Should there be “Appendix F”- type Standards and Device Certification for Face Image Capture Devices?

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NIST Biometric Quality Workshop II
7 November 2007

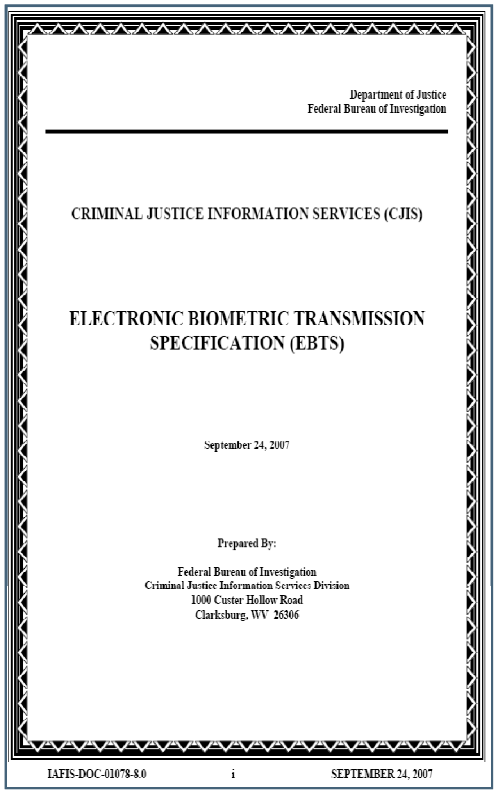
noblis
For the best of reasons

Outline

- What is EBTS Appendix F and what are its metrics?
- What are some equivalent metrics for face images and how could they be measured?
- Examples of such measurements for two cameras
- Conclusions and Recommendations

Appendix F

- **Appendix F, *IAFIS Image Quality Specifications***, of the *Electronic Biometric Transmission Specification* (EBTS), Ver. 8, 9/24/2007, prepared by FBI


Department of Justice
Federal Bureau of Investigation

CRIMINAL JUSTICE INFORMATION SERVICES (CJIS)

ELECTRONIC BIOMETRIC TRANSMISSION SPECIFICATION (EBTS)

September 24, 2007

Prepared By:

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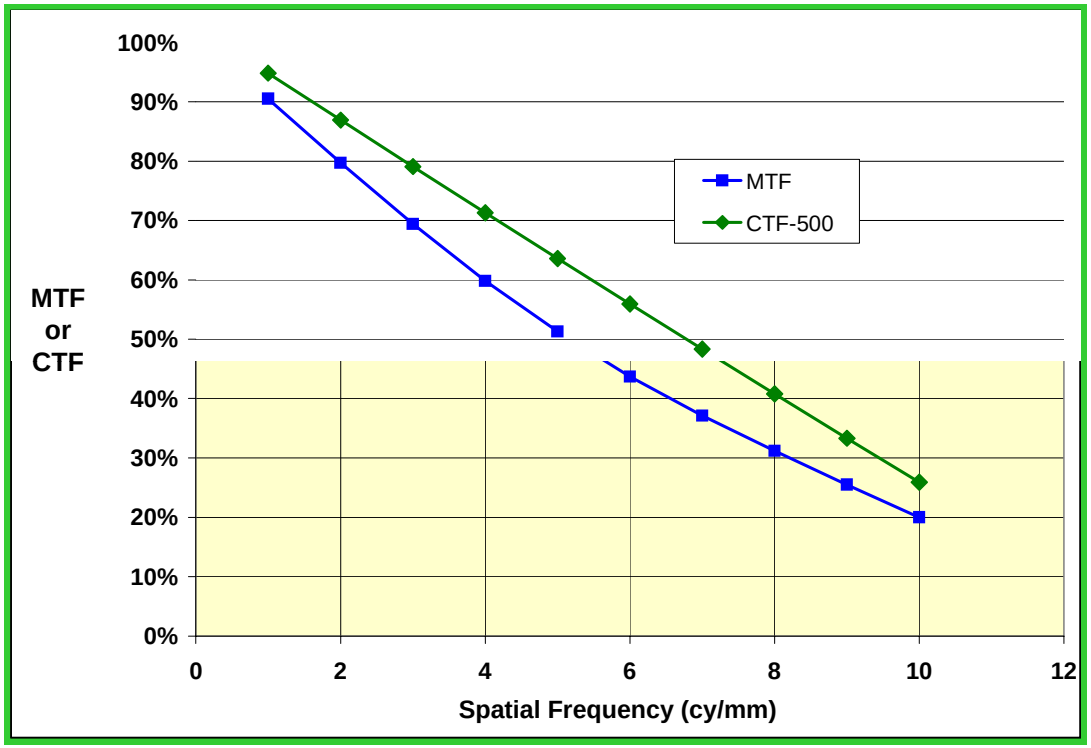
IAFIS-DOC-01078-8.0 i SEPTEMBER 24, 2007

