Interoperability Testing of Optical Security Document Readers in ***Fast**Pass*

Secure Document World 2016

Presented by
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The work has been supported by the FastPass project. The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 312583.

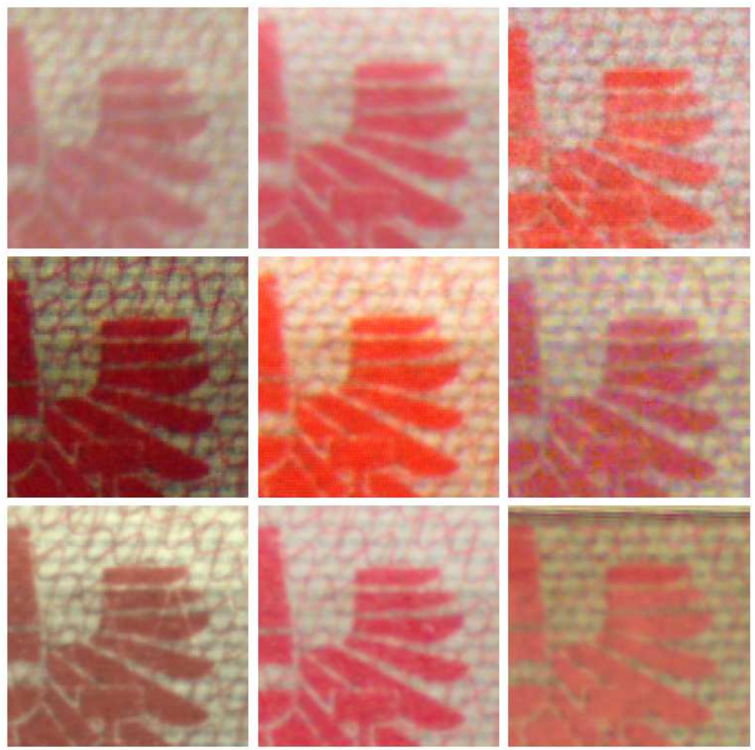
*Fast*Pass Document Reader Challenge

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

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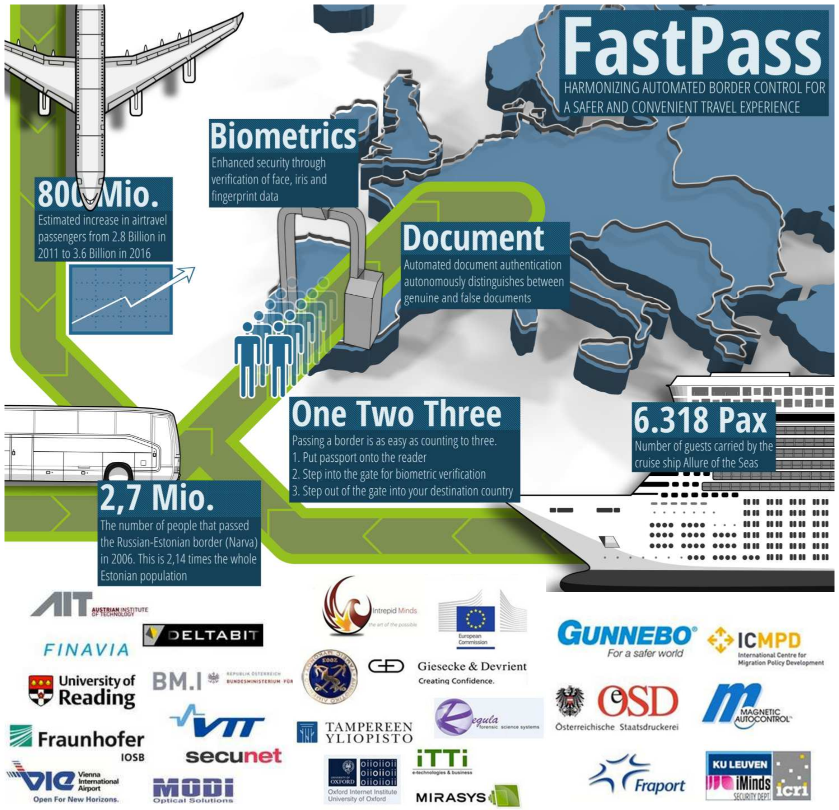
*Fast*Pass – The Project



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

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***Fast**Pass* – The system/technology, that

- **…is secure**
  - Resistent
    - to latest attacks on document scanner,
    - to biometric spoofing
  - Risk Assessment, Security Assessed by dedicated methodology
- **…you like**
  - UI developed with extensive feedback from different European border guards
  - Process and procedures developed with extensive evaluation from traveller groups
  - Respects privacy and data protection (Data protection impact assessment – DPIA)
- **…is harmonized – and shows new processes and scenarios**
  - ONE reference architecture serving many processes
  - First European solution for cars at land border with ABC
  - First solution for cruise ships
  - Real comparison of different approaches on an airborder crossing point

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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

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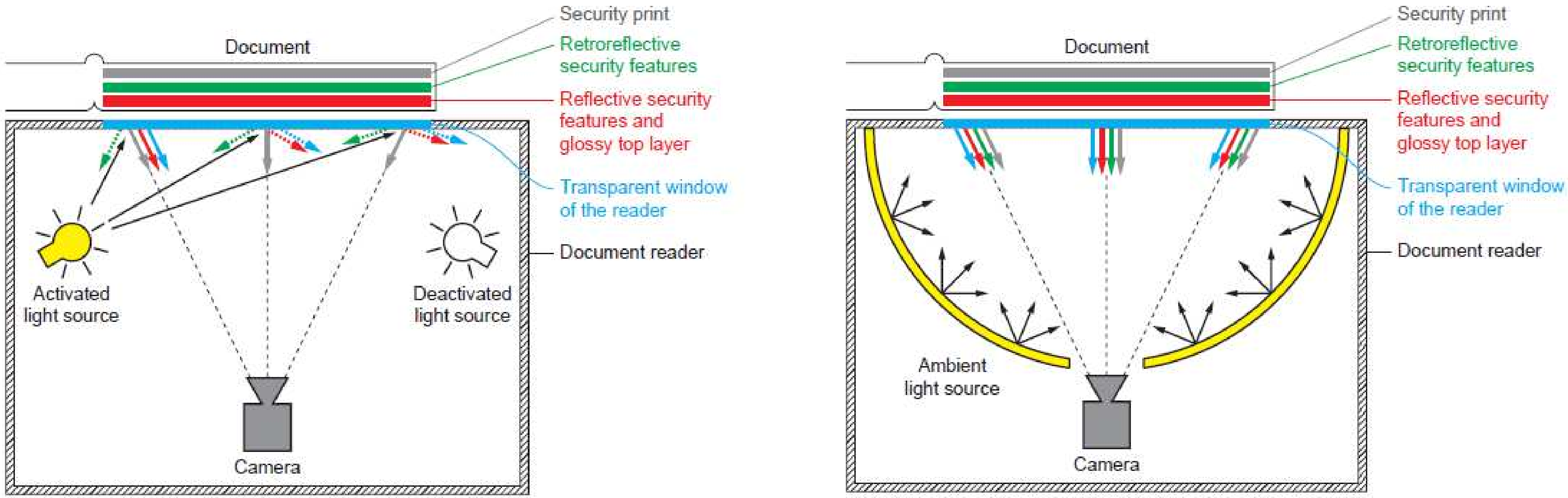
Dark Field vs. Bright Field



