Path-based Sensor Pattern Noise For Camera Source Identification

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Image Complexity

Since image can be modeled as a region smooth Markov Distribution. Correlation can be found in neighborhood pixels. The difference between neighborhood pixels can approximately reflect the texture complexity of image. Considering an image I, $\mathbf{I}_{i,j}$ represents the value of pixel (i, j), and $\mathbf{I}_{i,j+1}$, $\mathbf{I}_{i+1,j}$ represent the values of horizontal and vertical neighborhood pixels of $\mathbf{I}_{i,j}$, respectively. Then, the horizontal and vertical differences can be defined as:

$$x = \mathbf{I}_n - \mathbf{I}_{n+1} \quad (1)$$

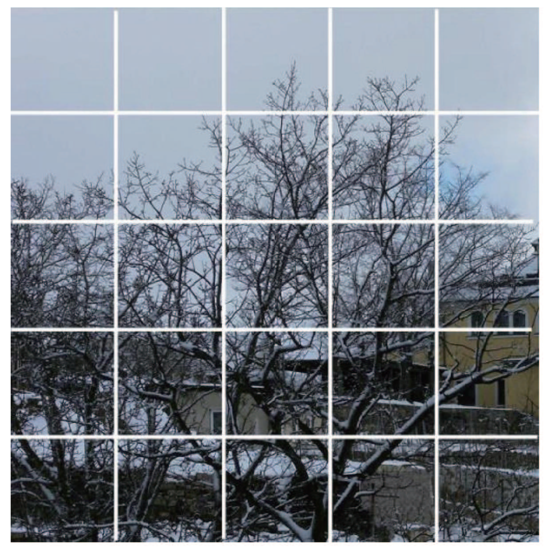
According to [10], the differences between neighborhood pixels can be modeled as a random Generalized Gaussian distribution (GGD) [11] variable with zero mean. The definition of GGD is given by:

$$\mathbf{p}_{\alpha,\beta}(x) = \frac{\beta}{2\alpha\Gamma(1/\beta)} exp(-(\frac{|x|}{\alpha})^2), \quad (2)$$

$$\alpha = \sigma\sqrt{\frac{\Gamma(1/\beta)}{\Gamma(3/\beta)}}, \sigma > 0, \quad (3)$$

where the Γ is the gamma function:

$$\Gamma(z) = \int_0^\infty e^{-t}t^{z-1}dt, z > 0. \quad (4)$$



(a)

0.26	0.29	0.36	0.40	0.31
0.43	0.49	0.70	0.80	0.52
0.78	0.77	0.83	0.83	0.66
0.70	0.66	0.63	0.62	0.55
0.57	0.56	0.53	0.52	0.53

(b)

Figure 1: (a) An image taken by camera Kodak-M1063. (b) The image complexity of each patch.

Objective

We consider low-complexity image always contains less content residual. Our objective is choosing low-complexity patches of images to construct reference SPN(patch-based SPN), and using patch-based SPN to improve the accuracy for camera source identification.

- patch-based SPN extraction as reference SPN,
- low complexity SPN extraction from test image,
- making correlation with corresponding reference SPN.

Patch-based SPN

n images $\mathbf{I}_i (i = 1, 2, \ldots, n)$ taken by camera c. The procedure of constructing global reference PB SPN is shown in Table Patch-based SPN Algorithm.For a fair comparison, the basic SPN and MLE method mentioned above are respectively used as the method to extract the reference SPN from the selected smooth images. In the rest of paper, we call these two methods as PBB SPN and PBM SPN, respectively. Then, these local reference SPN patches are combined to obtain a large reference SPN.

