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Illuminant maps analysis for image splicing detection

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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 approaches

Image forensic detection techniques search for *traces* that can be grouped into:

1. **Signal level**: signal specific properties, called *footprints*, left during the editing phase that can be revealed using signal processing-based tools.
2. **Scene level**: exploiting inconsistencies in scene shadows, lights, reflections, perspective, and geometry of objects. Main advantage: being fairly independent on low-level characteristics of images, they are extremely robust to compression, altering, and other image processing operations

Lighting-based inconsistencies

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

1. **Object light source inconsistencies**
2. **Illuminant colors inconsistencies**
   2.1 *Specular dichromatic reflectance models* [5]
   2.2 *Illuminant Maps (IMs)*

Illuminant Maps estimation

For the *Illuminant Maps* estimation, two different *state-of-art* techniques are used:

1. A *statistical-based* approach using **Generalized Grayworld Estimate (GGE)** algorithm [2]. Rely on hypotheses related to statistics of image pixels (e.g. the *gray world assumption* [6]).
2. A *physics-based* approach using **Inverse-Intensity Chromaticity (IIC)** method [4]. Rely on theoretical formulations of how light interacts with objects (e.g. *the dichromatic reflectance model*)

Image

Illuminant map

Proposed approach

The current *state of the art* approaches requires human interaction.

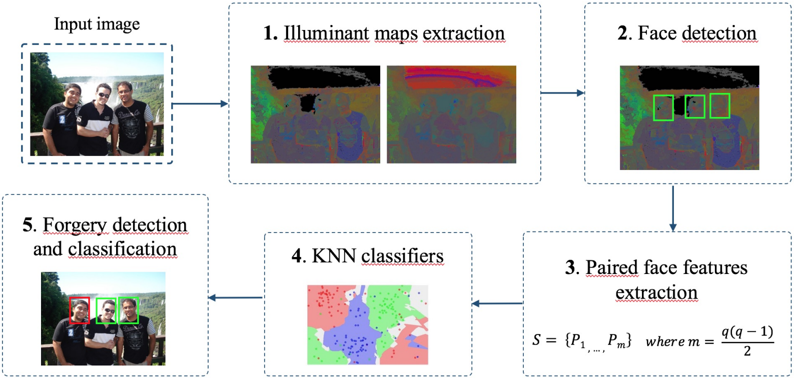
$$\Downarrow$$

Main goal: make the approach user independent.

Two different starting points:

- **Face forgery detection module**: specifically for detecting forgeries involving people. Based on the work presented by Carvalho et al. [1]. Improving and automating the detection process.
- **Regional forgery detection module**: image content independent. Based on the work presented by Fan et al. [2]. A more general and experimental approach.

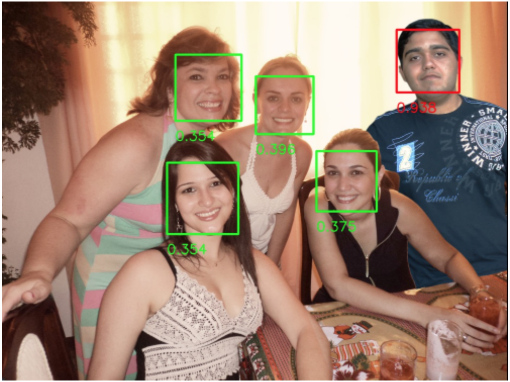
Face forgery detection module - 1



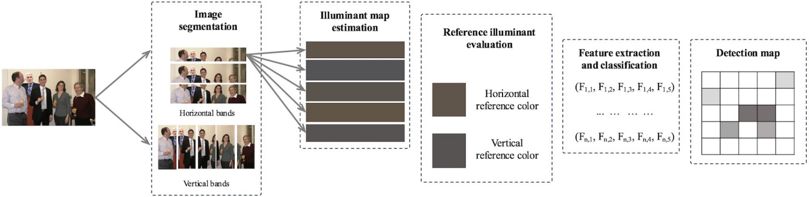
Introducing a *face detector* and *soft classification scores*.

