Improvements on Sensor Noise based on Source Camera Identification using GLCM

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ABSTRACT
In the fields such as forensics, medical imaging, e-commerce, and industrial photography, authenticity and integrity of digital images is essential. Digital images are becoming prime focus of work for the researchers. Typical image forensics includes source device identification, source device linking, and classification of images taken by unknown cameras, integrity verification, and authentication. Source camera identification provides different techniques to identify the characteristics of the digital devices used. Study of these techniques has been done as literature survey work; from this sensor imperfection based technique is chosen. Sensor pattern noise (SPN), carries abundance of information along a wide frequency range allows for reliable identification in the presence of many imaging sensors. Our proposed system consists of a novel technique used for extracting sensor noise from the database images, and then the feature extraction method is applied to extract the features. The model used for extracting sensor noise consists of use of Gradient based operators and Laplacian operators, a hybrid system consisting of best results from the above two operators obtain a third image giving the edges and noise present in it. The edges are removed by applying threshold to get the noise present in the image. This noisy image is then provided to the feature extraction module consisting of Gray level Co-occurrence Matrix (GLCM) and Discrete Wavelet Transform (DWT). A feature set of extracted features from the above techniques is obtained and used as the matching set for classification purpose. The KNN classifier is used for matching the images of test data set with the training dataset.

Keywords
Image Forensics, Source camera identification, Pattern noise.

1. INTRODUCTION
The term digital evidence means any probative information stored or transmitted in digital form that a party to a court case may use at trial [1]. Use of digital evidence in the courts has increased in the past few decades allowing for example the use of e-mails, digital photographs, word processing documents, instant message histories, internet browser histories, and databases, the contents of computer memory, Global Positioning System tracks, and digital video or audio les. Digital forensics science is partitioned into several sub-branches: computer forensics, network forensics, database forensics, mobile device forensics and recently multimedia forensics [2]. There are two main interests, source identification and forgery detection. Multimedia Forensics deals with digital representations of parts of reality, such as images, videos or audio captured from a digital camera, a camcorder. Goal of digital forensics is either authentication or integrity validation. Authentication is to identify the source imaging device of a given image. Integrity validation means determining whether the digital image has been modified, what kinds of manipulations are performed [3]. Digital forensics helps by extracting more essential information about an image from the surface, such as the source of the image, i.e. the imaging device (camera) from which the image was produced. Such digital forensics problem is known as camera identification. Typical image forensics includes source camera identification, source device linking, integrity verification, authentication, etc. Image forensics, which only relies on the intrinsic feature of the imaging device or the image itself, is becoming more and more important.

The basic problem in digital image forensics techniques is the attempt to solve the identification of the source of a digital image [4]. That is, to determine by what means a digital image has been created, e.g., digital camera, scanner, generative algorithms, etc. Digital watermarking has been introduced as a means for authenticating digital documents that are most likely to undergo various processing [5]. Although this approach allows the extractor to establish the degree of authenticity and integrity of a digital image, it practically requires that the watermark should be embedded during the creation of the digital object, which limits watermarking to applications where the digital object generation mechanisms have built-in watermarking capabilities.

Therefore, in the absence of widespread adoption of digital watermarks, watermarking cannot be offered as a general solution to the complex problem of authentication. Image source identification research investigates the design of techniques to identify the characteristics of digital data acquisition device (e.g., digital camera and cell-phone) used in the generation of an image [6]. The success of image source identification techniques depends on the assumption that all images acquired by an image acquisition device will exhibit certain characteristics that are intrinsic to the acquisition devices because of their (proprietary) image formation pipeline and the unique hardware components they deploy, regardless of the content of the image. It should be noted that such devices generally encode the device related information, like model, type, date and time, and compression details, in the image header, e.g., EXIF header. Since this information can be easily modified or removed, it cannot be used for forensics purposes [6].

The remainder of this paper is organized as follows. Section II describes related work and literature survey. Section III briefly addresses the proposed novel technique for identifying the source camera of digital image. Finally, Section IV concludes the paper.

2. RELATED WORK
There has been a lot of search done on Source camera identification. It provides a means to identify the exact device used for generating the image that has been important for forensics. The literature survey of the different techniques and

methods applied has been done and a new system has been proposed. Sensor Pattern Noise is related to sensor imperfection based method for Source Camera Identification which uses the sensor noise of each device and stores the features that can be used for classification and identification. Every camera source has its own intrinsic features related to the device. These features are used as unique identification mark to identify the image into its desired category or source. Main idea behind source camera identification is to search among various devices of different brands and models to get the exact device with its model number based on the image at hand below figure 1 shows the techniques.

