The Impact of Exposure Settings in Digital Image Forensics

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09/10/2018

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IKIP 2018

Outline

Motivation: StegoAppDB – A Benchmark Image Database for Steganography Apps [1]

Steganalysis under Different Exposure Settings

Camera Device Identification under Different ISO Settings

[1]This work was partially funded by the Center for Statistics and Applications in Forensic Evidence (CSAFE) through Cooperative Agreement #70NANB15H176 between NIST and Iowa State University.

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- "Steganalysis" is a forensic process to detect steganography using statistics, machine learning, and other methods.
- Academic steganography and steganalysis techniques are very successful in the academic environment using sophisticated embedding and detection methods, and data typically collected from digital still cameras.
- However, large gaps exist between academic results and applications used by forensic analysts, especially for detecting stego images created from mobile apps.

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Steganography and Steganalysis in the wild

Seven selected stego apps from Google Play Store

App Name	# Installs	Output Format	Open Source
PixelKnot	100,000 - 500,000	JPEG	yes
Steganography Master	10,000 - 50,000	PNG	no
Steganography_M	10,000 - 50,000	PNG	no
Da Vinci Secret Image	5,000 - 10,000	PNG	no
PocketStego	1,000 - 5,000	PNG	no
MobiStego	1,000 - 5,000	PNG	yes
Passlok Privacy	1,000 - 5,000	JPEG	yes

Building StegoAppDatabase

- Design a database that is authenticated, has a large number of images, from a variety of cell phone models.
- Create a collection of images from mobile phones, including stego images from apps.

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Questions

- Which exposure settings/scenes shall we use? Auto Exposure?
- How can we make the image data more representative?

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Experiments on BOSSbase

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- BOSSbase [Bas and Filler, 2011]: The most popular image database for steganography and steganalysis.
- 10,000 cover images, EXIF data, seven digital still cameras.
- Images were collected in auto-exposure settings or semi-auto settings, with the intent to produce high visual-quality images.

Experiments on BOSSbase

- Select images taken by the PENTAX 20D in BOSSbase: 603 images with ISO 200 and 358 images with ISO 100.
- Cut all those 961 images into 5 pieces.
- Implement embedding algorithm "Mipod" [Sedighi, 2016] with 0.1 payload size.
- Use the "Spatial Rich Model" [Fridrich and Kodovsky, 2012] for feature extraction, and the FLD ensemble classifier [Kodovsky, 2012] for classification.

