Exploiting PRNU and Linear Patterns in Forensics Camera Attribution Under Complex Lens Distortion Correction

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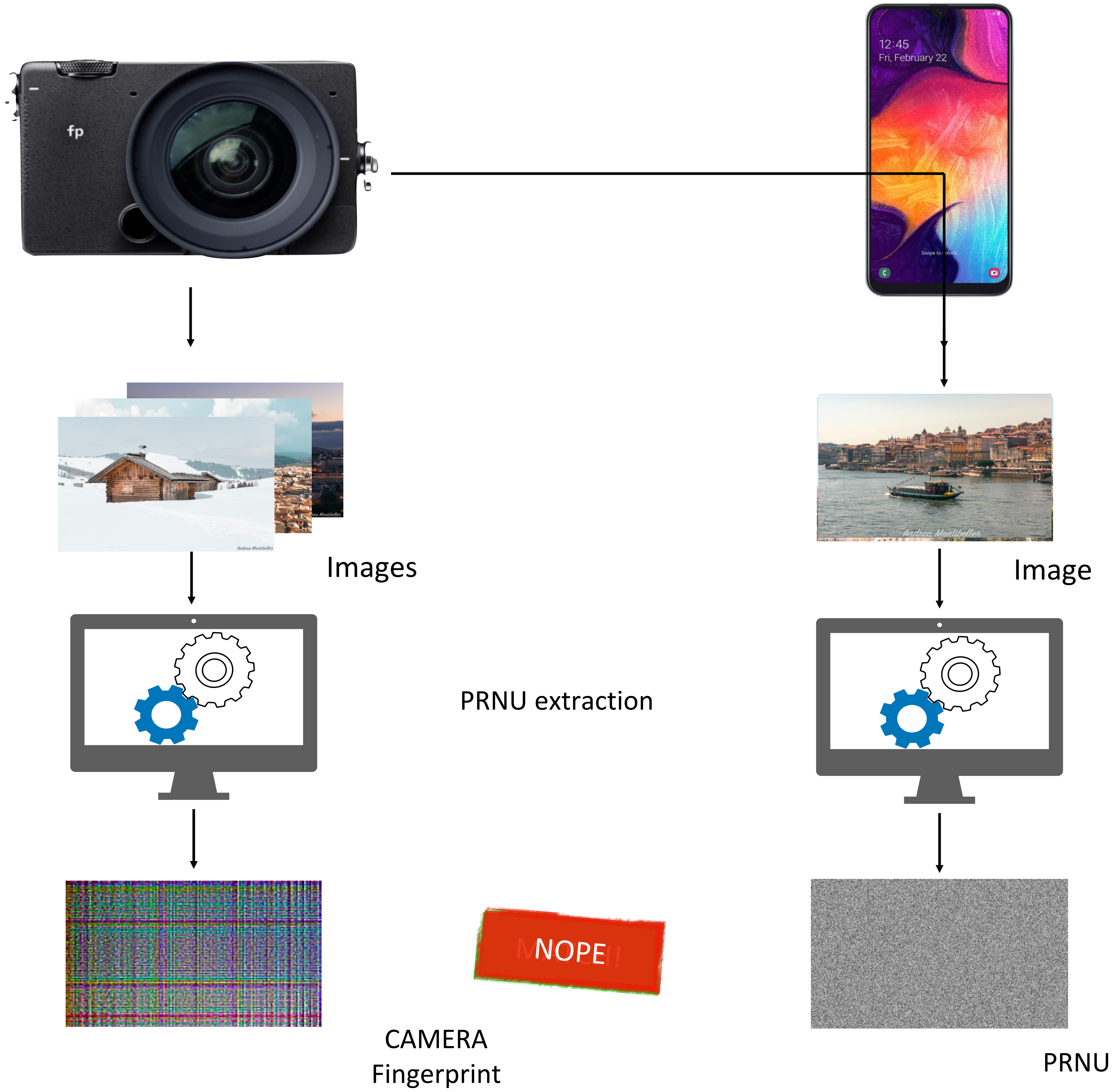
Universidade Vigo

Outline

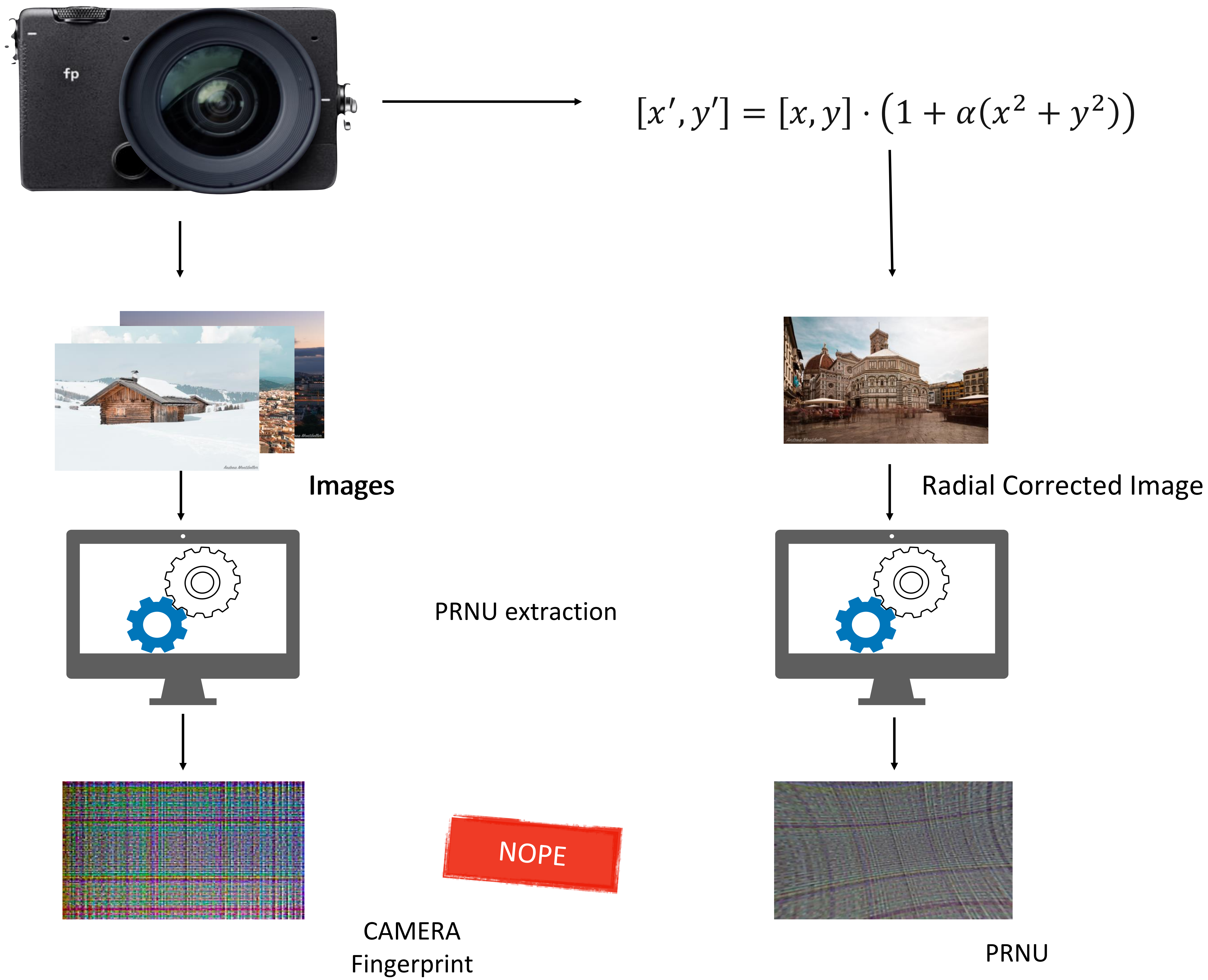
- Camera Attribution
- Camera Attribution of Radial Corrected Images
- In and Out Camera Radial Correction
- State of The Art
- Complementarity
- Proposed Solutions
- Experimental Results
- Conclusions

