Segment Maxima Gamut Boundary Descriptor (SMGBD) Method for Single and Multiple Views

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1 Introduction

The Segment Maxima Gamut Boundary Descriptor (SMGBD) method is a robust technique used to describe the color gamut boundary of an image in the CIELAB color space. This paper details the process of creating both single-view and multiple-view visualizations of the Gamut Boundary Descriptor (GBD) surface, providing comprehensive insights into the structure of the color gamut.

2 CIELAB Color Space Conversion

The SMGBD method begins with converting the image from the RGB color space to the CIELAB color space, which is designed to be perceptually uniform. The conversion process is as follows:

1. Convert the RGB values to XYZ tristimulus values.
2. Convert XYZ values to CIELAB using the equations:

$$L^* = 116 \cdot f\left(\frac{Y}{Y_n}\right) - 16, \tag{1}$$

$$a^* = 500 \cdot \left[f\left(\frac{X}{X_n}\right) - f\left(\frac{Y}{Y_n}\right)\right], \tag{2}$$

$$b^* = 200 \cdot \left[f\left(\frac{Y}{Y_n}\right) - f\left(\frac{Z}{Z_n}\right)\right], \tag{3}$$

where the function $f(t)$ is defined as:

$$f(t) = \begin{cases} t^{1/3} & \text{if } t > \left(\frac{6}{29}\right)^3, \\ \frac{1}{3}\left(\frac{29}{6}\right)^2 t + \frac{4}{29} & \text{otherwise.} \end{cases} \tag{4}$$

3 Gamut Boundary Descriptor (GBD) Calculation

The Gamut Boundary Descriptor (GBD) is calculated by identifying the convex hull of the color points in the CIELAB space. The convex hull represents the smallest convex set that encloses all the color points, effectively defining the boundary of the color gamut.

3.1 Convex Hull Calculation

The convex hull of the CIELAB color points is computed using the following steps:

1. Extract the L^*, a^*, and b^* values from the CIELAB image data.
2. Form a 2D array $\mathbf{P}$ by stacking the a^*, b^*, and L^* values as:

$$\mathbf{P} = \begin{bmatrix} a_1^* & b_1^* & L_1^* \\ a_2^* & b_2^* & L_2^* \\ \vdots & \vdots & \vdots \\ a_n^* & b_n^* & L_n^* \end{bmatrix}. \tag{5}$$

3. Calculate the convex hull of the points $\mathbf{P}$ using algorithms such as Quickhull.

4 Single-View Visualization of the GBD Surface

To visualize the GBD surface, a single view is created, focusing on one specific angle to highlight the structure of the color gamut.

4.1 3D Plotting of the GBD Surface

The 3D GBD surface is plotted using the following steps:

1. For each triangle (simplex) in the convex hull, the corresponding L^*, a^*, and b^* values are used to define the vertices of the triangle.
2. The RGB color corresponding to each LAB value is calculated by converting the LAB data back to RGB.
3. The triangles are plotted using the RGB colors, creating a 3D surface that represents the gamut boundary.

4.2 Single Viewing Angle

The following viewing angle is used to present the GBD surface in a clear and informative way:

- Elevation $= 20^\circ$, Azimuth $= -135^\circ$

5 Multiple-View Visualization of the GBD Surface

In addition to the single view, multiple views of the GBD surface are generated to offer a more comprehensive understanding of the color gamut's structure.

5.1 3D Plotting of the GBD Surface for Multiple Views

Similar to the single-view plotting, the 3D surface is constructed by triangulating the convex hull of the LAB data and coloring the surface using the corresponding RGB values. However, in this case, multiple perspectives are provided.

5.2 Multiple Viewing Angles

To visualize the GBD surface from different perspectives, the following view angles (elevation and azimuth) are used:

- View 1: Elevation = $20°$, Azimuth = $-135°$
- View 2: Elevation = $30°$, Azimuth = $45°$
- View 3: Elevation = $60°$, Azimuth = $-45°$
- View 4: Elevation = $90°$, Azimuth = $90°$

These views provide a thorough examination of the GBD surface, allowing for the analysis of the gamut boundary's shape and extent.

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.