Iris Recognition Reliability: Authenticity Assessment + Influence of Illuminant Wavelength

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International Biometric Performance Conference March 5-9, 2012, Gaithersburg

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Agenda

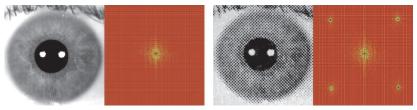
Authenticity assessment

- Frequency analysis
- Method variants
- Selected results and conclusions

2 Influence of Illumination Wavelength

- Equipment and database
- Selected results and conclusions

Frequency analysis for authenticity assessment

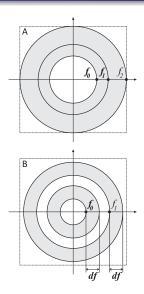


Images and corresponding amplitude spectra for authentic iris (left) vs. iris printout (right)

- 1. Straightforward method for detection of regular occurrence of dots within the image
- 2. Image used for recognition may be employed (i.e. no additional hardware or new capture procedures are required)
- 3. (Rough) iris segmentation is required: 'easy' for authentic irises, unpredictable for artefacts

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Method variants Frequency windows



A: Two fixed windows

$$q_A = \frac{h(f_1, f_2)}{h(f_0, f_1)}$$

B: One fixed and one moving window

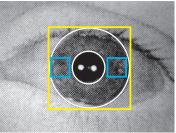
$$q_B = \max_{f_1} \frac{h(f_1, f_1 + df)}{h(f_0, f_0 + df)}$$

where f_0, f_1 are parameters in A, f_0, df are parameters in B, hcalculates maximum (or average) values within frequency window (raw and log amplitudes are considered)

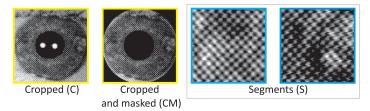
'Alien frequencies' expected in the inner or the outer window

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Method variants ROI selection



Iris printout image



Databases

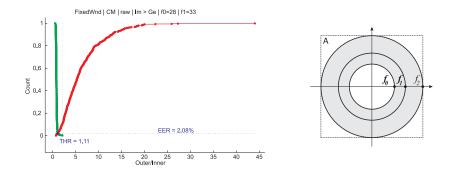
1. Equipment

- DB1: IrisCUBE (prototype) camera, HP LaserJet 1100
- DB2, DB3, DB4: IrisGuard AD100, Lexmark 534
- DB5: IrisGuard AD100, Lexmark 534 & HP LaserJet 1320
- 2. Approximately 700 images of iris printouts (and images of the corresponding authentic eyes)
 - all printouts used to successfully spoof an example commercial camera

Authenticity assessment Infl. of Illumination Wavelength

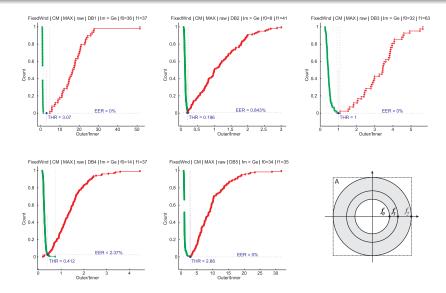
Frequency analysis Variants Results & conclusions

Selected results: best accuracy (EER) Winner: fixed window (A), raw amplitude, cropped and masked (all databases mixed)



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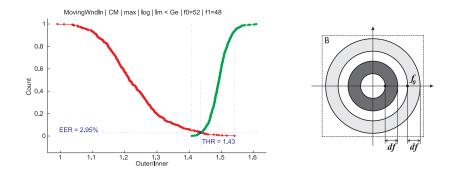
Selected results: best accuracy (EER) Winner: fixed window (A), raw amplitude, cropped and masked



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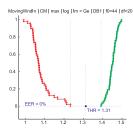
Selected results: best FAR (FNDR) for FRR (FADR) = 0

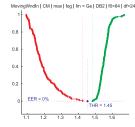
Winner: moving window (B), log amplitude, cropped and masked (all databases mixed)



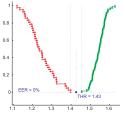
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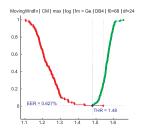
Selected results: best FAR (FNDR) for FRR (FADR) = 0 <u>Winner: moving window (B)</u>, log amplitude, cropped and masked

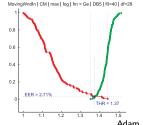


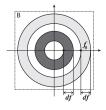


MovingWndln | CM | max | log | Im < Ge | DB3 | f0=64 | df=36









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Conclusions

- 1. Possible usage: authenticity (liveness) detection or quality assessment
- 2. Difficult to offer low FRR (FADR) if zero FAR (FNDR) is demanded
- May offer low FAR (FNDR) if zero FRR (FADR) is demanded (detection of approx. 95% of artefacts used in successful spoofing attacks)
- 4. Sensitive to segmentation errors (artefact appearance difficult to be predicted)