- "Applies to systems that scan and capture fingerprints …, including hardcopy scanners such as ten-print card scanners, and live scan devices" …and fingerprint printers

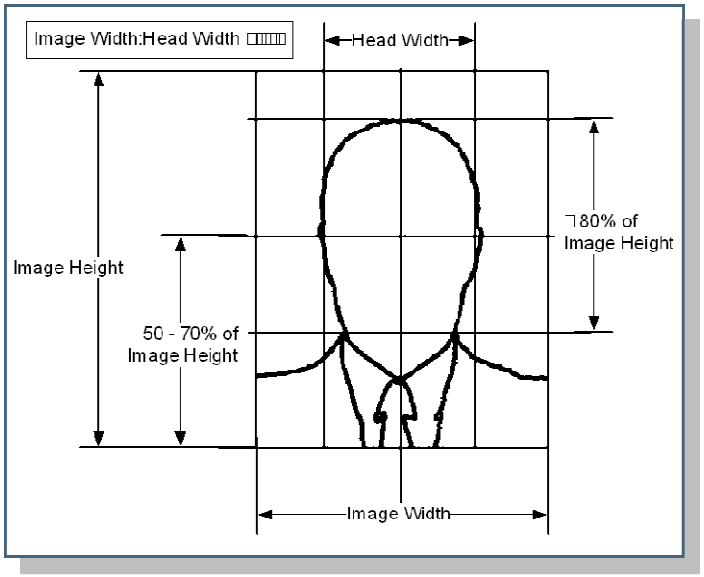
- Scanner "must be capable of producing images that exhibit good geometric fidelity, sharpness, detail rendition, gray-level uniformity, and gray-scale dynamic range, with low noise characteristics."

Appendix F Metrics for FP Scanners

- Output Resolution
- Linearity
- Geometric accuracy
- Spatial Frequency Response (MTF or CTF)
- SNR
- Gray-Level Uniformity



An Appendix F for Faces?

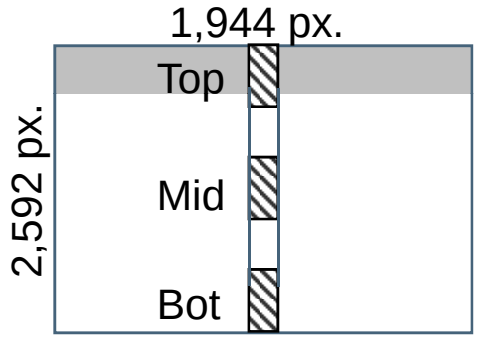


- **The challenge**: A much more complicated imaging environment for face images
  - Nonuniform or uncontrolled lighting
  - 3-dimensional structure
  - Need for color
  - Uncontrolled backgrounds
  - Variable apertures & exposure times
- **Face image interchange standards** provide limited guidance (e.g., Full Frontal specs in ISO 19794-5)
  - No saturation (over or under exposure) on the face
  - In focus from nose to ears and chin to crown
  - ≥ 2mm spatial resolution (≥ 1 cy/mm, or ≥ 0.5 cy/mm?)
  - No noticeable distortion
  - ≥ 7 bits of intensity variation (128 values) in the facial region
  - ≥ 180 pixels for the width of the head
  - should be converted to a defined standard RGB space, such as *sRGB*

Simple Visual Check of Resolution

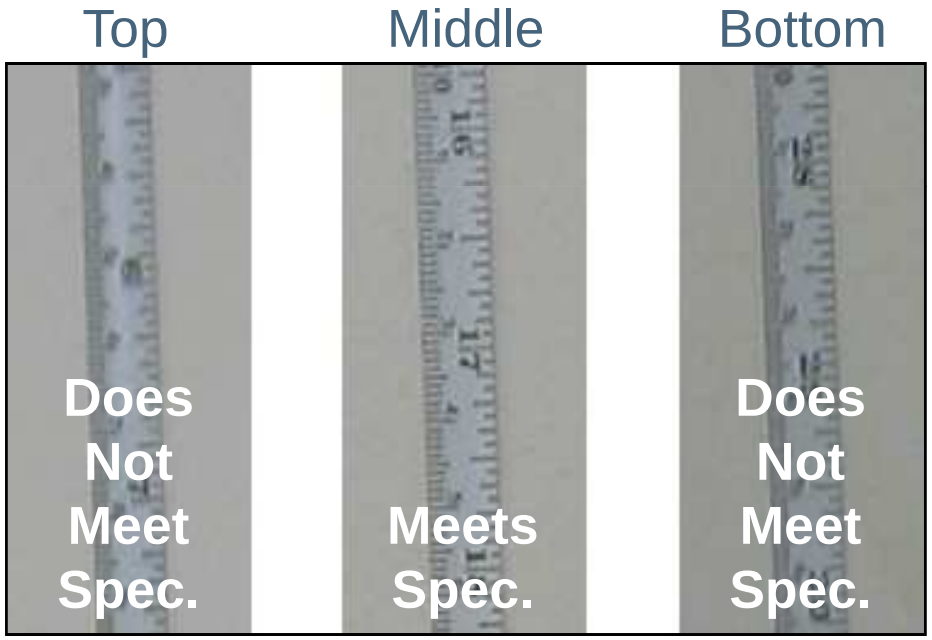
ISO 19794-5 A.2.5, Focus and depth of field (Informative)

