Exposing Digital Image Forgeries from Near Duplicate Images

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Abstract— **Nowadays image modification is easy due to availability of powerful digital image editing software. Images are powerful tool for communication, after images are posted on internet, other users can copy resize and re-encode them and then repost their version by generating similar but not identical copies. The main task is to find out original image between near duplicate image is difficult. It is difficult to adjust the illumination condition when Image composition or splicing operation performed on image to create composite image. Due to these illumination inconsistencies gives clue to detect forgery. But method that operate on illuminant color prone to estimation error, further improvement can be achieved by advanced illuminant estimator as skin color of the faces automatically detected in the image. After finding out the original image relationship within set of near duplicate images is shown by Image Phylogeny Tree (IPT) to finding the structure of transformation and their parameters among near duplicate image .The Technique is applicable to images containing two or more people.**

***Index Terms*— Color constancy, Forgery detection, Illuminant color, Image composition or splicing , Image Phylogeny Tree, Near duplicate Images .**

I. INTRODUCTION

Past few years have seen a considerable rise in the availability and sophistication of digital imaging technology (cameras, scanners, software) and their use in manipulating digital images. **I**mages are posted on the Internet, other users can copy perform some transformation on them and then repost their versions. Images are distributed by different information channel such as newspaper, magazines, websites and television. Due to availability of powerful tool we can easily manipulate image by using image processing techniques.

Images which are posted generating similar copies but not identical, due to which illegal contents are spread over internet to identify such duplicate images problem, researchers give name it as NDDR(Near Duplicate Detection and Recognition) It has several application such as

1)Security: To reduce illegal version of images find out the suspect information.

2)Forensics: If analysis is performed on original image better result obtained.

3)Copyright Enforcement: to analyze image recovery, its history in case the image leaks onto the Internet, potentially

Fig.1 (a) original image (b)Spliced image

having multiple variations.

By considering the concept of biological evolutionary process with analogy, we generate a tree named as Image Phylogeny Tree(IPT) to find out the history of transformation that generate this image to show the relationship between near duplicate image but the main task is to find out original image between near duplicate images. Image composition (or splicing) is one of the most common image manipulation operation. Consider example in fig. 1 in which image published in Egyptian newspaper. Egyptian minister leads the peace talk but in reality Barak Obama leads the peace talk. Authenticity of an image is investigated by forensic investigator by using all the available sources of tampering evidence. It is difficult to adjust illuminant condition during creation of manipulated image, due to illuminant inconsistencies gives clue to detect image forgeries.

Image contain faces are automatically detected by Partial Least Square analysis proposed by Scharwtz et al.[1] Illuminant Map is constructed by dividing the image into homogeneous region and each region is colored with extracted illuminant color. Features are computed based on texture and gradient based and form joint feature vector consisting of all possible pair of faces. An image as a forgery if at least one pair of faces in the image is classified as inconsistently illuminated but method that operated on illuminant color are prone to estimation error, it can be further improved by using advanced illuminant estimator as skin color information using a rough skin detector.

In Section II present related work regarding to find out the relationship between near duplicate image and also work regarding color constancy and illumination based approach to detect doctored image. Section III define computation of dissimilarity matrix and algorithm to construct IPT. Challenges of exploiting directly illuminant estimator explained in section IV. Section V present overview of proposed methodology followed by conclusion in Section VI.

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II. RELATED WORK

Based on the notion of tolerated transformation, Joly et al [2] proposes a definition what duplicate is, according to him if I_1=T(I), T ε *T,* Where *T* is set of tolerated transformation, I is original image. If image goes under family of transformation such as $I_3=T_3oT_2oT_1$ (I) on original image I, a tree of all near duplications can be constructed. If image has I_1 and I_1 has direct duplicate I_2 then Image I_2 is in turn duplicate of I.

There are two different approaches

a) Watermarking and Fingerprint based

b) Content based.

