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Two-Staged Image Colorization Based on Salient Contours

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***Abstract*—In this paper we present a novel colorization technique that manages to significantly reduce color bleeding artifacts caused by weak object boundaries and also requires only abstract color indications and placement from the user. It is essentially a two-staged color propagation algorithm. Guided by the extracted salient contours of the image, we roughly mark and divide the image in two differently treated image area categories: Homogeneous color areas of high confidence and critical attention-needing areas of edges and region boundaries. The method was tested with user drawn scribble images, but can be easily adopted by image exemplars employing techniques, as well.**

I. Introduction

Colorization is the process of adding color to monochrome images and video. A large amount of colorization approaches have been recently introduced, motivated by the need to colorize and bring to life historic grayscale images and movies and for providing color restoration/re-colorization solutions for destroyed fresco wall paintings and other various art items that gradated due to time and poor storing conditions. The desired colorized output is evaluated based on the achieved naturalness (i.e. correct colors applied on known objects and components of the image) but must also be visually pleasing (i.e. successful color blending and accurate color alterations on object boundaries).

To make a first rough classification, colorization methods can be distinguished to those that demand user drawn scribbles and those that employ colored reference images. In all cases the first objective is to create color marks on the target image. For interactive methods such as [1], [2], [3], [4], [5] the marks are placed by the user. This introduces the key weakness for such approaches. Extensive efforts and strategically placed color marks are demanded in order to achieve quality results. On the other hand, color transferring from reference images [6], [7], [8], [9], [10], [11] adds a significant computational burden to the overall colorization method, requiring careful tuning of various parameters. First the reference image must be accurately retrieved from image collections and multiple transformations and computations are needed before it can be used to correctly color-mark the respective image patches in the target image. Moreover, in many cases the reference image does simply not exist (discolored historic art work) or is impossible to identify (man-made objects that may be found in a variety of color combinations).

After creating color marks on the target image, all colorization techniques continue by utilizing these hints to initiate a color propagation algorithm. Color blending and accurate color alterations on object boundaries is critical in order to achieve natural looking colorized results. Traditionally, colorization methods employ some sort of propagation algorithm to spread color information provided in the form of marked pixels area. Assuming that a local linear relation between color and intensity exists [12], [13], [14], [15], researchers have tested various weighting functions (affinity functions) to correlate intensity values between image pixels.

In this direction, Levin et. al [1] proposed an interactive colorization technique, based on the premise that neighboring pixels that have similar intensities, should also have similar colors. Their method provides an effective framework for colorization tasks and is widely used in the literature [8], [7], [9]. Levin's propagation algorithm and more recent techniques based on the same propagation principal, suffer from color bleeding artifacts. Since no boundary/region information is incorporated, when different neighbouring regions present similar distribution of intensities the color diffuses from one region to another, causing visually obvious colorization mistakes. Furthermore, because these algorithms correlate every pixel to all other pixels in an image, when the user fails to assign a color mark for every possible image region, the closest color mark from another region spreads until the whole image is colored.

Thus, in order to achieve quality results the user must carefully produce the scribble image and essentially provide indirect information of object and color boundaries. In an attempt to confront this issue, more recent methods proposed edge detection and image pre-segmentation schemes to prevent undesired color blurring [7], [5], [9], and to better assign color propagation weights, but introduced a considerable computational overhead to the overall procedure.

Studying the core drawbacks of previous widespread techniques, we are aiming to produce a light-weighted system that will demand less color information and a more abstract color-marks placement while at the same time, it will colorize with focused attention on object boundaries regions so as to prevent color bleeding artifacts.

II. The Proposed Method

This section summarizes all the technical details of our colorization implementation. The block diagram of the process is depicted in Figure 2.

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