International Journal of Advance Engineering and Research Development (IJAERD)
Volume 1,Issue 5,May 2014, e-ISSN: 2348 - 4470 , print-ISSN:2348-6406

Analysis Of Photo Response Non –Uniformity Noise On Images Of Different Lighting Conditions

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Abstract— Photo Response Non-Uniformity (PRNU) Noise introduced by the sensors in the digital capturing device is widely used in the field of Image Forensics. This sensor pattern noise proved to give reliable evidences in Source Camera Identification and Image Forgery Detection. But the accuracy of identification rates of PRNU based techniques depends on the lighting conditions in which the particular camera device captures digital images for calculating their reference PRNU and also the lighting condition of the image under investigation. This paper tests the PRNU content of images of same scene under different lighting conditions in terms of correlation values of the extracted PRNU's from the images and the reference PRNU of the images under different illuminations.

Keywords- Photo Response Non-Uniformity (PRNU); Image Forensics; sensor pattern noise; Source Camera Identification; Image Forgery Detection; lighting conditions; illumination.

I. INTRODUCTION

Recently the misuse of the digital images is increasing day by day which requires constant monitoring of the integrity of the contents in the susceptible images. There is greater need for developing efficient techniques in the field of image forensics in order to reduce and tackle the crimes involving manipulations of digital images. So the characteristics of the digital cameras such as sensor pattern noise [1], sensor dust [2], correlations introduced by Color Filter Arrays [3], are widely used for Image Forensic analysis.

The pattern noise present in the images when images are taken using a particular camera remains in all images taken by the same device. The PRNU (Photo Response Non-Uniformity) Noise which is the crucial element of sensor noise is used for both Device Identification [1] and Integrity analysis [4], [5]. This paper analyses the impact of PRNU in images of the same elements in the different lighting conditions. The extraction of PRNU content from the individual images and their matching with the PRNU content of the Camera depends on the lighting conditions in which the test images are taken.

II. GENERATION OF PRNU BY IMAGE CAPTURING SENSORS

2.1. Image Acquisition Process In Digital Cameras

The visual contents in a digital image are formed after undergoing different processes inside the camera device. The optical lens passes the reflected light from the objects in the scene. The light energy (photons) is then converted into the corresponding electronic charge

by the imaging sensors which are manufactured generally in silicon substrate. The most commonly used sensors in consumer cameras are CCD sensors (Charge Coupled Devices), CMOS sensors (Complementary Metal Oxide Semiconductor) and recently Foveon X3 sensors. When photons from the scene fall into the photo sites, corresponding electric charge is produced in it. The electric charge produced in each sensor element is proportional to the amount of illumination obtained by it. There will be charge amplifiers which convert the charges so formed into voltage. This digital form of the image is stored in the desired format in the device. Several image processing steps are employed in the camera based on the purpose and quality of images required.

2.2. PRNU (Photo Response Non- Uniformity) Noise Origin

The PRNU (Photo Response Non- Uniformity) noise is formed due to the defects in the sensors whether it is CCD sensor or CMOS sensors. Whenever the elements in the scene reflect the light, the corresponding pixel values generated by sensors differ due to imperfections in the sensor [1]. The variation in the pixel sensitivity causes a non-uniformity sensor pattern noise called PRNU. This PRNU is content dependent and it is present in all images taken by the same camera. Several image forensic techniques based on PRNU are employed in order to identify the origin of particular images as proposed in [1], [4], [5] etc. These PRNU content can be also utilized to find whether image is manipulated or not [4], [5]. These tests works on the basis of comparing the standardized PRNU values generated for each camera with the noise extracted from the particular image.

III. EFFECT OF PRNU EXTRACTION ON DIFFERENT ILLUMINATION OF SCENE

As, the name suggests 'Photo Response Non-Uniformity Noise', accumulates in image due to difference in the way in which sensors generate the values of pixels which may be slightly different from the actual value [1] when reflected light comes in the sensor. The PRNU content of individual images can be extracted by subtracting the noise free image from the actual image. The noise residuals are obtained from appropriate denoising filters as suggested in [1], [6]. The wiener filtering gives better results. Many pre-processing steps like color interpolation noise removal are employed to increase the accuracy of PRNU based identification rate [5]. The comparison of PRNU content in different images with the reference PRNU generated from the images of a particular camera is being done using normalized cross correlation method [1].

