A Survey on Distinguishing Computer Generated and Digital Camera Images for Digital Image Forensics

Dr. Indumathi J[1], Amala S.P[2], and Mokhtar Mohammed[3]

[1]Associate Professor, [2,3]Research Scholar
Department of Information Science and Technology, College of Engineering,
Anna University, Chennai, India

Abstract: *With the proliferation of Digital images and the ever emerging new image processing techniques and image editing software, fabrication of Digital images have become more common. Moreover today's computer graphics rendering software is capable of generating highly photorealistic images. This is the biggest challenge in the field of image authentication. This paper discusses about the image tampering in the past and gives a brief survey on the various techniques for distinguishing computer generated and digital camera images with the features.*

Keywords: *Digital image forensics, image authentication, computer generated images*

1. Introduction

Digital images has touched many aspects of our daily life starting from our morning newspaper to our medical images. Many image editing and rendering tools have been developed which emphasis on the realistic renderings with 3D effects and much more. This has led to the new challenges towards the credibility of digital images which creates an impact on various fields. Image manipulation is not new and started ever since Frenchman Nicephore Niepce created the first photograph in 1814. In those days doctoring images required heavy work in the darkroom.

But today with the advent of internet and easily available and easy to use image editing software creating a doctored image have been made simpler and the identification of photorealistic computer graphic images has become very challenging. Fig. 1 shows the photorealistic image by google earth.

Fig. 1: Google Earth Photorealistic Buildings (2008)

The organization of this paper is as follows. Section 2 discusses the image tampering in the past. The various techniques, approaches and models for Identifying Computer Generated and Digital Camera Images are discussed in Section 3 with a table of the features for those techniques or approaches or models and the final conclusions are given in Section 4.

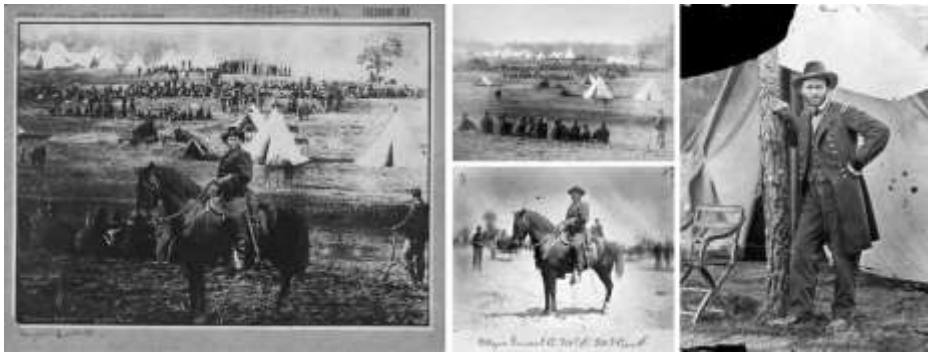
2. Image Tampering in the Past

Image tampering is not new. It has been done throughout the history. Fig. 2(a) shows the picture of Abraham Lincoln which is created by merging his head on to John Calhoun's body.

(a) (b)

Fig. 2: Abraham Lincoln's portrait created by merging his head on to John Calhoun's body

Fig. 3 (a) appears to be of General Ulysses S. Grant in front of his troops at City Point, Virginia, during the American Civil War. (c) the head in this photo is taken from a portrait of Grant; (b) the horse and body are those of Major General Alexander M. McCook; and the background is of Confederate prisoners captured at the battle of Fisher's Hill, VA.



(a) (b) (c)

Fig. 3: Doctored photograph purporting to be of General Ulysses S. Grant in front of his troops at City Point, Virginia, during the American Civil War.

(a) (b)

Fig. 4: Commissar Removed

Stalin routinely air-brushed his enemies out of photographs. In Fig. 4(a) a commissar was removed from the original photograph after falling out of favor with Stalin.

(a) (b)

Fig. 5: Mao Tse-Tung

In Fig. 5, doctored photograph, Mao Tse-tung, shown on the far right, had Po Ku removed from the original photograph Fig. 5(b), after Po Ku fell out of favor with Mao.

Thus we find the authenticity of the images are being compromised from the past. Therefore there is a need for identifying, detecting and dististinguisng a computer generated and a digital camera image.

