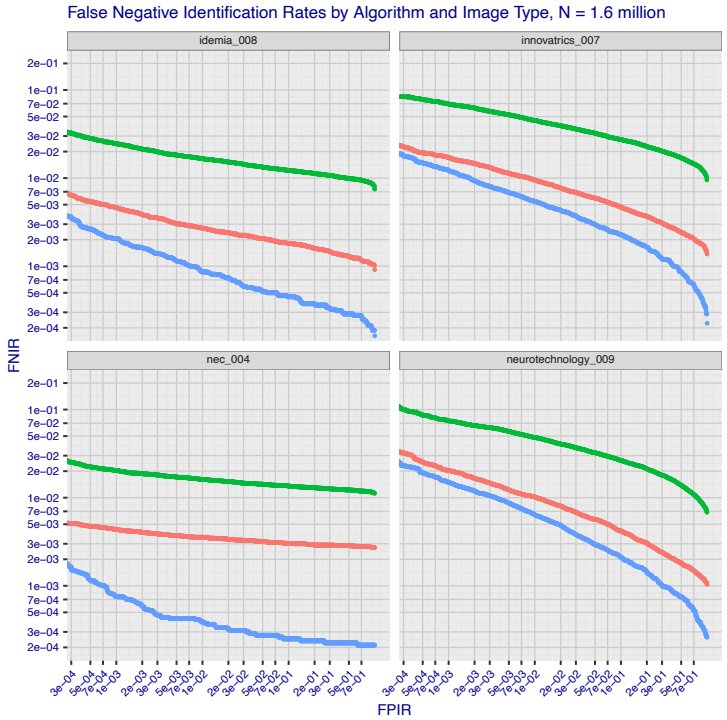
Short terms solutions

- Better face recognition algorithms
- Quality assessment
  - At capture time
  - Over an enterprise
  - Imaging systems

Longer term solutions

- Tighter integration of quality assessment + cameras
- Face-aware capture devices (ISO/IEC 24358)

Recognition engines have improved but low mate score persist



	Algorithm	Miss Rate Percent at Rank 1	Miss Rate Percent at Rank 1 AND score > T T set for FPIR(T) = 0.003
1	NTechLab-010	0.17	0.50
2	Canon-000	0.21	1.24
3	Paravision-007	0.24	0.72
4	NEC-004	0.29	0.39

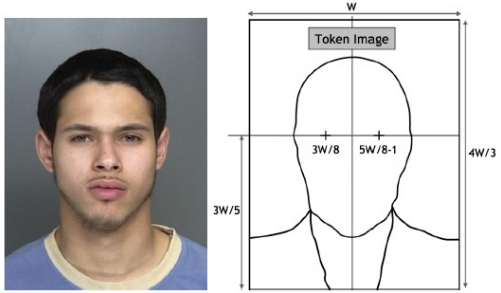
So 0.33% of mates at rank 1 have a "weak" score

Probe
- VISA vs. AIR BORDER
- VISA vs. LAND BORDER
- VISA vs. VISA

Experiment details:
1. FRVT 1:N
2. N = 1.6 million
3. Enroll: High quality "visa" portrait
4. Search: Medium quality airport border crossing webcam

Operational need + role

- Collect photographs that will support high accuracy face recognition for storage in databases or on ID credentials.
- The reference photo is widely specified as a frontal portrait, conforming to requirements of an ISO standard, ISO/IEC 39794-5:2019
- Quality assessment is often manual (photographer, consular officer), less often automatic (with commercial software)