"Greater than one millimetre resolution will be considered accomplished if the individual millimetre markings of rulers placed on the subject's nose and ear facing the camera can be seen simultaneously in a captured test image."

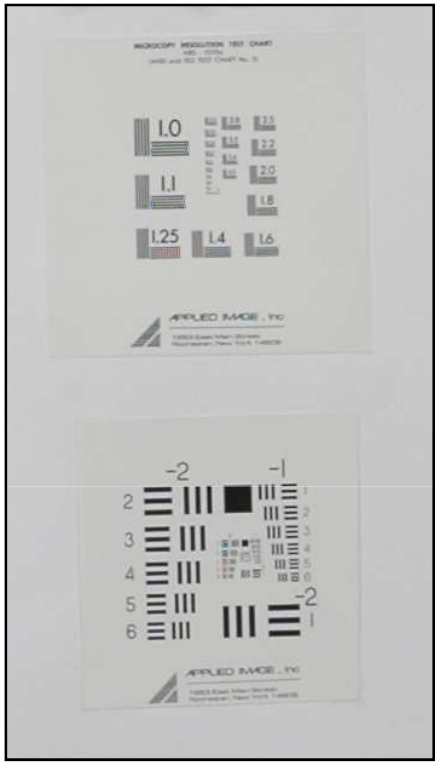


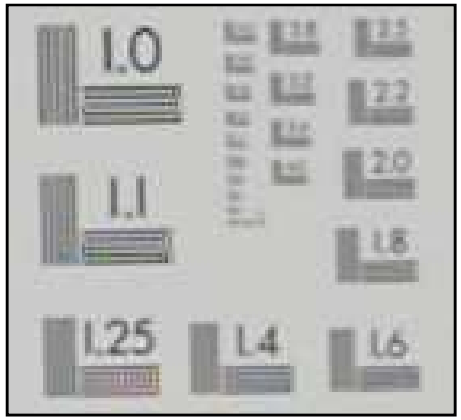
"Point & shoot" digital camera
Focal Length: 9.9mm (~ 48 mm equiv.)
ISO 50, 1/5 sec, F/4.5
Used in landscape mode
Distance to subject: ~ 1.2m (4 ft.)
Vertical field of view: ~ 25 inches

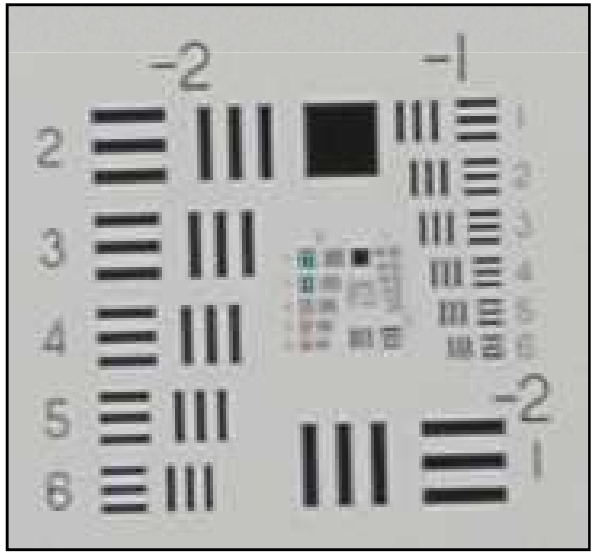
Portions of field of view



Visual Measurement of Resolution







USAF 1951
Test Target

Line pairs per millimeter (each pair consisting of one black bar & one white bar)

Element of Group	Factor (math)	Factor (numerical)
1	2^{0}	1.00000
2	$2^{-1/6}$	0.89090
3	$2^{-2/6}$	0.79370
4	$2^{-3/6}$	0.70711
5	$2^{-4/6}$	0.62996
6	$2^{-5/6}$	0.56123