Experiments on BOSSbase

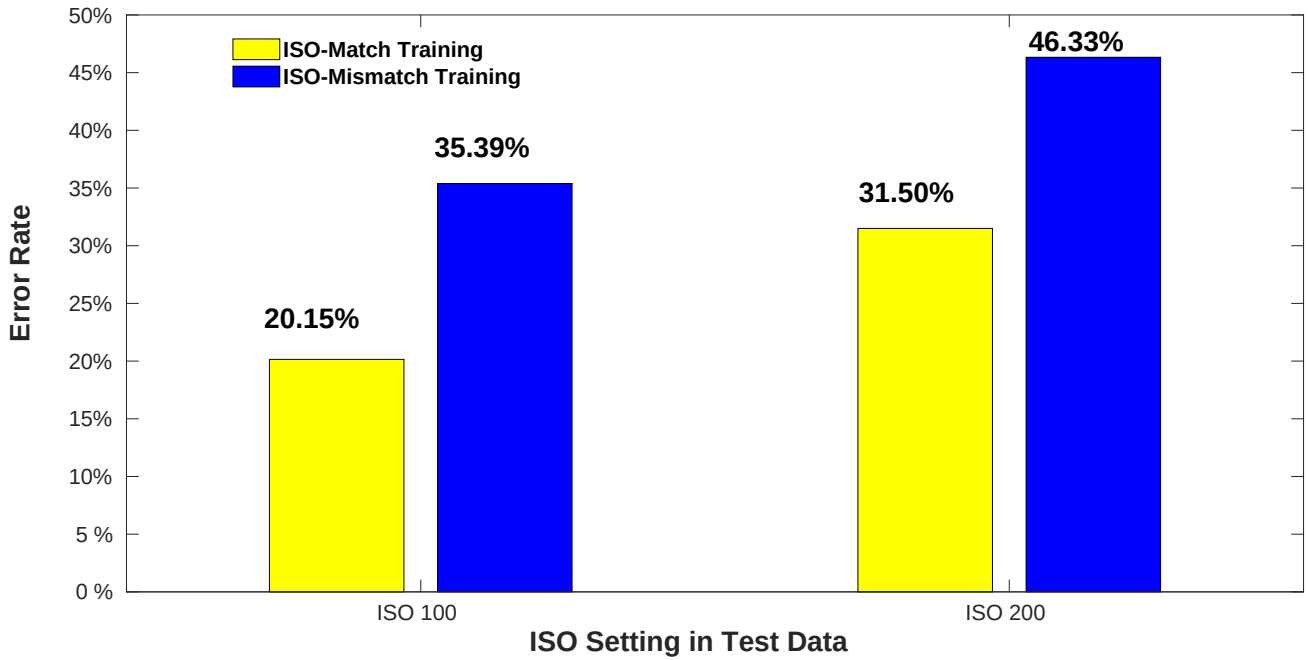

Figure 1: Steg Detect Error rates on different ISO data from BOSSbase.

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Discussion and further experiments

- In the auto-exposure mode, a digital camera is programmed to choose an ISO value and exposure time, such that the digital photograph has a high signal-to-noise ratio (SNR) and low "image noise."

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- According to the ISO standard [ISO 12232, 2006], images with higher ISO or longer exposure time have larger grey values and more noise than images with lower ISO and shorter exposure time.

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- According to the ISO standard [ISO 12232, 2006], images with higher ISO or longer exposure time have larger grey values and more noise than images with lower ISO and shorter exposure time.
- We apply a wavelet denoiser for each image we used in BOSSbase to get a clean image, and then compute the noise level as the mean of the residual image.

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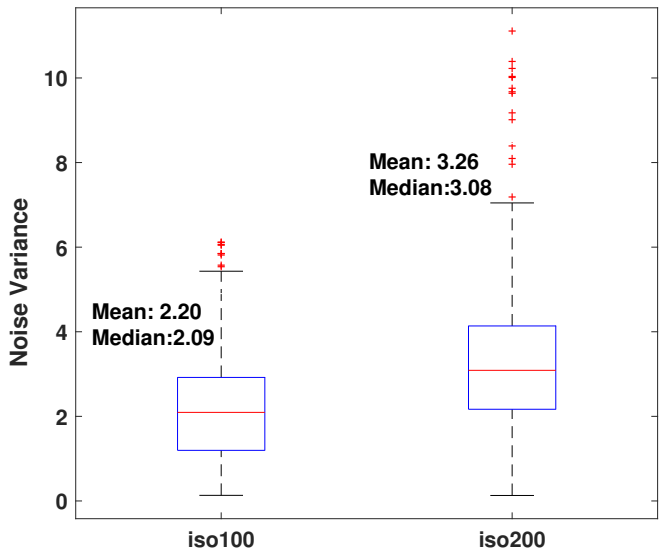
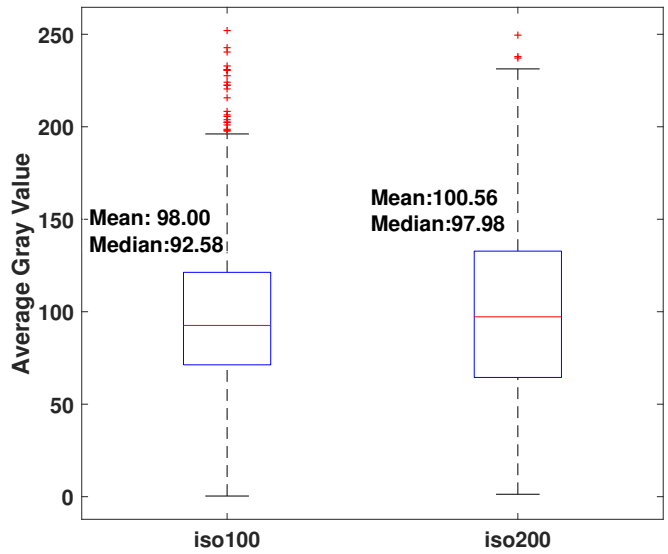
Further experiments on BOSSbase.