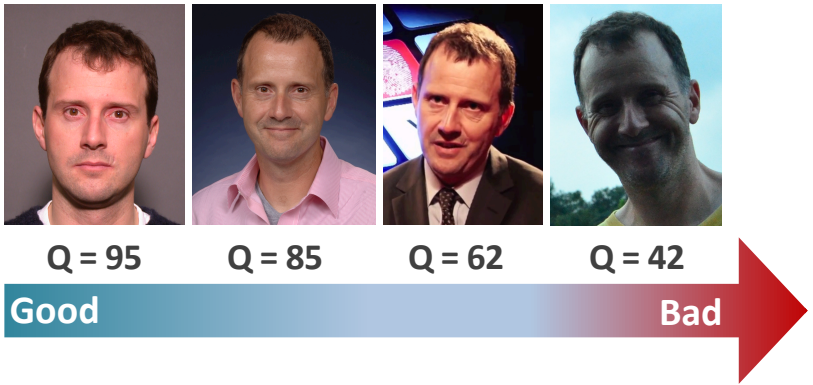
ISO/IEC 19794-5 Token Face geometry, photometry, behavior are all regulated

Image dimensions, eye and head position are all parametric on W

Alternative standard views possible, in principle, but that ship sailed c. 2004.

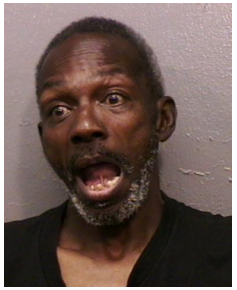
Automated help: Quality values

- **Scalar Quality:** Single value represents **utility** of image to a recognition engine
- In fingerprint operations, quality values are used extensively. Sometimes attending operators are paid by based on quality statistics.

