Introduction

This document describes the commands and concepts used in the sample implementation of the TekColor™ Editor . This manual does not describe how to build or install the TekColor Editor. It assumes you can start the TekColor Editor using the operating system and X Window System commands provided with your system. This document introductory in nature and scope.

This document is divided into three sections. Section one presents an introduction to the TekColor Editor and the TekColor™ Color Management System. Section two presents a detailed description for each regions of the interface and the commands available within the editor.

TekColor Introduction

A color description is the definition of a particular color that allows that color to be reproduced at a later time. The specification can be numeric or verbal, depending on the color model. Verbal specifications often are not precise enough to permit accurate color reproduction. In the case of the TekColor Editor a point and click interface provides an easy, intuitive access to a variety of numeric color specifications.

The goal of color specification is precise, uniform color definition, and many paths have been taken in an effort to reach that goal. Both human factors and device limitations have complicated the process in the past, and, although the TekColor system successfully accommodates these variables, it is useful for anyone working with color to understand how these factors affect color perception and color spaces. It is, after all, humans that ultimately judge the success of any color system.

This section discusses the process of specifying color, including the complicated variables involved in color perception. Information is presented in two categories: Human Perception and Color Spaces.

Human Perception

Color is a deceptively simple concept but surprisingly complex, involving physiological,

physical and psychological phenomena. The color sensations reported by typical observers with normal color vision vary based on a number of factors.

Hue

The typical observer will report colors based on the wavelength of the stimulus light. This sensation of color is known as hue. Hue is first and foremost among the psychological factors affecting color perception. When dealing with hue one must remember it is a perception. Although most observers select the same sector of the spectrum as "red", disagreement is common place at which point in the spectrum becomes "orange".

Saturation

The *saturation* of a hue refers to the amount of the bandwidth of light that is contributing to the color sensation. The bandwidth of a stimulus is measurable, but in human terms, saturation involves more than bandwidth alone. For not all hues having equal bandwidth appear equally saturated.

A hue can be made to look "less saturated" by mixing it with its opponent color. For example, on a crt, blue is desaturated by adding red and green (which are the components of blue's opponent color, yellow). A hue can also be desaturated by mixing it with a neutral, achromatic hue, such as gray or white. This later kind of saturation can be measured. Often researchers will start with a neutral color and then determine how much of a pure hue must be added to the neutral color in order for the hue to be detectable.

Lightness

Another factor classified as psychological is lightness, which describes the variation of a hue along the scale from dark to light. This psychological attribute of color has to do with the perceived lightness of a color and must not be confused with the CIE metric lightness (L*), which is quantified.

Lightness refers to the range of colors within a single hue ranging from dark to light. As an example of the lightness scale, think of the range of achromatic colors, spanning from black through gray to white, a range often referred to as the gray level. Such a range exists for any hue in the color space.

Other factors such as luminance, illuminance, reflectance, and brightness to name a few also affect how we perceive color. Factors such a color contrast and color constancy have also been identified as pyschological factors affecting color perception.

Color Spaces

Color spaces are mathematical abstractions that describe the human visual color domain. Color spaces are usually presented in terms of color models — conceptual devices that assist in the task of defining and specifying colors. A color model is a theoretical multi-dimensional "solid" that represents the colors that can be specified in a particular system.

Some color spaces operate as true mathematical domains, in which colors can be specified with a set of mathematical coordinates. Other color spaces allow colors to be defined with a specific set of words and word modifiers. In either type of color space, the specification is used to describe a specific color in its context to and relationship with the other colors in that color space.

In this way, color spaces provide both a coordinate system with which to specify color and a visual model for seeing how colors relate to each other. To illustrate the way this works, consider two very different color spaces: the RGB color space and the TekHVC color space.

RGB Color Space

The RGB color space is one of the earliest approaches to specifying color for computer systems, and is still the predominant color space. RGB stands for "red," "green," and "blue," the three colors of phosphors used on a color computer display screen. The RGB color space is related directly to the hardware that drives the graphic display. Colors in the RGB color space are specified as a set of three numbers, an RGB triplet, representing the relative values of red, green, and blue required to generate a particular color.

The RGB approach is popular in part because it is very easy to implement: an RGB color specification can be used directly by the display hardware, without having to be first transformed into a set of values that the hardware can use. Because it speaks directly to the hardware, though, the RGB system suffers on two counts. First, it is not particularly intuitive, because humans do not perceive color in terms of red, green, and blue components (the additive color principle); and second, it is, by its very nature, device-dependent.

Device-dependent means that any color definition is directly and firmly tied to the device on which the definition was made. Thus, a color generated from an RGB triplet on one device can appear very different when sent to another device.

