Constrained Line Gamut Boundary (CLGB) Method for Multiple Hue Angles

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1 Introduction

The determination of gamut boundaries is essential for understanding the range of colors present in an image or achievable on a color reproduction medium. The Constrained Line Gamut Boundary (CLGB) method is a specific approach designed to calculate intersections of the gamut boundary at multiple hue angles, particularly useful for applications in color gamut mapping.

2 CIELAB to LCH Conversion

To facilitate the CLGB method, it is necessary to convert the image from the CIELAB color space to the LCH (Lightness, Chroma, Hue) color space. This conversion is performed using the following equations:

$$C = \sqrt{A^2 + B^2}, \tag{1}$$

$$H = \arctan 2(B, A). \tag{2}$$

The hue angle H is converted from radians to degrees:

$$H = \text{degrees}(H), \tag{3}$$

with H adjusted to ensure it is within the range $[0^\circ, 360^\circ]$.

3 Gamut Boundary Descriptor (GBD) Calculation

The Gamut Boundary Descriptor (GBD) is calculated by identifying the most extreme colors within segments of the color space. This method segments the color space based on the hue angle, facilitating the determination of the boundary at specific hues.

3.1 Segmenting the Color Space

The color space is segmented into multiple regions based on the hue angle H. For each segment, we identify colors that fall within a small tolerance range ΔH around the target hue. This tolerance is initially set to 5°, but it can be increased if insufficient points are found.

4 CLGB Method for Multiple Hue Angles

The CLGB method calculates the intersection of the GBD with planes of constant hue angles. The process involves the following steps:

4.1 Identifying Points at Target Hues

For each target hue H_t, the points in the LAB color space that correspond to this hue are identified using the following condition:

$$|H - H_t| < \Delta H, \tag{4}$$

where ΔH is the hue tolerance.

4.2 Delaunay Triangulation

Once the points near each target hue are identified, Delaunay triangulation is performed on these points in the a^*b^* plane. The Delaunay triangulation is a method for dividing the points into non-overlapping triangles, which allows for the construction of the 2D GBD boundary.

4.3 Intersection with Gamut Boundary

The intersection of the GBD with the plane of constant hue is determined by examining the triangles formed by Delaunay triangulation. The color of each triangle is determined by converting the LAB values of the triangle vertices back to RGB:

$$\text{RGB} = \text{LAB to RGB conversion}(L^*, a^*, b^*). \tag{5}$$

These RGB values are used to visualize the GBD boundary at the target hue.

5 Visualization of Gamut Boundary Intersections

The resulting GBD intersections are plotted for each target hue. The triangles formed by Delaunay triangulation are filled with the corresponding RGB colors, and the boundaries are displayed in the a^*b^* plane. The plot illustrates the gamut boundary intersections for each specified hue.

6 Reference

1. Morovič, J., & Luo, M. R. (2000). Calculating medium and image gamut boundaries for gamut mapping. Color Research & Application: Endorsed by Inter-Society Color Council, The Colour Group (Great Britain), Canadian Society for Color, Color Science Association of Japan, Dutch Society for the Study of Color, The Swedish Colour Centre Foundation, Colour Society of Australia, Centre Français de la Couleur, 25(6), 394-401.