Calculation of Depth of Field

1/1.8-inch CCD (8.9mm diagonal, 7.2mm width)
2592 x 1944 pixels (~5Mpixels)
Focal length (f) = 9.9mm
Subject distance (s) = 1.2 m (4 ft.)
F Stop (F) = 4.5
Assume diameter of circle of confusion (c) = pixel pitch = 0.00278 mm

$$D_{front} = \frac{cFs(s-f)}{f^2 + cF(s-f)}$$

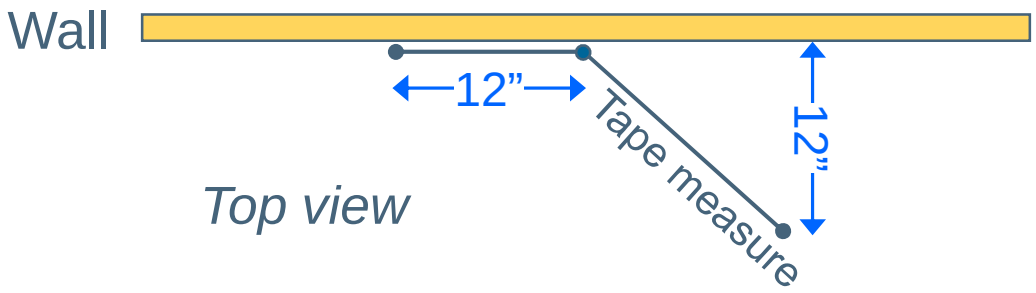
$$D_{rear} = \frac{cFs(s-f)}{f^2 - cF(s-f)}$$