(a) Boxplots of Noise Levels



(b) Boxplots of Grey Values

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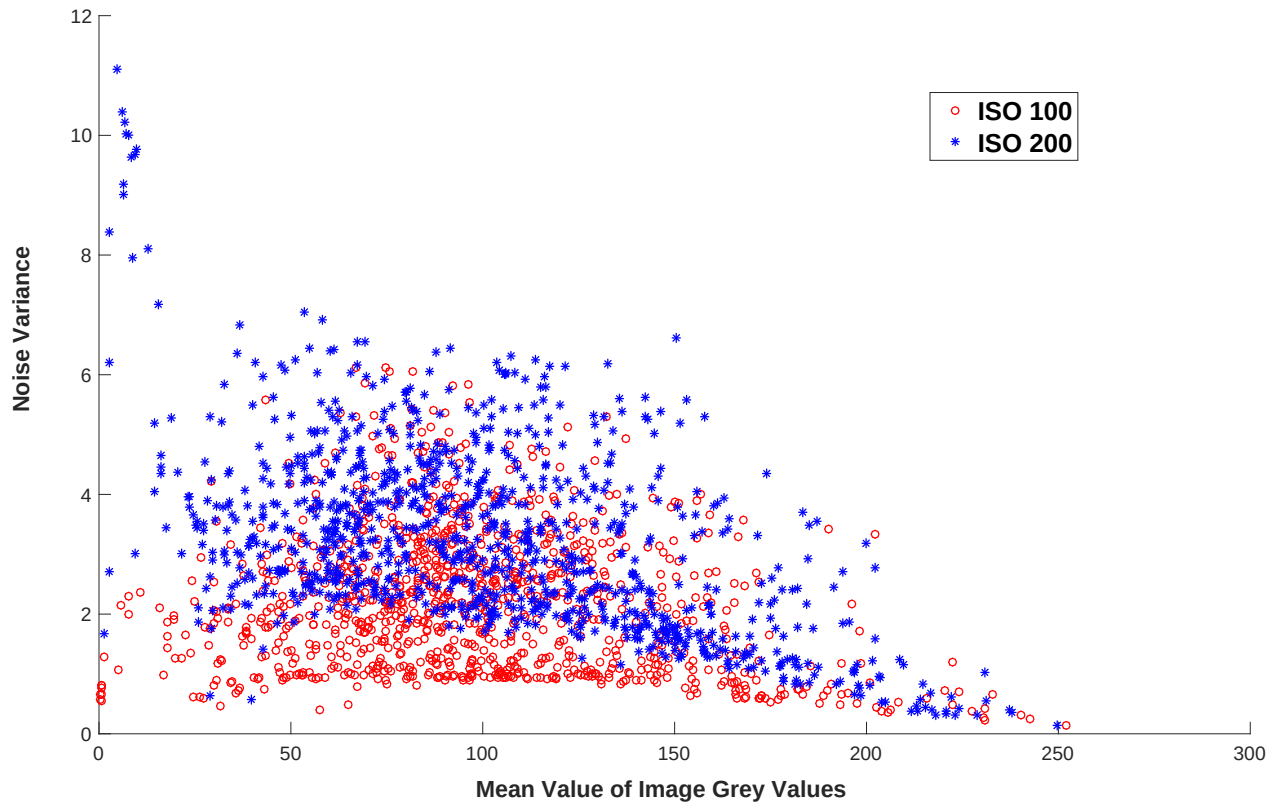

