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Pixel and Edge Based Illuminant Color Estimation for Image Forgery Detection

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Abstract

Images are one of the powerful media for communication. Image security is a main issue in the fields that using digital images. By the development of high resolution cameras, personal computers and photo-editing software's, the manipulation of images is becoming common. This paper mainly focuses on common form of image manipulation such as image splicing. The process of analysis is done with the help of inconsistencies in illuminant color of images. Illumination inconsistencies detection is a powerful way for image forgery detection. Inconsistency detection among different images can be identified with the help of pixel and edge based illuminant color estimation on image regions. From these illuminant estimators, extract shape and color features, which is then provided to a classifier for making decision. Classification using SVM and its performance is evaluated using distinct testing process. The main contribution of this method is, how illuminant color estimation on various constraints can be exploited as a forgery detection method and how these are provided for decision-making with minimal user interaction.

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*Keywords:*Splicing; Illuminant color estimation; Hog edge; Color moments; SVM Classification

1. Introduction

Nowadays digital images have wide popularity in many fields. With the development of advanced technologies available on internet we have to be ensure the authenticity of the images. So effective methods are needed for detection of forgeries in images. Image forgery detection is a process of detecting the authenticity of images or find

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out the forgeries in images. Many methods have been proposed for forgery detection. In this paper illuminant color is estimated for forgery detection. When light fall on an object, color of the object is reflected, depends on that color camera capturing the object. Objectshaving same color under a single illuminant condition. So when we forge an image, it is very difficult to maintain the consistency of illuminant condition. Forgery detection method used in this paper mainly detecting this type of inconsistencies. Image splicing is a most common type forgery. The paper mainly focussing on spliced image forgeries. Some other criteria's are used for image forgery detection[1] such as,compression properties,projective geometry,chromatic aberration, color filter array artifacts, pixel relation properties also used.

Illumination based image forgery detection mainly divided in to two, illuminant geometry based and Illuminant color based. Illuminant color based image forgery detection is checking the inconsistency between objects and light color. Sandeep Gholap and P. K. Bora[2] find forgery detection in digital images by detecting inconsistencies in color of image. While creating a spliced image forgery in image, it is very difficult to make illuminant color consistent. In this method, the color mismatches is estimated from illuminant color. Xuemin Wu, Zhen Fang[3] introduce a new method in which illuminant color estimation algorithm on each block content. Estimating illuminant color on selected and reference block, and the difference between the estimated and reference illuminant color is measured, if the difference is greater than a predetermined value then that block is spliced block. Christian Riess and Elli Angelopoulou[4] introduce a method with the help of illuminant map and distance map. In this method, the user select the area for checking forgery. By using illuminant color estimation algorithm estimate illuminant color of selected region. By generating an illuminant map and distance map, and by checking inconsistencies from these map gives the possible image tampering.

Illuminant geometry based forgery detection methods checks geometrical inconsistencies in images. Yingda Lv, Xuanjing Shen, Haipeng Chen[5] proposed the method defined is "neighborhood method". It was used to calculate surface normal matrix of image in the passive image identification algorithm based on illuminant direction. Micah K. Johnson and Hany Farid[6] proposed a method of forgery detection based on specular highlight. A specular highlight appears when shiny object illuminated, it shows a bright spot of light. Highlighted the point with respect to light sources direction. When creating a forgery it is often difficult to maintain the consistency of highlighted points, this can be used as the evidence of tampering.

Micah K. Johnson& Hany Farid[7] proposed a low dimensional model in the lighting environment and estimate the low dimensional model's parameters from a single image. This lighting model inconsistency are used as the evidence of tampering. This approach is applicable to more complex lighting environment. This estimation requires the manual selection for contour of image. But the disadvantage is the different part of image under different lighting is not a suitable for forgery detection.Wei Fana,Kai Wanga, Franc¸ois Cayrea,and Zhang Xiong[8] proposed a extension consists of using 3D lighting environments. Proposing a different approach by using shape-from-shading (SFS) to estimate the 3D normal's of the underlying object. The main issue with this method is the estimation of the 3D shape of the object. Advantage of this approach is improving the accuracy of shape recovery and investigating the effect for more complicated objects.

The remaining paper is organized as follows. Section 2 gives overview of the proposed forgery detection method. Section 3 presents the methodology in detail. Section 4 presents experimental results and studies the performances of the method. Section 5 concludes the paper.

