Using the Computer as an Aid to Study Harmonies and Contrasts of Color in Images Reproduced on a Computer Display

G. Fournier[1], M. Lessard[2], E. Dumais[3]
[1]*system engineer and color teaching consultant,* [2]*software engineer,* [3]*artist and color teacher*
Corresponding author : G. Fournier (gfour@sympatico.ca)

ABSTRACT

This study makes a case for the replacement of numeric parameters by electronic color terms, commonly used in computer programming for the selection or adjustment of colors, to locate colors on slices cut through the Sophie Color Model, a 4096 colors based cylindrical shaped model which integrates the characteristics of the RGB, HSL and HSB color spaces. It is suggested that this way of proceeding makes possible the use of a computer as a valuable aid to study color harmonies and contrasts in images reproduced on a computer display.

1. INTRODUCTION

The Sophie Color System that is presented in this paper is the result of the collaboration over many years of three specialists in complementary disciplines, passionate for color, who shared the common belief that the computer was an ideal instrument of learning that could be adapted to the learning and teaching of color theory and serve as an aid to study the principles of harmony and contrast of colors.

The project started as early as 1971, before the advent of the home computer and at a seminar held in Montreal in 1978 by the ACFAS society under the theme "Communication between Arts and Sciences", I was invited to present a paper entitled "Color and the Computer – an Interactive System to Generate Colors". That system consisted of a color data base stored on disks at the Laval University Computer Data Processing Center located in Quebec City and connected by a telephone line to a terminal located in the conference room. As an outcome of that conference, a one year pilot experiment to test that system in the classroom was conducted by Elise Dumais, a progressive color teacher I met at that seminar. A detailed review of that experiment is given in two articles of the journal *Information Couleur*[1,2] published by the Centre Français de la Couleur (CFC).

However it was not until 1986, when the first personal computers were available at a reasonable price, that I could reproduce on an Amiga color monitor the color charts of the Macbeth, Munsell and Universal Color Language atlases which were used by Mrs. Dumais to teach her students rudiments of color order systems and to demonstrate how to use these to learn the principles of color harmony and contrast.

The same year, at a meeting of an Amiga computer user club, I met Marco Lessard, then a student in computer science at Laval University, who offered his services to develop the dedicated software applications required to extract color data from images displayed on a computer screen, and to transfer the same data in a spreadsheet program so that I could make a statistical analysis of the extracted data to search for harmonious color combinations.

2. THE SOPHIE INTEGRATED ELECTRONIC COLOR MODEL

Among the variety of conceptual representations of the RGB computer color spaces available, the RGB color cube, the HSL double cone and the HSB inverted cone became through the years standards universally used by programmers in the development of tools for the selection and adjustment of colors in most of the major painting and digital image processing programs. The Sophie Color System is essentially an eclectic color order system that integrates the RGB, HSL and HSB systems into a color language based system that privileges terms used in computer programming.

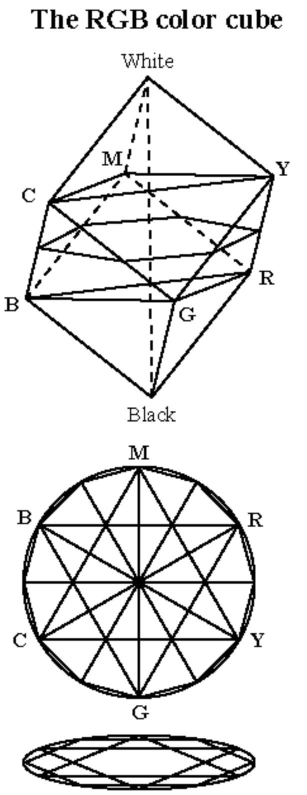


Figure 1: Insertion of the RGB color cube into a cylinder.