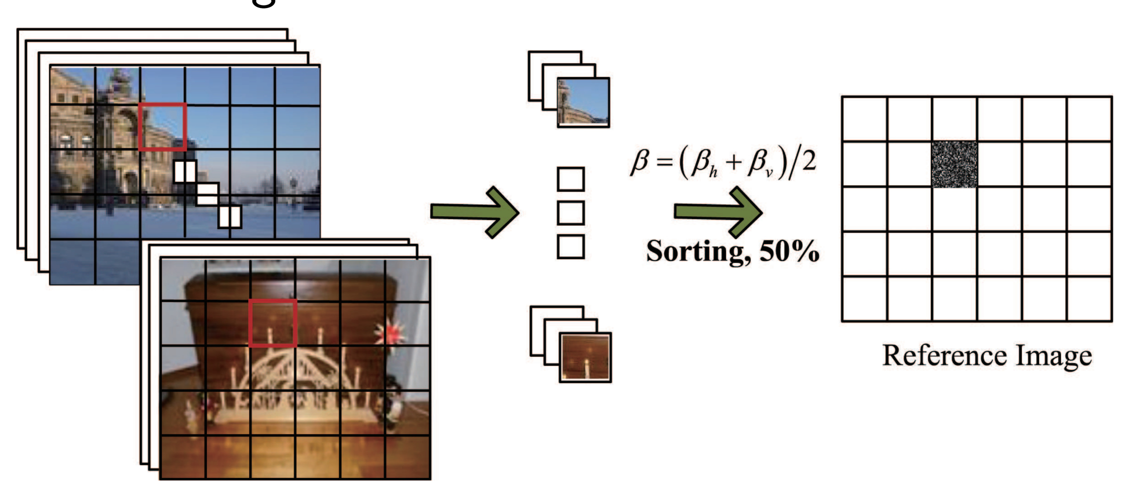


Figure 2: The block diagram of patch-based SPN generation.

Patch-based SPN Algorithm

1) Divide image into patches as a size of 128×128.
2) Calculate complexity parameter β of each patch.
3) Sorting according to the value of β.
4) Get local reference SPN by 50% minimum β.
5) Construct global reference SPN.

Experimental Studies

A total of 1050 images from 7 cameras, which come from the "Dresden Image Dataset" [14], are considered. For all experiments, the reference SPN is extracted from 50 images, and the test images is a set of 700 images, 100 images for each camera. For the comparison purpose, Basic SPN method [4] and MLE method [13] are employed as the baseline. In order to conduct a fair comparison, we utilize the same correlation criterions of the PCE, which is given by:

$$PCE(u) = \frac{ncc(\mathbf{S}_{perk}, u)^2}{\frac{1}{mn-|N|}\sum_{s \notin N} ncc(s, u)^2} = \frac{\mathbf{r}_{xy}{}^2(0)}{\frac{1}{mn-|N|}\sum_{u \notin N} \mathbf{r}_{xy}{}^2(u)} \quad (5)$$

Table 1 and Table 2 demonstrates the identification accuracies of the proposed methods PBB and PBM for each camera. We receive a better performance compared with the baseline proposed in [4] and [13].

Simulation Studies

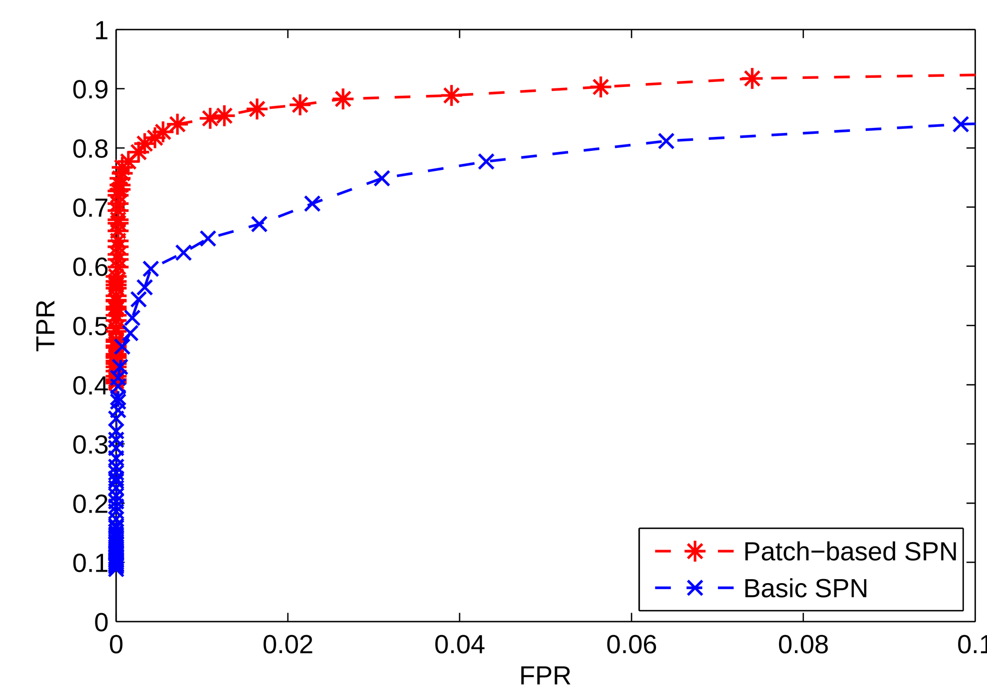


Figure 3: Roc curves of Basic and PBB SPN for image size 256×256.