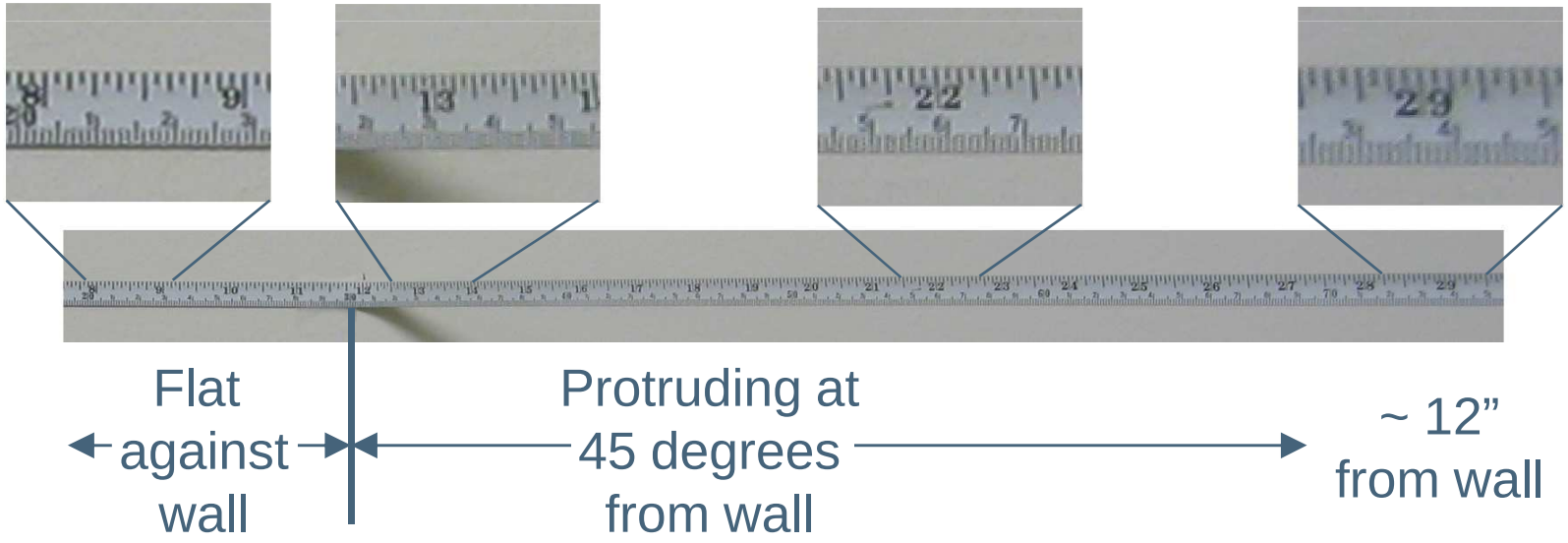
$$D_{DoF} = D_{front} + D_{rear}$$

$$D_{DoF} \cong \frac{2cs^2F}{f^2}$$

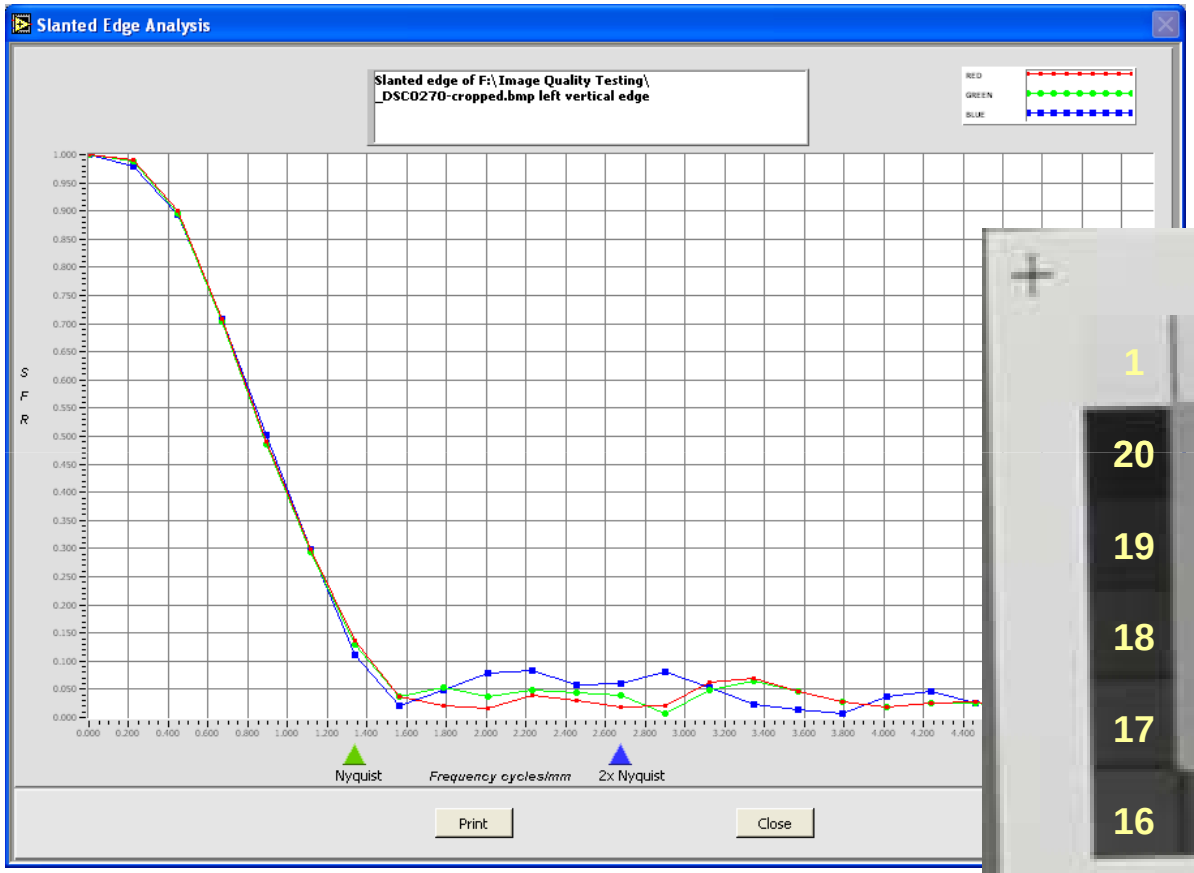
$$D_{DoF} \cong 37\text{cm} \cong 14.5"$$

