Interoperability Testing of Optical Security Document Readers

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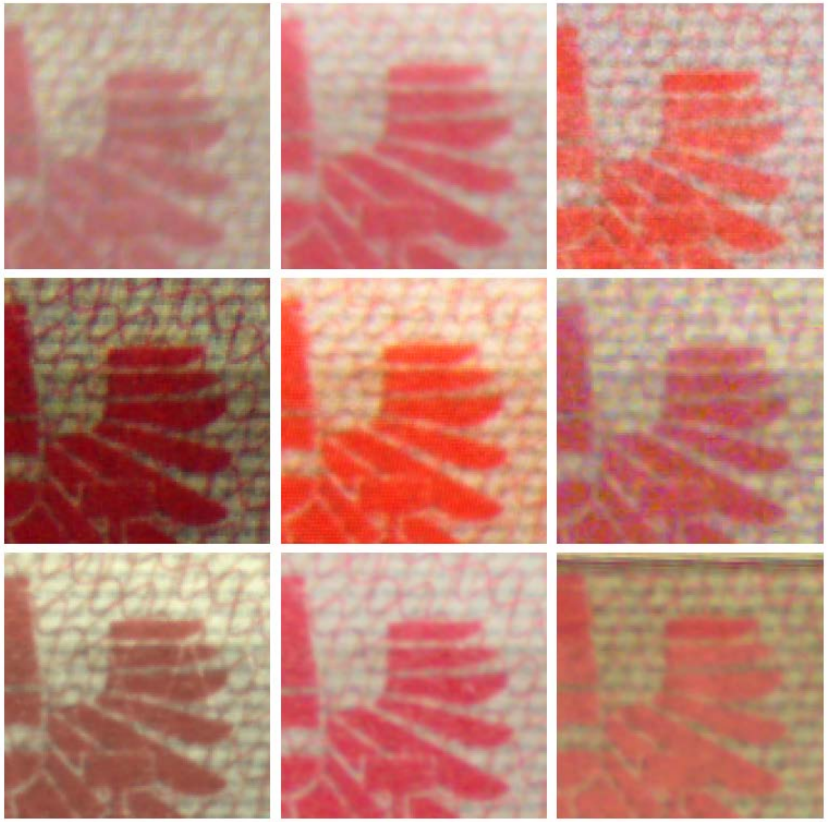
What is this Talk About?

Motivation

- Authentication of security documents
  - multiple modular devices
  - single database of security document templates

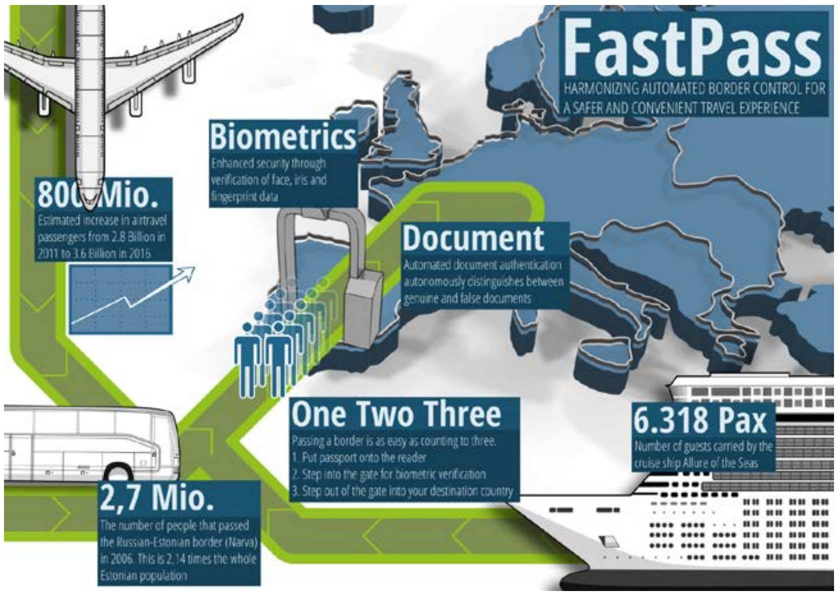
Goals of the study

- ***Benchmarking***
  - features relevant to image quality
- ***Interoperability***
  - new methods for harmonized use
- ***Compression***
  - compact storage (document DB)
  - transmission of security features



Security patch acquired by different readers

FastPass – The Project



Goal
- **Harmonised, modular reference system for ABC**
- **User-centric approach**

