Best Practices for
Taking Face Photographs
and
Face Image Quality Metrics

NIST Biometric Quality Workshop

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Motivation and Outline

- **Motivation for face image quality measurement:**

  - **U.S. Department of State using automated face recognition for Nonimmigrant, Immigrant, and Diversity Visa application processing**

  - **Ensure accurate automated and manual face recognition**

- **Through ISO/IEC JTC1 SC37, proposed adding a best practices Annex to ISO 19794-5** (Information Technology — Biometric Interchange Formats — Part 5: Face Image Data)

- **Nature of problem - how should we measure face image quality?**

  - **Using test patterns**

  - **Using face images and face image quality metrics**

Some Examples of Problems

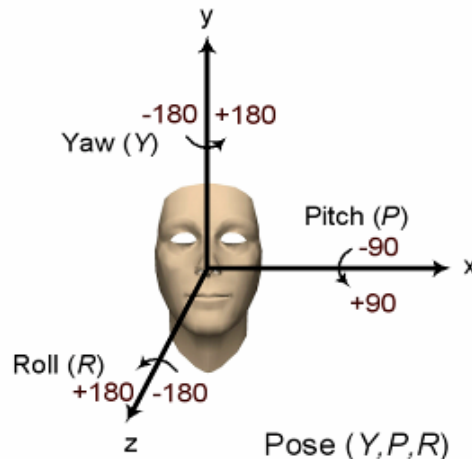# Amendment to Add Best Practices Annex to ISO 19794-5

AMENDMENT 1, *Conditions for Taking Photographs for Face Image Data*
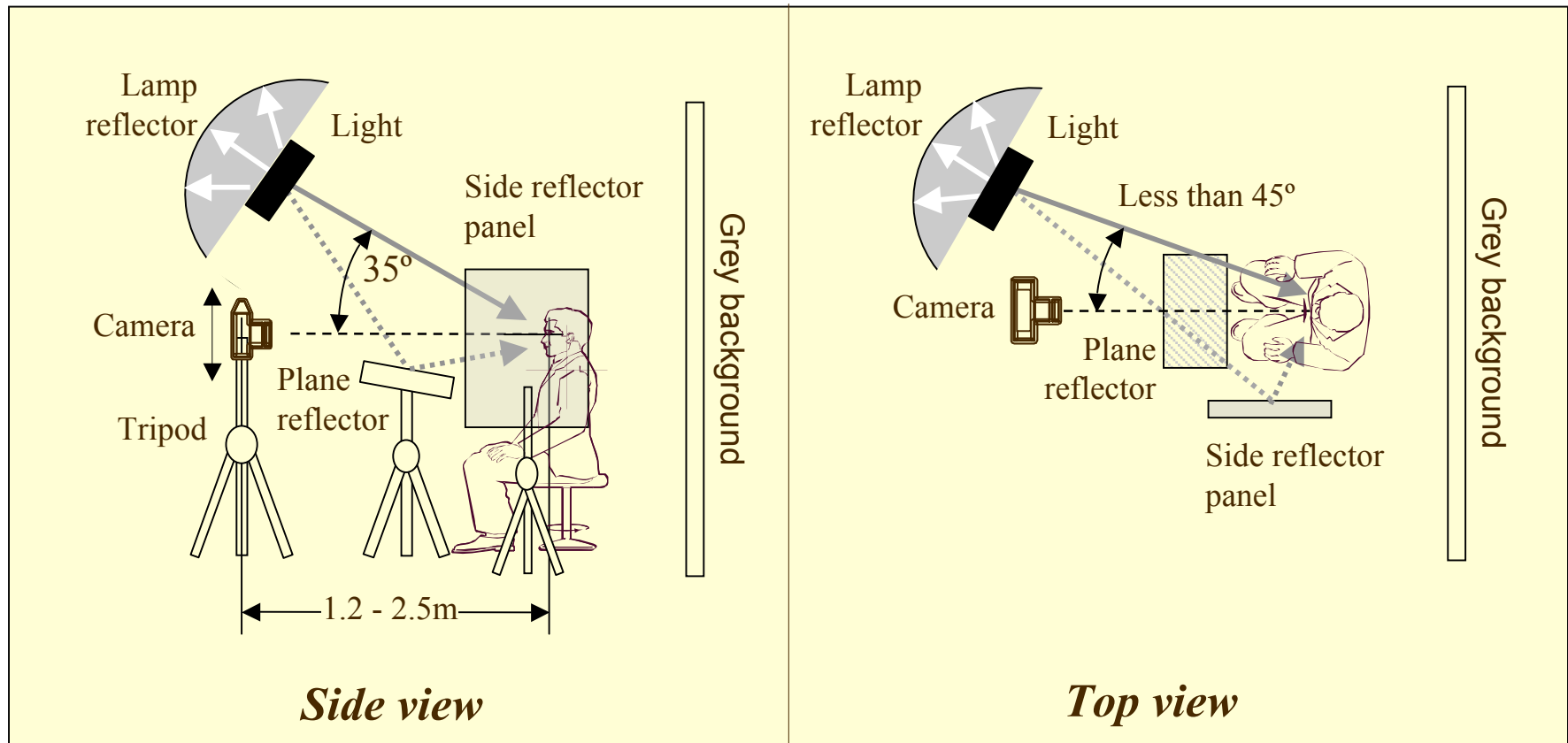
Editor: Tetsuo (Ted) Tomonaga of Japan
Co-editor: Donald D'Amato

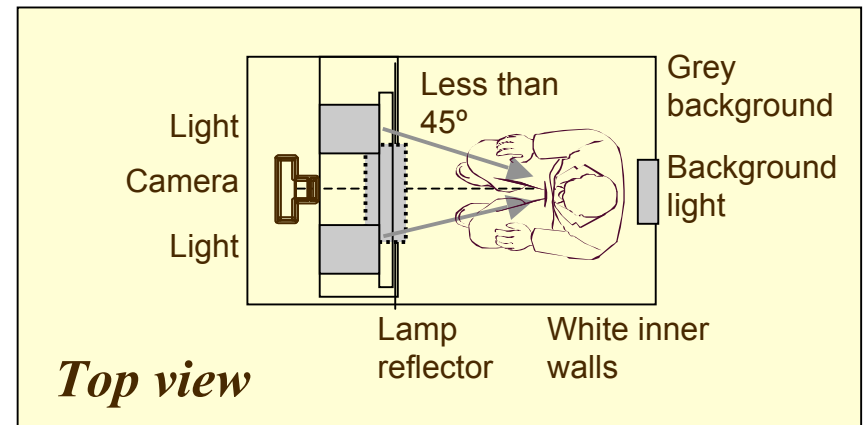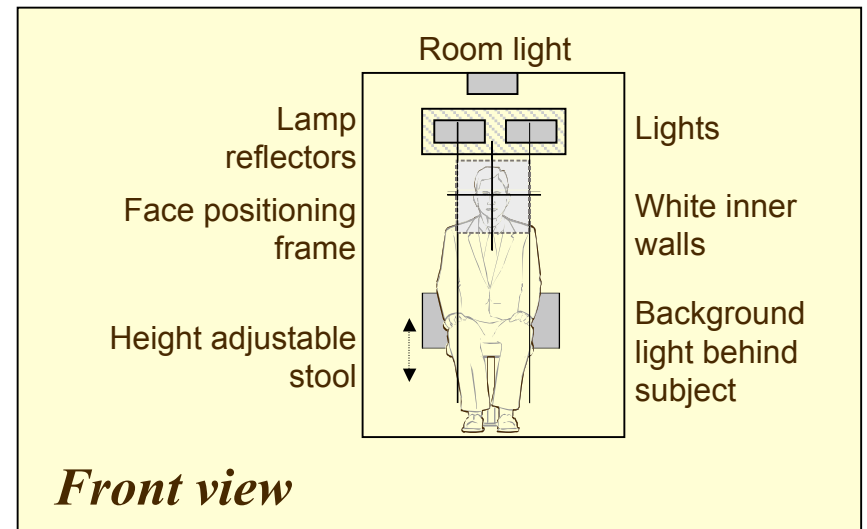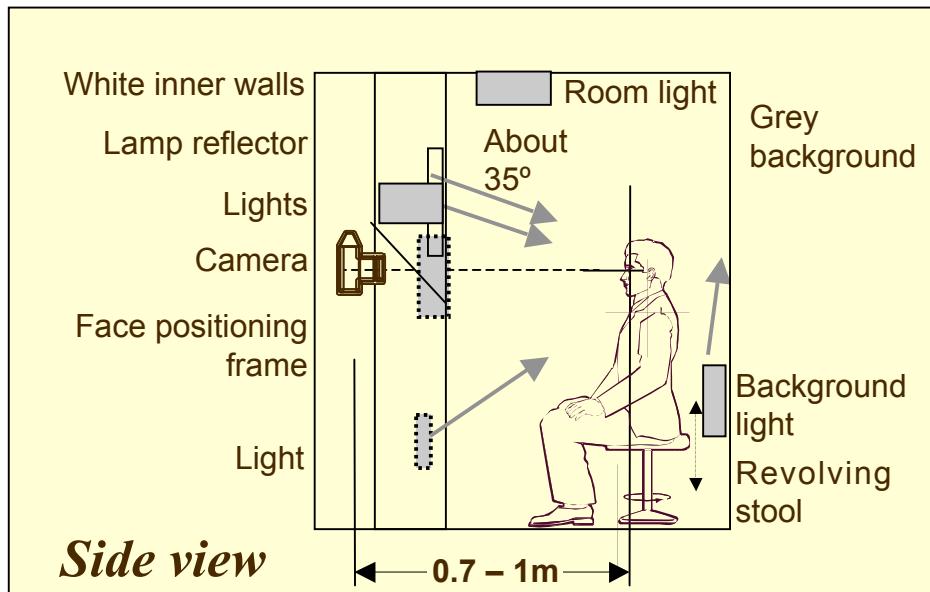Circulated to ISO/IEC JTC1 SC 37 National Bodies for PDAM ballot, with due date of 5-28-2006