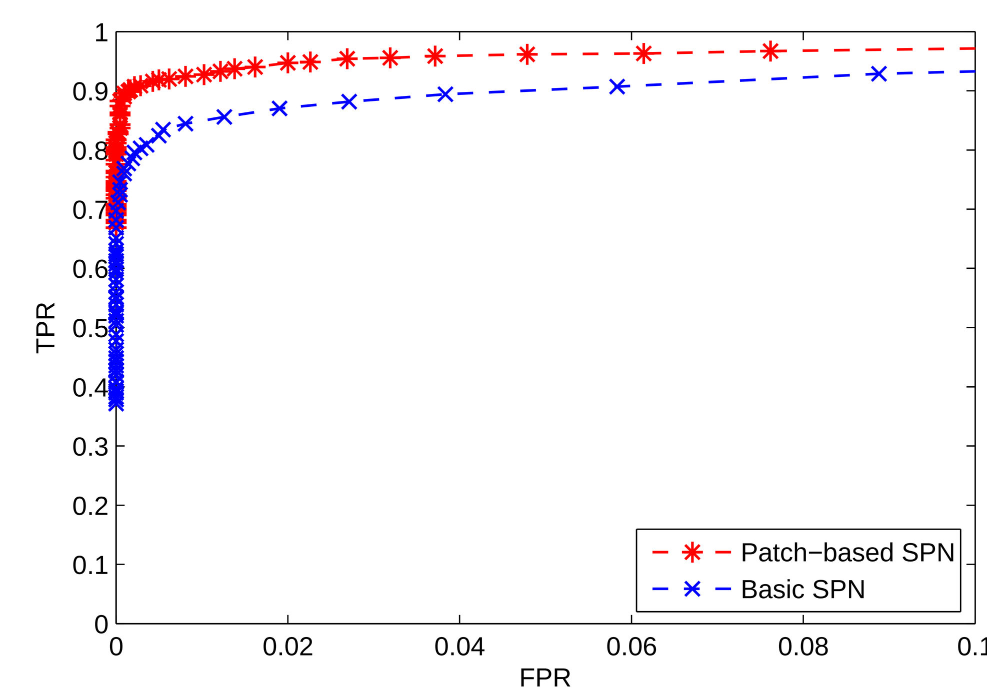


Figure 4: Roc curves of Basic and PBB SPN for image size 512×512.

Table 1. Accuracy of Basic SPN and proposed PBB SPN

Image size	Method	Casio-EX Z150	FujiFilm FinePixJ50	Kodak M1063	Nikon D200	Olympus mju	Panasonic DMC	Pentax OptioA40
256×256	Basic SPN	93%	88%	48%	86%	90%	94%	90%
	PBB SPN	92%	99%	85%	99%	88%	95%	90%
512×512	Basic SPN	98%	85%	91%	95%	93%	94%	95%
	PBB SPN	99%	100%	93%	99%	90%	98%	97%

Table 2. Accuracy of MLE SPN and proposed PBM SPN

Image size	Method	Casio-EX Z150	FujiFilm FinePixJ50	Kodak M1063	Nikon D200	Olympus mju	Panasonic DMC	Pentax OptioA40
256×256	MLE SPN	97%	97%	72%	93%	90%	98%	92%
	PBM SPN	89%	99%	77%	98%	90%	96%	87%
512×512	MLE SPN	99%	90%	95%	98%	93%	96%	98%
	PBM SPN	99%	99%	93%	99%	92%	100%	97%

From Table 1, we can see a significant improvement with an image size of 256×256 with an average increase up to 8% in accuracy. For the size of 512×512, the improvements reach 4%. Similar results can be found in Table 2. ROC curves have been also used in this paper to assess the performance of camera source identification as well as the accuracy. We plot the ROC curves for these four-groups comparisons, as shown in Fig. 3-6.