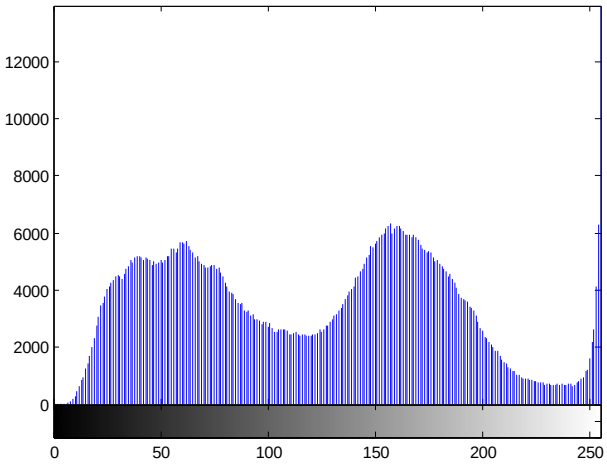
The reference (test) pictures taken from a camera in order find the reference PRNU are taken when there is a particular amount of illumination in the scene. The image that should be verified may be illuminated in the same way or different. So if the illumination in both cases is of greater variation, then it may affect the cross correlation value which is used as the proof for establishing the origin and authenticity of a particular image. Section V explains the results of these in detail.

IV. EXPERIMENTS AND RESULTS

The experiment is conducted on images of the same scene taken from SONY 12.1 Megapixel camera in different illuminations. Histograms of these images were plotted and analyzed. The reference PRNU was calculated from plain images taken from the same

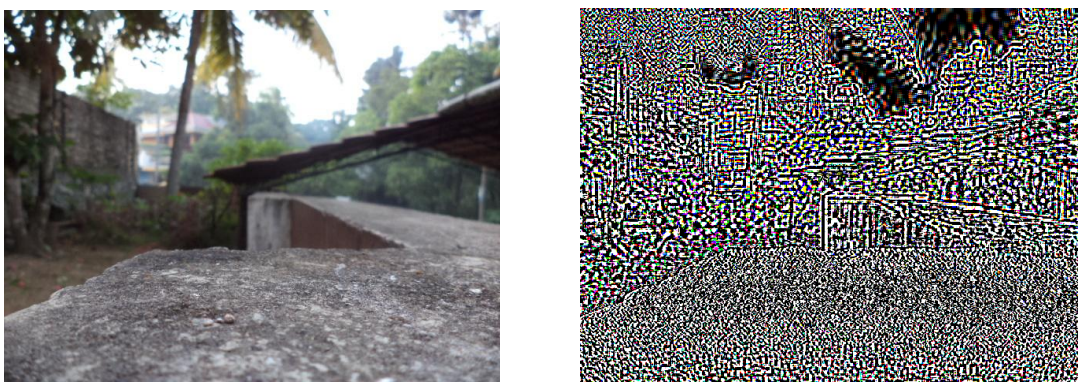
camera .The sensor pattern noise done of the images were calculated. The normalized correlation value between the noise extracted from images and the reference noise value were computed and compared. As the illumination of the scene increases the extracted PRNU value goes on increasing. So if there is low illumination, the value of cross correlation decreases because the extracted noise may contain less clean PRNU value.

(a) **(b)**

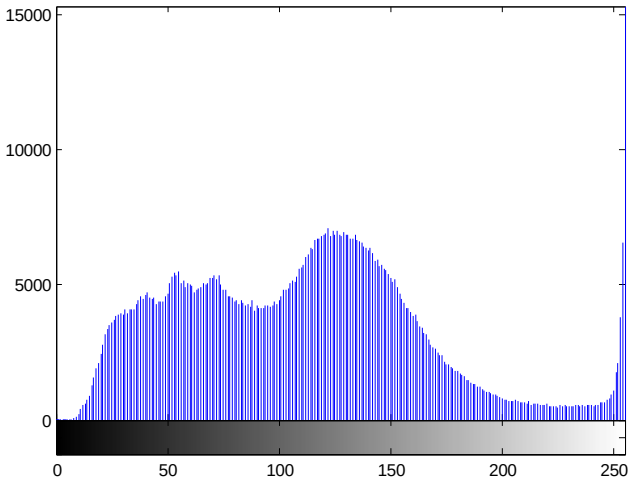


(c)

Figure 1. (a) Test Image 1 taken in flash mode (well illuminated) (b) Noise Residual of Test Image 1 (c) Histogram of Test Image 1.



