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Digital camera identification using PRNU: A feature based approach

K.R. Akshatha [a, e], A.K. Karunakar [b, e, *], H. Anitha [a, e], U. Raghavendra [c, e], Dinesh Shetty [d]

[a] Department of Electronics and Communication Engineering, NMAMIT Nitte, Karkala, 574110, India
[b] Department of Computer Applications, NMAMIT Nitte, Karkala, 574110, India
[c] Department of Instrumentation and Control Engineering, NMAMIT Nitte, Karkala, 574110, India
[d] Department of Electrical and Electronics Engineering, NMAMIT Nitte, Karkala, 574110, India
[e] Manipal Institute of Technology, Manipal University, Manipal, 576104, Karnataka, India

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ABSTRACT

Source camera identification is one of the emerging field in digital image forensics, which aims at identifying the source camera used for capturing the given image. The technique uses photo response non-uniformity (PRNU) noise as a camera fingerprint, as it is found to be one of the unique characteristic which is capable of distinguishing the images even if they are captured from similar cameras. Most of the existing PRNU based approaches are very sensitive to the random noise components existing in the estimated PRNU, and also they are not robust when some simple manipulations are performed on the images. Hence a new feature based approach of PRNU is proposed for the source camera identification by choosing the features which are robust for image manipulations. The PRNU noise is extracted from the images using wavelet based denoising method and is represented by higher order wavelet statistics (HOWS), which are invariant features for image manipulations and geometric variations. The features are fed to support vector machine classifiers to identify the originating source camera for the given image and the results have been verified by performing ten-fold cross validation technique. The experiments have been carried out using the images captured from various cell phone cameras and it demonstrated that the proposed algorithm is capable of identifying the source camera of the given image with good accuracy. The developed technique can be used for differentiating the images, even if they are captured from similar cameras, which belongs to same make and model. The analysis have also showed that the proposed technique remains robust even if the images are subjected to simple manipulations or geometric variations.

Introduction

Digital images/videos have become one of the principal mode of communication, because of their immediacy and easy way to understand the content. Advances in digital technologies have given birth to cost-effective digital acquisition devices such as mobile phones, digital cameras etc., which made it easier to generate the digital audiovisual data and modifying these contents is found to be

* Corresponding author. Manipal Institute of Technology, Manipal University, Manipal, 576104, Karnataka, India.
E-mail addresses: akshathakr.bhat@gmail.com (K.R. Akshatha), karunakar.ak@manipal.edu (A.K. Karunakar), anitha.h@manipal.edu (H. Anitha), raghux109@gmail.com (U. Raghavendra), dinesh1383@gmail.com (D. Shetty).

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common because of the easy availability of sophisticated photo editing softwares. Therefore, the authentication and validation of the given digital content have become difficult due to the possible various origins and the alterations that could have been performed on them (Farid, 2006). Hence, there is a need for the new techniques or methods to recover the history of the image/ video and to evaluate their quality and truthfulness. Digital image forensics deals with detection of source and originality of the images and identifies the manipulations performed on them (Rocha et al., 2011). The evaluation and the investigation of digital image or video can produce a scientific evidence before the court of law for cases like surveillance, cyber crime etc. Source camera identification is the branch of digital image forensics, aims at identifying the source camera used for capturing the images, which helps in several forensic investigations (Redi et al., 2011; Garfinkel, 2010).

Related work

The common source camera identification methods use lens aberration (Choi et al., 2006), sensor noise (Lukas et al., 2006; Kurosawa et al., 2013), chromatic aberration (Van et al., 2007), CFA interpolation/ demosaicing artifacts (Bayram et al., 2005, 2008) and image statistical features (Kharrazi et al., 2004). In the recent years, source camera identification using PRNU noise is considered to be a reliable approach (Chen et al., 2008; Kang et al., 2012; Chan et al., 2012, 2013; Gisolf et al., 2013), as this is one of the characteristic of individual sensor and hence it can be used for differentiating the images captured from similar cameras which belongs to same make and model (Janesick and Blouke, 1995).

Lukas et al. used PRNU and correlation based approach for identification of source camera (Lukas et al., 2006). In this process the images are denoised using wavelet based filters (Mhak et al., 1999) and the noise residuals are computed by subtracting the denoised images from the original frames. This noise residue contains the significant component of PRNU which is affected by scene content. The PRNU noise of a specific camera which is denoted as reference noise pattern, is estimated by taking the average of noise residuals of multiple images taken from that camera. Finally, to determine the source camera of the given image, the correlation is performed between estimated PRNU of the test image and the reference PRNU patterns of various cameras and the one which results with highest correlation is identified as the source of the given image. It is observed that the traces of the scene left on the noise residual and the random noise components, will reduce the accuracy in estimating the PRNU. The efficiency of this method was not found to be satisfactory when the pictures of different sizes and cropped images were used. Another major drawback of this method is the lack of the robustness for geometric transformations. Several attempts have been made in the recent years to improve the PRNU based source camera identification. A method to enhance the sensor pattern noise is done by weighting noise components inversely proportional to their magnitude in order to attenuate the interference of scene details (Chang, 2010). A confidence map and pixel based weighted correlation method to eliminate the scene effect in the PRNU noise is proposed to enhance the accuracy (Chan et al., 2013). Another new method is proposed to extract the PRNU noise from the images using simplified version of the Total Variation (TV) based noise removal algorithm to denoise the data without blurring the edges (Gisolf et al., 2013). This method has increased the speed of PRNU extraction without losing the accuracy. Another sensor noise based approach uses non-uniformity of dark currents on CCD (Charge Coupled Device) arrays, which causes a fixed pattern noise for source identification (Kurosawa et al., 2013, 1999). This pattern noise can be corrected by subtracting dark frame from the images and hence the PRNU plays a significant role in source camera identification.

Kharrazi et al. proposed a feature based approach for source identification, where the image is represented by numerical feature vector, in which some are extracted in the spatial domain and rest are from the wavelet domain (Kharrazi et al., 2004). These features include color related features, image quality measures and statistical features from the wavelet domain, which are used along with multiclass SVM classifiers. A feature fusion scheme was implemented using binary similarity measures, image quality measures and higher order wavelet statistics in conjunction with SVM classifier to identify the images originating from several cameras (Celiktutan and Sankur, 2008). Orozco et al. proposed a method which uses the mixture of two techniques i.e. sensor imperfections and wavelet transform to get better identification accuracy (Orozco et al., 2008).

Most of the PRNU based source camera identification methods, generally uses correlation based approaches which were highly effected by the scene contents and the random noise components present in the estimated PRNU. Whenever the images are subjected to simple image manipulations and geometric variations the process demands additional effort for identification. Also there is a necessity of using equal sized images for performing correlation between different images. In addition the conventional feature based approaches require a large set of features to achieve good identification accuracy, hence extracting more discriminating features from the images is necessary. In order to overcome all these problems the sensor pattern noise is used in a feature based approach to have an effective model for source camera identification.

This work focuses on building a new feature based platform to have an effective tool for SCI, which is robust for basic image manipulations/ geometric variations. The method builds a statistical model consisting of higher order wavelet statistics of the PRNU noise to provide good discrimination among different source cameras. These features are used to train a SVM classifier so as to build a decision system to classify the unknown image into corresponding source category.

Proposed source camera identification algorithm

The proposed method uses the sensor noise as a camera fingerprint in a feature based approach, which can be used effectively to identify the source camera used for capturing the images. The block diagram of the proposed algorithm is