Robust source camera identification

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Motivation

- ▶ Get from a photo the camera model or camera instance that took this photo
- ▶ End users: law enforcement agencies and journalists
- ▶ To do so: focus on image noise, especially the unintentional Photo Response Non-Uniformity (PRNU) which acts as a unique camera fingerprint since manufacturing

PRNU estimation intuition

same camera images · noise extraction → noise extracted · mean → estimated PRNU
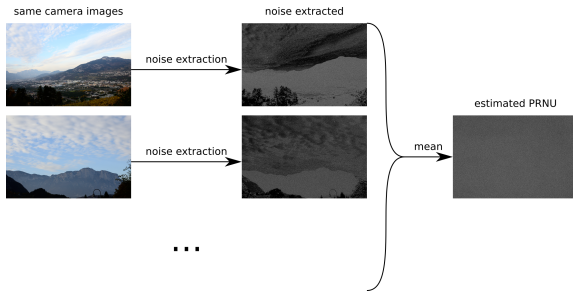
Noise extracted = scene residue + random noise + PRNU

PRNU estimation intuition
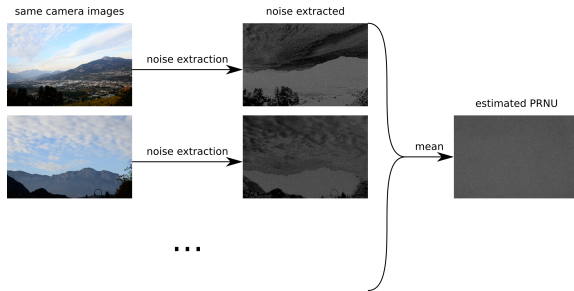
Noise extracted = scene residue + random noise + PRNU
In the following experiments will estimate and compare PRNUs
from a very controlled setup to a use case setup.

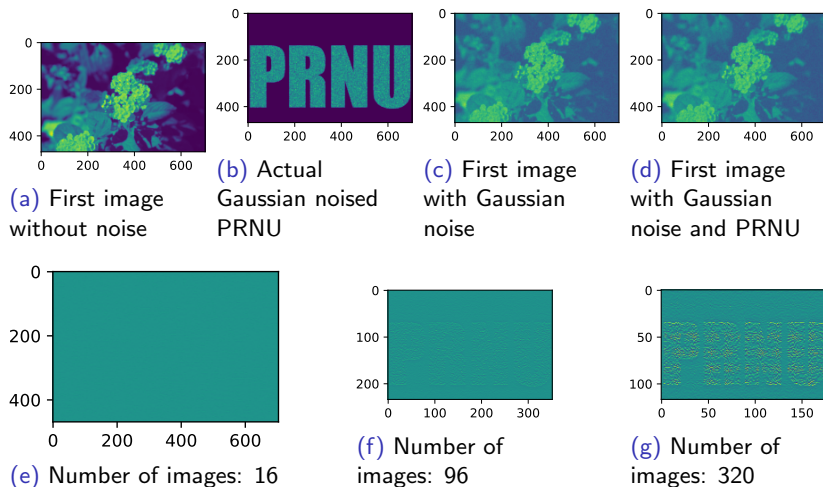# PRNU estimation with controlled noise

(a) First image without noise

(b) Actual Gaussian noised PRNU

(c) First image with Gaussian noise

(d) First image with Gaussian noise and PRNU

(e) Number of images: 16

(f) Number of images: 96

(g) Number of images: 320

Figure: PRNU estimation with different number of images having Gaussian noise and Gaussian noised PRNU.

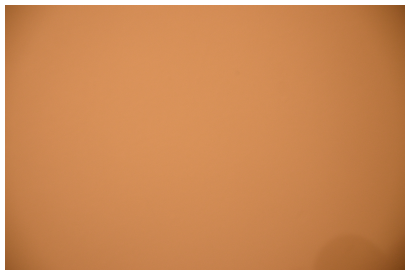# Examples of flat-field photos

Figure: Example of RAISE dataset flat-field photo with Nikon D7000 camera. The scene looks like an orangeish wall.
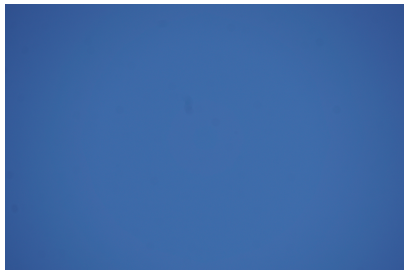

Figure: Example of flat-field photo taken with a SONY ILCE-6000 camera. The scene is a cloudless sky.

Distinguish cameras with flat-field photos

- ▶ Evaluate how close two PRNUs are
- ▶ Signed Peak to Correlation Energy (sPCE) in $\mathbb{R}$:
  - ▶ Correlation high: similar PRNUs
  - ▶ Correlation near zero: different PRNUs

Distinguish cameras with flat-field photos

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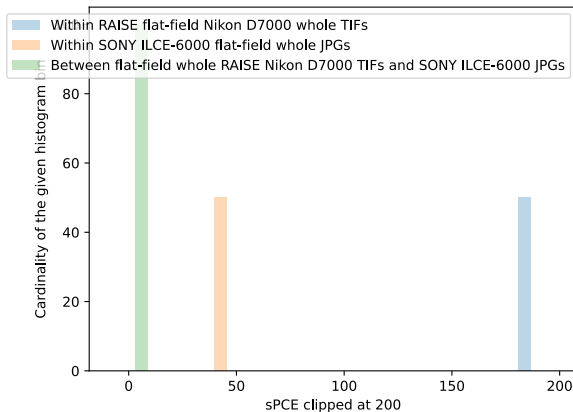 - ▶ Correlation near zero: different PRNUs

Figure: sPCEs of pairs of flat-field images within and across RAISE Nikon D7000 and Nikon D90 cameras.

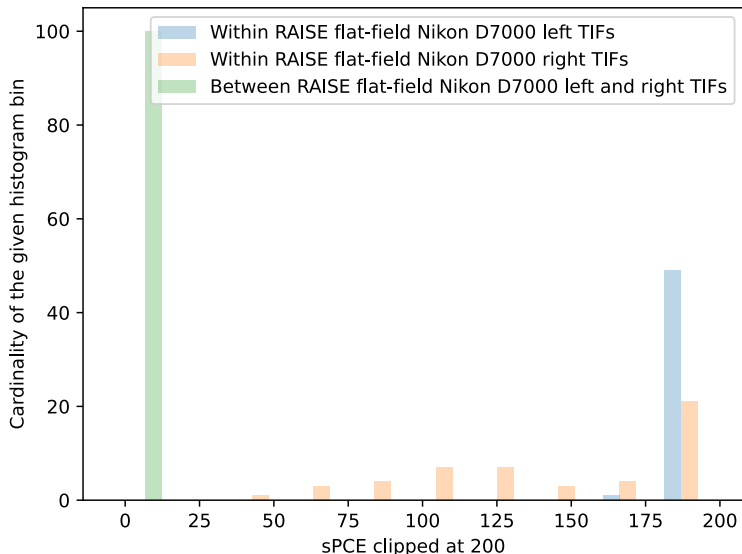# Distinguish camera halves with flat-field photos

Figure: sPCEs of pairs of flat-field images within and across left and right halves of RAISE Nikon D7000 camera.

Example of non-flat-field photo

Figure: Example of RAISE dataset non-flat-field photo for Nikon D7000 camera.

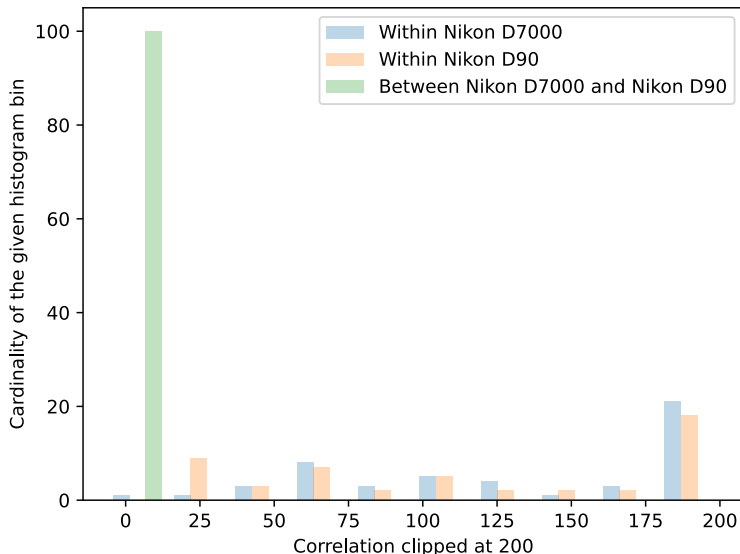# Distinguish cameras with non-flat-field photos

Figure: sPCEs of pairs of non-flat-field images within and across RAISE Nikon D7000 and Nikon D90 cameras.

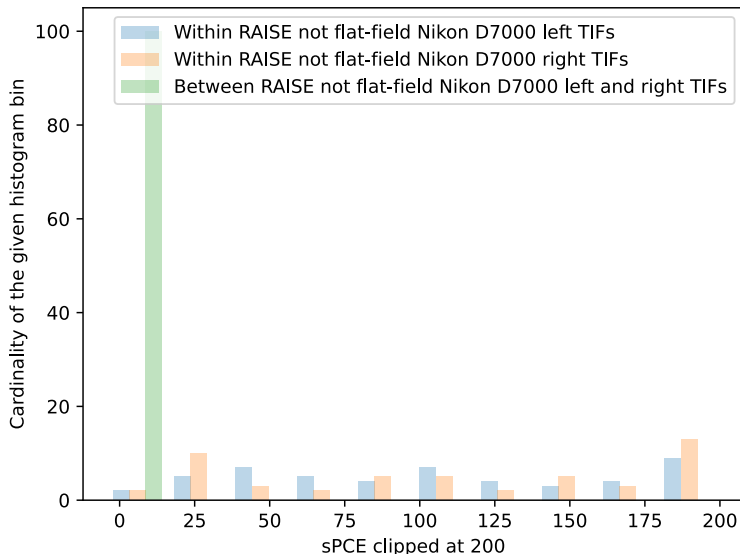# Distinguish camera halves with non-flat-field photos

Figure: sPCEs of pairs of non-flat-field images within and across left and right halves of RAISE Nikon D7000 camera.

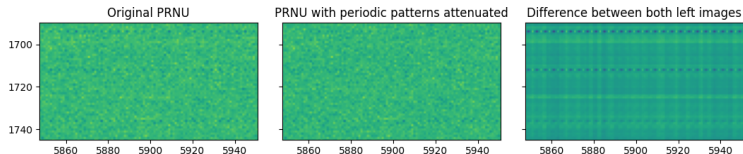# PRNU post-processing to remove periodic patterns

Figure: PRNU in the image domain with attenuated axes. We clearly notice the removal of the dotted lines.
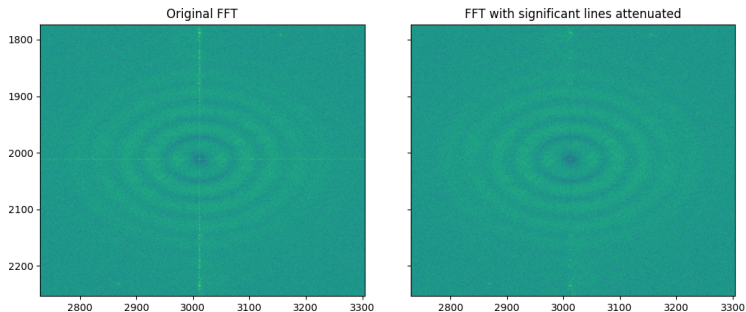

Figure: PRNU in the Fourier domain with attenuated axes.

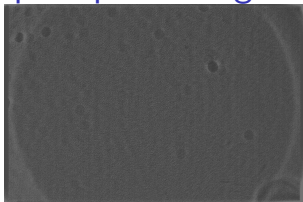# PRNU post-processing to remove circle artifacts

Figure: RAISE Nikon D7000 camera estimated PRNU.
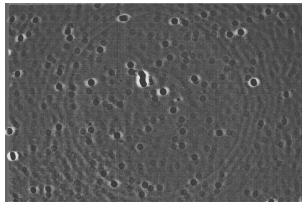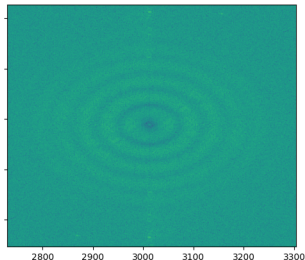

Figure: SONY ILCE-6000 camera estimated PRNU.
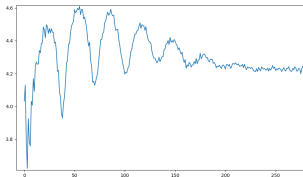

Figure: FFT with significant axes attenuated.

Figure: Radial profile in the Fourier domain.

Meta-information

- ► Smartphone heavier image processing pipeline leads to incorrect camera attributions
- ► Even without this post-processing, the current state of the art about PRNU lack of reproducibility and experiments
  - ► Plan to submit an IPOL MLBriefs article by the end of the internship on July 27.
  - ► Focused on understanding and experimenting each concept of the PRNU estimation and comparison to continue in the best way this topic in the thesis that will follow this internship. This thesis will be funded by the "Agence Ministérielle pour l'IA de Défense" (AMIAD) located at the École Polytechnique.

Image processing pipeline

Raw image acquisition

Demosaicing

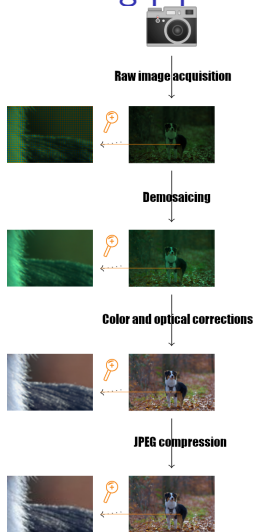Color and optical corrections

JPEG compression

Figure: Simplified image processing pipeline, and noise curve associated with each step.
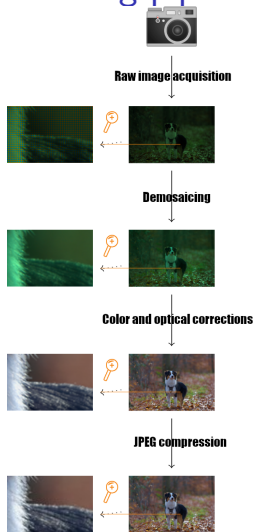
Image processing pipeline

Figure: Simplified image processing pipeline, and noise curve associated with each step.

Traditional image processing pipeline differs from smartphone one:

- ▶ Pixel binning
- ▶ Burst mode and multiple sensors

By blurring the PRNU the same way, these changes involve non unique artifacts, hence incorrect camera attributions. Urgency as existing methods for smartphones are about to become useless.