

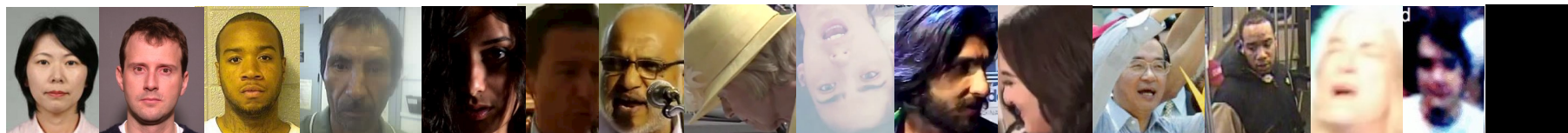
Face Image Quality Standardization

Patrick Grother
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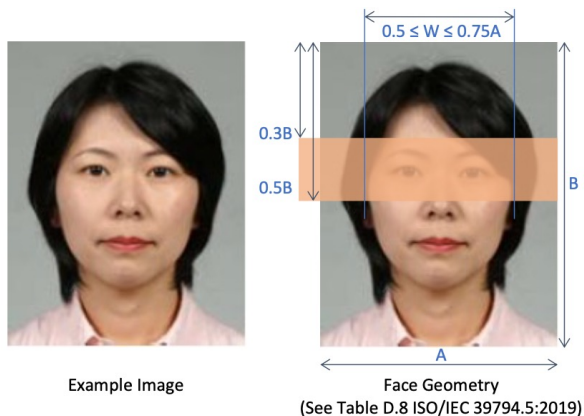
International Face Performance Conference
November 15, 2022

THIS WORK SUPPORTED BY

- DHS OBIM
- NIST



A tale of two face standards



Example Image

Face Geometry
(See Table D.8 ISO/IEC 39794.5:2019)

ISO/IEC 19794-5

ISO/IEC 39794-5



**REQUIREMENTS ON DATA ENCODING AND
APPEARANCE OF THE FACE**



ISO/IEC 29794-5 Face Image Quality

- Has requirements on QA software applied in three use-cases
- Includes definitive image-processing steps for some quality checks



**NO STANDARDIZED CONFORMANCE
CHECKS!**

- RELIANCE ON PHOTOGRAPHER
- TRAINED REVIEWER
- COTS QUALITY CHECKING SOFTWARE

ISO/IEC 29794-5 Face Image Quality

1. Capture-device related quality checks

- 6.3.2 Background uniformity
- 6.3.3 Illumination uniformity
- 6.3.4 Moments of the luminance distribution
- 6.3.5 Under-exposure
- 6.3.6 Over-exposure
- 6.3.7 Dynamic range
- 6.3.8 De-focus
- 6.3.10 Compression ratio
- 6.3.11 Unnatural colour

2. Subject-behavior related quality checks

- 6.3.9 Motion blur
- 6.4.2 Single face present
- 6.4.3 Eyes visible
- 6.4.4 Eyes open
- 6.4.5 Mouth occlusion
- 6.4.6 Mouth closed
- 6.4.8 Inter-eye distance
- 6.4.9 Horizontal position of the face
- 6.4.10 Vertical position of the face
- 6.4.11 Pose
- 6.4.13 Expression neutrality

3. Cannot be measured from an image

- 6.5.1 Shoulder presentation
- 6.5.2 Camera to subject distance
- 6.5.3 Radial distortion
- 6.5.4 Pixel aspect ratio

4. October 2022 comments from:

- Christoph Busch (H. Darmstadt)
- Pierre Gacon (Idemia)
- Olaf Henniger (Fraunhofer)
- Markku Metsamäki (FI Border)
- Benjamin Tams (secunet)
- Jim Wayman (DHS)
- Andreas Wolf (BDR)

5. Progression

1. 2022-11 Proposed disposition of comments
2. 2023-01 Discuss comments, produce WD 6
3. 2023-04 CD 1
4. 2023-07 DIS 1
5. 2023-12-23 DIS 2 to ISO for publication

6. August 2022 public draft freely available here:



<https://isotc.iso.org/livelink/livelink?func=ll&objId=22304355&objAction=Open&viewType=1>

Example of quality component considered intractable

Distortion occurs in all conventional photos

- How much is too much?