Agenda

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Influence of Illumination Wavelength

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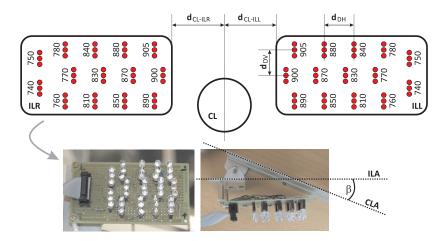
Equipment

- 1. Analogue camera with increased IR sensitivity
- 2. Fixed lens with IR filter

(100% transparency for wavelengths higher than 720 nm)

- 3. Two illuminants
 - placed equidistantly on the left and right sides of the lens
 - containing 14 sections of IR LEDs (each section consists of 3 LEDs and corresponds to one wavelength)
 - the spectral bandwidth of the illuminating diodes at 50% ("half width"):
 - 30nm for lambda 740-780 nm,
 - 35 nm for lambda 810-840 nm,
 - 40 nm for lambda 850-870 nm, and
 - 75-80 nm for lambda 890-905 nm.
 - LEDs power compliant with IEC 60825-1 (Ed. 1.2)

Equipment

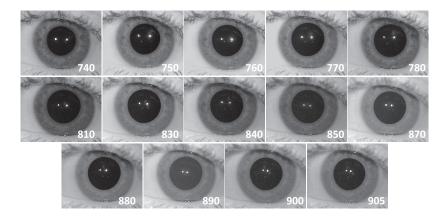


ILR, ILL: illuminants (right, left) CL: camera lens CLA: line perpendicular to the lens axis ILA: line perpendicular to the illuminant axis $\begin{array}{l} \mathsf{d}_{\mathsf{CL-ILR}} = \mathsf{d}_{\mathsf{CL-ILL}} \approx 60 \text{mm (adjustable)} \\ \mathsf{d}_{\mathsf{DV}} \approx 15 \text{mm} \\ \mathsf{d}_{\mathsf{DH}} \approx 10\text{-}15 \text{mm} \\ : \text{adjustable for best iris illumination} \end{array}$

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Database

Images for 50 different eyes (8 images per eye; a subset of a larger set for 200 different eyes was used)



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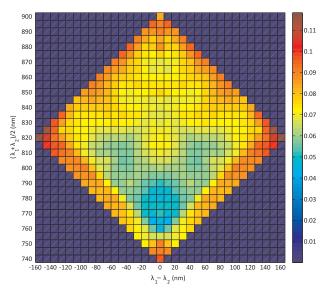
Equipment and database Results & conclusions

Selected results Median EER (%) for matcher No. 1 (academic)

	905	L	11.3	11.4	8.9	9.4	8.4	9.4	9.0	8.8	8.9	9.2	8.8	9.4	8.9	10.1
λ_2 (nm) verification sample	900		11.9	11.7	9.7	9.6	8.5	9.2	9.1	9.2	9.6	9.4	8.6	9.6	8.3	8.9
	890		10.3	9.2	7.7	8.0	7.6	8.8	7.8	8.4	8.2	7.6	7.9	9.2	9.6	9.4
	880		9.8	9.8	7.8	7.5	7.4	7.9	7.4	7.6	7.5	7.5	8.8	7.9	8.6	8.8
	870		8.8	9.0	7.6	7.1	7.2	7.8	7.1	7.6	7.4	7.3	7.5	7.6	9.4	9.2
	850		8.8	9.3	7.4	6.0	6.0	7.3	7.1	7.1	7.6	7.4	7.5	8.2	9.6	8.9
	840		8.5	8.9	7.0	6.8	6.1	6.8	6.9	7.0	7.1	7.6	7.6	8.4	9.2	8.8
	830		8.2	8.4	6.1	6.0	5.6	7.3	6.9	6.9	7.1	7.1	7.4	7.8	9.1	9.0
	810		8.3	8.4	6.0	6.2	6.0	7.3	7.3	6.8	7.3	7.8	7.9	8.8	9.2	9.4
(mn	780		7.7	7.3	4.9	5.1	4.8	6.0	5.6	6.1	6.0	7.2	7.4	7.6	8.5	8.4
λ ₂ (770		7.4	7.1	4.3	5.5	5.1	6.2	6.0	6.8	6.0	7.1	7.5	8.0	9.6	9.4
	760		7.2	6.7	4.7	4.3	4.9	6.0	6.1	7.0	7.4	7.6	7.8	7.7	9.7	8.9
	750		8.8	9.3	6.7	7.1	7.3	8.4	8.4	8.9	9.3	9.0	9.8	9.2	11.7	11.4
	740		9.9	8.8	7.2	7.4	7.7	8.3	8.2	8.5	8.8	8.8	9.8	10.3	11.9	11.3
			:	:	:	:	:	:	:	:	:	:	:	:	:	
			740	750	760	770					850		880	890	900	905
	$\lambda_{_1}$ (nm) enrollment template															