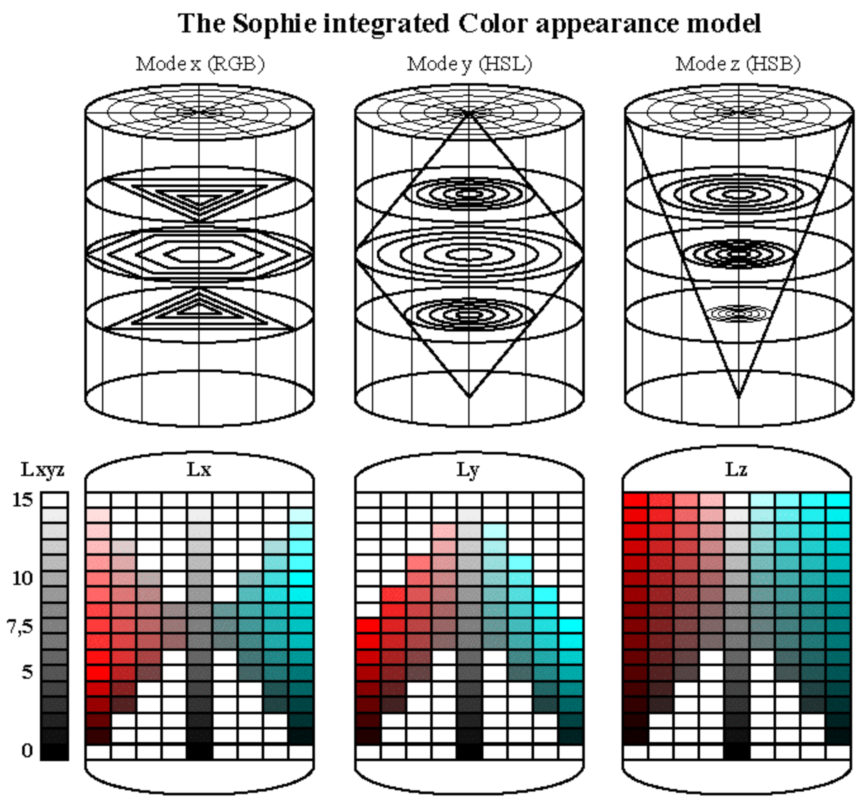


Figure 2: Presentation of harmonious color groupings of varying appearances are obtained from same color palette depending on the Mode of presentation chosen.

The Sophie model offers three different ways to study harmony and contrasts of different types in images reproduced on a computer display depending on which of the three classic RGB, HSL and HSB color models is chosen to represent the 4096 RGB color space.

Prior to their integration, the RGB, HSL and HSB models are transformed into nests of four reduced models which shapes are identical to the original model. As for the integration of the RGB cube into a cylindrical shaped model, it is necessary first to project on color circles, colors situated at the limits of the variously shaped slices obtained by cutting through the RGB cube model, at each of the fifteen grey levels of the central neutral axis (Fig. 1)

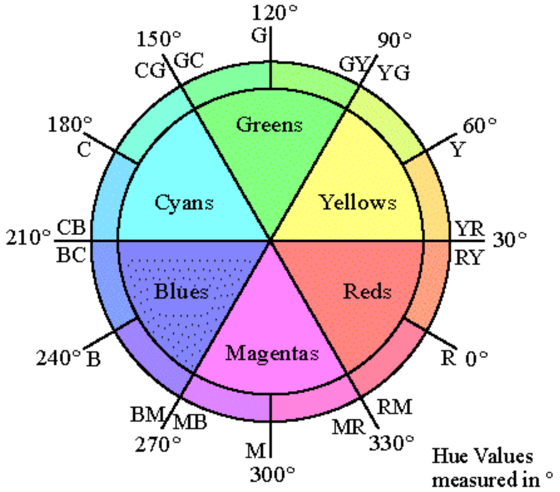
The nested models present at their surfaces groups of colors which show a level of purity that decreases as we reach the Medium Grey point at the centers of the models. These groups of colors of uniform level of purity are then mapped to the corresponding surfaces of the four cylinders of the Sophie Color Model in three different ways, depending on which of the three modes of representation of the color space is chosen (Fig. 2).

3. THE SOPHIE ELECTRONIC COLOR LANGUAGE

The logic used to describe the three dimensions of color (e.g. Hue, Saturation or Purity, and Luminosity) is essentially the same as that used in the Color Naming Language (CNS), a computer method of specifying colors by names developed by Berk, Brownston and Kaufman[3] in 1982.

However due to the peculiarities of the Sophie Color System that aims at using the computer as an aid to study the harmony and contrast of color, objective terms that can be readily converted to numeric codes by the computer were preferred to subjective terms such as Orange and Purple that could be interpreted differently depending on the computer user.

Descriptive terms for the Hue parameter (H)



The Yellows gamut

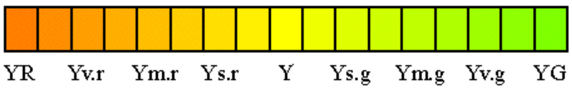


Figure 3: The color circle is divided into six gamuts of colors with a primary color (e.g. R, Y, G, C, B, M) as a *central color*. Each gamut is limited by two *intermediate colors* which are additive mixtures, in equal proportions, of two adjacent primaries and as such can be classified in either of the two gamuts they separate.

Tints of colors between the *central color* and the two *intermediate colors* are defined by a combination of the name of the *central color* (written with a capital letter) and the name of the *primary* (written with small letters) which acts as a modifying adjective.

Descriptive terms for the Purity parameter (P)

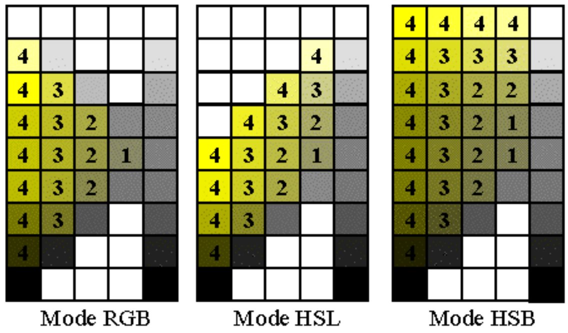


Figure 4: The term Purity refers to the color appearance of colors at the surface of the four nested cubes representing the RGB color space.