❑ Provides explicit guidance for the design of photographic studios and photo booths

❑ Supplements information provided in the standard and existing Annex A

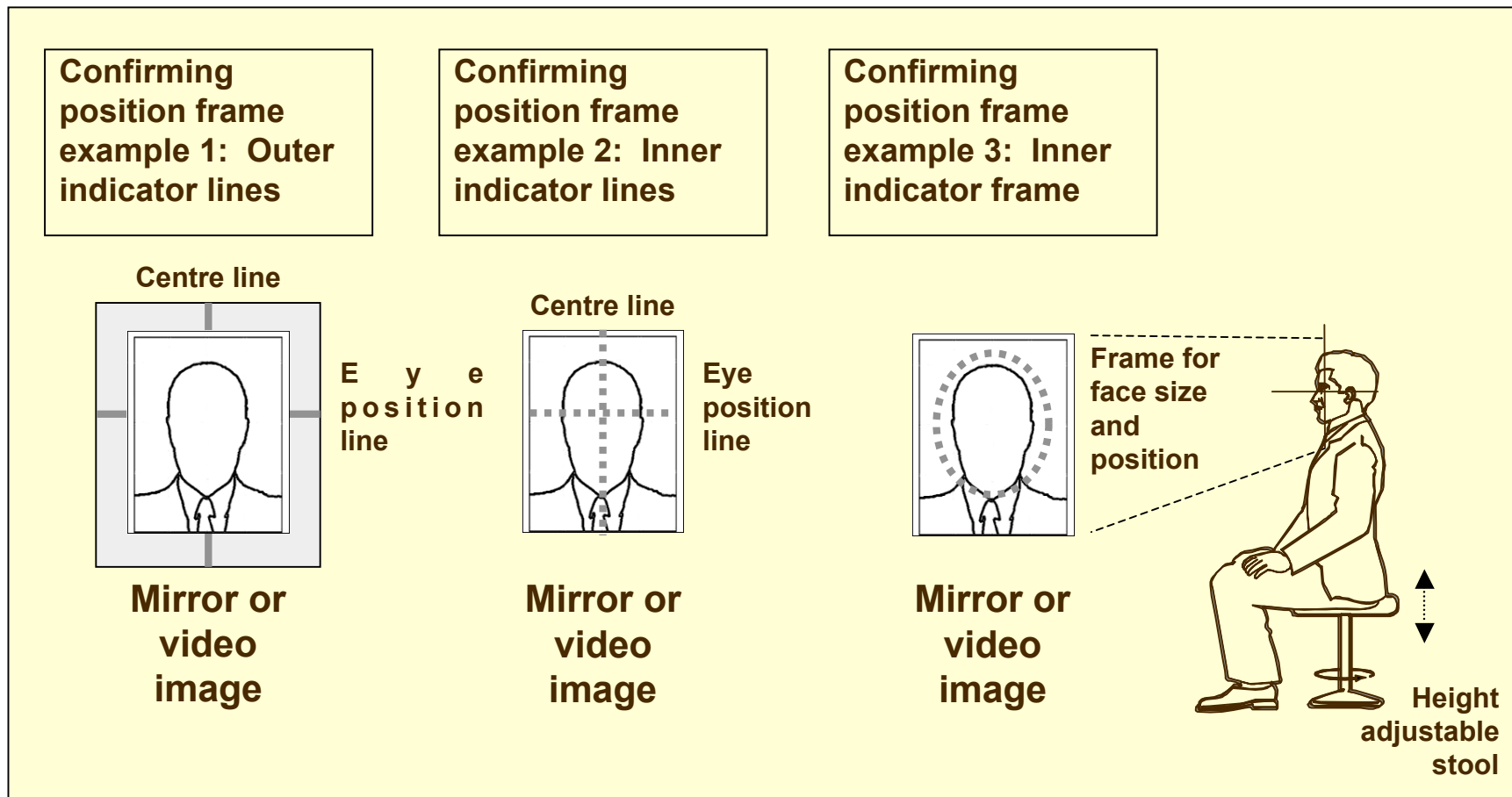❑ Provides guidance on printing quality and on scanning printed face photographs

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Single Lamp Arrangement for a Photo Studio

Side view

Top view

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Lighting and Camera Arrangement for a Photo Booth

Side view

- White inner walls
- Lamp reflector
- Lights
- Camera
- Face positioning frame
- Light
- Room light
- About 35°
- Grey background
- Background light
- Revolving stool
- 0.7 – 1m

Front view

- Room light
- Lamp reflectors
- Face positioning frame
- Height adjustable stool
- Lights
- White inner walls
- Background light behind subject

Top view

- Light
- Camera
- Light
- Less than 45°
- Grey background
- Background light
- Lamp reflector
- White inner walls

