Color Appearance Models and Dynamic Range Reduction

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Abstract

When viewing photographs on a monitor, we are adapted to the lighting conditions of our viewing environment, which can be very different from the lighting conditions in which the photograph was taken. As a result, our perception of these photographs depends directly on the environment in which they are displayed. For high dynamic range images, the disconnect in perception of scene and viewing environments is potentially much larger than in conventional film and photography. To prepare an image for display, luminance compression alone is therefore not sufficient. We propose to augment current tone reproduction operators with application of color appearance models as an independent preprocessing step in order to preserve chromatic appearance across scene and display environments. The method is independent of any specific tone reproduction operator and color appearance model (CAM) so that for each application the most suitable tone reproduction operator and CAM can be selected.

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1 Overview

The field of high dynamic range imaging is rapidly becoming more widely accepted with improved image capture techniques, graphics algorithms' ability to produce arbitrarily large dynamic ranges and emerging standards in high dynamic range file formats. However, current monitor technology imposes severe constraints on the range of luminance values that may be displayed, although this may change in the near future.

While most offices and homes remain equipped with low dynamic range display devices, there is an increasing need to prepare high dynamic range images for display on such devices. The field of tone reproduction is addressing this need with new algorithms becoming available on a regular basis. However, an inherent problem in tone reproduction is accounting for the disconnect between the conditions of the environment in which the photograph is taken and the environment in which the photograph is viewed.

Tristimulus colorimetry, which predicts if two patches with different spectral power distributions appear the same if viewed under identical lighting conditions, is not sufficient in high dynamic range imaging, since the lighting conditions between scene and viewing environments will vary considerably [Fairchild and Johnson 2002].

Color appearance models such as CIECAM02 [Moroney et al. 2002] describe the environment with a small number of key parameters in order to predict how colors will appear to the observer. These models are essentially comprised of two steps. The first step is the chromatic adaptation transform, which corrects for the difference in white balance between viewing environments. The second step predicts the changes in relative color appearance attributes such as lightness, brightness and hue due to varying surround conditions across different viewing environments [Fairchild 1998].

2 Algorithm

To address color appearance issues in high dynamic range imaging, comprehensive color appearance models may be devised which include a tone reproduction step [Pattanaik et al. 1998]. In our work we show that color appearance and tone reproduction are orthogonal issues that may be solved in sequence. The key advantage of our approach is that future developments in tone reproduction do not affect color appearance issues and vice-versa. We also believe that no single operator will be suitable for all possible tasks such as film, photography, computer graphics and scientific- and medical visualization. A more likely scenario is that some operators will be more applicable for certain specific tasks, whereas other operators will be more suitable for other tasks.

To successfully separate color appearance issues from luminance compression, we propose to adjust for color appearance prior to tone reproduction. First, the surround parameters of the input are estimated, then the color appearance model of choice is applied with those surround parameters, and then the inverse model is invoked with surround parameters appropriate for the display environment. Because these steps are likely to alter the dynamic range of the image, we reset the luminance values prior to tone reproduction. The result is an image with chromatic content commensurate with the display environment, but with a retained high dynamic range in luminances.

References

FAIRCHILD, M. D., AND JOHNSON, G. M. 2002. Meet iCAM: an image color appearance model. In *IS&T/SID* 10^{th} *Color Imaging Conference*, 33–38.

FAIRCHILD, M. D. 1998. *Color appearance models*. Addison-Wesley, Reading, MA.

MORONEY, N., FAIRCHILD, M. D., HUNT, R. W. G., LI, C. J., LUO, M. R., AND NEWMAN, T. 2002. The CIECAM02 color appearance model. In *IS&T* 10^{th} *Color Imaging Conference*, 23–27.

PATTANAIK, S. N., FERWERDA, J. A., FAIRCHILD, M. D., AND GREENBERG, D. P. 1998. A multiscale model of adaptation and spatial vision for realistic image display. In *SIGGRAPH 98 Conference Proceedings*, 287–298.

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