UNIVERSITÀ
DEGLI STUDI
FIRENZE

Scuola di Ingegneria
Corso di Laurea Magistrale in Ingegneria Informatica

Review of illuminant inconsistencies-based methods for image splicing detection

Lorenzo Cioni

Anno Accademico 2015/2016

Introduction

Digital images are easy to manipulate thanks to the availability of the **powerful editing software** and **sophisticated digital cameras**.

The development of methods for verifying **image authenticity** is a real need in forensics.

Purpose: to detect image splicing aimed at *deceiving* the viewer.

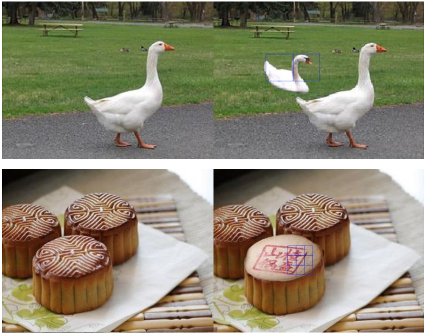
Forgery detection

Image splicing detection techniques are based on *inconsistencies*:

1. **Image resampling, copy-paste**: deduced from image metadata.
2. **Compression-based inconsistencies**: JPEG compression introduces blocking artifacts. Manufacturers of digital cameras and image processing software typically use different JPEG quantization tables.
3. **Neighboring pixels relationship inconsistencies**: when an image is spliced some artifacts can be created.
4. **Intrinsic image properties inconsistencies**: e.g. scene lights, shadows or perspective.

Lighting-based inconsistencies

Methods based on **lighting inconsistencies** are particularly *robust*: a perfect illumination adjustment in a image composition is very hard to achieve.



Lighting-based inconsistencies

These methods can be divided into two types of approaches:

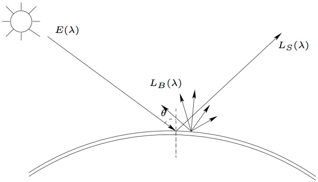
1. **Object light source inconsistencies**: detected using *shadows*, *face geometry*, *generic object surfaces*.
2. **Illuminant colors inconsistencies**: assuming that a scene is lit by the same light source, all objects must have the same illuminant colors.
   2.1 *Specular dichromatic reflectance models*
   2.2 *Illuminant Maps (IMs)*

Spectral dichromatic reflectance models

[Gholap and Bora 2008]

Reflection of any materials can be modelled as additive mixture of two components: **diffused reflection**. $L_B(\lambda)$, and **surface reflection**, $L_S(\lambda)$. So, the *reflected light* can be written as:

$$L(\Theta, \lambda) = m_S(\Theta) * L_S(\lambda) + m_B(\Theta) * L_B(\lambda)$$

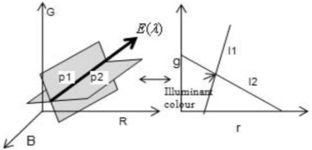


The two vectors $L_B(\lambda)$ and $L_S(\lambda)$ span the two dimensional plane called **dichromatic plane**.

Spectral dichromatic reflectance models

[Gholap and Bora 2008]

From the two *dichromatic plane*, the **dichromatic line** is estimated: given two dichromatic lines of different objects, they intersects at a point giving the chromaticity values of the illuminant color.



Detection: if a object is spliced into the image, ad error is introduced in the estimation.

Illuminant estimation / color constancy methods

Color constancy: create an image, where the object representation is independent of the illumination color. Under some assumptions this is equivalent to estimating the illuminant color.

- **Gray world, maxRGB**: statistical-based
- **Gamut mapping**: statistical-based
- **Gray edge-* methods**: statistical
- **Color by correlation**: physics-based
- **Inverse-Intensity Chromaticity** (IIC): physics-based

Illuminant Maps [Riess and Angelopuolou 2010]

Illuminant Maps locally describe the *color of the illuminant* of a image.