(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

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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

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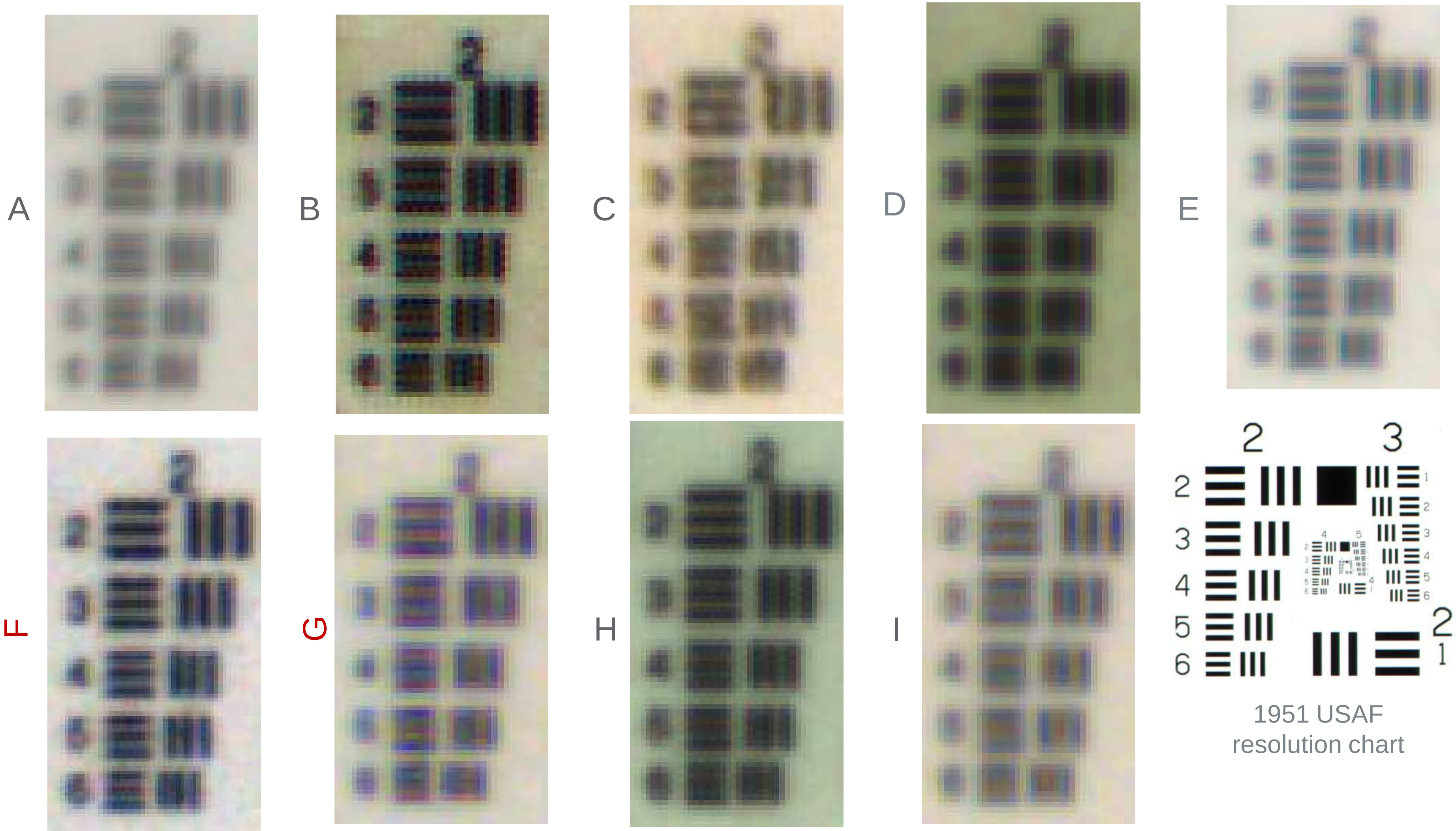
Optical Resolution



1951 USAF
resolution chart

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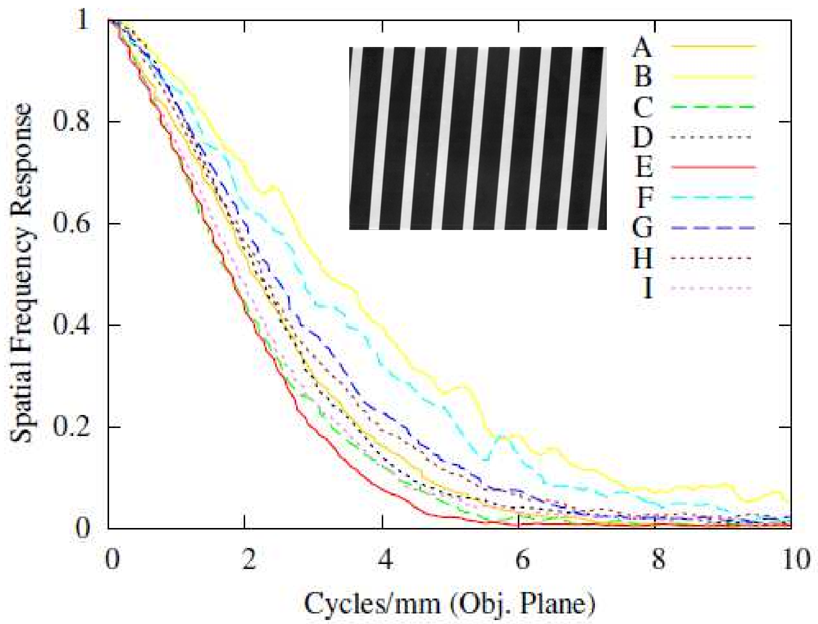
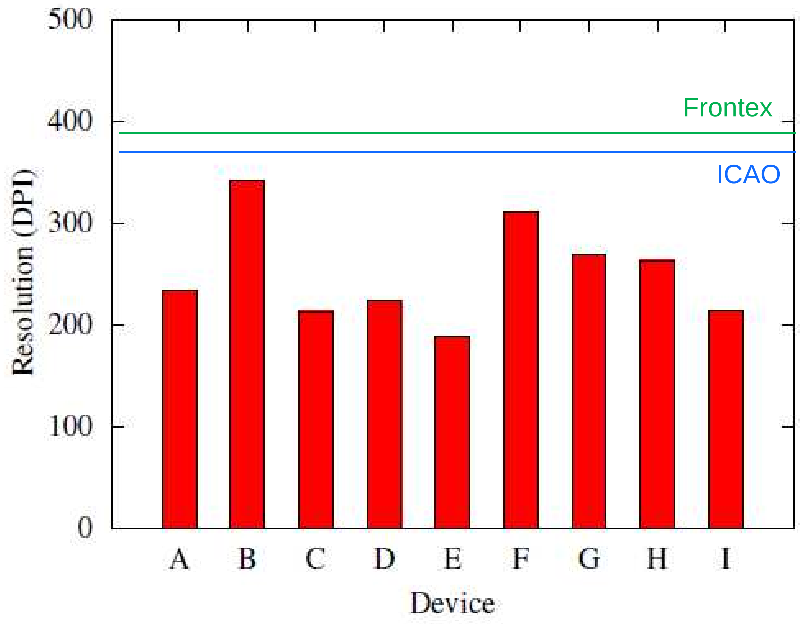
Optical Resolution - Results