Figure 2: Noise level v.s. average grey value

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Experiments on Images from one iPhone 7

Table 1: Misclassification rates on data with different ISO settings

		Exposure time =1/200s	Exposure time =1/50 s
Test data ISO	Training data ISO	Avg. error rate (a)	Avg. error rate (b)
100	100	**7.72%**	**14.92%**
	200	28.89%	24.93%
	1000	38.04%	40.70%
200	100	17.89%	26.18%
	200	**9.90%**	**18.67%**
	1000	30.39%	46.79%
1000	100	48.50%	42.16%
	200	42.18%	34.04%
	1000	**18.08%**	**12.57%**

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Table 2: Misclassification rates on data with different exposure time

		ISO = 100	ISO = 200
Test exposure time	Training exposure time	Avg. error rate (c)	Avg. error rate (d)
1/200 s	1/200 s	**7.72%**	**9.90%**
	1/50 s	16.89%	20.52%
	1/10 s	37.88%	40.71%
1/50 s	1/200 s	24.47%	25.13%
	1/50 s	**14.92%**	**18.67%**
	1/10 s	27.89%	28.18%
1/10 s	1/200 s	34.31%	24.50 %
	1/50 s	24.09%	19.90 %
	1/10 s	**15.95%**	**12.20%**

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Summaries of the Impact of Exposure Settings on Steganalysis

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- Behind the exposure settings are the noise levels, which play an important role in steganalysis.
- Applying a well-trained classifier to target data with different exposure settings brings significantly higher errors.
- Adapting the exposure parameters for the target images can significantly improve the performance of a forensic analyzer.
- In order to build a benchmark image database for detecting stego apps, the diversity of exposure settings for images in such a database must be taken into account.

PRNU-based Camera Device Identification under Different ISO Settings

Photo-Response Non-Uniformity

- Multiplicative noise, known as the camera fingerprint.
- Independent of temperature and time
- Inhomogeneous nature of silicon sensor for the digital camera.
- Similar for all images from the same camera, but different between distinct devices.
- The correlation between the reference PRNU and the target ones are widely used for device identification.

