Blind Biometric Source Sensor Recognition using Advanced PRNU Fingerprints

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1. Introduction

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Introduction
Devices (Sensors) add signatures to the data they produce

- **Intrinsic:** artefacts that are due to optical, electrical, or mechanical limitations of the device
- **Extrinsic:** generated by modulating the process parameters according to a specified pattern that may encode the serial number of the sensor or other information

**Forensic characterization:** Identify characteristics of the device by observing the produced data
Photo-response non-uniformity
CCD/CMOS Sensors
intrinsic property
noise-like pattern
Variations in quantum efficiency among pixels
PRNU noise residual: PRNU extracted from a single image
PRNU fingerprint: Averaged PRNU extracted from multiple images from same sensor
Forensic Investigation
## CASIA-Iris V4 Database

<table>
<thead>
<tr>
<th>Subset name</th>
<th>Short name</th>
<th>Sensor</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>CASIA-Iris-Interval</td>
<td>intv</td>
<td>CASIA close-up iris camera</td>
<td>320 × 280</td>
</tr>
<tr>
<td>CASIA-Iris-Lamp</td>
<td>lamp</td>
<td>OKI IRISPASS-h</td>
<td>640 × 480</td>
</tr>
<tr>
<td>CASIA-Iris-Twins</td>
<td>twin</td>
<td>OKI IRISPASS-h</td>
<td>640 × 480</td>
</tr>
<tr>
<td>CASIA-Iris-Distance</td>
<td>dist</td>
<td>CASIA long-range iris camera</td>
<td>2352 × 1728</td>
</tr>
<tr>
<td>CASIA-Iris-Thousand</td>
<td>thou</td>
<td>Irisking IKEMB-100</td>
<td>640 × 480</td>
</tr>
</tbody>
</table>
Previous work and results

- Iris-Sensor Authentication using Camera PRNU Fingerprints [UH12]
- Distinction rate varies between 0.21 and 23.26% (EER)
- Do poor EERs for some sensors come from low variance in image content? → uncorrelated data [LZA14]
- Have all images in a data set been acquired with the same sensor? → forensic investigation [LA15]
Proposed in [LA15]:

- **Sliding Window Fingerprinting (SWFP):**
  Iteratively computes PRNU FPs from consecutive images and compares their similarity.

- **Device Identification on Dataset Partitions (DIODP):**
  Partitions the dataset and performs source identification by assuming each partition is a different sensor.

- **Blind Camera Fingerprinting and Image Clustering (BCFAIC) [G B08]:**
  Agglomerative clustering of images by grouping images with similar PRNU together.
PRNU Contaminations and Enhancement Techniques
Undesired contaminations affect both PRNU fingerprints and noise residuals.

Sources:
- Non-unique artifacts (NUAs)
- Image content

Degrade quality of the PRNU and decrease discriminative power of distinct sensors.
Image content related contamination

- Covers high-frequency components of the image
- Edges and textured image regions
- Correlated content among various images
- Hard to separate from the PRNU
- Visible in the extracted PRNU

[Li10]
Applied Enhancement Techniques

- Image content contamination suppression using various attenuation models in DWT domain
  - Enhancement model Li [Li10]
  - Enhancement model Caldelli [R C+10]

- Idea: The larger a component in the PRNU, the more likely it is contaminated by the image content

![Attenuation function Li](image1.png)  ![Attenuation function Caldelli](image2.png)
Results and Conclusion
Results: Sliding Window Fingerprinting

**intv - Li**

- FP #1
- FP #628
- FP #1257

**intv - Caldelli**

- FP #1
- FP #522
- FP #1045

**twin - Li**

- FP #1
- FP #522
- FP #1045

**twin - Caldelli**

- FP #1
- FP #628
- FP #1257
Results: Device Identification on Dataset Partitions

thou - Li

intv - Li

thou - Caldelli

intv - Caldelli
### Results

**Blind Camera Fingerprinting and Image Clustering**

<table>
<thead>
<tr>
<th>EnhLi3</th>
<th>intv</th>
<th>lamp</th>
<th>twin</th>
<th>dist</th>
<th>thou</th>
</tr>
</thead>
<tbody>
<tr>
<td># P</td>
<td>11</td>
<td>15</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>P &gt; 100</td>
<td>4</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<tr>
<td>P &lt; 10</td>
<td>3</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Unass. IMGs</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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</tbody>
</table>

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<th>lamp</th>
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<th>thou</th>
</tr>
</thead>
<tbody>
<tr>
<td># P</td>
<td>17</td>
<td>20</td>
<td>6</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>P &gt; 100</td>
<td>4</td>
<td>7</td>
<td>1</td>
<td>1</td>
<td>2</td>
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<tr>
<td>P &lt; 10</td>
<td>5</td>
<td>4</td>
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Conclusion

- Results of applied PRNU enhancements comparable to previous results without enhancement
- Overall correlation scores show a slight offset (decrease)
- Results for CASIA-Iris V4 datasets indicate:
  - Single sensor: \textit{dist, twin, thou, lamp}
  - Multiple sensors: \textit{intv}
- Intra-set correlation scores mostly low, which indicate low quality PRNU extraction
- Unknown factors that lower PRNU quality
References


Thank you!