2. Overview

The overview of proposed forgery detection technique illustrated in fig 1. Estimating illuminant color of input image and extracting illuminant features is lead to the detection of forgery. For the illuminant color detection of skin, mainlyfocuses on face region of each input image. Before that perform the segmentation operation. Segmentation is a preprocessing step of illuminant color estimation.From that segmented image estimate the illuminant color. Illuminant color estimated using pixel and edge based methods. Illuminant map is generated from the estimated illuminant color. Extracting of shape and color features is done from the illuminant map. For shape feature HOG Edge feature is used. For color feature extraction, color moments features are used. Moments with first and second moments are extracted. Classification with SVM is performed in order to check accuracy of method.

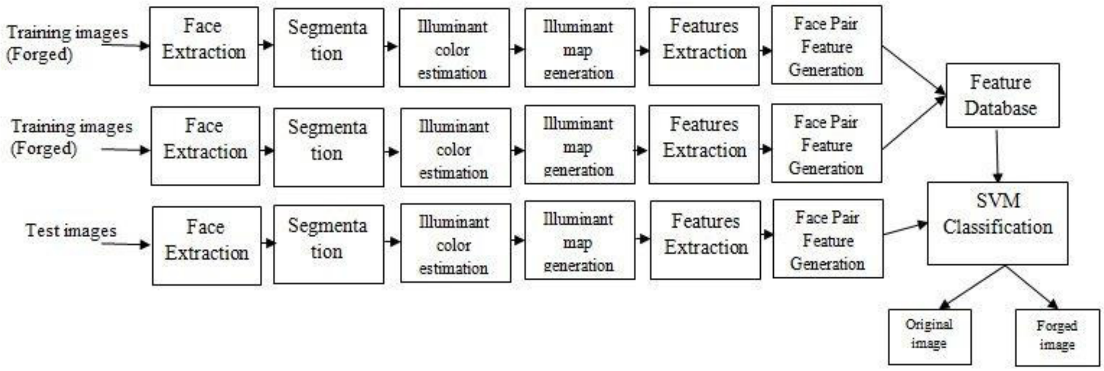

Fig. 1. Block diagram of forgery detection method

3. Methodology

In this section, explaining the details of the proposed image forgery detection method. The illuminant color is estimated with pixel[9]and edge[10] based illuminant color estimation methods. The HOG edge[11] and color moments[12] features are used as the illuminant features.

3.1. Face extraction

In this method manual extraction of face region is used because it helps to minimizes false detectionof faces region. In the case of automatic face extraction, it may have the chance false detection of faces region as compared to manual approach. For example an image with foreground and background are illuminated with flash light and ambient light respectively. In such case illuminant color difference is hard to find out, it will leads to false detection of face region in automatic approach. This difficulty can be excluded in manual approach.

3.2. Segmentation

Segmentation is a process of segmenting an image in to region. Segmentation is a preprocessing step of illuminant color estimation. Here we are using Graph Cut Segmentation[13] approach. The main idea behind this segmentation process is, from the undirected graph G = (V, E), v Є V is the set of vertices, which is representing pixels in the image. Edges representing similarity between the pixels. That is (vi, vj) Є E is the pairs of near by vertices. For segmentation using a graph based representation of the image, define a predicate for boundary between two regions, based on this predicate develop an efficient segmentation algorithm. Nearest neighbor graph is one of the common approach to image segmentation, finding clusters of similar points.

3.3. Illuminant color estimation

*Pixel based illuminant color estimation:*The pixel values of the entire image are use for illuminant color estimation. In this method it focused on low level features. Such as Gray World, Max-RGB, Shades of Gray. Simple and less complex calculation is used for the estimation, with the help of some static variables. So it is also known as static illuminant color estimation.
Gray World Hypothesis: In Gray World, Illuminant color is estimated from average pixel values of images. Under a neutral light source or white light source, average reflectance of the entire image is achromatic (having no colors), if any deviation from this condition is due to color of illumination. This average reflected color will be the light source

color. The input image $f(x)$ with the assumption that input image is illuminated by single light source. Gijsenij and van deWeijer[14] grey world illuminant estimation in terms of minkowski norm (p-norm) written in eqn1. i.e.

$$ke = \left(\frac{\int (f^{\sigma}(x))^{p} dx}{\int dx} \right)^{\frac{1}{p}} \quad \text{, where } p = 1 \tag{1}$$

Max-RGB Hypothesis: In Max-RGB illuminant color estimated from maximum response of Red Green Blue (RGB) channel. Maximum response is obtained from perfect reflectance. A surface having perfect reflectance property will respond (reflect) for the full range of light colors it captures, when light incident on it. Then this reflected color is actually the color of light source. The input image $f(x)$, with the assumption that input image is illuminated by single light source. Computed by maximum response of 3 channel estimated. i.e.