Watermarking and fingerprint rely on embedding signature in original image while content based rely on analysis of images in order to extract relevant features. Kennedy et al. [3] proposed the problem of parent child relationship between pairs of images, their low level pixel content give significant clue about parent child relationship. De Rosa *et al.* [4] aim at exploring image relationships based on the conditional probability of dependency between two images. If there is dependency between two images I_A and I_B, one of the two images can be obtained by applying image processing function to other image .In this paper work is based on De Rosa et al. approach to construct IPT.

Forgery detection method based on illumination method are either geometry based or color based .In geometry based , detecting inconsistencies between light source position [5]-[11] and object whereas in color based detecting inconsistencies between light color and object color [12],[13].

Johnson and Farid [6][7] and [8] shows detection of forgery image is more appropriate in single lightning environment but less in more complex lightning environment, proposed a low dimensional model , estimate parameter in complex lightning environment to detect forgery. Inconsistencies in the lighting model are then used as evidence of tampering. After that Kee and Farid [9] extended this approach for 3D lighting environment. In the case of faces, a dense grid of 3-D normal improves the estimate of the illumination direction. To achieve this, a 3-D face model is registered with the 2-D image using manually annotated facial landmarks. Fan *et al.* [10] used shape-from-shading technique and for the description lightening environment 3D surface normal is used. Golan and Bora [12] introduced physics-based illumination cues to image forensics and proposed a method to find the forgery in digital images by exploiting color mismatches among the objects in the image. In the proposed method, the color mismatch is decided by estimating the illuminant color of different objects in the image.

Wu and Fang assumes [13] due to splicing operation inconsistencies are introduce .Color inconsistencies which are introduced are use for forgery detection in which image is divide into block .Illuminant color is estimated from each block and difference between illuminant color is measured if greater than threshold then block is labeled as splice block. But limitation of this method is it requires manual selection of manual “reference block”.

The phenomenon of color constancy: how a visual system is able to ensure that the colors it perceives remain stable, regardless of the prevailing illumination, has received considerable attention in the context of both human and computer vision. A visual system might achieve color constancy by a variety of means and it is useful to classify approaches into color invariant, or illuminant estimation procedures. In illuminant estimation procedures, color constancy is achieved by first obtaining an estimate of the illuminant in a scene from the image data recorded for that scene. Once the scene illuminant is known, the recorded image data is corrected to discount the color of the scene light and thus render the image color constant. Color invariant approaches on the other hand, achieve constancy without explicitly estimating the scene.

Bender [14] presented an approach to multi-illuminant Estimation but in practice oversmooths the illuminant boundaries. Gijsenij [15] presented methodology that enables color constancy under multiple light sources. The methodology is designed according to the following criteria:
1) It should be able to deal with scenes containing multiple light sources; 2) it should work on a single image;
3) No human intervention is required; and 4) no prior knowledge or restrictions on the spectral distributions of the light sources is required. Although the proposed framework is designed to handle multiple light.Moritz, Hans and Erik [16] proposed a novel method to estimate illuminant color from skin color feature. In this paper, we build upon the ideas by [4] [5] and [13], edge based color constancy information by Gijsenij [17] and estimate illuminant color from skin color by Moritz [16]

III. IMAGE PHYLOGENY

Evolution of near duplicate images which are gone through transformation is described by an Image Phylogeny tree. That Requires the prior knowledge of the set of near duplicates, and also a dissimilarity function d that computes small values for similar images, and large values for distinct images, those that have suffered more significant transformations.

Let T_β be the transformation from a family *T* then dissimilarity function between two images I_A and IB is given as

$$d\, I_{A,}\, I_B = |\, I_B - T_\beta(I_A)| \qquad (1)$$

When I_A and I_B have different dimensions, d $I_{A,}$ I_B would calculate the image metric of the residual on I_B’s image dimensions, while d $I_{B,}$ IA would calculate the image metric of the residual on I_A’s image dimensions. There are two important factor while constructing image phylogeny tree from set of near duplicate image; dissimilarity function and tree building algorithm.

