Source Camera Identification Based on Sensor Readout Noise

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ABSTRACT

A digitally developed image is a viewable image (TIFF/JPG) produced by a camera's sensor data (raw image) using computer software tools. Such images might use different colour space, demosaicing algorithms or by different post processing parameter settings which are not the one coded in the source camera. In this regard, the most reliable method of source camera identification is linking the given image with the sensor of camera. In this paper, the authors propose a novel approach for camera identification based on sensor's readout noise. Readout noise is an important intrinsic characteristic of a digital imaging sensor (CCD or CMOS) and it cannot be removed. This paper quantitatively measures readout noise of the sensor from an image using the mean-standard deviation plot, while in order to evaluate the performance of the proposed approach, the authors tested against the images captured at two different exposure levels. Results show datasets containing 1200 images acquired from six different cameras of three different brands. The success of proposed method is corroborated through experiments.

Keywords: *Device Linking, Digital Image Forensics, Digital Negative, Mean-Standard Deviation Plot, Sensor Readout Noise*

1. INTRODUCTION

An interesting question in digital image forensics is: can we prove a given digital image is an output of a suspected camera? In film photography, there are some methods for camera identification using camera imperfections, such as scratches on the negative caused by the film transport mechanism (Lukas, 2005). In digital photography, raw image files are called digital negatives, as they fulfil the same role as negatives in film photography; that is, the negative is not directly usable as an image, but has all the information needed to create an image. The process of converting a raw image file into a viewable format is called developing a raw image. A raw image file contains minimally processed data from the imaging sensor of a digital camera. If we set camera's output as raw, it means we are bypassing certain in-camera processing steps like colour space transformation, demosaicing and post processing operations such as white balancing, bit depth reduction, gamma correction and compression. Raw image conversion software allows user to select different processing algorithms or parameters which may often encode the image in a source device-independent format. Using such images

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in device linking process may lead to misclassification. In this work, we determine origin of the digitally developed image (using raw image conversion software) based on sensor imperfections. Such solutions would provide useful forensic information to law enforcement and intelligence agencies about the authenticity of an image. All compact cameras are not facilitated to produce raw images. However, the so called high end cameras like DSLR cameras are also getting popular very fast and being increasingly used by both professionals and ordinary users due to their falling costs.

Although image file header contains information regarding camera make and model, in addition to the shooting data and image file information, the content of the file header is editable and can be removed. Hence the photo file header can no longer provide reliable information for identifying source camera. Watermarking is also a powerful tool for the determination of image origin (Blythe, 2004), but most digital cameras available in the market do not have this facility.

The rest of the paper is organized as follows: Section 2 discusses the related work about source camera identification. Section 3 describes the basic processing stages carried out inside a typical digital camera. Section 4 explains origin of readout noise in digital camera and how to measure it using the mean-standard deviation plot. Section 5 describes the proposed approach for the identification of source camera model based on readout noise. Section 6 demonstrates the preparation of dataset and the experimental results. Section 7 discusses the limitations of the proposed approach and Section 8 concludes the paper.

2. RELATED WORK

A decade of research in identifying source camera of digital images, researchers mostly concentrated to link the given image with its device, based on sensor imperfections, CFA interpolation, JPEG quantization (Sorell, 2008) and lens aberration (Choi, 2006).

Since digital imaging sensor is not a perfect device, the determination of image origin based on inherent sensor imperfections is identified as a reliable method. Kurusawa et al. (1999) have initially addressed the problem of source camera identification. They have developed a method for individual video camera identification method using the correlation coefficient of the Fixed Pattern Noise (FPN). FPN is caused by the dark current which is a signal collected from the sensor when it is not exposed to light. The authors have extracted FPN from dark frames. This limits the method to use only dark frames. Another approach proposed by Geradts et al. (2001) is the analysis of pixel defects. The authors have shown that hot pixels or dead pixels (defective pixels) could be used for reliable camera identification even from lossy JPEG compressed images. However, recent cameras do not contain any defective pixels or it is possible to eliminate defects by post processing their images on-board. Lukas et al. (2006) have proposed a method for the problem of digital camera identification based on sensor's pattern noise. The authors have used high quality images like raw, tiff etc. with native resolution. The method uses pixel non-uniformity noise which is a stochastic component of the pattern noise to all digital imaging sensors. This is determined by averaging the noise obtained from multiple images taken by the same camera using a denoising filter. The presence of this noise in a given image is established using correlation as in the detection of spread-spectrum watermark. Further the sensor fingerprint (i.e., sensor pattern noise) has been used for camera model identification (Filler, 2008). Camera identification from printed images (Goljan, 2008a) and cropped & scaled images (Goljan, 2008b) have also been attempted. Sensor pattern noise has also been used for determining the image integrity (Chen, 2008) and for identifying whether the given image is computer generated or digital camera image (Dehnie, 2006).

Chang-Tsun Li has investigated the limitation in extracting the Sensor Pattern Noise (SPN). The SPNs extracted from images can be