Details
- **EU FP7 Security**
- **Jan 2013 – Dec 2016**
- **27 Partners, led by AIT**

Challenges
- **Fast & secure ID check**
- **Interoperable modular concept**

Why?
- **Address „Automated document verification“ for ABC**

Further Info
- **Please visit:**

www.fastpass-project.eu

Tested Devices

3M AT9000 MK2

ARH Combo Smart

ARH PRMc

Bundesdruckerei VE 600

DESKO ICON Gen I

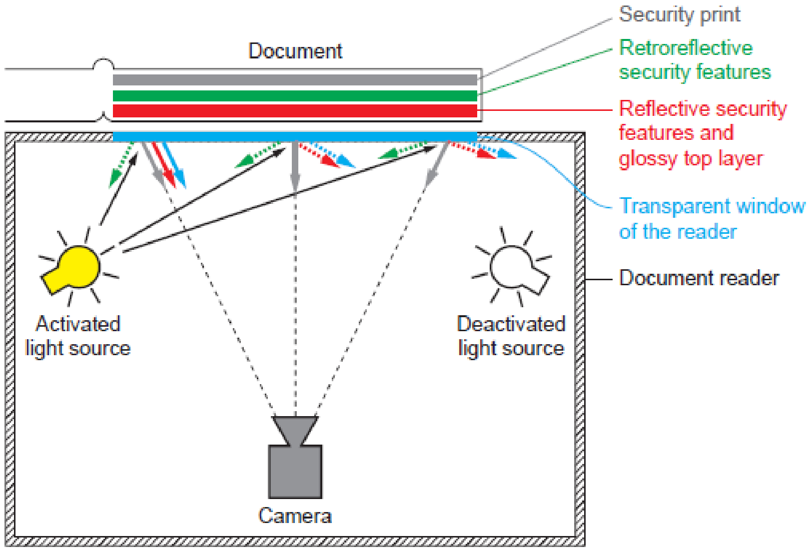
DESKO PENTA Gen 4.0

Regula 7024m.111

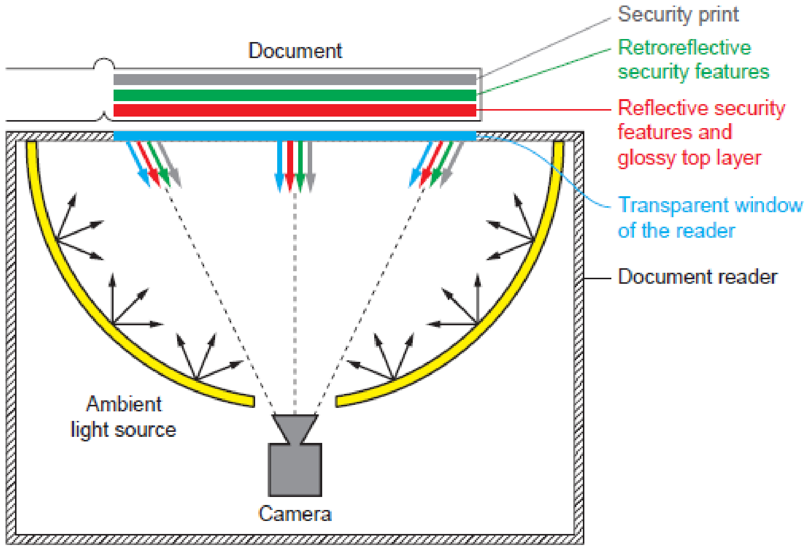
Regula 7034.111

Suprema RealPass-V

Dark Field vs. Bright Field



(a) Dark-field Illumination

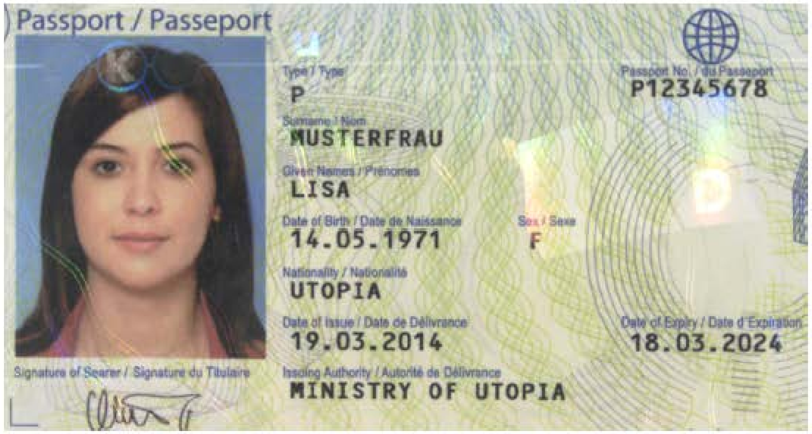


(b) Bright-field Illumination

- **Multiple** point light sources
- Difference (reflection image) with potential for inspecting OVDs
- Easier colour calibration, but multiple acquisitions required

