

Chapter 16

Conditions for Effective Detection and Identification of Primary Quantization of Re-Quantized JPEG Images

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ABSTRACT

The choice of Quantization Table in a JPEG image has previously been shown to be an effective discriminator of digital image cameras by manufacturer and model series. When a photograph is recompressed for transmission or storage, however, the image undergoes a secondary stage of quantization. It is possible, however, to identify primary quantization artifacts in the image coefficients, provided that certain image and quantization conditions are met. This chapter explores the conditions under which primary quantization coefficients can be identified, and hence can be used image source identification. Forensic applications include matching a small range of potential source cameras to an image.

INTRODUCTION

In previous work (Sorell, 2008) which is summarized briefly in this chapter, the author demonstrated that the choice of Quantization Table in the JPEG image compression algorithm used in a digital camera is highly dependent on the particular camera manufacturer, and to a lesser extent on the model series. A sample set of over 5000 digital photographs were used to extract 330 Quantization Tables from 27 different camera models from 10

brands, and it was shown that just 42 Tables were common to more than one camera model. After aggregating the results by camera model *series*, just 25 tables were found to be common across more than one manufacturer, and of this set, 19 of a possible 20 were common to the manufacturers Nikon and Olympus, suggesting a common source of JPEG encoding algorithm.

The Quantization Table is a useful source discriminator in cases where metadata (notably Exif metadata, see JEITA (2002)) has been removed or is suspected of having been modified. Under certain conditions, the effect of the original

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quantization can also survive subsequent compression, such that it is at least possible to narrow down the range of potential source cameras of a recompressed image of interest. Further, if the quantization history of a set of images can be established, it is possible to collate image sets by that quantization history.

In Sorell (2008), a multi-hypothesis test based on the 330 sample Quantization Tables was demonstrated, using a weighted sum of matched filters for each of the 64 quantization coefficients. This chapter takes that analysis further, by examining the conditions under which detection of two-stage quantization is possible, using these results to establish the subset of plausible primary Quantization Tables.

Previous work on this problem includes Farid (2006), which provided an incomplete analysis based on single photographs from 300 candidate cameras; Lukáš and Fridrich (2003), which used a neural network approach for pattern matching; and Neelamani et al (2006), which focused on a maximum-likelihood approach for overall Quantization Table estimation.

MOTIVATION

In Sorell (2008), we used multiple commercial online sources to identify as many camera brands and models as we could find as listed on January 1, 2007. We identified over 70 brands of cameras and mobile phones with built-in cameras, with a total of over 2500 models. We note that many camera models follow an obvious series within a particular brand and that some cameras are identical but have different model names depending on the market in which the cameras are released. In addition, we recognise that our list is almost certainly incomplete and that some are branded versions of unbranded OEM (original equipment manufacturer) models.

Various market sources indicate that over 500 million digital cameras, and a similar number of

mobile phones with in-built digital cameras, had been sold worldwide by the end of 2006. It is well known that digital photography has almost completely displaced conventional film photography in the consumer market, and it is common knowledge that digital photography bypasses the conventional censorship bottleneck available through a film development service.

A further challenge is that as film cameras are withdrawn from the market, crime scene forensic photography will be forced to move from film to digital equipment. The challenge is to establish the forensic chain of evidence in such a way that digital images (not to mention digital video) can meet the burden of proof in court. Thus, the development of digital camera forensic techniques is timely.

The number of camera models available actually suits forensic purposes quite well – small enough that a complete database of all cameras is technically and commercially viable, but large enough that identification of the make and model series of a candidate camera is of significant assistance in forensic investigation.

JPEG COMPRESSION

The JPEG standard is defined in ITU (1993) and the details of the standard are given in Wallace (1991) for the interested reader. There are a number of modes of operation of the JPEG compression algorithm, but we consider only the progressive mode which is designed for lossy compression of continuous-toned images and is ubiquitously implemented in digital cameras and image editing software. The JPEG compression stages are introduced briefly here.

Image Compression

The JPEG compression algorithm takes as its input three color planes representing Red, Green and Blue light. These undergo a reversible color-space

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