Camera Attribution



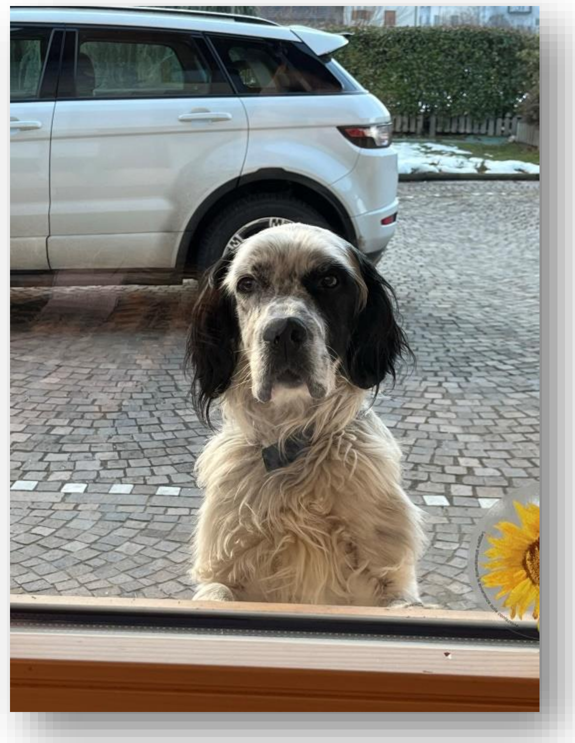
Lukas, Jan, Jessica Fridrich, and Miroslav Goljan. “Digital camera identification from sensor pattern noise.” IEEE Transactions on Information Forensics and Security 1.2 (2006): 205-214.