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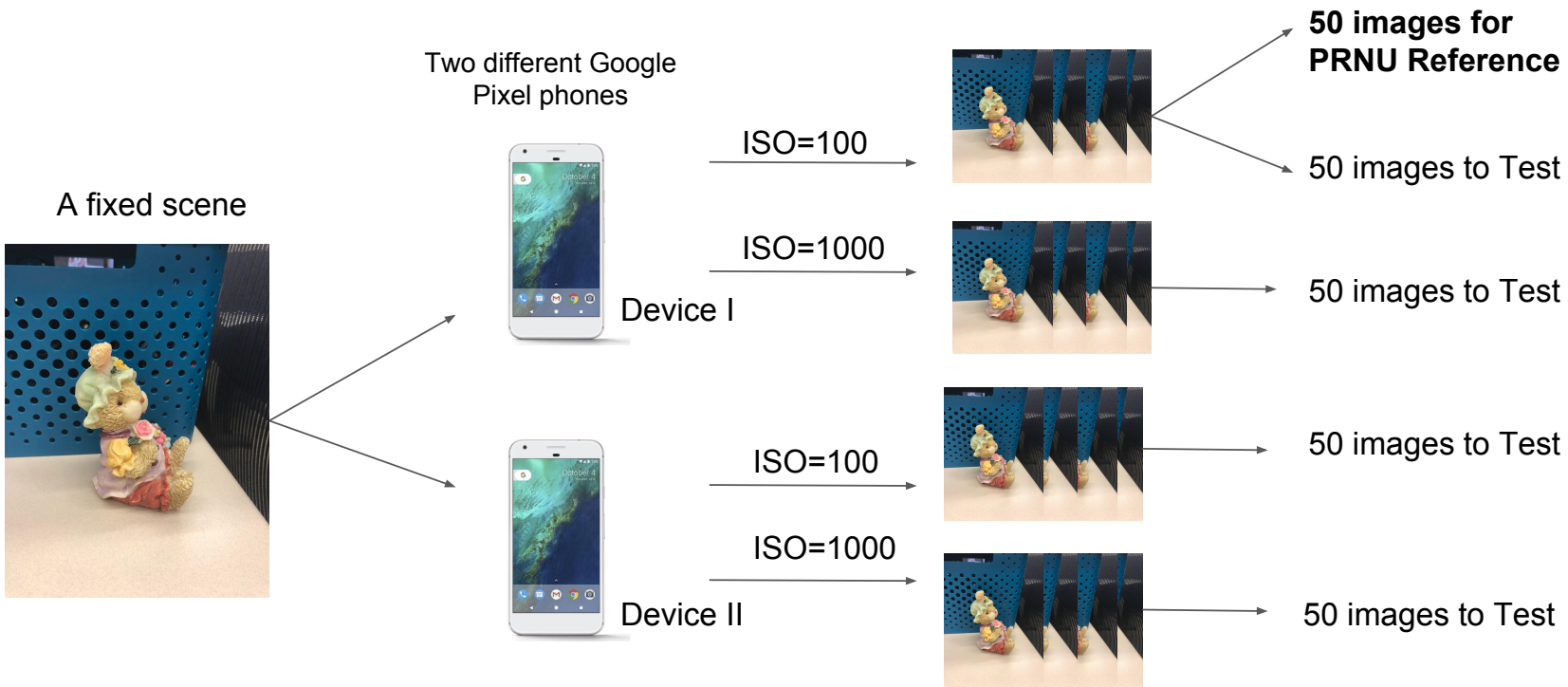
Experimental Design for the Camera Identification under Different ISO Settings (Exposure Time =1/50 s)



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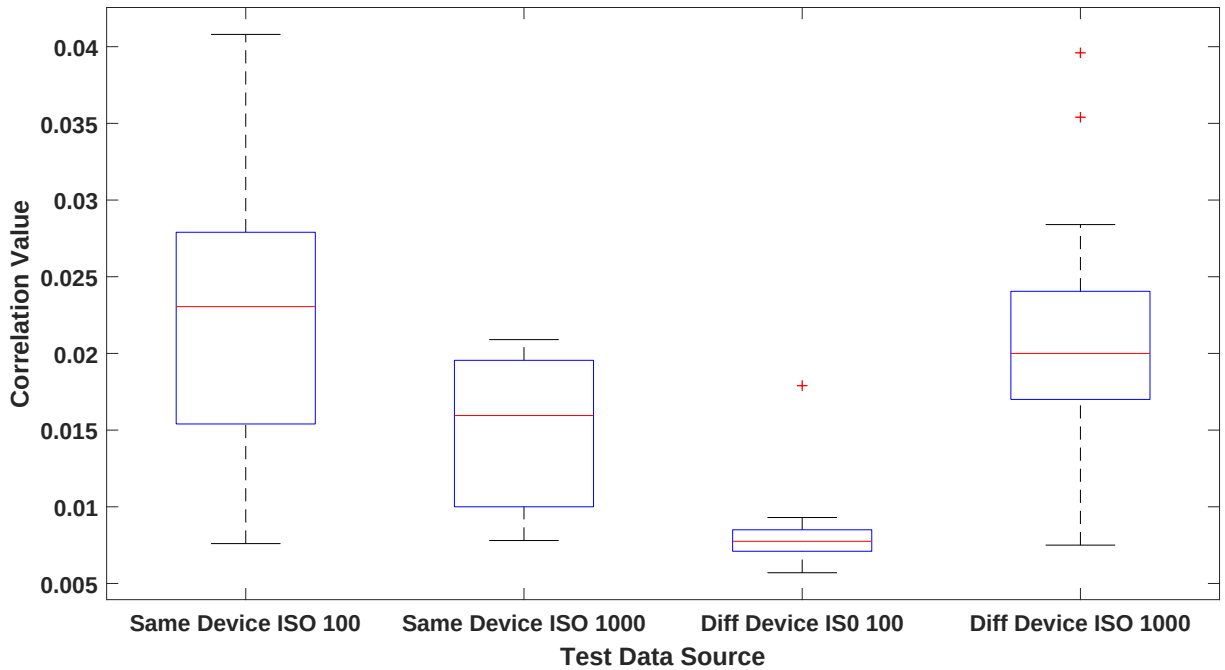
Experimental Result for the Camera Identification under Different ISO Settings