- **Single** large illumination source
- Preserves high dynamic range and at the same time produces an almost glare-free image
- Single fast acquisition, but more expensive

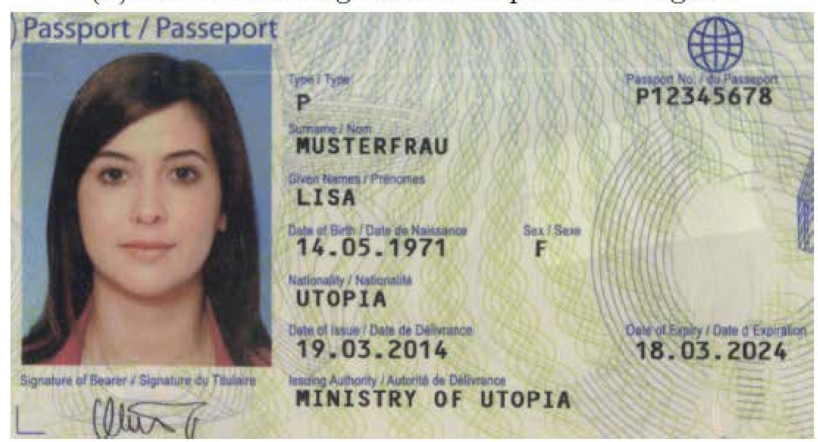
Dark Field vs. Bright Field - Examples



(a) Dark-field image without anti-glare

(b) Dark-field image with suboptimal anti-glare

(c) Bright-field image



(d) Dark-field image with good anti-glare

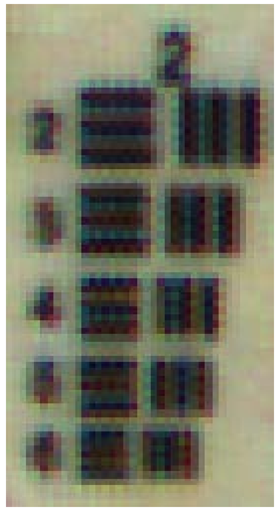
Anti-Glare

- 6 out of 9 devices featured anti-glare functionality; 3 out of 6 with consistent OVD-free images
- **Minor accordance** between glare responses of the same document.
- Ideally, **glare-free and separate reflection image(s)** are available.