Camera Attribution of Radial Corrected Images



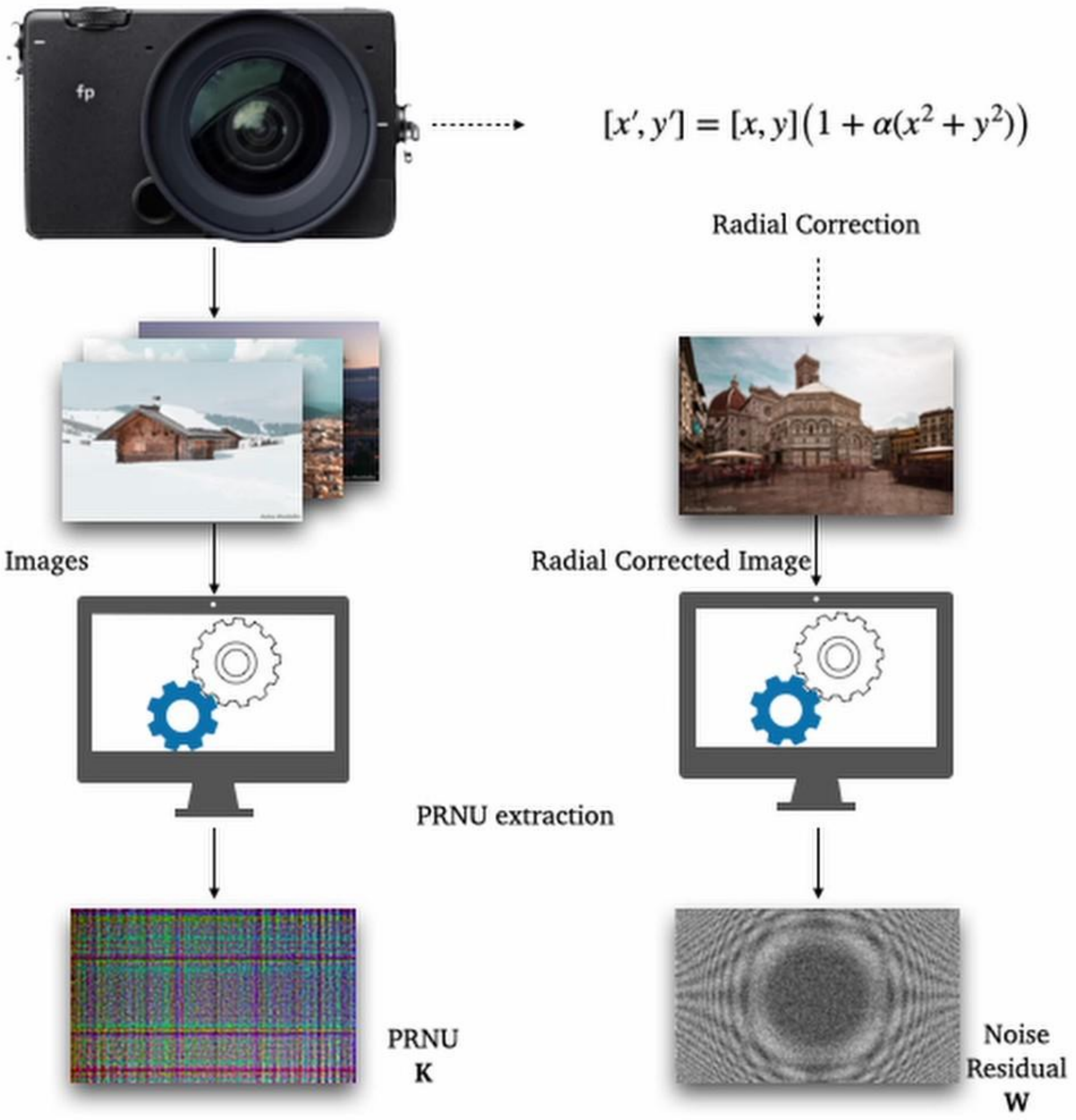
In and Out-Camera Radial Correction

In-Camera Radial Correction



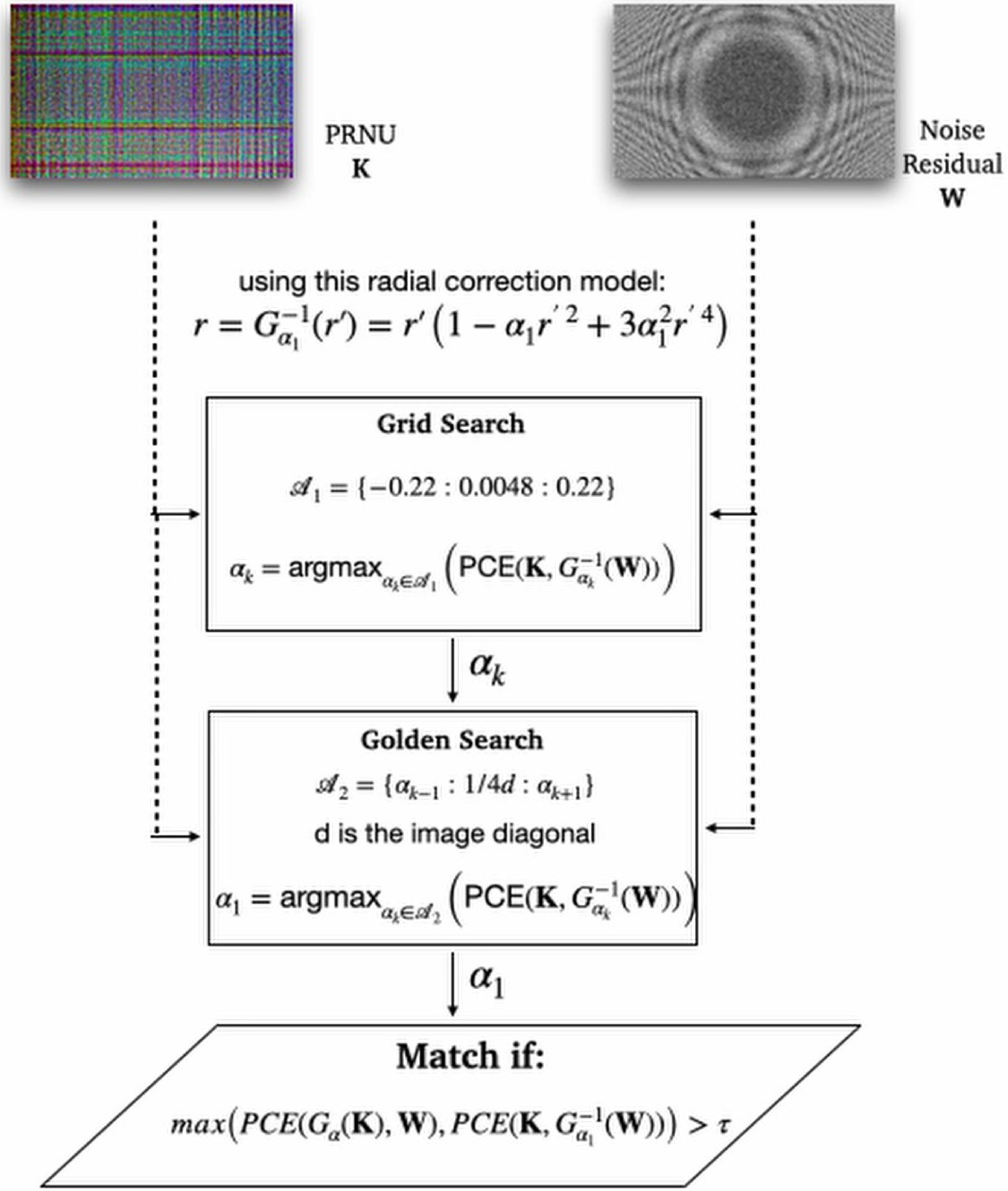
Out-Camera Radial Correction

State of the Art: Sensor-fingerprint based identification of images corrected for lens distortion



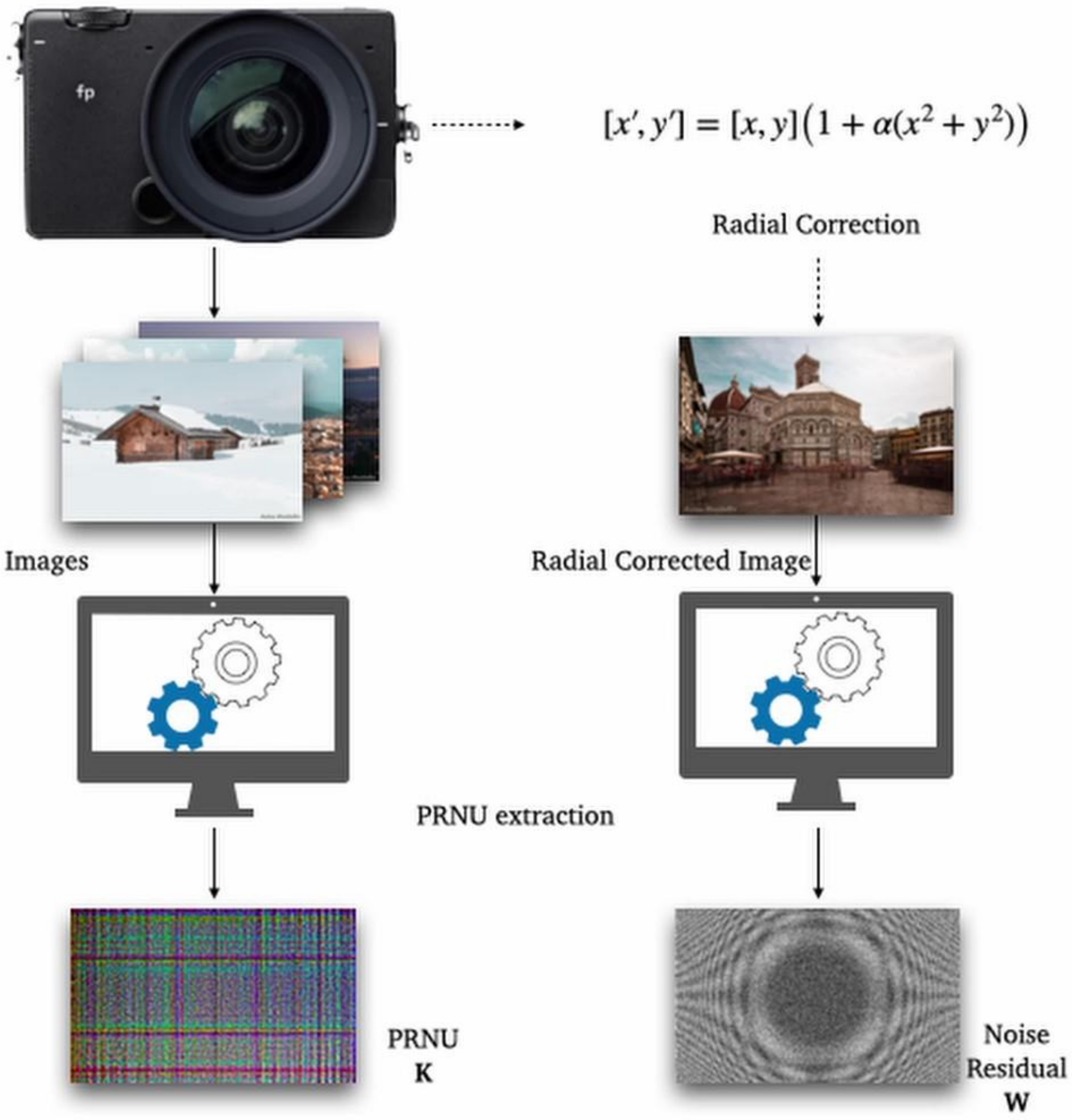
[9] Goljan, Miroslav, and Jessica Fridrich. "Sensor-fingerprint based identification of images corrected for lens distortion." *Media Watermarking, Security, and Forensics 2012*. Vol. 8303. Spie, 2012.