User Interface: Head Positioning Frame

Confirming position frame example 1: Outer indicator lines

Confirming position frame example 2: Inner indicator lines

Confirming position frame example 3: Inner indicator frame

Centre line

E y e position line

Mirror or video image

Centre line

Eye position line

Mirror or video image

Frame for face size and position

Mirror or video image

Height adjustable stool

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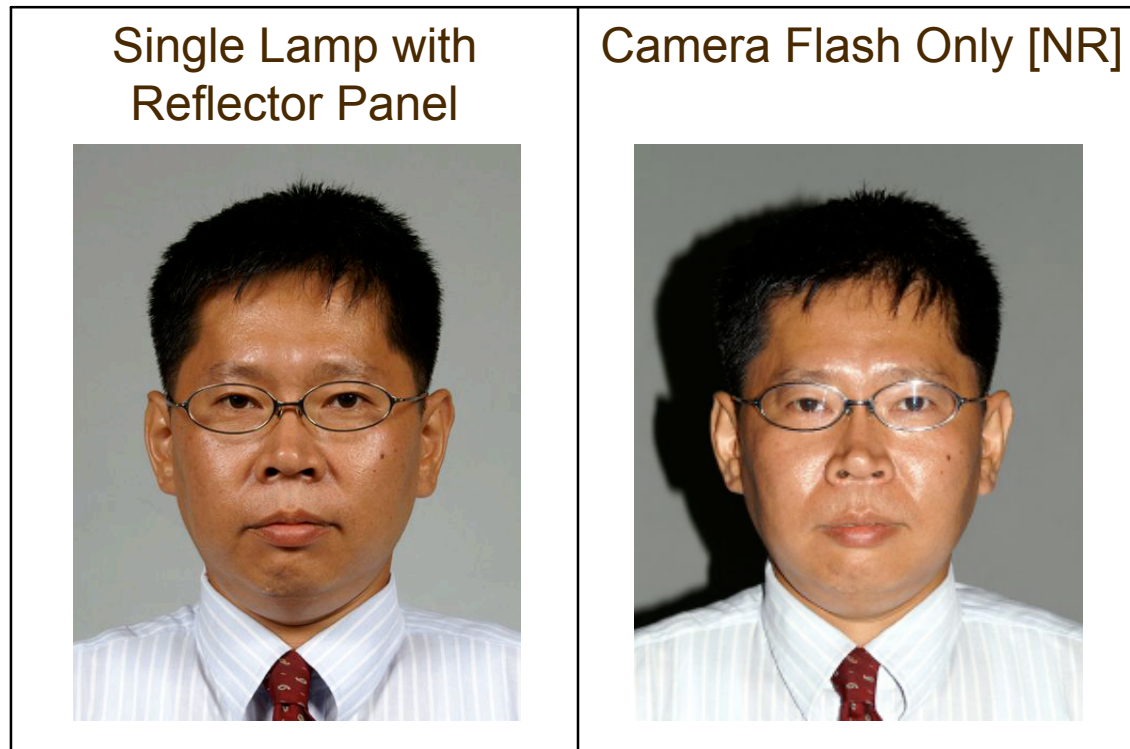# Evenness of Illumination

Two lights and a background light	Single light and a side reflector panel	Single light (without a side reflector panel) [NR]
Left-Right ΔEV=0.2		Left-Right ΔEV=1.5

Exposure Value : $EV = Log_2\left(\dfrac{F^2}{T}\right) = 2Log_2(F) - Log_2(T)$

NR: Not recommended

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Effect of Using On-Camera Flash
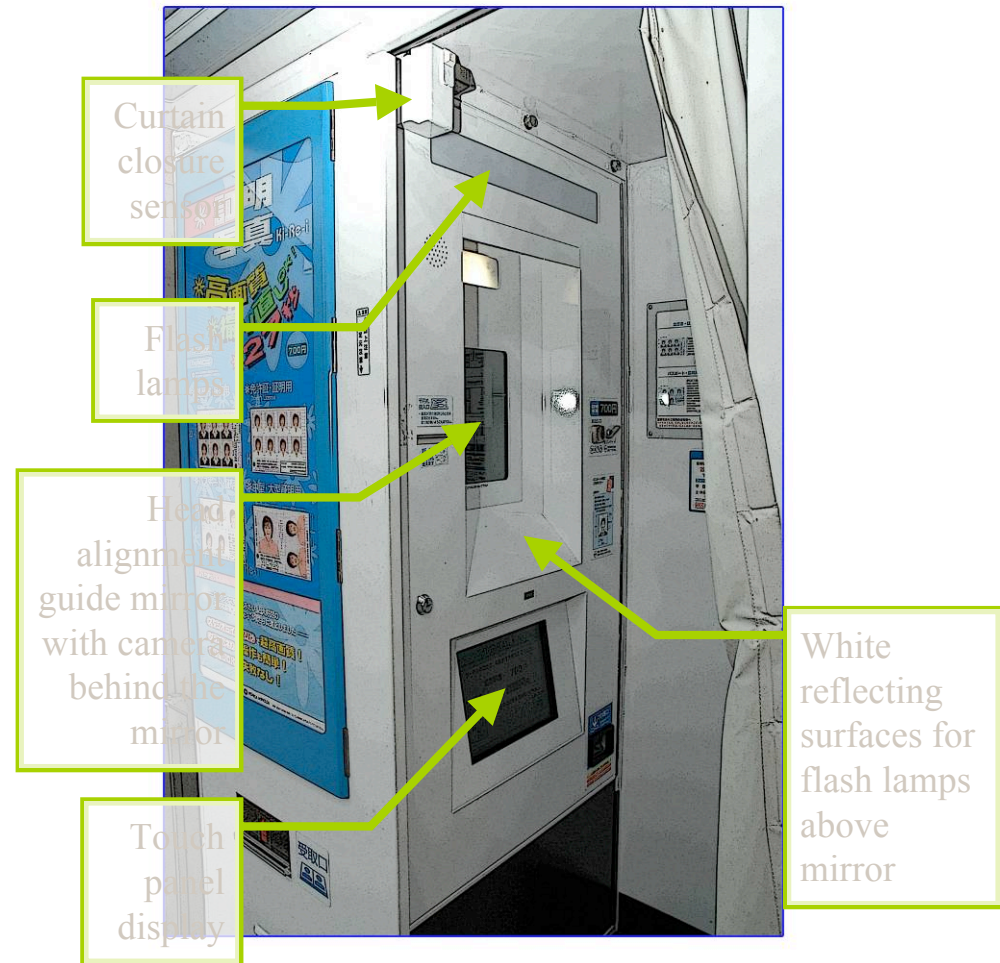
Single Lamp with Reflector Panel	Camera Flash Only [NR]

Note glare on glasses & specular reflections from face, deep shadow on background–blending with dark hair