By analyzing JUST the image, error rates > 0 because

- some faces will naturally look distorted
- Some distorted faces will look natural

NIST



a) Good appearance

b) Good appearance

c) Good appearance

Source: ISO/IEC 39794-5:2019



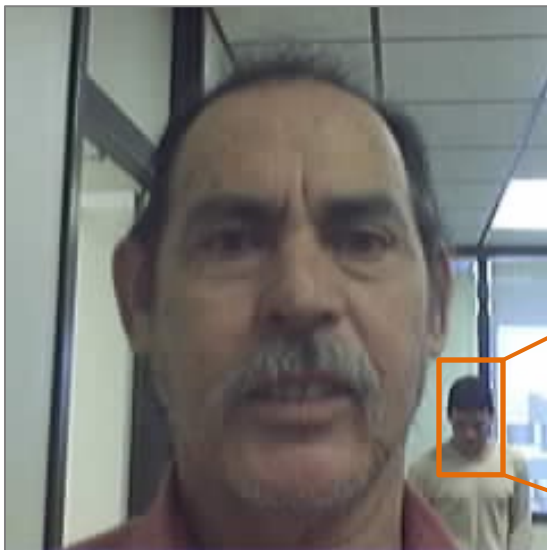
d) Too strong magnification distortion

e) Too strong magnification distortion

f) Too strong magnification distortion

Example component: Number of faces

240
pix



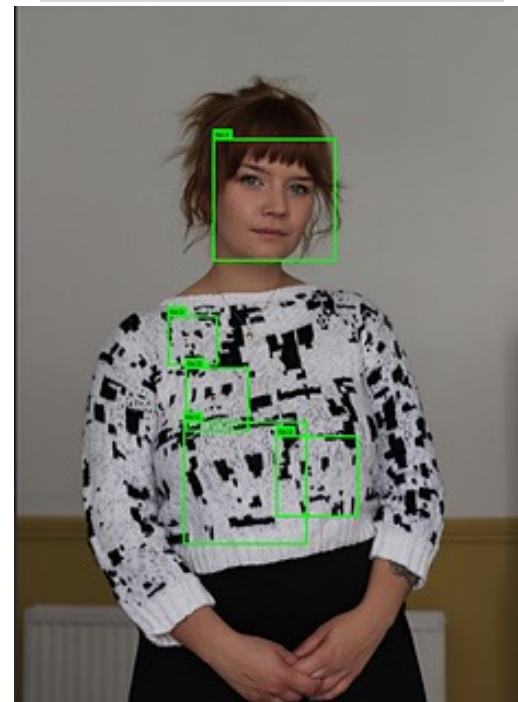
240 pix

Source: MEDS, NIST Special Database 32



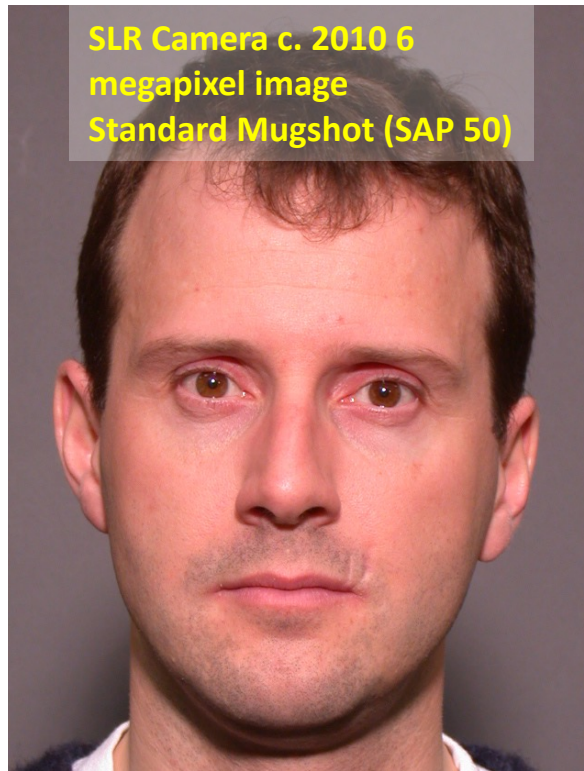
Very high non-mate scores
from many algorithms

Source:
<https://www.ravelry.com/patterns/library/anti-surveillance-jumper>



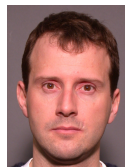
Detour: Resolution ... how low is “low resolution”?