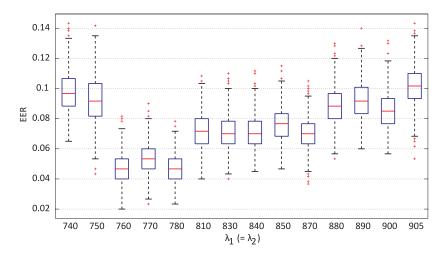
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Selected results Median EER (%) interpolated every 10nm for matcher No. 1 (academic)



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Selected results EER boxplot for matcher No. 1 (academic) when $\lambda_1 = \lambda_2$



Legend: the bottom and top of the boxes: 25th and 75th percentile; red band near the middle: median value; whiskers: 1.5 IQR; plus signs: outliers

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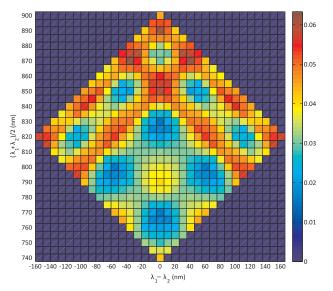
Equipment and database Results & conclusions

Selected results Median EER (%) for matcher No. 2 (commercial)

	905	L	5.2	4.6	3.8	3.6	4.3	4.6	3.8	4.4	5.7	4.1	4.0	5.5	5.2	4.8
λ_2 (nm) verification sample	900		5.8	5.0	4.1	3.8	4.5	4.3	3.8	4.4	5.6	4.2	4.2	5.4	4.6	5.2
	890		5.9	5.0	4.6	4.2	5.0	5.2	4.5	5.1	6.2	4.9	4.9	6.1	5.4	5.5
	880		4.1	3.2	2.7	2.4	3.2	3.4	2.3	3.5	5.1	3.0	3.4	4.9	4.2	4.0
	870		3.8	3.1	2.6	2.4	3.2	3.2	2.2	3.4	5.1	3.0	3.0	4.9	4.2	4.1
					_	_			_				_			
	850		5.6	5.3	5.0	4.7	5.2	5.0	5.0	5.2	6.0	5.1	5.1	6.2	5.6	5.7
	840		4.3	3.4	3.0	2.8	3.6	3.5	2.8	3.8	5.2	3.4	3.5	5.1	4.4	4.4
	830		3.0	2.4	1.9	1.6	2.5	2.7	1.5	2.8	5.0	2.2	2.3	4.5	3.8	3.8
	810		3.9	3.3	2.9	2.7	3.3	3.2	2.7	3.5	5.0	3.2	3.4	5.2	4.3	4.6
	780		3.9	3.1	2.8	2.5	3.4	3.3	2.5	3.6	5.2	3.2	3.2	5.0	4.5	4.3
λ ₂ (770		3.2	2.3	1.8	1.7	2.5	2.7	1.6	2.8	4.7	2.4	2.4	4.2	3.8	3.6
	760		3.4	2.5	2.3	1.8	2.8	2.9	1.9	3.0	5.0	2.6	2.7	4.6	4.1	3.8
	750		3.8	2.9	2.5	2.3	3.1	3.3	2.4	3.4	5.3	3.1	3.2	5.0	5.0	4.6
	740		4.4	3.8	3.4	3.2	3.9	3.9	3.0	4.3	5.6	3.8	4.1	5.9	5.8	5.2
			-	-		-	-	-		-	-			-		
			740	750	760	۲70 کړ					850		880	890	900	905
	$\lambda_1^{}$ (nm) enrollment template															

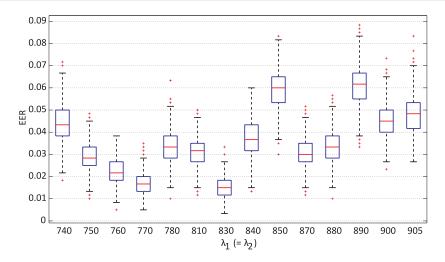
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Selected results Median EER (%) interpolated every 10nm for matcher No. 2 (commercial)



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Selected results EER boxplot for matcher No. 2 (commercial) when $\lambda_1 = \lambda_2$



Legend: the bottom and top of the boxes: 25th and 75th percentile; red band near the middle: median value; whiskers: 1.5 IQR; plus signs: outliers

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Conclusions

- 1. Recognition performance for different wavelengths seems to be uneven
- 2. The interoperability among capture systems using different illumination wavelengths might not be guaranteed
- 3. Need for evaluations on larger datasets (ongoing) and for greater number of matchers (any parties willing to cooperate are welcome)

Contact

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