Setting ISO=100, and exposure time=1/50 s, the PRNU reference is generated by 50 images with a fixed scene indoor.



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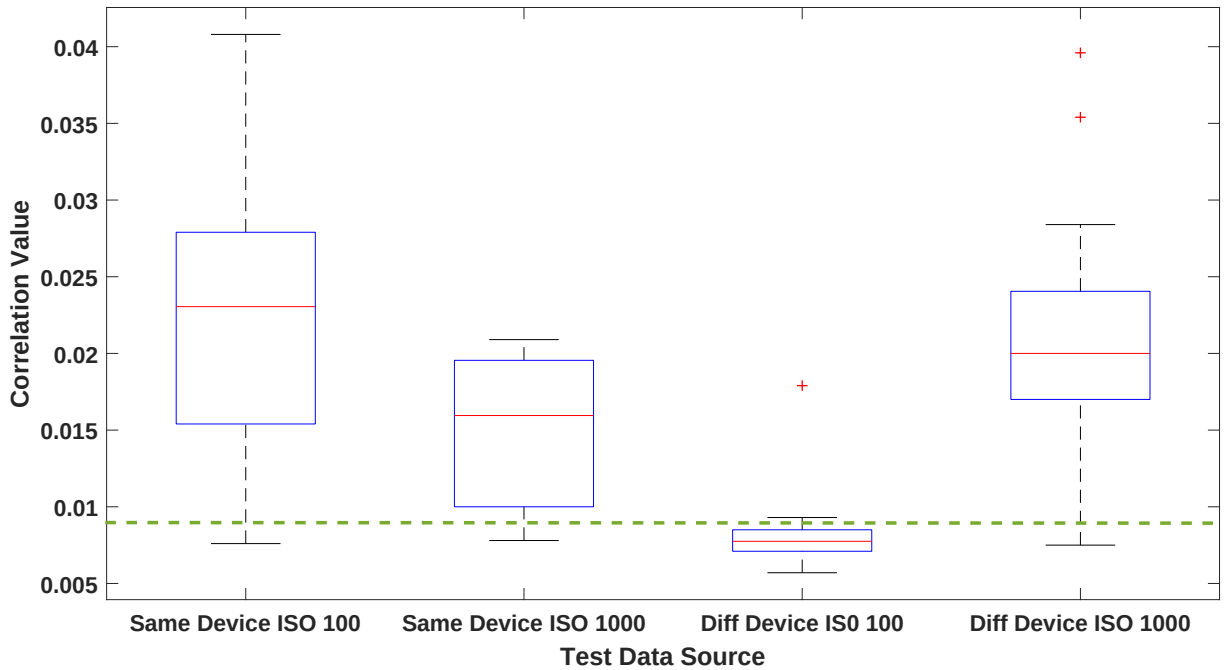

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Demo of StegoAppDB

Questions?

The End

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