SLR Camera c. 2010 6
megapixel image
Standard Mugshot (SAP 50)



3000 x 2000

e-Passport
2004...2016
0.3 megapixels



640 x 480

Input layer for
typical
leading DNN c.
2022

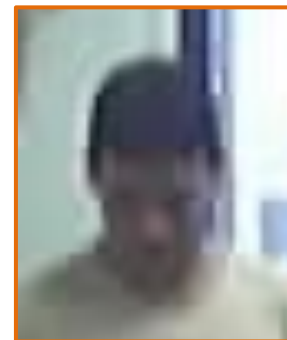


112x112



32 x 24

Background
face from prior
slide

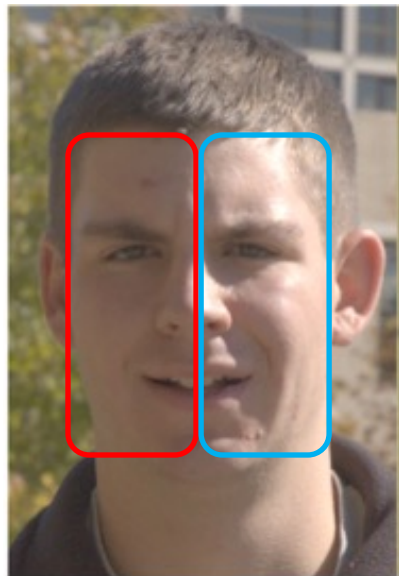


32 x 24
NOT TO SCALE



Up-sampled image fed
into a typical CNN gives
high non-mate scores

Example component: Illumination uniformity



Proportion of pixels with
greylevel i on left side

Proportion of pixels with
greylevel i on right side

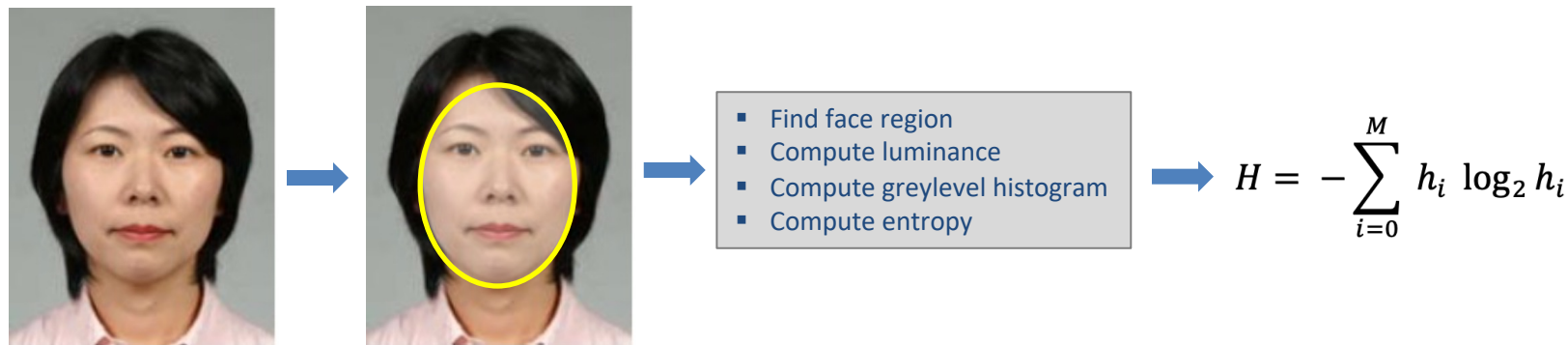
$$D = \sum_{i=0}^M \min(p_i, q_i)$$

$D \rightarrow 1$ implies symmetric lighting

Quality value encoded in an interchange record

$QS = \text{round}(100 D)$

Example component: Dynamic Range



COMPUTE QUALITY SCORE: EITHER LINEAR TO [0,100]

Quality increases linearly with entropy
 $QS = 12.5 H$

OR SOMETHING NON LINEAR

Quality is very low if H below ~ 5 bits
 $QS = \frac{100}{1+e^{-(H-5)}}$

- ISO/IEC 29794-5 is draft.
- Exact mapping here yet to be confirmed.
- Decision should be based on false non-match rates.

H

Quality component: Underexposure

1. Dark skin is difficult to image
 1. Low diffuse reflection
 2. High specular reflection
2. Sufficient underexposure will lead to detection or false negative recognition error
3. Hot spots may give false positives
4. Are DNNs tolerant?