$\max(f(x)) = \max_R(x), \max_G(x), \max_B(x)$,Gijsenij and van deWeijer[14]introduce

max-RGB estimation I n terms of minkowski norm written in eqn 2,

$$ke = \left(\frac{\int (f\ (x))^{\infty} dx}{\int dx} \right)^{\frac{1}{\infty}} \quad \text{, where } p = \infty \tag{2}$$

Shades of Gray: Gray world and the max-RGB illuminant color estimation in terms of Minkowski norm, is called shades of gray. Gijsenij and van deWeijer[14] introduce shades of grey estimation in terms of minkowski norm. Written in eqn 3, i.e.

$$ke = \left(\frac{\int (f\ (x))^{p} dx}{\int dx} \right)^{\frac{1}{p}} \quad \text{, where } p = 6 \tag{3}$$

*Edge based illuminant color estimation:*Edge based illuminant color estimation is using low or higher order derivatives. In these methods edges and colors towards illuminant direction. Points that coincide the illuminant direction is used to accurately estimate the light source color. Highlights produce that points. Edge based illuminant color estimation mainly contain, First and second order gray edge and Weighted gray edge.

First Order Gray Edge : First derivative of the reflected scene is estimated. Minkowski norm of that value will give the first order gray edge output. Mathematical expression[11] is in eqn. 4,

$$ke = \left(\frac{\int (f_x^{\sigma}(x))^{p} dx}{\int dx} \right)^{\frac{1}{p}} \quad \text{, where } p = 1, x = 1, \sigma = 0 \text{ to } 5 \tag{4}$$

Second Order Gray Edge: Second derivative of the reflected scene is estimated. Minkowski norm of that value will give the second order gray edge output. Mathematical expression[11] is in eqn 5.,

$$ke = \left(\frac{\int (f_{x,x}^{\sigma}(x))^{p} dx}{\int dx} \right)^{\frac{1}{p}} \quad \text{, where } p = 1, x = 2, \sigma = 0 \text{ to } 5 \tag{5}$$

Weighted Gray-Edge: Weighted Gray-Edge[11] algorithm is computed by,

$$ke = \left(\int | w(f)^{k} f_{c,x}(x) |^{p}\ dx \right)^{\frac{1}{p}} \tag{6}$$

Where, $f_{c,x}$is derivative of color channel $c \in RGB$ of image$f$, $w(f)$is the weighting function assign a every value of image f to a weight, to enforce the weight k is used. Weighting schemes depends on weighted gray edge algorithm.Based on the photometric properties classifying edges such as material edges, shadow or shading edges, and specular edges. A material edges is a edge that is obtained from transition of scene. Shading edges are obtained from geometrical constraints. Shadow edges generated from an object when it cover the light source. Specular edges

are edges that are generated from specular highlights, it is visible in shiny objects. Here we are using specular edge weighting scheme.
Specular Edge Weighting Scheme: In the specular direction the projected derivative of image is called the specular variant[11] and is mathematically defined as,

$$O_x = \left(f_x . \hat{C}^i \right) \hat{C}^i \tag{7}$$

Where,

$$\hat{C}^i = \frac{1}{\left(\sqrt{R^2 + G^2 + B^2}\right)} (R, G, B)^T$$

Specular weighting scheme is the ratio of the specular variant versus the total amount of derivative energy, this value gives the specular edge weighting scheme[11] given by,

$$w_{s,specular} f(x) = \frac{| O_x |}{\| f_x \|} \tag{8}$$

Where,

$| O_x |$ is the absolute value of O_x

$\| f_x \| = \left(\sqrt{f_{R,x}^2 + f_{G,x}^2 + f_{B,x}^2} \right)$

where, x is derivative order, p is minkowski norm, σ gaussian smoothening order and k is a constant.

3.4. Illuminant Map:

From the segmented output illuminant color is estimated using pixel and edge based methods with the same index number. Based on the estimated illuminant color, apply it for the segments. The resulting output will be a colored representation ofimage is termed as Illuminant Map.

3.5. Shape feature extraction – HOG Edge

From the Illuminant map edges act as a segment border. The statistical characters of edges are likely to be differ from original images, when an image is spliced. So from the illuminant map, extract selected edge points using various edge detectors. Apply these points separately into Histogram of Gradients (HOG) input to extract shape feature. HOG is used for object detection purpose and act as feature descriptors.

3.6. Color feature extraction-Color moments(CM)

Color moments are measures that characterize the color distribution in an image. Color moments are mainly used for color indexing purposes as features in image retrieval applications based on color. Inorder to find out similar image from the database images with the pre-computed features. First and second color moments such as mean and standard deviation are estimated. Color moments are scaling and rotation invariant.

