A Color Classification Algorithm for Color Images

Shoji Tominaga
Department of Psychology, Stanford University
Stanford, California 94305, USA

Abstract

We describe a color classification algorithm that partitions color image data into a set of uniform color regions. The algorithm uses a recursive method to detect clusters of color data. The algorithm can be divided into two main steps. First, we map the device dependent image data into an approximately uniform perceptual color space. Second, we apply a recursive histogram analysis to the data represented in this perceptually uniform space. The histogram analysis is designed to identify the spatial subregions within the image that correspond to a uniform color. Once a region has been identified, the corresponding data are removed and the histogram analysis is repeated on the remaining data set. The performance of the algorithm is discussed with respect to a test image.

1. Introduction

We describe an algorithm that accepts high resolution color images as input, and yields a new representation of the data in the form of a set of spatial regions, each described by a single color value. The algorithm is designed so that the number of colors used to represent the spatially uniform color regions in the output image is quite small (say 4 bits per spatial region) compared to the number of colors used to specify the data in the input image (say 24 bits per pixel). The ability to classify spatial regions of the input image into a small number of uniform regions can be useful for several problems including data reduction, image segmentation, and feature extraction [1],[2],[3],[4].

The algorithm can be divided into two main parts. First, the input image data are mapped from device coordinates into an approximately uniform perceptual color space defined in terms of hue, lightness, and saturation. Examples of perceptually uniform spaces are the Munsell color system or the CIE-L* a*b* color system in color science. The mapping we describe is quite close to the Munsell system, but somewhat more convenient for numerical processing. Second, we classify connected spatial subregions of the image based on their color specifications in the uniform color space. Using a method based on histogram analysis, we seek spatial regions in the image that can be classified as a uniform region based on both (1) their similarity in color and (2) their identification as a cluster in the uniform color space. The histogram analysis for extracting uniform regions is recursive. Following the identification of a class, we remove the data identified with the class from the data set and apply the histogramming method to the remaining data. The final output consists of a set of uniform color regions.
2. Color Specifications

There are several systems for a perceptually uniform color space defined by hue, lightness, and saturation. The Munsell color system is based on such psychological ordering of object colors. The three attributes called Munsell Hue (H), Value (V), and Chroma (C) make a space of cylindrical coordinates. Fig. 1 shows the chromaticity plane by (H, C). There exists no analytical formula for conversion between the tristimulus values and Munsell attributes, but only a table [5]. Hence a direct-mapping method was derived to assign observed RGB signals to Munsell attributes for each pixel in an image quickly [6].

We first define an observation space of the color signals by a five (or four)-dimensional vector

\[ s = [1, (p_{B/W}^{1/3}), p_{R}^{1/3}, p_{G}^{1/3}, p_{B}^{1/3}]^T, \]  

where the first element is a constant bias, and \( p_i \) \((i = (B/W), R, G, B)\) are the effective reflectances obtained from an imaging device. \( T \) denotes matrix transposition. Let \( p \) be a three-dimensional

![Fig.1 Chromaticity plane of the Munsell color system.](image)