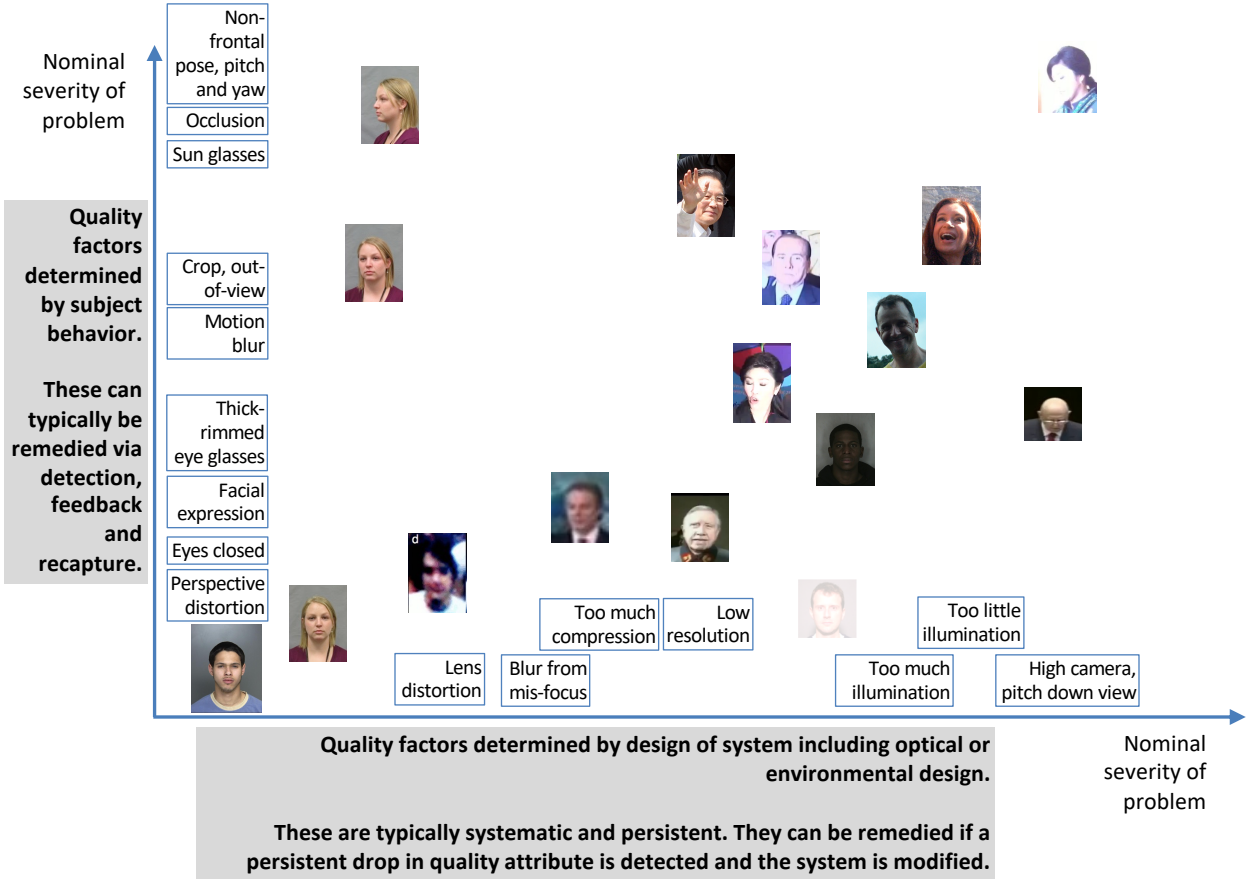


Face Image Quality Analysis

- Image defect detection
- Image conformance checks
- Actionable feedback



Subject- vs. Imaging-specific problems



Quality Use-Cases

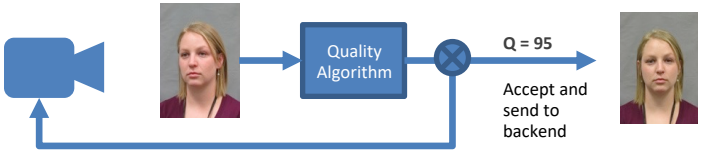
#1. ATTENDED ENROLLMENT
- Repeat capture until $Q \geq Q_c$
- Retain best after K attempts

#2. SELECT BEST IMAGE FROM A SEQUENCE
- Retain one
- Discard others

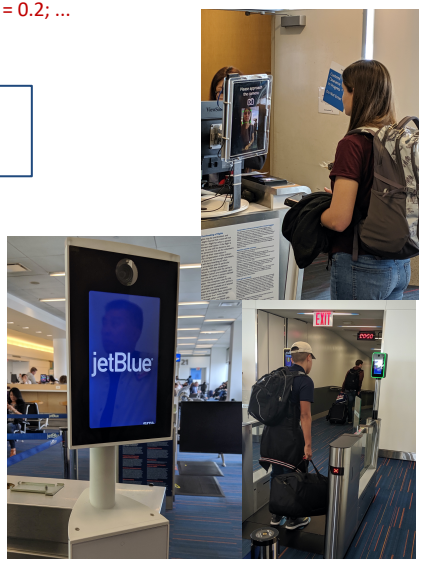
#3. FULLY AUTOMATED CLOSED LOOP CAPTURE

#4. AS A SURVEY STATISTIC
- Tracking quality across collection sites, cameras
- Tracking quality through days, across seasons

#5. FUSION
- Augmenting a fusion process, e.g. weighting samples



#3. FULLY AUTOMATED CLOSED LOOP CAPTURE



Deviations from ISO Passport in context

ISO* MUGSHOT+ WEBCAM LFW IJB-C LEGACY-CAM+ REFLECTEDX

Cooperative Enrollment where quality assessment is traditionally most useful at initial collection.

Non-Cooperative

ISO Standard | Expression | Gaze | Too close | Pose Angle

- ISO's idea of "poor" images is better than many images contemplated in many field operations.
- ISO aspires to collect reference samples that are pristine, for storage in authoritative databases.
  - This is the primary use-case for quality algorithms

* http://webstore.ansi.org

\+ http://www.chicagonow.com/cta-tattler/2013/07/chicago-cops-use-face-recognition-software-to-nab-cta-mugger

X http://io9.com/hidden-faces-can-be-found-by-zooming-into-hi-res-photos-1491607189

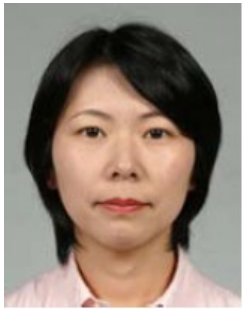
Quality Sorting on Wild Images

Is an algorithm able to rank within this band?