3. Identifying Computer Generated and Digital Camera Images

One of the fundamental problems digital image forensics techniques attempt to solve is the identification of the source of a digital image. When the reliability of the digital image is put into question, it is advisable to check the origin of the image. i.e., whether the image has been captured by a camera or has it been generated by a computer (computer graphics). Thus before we apply the source camera identification techniques, we can check if an image was produced by a camera in the first place. The techniques for detecting a computer generated image falls into three categories [Ng and Chang (2009)]: (1) statistical wavelet features, (2) physical models of images and (3) camera related characteristics.

Lyu and Farid [6] introduced a statistical model based on first- and higher-order wavelet statistics that is able to reveal the difference between Computer Graphics imagery and digital photographs that are indistinguishable to the human eye [Lyu et al., (2005)]. Ng et al., (2005) proposed a geometry based image model that is motivated by the physical differences between CG image and a photograph [7] [8]. The authors develop two levels of image discrimination: image-process authenticity and scene authenticity.

Dehnie et al., (2006) [1] used noise characteristics to establish the difference between different camera classes and CG images. The idea is that even though different cameras possess unique noise characteristics, statistical properties exist that correlate these characteristics across cameras to some degree. CG images do not possess these common noise characteristics.

Dirik et al. (2007) detecting the presence of CFA interpolation as opposed to estimating CFA interpolation coefficients. [2] The presence of chromatic aberration in an image is also used as a feature. In a variety of test cases using an SVM classifier, Dirik et al. [2007] show accuracy of over 90%.

Gallagher and Chen (2008) also proposed a demosaicing detection approach, this time by considering the weighted linear combination of neighbouring pixel values. [4] The authors suggest that the weights directly affect the variance of the distributions from which interpolated pixels values are drawn.

Rocha and Goldenstein [2007, 2010] have showed that the Progressive Randomization meta-descriptor, introduced for Steganalysis [Rocha and Goldenstein 2006], is also suitable for distinguishing computer generated from natural images. [9] The method captures the differences between image classes (e.g., natural and CG images) by analyzing the statistical artifacts inserted during controlled perturbation processes with increasing randomness.

Johnson M. K et al. (2010) identified the corresponding regions between the CG and real images using a mean-shift cosegmentation algorithm [5]. They propose a graphical image rendering algorithm. The realistic

color, tone, and texture is transferred to the CG image and thereby show that these transfers improve the realism of CG images.

Zhang, R. Wang, T. T. Ng (2011) analysed the statistical property of local edge patches in digital images [14]. They constructed a visual vocabulary that avoids troubles in traditional partitioning algorithms such as k-means.

Shaojing Fan et al. (2012) showed the fundamental differences between the two image categories and classified them based on image contour information [10]. The authors investigate the proper seclection of image features which has an impact on the detection rate. Also in another work Shaojing with other authors showed that visual realism depends not only on image properties, but also on cognitive characteristics of viewers [11]. In 2014, two experiments were conducted to show the human perception.

Farid H., Bravo M. J., (2012) used images of varying resolution, JPEG compression, and color to explore the ability of observers to distinguish computer generated from photographic images of people [3].

The list of the methods/approach or technique with its features are given in Table I.