Source: NIST Special Database 32 aka "MEDS", subject S171

Google's Real Tone (in Pixel 6+ phones)

<https://store.google.com/intl/en/ideas/real-tone/>

- For aesthetic purposes
- Not specifically for biometrics, though it may have benefits
- Ask phone camera developers to include an API dedicated to *biometric* face capture leveraging e.g. high bit-depth sensors, computational photography.

Image equity: Making image tools more fair for everyone

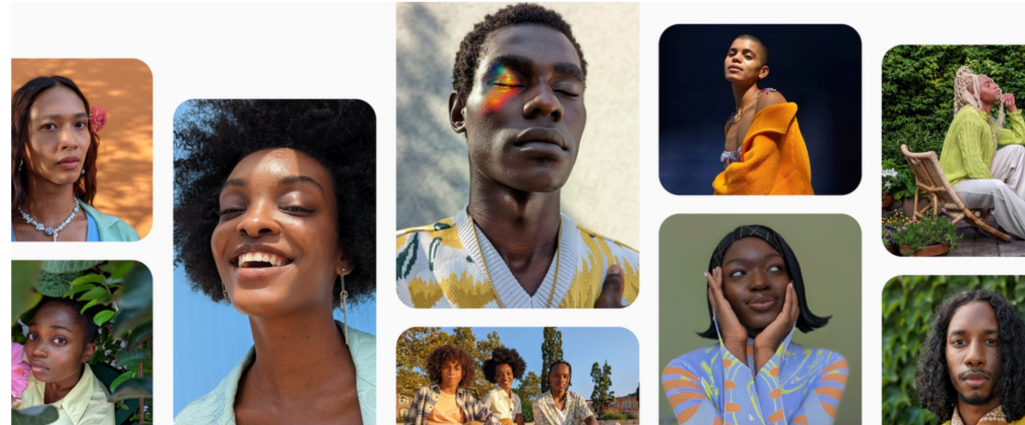
Oct 19, 2021
3 min read

As part of Google's Product Inclusion efforts, our teams are building more equitable camera and imaging products for people of color.



Florian Koenigsberger
Google Image Equity Lead

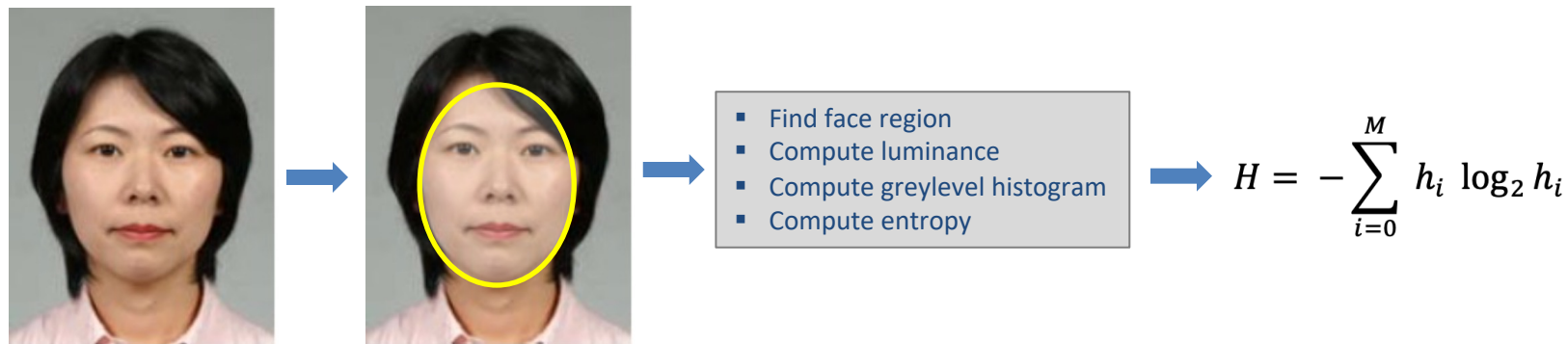
Share



Pictures are a big part of how we see each other and the world around us, and historically [racial bias in camera technology](#) has overlooked and excluded people of color. That same bias can carry through in our modern imaging tools if they aren't tested with a diverse

- <https://blog.google/products/pixel/image-equity-real-tone-pixel-6-photos/>
- <https://blog.google/inside-google/company-announcements/super-bowl-ad-2022/>

Example component: Dynamic Range



EITHER

Quality increases linearly with entropy
 $QS = 12.5 H$

OR

Quality is very low if H below ~ 5 bits
 $QS = \frac{100}{1 + e^{-(H-5)}}$

THREE USE CASES

Mandatory	UC1: Creation of reference samples Seek rules like accept if $QS > 75$ say
Optional	UC2: Probe for instantaneous recognition
Optional	UC3: System enrolment, current or later creation of a reference, delayed recognition.