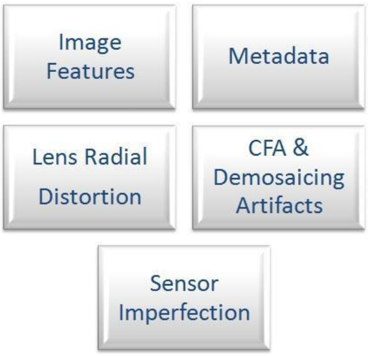

Figure 1: Various techniques of Source Camera Identification

A lot of research work is done in recognition of Camera Source Identification. Discussion about sensor imperfection technique will be done in this part.

Ahmed Bouridane et al. [7] proposed an image sharpening method for enhancing source camera based on SPN estimation. They presented sharpening method, namely Unsharp Masking method, which was aimed to amplify the SPN noise present in the image in order to enhance its estimation accuracy.

The experiments showed that the camera identification performance achieved with the proposed approach significantly improved.

Hitoshi Kitazawa et al. [8] proposed a novel camera identification method based on the pair wise magnitude relation of cluster-pairs. This method provided reliable camera identification which were robust to the effects of scene content and image processing engines. In order to reduce the effects of noise contamination, they clustered pixels according to the PRNU noise value of a tested camera. The method was based on the fact that the probability of the pair wise magnitude relation of different cluster-pairs being identical for images taken by the same camera is higher than that for images taken by different cameras, because of the PRNU noise.

Table 1: Comparative Analysis

Parameters / **Proposed System**	**Proposed Method**	**Image Format**	**Performance**	**Image Resolution**	**Device Used**	**Database Size**
Image Sharpening for Efficient Source Camera Identification [7]	Estimation of sensor pattern noise using sharpening	Jpeg	Based on TFP and TFN	Variable Resolution	Digital Camera	1200
Robust Digital Camera Identification Based on Pair wise Magnitude Relations of Clustered Sensor Pattern Noise [8]	Pair clustering in DFT domain using Weiner filter	Jpeg	Based on FAR and FRR	1600 x 1200	Digital Camera	10000
Source Identification Of Camera Phones Using SVD [9]	SVD	Jpeg	Based on PCE values	Variable from 1536 x 2048 to 3264 x 2488	Mobile Phones	1000
A Context adaptive predictor of SPN [10]	PCAI	Jpeg	90 %	Variable from 2592 x 1944 to 4288 x 2848	Digital Camera	1200
Improvements on sensor noise based Source Camera Identification [11]	CFA using denoising filter	Jpeg	93.41 %	Variable from 960 x 1280 to 1728 x 2304	Digital Camera	2925
Digital Camera Identification from Sensor Pattern Noise [12]	Denoising filter to obtain noise	Jpeg	Based on FAR and FRR	Variable from 960 x 1280 to 1728 x 2304	Digital Camera	2700

Ahmad Ryad Soobhany et al. [9] introduced a novel PRNU extraction method using SVD and demonstrated to distinguish between camera phones of same model. The extraction model described how SVD can be used as an image decomposition method for which signatures were extracted from the individual images that can be associated with their respective source devices. The identification results of the test were performed on 10 cameras which results that it can differentiate between two cameras of the same make and model along with the suggestion of signature is being highly related to the SPN of the camera. They also showed that the PRNU signature could be extracted relatively straightforwardly with most real-world/natural images.

Xiangui Kang et al. [10] proposed a context adaptive SPN predictor which was used for SPN extraction and was applied it to enhance the ROC performance of CSL. The proposed PCAI SPN method suppressed the effect of image content better because it is adaptive to image edge and local variance. SPN was directly extracted from the spatial domain with a pixel-wise adaptive Wiener filter, based on the assumption that the SPN is a white signal.

Extensive experiments showed that the ROC performance of the proposed method gave the existing state-of-the-art methods on different sizes of images and had the best performance in resisting mild JPEG compression.

S. Bayram et al. [11] proposed an improvement over source camera identification based on sensors pattern noise, it was a scheme that enabled application of the method in a more realistic forensics scenario, which was realized by incorporating the digital cameras “Demosaicing characteristics” into the decision process which increased the reliability of the decision.

Basically, in the camera identification approach based on [12], the source camera of a query image was determined according to the correlation between the PRNU noise of a tested camera and the noise of the query image. The distribution of correlations for images was taken by different cameras of various manufacturers and was experimentally estimated, a threshold was determined from the distribution; a specified false acceptance rate (FAR) was achieved.

As seen in above table 1, various methods have been applied for extracting this SPN and using it for device identification. Most common method is use of filters for this purpose, Weiner filter is used by Yoichi Tomioka [8] for extraction of SPN and then feature extraction and classification is obtained. The system designed by Y. Sutcu for improvements on sensor noise [11] used denoising filter for extraction of SPN. Method 1 implemented by Miroslav Goljan [12] used wavelet-based denoising filter to determine Camera reference pattern. The SPN extraction method gives the best possible results for source identification. The overall analysis of the methods studied above shows that SCI depends on the type of method applied and system designed for the extraction of noise. The other methods like meta data, CFA, image features also yield good results but have been worked a lot but sensor imperfection which entirely depends on SPN extraction is not been researched. We describe our own system for SPN extraction which is entirely new, fast and efficient method for SPN extraction making use of edge detection and thresholding. Sensor pattern noise extraction methods applied to existing systems is studied and analyzed, based on the analysis we propose our unique and novel technique.

3. PRPOPOSED SYSTEM

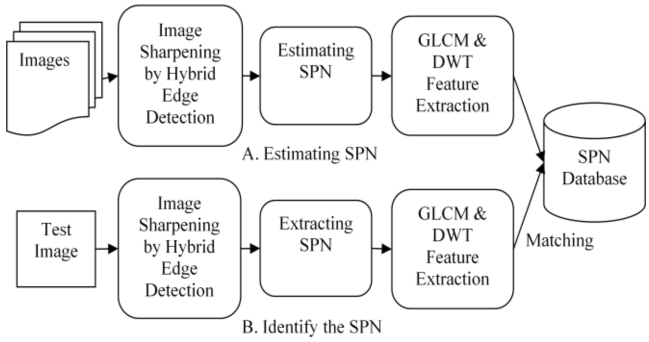

Figure 2: Proposed System

As you can see in the above figure 2 our proposed system consists of a novel technique used for extracting sensor noise from the database images, and then the feature extraction method is applied to extract the features. The model used for extracting sensor noise consists of use of Gradient based operators and Laplacian operators, a hybrid system consisting of best results from the above two operators obtain a third image giving the edges and noise present in it. , we will be applying CANNY mask on each plane of the image and get the edge features of the image database and will be storing it in variable A. Again on the same image database we will be applying LAPLACE on each plane of the image and get the edge features of the image database and will be storing it in variable B. After this process we will be comparing A and B in terms of RGB planes to get best information from the features and will be storing it in third variable C to form new image, which is nothing but to compare A(x, y, p) and B(x1, y1, p1) and get highest values obtained from Canny and Laplace and will store in C(x2, y2, p2). Now C is used to extract pattern noise by subtracting it from original image and then use thresholding to get the noise from the image. Here x, x1, x2,y,y1,y2 represents pixel co-ordinates for a given image, and p,p1,p2 represents plane for that particular image.

Our proposed feature set includes not only image related features but also sensor noise based features which are created from hardware imperfection. The edges are removed by applying threshold to get the noise present in the image. Subtract the image obtained above from original image and then apply thresholding to get the noise image, this noisy image is then provided to the feature extraction module. The GLCM is used to extract various features based on its properties such as Homogeneity, Contrast, Correlation, and Entropy along with the DWT [13]. This obtained image is given as an input image for DWT and GLCM [14] to extract different features like Homogeneity, Contrast, Correlation, and Entropy.

These extracted features form feature set for given image database. To classify test image given into its category we compare DWT and GLCM features from that image to features stored in feature set. The best possible match of the image gives class of that particular image. A feature set of extracted features from the above techniques is obtained and used as the matching set for classification purpose. The KNN classifier [15] is used for matching the images of test data set with the training dataset giving best results then the available techniques for SCI using sensor pattern noise.

Thomas Gloe et al. [16] introduced a novel image database especially for the purpose of development and benchmarking of camera-based digital forensic techniques. We will be using this standardized database for our technique. The "Dresden Image Database" is intended to become a useful resource for researchers and forensic investigators. Using a standard database as a benchmark makes results more comparable and reproducible, also more economical and will avoid potential copyright and privacy issues on the Internet. The important advantage of this source is its diversity.

4. CONCLUSION

In this paper, we propose a novel technique using edge detection to get the image edges and also some edges representing the noise elements. The edges are removed by applying threshold to get the noise present in the image. This noisy image is then provided to the feature extraction module consisting of Gray level Co-occurrence Matrix (GLCM) and Discrete Wavelet Transform (DWT). The Source camera identification performance is dependent on various parameters. The proposed designed system for SCI aims to use K-Nearest Neighbor Classifier for calculating the classification rate and getting the exact category or source for a given test image. The performance evaluation criterion for the proposed system is obtaining a high accuracy and efficiency in identifying the exact source for the test image. The overall performance evaluation of proposed system entirely depends on the above parameters including the recognition rate, False Acceptance Rate (FAR) and False Recognition Rate (FRR) by using K-Nearest Neighbor Classifier. Proposed technique will boost the performance and improve the classification rate to a great extent as compared to them. Source Camera Identification is growing area and has a wide scope so lot of work is yet to be done so can be used as an important area for research purpose.

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