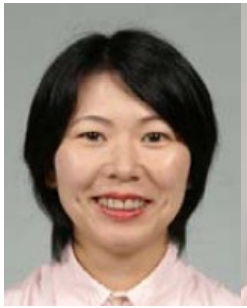
Figure 3: Visualization of the "visual" quality for the images in the IJB benchmark. Following the arrow, the sigmoid scores (α) get higher. From the perspective of the Multicolumn Network, those bottom images are treated as of higher "visual" quality than the top images. As expected, this is highly correlated with the way we define good face images.

W. Xie, A. Zisserman, *Multicolumn Networks for Face Recognition*,
British Machine Vision Conference, 2018
http://www.robots.ox.ac.uk/~vgg/publications/2018/Xie18b/xie18b.pdf

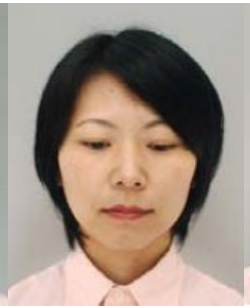
Face Quality Role #2: Image fault reporting



ISO Standard



Expression



Gaze

Too close

Pose Angle

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NON-CONFORMANT EXAMPLES

- ISO's idea of "poor" images is better than any image contemplated in unconstrained FR.
- ISO aspires to collect reference samples that are pristine, for storage in authoritative databases.

Figure 14 — a) Compliant portrait, b) Image contrast unacceptably low, c) Too low background contrast.

Shadows should not be visible on the background behind the face image. In particular, there shall not be asymmetric shadows. There shall not be any objects visible in the background like supporting persons, chair backs, furniture, carpets, patterned wall papers or plants. For examples see Figure 15.

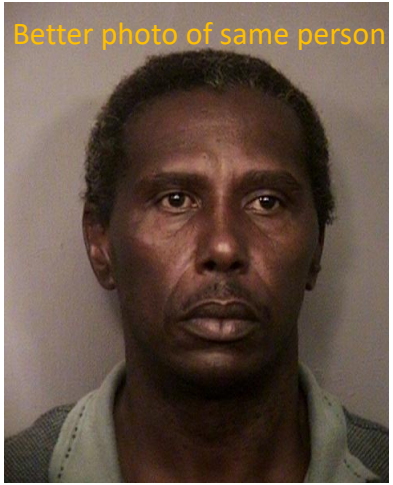
Figure 15 — a) Asymmetric shadow on the left, b) Inhomogenous background, c) Body parts visible behind the head.

Quality values vs. Image Conformance Checks

Application	Quality Value (Q = 42)	Image Conformance Checks (Q vector)
Enrollment	Yes, photo acceptance decision	Yes, actionable feedback
Selecting one image from a set sequence	Yes	Yes (but need additional classifier)
Selecting an acceptable image during closed-loop capture	Yes	Yes (but need additional classifier) e.g. rule based yaw < 20, IOD > 60
Quality surveys	Yes	Yes
Informing a human of the value of an image	?	Alerting human to specific image defects
Fusion	Yes	No

Poor Quality Aspects Correlate With Membership of Demographic Groups

1. Fixed height camera, tall or short subjects ⟶ elevated pitch angle ⟶ higher FNMR
2. Fixed height camera, travelers in wheelchairs ⟶ elevated pitch angle ⟶ higher FNMR
3. Underexposure, dark skinned individuals, or overexposure, fair skinned individuals ⟶ loss of “signal” ⟶ higher FNMR, FMR