- 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

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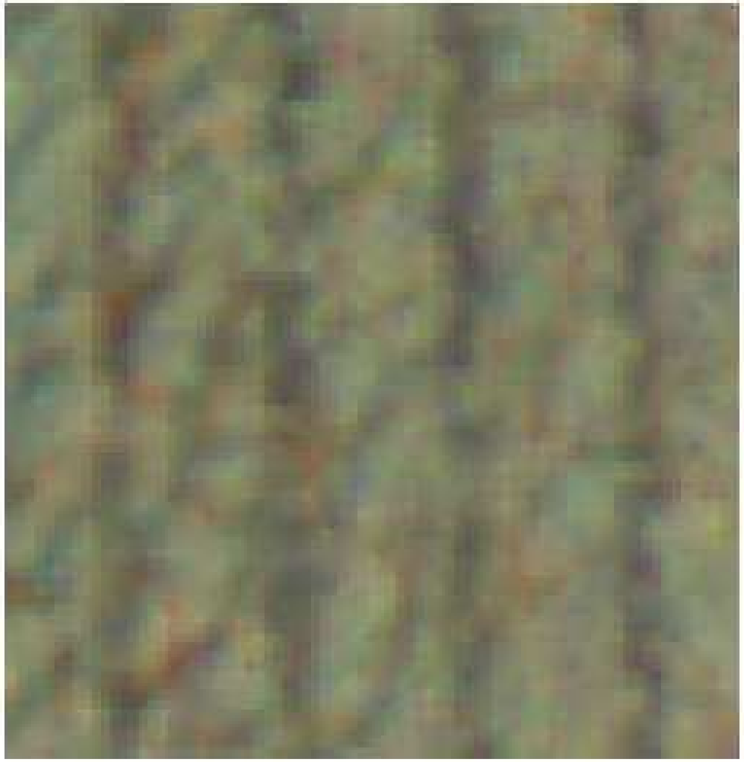
Optical Resolution - Examples



Microprinted text

Standard security print

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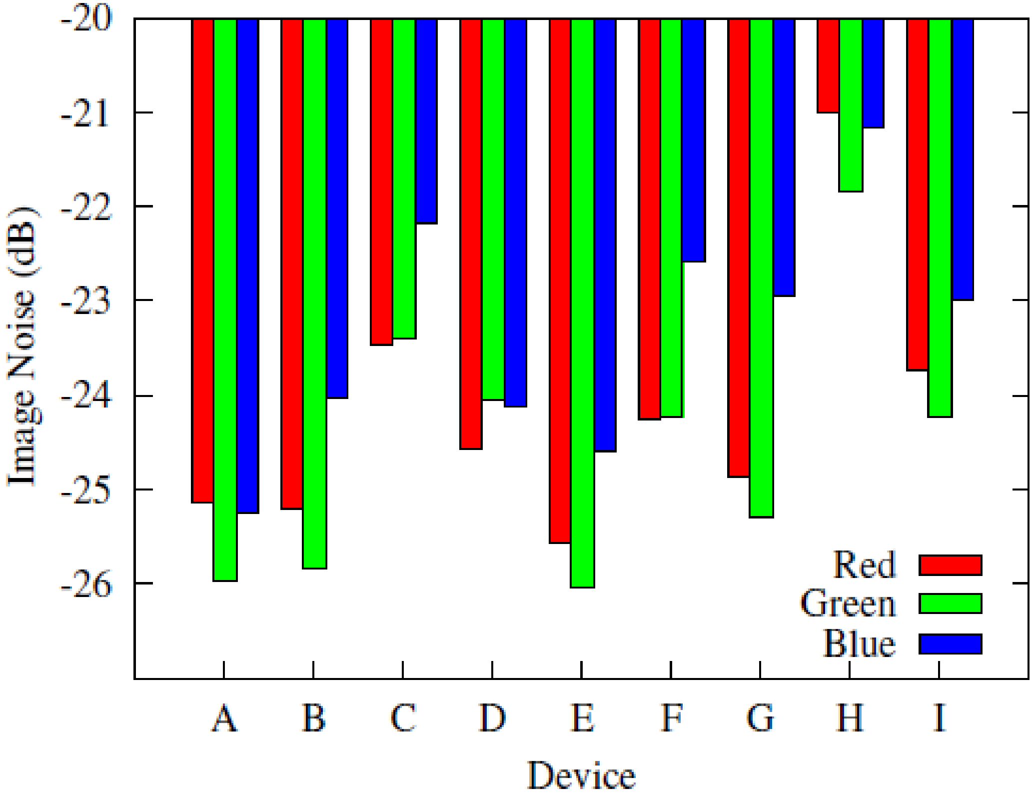
Image Noise



(a) Noise (w/o glare suppression)

- Assessed in VIS spectrum using white/black checkerboard pattern
- Image **noise increases when glare reduction is turned on** (devices G and I)