Simple Measurement of Depth of Field

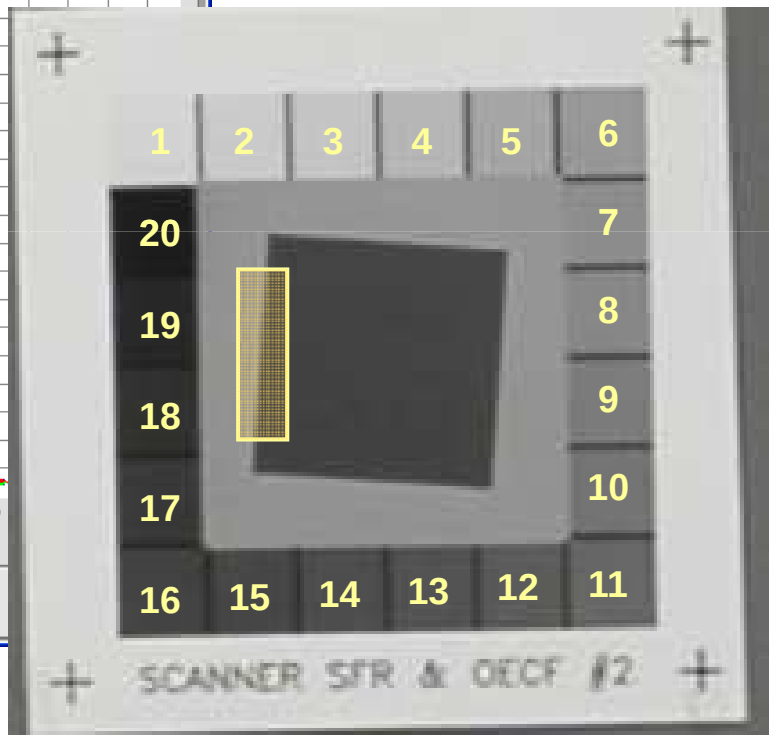




Quantitative Measurement of Resolution: Horizontal SFR for a Digital SLR

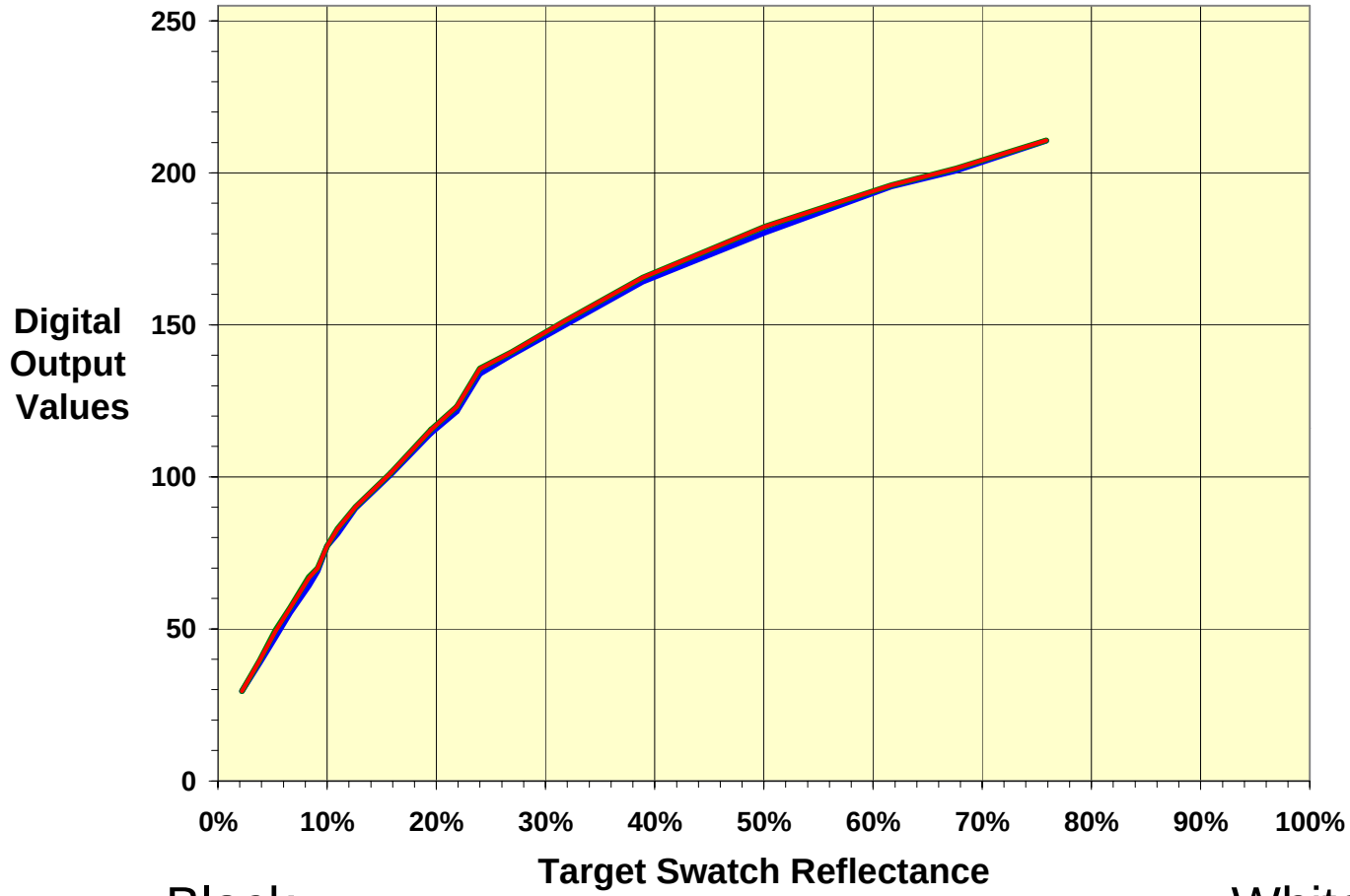


Applied Image, Inc.
QA-62-SFR
Scanner Test Chart



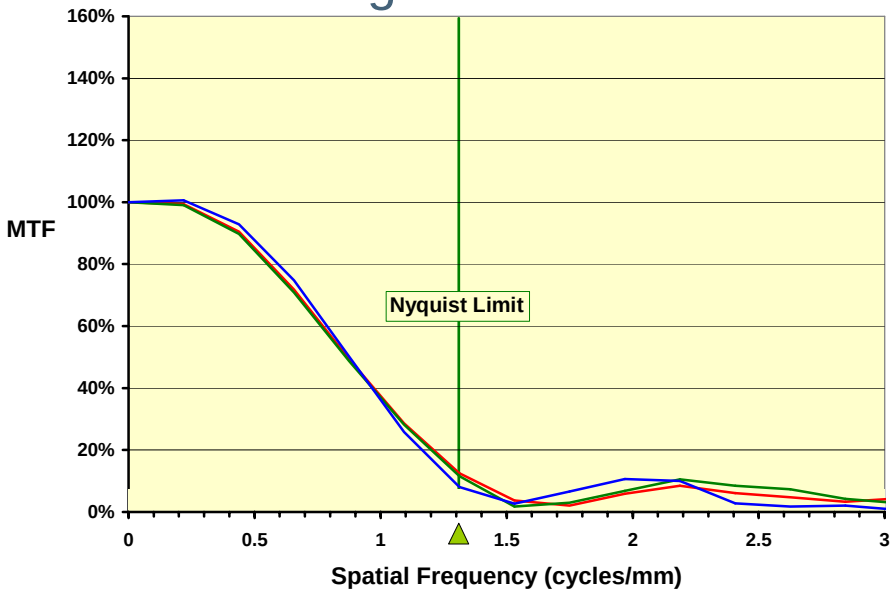
To download this and other tools, see http://www.i3a.org/downloads_iso_tools.html

Measured OECFs for a Digital SLR (using *Adobe RGB* color space)



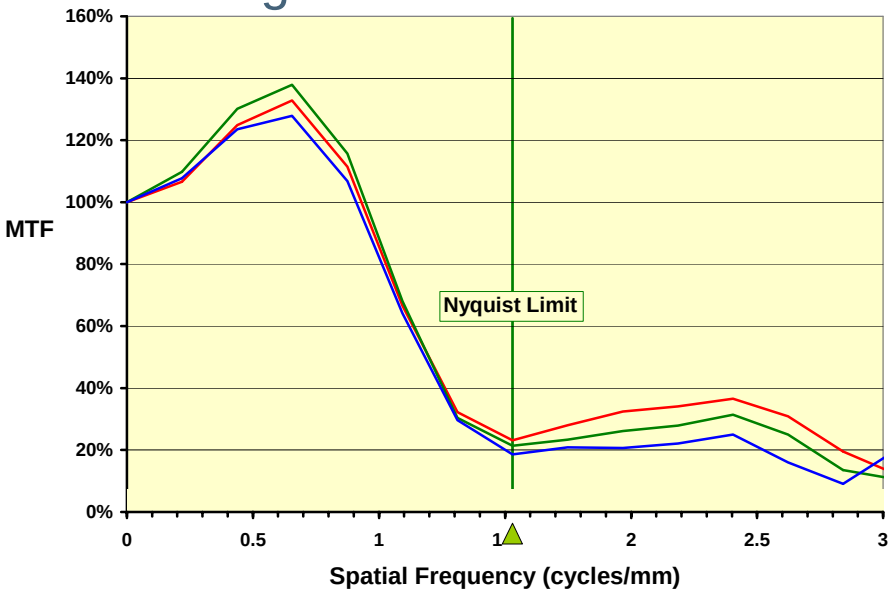
Horizontal SFRs for Two Digital Cameras

Digital SLR



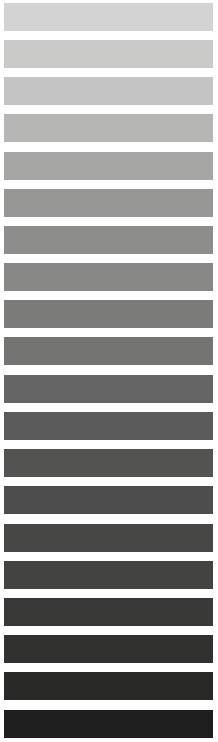
Well behaved
Moderate drop-off at high frequencies
Minimal aliasing expected

Digital "Point and Shoot"



Response boosted at intermediate frequencies
Some aliasing expected