TABLE I: Identifying Computer Generated and Digital Camera Images

IDENTIFYING COMPUTER GENERATED AND DIGITAL CAMERA IMAGES		
YEAR/ AUTHOR(S)/ PAPER	METHODOLOGY/ APPROACH/ TECHNIQUE/ FRAMEWORK	FEATURES
Lyu et al., (2005)	Statistical model based on first- and higher-order wavelet statistics	Difference between computer generated image and photograph was shown.
LYU, S. and FARID, H. 2005. How realistic is photorealistic? IEEE Trans. Sig. Proc. 53, 2, 845–850.		
Ng et al., (2005)	Geometry based image model based on physical differences between CG image and a photograph.	Showed image-process authenticity and scene authenticity.
NG, T.-T., CHANG, S.-F., AND TSUI, M.-P. 2005. Physics-motivated features for distinguishing photographic images and computer graphics. In Proceedings of ACM Multimedia Conference. ACM, 239–248.		
Dehnie et al., (2006)	Used noise characteristics to establish the difference between different camera classes and CG images.	Even though different cameras possess unique noise characteristics, statistical properties exist that correlate these characteristics across cameras to some degree.
DEHNIE, S., SENCAR, T., AND MEMON, N. 2006. Identification of computer generated and digital camera images for digital image forensics. In Proceedings of the International Conference on Image Processing. IEEE.		
Dirik et al. (2007)	CFA interpolation and chromatic aberration	Showed accuracy of over 90%.
DIRIK, E., BAYRAM, S., SENCAR, T., AND MEMON, N. 2007. New features to identify computer generated images. In Proceedings of the International Conference on Image Processing. IEEE.		
Rocha and Goldenstein (2007)	Progressive Randomization meta-descriptor	The method captures the differences between image classes (e.g., natural and CG images) by analyzing the statistical artifacts inserted during controlled perturbation processes with increasing randomness.
ROCHA, A. AND GOLDENSTEIN, S. 2007. PR: More than meets the eye. In Proceedings of the International Conference on Computer Vision. IEEE, 1–8.		
Gallagher and Chen (2008)	proposed a demosaicing detection approach	Difference between computer generated image and photograph was shown.
GALLAGHER, A. AND CHEN, T. 2008. Image authentication by detecting traces of demosaicing. In Proceedings of the International CVPR Workshop on Vision of the Unseen. IEEE.		

Ng and Chang (2009) NG, T.-T. and CHANG, S.-F. 2009. Identifying and prefiltering images. IEEE Signal Process. Mag. 26, 2, 49–58.	Classified the techniques	statistical wavelet features, physical models of images and camera related characteristics.
Johnson M. K et al. (2010) JOHNSON M. K., DALE K., AVIDAN S., PFISTER H., FREEMAN W. T., MATUSIK W. CG2Real: "Improving the realism of computer generated images using a large collection of photographs." *IEEE Transactions on Visualization and Computer Graphics*, 17(6), 2010.	a mean-shift cosegmentation algorithm for graphical image rendering.	Simple image based approach is used to render highly photorealistic images
Zhang, R. Wang, T. T. Ng (2011) ZHANG, R. WANG, T. T. NG, "Distinguishing photographic images and photorealistic computer graphics using visual vocabulary on local image edges." *International Workshop on Digital-forensics and Watermarking (IWDW)*, Oct. 2011.	SVM classifier for image classification	constructed a visual vocabulary that avoids troubles in traditional partitioning algorithms.
Farid H., Bravo M. J., (2012) FARID H., BRAVO M. J., "Perceptual discrimination of computer generated and photographic faces", *Digital Investigation*, March 2012, 1-8	used images of varying resolution, JPEG compression, and color to explore the ability of observers to distinguish	blurring of the perceptual boundary, a significant forensic challenge is addressed.
Shaojing Fan et al. (2012) SHAOJING FAN, RANGDING WANG, YONGPING ZHANG, KE GUO, "Classifying computer generated graphics and Natural images based on image contour information.", *Journal of Information & Computational Science* 9: 10 (2012).	classified the image categories based on image contour information	The approach is based on the fundamental difference between computer generated and camera images
Shaojing Fan et al. (2012) SHAOJING FAN, TIAN-TSONG NG, JONATHAN S. HERBERG, BRYAN L. KOENIG, SHIQING XIN, "Real or Fake?: human judgments about photographs and computer-generated images of faces", *SA '12 SIGGRAPH Asia 2012 Technical Briefs*. 2012.	Modified the intrinsic reflectance components and intrinsic shading components (grayscale) of the images	Showed the cognitive characters of the readers
Shaojing Fan et al. (2014) SHAOJING FAN, RANGDING WANG, TIAN-TSONG NG, CHESTON Y.-C. TAN, JONATHAN S. HERBERG, BRYAN L. KOENIG. "Human Perception of Visual Realism for Photo and Computer-Generated Face Images", *ACM Transactions on Applied Perception (TAP)*, Volume 11 Issue 2, July 2014. Article No. 7	Inverted, misaligned and scrambled the faces.	Showed the influence of human perception

4. Conclusion

Recent advances in computer graphics has led to the creation of highly photo realistic images deceiving the viewers. In this paper, the tampering that has occurred in the past is discussed and the views of various authors on identifying and distinguishing computer generated images from digital camera images are also discussed. The explicit features pertaining to the technique, methodology or algorithm are also tabulated.

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