1 Introduction and Related Work

High dynamic range (HDR) imaging provides more physically accurate measurements of pixel intensities, but displaying them may require tone mapping as the dynamic range between image and display device can differ. Most tone-mapping operators (TMO) focus on luminance compression ignoring chromatic assets. The human visual system (HVS), however, alters color perception according to the level of luminosity. At photopic conditions color perception is accurate and as conditions shift to scotopic, color perception decreases. Mesopic vision is a range in between where colors are perceived but in a distorted way: red intensities’ responses fade faster producing a blue-shift effect known as Purkinje effect.

Remarkable approaches to mesopic vision in tone mapping include [Durand and Dorsey 2000] efforts which specialize [Ferwerda et al. 1996] rod-cone interaction model for night scenes, and [Khan and Pattanaik 2004] blue-shift model for moonlit scenes. In either case, each of them deals with a specific subrange of mesopic vision. As for Ferwerda et al.’s model, it concerns more on loss of visual acuity in scotopic vision than on chromatic changes in mesopic vision.

2 Proposed operator for mesopic vision

The proposed operator uses the experiments of [Ikeda and Ashizawa 1991] which deals with full mesopic range. Color adjustments are also more perceptually accurate due to the use of the \( L^*a^*b^* \) color space. The presented method is decoupled from luminance compression allowing it to work with existing TMOs. Additionally the technique has a low fingerprint that slightly affects performance, making it suitable for real-time applications.

Given an HDR image the goal is to change hue according to the overall image’s luminance. Luminance compression follows as described in [Reinhard et al. 2002] with CIE Yxy color space, although other luminance compression operators might be used instead. As for the chromatic changes, it starts by computing a simple arithmetic average luminance of the image, \( I_{avg} \). The lightness response of such luminance, \( E(I_{avg}) \), is then retrieved from Ikeda and Ashizawa’s equivalent lightness curve (S-shaped function in Figure 2) which can be approximated with Equation 1.

\[
E(I) = \frac{70}{1 + \left( \frac{19}{7} \right)^{0.383} + 22} \tag{1}
\]

Results are shown in Figure 1. The proposed operator reproduces the Purkinje effect in all mesopic range, and keeps color distances and HVS responses in a linear fashion. The operator can be integrated with existing luminance compression algorithms and introduces a small overhead, being suitable for real-time applications.

References


