Identification of In-Field Sensor Defects in the Context of Image Age Approximation

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Abstract

Image sensor defects that develop in field over a camera's lifetime are at the core of temporal image forensics, as by knowing their onset time a temporal order can be assigned among pieces of evidence. In this context, only defects that have developed within the time interval of the available data set are relevant. The available methods for defect detection, based on regular scene images, aim to identify all present defects (e.g., to conceal them). In this paper, we propose two novel defect detection techniques. Because of their properties, these methods only detect defects relevant for image age approximation. This is important since defects that do not provide additional age information can negatively affect the process of image age approximation.

Conclusion

In this paper, we introduced two novel defect detection methods in the context of image age approximation. The 'spatial & temp.' method shows a significantly better performance, as compared to the 'spatial only' approach. In particular, a 0.0227, 0.3856, 0.1889 and 0.3368 higher average f1-score is reached (Nikon, Canon, Pentax K5 and Pentax K5II). This indicates that more defects can be detected and used for a subsequent age approximation, which increases the approximation accuracy. As the experiments have shown, the combination of temporal and spatial properties increases the robustness with respect to a varying amount of input images additionally. Because of the high scene dependency observed, this 'temporal only' method is not very reliable.

Spatial Only Method

Introduced in [1], a pixel is regarded as a defect candidate if the inequality

$$\sigma^2(\vec{r}_2) > t, \quad \text{where } t = \mu + \sigma * w$$

holds.

Spatial & Temp. Method

A pixel is considered defective if,

$$\sigma^2(\vec{r}_1) < \sigma^2(\vec{r}_2) \ \wedge\ \|\vec{r}_2'\|_1 > \alpha * |R_2|,$$

$$\text{where } \vec{r}_2'(i) = \begin{cases} \vec{r}_2'(i) = 0, & \text{if } t_l < \vec{r}_2(i) < t_u \\ \vec{r}_2'(i) = 1, & \text{otherwise,} \end{cases}$$

$$\text{and} \quad t_{l,u} = \lceil \text{median}(\vec{r}_1) \rceil \mp w_S * \sigma(\vec{r}_1).$$

Temporal Only Method

A pixel is considered defective if,

$$\sigma^2(\vec{s}_1) > \sigma^2(\vec{s}_2) \ \wedge\ \|\vec{s}_1'\|_1 > \alpha * |S_1|,$$

$$\text{where } \vec{s}_1'(i) = \begin{cases} \vec{s}_1'(i) = 1, & \text{if } \vec{s}_1(i) < \hat{c} + w_T \\ \vec{s}_1'(i) = 0, & \text{otherwise} \end{cases}$$

$$\text{and} \quad \hat{c} = \min(\vec{s}_2).$$

Data Sets

- Four available data sets:
  - Nikon E7600, 1768 images (S_N)
  - Canon PowerSht A720IS, 4379 images (S_C)
  - Pentax K5, 4725 images (S_{P1})
  - Pentax K5II, 1881 images (S_{P2})

Results - Impact on Age Approximation

Set	Method	KDc	NB KDE	SVM
nikon01	spatial only	0.8653	0.7822	0.8949
	spatial & temp.	0.9041	0.7886	**0.9232**
canon01	spatial only	0.8299	0.8720	0.8030
	spatial & temp.	0.8172	0.9139	**0.9867**
pentax01	spatial only	0.7671	0.9367	0.9323
	spatial & temp.	0.7250	**0.9435**	0.9202
pentax02	spatial only	0.6876	0.8786	0.8518
	spatial & temp.	0.6710	0.8718	**0.9041**

Table 1: Average age approximation accuracy.

Results - Reduced Input Images

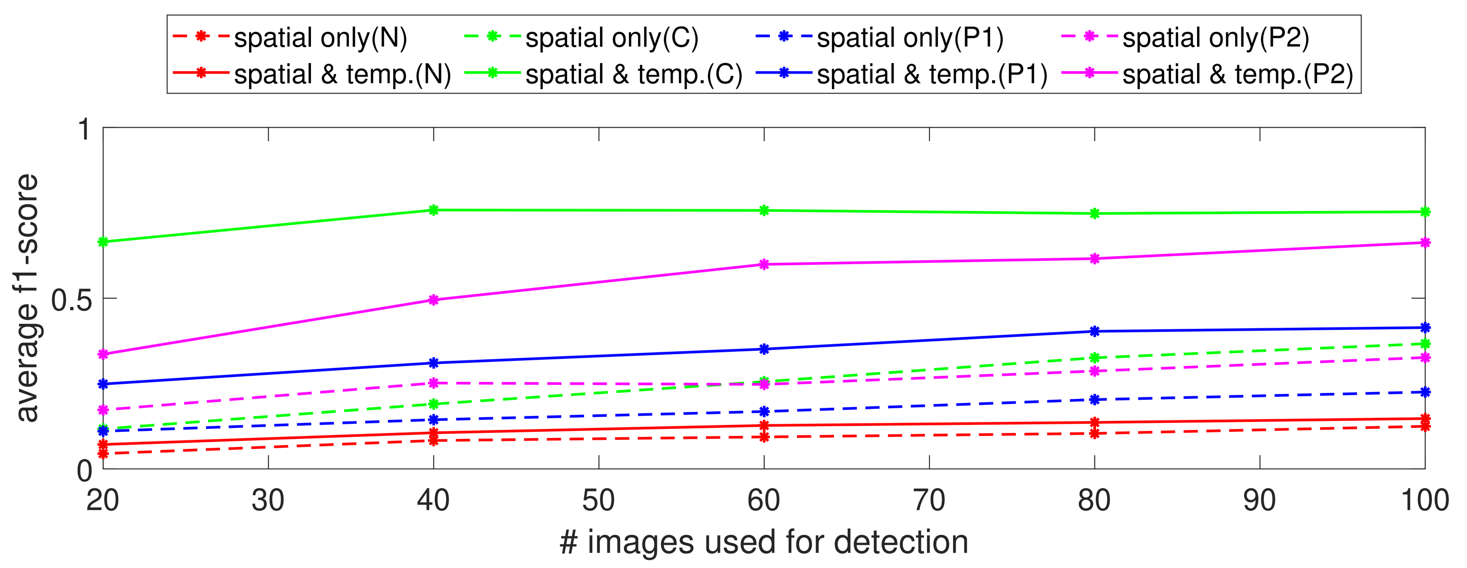

Figure 1: Shows the maximum average f1-score over the amount of used input-images.

Results - Detection Perfromance

Method	nikon01	canon01	pentax01	pentax02
spatial only	0.1247	0.3666	0.2250	0.3262
spatial & temp.	**0.1474**	**0.7531**	**0.4139**	**0.6630**
temporal only	0.0594	0.6830	0.1882	0.1788

Table 2: Average maximum f1-score.

References

[1] J. Fridrich and M. Goljan, "Determining approximate age of digital images using sensor defects," in *Media Watermarking, Security, and Forensics III* (N. D. Memon, J. Dittmann, A. M. Alattar, and E. J. Delp, III, eds.), vol. 7880, pp. 49—59, International Society for Optics and Photonics, SPIE, 2011.