There are some possible image transformations an image can undergo to produce near duplicate of itself.

- Quality transformations (like blur, noise, re-encoding, and change of brightness or contrast).
- Postproduction transformations (like cropping, insertion of text or logos, picture in picture, and background replacement).

A. Image Phylogeny Algorithm

For the construction of image phylogeny tree modified oriented Kruskal’s Minimum Spanning Tree algorithm is used .Input require for algorithm is dissimilarity matrix M with respect to n near duplicate image .Interpretation in tree shows that transformation from parent to child changes in image , data structure keeps opposite in relationship pointing edge from child to parent.

```
Algorithm Oriented kruskal
Require: a dissimilarity matrix M, number of duplicate near image n
for i ε [1…n] do .                          Initialization
Parent[i] ← i
end for
Sorted ← sort positions (i; j) of M into nondecreasing order
nedges ← 0 .                        Controls stopping criterium
for each position (i; j) ε Sorted do
if (Root(i) != Root(j)) then .      Test I: joins different trees
  if (Root(j) = j) then .            Test II: endpoint must be a root
Parent[j] ← i
nedges ← nedges + 1
end if
end if
if (nedges = n    1) then .     The IPT has already n-1 edges
return Parent .                  Returning the final IPT
end if
end for
```

The main task is to detect original image between n near duplicate image .Following section explain how to detect original image within n near duplicate image.

IV. CHALLENGES IN EXPLOITING ILLUMINANT MAP

The input image is subdivided into homogeneous region of similar color .an illuminant color is locally estimated using pixel within each super pixel. Re-coloring each super pixel with its local illuminant color estimator gives an intermediate representation called Illuminant Map. Consider example Fig 3 shows image and its illuminant map in which inconsistencies can be directly observe: All fruits in scene have transition from red to blue except orange in the top right have multiple green spots which is inserted in image. Consider another example in which analysis is more challenging Fig. 4. The top left image is original, while the bottom image is a composite with the right-most girl inserted.

Consider another example in which analysis is more challenging Fig. 4. The top image is original, while the bottom image is a manipulate with the right-most girl inserted, by observing illuminant map ,there are Several illuminant estimates are clear outliers, such as the hair of the girl on the left in the bottom image, which is estimated as strongly illuminated. In Fig. 3, however, it is difficult to justify the Image is doctored or not directly hence experts concentrate on more reliable region such as faces. It is also challenging to argue, based on these illuminant maps, that the right-most girl in the bottom image has been inserted, while, e.g., the right-

Fig. 3. Illuminant map that directly shows an inconsistency

Fig. 4 Example illuminant maps for an original image (top) and a spliced image (bottom). The illuminant maps are created with the IIC-based illuminant Estimator.

most boy in the top image is original. To avoid such human decision pattern recognition scheme operated on illuminant map is use. But the estimation of illuminant color is error prone and affected by material in the scene. Hence we need advanced illuminant color estimator as skin color which provides reliable information to form scene illuminant estimator particular to faces. The notion behind this is the light penetrates into the body of material where it is scattered and selectively absorbed that form the characteristic of material. The body reflection provides characteristic of object color. Skin composed of thin layer epidermis and dermis which is thick layer. Epidermis has the property of optical filter. In dermis light is absorbed and scattered [16]. Pigmentation is the most effective skin characteristics but it depends upon many factors [18]. However the intramaterial variation is smaller than estimation error occurring due to material in scene.

V. ALGORITHMIC DETAILS

A. SASI: Statistical Analysis of Structural Information

(SASI)[19] Algorithm for texture descriptor is used to extract texture information from IM. The main advantage of using SASI is its capability of capturing small granularities and discontinuities in texture pattern. It measures the structural properties of textures.

