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Score-Based Likelihood Ratios for Camera Device Identification Using Cameras of the Same Brand for the Alternative Device Population

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February 24, 2022

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The forensics problem

• An investigator has two pieces of evidence:



A digital image containing illegal material



A person of interest's (POI's) mobile phone

- Did the POI's phone take the image?
- How strong is the evidence?



Score-based likelihood ratios (SLRs)

- Statistical method for quantifying the strength of evidence
- More about SLRs in a bit...

Camera fingerprints

- Slight variations in the size of pixels in the sensor array serve as camera fingerprint [1]
- A camera leaves its fingerprint in its images
- Camera fingerprints are estimated from the "noise" from 30+ images



Does the fingerprint in the questioned image match the POI's camera's fingerprint?

- Similarity score
- Correlation distance (1 minus the correlation)
- Imagine that the score is 0.9. What does this mean?
- Look at examples of similarity scores for reference:
 - "same phone" scores
 - "different phone" scores

Is there probative value in the similarity score?

- Can we tell the difference between same phone scores and different phone scores?
- What if the questioned image comes from a phone that is the same model as the POI's phone
- What if the brand is the same?



Digital images from 32 phones

<u>iPhones</u>

- iPhone 6s (4)
- iPhone 6s Plus (2)
- iPhone 7 (4)
- iPhone 7 Plus (2)
- iPhone 8 (2)
- iPhone X (2)
- iPhone 11 (2)

<u>Androids</u>

- Pixel 1 (4)
- Pixel 2 (4)
- Pixel 4 (2)
- OnePlus 5 (2)
- Galaxy S8 (2)

Experiments

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- Case 1: different phones, but same model and brand
- Case 2: different phones and different models, but same brand
- Case 3: different phones, models, and brands
- Case 4: same phone

Case 1 Example: The POI's phone is a Pixel 1 and the questioned image is from a different Pixel 1.



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Rates of misleading evidence

model	different phone	False Positive Rate	False Negative Rate
iPhone 6s	all brands	0%	0%
iPhone 6s	same brand	0%	0%
iPhone 6s	same model	0%	0%
iPhone 7	all brands	0%	0%
iPhone 7	same brand	0%	0%
iPhone 7	same model	0%	0%
Pixel 1	all brands	71.7%	0%
Pixel 1	same brand	55.0%	2.5%
Pixel 1	same model	0%	0%
Pixel 2	all brands	48.3%	0%
Pixel 2	same brand	32.5%	0%
Pixel 2	same model	0.8%	0%

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Conclusions

- Which "different phones" we use for reference can drastically affect the outcome
- If there is reason to believe that the questioned image comes from the same model as the POI's phone, "different phones" should be limited to that model

Acknowledgements

This work was funded (or partially funded) by the Center for Statistics and Applications in Forensic Evidence (CSAFE) through Cooperative Agreements 70NANB15H176 and 70NANB20H019 between NIST and Iowa State University, which includes activities carried out at Carnegie Mellon University, Duke University, University of California Irvine, University of Virginia, West Virginia University, University of Pennsylvania, Swarthmore College and University of Nebraska, Lincoln.

References

[1] Lukas, Jan, Jessica Fridrich, and Miroslav Goljan. "Determining digital image origin using sensor imperfections." *Image and Video Communications and Processing 2005*. Vol. 5685. International Society for Optics and Photonics, 2005.