Color Gamut Viewer application

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1 Introduction

The Color Gamut Viewer app converts an image from RGB to LAB color space, creates a convex hull of the color points, and plots them in a 3D space.

2 Step-by-Step Explanation

2.1 Image Loading and Conversion to LAB Space

The script starts by loading an image and converting it from the RGB color space to the LAB color space:

$$\text{LAB\_image} = \text{RGBtoLAB}(\text{image}), \tag{1}$$

where RGBtoLAB is a function that transforms the RGB values to the LAB color space, defined as:

$$\begin{aligned} L^* &= 116 \cdot f(Y/Y_n) - 16, \\ a^* &= 500 \cdot (f(X/X_n) - f(Y/Y_n)), \\ b^* &= 200 \cdot (f(Y/Y_n) - f(Z/Z_n)). \end{aligned}$$

Here, X, Y, and Z are the tristimulus values, and $f(t)$ is a piecewise function:

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

2.2 Reshaping and Extracting LAB Components

The LAB image is then reshaped into a list of LAB values, where each pixel's color is represented as a 3-dimensional vector (L^*, a^*, b^*). The components are extracted as separate arrays:

$$L = \{L_i^*\}, \quad a = \{a_i^*\}, \quad b = \{b_i^*\}, \tag{2}$$

where i ranges over all pixels.

2.3 Constructing the Convex Hull

A convex hull is constructed from the set of LAB color points. Mathematically, the convex hull of a set S in a vector space is the smallest convex set that contains S. It can be represented as:

$$\text{Hull}(S) = \left\{ \sum_{i=1}^{k} \lambda_i x_i \;\middle|\; \lambda_i \geq 0, \sum_{i=1}^{k} \lambda_i = 1, x_i \in S \right\}. \tag{3}$$

2.4 Converting LAB Values Back to RGB

The LAB values are then converted back to the RGB color space for visualization. This inverse transformation is given by:

$$\begin{aligned} X &= X_n \cdot f^{-1}\left(\frac{L^* + 16}{116} + \frac{a^*}{500}\right), \\ Y &= Y_n \cdot f^{-1}\left(\frac{L^* + 16}{116}\right), \\ Z &= Z_n \cdot f^{-1}\left(\frac{L^* + 16}{116} - \frac{b^*}{200}\right). \end{aligned}$$

The XYZ values are then transformed back to RGB using a linear transformation.

2.5 3D Scatter Plot and Surface Plotting

The script generates a 3D scatter plot using the (a^*, b^*, L^*) values, colored by their corresponding RGB values. It also plots the convex hull surface by connecting the points in the LAB space.

For each triangle in the convex hull, the script plots a surface using the average RGB color of the triangle's vertices.

2.6 Final Visualization

The 3D plot is displayed with appropriate labels for the axes and saved as an image file.