Red, Green, and Blue Values for the 20 Gray Steps in the QA-62 (for a Digital SLR)



Patch	Red avg.	Grn avg.	Blu avg.	Red stdev	Grn stdev	Blu stdev
1	210.7	210.7	210.5	1.6	1.4	1.4
2	201.5	201.5	200.7	1.5	1.2	1.2
3	196.0	196.0	195.5	1.6	1.2	1.2
4	182.3	182.3	180.4	1.2	1.1	1.1
5	165.5	165.5	164.2	1.7	1.2	1.2
6	151.1	151.1	149.7	1.8	1.5	1.5
7	141.0	141.0	140.1	1.7	1.3	1.3
8	135.6	135.7	133.9	2.0	1.5	1.4
9	123.1	123.1	121.5	1.7	1.5	1.5
10	115.5	115.5	114.5	2.1	1.4	1.4
11	101.3	101.3	100.8	1.7	1.4	1.4
12	90.1	90.1	89.8	2.1	1.8	1.8
13	82.9	82.9	81.4	1.6	1.2	1.1
14	77.3	77.3	77.3	1.4	1.4	1.4
15	70.0	70.0	69.0	1.4	1.1	1.1
16	66.7	67.1	64.2	2.6	1.6	1.7
17	56.9	57.0	55.4	1.8	1.4	1.4
18	49.2	49.5	47.3	2.0	1.9	1.7
19	39.6	39.6	38.8	1.9	1.3	1.3
20	29.5	29.5	29.5	1.8	1.6	1.6

