PRNU Variance Analysis for Morphed Face Image Detection

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Outline

What is Face Morphing?

Morphing - Creation of an artificial target image which resembles information of two (or more) source images

(a) Subject 1 (b) Morph (c) Subject 2

Figure: High Quality face morph of two subjects.

The Magic Passport

- Face selected as primary biometric trait for electronic Machine Readable Travel Documents (eMRTD) in 2002
- “The Magic Passport”[1]: Use morphed face images of multiple subjects for passport application (enrolment)

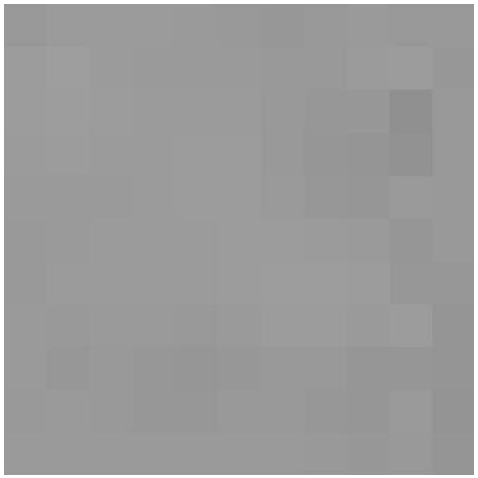
Figure: Passport application with morphed image.

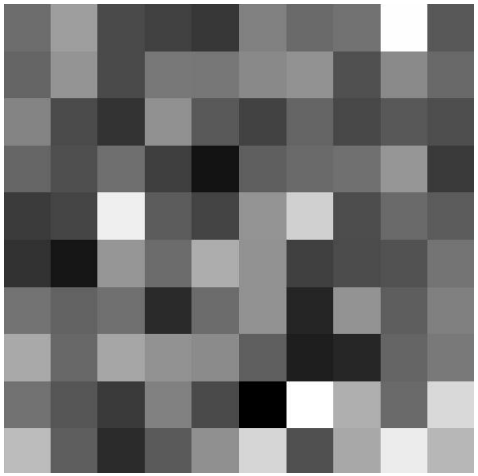
The Magic Passport (cont.)

Figure: Both subjects are able to pass ABC with the same passport.

→ **SERIOUS RISK** for Automated Border Control (ABC)

PRNU





What is PRNU?

- PRNU: Photo-response non-uniformity
- Intrinsic property of CCD/CMOS sensors
- Noise-like pattern
- Variations in quantum efficiency among pixels

Why PRNU?

1. **Universality**: All imaging sensors exhibit PRNU.
2. **Generality**: The PRNU is present in every picture independently of camera or scene content.
3. **Robustness**: It survives many typical processing procedures and even high quality printing and scanning [2].

PRNU-based Morphing Detection Approach

- Goal: Blind detection of morphed images without the need of reference image
- Analyse the variations in different parts of the image caused by morphing in spectral domain through non-linear warping