The RGB color model is portrayed as a cube, with its corners representing the pure primary colors of red, green, and blue, the secondary colors cyan, magenta, and yellow, and the lightness coordinates of white and black. All displayable visible colors are contained within the confines of this imaginary cube. Figure 1-1 shows the "solid" representation of the RGB color model.

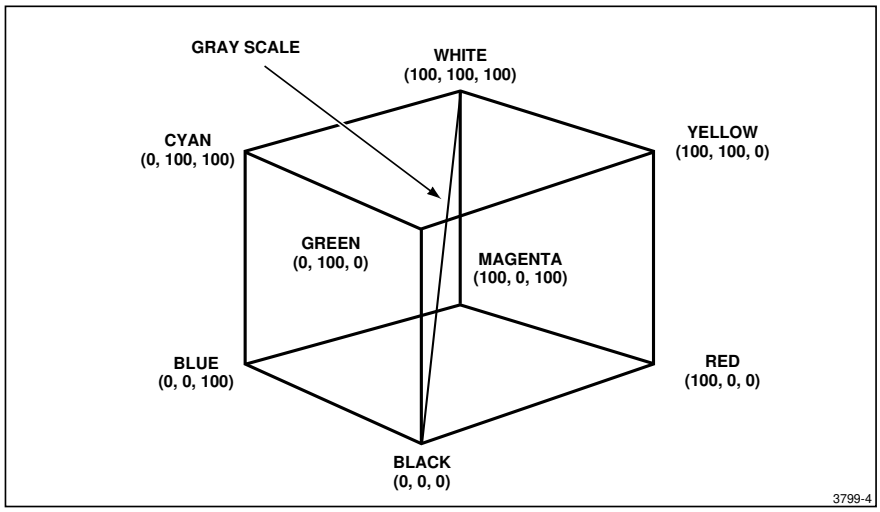

Figure 1-1. RGB Color Space as Represented by a Cube.

The TekHVC Color Space

In contrast to the RGB color space, the TekHVC color space, at first seems quite complicated. Instead of representing the set of colors that can be displayed by a particular device, the TekHVC color space represents all visible color.

Colors specified in the TekHVC color space retain the same HVC coordinates, regardless of the device imaging them, which gives them device-independence. The set of colors that can be displayed on a particular device will be a subset of the entire TekHVC color space. A typical screen gamut is shown in Figure 1-2.

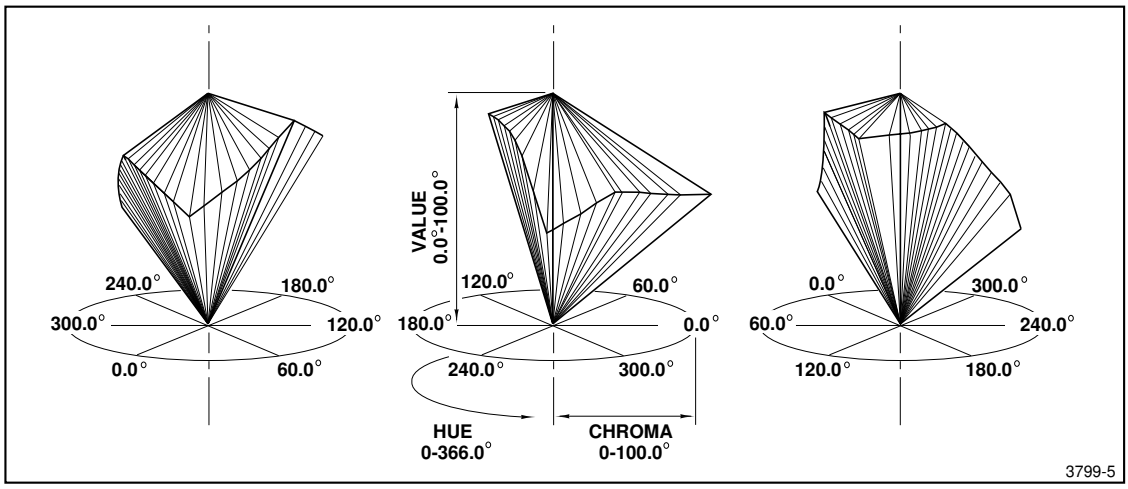

Figure 1-2. TekHVC Color Space Available for a Typical Display

The TekHVC color "solid" for a particular device is a complex shape with the lightness extremes of black and white located at its "poles" and the full-intensity pure hues at the points around its girth farthest from its neutral axis. All colors visible to humans are represented

within the confines of this color space.

The TekHVC color space is derived from the 1976 CIE u',v' chromaticity diagram and the related CIELUV color specification system. This derivation makes the TekHVC color space compatible with internationally recognized standards for color specification. Thus the TekColor Editor can be used to display a large number of color values.

The TekHVC color space creates a perceptual version of the CIE uniform color space that incorporates the three independent color parameters of hue, value, and chroma. The TekHVC system is described mathematically by a three-dimensional cylindrical coordinate system that is embodied in an irregularly shaped solid.