Optical Resolution

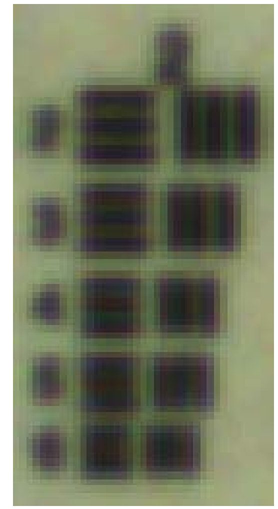
A

B

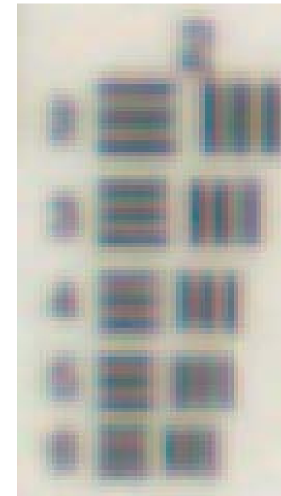


C

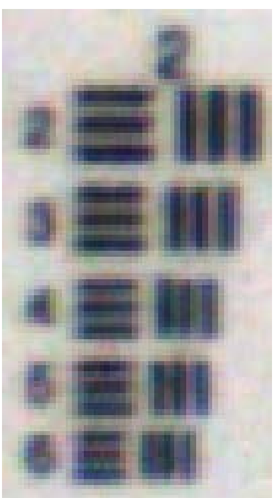
D



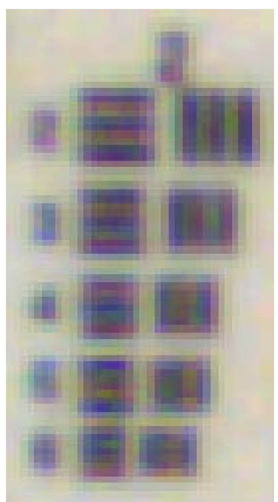
E



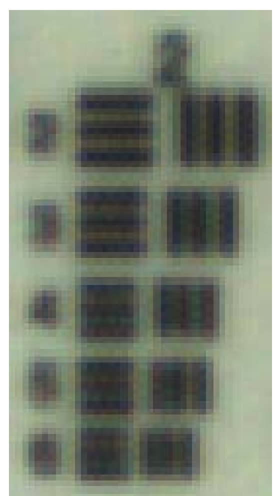
F



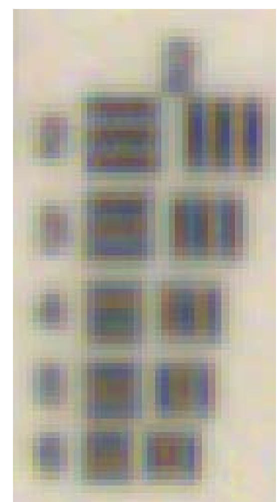
G

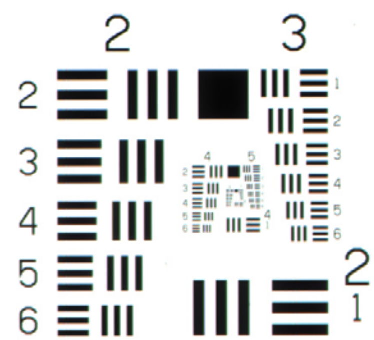


H



I

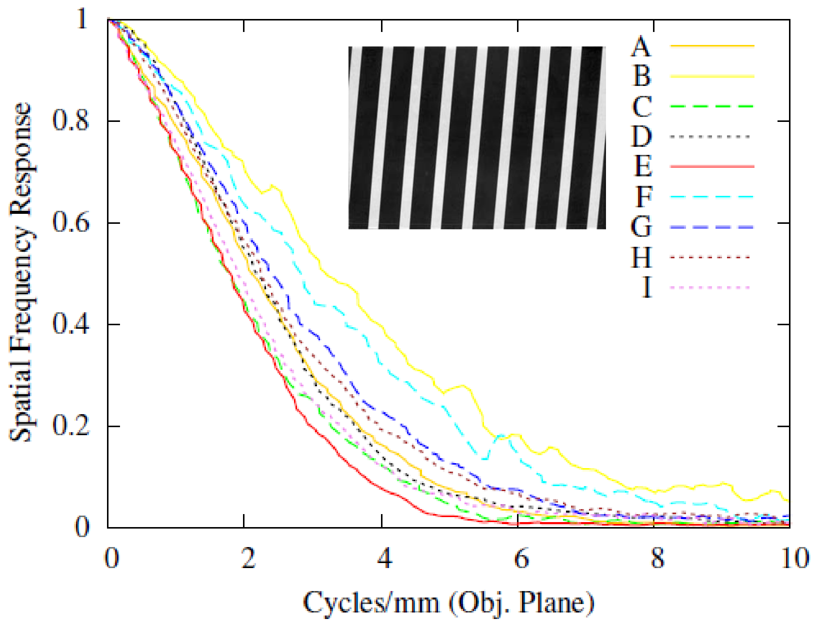




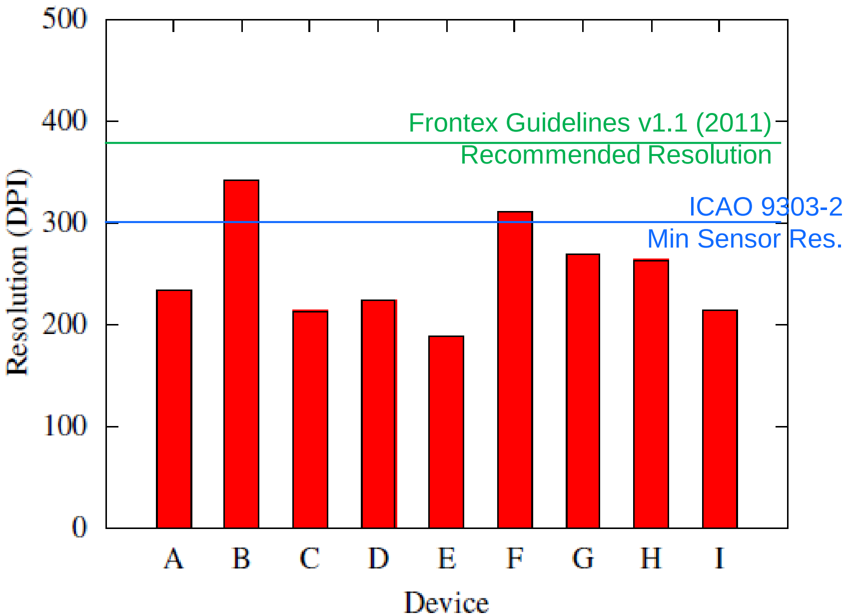
1951 USAF resolution chart

Optical Resolution - Results

- Measured **sensor resolutions matched with specs** (approx. +/-1.2%)
- Spatial Frequency Response (SFR) using slanted edge (ISO/IEC 12233) revealed much **weaker true optical resolution** power (up to -50%)
- All measured optical resolutions ranged below 350 DPI (Frontex recommendation: >385 DPI)