State of the Art: Sensor-Fingerprint based identification of images corrected for lens distortion



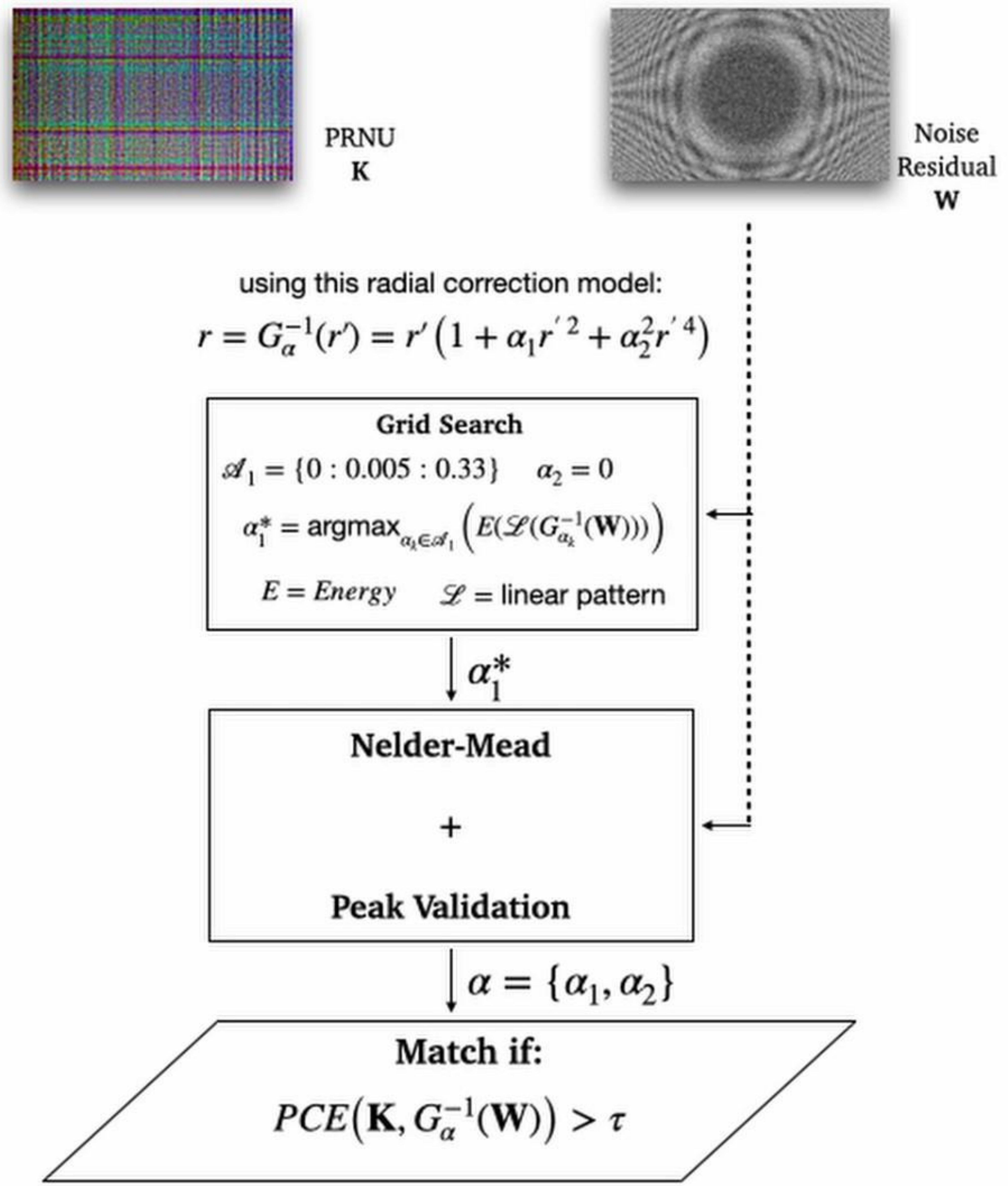
[9] Goljan, Miroslav, and Jessica Fridrich. "Sensor-fingerprint based identification of images corrected for lens distortion." *Media Watermarking, Security, and Forensics 2012*. Vol. 8303. Spie, 2012.

