Decolorize: Fast, Contrast Enhancing, Color to Grayscale Conversion

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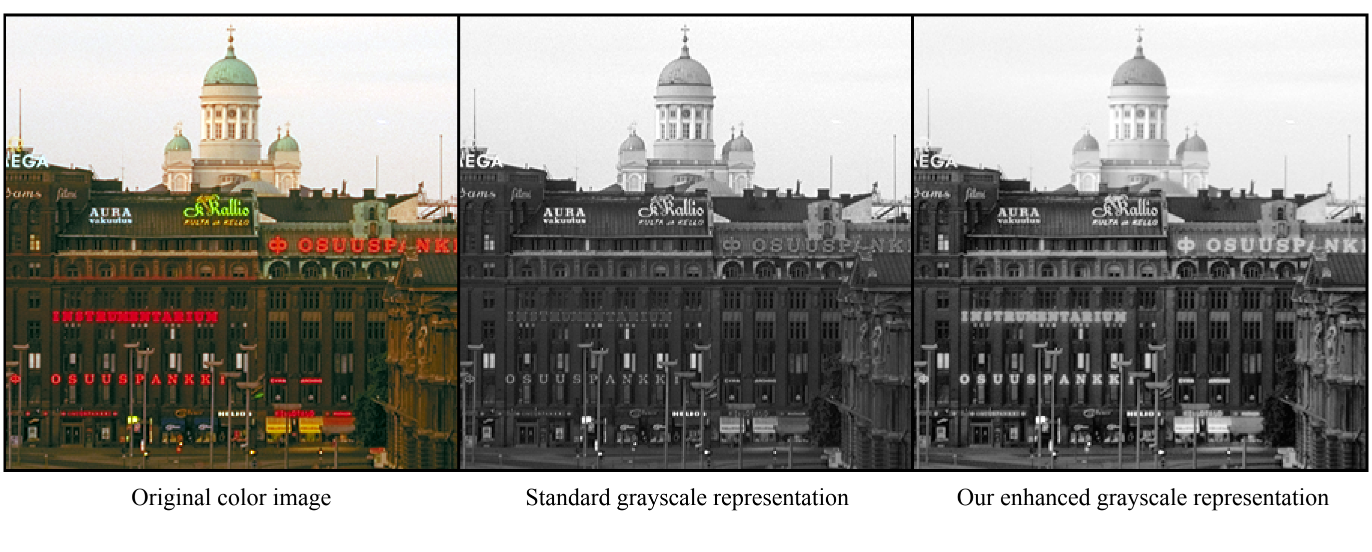
Our decolorize algorithm is a new, contrast enhancing, color to grayscale conversion technique which works in real-time. By representing color contrasts in grayscale with less detail loss than the standard color to grayscale mapping, this interpretive rendering technique offers a more informative depiction of a color scene. Although luminance predominates human visual processing, as an image independent linear color to grayscale mapping, it may not capture the perceived color contrasts. On the other hand, maximizing variation by principal component analysis can result in high contrasts but, as an image dependent linear color to grayscale mapping, it may not prove visually meaningful. Our decolorize algorithm is designed to enhance contrast in a visually meaningful way by augmenting luminance to reflect chromatic differences. The enhanced grayscale image can take the place of the luminance image in existing systems for displaying, analyzing, and recognizing images. For instance, our decolorize algorithm could readily be embedded in the driver software that renders color images on a grayscale printer. As our technique imposes a globally consistent, image dependent, color ordering relation, it could enable the traditional tools of grayscale image processing to take better account of color information, thereby extending the usefulness of morphological image processing, median filters, and other order statistic methods.

The key advantages of our decolorize algorithm are simplicity, speed and mathematical guarantees on the results. Instead of relying on computationally expensive numerical optimization, we introduce novel techniques for image sampling and dimensionality reduction, sampling color differences by Gaussian pairing and analyzing color differences by predominant component analysis. We keep our running time linear in the number of pixels, unlike the Gooch et al. algorithm [Proc. of SIGGRAPH 2005, pp. 634–6391], and independent of the number of colors in the image, unlike the Rasche et al. algorithm [Proc. of EUROGRAPHICS 2005, pp. 423–432]. Our decolorize algorithm ensures continuous mapping, global consistency, and grayscale preservation, as well as predictable luminance, saturation, and hue ordering properties. The degree of contrast enhancement, the scale of contrast features, and the need for noise suppression can easily be adjusted.

Our decolorize algorithm performs global color to grayscale conversion by expressing grayscale as a continuous, image dependent, piecewise linear mapping of the RGB color primaries and their saturation. We apply sampling by Gaussian pairing to analyze the distribution of color contrasts present in the image. We obtain a robust random sample of color differences belonging to image features of varying sizes by pairing each image pixel with a pixel chosen randomly according to a displacement vector drawn from a Gaussian distribution. The RGB image colors are converted to the YPQ color space, which consists of an achromatic luminance channel and a pair of chromatic opponent-color channels. We apply predominant component analysis to find the color axis that best represents the chromatic contrasts lost in the standard color to grayscale mapping. Unlike principal component analysis which optimizes the variability of colors, predominant component analysis optimizes the differences between colors. The predominant chromatic channel is a linear projection of the chromatic data along a color axis that captures the direction of the prevailing chromatic contrasts while reflecting the polarity of the prevailing luminance contrasts. We merge the luminance channel with the predominant chromatic channel to obtain the desired degree of contrast enhancement. Finally, we use color saturation to further calibrate the dynamic range of the enhanced grayscale values. In effect, the decolorize algorithm linearly combines the luminance channel with feedback from either the predominant chromatic channel or the saturation channel, so that the enhanced contrast originates from either a linear or a polar representation of the chromatic data.

Our technical report describes our color to gray scale conversion algorithm and compares its results to the previously published methods:
http://www.cl.cam.ac.uk/TechReports/UCAM-CL-TR-649.html

Our web site also includes additional figures as well as the MatLab source code for our algorithm:
http://www.eyemaginary.com/Portfolio/TurnColorsGray.html



Original color image | Standard grayscale representation | Our enhanced grayscale representation