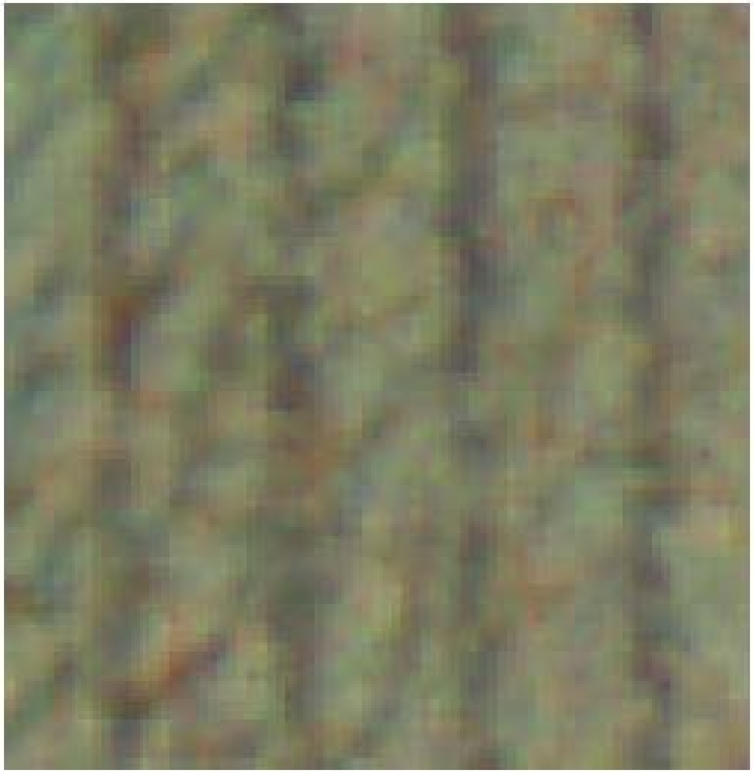


(a) Spatial Frequency Response



(b) Optical resolution from SFR

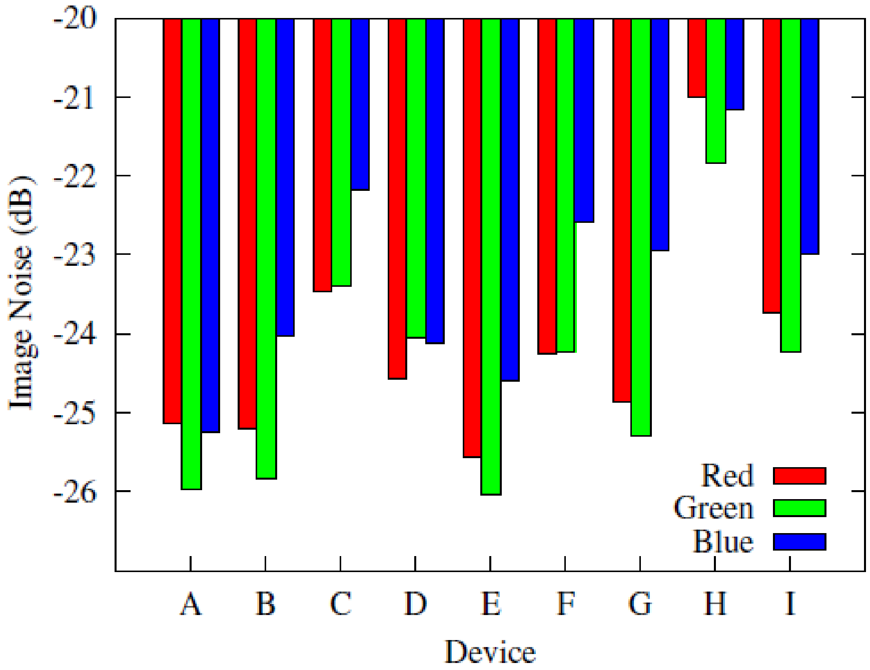
Optical Resolution - Examples



Microprinted Text

Standard Security Print

Image Noise



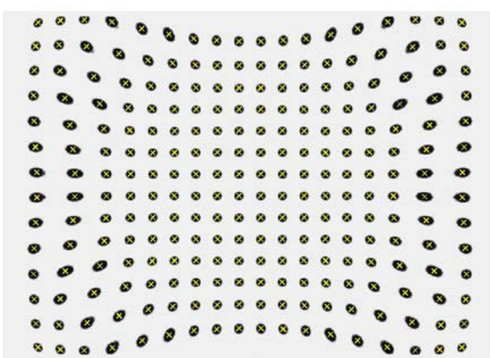
Noise w/o glare suppression

- Assessed in VIS spectrum using white/black checkerboard pattern
- Broad range of sensor noise levels (4 dB)
- Image **noise increases when glare reduction is turned on** (devices G and I)

