UNIVERSITÀ
DEGLI STUDI
FIRENZE

Scuola di Ingegneria

Corso di Laurea in Ingegneria Informatica

Image splicing detection with local illuminant estimation

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Anno Accademico 2015/2016

Dedica

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Introduction

Recently advanced image processing tools and computer graphics techniques make it straightforward to edit or modify digital images. In a forensics scenario, this raises the challenge of discriminating original images from malicious forgeries. Particular region from an image is pasted into other image with purpose to create image splicing.

Image splicing is a common type of image tampering (manipulation) operation. The image integrity verification as well as identifying the areas of tampering on images without need to any expert support or manual process or prior knowledge original image contents is now days becoming the challenging research problem.

Investigating image's lighting is one of the most common approaches for splicing detection. This approach is particularly robust since it's really hard to preserve the consistency of the lighting environment while creating an image composite (i.e. a splicing forgery).

In this scenario, there are mainly two main approaches:

1. based on the object-light geometric arrangement

2. based on illuminant colors

We focused our attention on the illuminant-based approach, which assumes that a scene is lit by the same light source. More light sources are admitted but far enough such as to produce a constant brightness across the image. In this condition, pristine images will show a coherent illuminant representation; on the other hand, inconsistencies among illuminant maps will be exploited for splicing detection.

Illuminant Maps locally describes the lighting in a small region of the image. In the computer vision literature exists many different approaches for determining the illuminant of an image has been proposed. In particular, such techniques are divided into two main groups: statistical-based and physics-based approaches.

Regarding the first group, we start investigating on the *Grey-World algorithm* [1], which is based on the Grey-World assumption, i.e. the average reflectance in a scene is achromatic. In [3], this algorithm proved to be special instances of the Minkowski-norm. Van de Weijer et al. [7] than proposed an extension of the Gray-World assumption, called *Gray-Edge hypothesis* [7], which assumes that the average of the reflectance differences in a scene is achromatic. The reflectance differences can be determined by taking derivatives of the image. Therefore, the authors present a framework with which many different algorithms can be constructed. We focus our attention on the last case, called generalized *Grey-World algorithm (GGE)*. The resulting illuminant maps presents also global illuminant features because of the gray-world and grey-edge assumptions.

For the latter group, was investigate the method proposed by Riess et al. [4], which extends the *Inverse Intense Chromaticity* (*IIC*) space approach proposed by Tan et al. [5] and tries to model the illuminants considering the dichromatic reflection model [6]. In this case, the illuminant map is evaluated dividing images into blocks, named superpixels, of approximately the same object color, then the illuminant color is evaluated for each block solving the lighting models locally.

Carvalho et al. [2] then presents a method that relies on a combination of the two approaches for the detection of manipulations on images containing human faces. In addition to maps, a large set of shape and texture descriptors are used together. Note that, from a theoretical viewpoint, it is advantageous to consider only image regions that consist of approximately the same underlying material:

for this reason, in [2] the authors focused their analysis on human faces.

In [2] it is also shown that the difference between the two maps, GGE and IIC, increased when fake images are processed. This insight leads to the idea that it is possible to localize tampered image regions simply by considering IM differences with some metric, avoiding the computation of multiple descriptors.

Chapter 1

Related work

1.1 Image splicing

When dealing with a digital image, it is quite common to wonder if it is original or has been counterfeited in some way. Images and videos have become the main information carriers in the digital era and used to store real world events, but they are very easy to manipulate because of the availability of the powerful editing software and sophisticated digital cameras.

The contexts where doctored pictures could be involved are very disparate; they could be used in a tabloid or in an advertising poster or included in a journalistic report but also in a court of law where digital (sometimes printed) images are presented as crucial evidences for a trial in order to influence the final judgement. So, especially in the last case, reliably assessing image integrity becomes of fundamental importance.

Image forensics specifically deals with such issues by studying and developing technological tools which generally permit determining, by only analyzing a digital photograph (i.e., its pixels), if that asset has been manipulated or even which could have been the adopted acquisition device (such an issue is not relevant to the topic of the present paper). Moreover, if it has been established that something has been altered, it could be important to understand in which part of the image itself such a modification occurred, for instance, if a person or a specific object has been covered, if an area of the image has been cloned,

if something (i.e., a face or a weapon) has been copied from another different image, or, even more, if a mixture of these processes has been carried out.

1.1.1 Some famous cases

Photography has lost its innocence since the early days of his birth. In fact already in 1860, only a few decades after Niépce created the first photo, the first manipulated photographs were identified in 1826. With the advent of digital cameras, camcorders and sophisticated photo editing software, digital image manipulation is becoming more common.

O.J. Simpson - June 1994 This altered photography O.J. Simpson appeared on the cover of the magazine Time Magazine, soon after his arrest for murder.

In fact, the photograph was altered compared to the original image that has appeared on the cover of Newsweek magazine. Time magazine was accused of manipulation of the photography in order to make darker and menacing figure of Simpson.

Figure 1.1: The Time Magazine and O.J. Simpson

Iraq - April 2003 This composition of a British soldier in Basra, which keeps pointing toward a civilian Iraqi gesticulates covered, she appeared on the cover of the Los Angeles Times, immediately after the invasion of Iraq.

Brian Walski, a staff photographer for the Los Angeles Times and a veteran of the news with thirty years of experience, was summarily fired from his publisher for their merged two of

Figure 1.2: An example of image composition

his shots in order to improve the composition.

George W. Bush - March 2004
This image, taken from promo released for the election campaign of George w. Bush, outlined a packed audience of soldiers as a backdrop to a child who was flying the American flag. This image was digitally souped-up, using a crude copy and paste, removing Bush from the podium.

After admitting the tampering with the staff of the television station edited and sent to Bush promo with the original photo.

Figure 1.3: An example of image composition

1.2 Methods based on light inconsistencies

Chapter 2

Splicing detection using local illuminant estimation

2.1 Background theory

2.1.1 Illuminant maps

Riess work

Generalized Greyworld algorithm

Inverse Intensitiy Chromaticiy

2.2 Proposed approach

2.2.1 Overview

2.2.2 Face splicing detection module

Descrizione della tecnica

2.2.3 Region splicing detection module

Descrizione della tecnica

Chapter 3

Experiments and results

3.1 Evaluation datasets

Overview

3.1.1 Columbia

3.1.2 DSO-1

3.1.3 DSI-1

3.1.4 NIMBLE

3.2 Performance

Conclusions

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