Hue is the property associated with color family and color name. Hue is designated as an angle ranging from 0.0 to 360.0 . In the TekHVC color model, Hue=0.0 represents an axis of colors with the best achievable red at one end of the axis. This definition conforms to the layout of conventional color-order systems such as the Munsell System and the Swedish Natural Color System (NCS).

The second parameter of TekHVC color space is *Value*. Value describes the variation in lightness from black to white. In the neutral center of the system, value has the largest range, spanning from black (0.0) to white (100.0). Value is a function of luminous intensity.

Chroma is the TekHVC parameter that describes the saturation or vibrancy of a color, which represents its difference from the neutral center at the same level of lightness. Chroma is expressed as a value in the range from 0.0 to over 100 units. However, because some colors are perceived as being more saturated than others, the maximum achievable chroma for any hue/lightness designation is often less than 100.0. This is an inherent part of human color perception and must be built into any user-oriented color interface.

The TekHVC system provides a color space that demonstrates enhanced visual uniformity. Equal physical distances along any given dimension of hue, value, or chroma are representative of equally perceived color differences.

The TekHVC color space improves on earlier color models by enhancing the overall uniformity of the display color space and allows reversible transformation between RGB, CMYK, the TekHVC color space, CIELUV, or any color system relatable to one of these models.

The TekHVC color space allows device-independent color specification. Its relationship to the CIELUV color space allows TekHVC color specifications to be meaningful in relation to internationally recognized color standards. The TekHVC color system also allows perceptual matching of colors between a wide range of devices.

The TekColor Human Interface

TekHVC color specifications are numerically more complex than the RGB color specifications. But since the color space is perceptually based, it lends itself to a visual interface.

The TekColor Editor is one implementation of *The TekColor Human Interface*. T*he TekColor Human Interface* is the interactive color interface developed for the TekHVC color space and consists of a set of graphic commands and subroutines that provide for a visual means for color manipulation, selection, and editing. The actual appearance and content of the TekColor Human Interface editor depends heavily on the implementation.

Each implementation of the user interface to the TekHVC color space, employs two-dimensional graphics to systematically illustrate the three-dimensional TekHVC color solid. The interface described in this document presents constant hue leaves that represent the available value and chroma ranges for any selected hue. A "hue leaf" is like a leaf in a book. The idea of a hue leaf is shown in Figure 1-3.