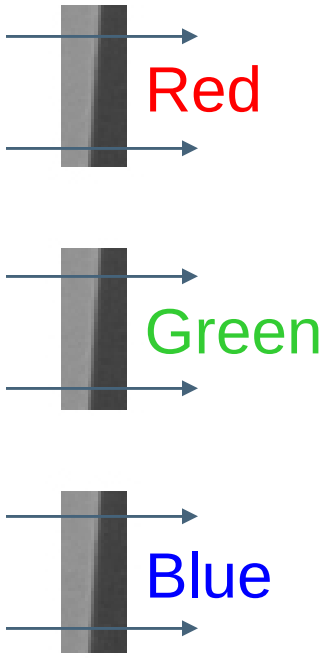
Camera was carefully white balanced

R, G, and B values are almost identical for all patches

Standard deviations are quite low

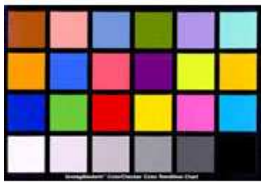
Color Channel Misregistration (in pixels) for Two Digital Cameras

Left Vertical Edge



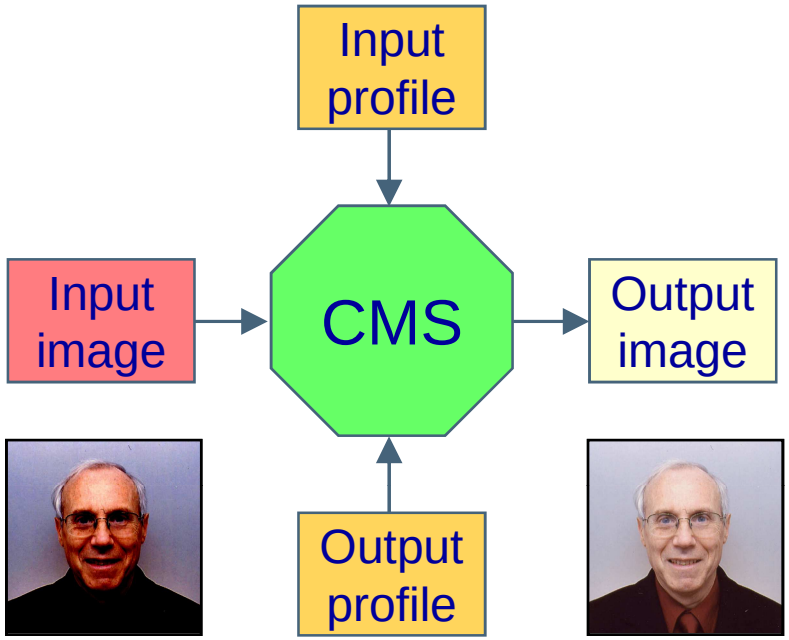
	Digital SLR		Point & Shoot	
Transition	Red Green	Green Blue	Red Green	Green Blue
Left Vertical	0.01254	-0.11959	0.26206	-0.15877
Right Vertical	0.03471	0.12691	-0.08028	0.48164
Lower Horizontal	0.07711	0.08563	0.30137	0.26658
Upper Horizontal	0.01735	0.05052	0.04387	-0.05623

Color Measurement



Macbeth ColorChecker

IT8.7/2



Color error can be measured in *Lab* space

$$\Delta E = \sqrt{(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2}$$

Potential Face Camera Metrics

- Sampling frequency (ppi) and geometric distortion
- Quantization (bpp)
- OECF (Capture γ and exposure accuracy) - ISO 14524
- Spatial resolution (MTF) and depth of field - ISO 12233 and ISO 16067-1
- Channel registration and color accuracy
- Noise (S:N) - ISO 15739 - and uniformity
- Dynamic range
- Vignetting & flare

Conclusions and a Recommendation

- Megapixel digital still cameras and some video cameras can produce face images compliant with ISO 19794-5
- However, camera specifications for face capture are needed to ensure high quality
- An Appendix F-like set of specifications for face image capture can be written and should be based upon existing ISO standards
- Specifications for lighting and the capture environment are important and should be developed separately
- Government agencies using or considering the use of face recognition should be involved in the development of camera specifications
- However, a camera certification program does not seem feasible – too many camera makes and models; newer models replace previous versions every few months