D79 Identification of Images From Cameras

Zeno J. Geradts, PhD, Cor Veenman, PhD, and Erwin Alles, MS, Netherlands Forensic Institute, Ministry of Justice, Laan van Ypenburg 6, Den Haag, 2497 GB, NETHERLANDS*

The goal of this presentation is to describe methods for identifying an image from a camera.

This presentation will impact the forensic science community by validating methods of pixel defects and noise.

In forensic casework the question of authenticity has to be answered if a certain image has allegedly been made with a specific digital camera. Another question that may be asked is if two images have been made with the same camera. In order to answer this question noise, pixel artifacts, and information from the headers and footers of image files can be used. Furthermore, the method of examination of pixel artifacts combined with headers and footers is useful for integrity research: finding traces of manipulation (e.g., cut and paste) of the images.

A digital image is composed from a matrix of pixels (picture elements). For capturing a digital image CMOS (Complementary Metal Oxide Semiconductor) or Charge Coupled Device (CCD) are used in cameras. When manufacturing image sensors, they sometimes contain artifacts. An artifact is visible in the image as a pixel artifact if the image sensor element has a different light sensitivity compared to the surrounding image sensor elements.

For the examination of pixel artifacts we have developed a standard operating procedure in our forensic casework. For the examination there are two approaches. If the camera is available, test images are made with the camera with a white, grey or a black surface. These images are used as a reference set. If the camera is not available, one set of images as reference set will be used.

In some of our casework pixel artifacts could be visualized without averaging or image processing, since they were visible in the images themselves without any processing. However, for visualizing the pixel artifacts it is often necessary to add and average the intensities of the images. As a result, fluctuations in the images due to the image itself will be averaged. In order to visualize the pixel artifacts a filter, for instance a median filter can be used.

The locations of the pixel artifacts in the reference images are compared with the location of the pixel artifacts of the questioned images. If the locations of the pixel artifacts agree with each other, this provides strong support for the hypothesis that they have been made with the same camera. The conclusions are not quantitative however, since not enough statistical data is available from the randomness of pixel artifacts.

Conclusions from pixel artifacts are reported as level of support to the hypothesis that an image has been acquired with a specific camera, and/or the level of support to the hypothesis that the have been acquired by a different camera. The following levels of support can be given: “no support”, “limited support”, “moderate support”, “strong support”, or “very strong support”. In cases with similar support to both hypotheses, no conclusion can be drawn due to discrepancies.

Header and footer-information is often available in the digital files that are received. The information in the headers and footers is not visible in the image it self, however by using software (for example a hexviewer) the information can be made available. In JPEG-images from cameras this information often provides camera settings and brand and type of the camera itself, and sometimes provides information with which software the image has been edited. It is possible to modify the header and footer information by using software, so for forensic casework the examiner has to be aware of this possibility before drawing conclusions. If the header provides information that the image has been taken with a specific camera, it is possible that someone has altered the contents of this header, and that the picture actually has been taken with a different camera.

Another method is investigating the noise that is always present in digital images. The various causes for noise in digital images are:

- Photo response non-uniformity
- Photon shot noise
- Dark current
- Dark current shot noise
- Reset noise
- Amplifier gain non-uniformity
- Quantization noise

Most of these noise contributions are caused by a stochastic process and thus different from frame to frame. Two causes are, to a certain extend, constant from frame to frame: the photo response non-uniformity (PRNU) and the dark current. The former is a result of minor differences in sensitivity to a certain intensity and is easily visible in frames of constant illumination, so-called flat field images. In the latter case, noise is added by thermally generated free charge within a pixel. This charge generates a signal even when no light is measured by the sensor, hence the name “dark current.”

Both mechanisms are introduced during manufacturing of the sensor and are a result of numerous causes, e.g., material in homogeneity, slight non-idealities in the lithography optics, dust particles during any stage of the

 ** Presenting Author*

production process, etc. Even though these contributions to the noise are not really noise in that the resulting signal is not random, they introduce noise-like deviations from the ideal, noise-free image: pixel-to-pixel variations of intensity in the order of 1% full scale.

Of the two contributions, the PRNU in pictures taken under normal circumstances (regular lighting conditions, shutter times below one eight of a second, room temperature) is dominant over the dark current contribution. As PRNU is a constant pattern, this pattern can be used to identify the camera that took the picture. To do so, a reference pattern is obtained by means of flat fielding. To remove the random components of the noise, a large number of flat field images was taken and averaged.

To compare a given picture with such a reference pattern, the noise has to be extracted. This is done by applying a Gauss filter which removes scene information from the obtained noise. The resulting pattern is then compared to the reference pattern by means of the two-dimensional cross correlation.

For this research a large collection of cameras was available, among which webcams, phone cams, and handheld compact cameras, of varying quality and price. Of each model, multiple cameras were tested.

Noise, Camera, Identification