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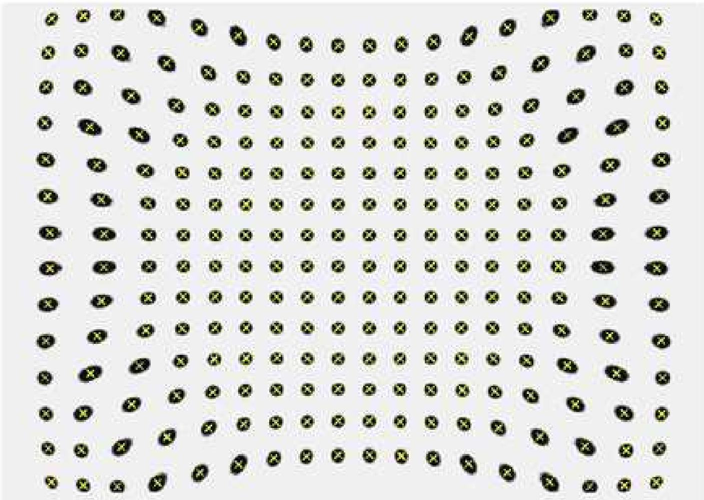
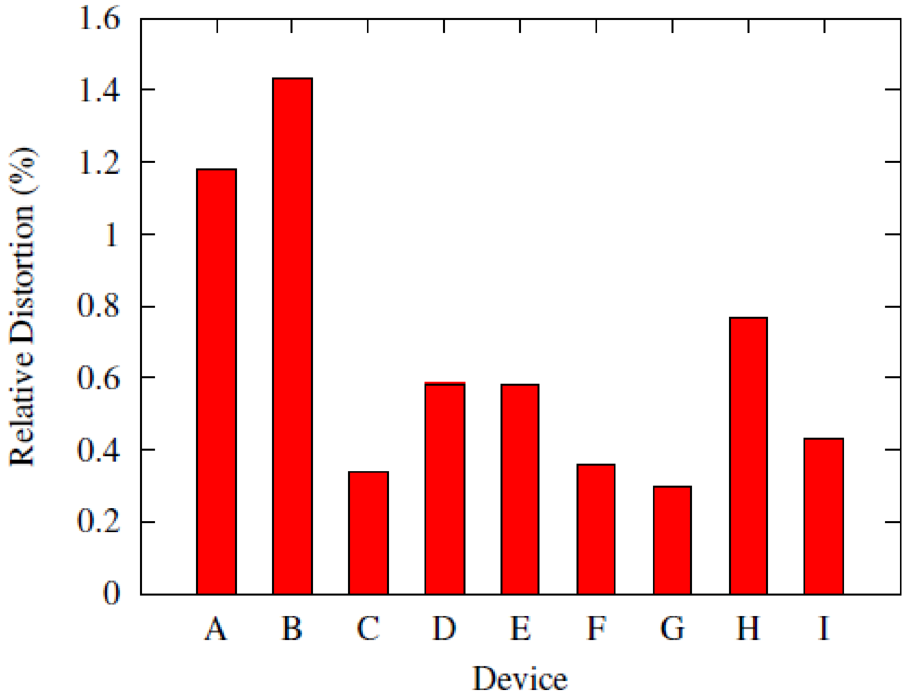
Geometric Distortion



Illustrated wave distortion



Maximum radial distortion

- **Low geometric distortion** (< 1.5%, invisible to humans) for all readers
- Most likely, devices are **already calibrated**

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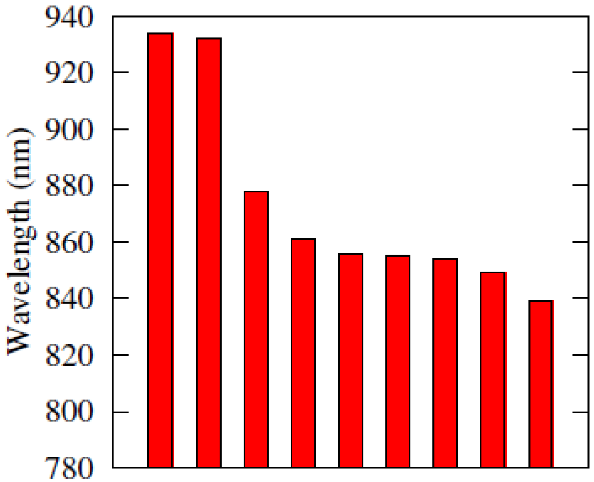
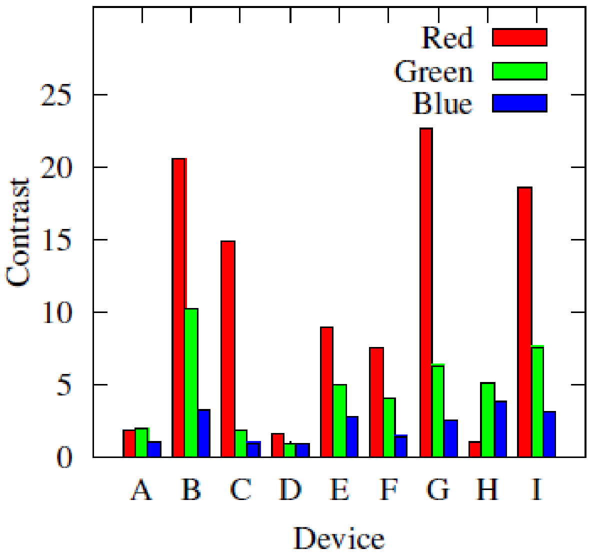
UV & NIR Illumination

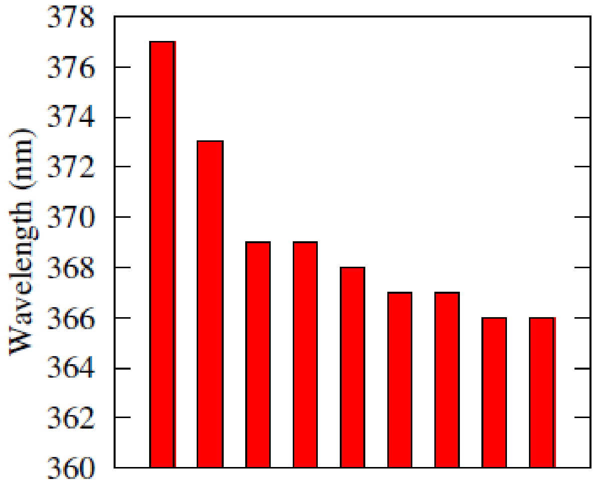
- No apparent correlation between illumination specs and image quality
- Most of the differences are most likely due to different
  - Illumination positions
  - Camera settings & calibration
  - Image processing