B. HOG edge

Differing illuminant estimates in neighboring segments can lead to discontinuities in IM. Dissimilar illuminant estimates can occur for a number of reasons: changing geometry, changing material, noise, retouching or changes in the incident light. Thus, one can interpret an illuminant estimate as a low-level descriptor of the underlying image statistics. for interpretation of illuminant edge HOG edge algorithm is used. HOG edge algorithm include following step.

1) Extraction of edge point: Edge points of face region which is extracted from illuminant map by using canny edge detector [20].

2) Point description: the distribution of selected edge point is described by computing Histograms of Oriented Gradient and HOG edge descriptor is constructed around each of edge point.

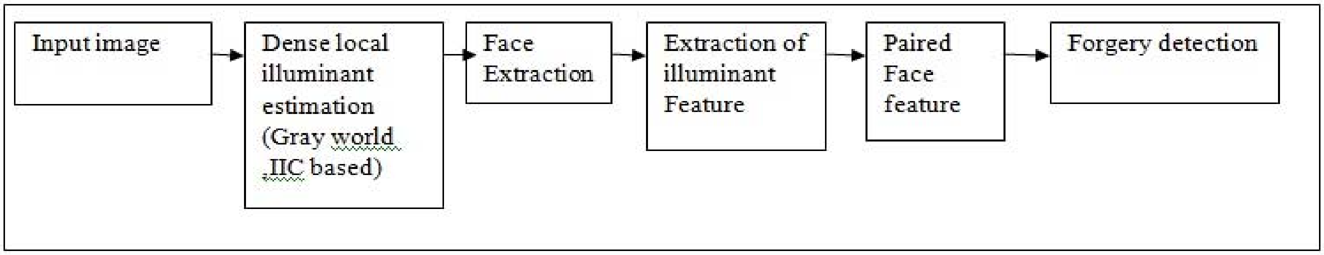


Fig. 5 Flow of proposed method

3) Visual Vocabulary: HOG vectors extracted varies due to size and structure of face under examination. Feature of fixed length are obtained by visual dictionary creation. Pseudo code for HOG edge explains below.

Algorithm 1. HOG edge visual dictionary creation
Require : V_{TR}(Training database example)
Ensure : Visual dictionary

1. $V_D \leftarrow ø$
2. $V_{NF} \leftarrow ø$
3. $V_{DF} \leftarrow ø$
4. For each face IM i ε V_{TR} do
5. $V_{EP} \leftarrow$ edge point extracted from i;
6. For each point j ε V_{EP} do
7. FV ← apply HOG in image i at position j;
8. If I is a doctored face then
9. $V_{DF} \leftarrow \{V_{DF}$ U FV } ;
10. Else
11. $V_{NF} \leftarrow \{ V_{NF}$ U FV } ;
12. End if
13. End for
14. End for
15. Cluster V_{DF} using n centers ;
16. Cluster V_{NF} using n centers ;
17. $V_D \leftarrow$ { centre of V_{DF} U centre of V_{NF} }
18. Return V_D

Agorithm 2 HOG edge face Characterization
Require: V_D, IM

Ensure : HFV (HOG feature vector)

1. HFV ← 2n dimensional vector, initialized to all zeros;
2. $V_{FV} \leftarrow ø$
3. $V_{EP} \leftarrow$ edge point extracted from IM ;
4. For each point i ε V_{EP} do
5. FV ← apply HOG in image IM at position j;
6. $V_{FV} \leftarrow \{ V_{FV}$ U FV } ;
7. End for
8. For each vector i ε V_{FV} do
9. Lower_distance ← +∞
10. osition ← -1;
11. For each visual word j ε V_D do
12. Distance ← Euclidean distance between i and j;
13. If distance < Lower_distance then
14. Lower_distance ← distance ;
15. Position ← position of j in V_D ;
16. End if
17. End for
18. HFV [position] ← HFV [position] +1;
19. End for
20. Return HFV ;

VI. Proposed Method

Method consist of five main component

A. Dense local illuminant estimation:

The input image is segmented into homogeneous region of similar color, each region is re-colored with extraction of illuminant color and give Illuminant Map (IM), Here two illuminant maps are obtained using separate color estimator as an extension of statistical generalized gray world by Weijer et al [17] and physics based inverse intensity chromaticity space proposed by Tan et al. [21].

