Interactive Colorization via Multi-Cues Manipulation

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ABSTRACT
Colorization plays an important role in image processing, which aims to change the original image color according to specific image color characteristics. In this article, the authors present a regional color editing method based on multi-cues manipulation, including interactive segmentation, inpainting and gradient-preserving optimization. Firstly, the user draws strokes specifying the target region which needs to change color, through which the target image can be segmented by the K-means color clustering method. Then the example-based inpainting technology is applied to achieve natural transition along the boundary. After color propagation, they apply an optimization algorithm to preserve the gradient. The experiment results demonstrate that the proposed approach can not only achieve a visual satisfactory local color propagation results, but also preserve the texture details well.

KEYWORDS
Colorization, Gradient Preservation, Image Inpainting, K-Means Clustering, Local Editing

INTRODUCTION
To change the appearance of or reconstruct an object or scene, some computer technologies need to be applied, such as 3D reconstruction (Zhang, 2010), image editing. Color editing is an essential operation in image editing. However, there exists two challenges that significantly influence the quality of the color editing. First, due to the complexity of the color ingredient, it is not easy to find a perfect mapping relationship among numerous colors. Second, the complicated distribution of colors decides that it is hard to automatically find out the expected regions which should be edited. To address these two problems, this paper proposes a novel regional colorization via multi-cues manipulation.

The proposed regional colorization method includes 4 stages, interactive strokes-driven region segmentation, inpainting-based boundary correction, statistical color transfer and gradient-preserving optimization. As an interactive algorithm, users need to prepare the target and reference image and draw some strokes to specify corresponding colors respectively. The strokes need to cover all the colors for the correct segmentation. The pixels of the target image are classified using the K-means color clustering with users’ specifying, which roughly cuts Region of Interest (ROI) out. The boundary of that region is modified by inpainting. Subsequently, color propagation is applied to the corresponding ROI pixels. With boundary correction, the transition from ROI to background is

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much more natural and believable. Finally, a gradient-preserving optimization algorithm is applied to preserve the texture details.

The contributions of this paper include three aspects: 1) propose the color clustering for region segmentation; 2) introduce example-based inpainting to boundary correction; 3) apply the gradient-preserving optimization algorithm to improve the detail performance. The rest of this paper is organized as follows. The state-of-the-art work in colorization can be summarized into global and local paradigms in Section “Related Work”. The technical details of each stages in the proposed method are presented in Sec. “Multi-cues Interactive Colorization Model”. Subsequently, some experimental analysis is discussed, and finally the conclusion is drawn.

RELATED WORK

Generally speaking, colorization could be roughly classified into two categories--global colorization and local colorization. Both of the two are essential tools for various visual editing task. Global colorization conveys the whole color characteristics of a reference image to a user-specified target image. Reinhard et al. (2001) proposed a global color mapping method mapping a reference image’s color characteristics to another target image using statistical analysis. The color of the reference image is propagated corresponding to the mean and standard deviation of the colors in the target image, keeping the image content naturally. As effective as it is, the quality of colorization relies on the similarity between target and reference images.

Subsequently, lots of complementary methods are proposed to improve Reinhard’s statistical mapping method (Reinhard et al., 2001) to achieve better color stylization results. Chang et al. (2005) proposed a basic color categories-based method that was applied within each pair of convex hull of the same category. Similarly, some approaches of mapping are presented, e.g. Tai et al.’s probabilistic segmentation color transfer (Tai et al., 2005), Wang et al.’s data-driven image color theme enhancement (Wan et al., 2010), Dong et al.’s dominant colors mapping based method (Dong et al., 2010) and Wang et al.’s training based method (Wang et al. 2011).

Many algorithms have been proposed for local colorization. An important color editing method is the propagation of new color to the whole image, e.g. Lischinski et al.’s adjustment method (Lischinski, 2006), Levin et al.’s optimization based colorization method (Levin et al., 2004) and Farbman et al.’s diffusion maps image editing method (Farbman et al., 2010). Besides, image segmentation is a simple and feasible solution of local colorization. Wen et al. (2008) proposed an image enhancement system by using the interactive color transfer algorithm based on an improved graph cut segmentation and a Gaussian probability-weighted color mapping. Editing propagation is an important theory for local color transfer. Wang et al. (2011) presented the mean value coordinates based local color transfer method. Li et al. (2010) cast the editing interpolation to the radial basis function interpolation, improving the efficiency of color transfer for large image and video. Chen et al. (2012) proposed a manifold-preserving colorization method by locally linear embedding (LLE) to represent each pixel as a linear combination of its neighbors in a feature space. Xu et al. (2013) proposed a sparse control model to generate a sound color division during the color propagation, in which the influence of edit samples is determined taking spatial distance, sample location and appearance into account. Yang et al. (2012) discussed the boundary artifacts are discussed and proposed a boundary correction scheme based on edge-aware filter to solve this problem in local color transfer.

A good color propagation algorithm should retain the content of the original image in the correct color relationships, while applying the desired color style. More and more researchers take detail preservation into account. Pitté et al. (2005) converted the high-dimensional color matching problem to one dimension PDF matching problem, and combined the gradient preserving scheme to maintain the color distribution of the image. Xiao et al. (2009) constructed the color transferred image by combining the reference image’s color histogram and the target image’s gradient map. Pouli et al. (2011) applied image decomposition into histogram matching. Bae, Paris & Durand (2006)
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