(a) Dominant IR Wavelength



(b) UV dull/luminescent Contrast



(c) Dominant UV Wavelength

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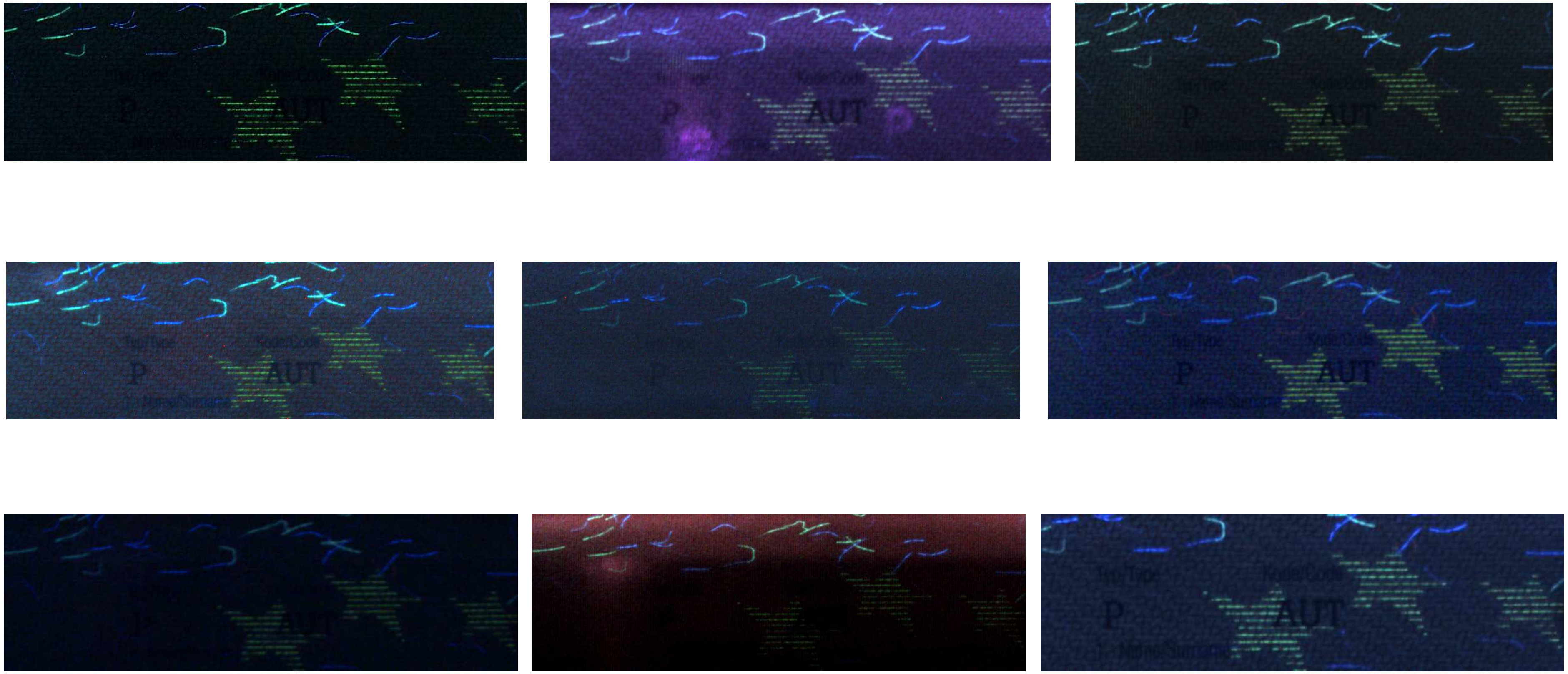
UV: Examples



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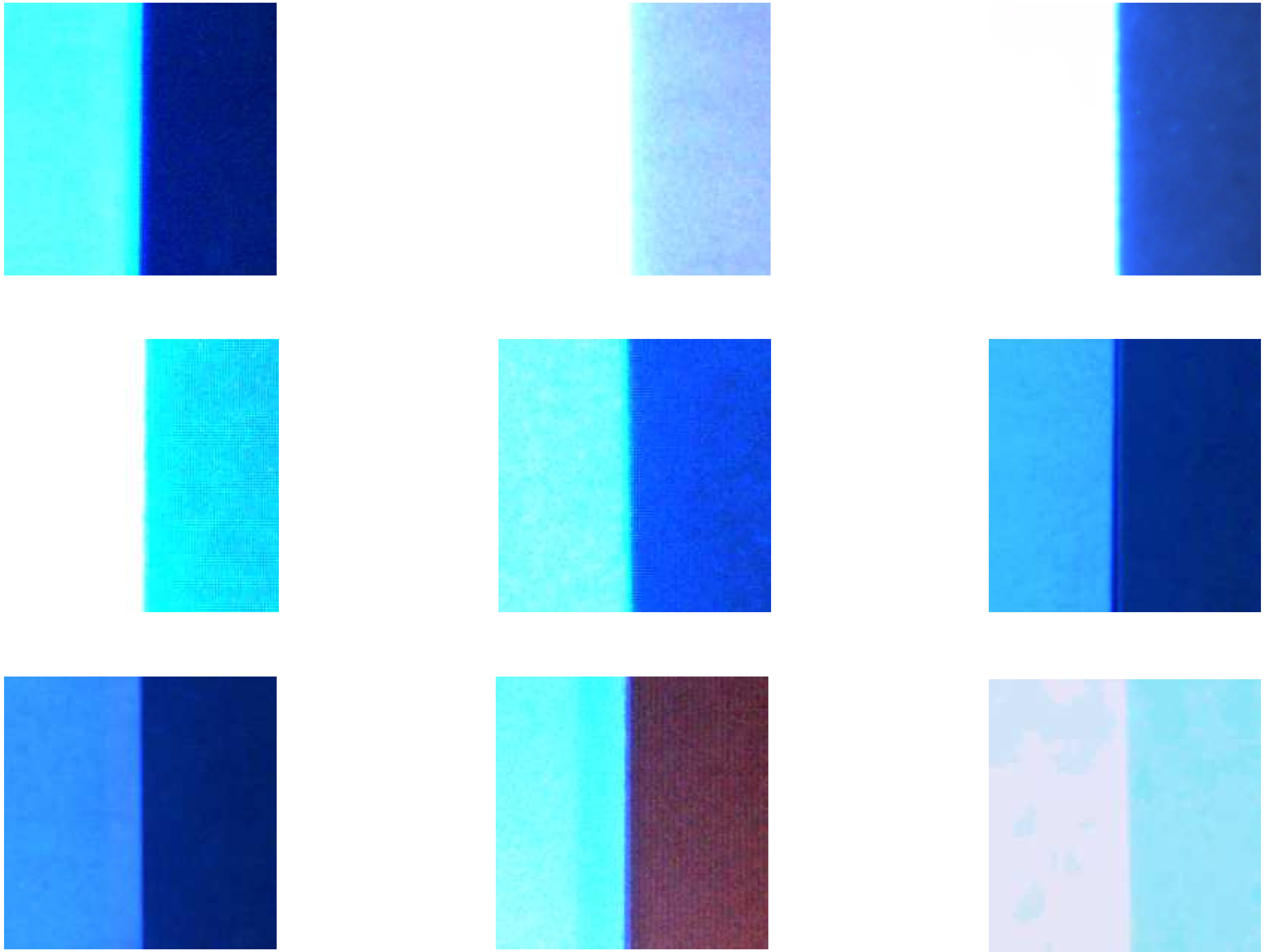
UV-luminescent vs UV-dull: Examples



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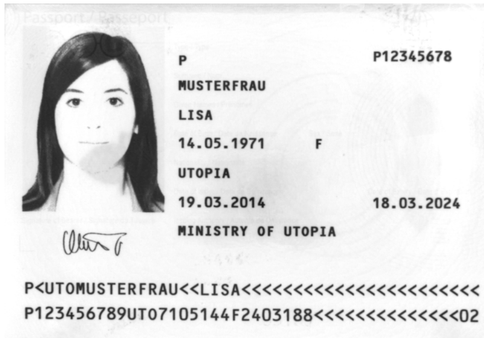
IR: Examples