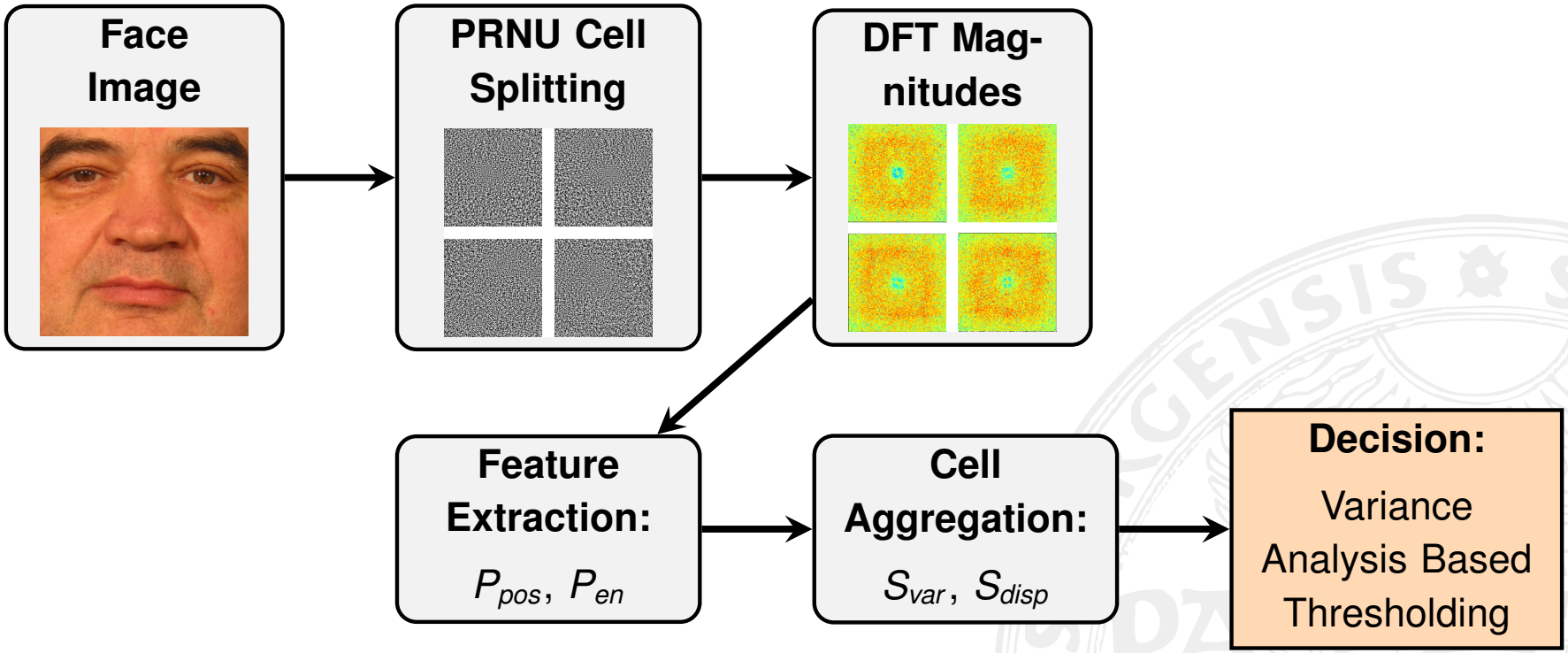
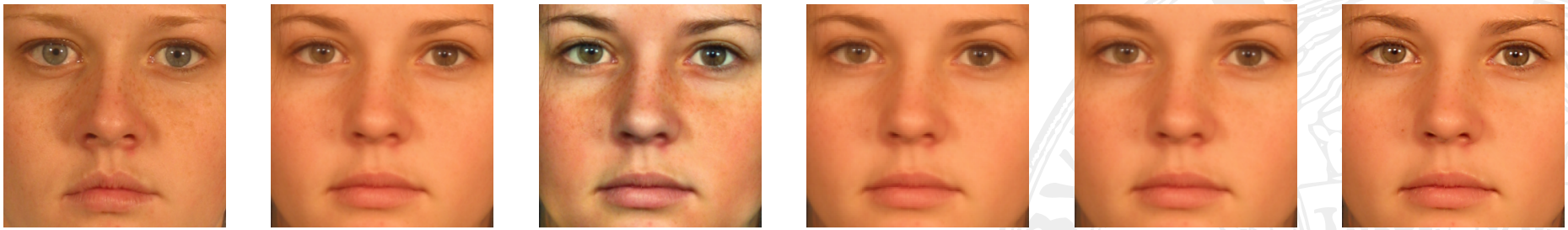


Figure: Processing steps.

Experimental Setup

- Dataset: Subset of FRGCv2
  - Face images with resolution of 320x320 pixels (ICAO compliant)
  - 961 bona fide images (male and female), 2414 morphed images
- PRNU extraction: Mihcak denoising filter [3] + FDR enhancement [4]
- Cell configurations: 2x2 . . . 10x10
- Post-processings: CLAHE (*EQU*), scaling (*SCL*), sharpening (*SHRP*)
- Experiment: Detection of unaltered and post-processed morphed face images



(a) Bona fide (b) Morph (c) EQU (d) SCL_{50} (e) SCL_{75} (f) SHRP

Figure: Dataset examples.

Experimental Results

Table: D-EER performance comparison of proposed PRNU variance analysis based detector with baseline proposed in [5]. The column *ALL* reports the D-EER including all attacks (*Morph* to *SHRP*).

Algorithm	Cells	D-EER					
		Morph	**EQU**	**SCL_{50}**	**SCL_{75}**	**SHRP**	**ALL**
Baseline [5]	8	2.2%	33.8%	0.7%	0.0%	10.8%	15.7%
Proposed	10	11.0%	15.9%	2.6%	3.8%	1.5%	10.5%
Difference		+ 8.8%	-17,9%	+1,9%	+3,8%	-9,3%	-5,2%

Results summary:

- The proposed PRNU variance analysis based approach is robust against a wide variety of post-processing attacks.
- Improvement of overall system performance (ALL) compared to baseline, when all altered and unaltered morphs are considered.

Conclusion and Future Work

Conclusion

- Morphed face images pose a serious risk to ABC.
- PRNU shows non-uniform variations across image regions after morphing procedures.
- We proposed a variance analysis based approach of PRNU features for morphed image detection.
- Improved performance (D-EER of 10.5%) and robustness against post-processings of morphed images compared to previous work.
- High robustness expected for other datasets and morphing techniques.

Future work

- Investigate generalisability of proposed approach (different cameras and datasets).
- Comparison against other SOTA morph detection systems.
- Does it also work as well for printed and scanned images?

References

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[3] M. Mihcak, I. Kozintsev, and K. Ramchandran, “Spatially adaptive statistical modeling of wavelet image coefficients and its application to denoising”, in *Proceedings of the 1999 IEEE International Conference on Acoustics, Speech, and Signal Processing, ICASSP ’99*, Phoenix, AZ, USA: IEEE, Mar. 2009, pp. 3253–3256.

[4] X. Lin and C.-T. Li, “Enhancing sensor pattern noise via filtering distortion removal”, *IEEE Signal Processing Letters*, vol. 23, no. 3, pp. 381–385, 2016.

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Thank you for your attention!