H

Mandatory or Optional

#	Image quality aspect	Sub-clause	Collection of reference samples for ID documents	Collection of probe for instantaneous recognition	System enrolment, current or later creation of a reference, delayed recognition
1.	Unified quality score	6.2	M	M	M
2.	Background uniformity	6.3.2	M	O	O
3.	Illumination uniformity	6.3.3	M	O	O
4.	Illumination mean	6.3.4.2	M	O	O
5.	Illumination variance	6.3.4.3	M	O	O
6.	Illumination skewness	6.3.4.4	M	O	O
7.	Illumination kurtosis	6.3.4.5	M	O	O
8.	Under-exposure	6.3.5	M	O	O
9.	Over-exposure	6.3.6	M	O	O
10.	Dynamic range	6.3.7	M	O	O
11.	De-focus	6.3.8	M	O	O
12.	Image sharpness	6.3.9	M	O	O
13.	Motion blur	6.3.10	M	O	O
14.	Edge density	6.3.11	M	O	O
15.	Compression ratio	6.3.12	O	O	O
16.	Unnatural colour and colour balance	6.3.13	M	O	O
New	Polarization filter		M	O	O
New	Radial distortion		O	O	O
New	Pixel aspect ratio		O	O	O
17.	Camera lens focal length	6.3.14	O	O	O
18.	Camera subject distance	6.3.15	O	O	O
new	Single subject		M	M	M
new	Shoulders squared on		O	O	O
19.	Eyes visible	6.4.2	M	O	M
20.	Mouth occlusion	6.4.3	M	O	M
21.	Nose occlusion	6.4.4	M	O	M
22.	Inter-eye distance	6.4.5	M	M	M
23.	Horizontal position of the face	6.4.6	M	M	M
24.	Vertical position of the face	6.4.7	M	M	M
new	No head coverings	New	M	O	M
new	Pose angle yaw frontal alignment	6.4.8.1	M	O	M
new	Pose angle pitch frontal alignment	6.4.8.2	M	O	M
new	Pose angle roll frontal alignment	6.4.8.3	M	O	M
26.	Expression neutrality	6.4.9	M	O	O
27.	Mouth closed	6.4.10	M	O	M
28.	Eyes open	6.4.11	M	O	O

- Snapshot from 2022 draft of ISO/IEC 29794-5
- Requirements on what software library must support?
- Requirements on what must be done in each use-case?

Presentation Attack: Impersonation

by maximizing
similarity score

A: Instruments

- Replay
- Cosmetics
- Masks



Presentation Attack: Evasion

by
minimizing
similarity score

B: Instruments

- Replay
- Masks
- Cosmetics
- Image manipulation



C: Behaviours

- Adverse Pitch | Yaw
- Pronounced expression
- Occlusion
- Motion Blur

Common Image Quality Problems

D: Imaging problems

- Blur
- Illumination
- Exposure
- ...

Incorrect Arrests in Michigan and New Jersey

PROBE

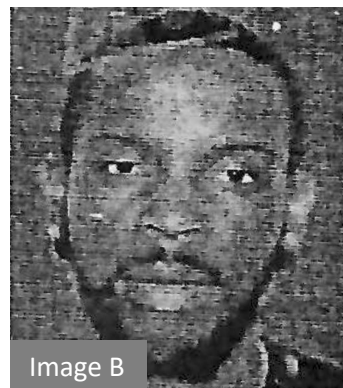


<https://www.cbsnews.com/news/facial-recognition-60-minutes-2021-05-16/>

INCORRECT PERSON
ROBERT WILLIAMS



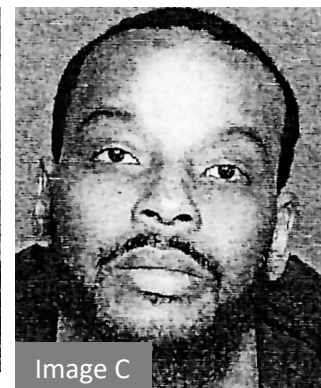
PROBE



<https://www.cnn.com/2021/04/29/tech/nijeer-parks-facial-recognition-police-arrest/index.html>

INCORRECT PERSON
NIJEER PARKS

GALLERY
RETRIEVED



<https://www.nytimes.com/2020/12/29/technology/facial-recognition-misidentify-jail.html>

NEWS
PHOTO



Future roles for quality?