Face forgery detection module - 2

The output of the algorithm consist in a **forgery score** for the image and a score for each detected face.



Regional forgery detection module - 1

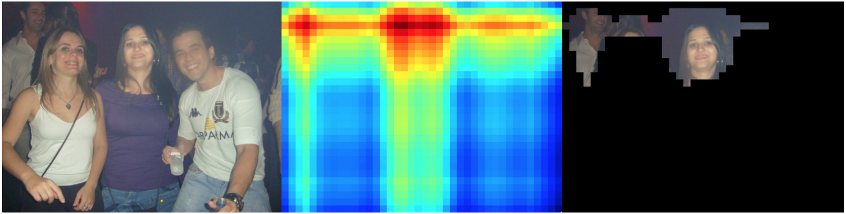


Two different considered **reference colors** are considered:

- *Median*: the median illuminant color for each direction
- *Global*: the whole image illuminant color

Regional forgery detection module - 2

The output of the algorithm consist in a **forgery score** for the image and the forgery **regional mask**.



Work best in presence of **uniform backgrounds colors** and simple light settings.

Evaluation datasets

- **DSO-1**: 200 indoor and outdoor images (100 original and 100 doctored) with an image resolution of 2048 x 1536 pixels.
- **DSI-1**: 50 downloaded images (25 original and 25 doctored) with different resolutions. Original images are downloaded from *Flickr*, doctored images collected from different websites.

Figura : DSO-1 sample spliced image

Figura : DSI-1 sample spliced image

Experimental results - 1

Experimental results for face forgery detection module.

Test case	**Train**	**Test**	**Accuracy**	**AUC**	**F-Score**
Test 1	DSO-1	DSO-1	0.84	0.90	0.78
Test 2	DSI-1	DSI-1	0.89	0.92	0.89
Test 3	DSO-1	DSI-1	0.59	0.58	0.64
Test 4	DSI-1	DSO-1	0.63	0.60	0.54

Tabella : Performance of face forgery detection module over paired faces using non-uniform weights.

Good results in cross-validation evaluations. In a cross dataset approach, the dataset used for training makes the difference.

Experimental results - 2

Experimental results for regional forgery detection module.

Test case	Train	RC	ACC	AUC	F-Score
Test 1	-	Median	0.49	0.32	0.25
Test 2	-	Global	0.52	0.40	0.27
Test 3	SplicedCC	Median	0.54	0.53	0.26
Test 4	SplicedCC	Global	0.57	0.57	0.31
Test 5	SplicedDSO	Median	0.53	0.50	0.27
Test 6	SplicedDSO	Global	0.61	0.63	0.33

Tabella : Performance of region forgery detection module

Better results achieved using the **global illuminant color** as reference.

Very low accuracy: not suitable for a forensic approach.

Conclusions

- Two different approaches for forgery detection are presented: a face forgery detection module and a generic region forgery detection module.
- Face module achieved most promising results, but it works only with images involving people forgeries.
- **Future developments**: given that our method compares skin material, it is feasible to use additional body parts, such as arms and legs, to increase the detection and confidence of the method.
- Further improvements can be achieved when more advanced illuminant color estimators become available.

References

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

[2] Y. Fan, P. Carrè, and C. Fernandez Maloigne. *Image splicing detection with local illumination estimation*. In Image Processing ICIP, 2015.

[3] J. Van de Weijer, Th. Gevers, A. Gijsenij, *Edge-Based Color Constancy*, IEEE Trans. Image Processing, accepted 2007.

[4] 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.

[5] S. Gholap and P. Bora. *Illuminant colour based image forensics.* In TENCON IEEE 2008.

[6] G. Buchsbaum. *A spatial processor model for object colour perception*. Journal of the Franklin Institute, 1980.