B. Face Extraction:

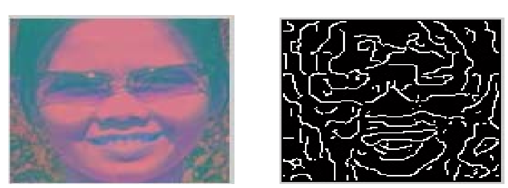
Partial least Square Analysis method is used to extract faces from images represented by bounding boxes around all faces in an image .Automatically face detector can be employed.

C. Computation of illuminant feature:

Texture and gradient based feature are extracted from IM for all face regions. SASI algorithm is used to compute feature based on texture of IM and HOG edge algorithm is used for interpretation of discontinuities in IM for neighboring segment. Incorporate skin color of faces as illuminant estimator which provides reliable information to form scene illuminant. This approach applies gamut mapping to skin pixels only: the illuminant is estimated as the mapping that can be applied to the gamut of the skin colors in the input image, resulting in a gamut that lies completely within the skin canonical gamut.

D. Paired face features:

mainly the focus is on to assess whether pair of face in image is consistently illuminated. The SASI and Hogedge descriptors capture two different properties of the face regions.



(a) (b)

Fig 5(a) face extraction from IM (b) HOG edge feature Extraction

Joint feature vector are formed such as SASI with generalized gray world, SASI with IIC, Hog edge with generalized gray world, Hog edge with IIC. The information provided by the SASI features is complementary to the information from the Hog edge features .Thus, machine learning-based fusion technique for improving the detection performance is used.

E. Classification: Machine learning approach is used to classify the feature vector .Image is forgery if at least one pair is classified as inconsistently illuminated.

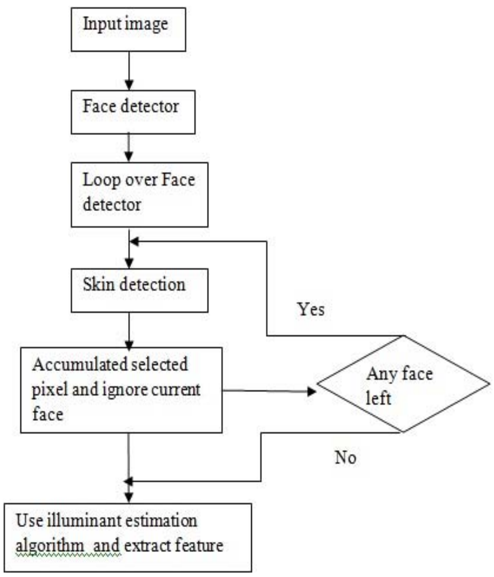


Fig. 6 Flow of skin color as illuminant estimator

Incorporating this illuminant estimator with proposed method will yield good result.

VII. CONCLUSION

In this paper, original image is detected from n near duplicate image and relationship is shown by image phylogeny tree. The main purpose to construct IPT is to find out the structure of transformation and their parameter. Illuminant color is estimated by using statistical generalized gray edge method and physics –based method as inverse intensity chromaticity color space. Join feature are extracted based on texture and gradient from illuminant Map for all face region. SASI and Hog edge algorithm are complementary to each other hence to form join feature vector late fusion technique named SVM – Meta fusion is used. We consider an image as a forgery if at least one pair of faces in the image is classified as inconsistently illuminated. Advanced illuminant estimator as skin color of faces is incorporated due to challenges in exploiting Illuminant Map and method that operate on illuminant color prone to estimation error, will yield good result. Here skin detection method is incorporated to detect forged image, so that it will helpful to detect pornography composition.

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