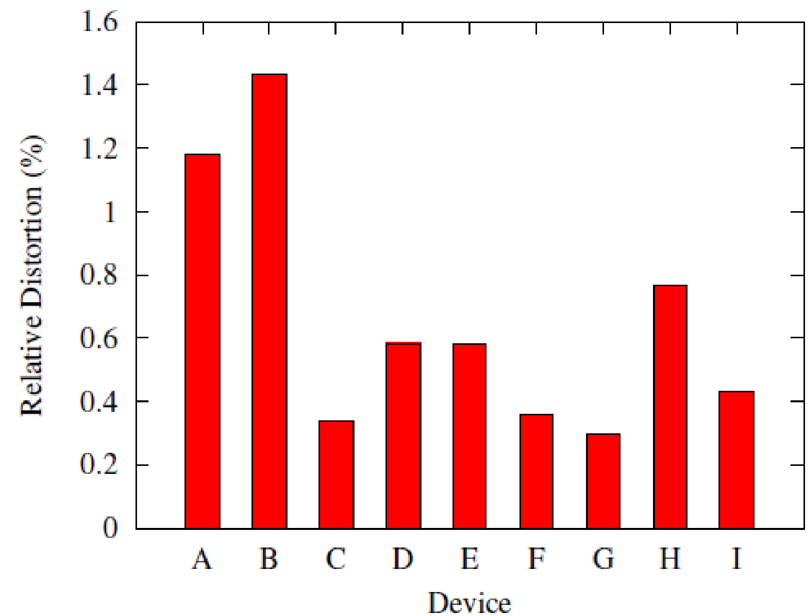
Geometric Distortion

- **Low geometric distortion**
  (< 1.5%, invisible to humans)
  for all readers

- Most likely, devices are **already calibrated**



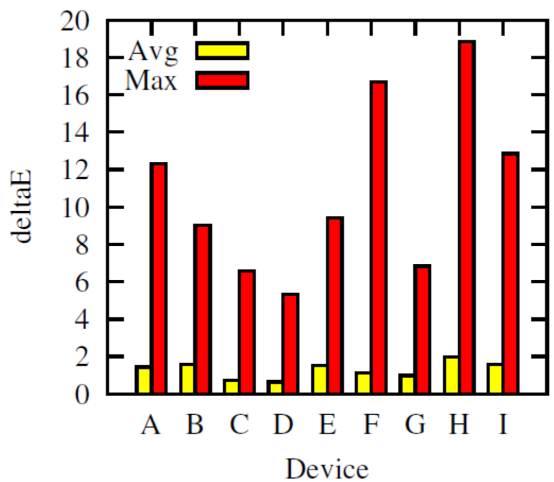
Illustrated wave distortion



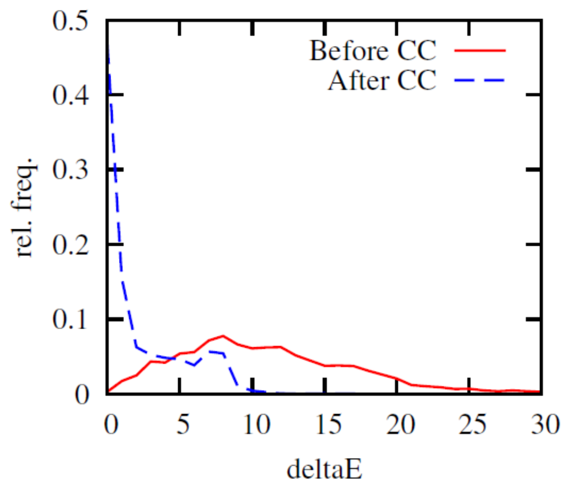
Maximum radial distortion

Colour Accuracy

- **Perceptual distance** between two colours: **DeltaE** metric
- Calibration based on the IT8.7/8-1993 **colour target** (VIS image)
- **FFC (Flat Field Correction)**: compensate different sensitivity of sensor detectors & illumination
- **CC (Colour calibration)** improves colour similarity for equal passports significantly



(a) Colour accuracy after CC



(b) Before vs. after calibration

Before and After: CC

- Mean and standard deviations of DeltaE were clearly improved
- **Before:** mean = **11.629**; std = **6.228**,
- **After:** mean = **2.587**; std = **2.829**

A B C D E F G H I

Calibration Impact

- Pairwise image similarities using PSNR / SSIM metrics for entire passport images:

$$\mathrm{SSIM}(I,O) = \frac{(2\mu_I\mu_O + c_1)(2\sigma_{IO} + c_2)}{(\mu_I^2 + \mu_O^2 + c_1)(\sigma_I^2 + \sigma_O^2 + c_2)} \qquad \mathrm{PSNR} = 20\log_{10}\left(\frac{2^8-1}{\sqrt{\mathrm{MSE}}}\right).$$

	PSNR (dB)			**SSIM**		
	Mean μ	StdDev σ	AbsErr e	Mean μ	StdDev σ	AbsErr e
CC and FFC	**23.91**	3.04	0.992	**0.956**	0.020	0.006
FFC only	19.37	2.44	0.798	0.876	0.056	0.018
No calib.	19.45	2.60	0.849	0.886	0.050	0.016

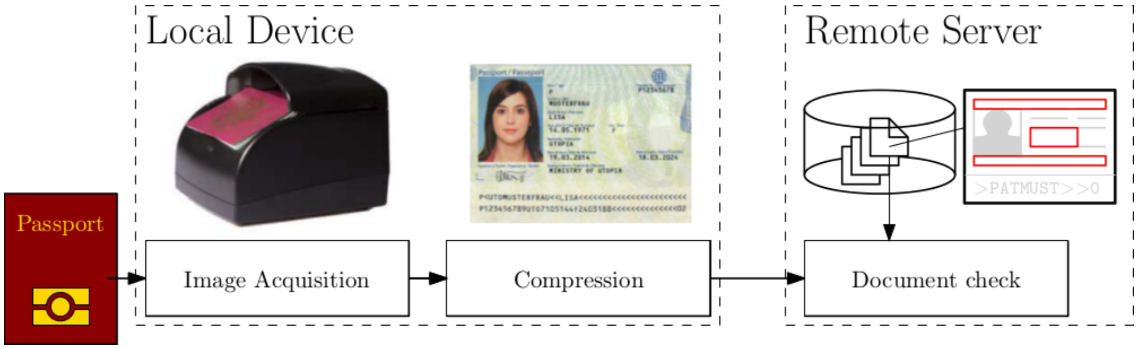
- **FFC:** overlap of confidence intervals for PSNR (19.37 vs. 19.45 dB) and SSIM (0.876 vs. 0.886),
- **CC:** image quality is clearly enhanced for PSNR (23.91 dB) and SSIM (0.956).

Benchmarking & Interoperability Conclusions

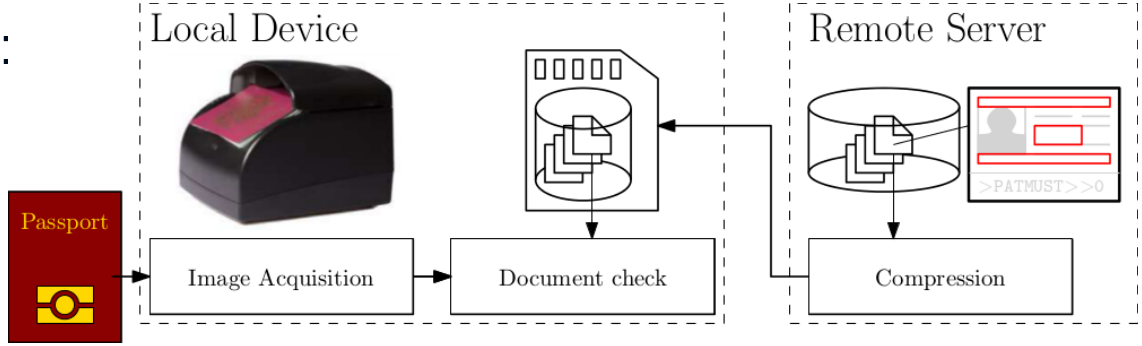
- Effective optical resolution does not fully exploit capabilities
- Relatively broad range of sensor noise levels (4 dB range)
- All readers provided very low geometrical lens distortions
- Illumination wavelength / bandwidth one of several factors influencing quality
- Camera settings & image processing have much stronger impact
- Glare reduction is essential for accurate processing of glossy documents
- Shading and color calibration are necessary for successful interoperability

