B9 Implementation of the Likelihood Ratio Framework for Camera Identification Based on Sensor Noise Patterns

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After attending this presentation, attendees will understand some of the typical problems that may arise when applying the Bayesian framework of evidence evaluation to camera identification based on sensor noise patterns.

This presentation will impact the forensic science community by illustrating practical issues when the Bayesian framework of evidence evaluation is applied based on similarity scores between traces.

In digital forensics, the question of which particular camera was used to make a certain photograph may arise, e.g., in child pornography casework where an accused is suspected of producing photographs in addition to possessing them. Instead of looking at metadata, one may look at identifying characteristics present directly in the image due to small deviations in the image sensor itself. These small deviations in the image sensor mostly arise from the pixels in the image sensor having non-uniform sizes, and hence capture more or less light, even when all pixels are under the same illumination. This phenomenon is called photo response non-uniformity, or PRNU, and can be used as an identifying characteristic. Therefore, camera identification comes down to verifying whether the PRNU pattern from a questioned image corresponds to the PRNU pattern from reference images from a camera.

Extraction of PRNU patterns can be done effectively and efficiently with state of the art methods. The similarity between patterns is calculated using Pearson's correlation coefficient, which will increase if the similarity increases. The goal of the presentation is the assessment of the strength of the evidence of eventual similarity of PRNU patterns. Assessing the similarity between two sources, i.e., individualizing the sources, is classically approached by using a verbal scale (e.g., "strong support" for a certain hypothesis). This scale may be based on estimations of probabilities or on thresholds set by the expert. It is clear that both approaches are to a certain extent subjective: it likely depends on the amount of experience of the investigator and may vary from investigator to investigator. In forensics, a framework gaining popularity to assess the value of the evidence is the likelihood ratio (LR) framework under a Bayesian reasoning approach; from here on: "LR framework." The goal of the LR framework is to accurately assess the strength of evidence in the light of clearly defined opposing hypotheses, and not to comment on the probability of traces being from a common source, which is considered principally impossible. Furthermore, it should harmonize the value of the evidence and ease the interpretation of the evidence in different disciplines.

In Nordgaard and Hoglund, the LR framework is implemented for PRNU-based camera identification, where the focus is on the measurement uncertainty of the strength of evidence.[1] The current presentation focuses on general problems that are encountered when interpretation of results is performed in the LR framework. In two (fictive) case examples, namely for a mobile phone camera and a good quality Sony DSC-S500 camera, the results of the LR approach are described. It turns out to be very possible to obtain statistical distributions underlying the reference data for both "matching" and "non-matching" comparisons, for both types of cameras. Based on these, LRs can be calculated. For the mobile phone cameras, it turns out that in the tail of the distributions problems will emerge: the LR decreases as a function of the correlation between PRNU patterns, which is nonsensical. For the Sony camera this point is even clearer. Again the LR function is not increasing on the whole range of correlations encountered. Moreover, LRs under Hp are absurdly high. The reason for this is that the statistical fit of the distribution for "non-matches" is constantly evaluated in a range where there is no reference data. Clearly the numbers that are being returned cannot be trusted. The problem is that extrapolation takes place in the tail of the fit for correlation scores under H_d, which is a bad statistical procedure. All in all, under these circumstances it is not possible to come up with reliable LRs, and the reason for this is that the correlation scores under both hypotheses are separated too well.

The issue of widely separated distributions, and the resulting unreliable LRs is not a problem that is unique for PRNU-based comparison: if the informative value of any forensic comparison (be it fingerprints, speech, glass particles, etc.) is high, the problem emerges. Although this may be considered to be a problem of luxury, the question remains how to deal with it. The alternative of checking whether comparison scores are larger or smaller than some threshold value yields LRs that are smaller but more reliable.

Reference:

1. J Forensic Sci. 2011 Mar;56(2):390-402. doi: 10.1111/j.1556- 4029.2010.01665.x. Epub 2011 Jan 25.

Camera Identification, Bayesian Framework, Likelihood Ratios

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