State of the Art: Estimation of lens distortion correction from single images



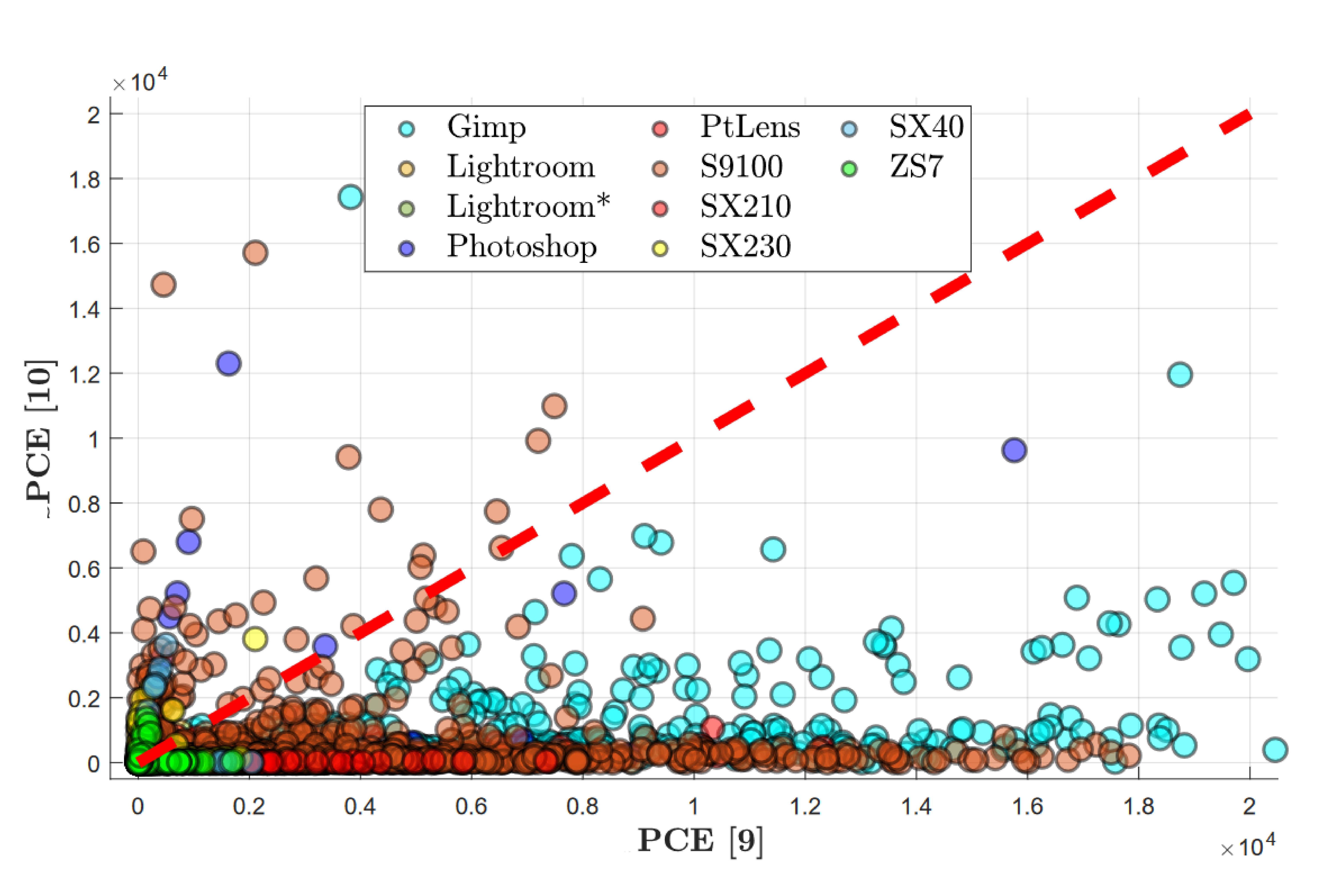
[10] Goljan, Miroslav, and Jessica Fridrich. "Estimation of lens distortion correction from single images." *Media Watermarking, Security, and Forensics 2014*. Vol. 9028. SPIE, 2014.

State of the Art: Estimation of lens distortion correction from single images



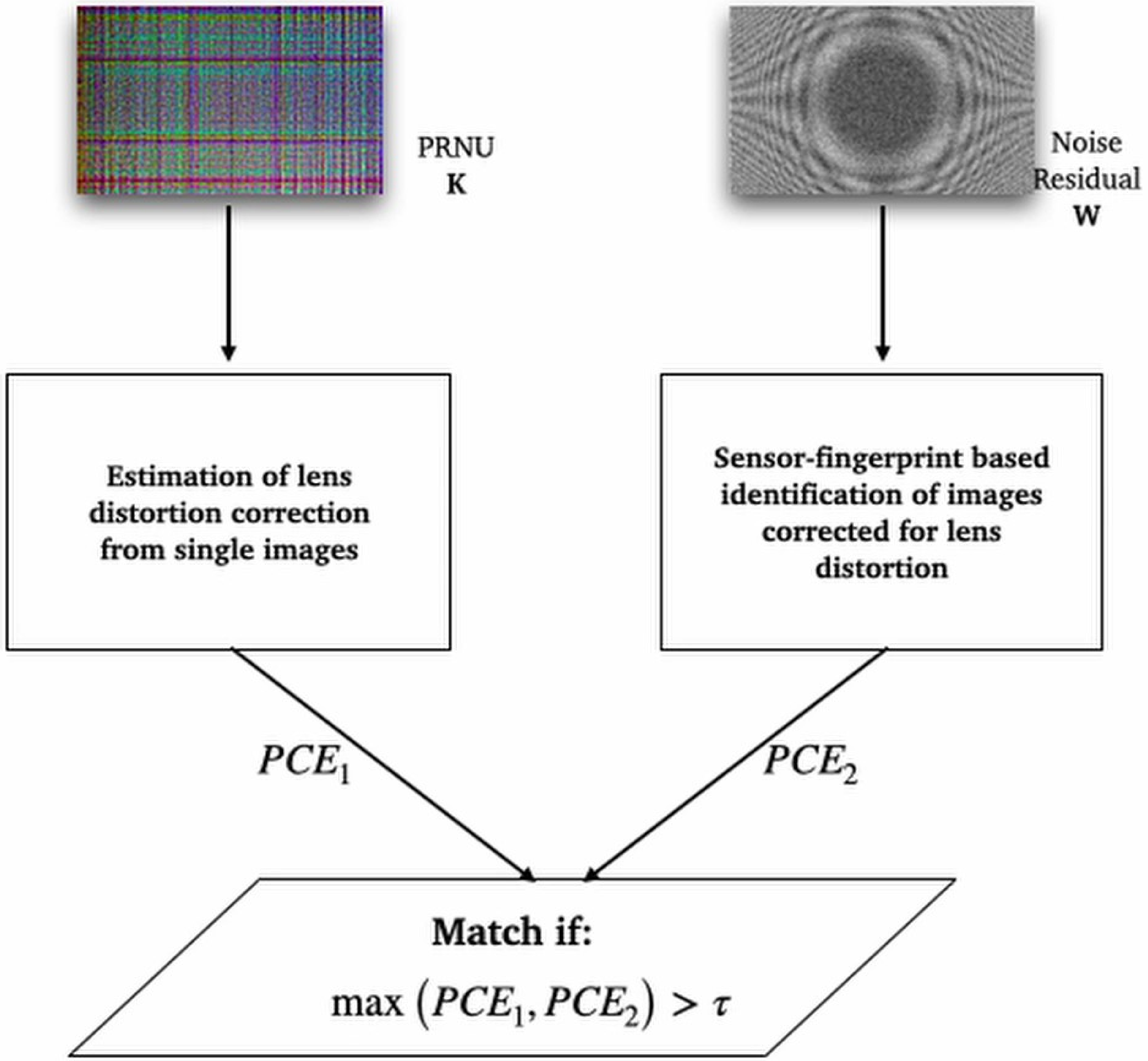
[10] Goljan, Miroslav, and Jessica Fridrich. "Estimation of lens distortion correction from single images." *Media Watermarking, Security, and Forensics 2014*. Vol. 9028. SPIE, 2014.