NR: Not recommended

Example of a Photo Booth

Curtain closure sensor
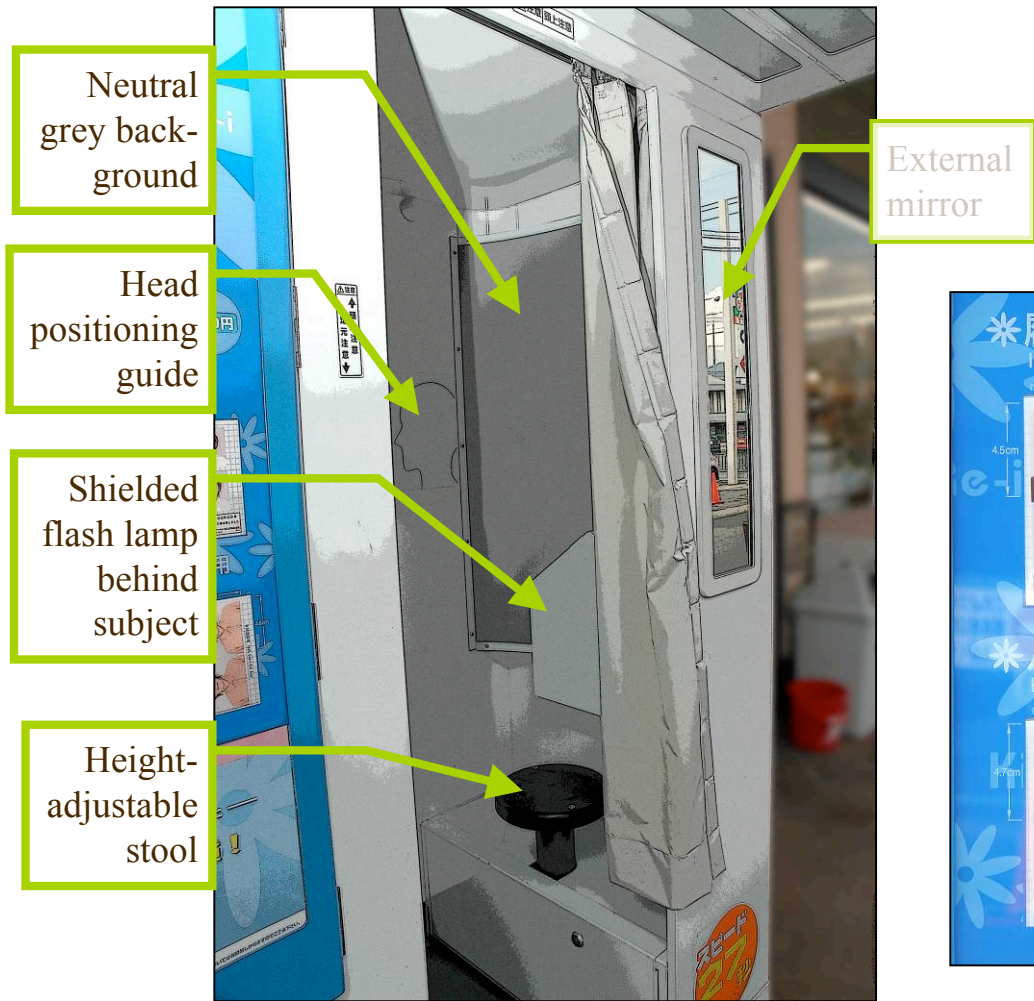
Flash lamps

Head alignment guide mirror with camera behind the mirror

Touch panel display

White reflecting surfaces for flash lamps above mirror

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Example of a Photo Booth

Neutral grey back-ground

External mirror

Head positioning guide

Shielded flash lamp behind subject

Height-adjustable stool

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Image Quality Measurements

- **Use <u>test targets</u> to calibrate camera (or scanner) and measure its characteristics**

  - **See http://www.i3a.org/downloads_iso_tools.html**

  - **Opto-electronic conversion function (OECF) – ISO 14524**

  - **Spatial frequency response (SFR) – ISO 12233 or ISO 16067-1**

  - **Noise measurements - ISO 15739**

  - **Color profile – See www.color.org**

- **Measure compliance of face images with specifications in ISO 19794-5**

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Color CCD Using a Typical Bayer* Pattern

x

$\approx c$

y

CCD
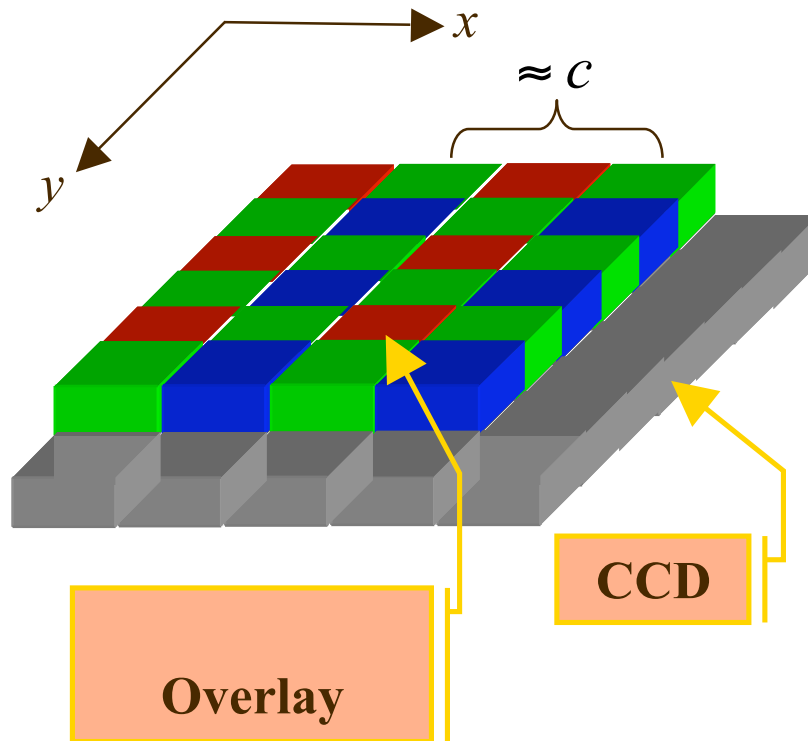
Overlay

CCD color imaging array
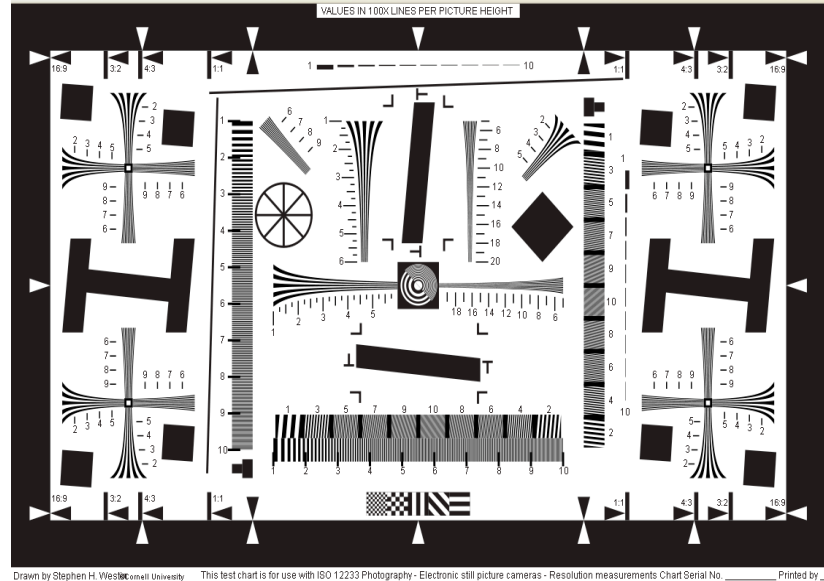 ½ of the elements are green
  ¼ are red
  ¼ are blue

RGB values assigned by
  interpolation

Overlay also filters out infrared,
  realigns the light, and provides
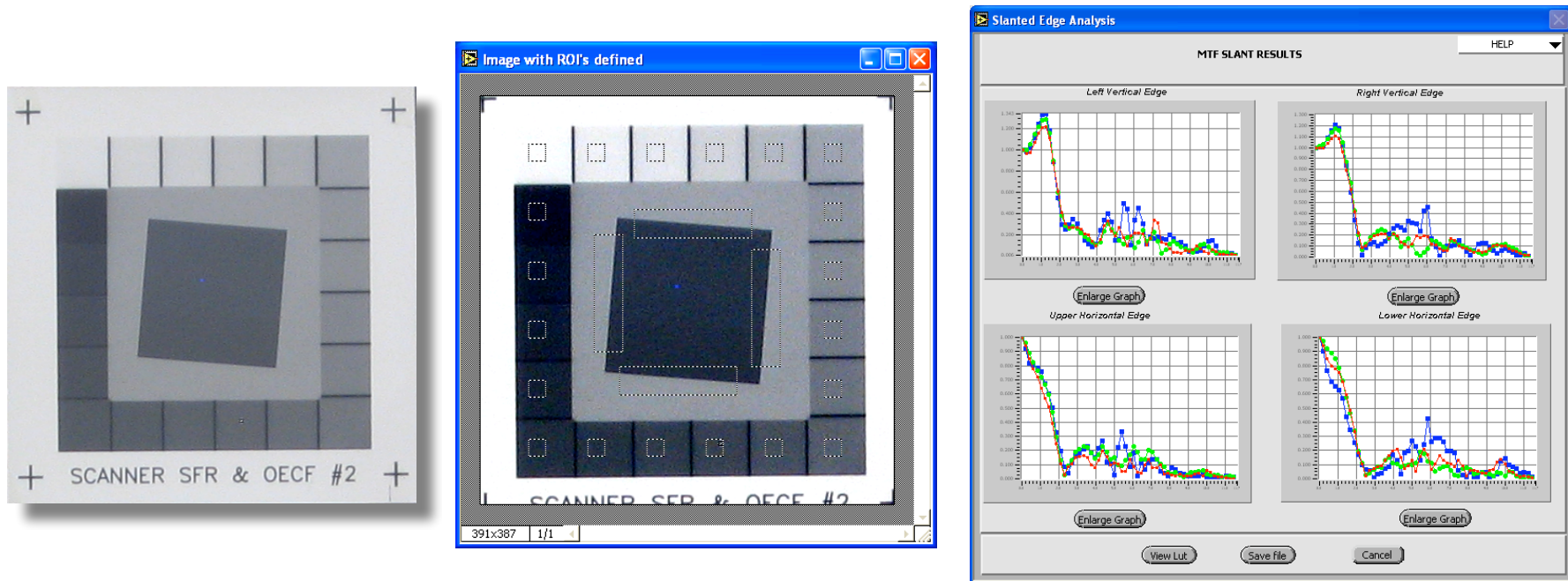 a low-pass, anti-aliasing filter

* Bryce E. Bayer, Kodak
  researcher, awarded U.S. Patent
  #3,971,065, July 20, 1976

Test Chart for Spatial Resolution Measurement: ISO 12233

- Contains many visual indicators of spatial resolution
- Slanted edge targets provide:
  - Oversampling of the edges – edge position resolved to better than a single pixel
  - High-resolution measurement of the edge-spread function (ESF)
  - Noise reduction of the Line Spread Function (LSF) or differentiated ESF
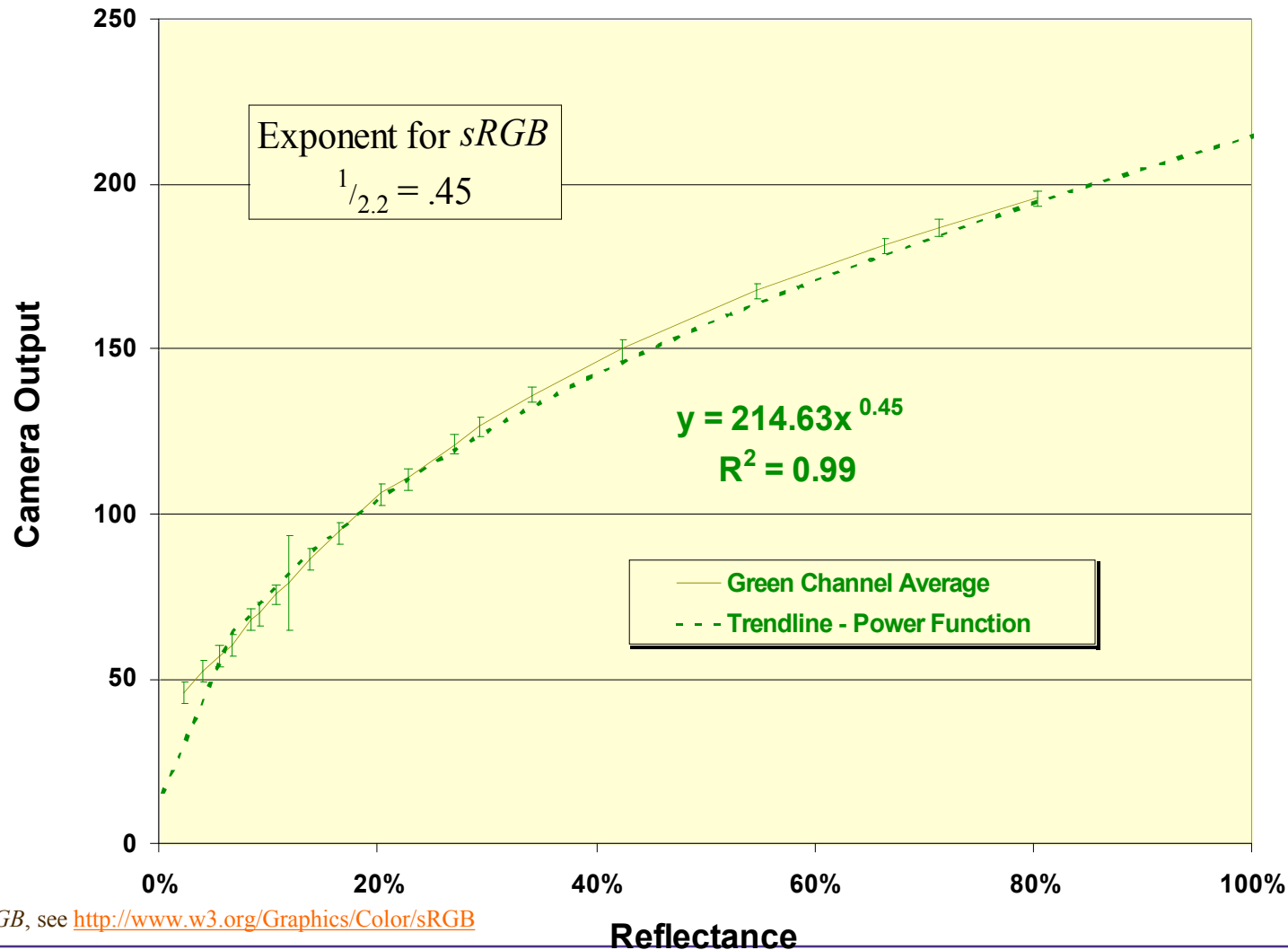 - Modulation Transfer Function (MTF) through the Fourier transform of the LSF

Drawn by Stephen H. Wester, Cornell University   This test chart is for use with ISO 12233 Photography - Electronic still picture cameras - Resolution measurements Chart Serial No. _____ Printed by __

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Slanted Knife Edge (Rotated Square) Target and MTF Measurement Software