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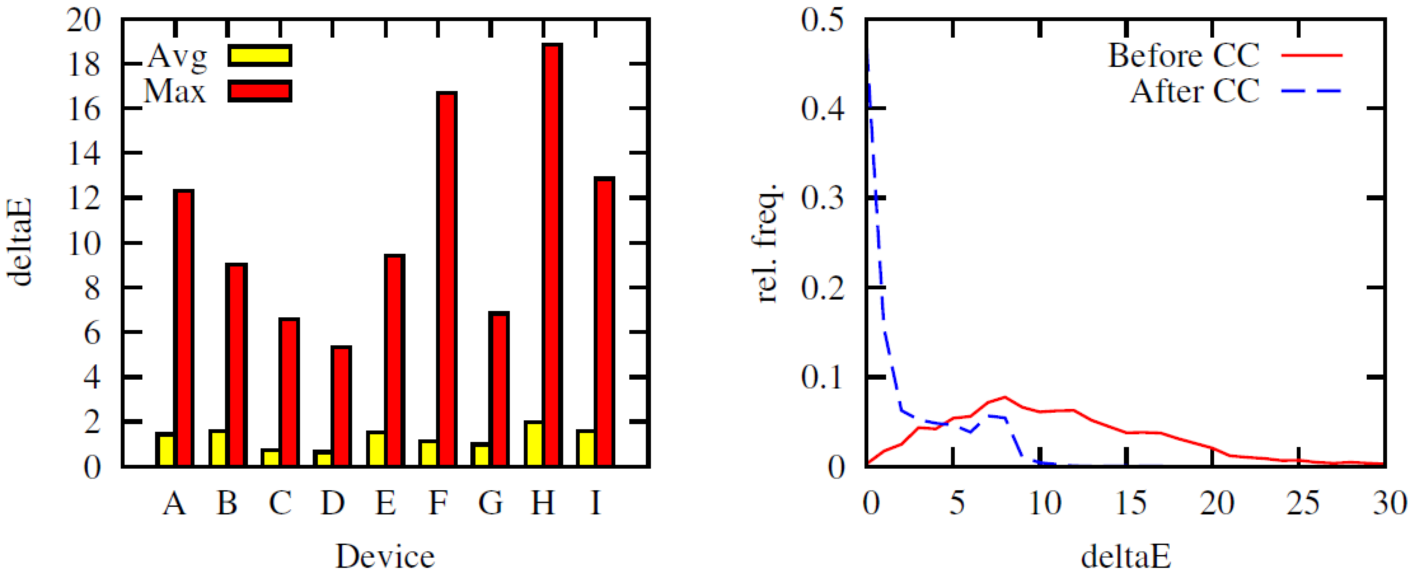
Colour Accuracy

- Perceptual distance between two colours: **DeltaE** metric
- Calibration based on the IT8.7/8-1993 colour target (VIS image)
- FFC: compensate different sensitivity of sensor detectors & illumination
- Colour calibration helps a lot to get similar output for a similar input



(a) Colour accuracy after CC (b) Before vs. after calibration

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Before and After Flat Field Correction (FFC)

Before FFC

After FFC

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Before and After Colour Calibration (CC)

- Mean and standard deviations 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

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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).

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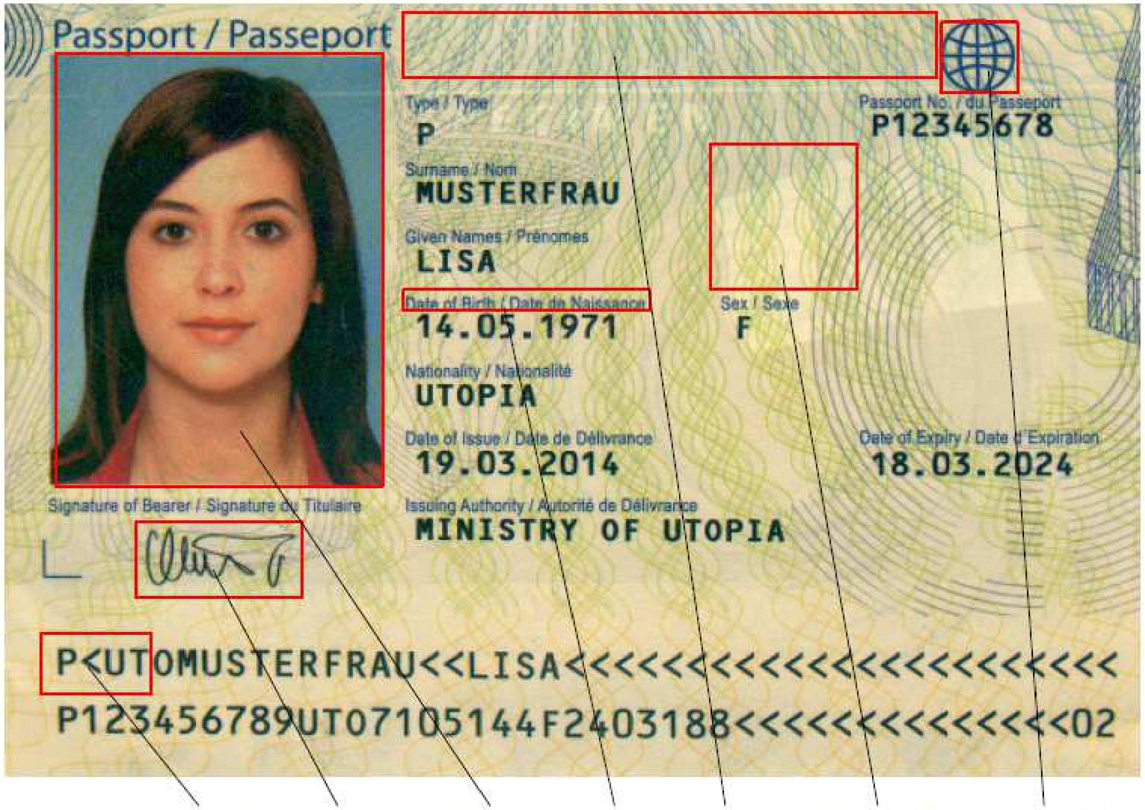
Colour Calibration Impact on individual patches



	MRZ	Signature	Photo	Font	Top-BG	BG/OVD	Emblem
ΔPSNR	6.92	5.76	0.76	5.59	5.73	6.49	3.82
ΔSSIM	0.145	0.102	0.003	0.085	0.141	0.181	0.067

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Glare vs. Anti-Glare

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

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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

