Journal of Information Security and Applications 000 (2017) 1–10

Contents lists available at ScienceDirect

Journal of Information Security and Applications

journal homepage: www.elsevier.com/locate/jisa

Detection of image seam carving by using weber local descriptor and local binary patterns

Dengyong Zhang[a,b], Qingguo Li[c], Gaobo Yang[a,*], Leida Li[d], Xingming Sun[e]

[a] School of Information Science and Engineering, Hunan University, Changsha 410082, China
[b] School of Computer & Communication Engineering, Changsha University of Science & Technology, Changsha 410005, China
[c] College of Mathematics and Economics, Hunan University, Changsha 410082, China
[d] School of Information and Electrical Engineering, China University of Mining and Technology, Xuzhou 221116, China
[e] School of Computer and Software, Nanjing University of Information Science & Technology, Nanjing 210044, China

ARTICLE INFO

Article history:
Available online xxx

Keywords:
Image forensics
Weber local descriptor (WLD)
Local binary patterns (LBP)
Kruskal–Wallis statistic
Seam carving

ABSTRACT

Seam carving is a popular content-aware image resizing technique by removing unnoticeable seams with low energies for aesthetic purpose. However, it might also be used for malicious forgeries such as object removal. In this paper, a blind forensics approach is proposed to detect resized images by seam carving. Since seam carving mainly changes local textures, two excellent texture descriptors including Weber Local Descriptor (WLD) and Local Binary Patterns (LBP) are exploited for seam carving forgery detection. Specifically, the histogram features of WLD and LBP are extracted from candidate images, respectively. Then, Kruskal–Wallis statistic is exploited to select a subset of more discriminative features. Finally, support vector machine (SVM) is exploited as classifier to judge whether an image is original or suffered from seam carving. Extensive experiment results on a large set of test images show that the proposed approach achieves better performance than the state-of-the-art approaches.

1. Introduction

With the popularity of inexpensive and portable image capture devices such as mobile phone, almost everybody can conveniently record and share digital images nowadays. Meanwhile, it is increasingly easier for ordinary users to create tampered images with various image editing software such as PhotoShop. Moreover, the tampered images are very difficult, if not impossible, to be distinguished from authentic photographs by naked eyes. Thus, image forgery detection is an active topic in the field of information security [1]. Seam carving is a widely-accepted content-aware image resizing technique for aesthetic purpose. It achieves superior resizing performance by compromising well between protecting important region and keeping overall content. Seam carving has been adopted in PhotoShop CS 6 and GIMP as adaptive scaling [2]. However, seam carving can also be used for malicious purposes. Firstly, it might be used to correct photo composition, which will be a cheating when the resultant image is used for photo competition. Secondly, it can also be deliberately used for object removal, which usually changes image semantics. Therefore, it is worthy of investigation to design a detection approach to expose those retargeted images after seam carving.

In recent years, there exist several approaches for seam carving forgery detection. Lu et al. presented an active approach to detect seam carving by exploiting the well-designed side information called forensic hash [3]. It is effective for seam carving detection and can even estimate some key parameters. However, forensic hash is usually forgery-specific and should be built in advance. Moreover, it might be removed by falsifiers. For blind detection, Sarkar et al. made the first attempt by exploiting 324D Markov features from candidate images to unveil seam carving [4]. Later, Fillion et al. proposed a detection approach by exploiting a set of intuitively motivated features such as wavelet absolute moments. For the resized images with more than 30% shrinkage, it improves the detection accuracy up to 91% [5]. Wei et al. presented a patch analysis approach for seam carving detection [6]. Suspicious images are divided into mini-squares. Then, an optimal type of patch is searched from nine types for each mini-square, which is likely to recover a mini-square from seam carving. Finally, Markov features are constructed by considering patch transition probabilities for connecting mini-squares in the subdiagonal, vertical and diagonal directions. It achieves detection accuracies up to 92.2%, 92.6% and 95.8% for resized images with 20%, 30% and 50% shrinkages, respectively. Motivated by the changes of energy and noise distri-

* Corresponding author.
E-mail address: yanggaobo@hnu.edu.cn (G. Yang).

http://dx.doi.org/10.1016/j.jisa.2017.09.003
2214-2126/

bution, Ryu et al. presented an energy bias and noise based approach for seam carving detection [7]. In our recent work, local binary pattern (LBP) is introduced into seam carving detection [8]. It exploits the same features of energy and noise bias, which are extracted in LBP domain instead of pixel-domain. Since LBP highlights the texture changes caused by seam carving, it leads to better performances over the state-of-the-art approaches.