Simulation Studies

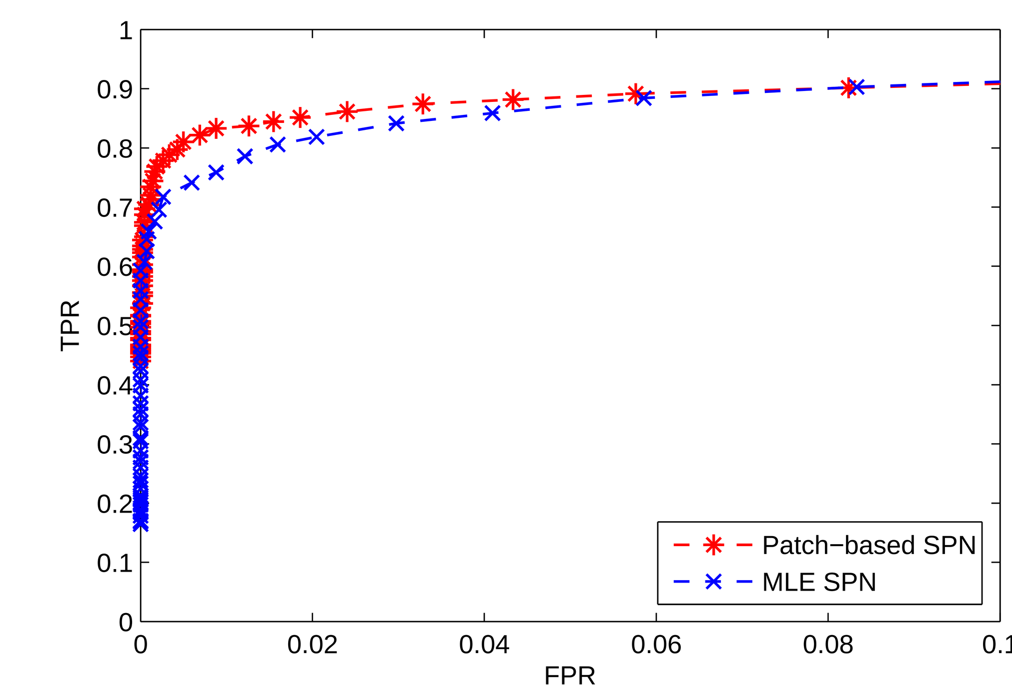


Figure 5: Roc curves of MLE and PBM SPN for image size 256×256.

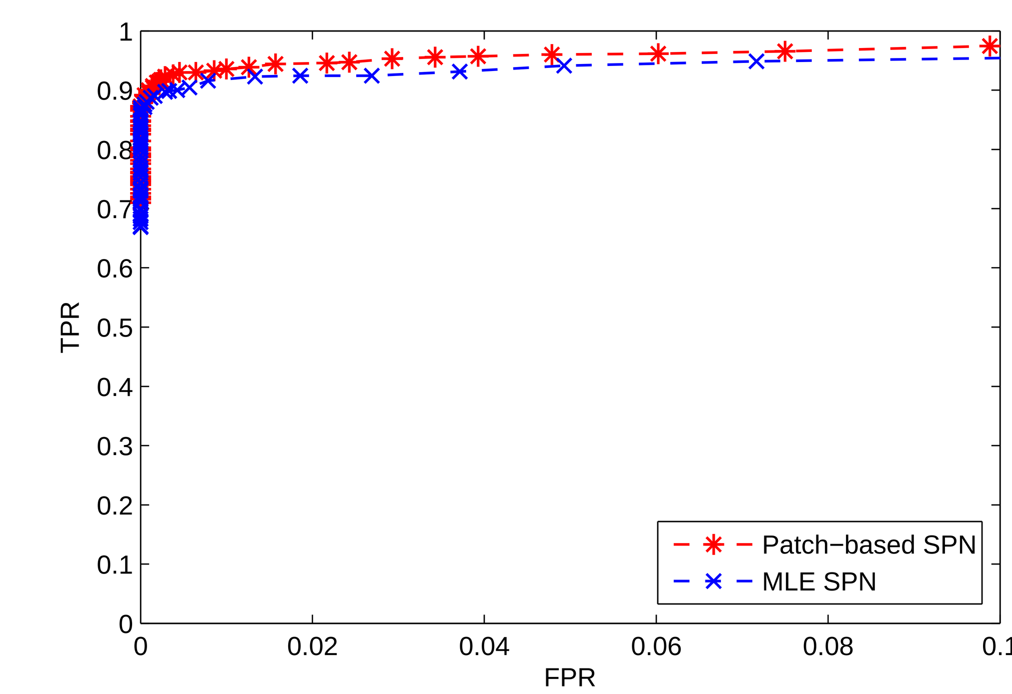


Figure 6: Roc curves of MLE and PBM SPN for image size 512×512.

Conclusion

A patch-based (PB) sensor pattern noise method was proposed for camera source identification. Based on the observation that the SPN extracted from the smooth image regions has less image content residual, the parameters of image complexity were estimated for selecting the patches to construct the reference SPN and extract the test SPN. Experimental results demonstrated that the proposed approaches outperform two previously proposed sensor pattern noise estimation methods.

Reference

[1] J. Fridrich, J. Lukáš and M. Goljan, "Digital camera identifica-tion from sensor pattern noise," IEEE Trans. Inf. Forensics Security, vol. 1, no. 2, pp.205-214, Jun. 2006.

[2] G. Wu, X. Kang, and K. J. R. Liu, "A context adaptive predictor of sensor pattern noise for camera source identification," in *Proc. IEEE International Conference on Image Processing*, pp. 237-240, 2012.

[3] M. Goljan, T. Filler, J. Fridrich, "Large scale test of sensor Fingerprint camera source identification," in Proc. *SPIE* Electronic Media Forensics and Security XI, San Jose, vol. 7254, pp. 0I 01-0I 12, Jun. 2009.