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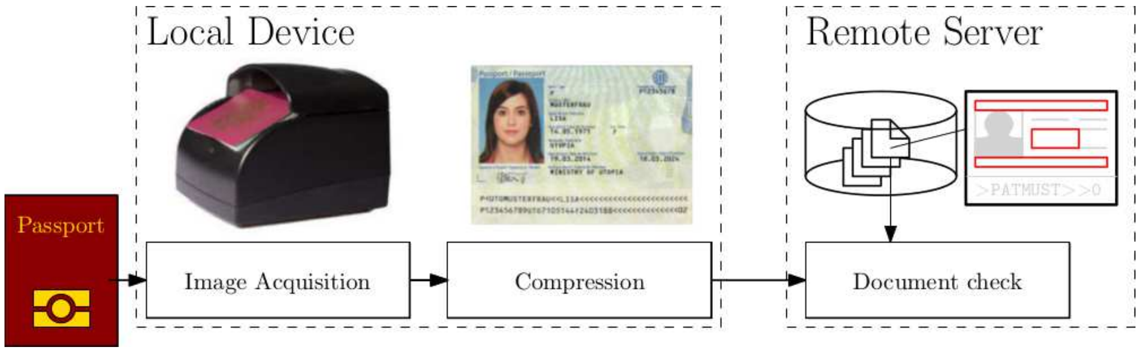
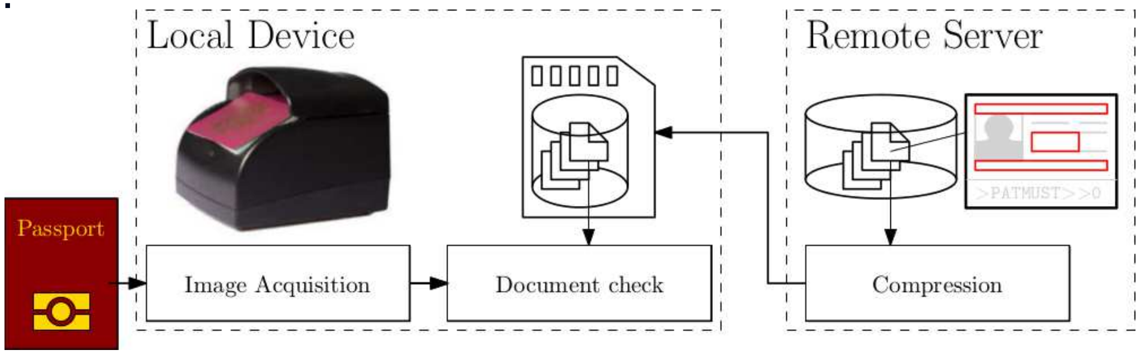
Compression

- **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?”

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Compression Setup & Algorithms

- **Database:** 1116 passport images
- **Algorithms:** 0.1 to 1 bits per pixel compression rate using:
- **JPEG** (ISO/IEC 10918-1, 1994), best supported algorithm based on 2D discrete cosine transform.
- **JPEG-XR** (ISO/IEC 29199-2, 2010) Photo Core Transformation, proposed by Microsoft's HD Photo.
- **JPEG 2000** (ISO/IEC 15444-1, 2000) next-generation wavelet-based compression standard.

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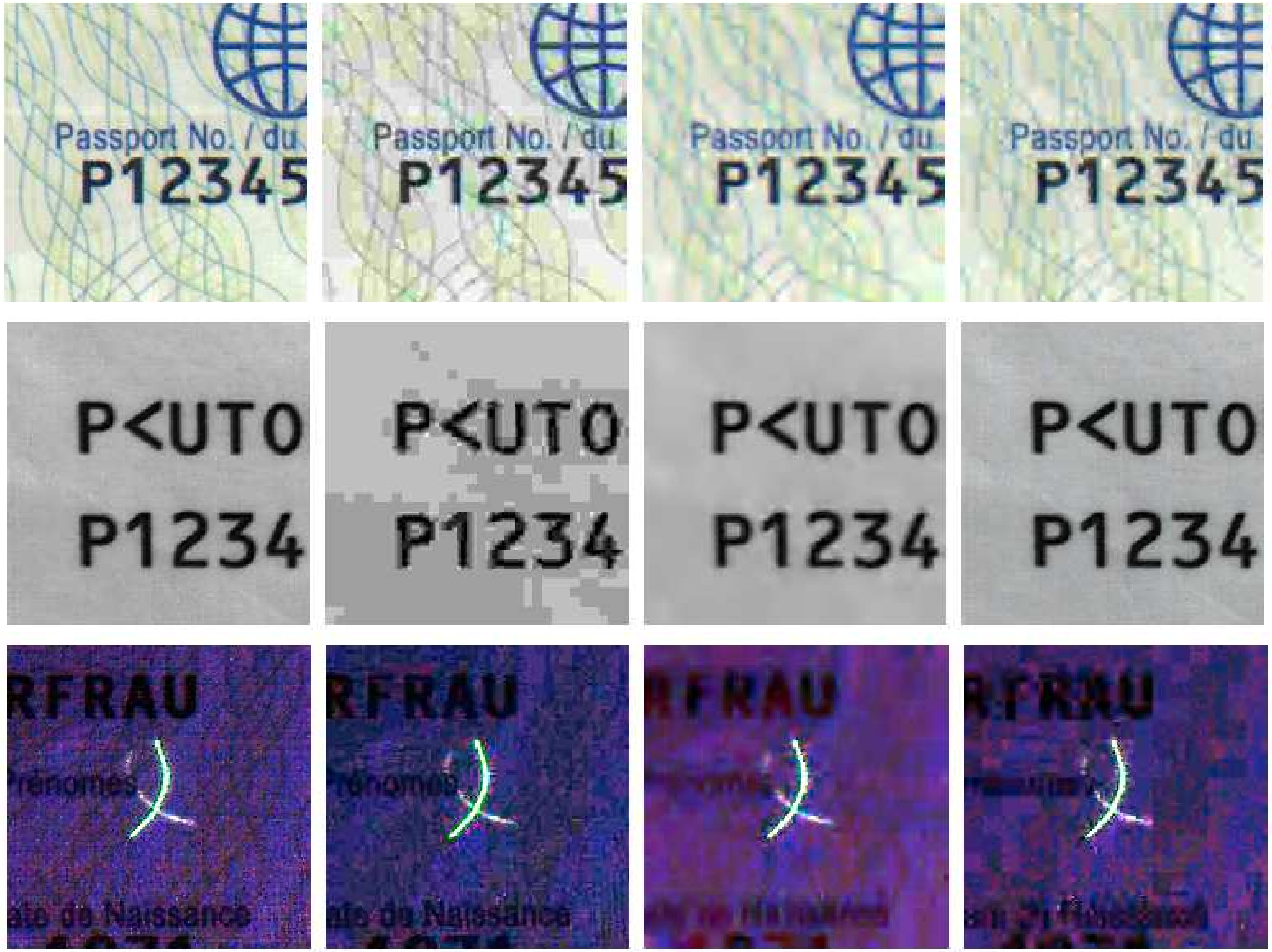
Compression Examples



