A Patch Analysis Approach for Seam-Carved Image Detection

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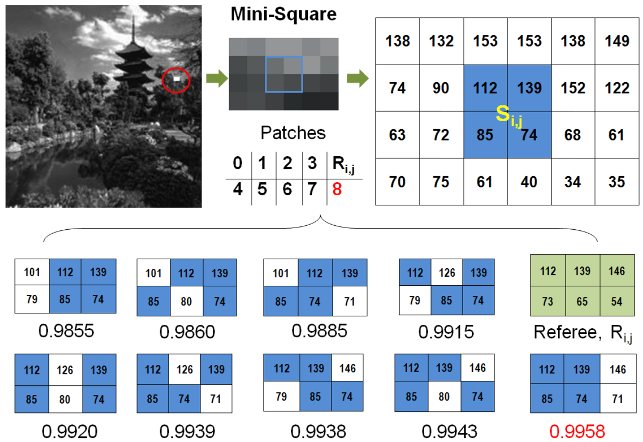

Figure 1: *Selection of the Optimal Patch Type. There are nine manners patching the mini-square to the referee pattern. In this example, the eighth type is selected as the optimal.*

1 Introduction

Seam carving is a content-aware image resizing method [Shamir and Avidan 2007], which assigns Sobel-operator-based energy to each pixel and describes seams as the eight-connected paths of pixels. Successive removal of the optimal seams, i.e., those seams with the lowest sum of energy, allows reduction in image size. Pixels with lower energy are generally removed earlier; implying that (1) the modifications to the image are difficult to identify and (2) low energy can be deliberately assigned to particular objects so that they can be removed from the image. These two observations reveal that, although difficult, it is important to design a seam carving detection method.

Existing methods to detect seam-carved images can be categorized into two classes: those derived from steganography attacks and those based on other statistical features. Sarkar et al. introduced a steganography attacking algorithm for seam carving detection in 2009 [Sarkar et al. 2009]. This algorithm uses a 324-dimensional Markov feature consisting of 2D difference histograms in the 8×8 block-based discrete cosine transform domain for input into an SVM classifier system. This way, although proven to be well suited to steganography attacks ($> 96\%$ accuracy), yields accuracies of 70.4% and 77.3% for detecting 20% and 30% seam-carved images respectively.

Fillion and Sharma proposed some new detection methods for seam-carved images in 2010 [Fillion and Sharma 2010]. The basic idea behind these methods includes the bias of energy distribution, the dispersal of seam behavior, and the affection of wavelet absolute moments. These statistical features achieved higher detection accuracies of 84.0% and 91.3% for 20% and 30% seam-carved images respectively.

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2 Our Approach

We believe that the detection accuracy can be further improved by finding an adequate detection method for seam-carving behavior. Specifically, the desired feature must reflect the fact that several insignificant pixels have been removed during the seam carving process. Here, we propose a novel method, referred to as "patch analysis" to detect seam-carved images.

After converting the test image into its intensity component I, our method divides I into 2×2 blocks called *mini-squares* . A mini-square, $S_{i,j}$, is defined as follows:

$$S_{i,j} = \begin{bmatrix} I(2i, 2j) & I(2i, 2j+1) \\ I(2i+1, 2j) & I(2i+1, 2j+1) \end{bmatrix}. \quad (1)$$

For each mini-square, we have nine types of 2×3 patches that roll it back from possible seam carving effects. These patches, shown in Fig. 1, can be constructed by interpolation between adjacent pixels. We also have a referee pattern for deciding the optimal patch type. The referee pattern, $R_{i,j}$, is a 2×3 image pattern generated from the local area of the corresponding mini-square:

$$R_{i,j} = \frac{1}{4} \sum_{a=0}^{1} \sum_{b=0}^{1} \begin{bmatrix} I(2i-1+a, 2j-1+b) & I(2i+1+a, 2j-1+b) \\ I(2i-1+a, 2j+b) & I(2i+1+a, 2j+b) \\ I(2i-1+a, 2j+1+b) & I(2i+1+a, 2j+1+b) \end{bmatrix}^T. \quad (2)$$

Using cosine similarity as the criterion, we assign each mini-square one type number in $\{0, 1, \cdots, 8\}$ to indicate the optimal patch type. We can consequently calculate three *patch transition probability matrices* that connect the mini-squares in three directions, namely, subdiagonal, vertical, and diagonal. The entries in these three 9×9 matrices, together with the probabilities of the nine types, form a 252-dimensional detection feature. This feature is sent to an SVM classifier system that detects whether the test image has been seam carved. While our description only focuses on detecting those images with vertical seam carving, the proposed method can be used to detect horizontal seam removal in a similar manner.

Our method results in the currently best detection accuracies, namely, 92.2%, 92.6% and 95.8% for 20%, 30% and 50% seam-carved images respectively. Besides the detection accuracy, this method has potential applications that deserves further research, for example, identification of the hot regions frequently crossed by carved seams.

References

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