Complementarity



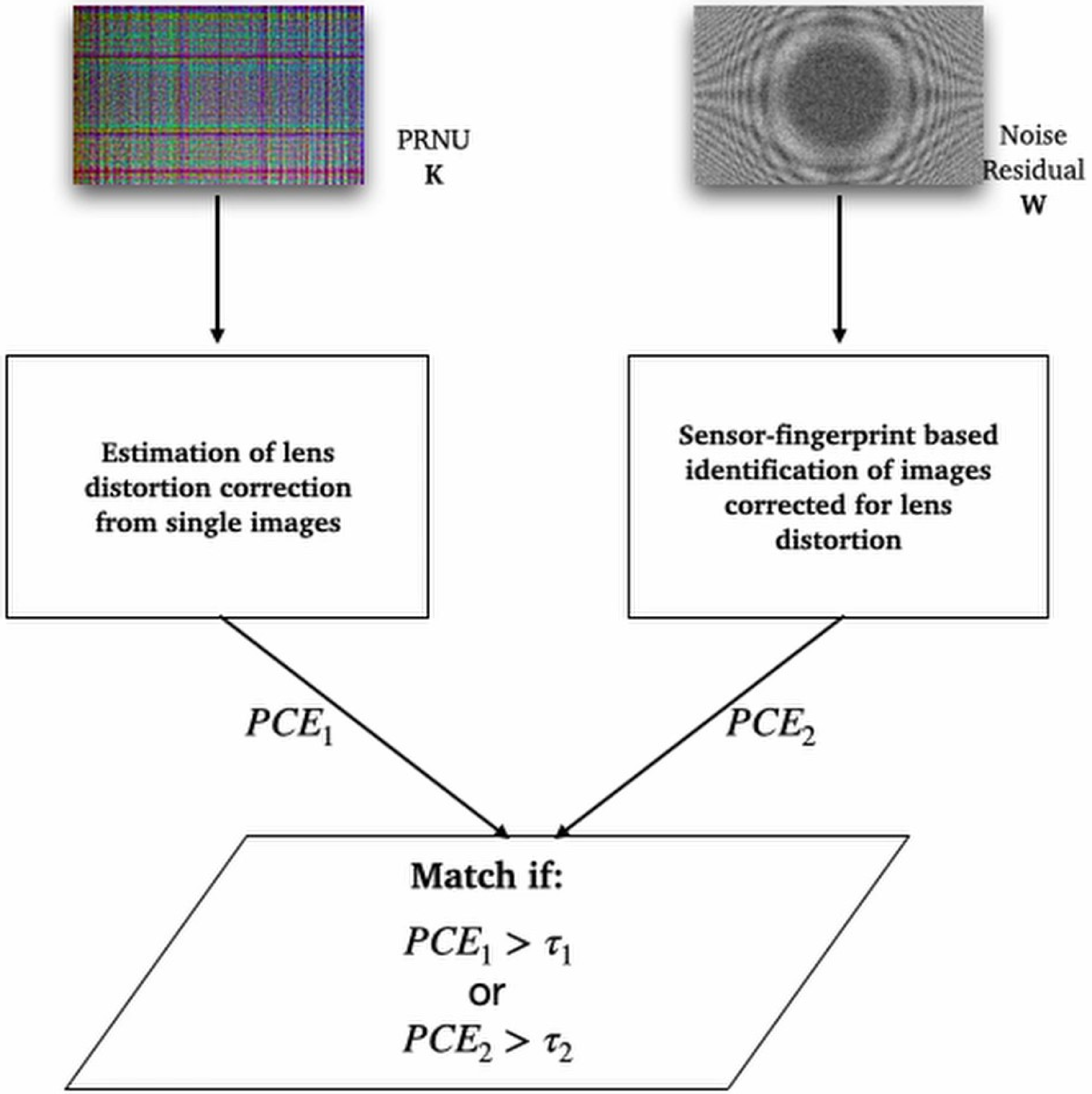
[9] Goljan, Miroslav, and Jessica Fridrich. "Sensor-fingerprint based identification of images corrected for lens distortion." *Media Watermarking, Security, and Forensics 2012*. Vol. 8303. Spie, 2012.
[10] Goljan, Miroslav, and Jessica Fridrich. "Estimation of lens distortion correction from single images." *Media Watermarking, Security, and Forensics 2014*. Vol. 9028. SPIE, 2014.

Proposed Solutions: MAX



[9] Goljan, Miroslav, and Jessica Fridrich. "Sensor-fingerprint based identification of images corrected for lens distortion." *Media Watermarking, Security, and Forensics 2012*. Vol. 8303. Spie, 2012.
[10] Goljan, Miroslav, and Jessica Fridrich. "Estimation of lens distortion correction from single images." *Media Watermarking, Security, and Forensics 2014*. Vol. 9028. SPIE, 2014.

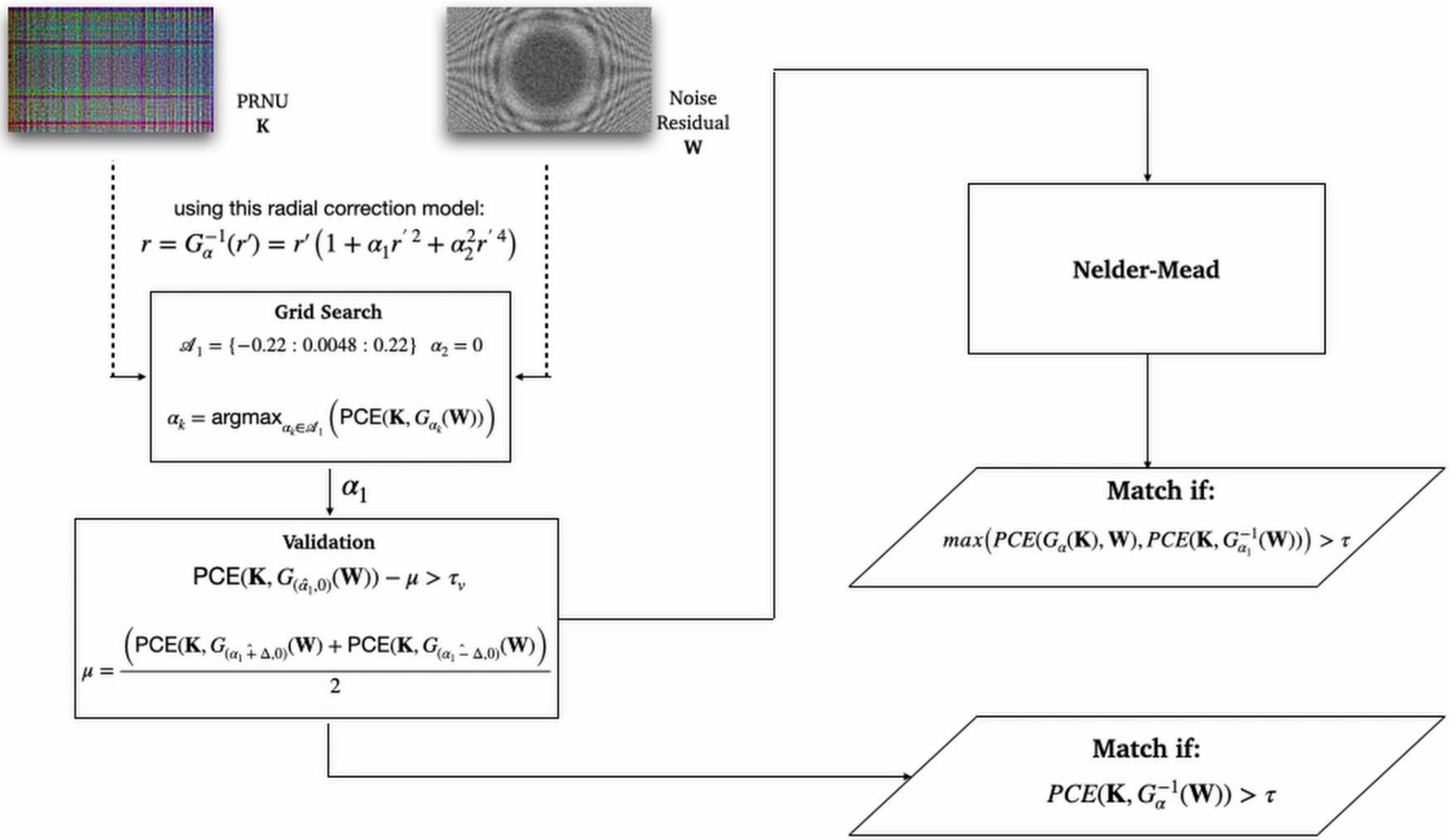
Proposed Solutions: OR



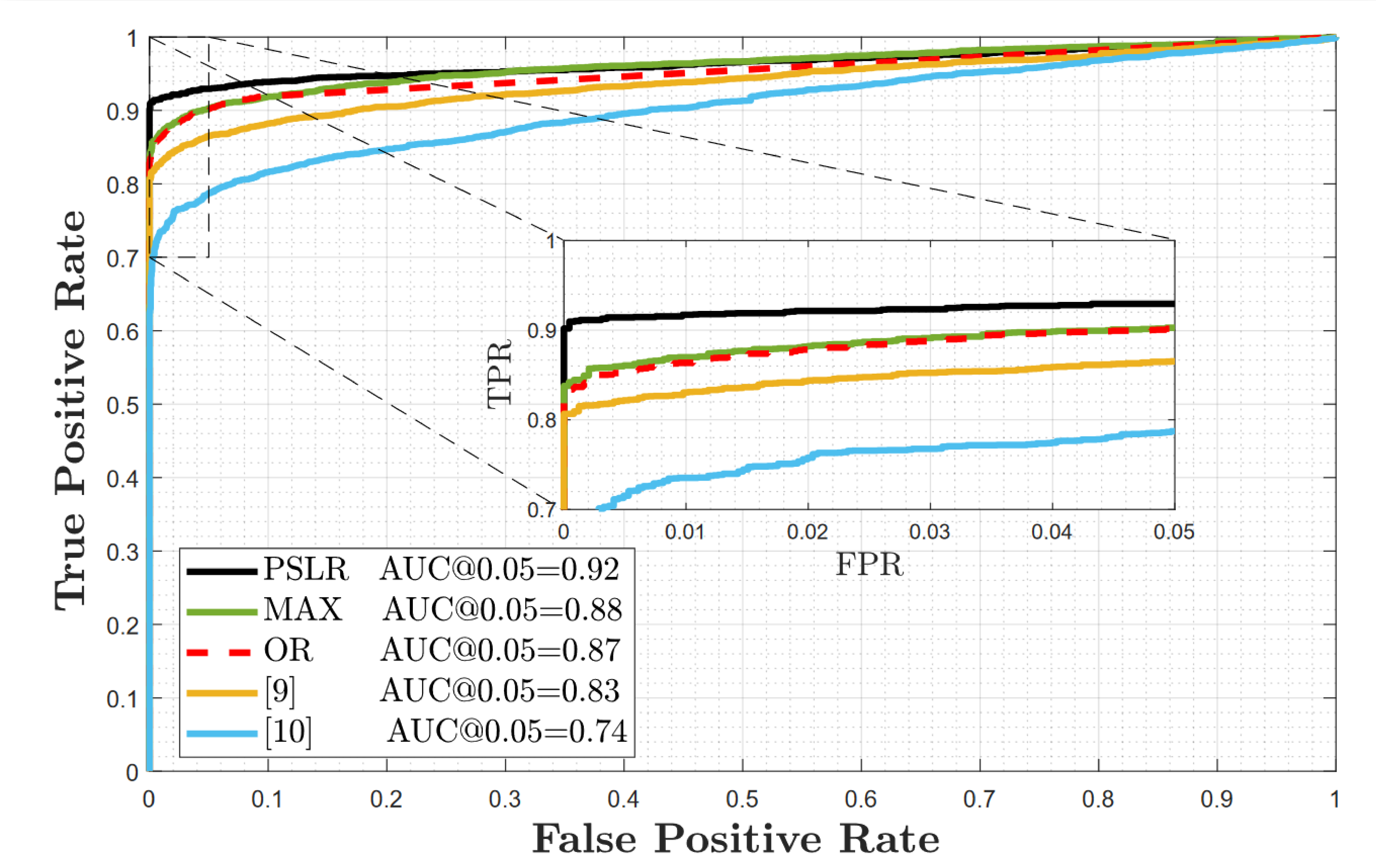
[9] Goljan, Miroslav, and Jessica Fridrich. "Sensor-fingerprint based identification of images corrected for lens distortion." *Media Watermarking, Security, and Forensics 2012*. Vol. 8303. Spie, 2012.
[10] Goljan, Miroslav, and Jessica Fridrich. "Estimation of lens distortion correction from single images." *Media Watermarking, Security, and Forensics 2014*. Vol. 9028. SPIE, 2014.

Proposed Solutions: PSLR

PCE-guided coarse parameter Search plus Linear Patterns-based Refinement



Experimental Results: ROC



[9] Goljan, Miroslav, and Jessica Fridrich. "Sensor-fingerprint based identification of images corrected for lens distortion." *Media Watermarking, Security, and Forensics 2012*. Vol. 8303. Spie, 2012.
[10] Goljan, Miroslav, and Jessica Fridrich. "Estimation of lens distortion correction from single images." *Media Watermarking, Security, and Forensics 2014*. Vol. 9028. SPIE, 2014.

Experimental Results: TPR@FPR0.05

	GIMP [3456x5184]	LIGHTROOM [3456x5184]	LIGHTROOM* [3456x5184]	PHOTOSHOP [3456x5184]	PT-LENS [3456x5184]	S9100 [3000x4000]	SX210 [3240x4320]	SX230 [1584x2816]	SX40 [2664x4000]	ZS7 [1920x2560]
[9]	0.96	0.44	0.41	0.91	0.64	0.97	0.98	0.82	0.98	0.79
[9] no DS	0.97	0.6	0.51	**0.96**	**0.91**	**1**	**1**	**0.98**	**1**	**0.98**
[10]	0.96	0.35	0.55	0.88	0.36	0.92	0.93	0.76	0.7	0.65

[9] Goljan, Miroslav, and Jessica Fridrich. "Sensor-fingerprint based identification of images corrected for lens distortion." *Media Watermarking, Security, and Forensics 2012*. Vol. 8303. Spie, 2012.
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[10]	0.96	0.35	0.55	0.88	0.36	0.92	0.93	0.76	0.7	0.65
MAX par	0.97	0.68	**0.75**	0.93	0.83	0.99	**1**	0.88	**1**	0.87
OR	0.96	0.67	0.74	0.93	0.83	0.99	**1**	0.88	**1**	0.86

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OR	0.96	0.67	0.74	0.93	0.83	0.99	**1**	0.88	**1**	0.86
PSLR	**0.98**	**0.75**	0.71	**0.96**	**0.9**	0.96	**1**	**0.98**	**1**	0.95

[9] Goljan, Miroslav, and Jessica Fridrich. "Sensor-fingerprint based identification of images corrected for lens distortion." *Media Watermarking, Security, and Forensics 2012*. Vol. 8303. Spie, 2012.
[10] Goljan, Miroslav, and Jessica Fridrich. "Estimation of lens distortion correction from single images." *Media Watermarking, Security, and Forensics 2014*. Vol. 9028. SPIE, 2014.

Experimental Results: Computational Cost x Images [seconds]

	GIMP [3456x5184]	LIGHTROOM [3456x5184]	LIGHTROOM* [3456x5184]	PHOTOSHOP [3456x5184]	PT-LENS [3456x5184]	S9100 [3000x4000]	SX210 [3240x4320]	SX230 [1584x2816]	SX40 [2664x4000]	ZS7 [1920x2560]
[9]	**85.3**	**87.9**	**91.6**	107.2	**100.3**	81.7	**81.3**	**25.1**	**56.3**	**27.8**
[9] fast	962.3	930.8	930.9	947.6	918.3	598.3	723.4	229	526.3	255.2
[10]	861.7	849.8	808.7	731.7	847.1	553.5	661.1	205.2	472.9	227.2
MAX par	861.7	849.8	808.7	731.7	847.1	553.5	661.1	205.2	472.9	227.2
MAX seq	947	937.3	900.3	839.9	947.4	635.2	742.4	230.2	529.2	255
OR	96.4	548.1	553.8	171.6	402.4	95.8	93.2	60.3	67.2	70.1
PSLR	197.1	308.6	284.2	162.2	140.3	**80.7**	234.1	147.2	125.4	51.8
PSLR CPU	667.76	932.29	962.46	576.83	474.04	197.75	621.83	363.18	287.46	151.83

[9] Goljan, Miroslav, and Jessica Fridrich. "Sensor-fingerprint based identification of images corrected for lens distortion." *Media Watermarking, Security, and Forensics 2012*. Vol. 8303. Spie, 2012.
[10] Goljan, Miroslav, and Jessica Fridrich. "Estimation of lens distortion correction from single images." *Media Watermarking, Security, and Forensics 2014*. Vol. 9028. SPIE, 2014.

Experimental Results: ALL

	GIMP 3456 × 5184		LIGHTROOM 3456 × 5184		LIGHTROOM* 3456 × 5184		PHOTOSHOP 3456 × 5184		PT LENS 3456 × 5184		S9100 3000 × 4000		SX210 3240 × 4320		SX230 1584 × 2816		SX40 2664 × 4000		ZS7 1920 × 2560	
	TPR	time [s]	TPR	time [s]	TPR	time [s]	TPR	time [s]	TPR	time [s]	TPR	time [s]	TPR	time [s]	TPR	time [s]	TPR	time [s]	TPR	time [s]
[9] ($\tau = 4.81$)	0.96	85.3	0.44	87.9	0.41	91.6	0.91	107.2	0.64	100.3	0.97	81.7	0.98	81.3	0.82	25.1	0.98	56.3	0.79	27.8
[9] no DS ($\tau = 7.65$)	0.97	962.3	0.6	930.8	0.51	930.9	**0.96**	947.6	**0.91**	918.3	**1**	598.3	**1**	723.4	0.98	229.0	**1**	526.3	**0.98**	255.2
[10] ($\tau = 2.83$)	0.96	861.7	0.35	849.8	0.55	808.7	0.88	731.7	0.36	847.1	0.92	553.5	0.93	661.1	0.76	205.2	0.70	472.9	0.65	227.2
MAXpar ($\tau = 5.28$)	0.97	861.7	0.68	849.8	**0.75**	808.7	0.93	731.7	0.83	847.1	**0.99**	553.5	**1**	661.1	0.88	205.2	**1**	472.9	0.87	227.2
MAXseq ($\tau = 5.28$)	0.97	947	0.68	937.3	**0.75**	900.3	0.93	838.9	0.83	947.4	**0.99**	635.2	**1**	742.4	0.88	230.3	**1**	529.2	0.87	255
OR ($\tau = 5.28$)	0.96	96.4	0.67	548.1	0.74	553.8	0.93	171.6	0.83	402.4	**0.99**	95.8	**1**	93.2	0.88	60.3	**1**	67.2	0.86	70.1
PSLR ($\tau = 5.83$)	**0.98**	197.1	**0.75**	308.6	0.71	284.2	**0.96**	162.2	**0.9**	140.3	0.96	80.72	**1**	234.1	**0.98**	147.2	**1**	125.4	**0.95**	51.8
PSLR CPU ($\tau = 5.83$)	**0.98**	667.76	**0.75**	932.29	0.71	962.46	**0.96**	576.83	**0.9**	474.04	0.96	197.75	**1**	621.83	**0.98**	363.18	**1**	287.46	**0.95**	151.82

Table 1: TPR and average execution time of [9], [10] and our proposed schemes, for different subsets.

[9] Goljan, Miroslav, and Jessica Fridrich. "Sensor-fingerprint based identification of images corrected for lens distortion." *Media Watermarking, Security, and Forensics 2012*. Vol. 8303. Spie, 2012.
[10] Goljan, Miroslav, and Jessica Fridrich. "Estimation of lens distortion correction from single images." *Media Watermarking, Security, and Forensics 2014*. Vol. 9028. SPIE, 2014.

Conclusions

- Combining PRNU-aided and Linear Patterns-aided method help improving in terms of accuracy
- GPU-accelaration allows to further optimize mathematical complex problems
- Adaptive and Variable Radial Corrections remain a problem
- Further optimizations, other than GPU acceleration, have to be implementated

Questions?

- Combining PRNU-aided and Linear Patterns-aided method help improving in terms of accuracy
- GPU-accelaration allows to further optimize mathematical complex problems
- Adaptive and Variable Radial Corrections remain a problem
- Further optimizations, other than GPU acceleration, have to be implementated