We still believe that if the inherent mechanism of seam carving are fully considered and the visual distortions caused by seam carving are further exploited, more discriminative features specific to seam carving forgery are possible to be designed to improve detection accuracy. The content-aware mechanism of seam carving makes the resized images without any common and noticeable distortions such as blurriness in blind forensics. Instead, information loss and possible shape distortions such as geometric deformation are the main artifacts of seam carving. However, it is still an open issue to measure geometric deformation and information loss without reference image in the field of image quality assessment (IQA). This is also a great challenge for seam carving detection. Thus, local and global texture changes are more feasible for seam carving detection than explicitly modeling shape distortions and information loss. In our earlier work [8], LBP, which is a simple yet effective local texture descriptor, is exploited to unveil local texture changes for seam carving detection. However, LBP considers only the signs of pixel differences between central pixel and its neighboring pixels. That is, LBP-based feature is an index of discrete patterns rather than a numerical feature, and can not provide any intensity information about image texture [9]. Luckily, weber local descriptor (WLD) is also an excellent texture descriptor for texture description and classification. It is composed of differential excitation and orientation [10]. Motivated by the fact that multiple texture descriptors might significantly improve texture classification performance compared with single descriptor, we attempt to simultaneously exploit LBP and WLD for feature extraction to improve the accuracy of seam carving forgery detection. Specifically, candidate images are firstly divided into blocks, and both LBP-based and WLD-based histogram features are extracted from each block. Then, Kruskal–Wallis statistic is exploited to select a subset of more discriminative features from them. Finally, SVM is exploited as classifier to judge whether an image has been suffered from seam carving or not.

The rest paper is organized as follows: Section 2.1 summaries image seam carving and makes a preliminary analysis of its detection. Section 3 briefly introduces LBP and WLD. Section 4 presents the proposed blind detection approach. Section 5 reports the experimental results and analysis, and we conclude this paper in Section 6.

2. Image seam carving and its possible artifacts for blind forensics

2.1. Preliminaries of seam carving

Seam carving is a content-aware image resizing technique. A seam is an 8-connected path of single pixel width, either from top to bottom or from left to right. Let I be an image of size $M \times N$. Let a vertical seam be an example. It is restricted by the horizontal offsets of no more than one pixel between adjacent rows. That is,

$$s^v = \{(i, col(i))\}_{i=1}^{n}, s.t. \forall i, |col(i) - col(i-1)| \le 1 \tag{1}$$

where i and $col(i)$ are the row and column coordinates, respectively. A vertical seam s is defined by summing the energies of those pixels along a connected path from top to bottom. Please note that the optimal seam s^* is found by minimizing the energy via dynamic programming, as shown in Eq. (2). The energy value of single pixel is given by Eq. (3), which is a Sobel-operator-based function.

$$s^* = \min_s \{E(s)\} = \min_{s, s=\{s_i\}_{i=1}^{n}} \left\{ \sum_{i=1}^{n} e(I(s_i)) \right\} \tag{2}$$

$$e(I) = \left| \frac{\partial}{\partial x} I \right| + \left| \frac{\partial}{\partial y} I \right| \tag{3}$$

To remove a vertical seam, the most adjacent pixels, which are located at the right side of those pixels along this seam, are moved left one pixel to fit the gap left by seam removal. Since a seam is a connected path with minimum energy, removing such a seam has less impact on the resultant image. In most cases, image seam carving preserves well visually important content by successively removing unnoticeable seams. Fig. 1 is an example of image seam carving with 30% vertical shrinkage. Fig. 1(a) is the original image. From Figs. 1(b) and (c), we observe that seams firstly pass through those pixels with lower energies. Fig. 1(d) is the resultant image. Apparently, seam carving keeps well the most important region of interests such as the castle, and does not leave any visually noticeable artifacts such as blurriness. In such a natural manner, seam carving is attractive for content-aware image retargeting.

However, seam carving still might lead to three types of possible artifacts, which include global structure deformation, local texture distortion and information loss [11]. Fig. 2 shows an over-squeezed image by seam carving, in which there is global structural deformation. It is straightforward that objective quality assessment of retargeted image might play an important role in seam carving detection. In the literature, there exist a few approaches for the quality assessment of seam carving. Fang et al. proposed a structural similarity-based objective assessment method for image retargeting [12]. A structural similarity map (SSIM) is defined to indicate how the structural information in source image is preserved in retargeted image. Hsu et al. also presented an objective quality assessment approach for image retargeting by exploiting perceptual geometric distortion and information loss [11]. However, to the best of our knowledge, these existing approaches are full-reference image quality assessment (IQA) approaches [13], which makes them unsuitable for the purpose of blind detection. That is, it is still an open issue to explicitly model retargeting distortions without reference images.

2.2. Most possible clue for seam carving detection

Among the possible artifacts caused by seam carving, geometric distortion is the most annoying since it usually leads to visually unpleasant shape deformation of prominent object. This implies that even without the aid of passive forensics, geometric distortion is highly likely to be perceived by naked eyes. Thus, geometric distortion seldom occurs in practical seam carving detection cases. For information loss, it is also a common concern for seam carving, its quality assessment and blind detection. However, it can be resolved in seam carving by integrating with other resizing techniques such as cropping and adaptive scaling or taking saliency map into the definition of energy function. Actually, seam carving keeps well the main content that an image conveys, especially its semantic information. Unluckily, it is still an unresolved problem to objectively measure the information loss caused by seam carving. Even for full-reference IQA approach, it is not trivial to assess the information loss with the original image as ground truth. In [11], a simple saliency loss ratio (SLR) is presented to measure the information loss. SLR is defined as the percentage of lost saliency map in image retargeting with respect to the original saliency map. Apparently, SLR is image content-dependent, which makes it contribute just a little for IQA. Since original images are unavailable