ISO 16067-1, *Photography - Electronic scanners for photographic images – Spatial resolution measurements – Part 1: Scanners for reflective media*
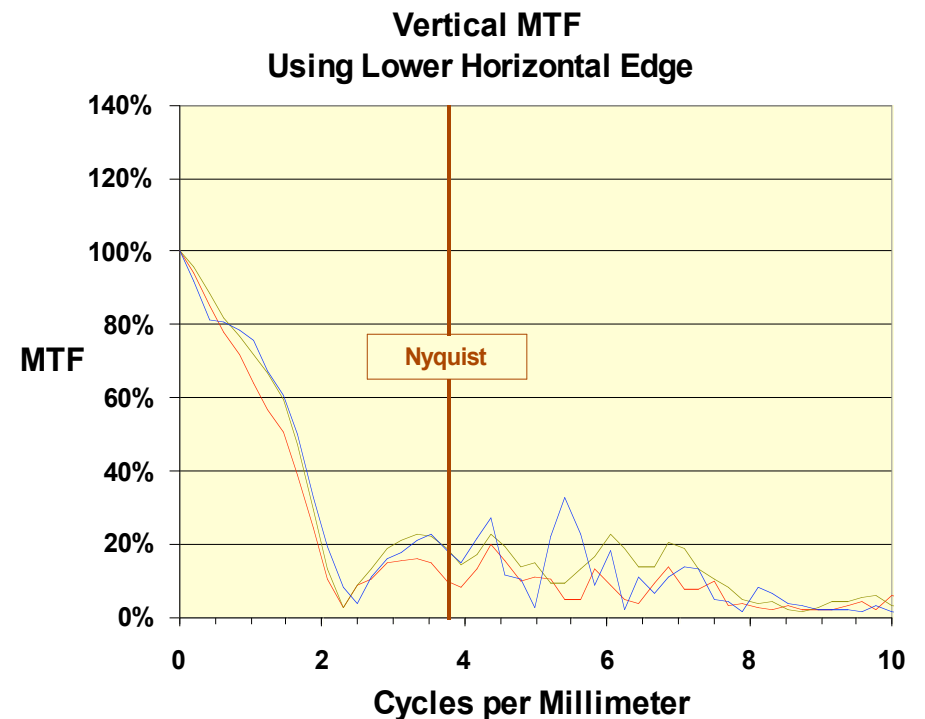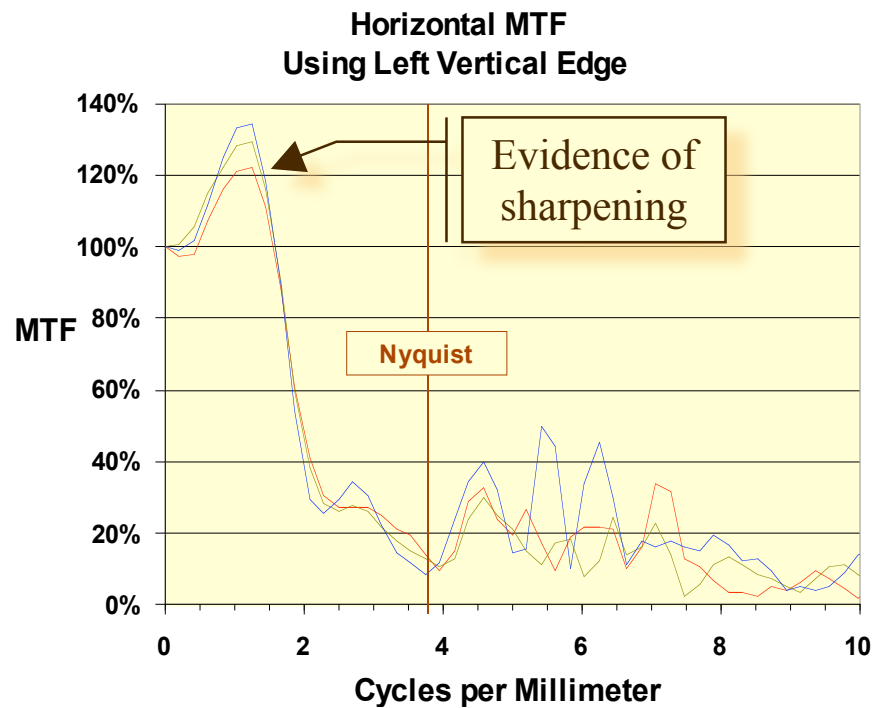
"… specifies methods for measuring and reporting the spatial resolution of electronic scanners for continuous tone photographic prints. … applies to both monochrome and colour print scanners."

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Measured Tonal Response Function (OECF) for a Moderate Quality Digital Still Camera

For details of *sRGB*, see http://www.w3.org/Graphics/Color/sRGB

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Modulation Transfer Functions for a Moderate Quality Digital Still Camera

Horizontal MTF Using Left Vertical Edge

Evidence of sharpening

Nyquist

MTF

Cycles per Millimeter

Vertical MTF Using Lower Horizontal Edge

Nyquist

MTF

Cycles per Millimeter

Quality Comparison of Direct Digital and Scanned Printed Photo
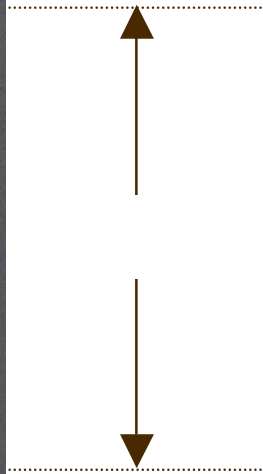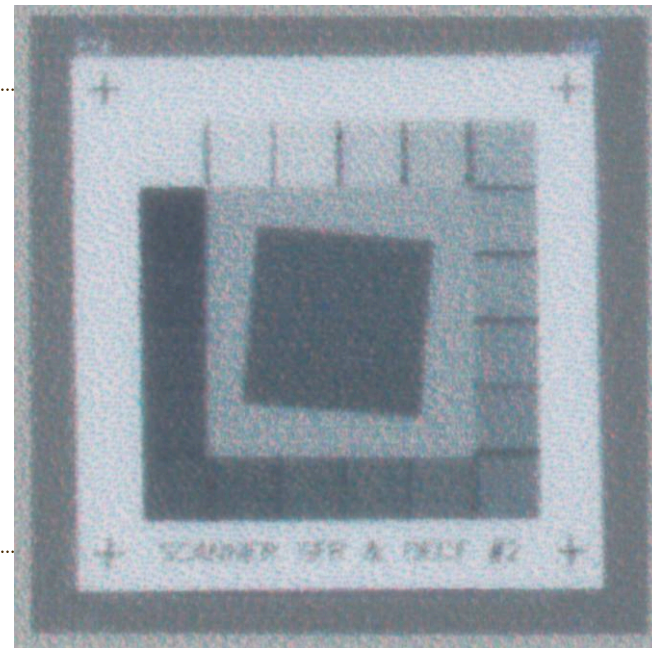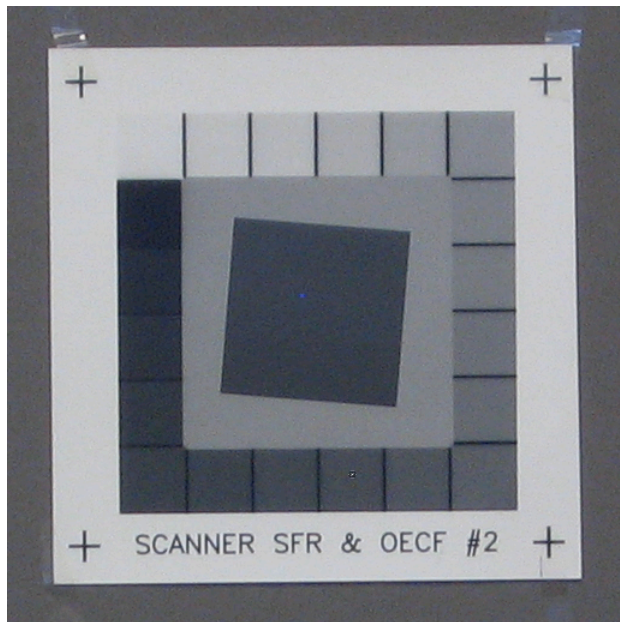
➤ Direct digital capture using moderate quality camera with optical zoom

➤ Same image printed with an inkjet printer using correct passport reduction ratio on glossy photo paper, highest quality setting

➤ Scanned at 2400 pixels/inch

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Depth of Field Calculation
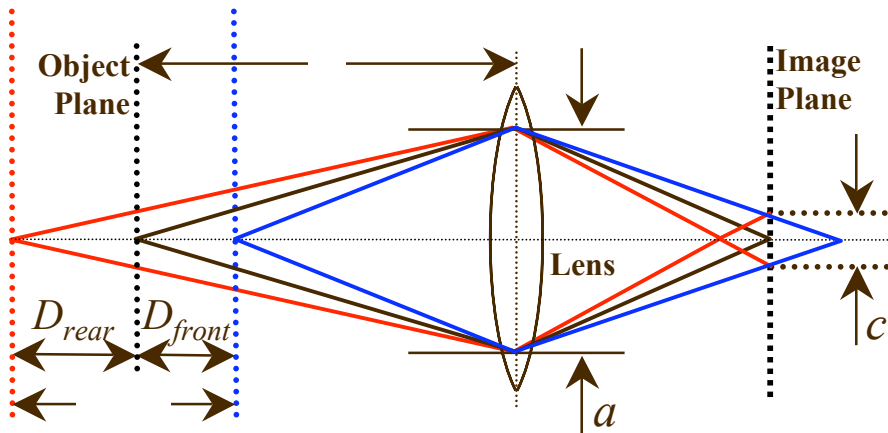
Since $s >> f$ and $f^2 >> cFs$

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

Example for a digital SLR :

$$f = 70mm, \ s = 1.5m,$$

$$F = 8, \ c = 0.016mm$$

$$D_{DoF} \cong 12cm$$

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

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

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

D_{front} = the front focal distance, the distance from the object plane
to the plane closest to the lens that is still in acceptable focus,

D_{rear} = the rear focal distance, the distance from the object plane
to the plane farthest from the lens that is still in acceptable focus,

c = the diameter of the circle of confusion,

s = the object distance, the distance from the lens to the object plane, and

$F = f/a$ is the F - stop, the lens focal length f divided by the effective lens
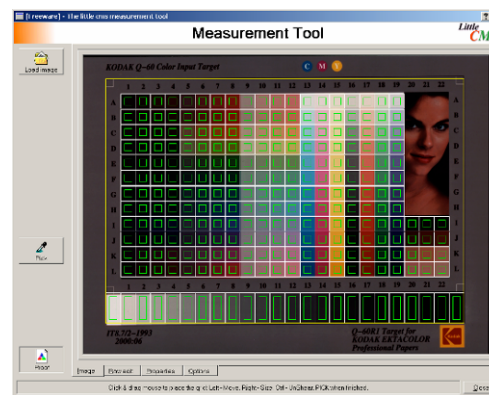aperture a

Gamuts for *sRGB* and a Scanner

High Quality Scanner

sRGB
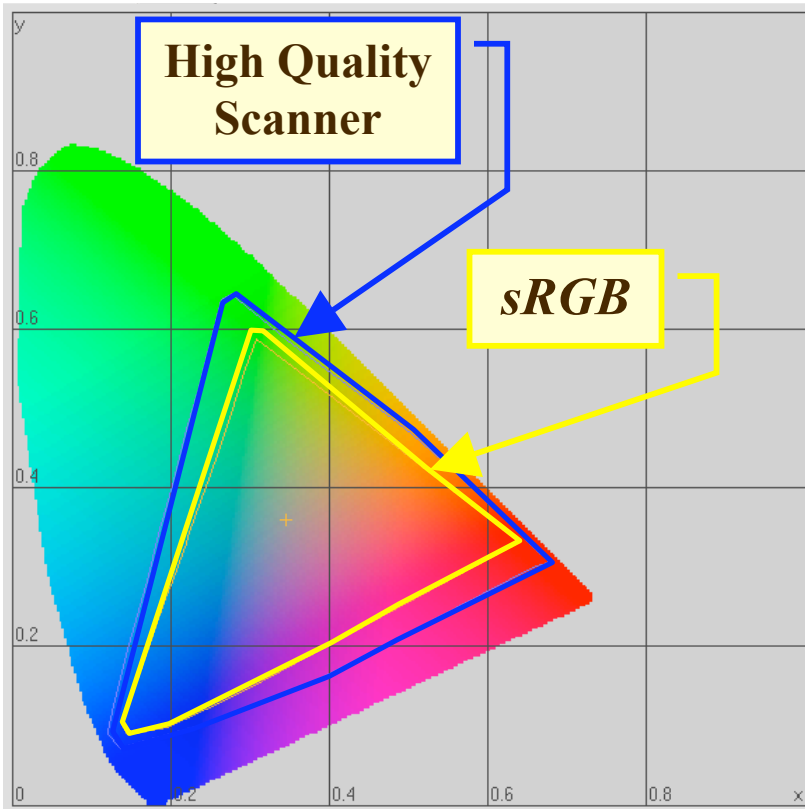
Macbeth ColorChecker

IT8.7/2

Little CMS
http://littlecms.com/

"Liberal open source license"

Desired Face Image Quality Metrics

Dynamic Range in Face – intensity density in the facial region should be at least 7 bits of intensity variation (at least 128 unique values) in face after conversion to grayscale (ISO 19794-5 7.4.2)

Eyes Closed/Obstructed – measured as a percentage, value should reflect degree of obstruction of eyes due to eyeglass rims, tint, or glare, bangs, eye patches, head clothing, or eyes closed (e.g., 100% obstructed if both eyes are closed; 50% obstructed if one eye is obstructed) (7.2.3, 7.2.11)

Color Balance – must reflect natural colors with respect to expected skin tones. This value can be affected by inappropriate white balancing or red-eye (7.3.4)

Lighting Uniformity on Face – measured as a percentage, value should measure symmetry as affected by shadows or hot spots on the face (7.2.7-7.2.10)

Background Uniformity – measured as a percentage, value should measure symmetry and consistency as affected by shadows on the background, textured backdrops, or extraneous objects in the background. (A.2.4.3)

Head Size – Head width to image width ratio should be between 5:7 and 1:2 (8.3.4, 8.3.5, A.3.2.2)

Centering – horizontal and vertical position of face (8.3.2, 8.3.3)

Distance Between Eyes – measured in pixels, should be at least 90 pixels between eyes (8.4.1) and preferably 120 pixels (A.3.1.1)

Focus –measures sharpness and resolution of the facial area. Depth of focus must maintain at least 2 mm per-pixel-resolution and preferably 1 mm per-pixel throughout the face. Image should not be overly sharpened. (7.3.3, A.2.5)

Rotation (yaw) – value should measure deviation from frontal in degrees, compliance requirement is < ± 5° (7.2.2)

**Tilt (roll)** – value should measure deviation from frontal in degrees, compliance requirement is < ± 5° (7.2.2)

Confidence in Face – measures the confidence of the eye finding and the confidence that the object is a face

Brightness Exposure/ Contrast – low score if too dark or too bright, exposure measured in RGB values–gradations in skin texture should be visible, no saturation on the face (7.3.2)

Desired Face Image Quality Metrics

✓ Would like well-distributed, thresholdable histograms on representative images

Poor

Good

Accept

Reject ← → Reject
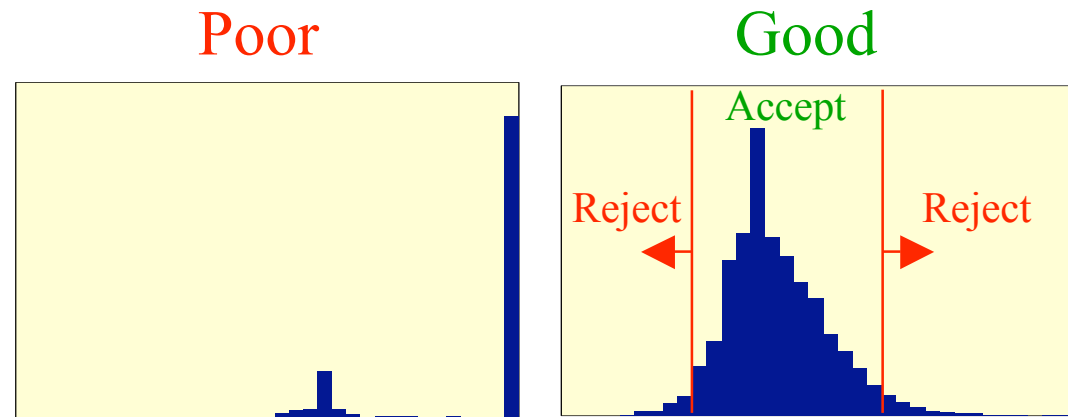
✓ Metrics should measure compliance with ISO 19794-5

✓ Desire good correlation of metrics with human perception

➢ At least four face image quality assessment products are commercially available