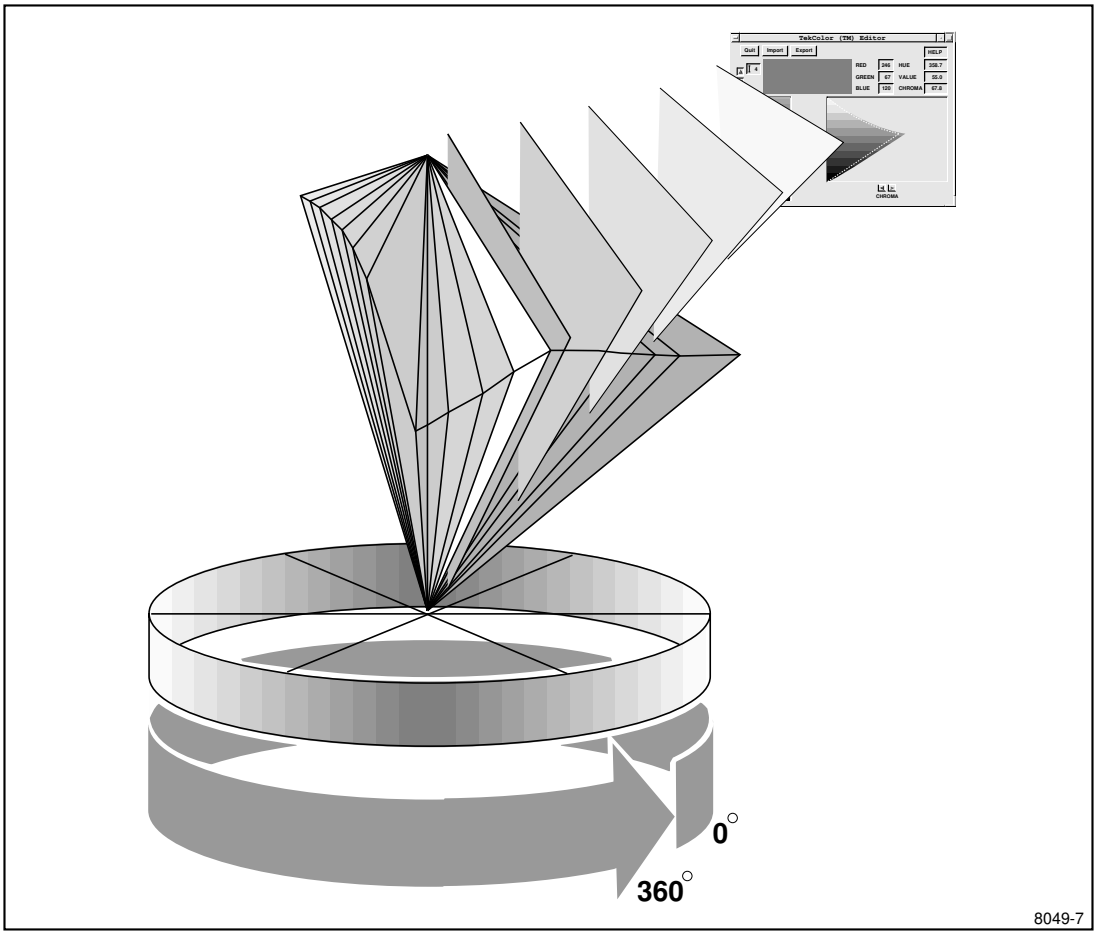

Figure 1-3. Hue Leaves of the TekHVC Color Solid.

This hue leaf method of looking through the color solid is similar to the Munsell Book of Color, a subset of the Munsell system of color specification, which is familiar to many artists and color scientists. The Munsell Book of Color presents hues a page at a time (and a hue at a time), radiating out around a central axis that represents lightness.

Presenting "slices" of the color solid in the form of hue leaves is a natural way to organize a collection of colors, because the process of color selection most often begins with selec-

tion of a color on the basis of its color family (hue).

Once a decision has been made about the hue, the next task is to decide what variant of that color family is desired: dark or light, vibrant or subdued. By presenting an interface organized in such a way, the TekColor Human Interface allows the user to move through the color system in a manner that is similar to the thought process associated with color selection.

When the TekColor Human Interface is initialized to the TekHVC system, the first hue page displayed is the Hue=0.0 leaf, which represents a family of red colors. The user can "step around" the hue circle, selecting the desired hue page by using a standard input device, such as function keys, a mouse, or other input mechanisms. The user can also select a general hue to edit by choosing a position along a vertical hue bar, which presents the full spectrum of hues. By moving the hue bar pointer into the yellow region of the hue bar, for example, a hue page for a family of yellows is displayed.

As you can see in the sample implementation shown in Figure 1-4, the hue leaf itself is enclosed in a rectangle, and chroma varies along the horizontal axis from 0.0 on the left to its upper limit on the right. Value is represented along the vertical axis, with 0.0 at the bottom and 100.0 at the top. The available limits on value and chroma for a particular device are represented by the triangle-like outline.

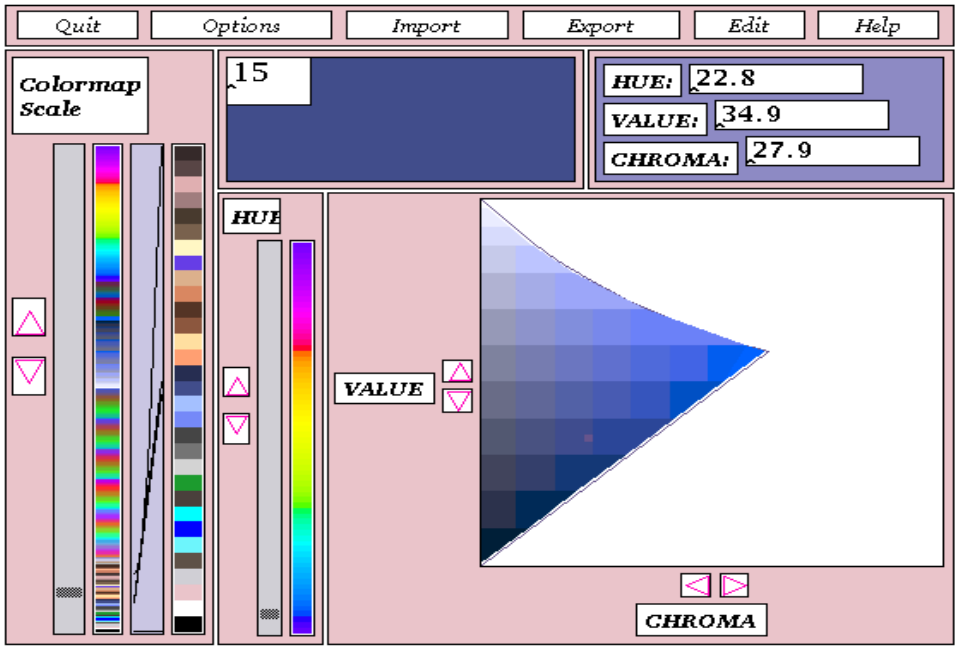

Figure 1-4. Basic Template of the TekColor Human Interface.