Source: NIST Special Database 32 aka “MEDS”, subjects S171, S001

ONGOING BENCHMARKS

1. FRVT 1:1 Verification

2. FRVT 1:N Search Performance

3. FRVT Morph Morphed Photo Detection

4. FRVT Quality Automated Quality Assessment

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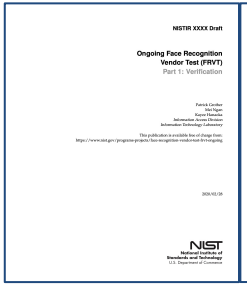
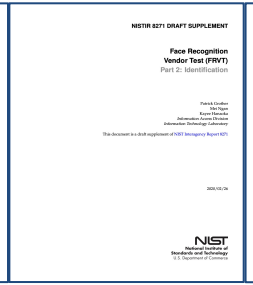
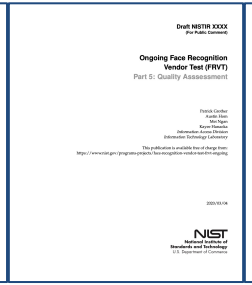
CURRENT PRODUCTS

Part 1: Performance of 1:1 Verification Algorithms	Part 2: Performance of 1:N Identification Algorithms	Part 3: Demographic Effects in Face Recognition	Part 4: Performance of Morph Detection Algorithms	Part 5: Performance of Image Quality Assessment Algorithms	Part 6: Performance of Face Recognition with Face Masks	Part 7: Use of Face Recognition in Paperless Travel
						
Last: 2021-10 Next: 2021-11-19	**Last: 2021-10** Next: 2021-11-19	Last: 2019-12-19 Next: 2021-12 est.	**Last: 2021-10** Next: 2021-10 est.	**Last: 2021-08** Next: 2021-11 est.	**Last: 2020-10** Next: 2021-11 est.	**Last: 2021-10** Next: 2021-12

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https://pages.nist.gov/frvt/html/frvt1N.html

FRVT: New Benchmarks

ONGOING BENCHMARKS

1. FRVT 1:1 Verification

2. FRVT 1:N Search Performance

3. FRVT Morph Morphed Photo Detection

NOW

4A FRVT Quality Automated Quality Quantification

FUTURE

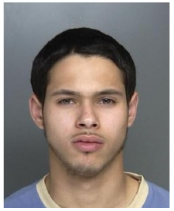
4B FRVT Quality Specific Image Defect Detection

FUTURE

5. FRVT Attack Presentation Attack Detection

FRVT Quality Tracks

TRACK 4A
Q Summaries



SCALAR: Q = 98

DECISION: Y, Accept

TRACK 4B
Q diagnostics

BOX 1. QUALITY BENCHMARK

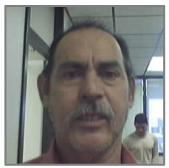
- Concept presented at the Nov Q Workshop
- Developer comment
- Start accepting algorithms 2022-01
- Align with ISO/IEC 29794-5
- Germany developing open-source implementation

BOX 2. IMAGING VARIABLES THAT INFLUENCE ACCURACY

- Illumination adequacy + uniformity
- Exposure
- Focus, blur
- Resolution / Sp. Sampling Rate

BOX 3. SUBJECT VARIABLES THAT INFLUENCE ACCURACY

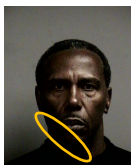
- Head orientation (R, P, Y)
- Expression neutrality
- Sunglasses, face masks
- Motion blur
- No, or additional, faces


Two People


No People

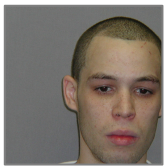

Noise


Over-exposure


Under-exposure


Hot Spots


Mis-focus


Cropped


Non-frontal

THANKS!

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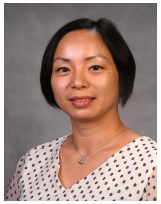
Patrick Grother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