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Results for Animetrics' Pose Correction Product
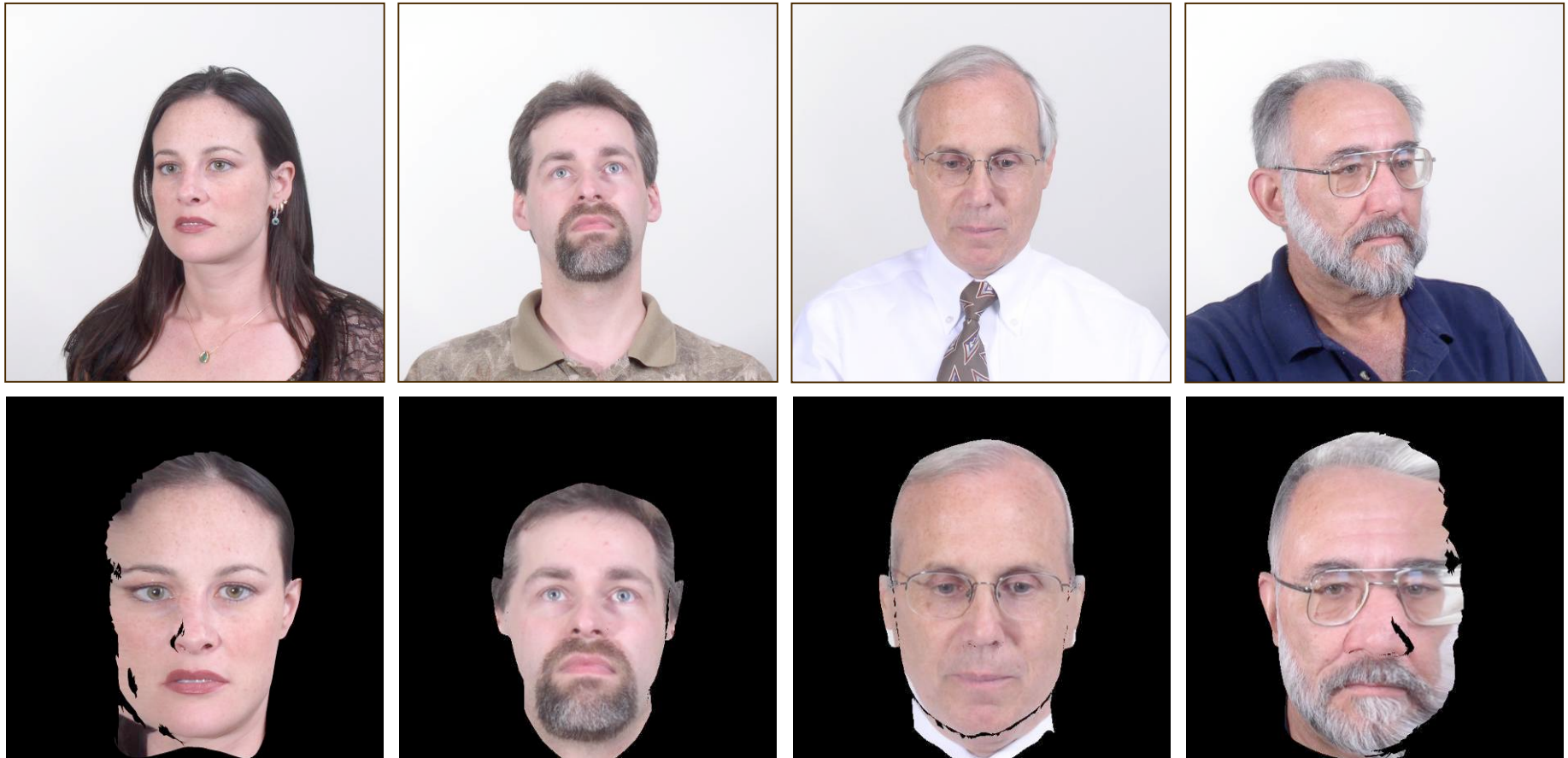
- Automatic, batch processing

- Estimates and corrects pitch, roll, yaw (up to 40°)

- User can input eye positions

- User may adjust minimum pose angle for corrections

Cumulative Match Characteristic for Uncorrected and Corrected Pose Angles

Corrected/Uncorrected ⬌ Frontal Mate

Identification Rate vs **Rank**

Legend:
- Yaw = ± 15º Corrected
- Yaw = ± 15º
- Yaw = ± 25º Corrected
- Yaw = ± 25º

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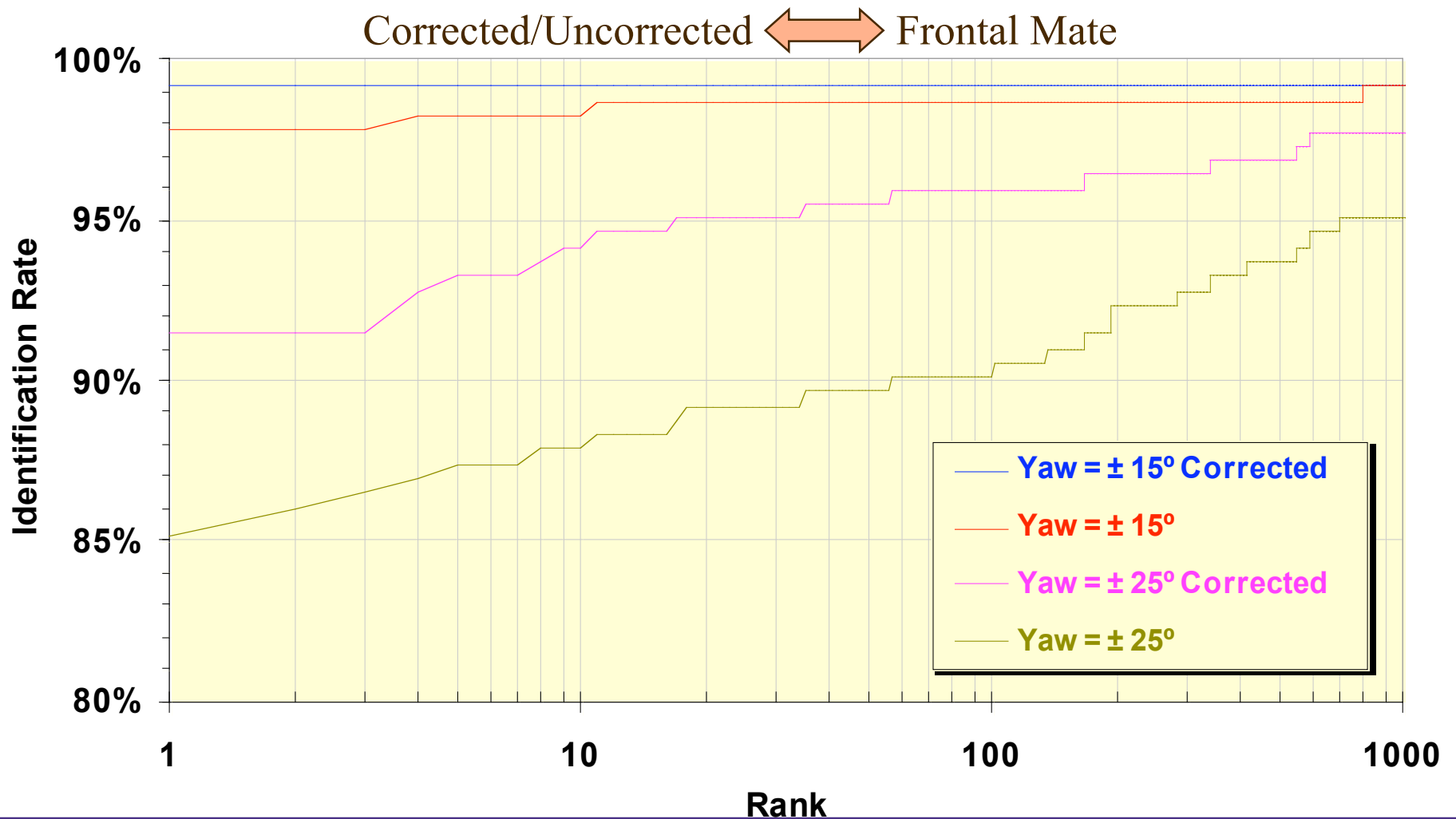
Receiver Operating Characteristic for Uncorrected and Corrected Pose Angles

Corrected/Uncorrected ⟷ Frontal Mate

Legend:
- Yaw = ± 15º Corrected
- Yaw = ± 15º
- Yaw = ± 25º Corrected
- Yaw = ± 25º

Y-axis: CAR (70% to 100%)
X-axis: FAR (0.0001% to 100%)

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