1. Estimate illuminant colors locally (*using IIC*)
2. Create the *illuminant map*
3. User selects a region with estimates of the dominant illuminants
4. Create a **distance map** between each local block

Image

Illuminant map

Distance map

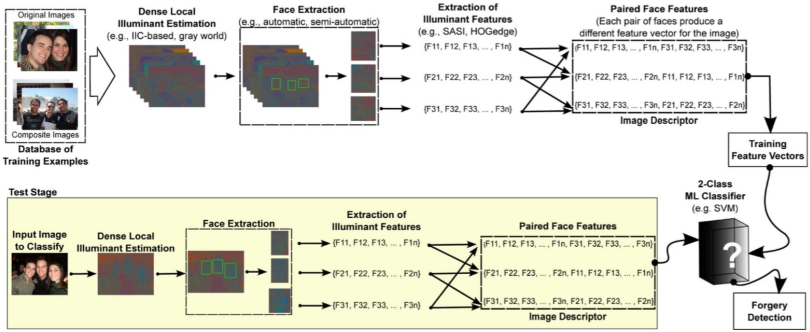
Illuminant Maps [Wu and Fang 2011]

The image is divided into overlapping blocks in order to estimate local illuminant colors.

1. Estimate illuminant colors locally (*using Gray-World, Gray-Edge and Gray-Shadow*)
2. Selecting best representation for each block using a *maximum likelihood classifier*
3. Some blocks are selected as **references**
4. Evaluate the **angular error** between suspicious block and the reference blocks: if the distance exceeds a *threshold*, the block is classified as spliced.

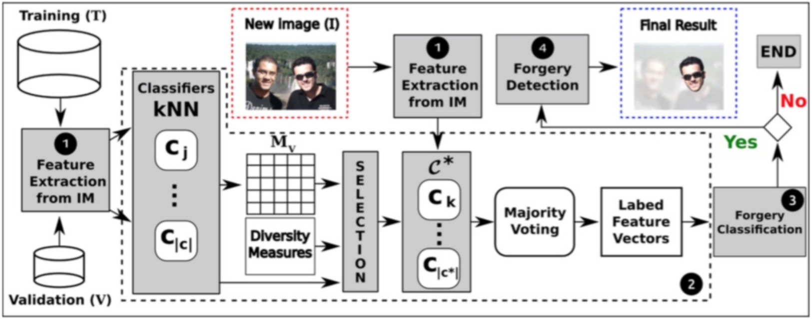
Illuminant Maps [Carvalho *et al.* 2013]

Tailored for image of *human faces*. Requires user interaction in the face definition step.



Illuminant Maps [Carvalho *et al.* 2016]

Use the **statistical differences** between pristine and edited images through specific image descriptor.

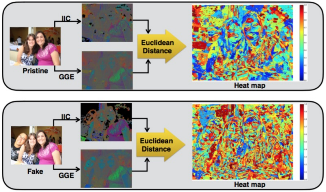


Illuminant Maps [Schetinger *et al.* 2016]

Extending previous work using different ways to use **combinations of different IMs**. It works on single ROIs.

1. IM estimation using CGE and IIC
2. **Statistical difference**:

$$\vartheta = \frac{1}{q}\sum_{i=1}^{q} \log(\|\lambda_i * (g_{GCE})^2 - \lambda_i * (f_{IIC})^2\|)$$



3. Create **image descriptor** combining multiple eigenvalues
4. SVM classifier

Riferimenti bibliografici

[1] Gholap, Sandeep, and P. K. Bora. *Illuminant colour based image forensics*. TENCON 2008-2008 IEEE Region 10 Conference. IEEE, 2008.

[2] Wu, Xuemin, and Zhen Fang. *Image splicing detection using illuminant color inconsistency*. Third International Conference on Multimedia Information Networking and Security. IEEE, 2011.

[3] C. Riess and E. Angelopoulou. 2010. *Scene illumination as an indicator of image manipulation*. In *Proceedings of the 12th international conference on Information hiding*, Berlin, Heidelberg, 66-80.

[4] T. Carvalho, et al. *Exposing digital image forgeries by illumination color classification*. IEEE transactions on information forensics and security 8.7 (2013): 1182-1194.

[5] T. Carvalho, et al. *Illuminant-Based Transformed Spaces for Image Forensics*. IEEE Transactions on Information Forensics and Security 11.4 (2016): 720-733.

[6] V. Schetinger et al. *Exploring Statistical Differences Between Illuminant Estimation Methods for Exposing Digital Forgeries*; 2016.