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Illuminant maps analysis for image splicing detection

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Introduction

This method is based on *T. Carvalho*, *V. Schetinger et al.* works presented in [1] and [2].

Main goal: finding image inconsistencies based on **illuminant estimation** in order to determine if an image has been **tampered** or not.

Illuminant Maps estimation

For the Illuminant Maps estimation, two different techniques are used:

1. A *statistical-based* approach using **Generalized Grayworld Estimate (GGE)** algorithm.
2. A *physics-based* approach using **Inverse-Intensity Chromaticity (IIC)** method.

2.1 Generalized Greyworld Estimate (GGE)

Generalized Greyworld Estimate is proposed in [2] as a combination of the *Grey-World* and *Grey-Edge method*s aimed to evaluate **color constancy**.

The main premise behind it is that in a normal well color balanced photo, the **average** of all the colors is a neutral gray. Therefore, it assumes that the *Minkowski norm* of the derivative of the reflectance in a scene is **achromatic**.

$$k\mathbf{e}^{n,p,\sigma} = \left(\int \left|\frac{\vartheta^n \mathbf{f}^\sigma(\mathbf{x})}{\vartheta \mathbf{x}^n}\right|^p d\mathbf{x}\right)^{\frac{1}{p}} \tag{1}$$

where $\mathbf{x}$ denotes a pixel coordinate, k is a scale factor, $|\cdot|$ is the absolute value operator, ϑ the partial differential operator, $\mathbf{f}^\sigma$ is the observed intensities at position $\mathbf{x}$, smoothed by a Gaussian kernel σ, p is the *Minkowski norm*, and n is the derivative order.

Generalized Greyworld Estimate (GGE)

The illuminant estimation of (1) is a framework for low-level based illuminant estimation based on three variables:

1. The order n of the image structure.
2. The Minkowski norm p which determines the relative weights of the multiple measurements from which the final illuminant color is estimated.
3. The scale of the local measurements as denoted by σ.

Advantages:

- the Minkowski norm of RGB values or derivatives can be computed *extremely fast*
- the method does not require an image database taken under a **known light source**

Inverse-Intensity Chromaticity (IIC)

Extension of the **dichromatic reflectance model**, which states that *the amount of light reflected from a point,* **x***, of a dielectric, non-uniform material is a linear combination of diffuse reflection and specular reflection*.

Given an image taken with a **RGB camera**, the response $I_c(\mathbf{x})$ for each color filter $c \in \{R, G, B\}$ is

$$I_c(\mathbf{x}) = m_d(\mathbf{x})B_c(\mathbf{x}) + m_s(\mathbf{x})G_c(\mathbf{x})$$

where m_d and m_s are geometric parameters of **diffuse and specular reflection**.

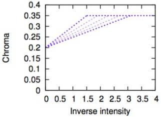
Let $\Delta_c(\mathbf{x})$ and $\Gamma_c(\mathbf{x})$ be the diffuse and **specular chromaticity**:
$\Delta_c(\mathbf{x}) = \frac{B_c(\mathbf{x})}{\sum_{iin\{R,G,B\}} B_i(\mathbf{x})}$ and $\Gamma_c(\mathbf{x}) = \frac{G_c(\mathbf{x})}{\sum_{iin\{R,G,B\}} G_i(\mathbf{x})}$

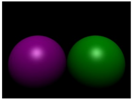
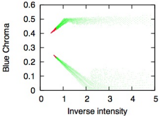
Inverse-Intensity Chromaticity (IIC)

In this model, the intensity $I_c(\mathbf{x})$ and the chromaticity $\sigma_c(\mathbf{x})$ of a color channel $c \in \{R, G, B\}$ at pixel position $\mathbf{x}$ are related by

$$\sigma_c(\mathbf{x}) = p_c(\mathbf{x}) \frac{1}{\sum_{i \in \{R,G,B\}} I_i(\mathbf{x})} + \Gamma_c(\mathbf{x}) \tag{2}$$

where $p_c(\mathbf{x}) = w_d(\mathbf{x}) \sum_i B_i(\mathbf{x})(\Delta_c(\mathbf{x}) - \Gamma_c(\mathbf{x}))$



The *domain* of the line is determined by $\frac{1}{\sum_i I_i(\mathbf{x})}$ and the *range* is given by $0 \leq \sigma_c \leq 1$. Domain and range together form the **inverse-intensity chromaticity (IIC) space**.

Riferimenti bibliografici

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

[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.