3.7. SVM Classification

For classification Support Vector Machine (SVM) is used. Classify the image as either forged or original. Assuming that all input faces are illuminated by the single light source, train the SVM with two classes with one class is for forged image and other for original image. When testing operation performed based on the test feature value image is classified either forged or original.

4. Results and Discussion

To check the accuracy of forgery detection using SVM classifier, and SVM istrained with 50 forged and 50 original image. SVM is tested using a total of 50 images where 25 are original and 25 are composite images downloaded from different websites in the Internet.Forgery detection testing is done with various illuminant color estimation methods such as Gray world, max-RGB, shades of gray, first order gray edge, second order gray edge and weighted gray edge with shape feature and color feature such as HOG edge and color moments are extracted separately,and finally the combined features also test for forgery detection. Accuracy of forgery detection calculated using confusion matrix generation.Confusion matrix used to evaluate the quality of the output of a classifier.

Equation for estimating accuracy in eqn. 9 :

$$\frac{(TP+TN)}{(TP+TN+FP+FN)} \tag{9}$$

Where, True Positive (TP), True Negative (TN), False Positive (FP), False Negative (FN). Table 1 shows the results of forgery detection when using gray world illuminant estimation and table 2 shows the result of forgery detection using max-RGB estimation. Table 3 shows shades of gray estimation, table 4 & 5 shows edge based estimation in first and second order.

Table 6 shows the result of weighted gray edge estimation. For feature extraction hog edge, color moments and combination of feature is also used. Also estimated the time taken for detecting the forgery. When using combined feature, forgery detection accuracy improved.From these results, weighted gray edge perform more accurate than other methods. When using single feature for feature extraction accuracy is 50-65%. If use combined features accuracy improved to 66-74%. The outputs of whole process are shown in fig. 2 and fig3.a,b,c shows the graphical representation of the forgery detection output by using various illuminant color estimation methods. When using color moments and hog edge feature individually weighted gray edge perform more accurate, also when combines these two features weighted gray edge perform more accurate than other methods.

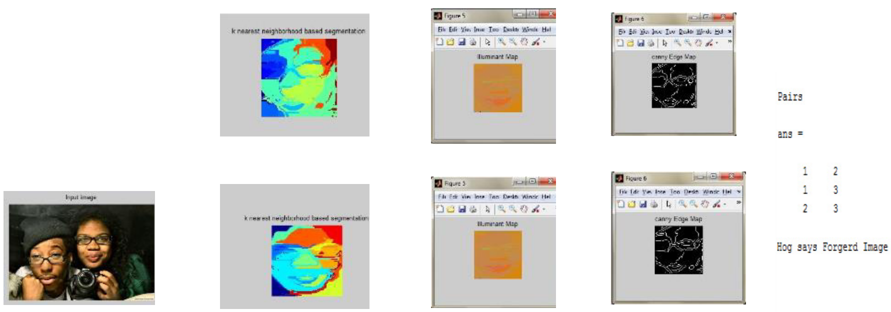

Fig.2.(a) input image; (b) segmented output; (c) illuminantmaps; (d) hog edge o/p; (e) forged o/p

Table 1. forgery detection output using Gray world estimation.

Features Used	Accuracy	Time
Hog-Edge	50	20
Color Moments	50	18
Combined Feature	66	22

Table 2. forgery detection output using max-RGB estimation.

Features Used	Accuracy	Time
Hog-Edge	52	19
Color Moments	54	20
Combined Feature	68	23

Table 3. forgery detection output using shades of gray estimation

Features Used	Accuracy	Time
Hog-Edge	46	18
Color Moments	46	19
Combined Feature	64	23

Table 4. forgery detection output -First order gray edge estimation

Features Used	Accuracy	Time
Hog-Edge	60	20
Color Moments	58	21
Combined Feature	70	22

Table 5.forgery detection o/p –Second order gray edge estimation

Features Used	Accuracy	Time
Hog-Edge	54	20
Color Moments	52	20
Combined Feature	66	22

Table 6. forgery detection output -Weighted gray edge estimation

Features Used	Accuracy	Time
Hog-Edge	68	30
Color Moments	66	34
Combined Feature	74	40