P	Purity
4	pure
3	m. pure
2	s. pure
1	greyish

Descriptive terms for the Luminosity parameter (L)

		Mode RGB	Mode HSL	Mode HSB
Lxyz		Lx	Ly	Lz
15-12		whitish	light	brilliant
11-9		clear	lightened	s. dull
8-7		neutral	intense	m. dull
6-4		obscure	darkened	dull
3-1		blackish	dark	v. dull

Figure 5: The value of the parameter Lxyz differs depending on which Mode of the Sophie Color Model is selected for the mapping of colors at the surfaces of the four concentric cylinders of the Sophie color model.

Prefixes: A prefix (**s.** for slightly, **m.** for moderately and **v.** for very much) is used to indicate the amplitude of a modification.

Along that line, the choice of the terms to translate into words the Hue parameter (H) that defines the position of a color on a color circle divided in 360 degrees, was limited to the use of names or combination of names of the additive primaries R, G, B and their complements Y, M, C to describe the hue of a color in a language comprehensible both to a human and a computer (Fig. 3).

Similarly, in order to simplify the interpretation of terms used to translate into words the degree of saturation or purity of a color pointed on a computer display, the Purity parameter (P) was arbitrarily defined as the term a computer user would most likely use to describe the relative purity appearance of the four nested cubes of a dismantled RGB color solid when displayed simultaneously on a computer screen (Fig. 4).

Finally, the use of three terms was necessary to translate into words the difference in luminosity appearance of a same color mapped differently on concentric color circles with a central Grey of different luminance values (Lx, Ly, Lz) depending on which mode of representation (RGB, HSL, HSB) is preferred. Each model offers different ways of forming significant groupings of colors which favors the study of typical types of contrasts e.g. clear/obscure tones (Mode RGB), light/dark tones (Mode HSL), brilliant/dull tones (Mode HSB) (Fig. 5).

4. USING THE SOPHIE COLOR SYSTEM TO STUDY COLOR HARMONIES AND CONTRASTS

With the help of a dedicated software application developed by Marco Lessard, a palette of 256 colors is extracted from a GIF format file of an image displayed on a computer screen and transferred to a spread sheet program which contains macro instructions to convert the numerical RGB color data of that palette to the equivalent descriptive color terms used in the Sophie Color Language.

A list of 256 colors is then produced with descriptive color terms to define the parameters Hue (H), Purity (P), Clarity (C), Intensity (I), and Brilliance (B), together with the count of the number of pixels for each of those colors.

Using that list it is possible to position each of the colors of the sampled palette on different harmonious color circles which facilitates the detection of complements, split-complements, triads, and other types of harmonious color combinations depending on the relative positions of colors as positioned around those circles.

That list is also used to position same colors on complementary color planes obtained by slicing the Sophie Color Model through the central neutral axis, which facilitates the detection of contrasts of color of different types depending on which of the three modes of representation of the RGB color space was preferred.

5. APPLICATION

One objective of the Sophie Color System is to use one's own computer as a piano to acquire knowledge about color theory and color harmonies. Actually the planes of color and the color circles obtained by slicing the cylinders of the Sophie Color Model, vertically and horizontally through the neutral axis, can be compared to staffs and color gamuts around the color circles compared to music scales.

In order to meet that objective, a software is being developed with a user-friendly interface that will instantly localize a color pointed on a computer display in a three-dimensional color space. Furthermore that color will be localized, in three different ways, on reference color circles and planes of opposing complementary colors, making intuitive the detection of various types of color harmony and contrast.

6. CONCLUSION

The Sophie Color System is the result of a long quest to use the computer as a performing assistant to detect and analyze harmonious color combinations and contrasts in images reproduced on a computer display in a very simple way.

For one thing, the Sophie Color Language vocabulary consists of terms that are commonly used in the design of tools for painting or photo retouching programs for the selection or adjustment of colors.

As for the Sophie Color Model, it integrates the RGB, HSL and HSB models which are virtual representations of the color space of the color of radiations emitted by pixels, which color models are closely related to the Hicketier, Ostwald and Munsell surface color solids widely used in the classroom to study the principles of harmony and contrasts of colors.

Given its simplicity the Sophie Color System could very well be used to simplify the use of the computer in the classroom to teach the principles of harmony and contrasts of color and as a primer on the study of other color systems and more sophisticated methods of image analysis[4,5]

References

1. G. Fournier, "La couleur et la recherche", in *Information Couleur*, Centre Français de la Couleur, 1rst quarter, 1978, pp. 17-18.
2. G. Fournier, "Recherche au Canada : Le Laboratoire couleur de demain", in *Information Couleur*, Centre Français de la Couleur, 1979, no 7, p. 52.
3. T. Berk, L. Brownston and A. Kaufman, "A New Color Naming System for Graphics Languages", in *IEEE Computer Graphics and Applications*, 1982, no 2, pp. 37-44.
4. Paul Green-Armytage, "Colour Zones – Connecting Colour Order and Everyday Language", in *Proc. AIC Color 01 Rochester*, 9th Congress of the A.I.C., 2001, pp. 976-979.
5. Mituo Kobayasi, "Mathematical Analysis of Color Combination and Color Composition of Images", in *Proc. AIC Color 01 Rochester*, 9th Congress of the A.I.C., 2001, pp. 914-917.