(a) Original (b) JPEG (c) JPEG 2000 (d) JPEG-XR

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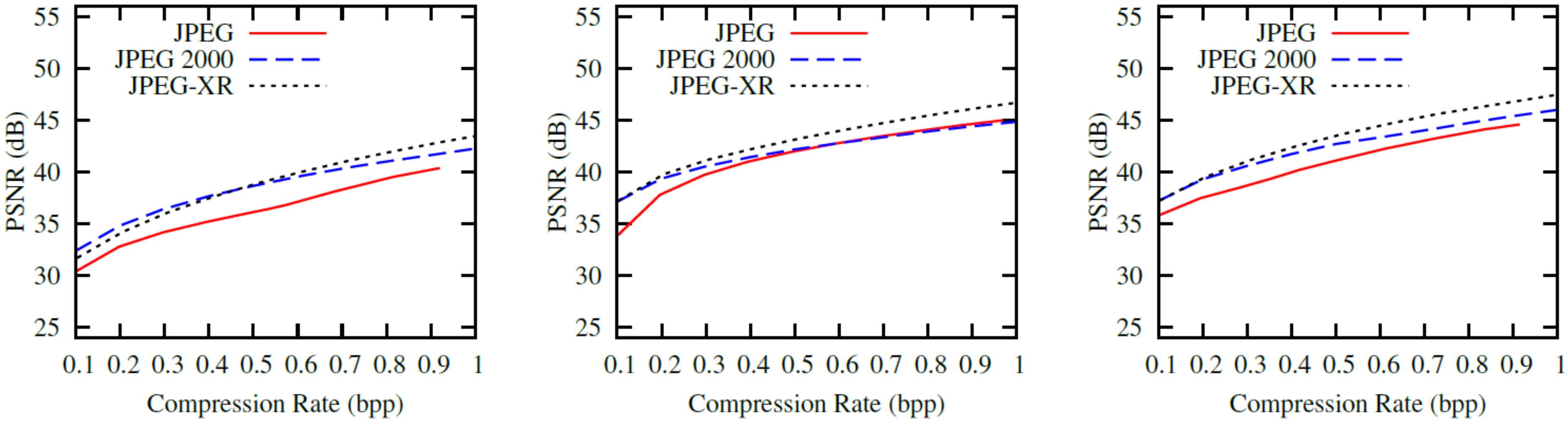
Passport Compression Behaviour

- **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.
- Difference between JPEG-XR and JPEG 2000 is **significant** for the lower and upper ends of tested compression rates



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

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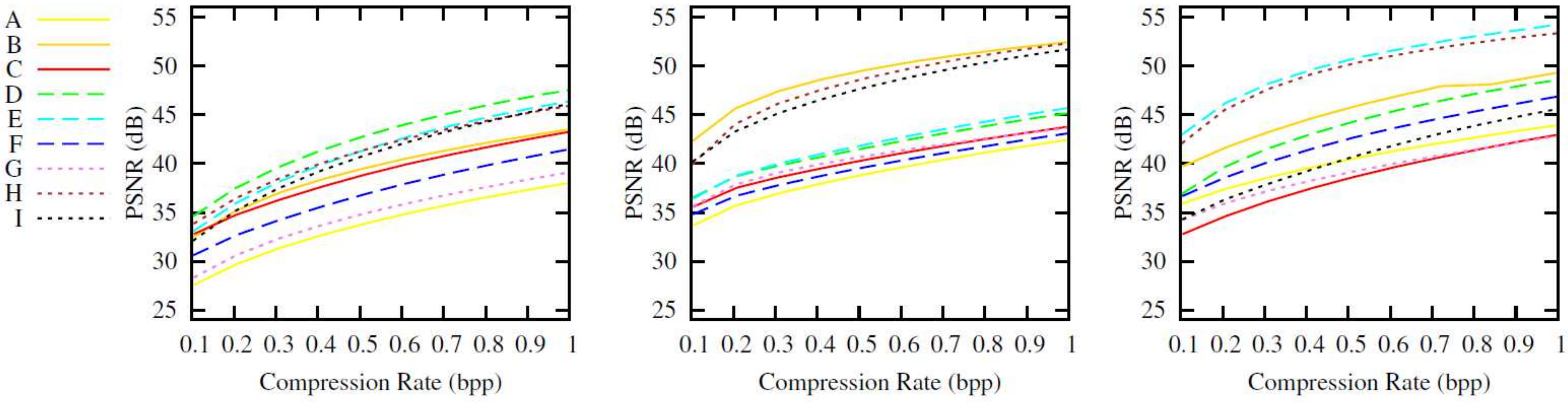
Device-specific Compression Behaviour

- Performance across readers for each of the individual spectra reveals image processing effects
- Compression behaviour largely reflected the optical resolution behavior
- Different order for VIS, UV and NIR spectra
- Attention: low PSNR performance is not an indicator of low image quality for a particular reader



(g) JPEG-XR on VIS (h) JPEG-XR on NIR (i) JPEG-XR on UV

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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**

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Future Work and Remaining Challenges

OVDs

- Harmonized inspection of DOVIDs
- Interoperable descriptors

Quality

- Quality indicators for inspection
- Relative importance of device characteristics

Mobile

- Mobile travel document authentication
- Fast read-out of MRZ & visible zone data

Evaluation

- ABC-specific dataset
- FastPass Trial: started Q1 2015 @ VIA

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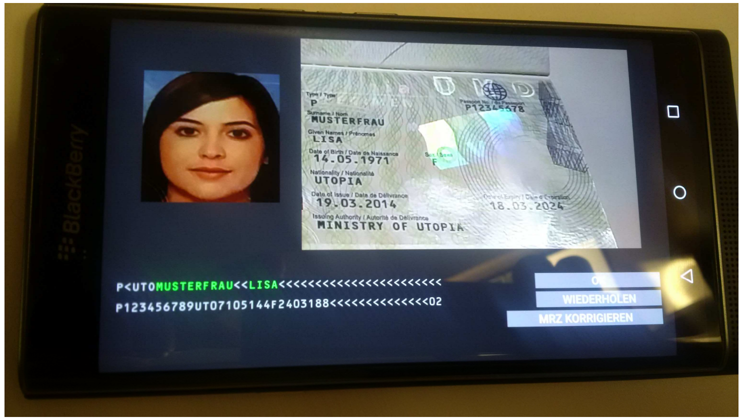
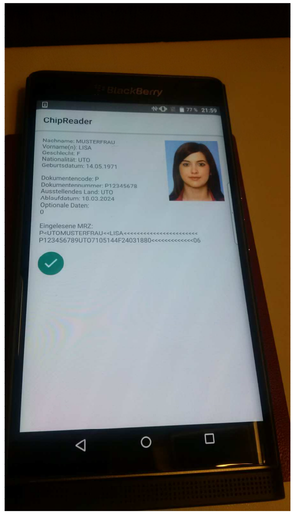
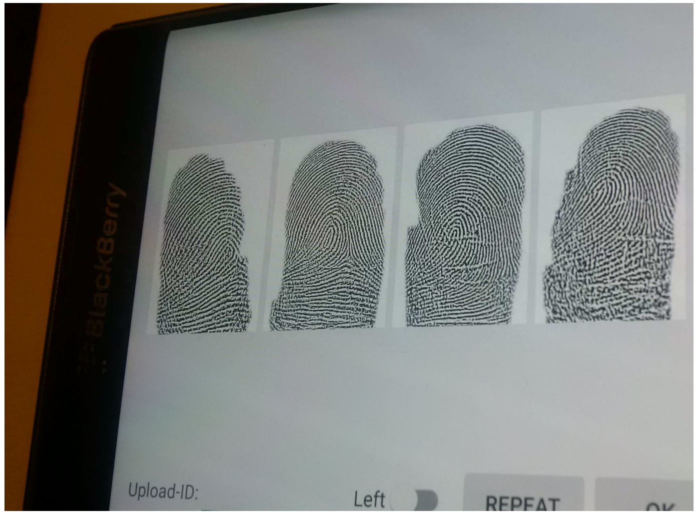
From FastPass to MobilePass to Smartphone







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Thank you for your attention!

Any Questions?

https://www.fastpass-project.eu/

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