1. Issue caution to an investigator when signal is "low / unavailable" (Image A) or "noisy" (Image B)
2. Issue caution to someone putting a poor image (Image C) in an authoritative database

The FRVT Program



- U.S. Government
- Department of Commerce
- 2000 – 2022
- Public
- Independent
- Free
- Open worldwide
- Collaboration with USG agencies

1:1

- 2017-02 ...
- Verification | Authorization | Non-repudiation

1:N

- 2018-01 ...
- Investigation | Duplicate detection | Identification

Morph Detection

- 2018-09 ...
- Single-image | Differential two-image

Quality Summarization

- 2019-02 ...
- Produce a number predicting mate matching outcomes

Quality Defect Detection

- 2022-08 ...
- Find specific image quality problems (blur, pose, sunglasses etc)

Presentation Attack
Detection

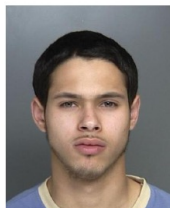
- 2023-01
- Is the image or video showing subversive behavior?

Twins Low False Match
Demonstration

- 2022-09 ...
- High resolution images

FRVT Quality Tracks

TRACK A Quality Summarization



SCALAR: $Q = 98$

DECISION: Y, Accept

BOX 0. QUALITY BENCHMARK

- One "visa – border" dataset
- No longer use wild
- Extend to use new "kiosk" dataset

TRACK B Specific Image Defect Detection

BOX 1. QUALITY BENCHMARK

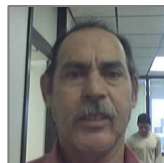
- Concept presented at the Nov Q Workshop 2021-11
- API + Concept Published 2021-07-07 for comment.
- Final specifications 2022-09
- Algorithms to NIST 2022-09
- Align with ISO/IEC 29794-5

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



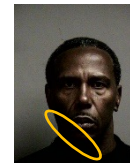
No People



Noise



Over-exposure



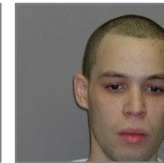
Under-exposure



Hot Spots



Mis-focus



Cropped



Non-frontal

ISO/IEC 29794-5

- » Defines a set of quality measurements
 - Compute a raw component value
 - Some computations are explicit
 - Some computations are abstract e.g. “estimate pose” without saying how
 - Compute an interpretable quality score [0,100]
 - Actionable feedback - “focus score too low”
- » Mandates subsets of those computations depending on use-case
- » Conceives of three use-cases

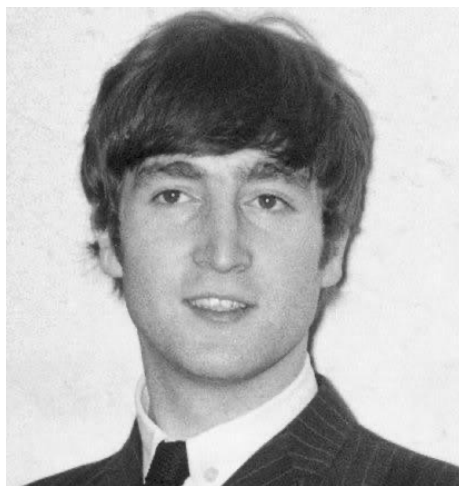
Quality evaluation

- » FRVT Specific Image Defect Detection
 - Do 29794-5 quality assessment algorithms work well?
 - Do 29794-5 relate to face recognition accuracy?

THANKS!

PATRICK.GROTHER@NIST.GOV

FRVT@NIST.GOV



Beatle John
Lennon between
the release of
the Red Album
and the Blue
Album, ~5 years.

Year	Developer	Algorithm	Score	FMR	Outcome
2021	Idemia	008	7438.78	< 5e-07	Strong match
2022	Paravision	010	0.38308	< 5e-07	Strong match
2014	Cogent	A20A	2521	0.48	Failed match
2014	NEC	E20A	0.562	0.002	Failed match