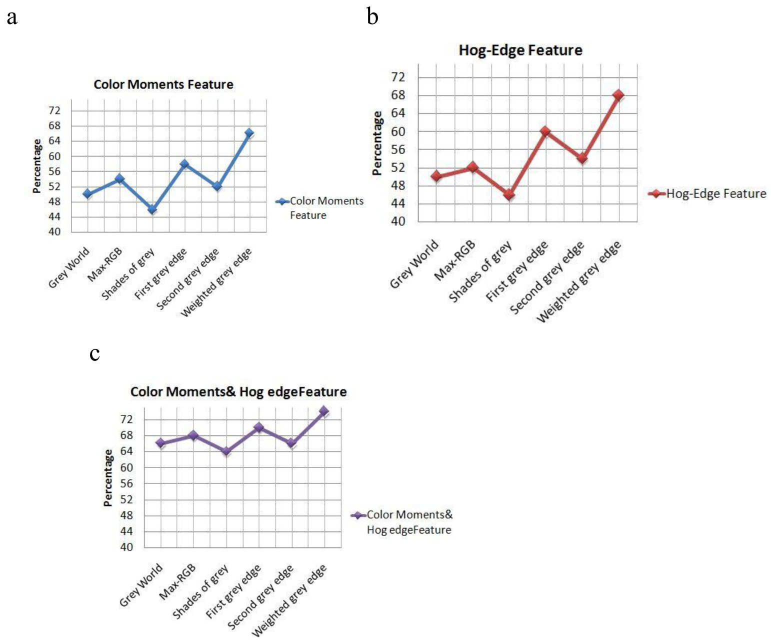

Fig.3. Graphical representation of accuracy of forgery detection (a) CM; (b) HOG Edge; (c) HOG Edge & CM.

5. Conclusion

This paper presents a new method for detecting forged images of humans using the illuminant color Estimation. A map of estimated illuminant color is generated from illuminant color estimation using Pixel and Edge based methods. Canny edge detector is used to obtain edges of illuminant map for the extraction of shape features using HOG Edge descriptor. HOG is used to get histogram of oriented gradients of edge points. Color feature extraction method uses color moments features. These two features are tested separately with different illuminant estimation methods for the comparative study. Combination of these two features is also used for forgery detection. From these results it is concluded that, the combined HOG Edge and color features gives more accuracy than the methods that use shape and color features separately. Accuracy is estimated using SVM Classifier. The Combined feature extraction with weighted gray edge testing process gives 74% of accuracy. The proposed method requires only a minimum amount of human interaction.

Reference

1. Hany Farid,Image Forgery Detection [A survey],IEEE signal processing magazine March-2009.
2. S. Gholap and P. K. Bora, Illuminant colour based image forensics, in Proc. IEEE Region 10 Conf., 2008,p. 1–5.
3. X.Wu and Z. Fang, Image splicing detection using illuminant color inconsistency, in Proc. IEEE Int. Conf. Multimedia Inform. Networking and Security, Nov. 2011, p. 600–603.
4. C. Riess and E. Angelopoulou, Scene illumination as an indicator of image manipulation, Inf. Hiding, , p. 66–80, 2010.
5. Yingda Lv · Xuanjing Shen · Haipeng Chen, An improved image blind identification based on inconsistency in light source direction, Springer Science+Business Media, LLC 2010
6. M. Johnson and H. Farid, Exposing digital forgeries through specular highlights on the eye, Proc. Int.Workshop on Inform. Hiding, 2007, p. 311–325
7. M. Johnson and H. Farid, Exposing digital forgeries in complex lighting environments, IEEE Trans. Inf. Forensics Security, p. 450–461, Jun. 2007
8. W. Fan, K. Wang, F. Cayre, and Z. Xiong, 3D lighting-based imageforgery detection using shape-from-shading,,Proc. Eur. Signal ProcessingConf. (EUSIPCO), Aug. 2012,p. 1777–1781.
9. K. Barnard, L. Martin, A. Coath, and B. Funt,A comparison of computational color constancy algorithms – Part II: Experiments With Image Data, IEEE Trans. Image Process., p. 985–996, Sep. 2002.
10.J. van de Weijer, T. Gevers, and A. Gijsenij, Edge-based color constancy, IEEE Trans. Image Process.,p. 2207–2214, Sep. 2007.
11. Arjan Gijsenij,Theo Gevers,Joost van de Weijer,Improving Color Constancy by Photometric Edge Weighting,IEEE Transaction on pattern analysis and machine intelligence,2012
12. Jau - Ling Shih,Ling - Hwei Chen, Color Image Retrieval Based on Primitives of Color Moments , European Journal of Computer Science and Informatio n Technology ,p.11-22, June 2013.
13. P. F. Felzenszwalb and D. P. Huttenlocher, Efficient graph-based image segmentation, Int. J. Comput. Vis.,p. 167–181,2004.
14. A. Gijsenij, T. Gevers, and J. van deWeijer, Computational color constancy: Survey and experiments,*IEEE Trans. Image Process.*, p. 2475–2489, Sep. 2011.