Find and Replace Color Gradients

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We propose a simple interactive technique for adjusting the global color balance of an image by finding and replacing color gradients. Our aim is to make it easier to control interactive color correction, a common user task in digital photography and video processing. For instance, our technique can assist in compensating for scene illumination, selectively emphasizing scene details, and applying a color scheme to impart a particular mood or theme. It may also prove useful in calibrating the mapping between the disparate color gamuts of different capture and display devices. In information visualization, color adjustment plays an important role in post-processing, where color distinctions are used to direct the viewer's attention to the relevant structure of the data. Our technique enables the user to improve the color composition of an image by choosing a harmonious combination of colors and adjusting their contrasts to highlight the key elements of the picture.

The user designates a set of source color gradients and a matching set of target color gradients to guide the algorithm in performing a continuous transformation of the image colors. As a line segment in color space, a color gradient is traditionally specified by the Cartesian coordinates of its endpoint colors. To direct color changes, a more flexible parameterization is offered by its spherical coordinates, composed of the central midpoint color, the color contrast radius, as well as the color orientation angles, the hue angle and the luminance angle. For a color shift, translate the midpoint. For a contrast adjustment, expand or contract the radius. For color variations, rotate the orientation angles. In this way, the user has independent control over color and contrast changes. Compared with previous work, our approach benefits from operating on color spans rather than individual colors. While a mapping between colors suffices only to define a translation in color space, a mapping between color gradients defines a more general affine transformation. Moreover, color gradients provide a convenient method for selecting object features, encompassing variations in surface orientation and reflectance.

We apply a feature-based warping technique to calculate a nonlinear volumetric deformation of the color space. First, we need to choose a color space that is appropriate for use in interactive color correction. A suitable color difference measure is applied to determine how the transformation of each color gradient should affect its surrounding colors. Euclidean distance in the perceptually uniform CIE-Lab color space can be extended to a weighted formula that allows the user to specify the relative importance of luminance, saturation, and hue differences. According to the GLAB formula, it is possible to set the default values of these weights to optimally represent human perception of large color differences. To assess the perceptual dissimilarity between categorically different colors, we rely on Shepard's model of generalization. Having obtained the field of influence of each color gradient mapping, we proceed to derive the linear transformation that maps its source gradient to its target gradient using Rodrigues' formula. Hence, the transformation of each color in the color space is governed by a sum combining the color gradient transformations weighted by the relative strength of their influence on the given color with the identity transformation weighted by the absolute lack of any influence on the given color. In effect, the resulting image can be seen as a composite of the original image and its color gradient transformations, with the mask of each layer determined by the region of influence of its color gradient.

Our talk will present the results of our technique, with a view towards the aesthetic consideration of color and contrast in graphic design. We will also briefly introduce our other work in interactive image enhancement developed at the Computer Laboratory of the University of Cambridge, including contrast brushes for local contrast enhancement and histogram warping for global contrast enhancement.

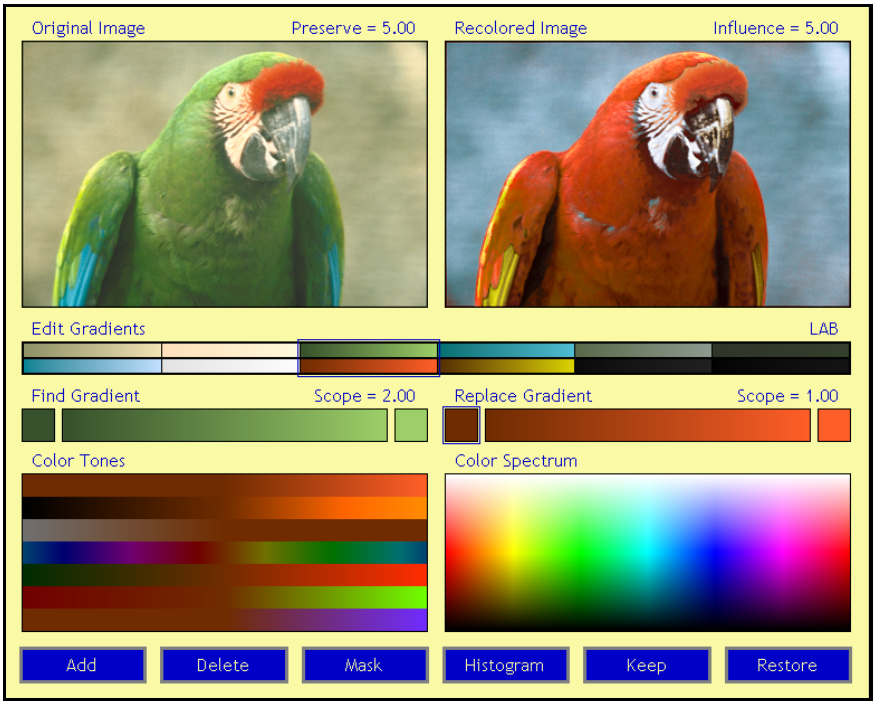

Figure 1: A prototype interface for finding and replacing color gradients.