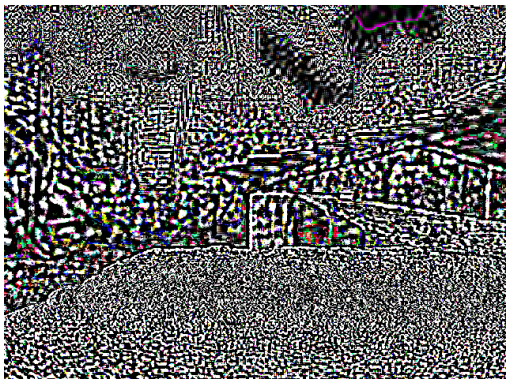
(a) **(b)**



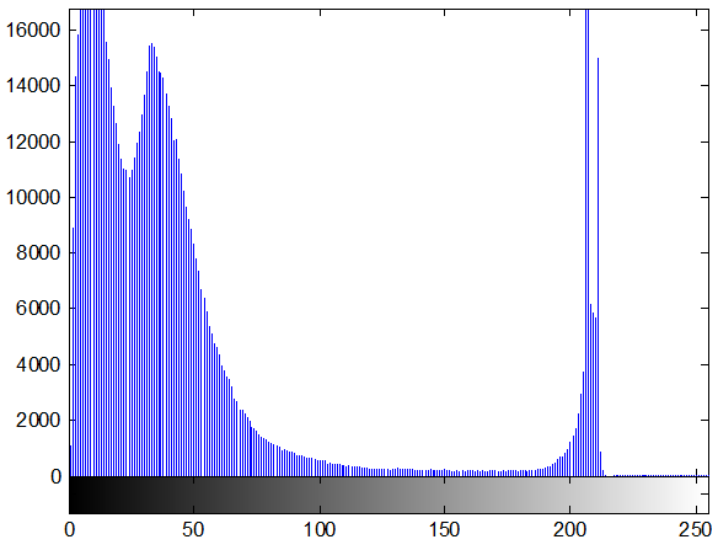
(c)

Figure 2. (a) Test Image 2 taken in Non-flash mode (normal illumination) (b) Noise Residual of Test Image 2 (c) Histogram of Test Image 2.

(a)



(b)



(c)

Figure 3. (a) Test Image 3 taken when day light was fading (b) Noise Residual of Test Image 3 (c) Histogram of Test Image 3.

In Figure .1, Test Image 1 is shown which was taken using SONY Camera (12.1 Megapixel) in Flash mode. Whereas in Figure .2, the Test Image 2 is shown which was taken using the same Camera in Non- Flash mode. The respective Noise Residuals are calculated and plotted in Figure .1(b) and Figure .2 (b) for Test Image 1 and 2 respectively. It is evident from their histograms (Figure .1(c) and Figure .2 (c)), that the second image taken in Non-Flash mode has less number of pixel in 200-255 intensity level range compared to the first image taken in the Flash Mode (artificially illuminated). In Figure .3, Test Image 3 is taken when day light was fading, and so there is low illumination in the scene.

The normalized cross correlation value is calculated by using the equation as suggested in [1]. The norm-cross correlation value is **0.0048** for Test Image 1; **0.0022** for Test Image 2; **-0.0012** for Test Image 3. Thus it is clear that as illumination goes on decreasing the cross correlation value between the Reference PRNU of the camera and the PRNU of the images goes on decreasing.

V. CONCLUSION

As the illumination in the scene differs, the reflected light from the scene which is detected by the sensors in the capture device varies. So the PRNU noise extracted from the scene may differ which affects the PRNU- based camera identification techniques and forgery detection in images. This happens because the images contain the less PRNU content when the illumination in the objects in the scenery is comparatively low. So the images should have sufficient illumination if they are to be checked by any PRNU based image forensic techniques. So whenever an image should be tested based on their PRNU content, the lighting on the scene when taking the test images for calculating the PRNU of the camera should be somewhat similar to that of the image under investigation.

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