Compression

- **Motivation:**
  - Mobile equipment



  - Large template DBs:

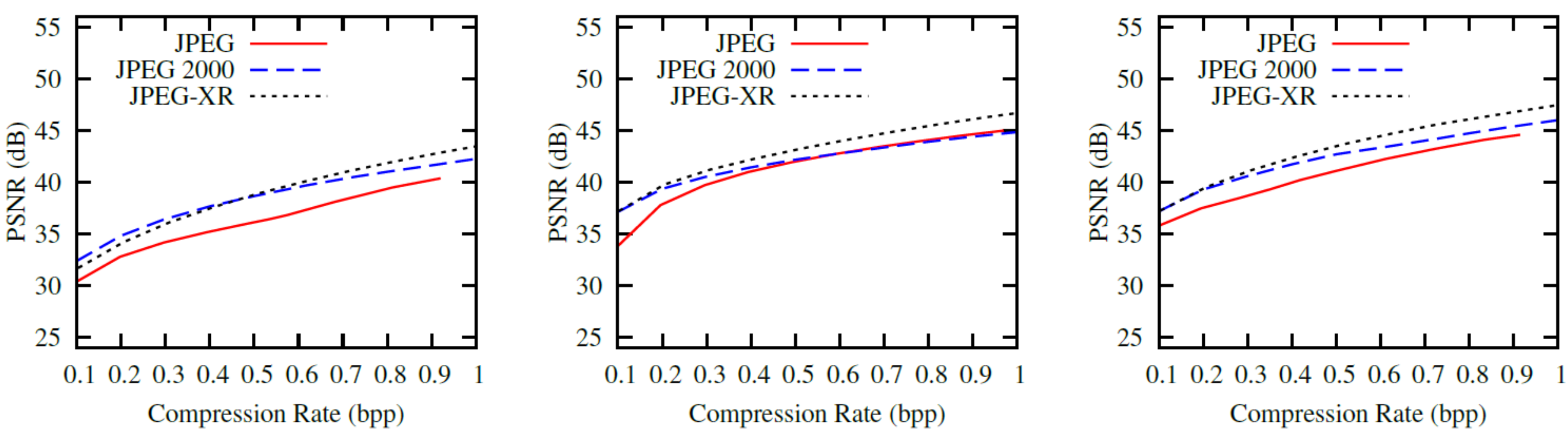


- **Questions**:
  - Up to which bitrate can/should passport images be compressed?”
  - “Which compression algorithm is most efficient for passports?”

Passport Compression Behaviour

- **Assessment via PSNR** with uncompressed reference: $\mathrm{PSNR} = 20\log_{10}\left(\frac{2^8-1}{\sqrt{\mathrm{MSE}}}\right).$

- **Best performance for JPEG XR** (less blurred content), followed by JPEG 2000 and JPEG
- **Setup for retaining >40 dB PSNR:**
  0.6 bpp for JPEG-XR, 0.7 bpp for JPEG 2000, and 1.0 bpp for JPEG.



(a) VIS (b) NIR (c) UV

Summary

Benchmarking	• Identified optical resolution & colour calibration weaknesses.
Interoperability	• Colour correction improves patch-based comparison
Compression	• Best: JPEG XR over JPEG 2000 and JPEG for lossy comp.
Further Tasks	• **Towards interoperable automated document authentication**

Future Work

OVDs	• Harmonized inspection of DOVIDs • Interoperable descriptors
Quality	• Quality indicators for inspection • Relative importance of device characteristics
Mobile	• Mobile travel document authentic. • Fast MRZ & visible zone data read
Evaluation	• ABC-specific dataset • FastPass Trial @ VIA

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