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Detecting seam carving based image resizing using local binary patterns

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ABSTRACT

Seam carving is the most popular content-aware image retargeting technique. However, it can also be deliberately used for object removal tampering. In this paper, a blind image forensics approach is proposed for seam-carved forgery detection. Since seam carving changes the local texture in an image, a local texture descriptor, i.e., local binary pattern (LBP), is exploited as pre-processing to highlight the local texture artifacts. Moreover, six new half-seam features are defined to unveil the energy changes in half images. They are combined with the existing eighteen energy bias and noise-based features to form twenty-four features. These features are extracted in LBP domain, instead of the conventional pixel-domain to highlight the local texture changes. Finally, support vector machine (SVM) classifier is exploited to determine whether an image is original or suffered from seam carving. Experimental results show that compared with the state-of-the-art methods, the proposed approach improves the detection accuracy by 3.5–19.1% for resized images with different scaling ratios.

1. Introduction

Content-aware image resizing (CAIR) has attracted increasing research attention with the rapid growth in mobile computing (Rubinstein et al., 2010). Among those CAIR techniques, seam carving (Avidan and Shamir, 2007) is the most widely accepted. Seam is defined as an eight-connected path of pixels, either vertically or horizontally. Successive removal of the optimal seams with lower energies allows reduction in image size. Because of its excellent performance, seam carving has been integrated into popular image processing softwares for adaptive scaling, such as Adobe Photoshop, GIMP, ImageMagic and iResizer. However, seam carving can also be deliberately used to remove an object from an image. Since the removed object is generally a semantic object, it might change the semantic content that an image conveys. Thus, seam carving can be deliberately used for object removal to achieve malicious purpose. Therefore, it is important to design a detection method for those images which suffer from the possible seam carving.

Up to present, there are a few existing approaches for the detection of seam carving operation. Lu et al. proposed an active forensics method based on forensic hash, which is actually the

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side information specifically designed for image seam carving (Lu and Wu, 2011). However, it has two drawbacks: First, falsifiers can easily remove the forensic hash since it is attached at the header of an image file. Second, since forensics hash is an active method, it must be built in advance. The earliest work for the passive detection of image seam carving is proposed by Sarkar et al. (2009). Inspired by the statistical features for image steganalysis, 324-dimensional Markov features are exploited for seam carving detection. However, it only achieves a detection accuracy of no more than 77.3%. Fillion et al. proposed a set of image features such as wavelet absolute moments for the detection of seam carving (Fillion and Sharma, 2010), which achieves a detection accuracy up to 84.0% and 91.3% for resized images with scaling ratio of 20% and 30%, respectively. Later, some passive forensics approaches are proposed for the detection of seam carving in JPEG images. Liu et al. proposed a shift-recompression-based feature mining approach to detecting seam-carved forgery in JPEG images (Liu et al., 2012). It can discriminate forged JPEG images from intact JPEG images. Liu and Chen also addressed the seam-carved forgery detection from the steganalysis point of view (Liu and Chen, 2014). An improved detection approach is proposed for seam-carved forgery detection in JPEG images, which merges calibrated neighboring joint density and rich model-based steganalysis (Xia et al., 2014). Moreover, Chang et al. proposed another detection method to detect seam carving in JPEG images (Chang et al., 2013). It is based on the facts that the seam-carved forgery might destroy the regular symmetrical property of blocking artifact characteristics matrix (BACM). Eighteen features are defined to detect the damage of BACM, and the support vector machine (SVM) classifier is trained to determine whether an image is an original or it has been suffered from seam-carving. Recently, Wei et al. (2014) proposed a patch analysis method to detect seam carved images. Images are firstly divided into 2×2 blocks, referred to as mini-squares, and then searched for one of nine types of patches that are likely to recover a mini-square from seam carving. The patch transition probability among three-connected mini-squares is exploited to improve the detection accuracy. It is reported that accuracies of 92.2% and 95.8% are achieved for 20% and 50% seam-carved images, respectively. In addition, Ryu and Lee (2014) exploited the energy bias and noise of suspicious images to reliably unveil the traces of seam carving, and superior performance was achieved as well.

However, the existing approaches cannot fully meet the needs of forensics. We believe that if the inherent nature and important properties of the seam carving process are fully considered, there is still some scope to further improve the detection accuracy. Different from other image tampering techniques such as image-inpainting, removing seams from an image does not necessarily bring visually annoying artifacts such as ghosting shadow or blurriness. This is actually the main challenge for the blind detection of image seam carving. In most cases, removing seams from an image only changes the local texture and the energy distribution. Therefore, the key issue of detecting seam carving is to design more sensitive features which can reflect the inherent nature of the seam carving process.

In this paper, a novel blind detection approach is proposed for detecting image seam carving using local binary patterns (LBP). In essence, LBP is a local texture descriptor which has been widely used in various image analysis applications (Ojala et al., 1996, 2002). By experiments, we find that when seams are carved out from an image, there are significant changes for the LBP values of those pixels along a seam. Therefore, we are motivated to extract the statistical features in the LBP domain, since they will be more sensitive than the same features extracted from the conventional pixel-domain. Meanwhile, it is widely-known that image seam carving functions well by removing those seams with minimum cumulative energies defined by the energy function. After removing those seams with relatively lower energies, the energy distribution will be greatly changed. Thus, the design of forensics features for image seam carving should be closely related to the energy bias within an image. Furthermore, six new half-seam features are defined to unveil the energy bias in upper half images. These six features are combined with the existing eighteen energy bias and noise-based features (Ryu and Lee, 2014), but they are also extracted in the LBP domain to form twenty-four features for pattern classification. Specifically, support vector machine (SVM) classifier is exploited to determine whether an image is original or suffered from seam carving. Experimental results show that the proposed approach achieves superior detection performance over existing approaches.

The remainder of this paper is organized as follows. Section 2 briefly reviews seam carving algorithm. Improved energy feature work on LBP matrix is calculated in Section 3. The experimental results are reported in Section 4 and we conclude this paper in Section 5.

2. Image seam carving

CAIR indicates that visually important region of interest (ROI) is not affected (or minimally affected) by an image resizing process. Rubinstein et al. (2010) firstly introduced the concept of seam carving into CAIR techniques. By defining a gradient related energy function, the seams with lowest energy are identified (Dong et al., 2009; Rubinstein et al., 2008, 2010). A seam is an 8-connected path of pixels crossing the image from top to bottom, or from left to right. Therefore, a vertical seam for an $n \times m$ image I is defined as Eq. (1), where i and col(i) denote row coordinates and the corresponding column coordinates, respectively. A horizontal seam is also defined similarly.

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

By successively removing seams which have as low energies as possible, the important image content is preserved during the resizing process. For this reason, the energy of each pixel is first measured by the energy function e.

$$e(I) = \left|\frac{\partial}{\partial x} I\right| + \left|\frac{\partial}{\partial y} I\right| \tag{2}$$

From the energy function e at a pixel, the energy of a vertical seam $E(s)$ is defined as follows: