

○ Problems in Color Communication

Like characters and graphs, color also plays a vital role in visual communication; and to execute communication between a pair of different systems, intricate problems are encountered in the physical and chemical phenomenon involving light and physical objects, as well as in physiological and psychological aspects which affect human beings.

As transmission media, there are RGB lasers, CG, TV, color film, prints, and several others, which again create complex problems concerning compatibility among different systems.

Presently, the color system to execute color communication is of 2 types: one is the psychophysical color system which can quantitatively express colors according to experiment data; and the other is perceived color system which enables one to identify the colors of light reflected from physical objects by using the vision center of cerebrum. In perceived color system, if other than nominal color names are to be encoded, some kind of symbols and numerical values which conform to specific rules would be required.

- 1 As psychophysical color system, there is the CIE system.
- 2 As perceived color system, there is the Munsell and Ostowald system.

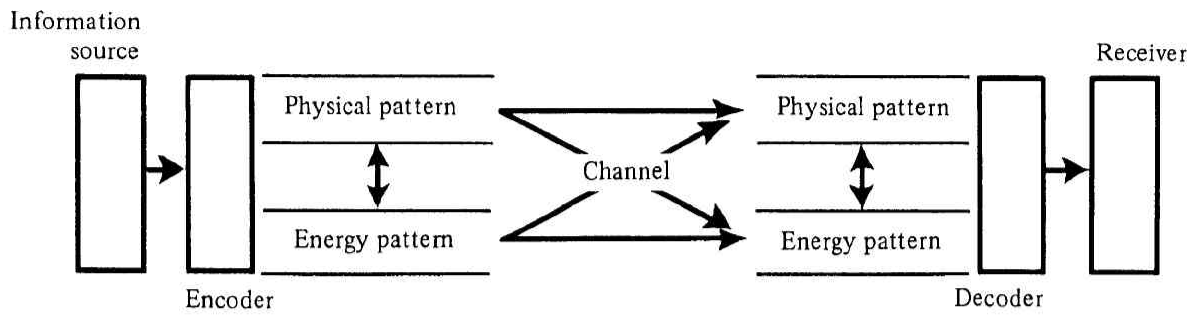
These color systems, however, are not necessarily suitable for executing smooth communication between, man-to-man, man-to-machine, machine-to-machine, and so on. And to utilize the massive color expressions realized by today's electronic technology, a new color code system is essential.

○ New Color Code System

In Munsell System, color chips are prepared by mixing color material; but with the present electronic color technology, enormous number of colors of both light and material can be expressed, and that very precisely. In man-to-man communication, printing is an effective method of creating physical patterns; and in machine-to-machine communication, RGB laser method is most effective. So if a consistent color code system acceptable to all these systems can be devised, color communication between different sets of systems would rapidly advance, greatly affecting the use of

colors in today's computer age.

○ Communication Model of Digital Color System



[Fig. 1]

The digital color system is based on the communication model shown in Figure 2, and colors are encoded using this model. Its physical pattern is composed of materials of the 3 primary colors Y, C, & M; while its energy pattern is composed of lights of 3 primary colors R, G, & B. Colors expressed by various combinations of these 3 primary colors constitutes the following type of color space.

- Color space is of the shape formed by inversely joining 2 cones.
- If the 3 primary colors are each changed in 'N' different ways, the number of colors expressed by their combinations is N^3 (for instance if $N=100$, the number of expressed colors becomes 1,000,000).
- If the brightness and saturation are on 'N' different levels, the color takes the form of $N^3 = N + \sum_{i=1}^{N-1} 6i(N-i)$ where two cone forms are combined vertically, the number of hues which the outer periphery color space becomes $6(N-1)$.

If 'N'=2 (brightness : 2 stages, white & black; saturation : 2 stages, uncolored & colored), then $6(N-1)$ becomes 6; that is the order of hues along clockwise direction becomes that of light spectrum: 1 Red, 2 Yellow, 3 Green, 4 Cyan, 5 Blue Violet, 6 Magenta.

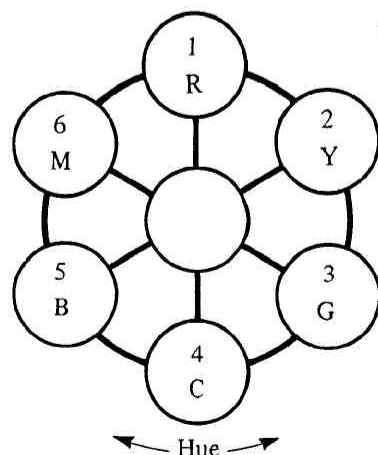
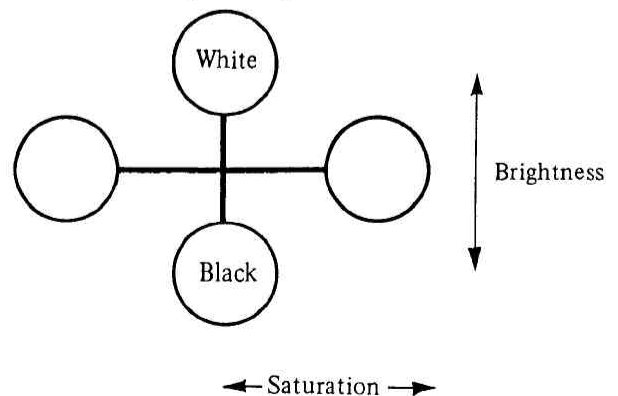


Figure-2 Basic concept of digital color



The 3 primary colors Y, C, & M are expressed in 2 stages of 0% and 100% in the following way.

	0	100	1	2	3	4	5	6
	BL	W	R	Y	G	C	B	M
C	100	0	0	0	100	100	100	0
M	100	0	100	0	0	0	100	100
Y	100	0	100	100	100	0	0	0

Similarly, the primary colors R, G, & B are expressed in the following way.

	BL	W	R	Y	G	C	B	M
R	0	100	100	100	0	0	0	100
G	0	100	0	100	100	100	0	0
B	0	100	0	0	0	100	100	100

In the digital color system, which is based on this concept, the brightness, saturation, and hues are variables; and everytime the brightness and saturation increase by 1 stage, the number of hues increases 6 times. The resultant colors, each having a corresponding Code No. are expressed as combinations of C, M, Y and R, G, B percentages. For example, if $N = 11$ (that is, when the primary colors are divided 10% at a time from 0% to 100%), the number of colors becomes $11^3 = 1331$. The outer periphery become 60 hues.

Similarly, if $N = 101$ (that is, when the primary colors are divided 1% at a time from 0% to 100%), the number of colors becomes $101^3 = 1030301$, and become 600 hues. Again if $N = 256$, the number of colors becomes about 16,770,000. As color technology makes progress, the number of colors which can be handled can be indefinitely increased in this way. Figure 3 shows a graphic representation of this concept.

Figure-3 Digital color specification system

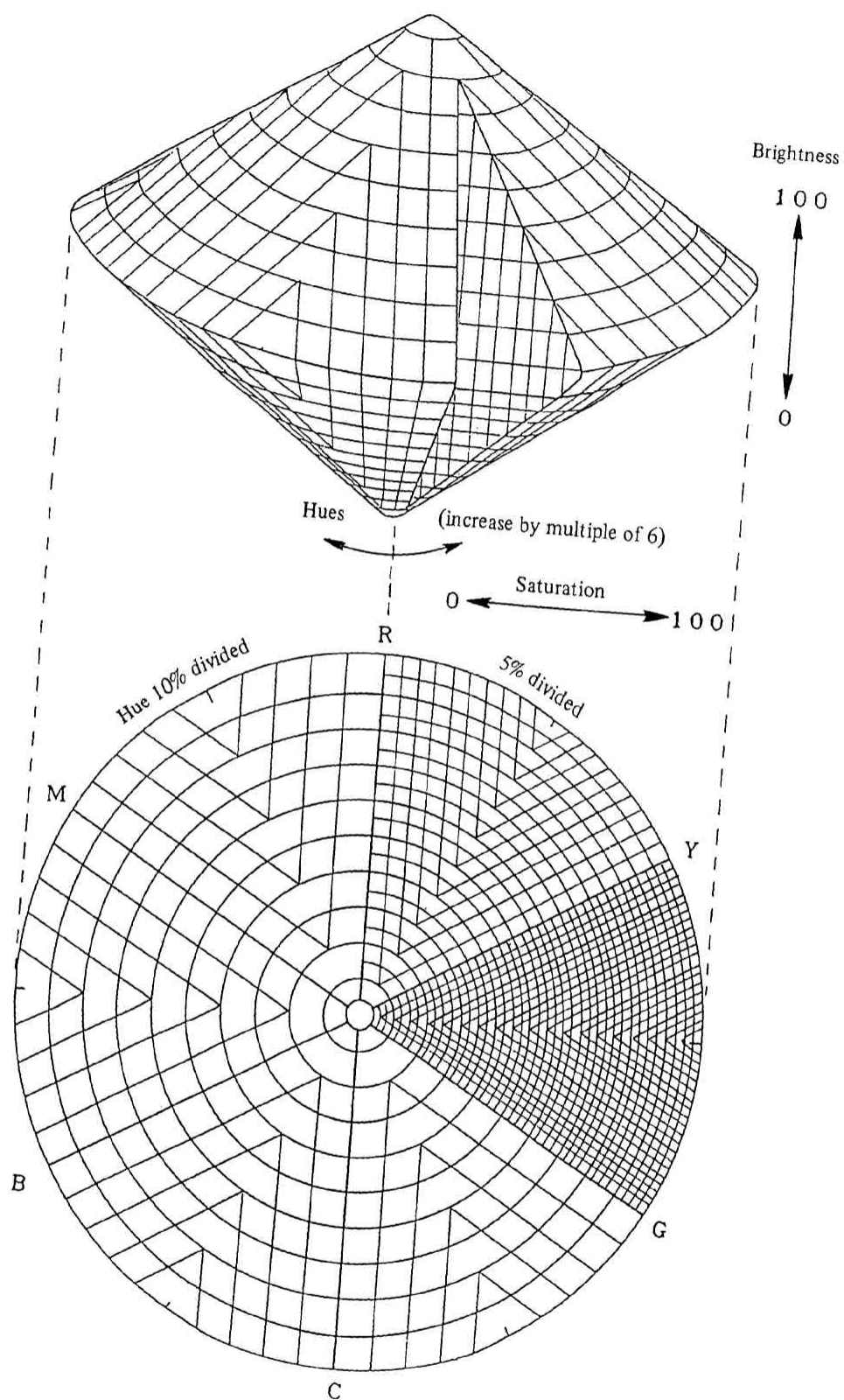
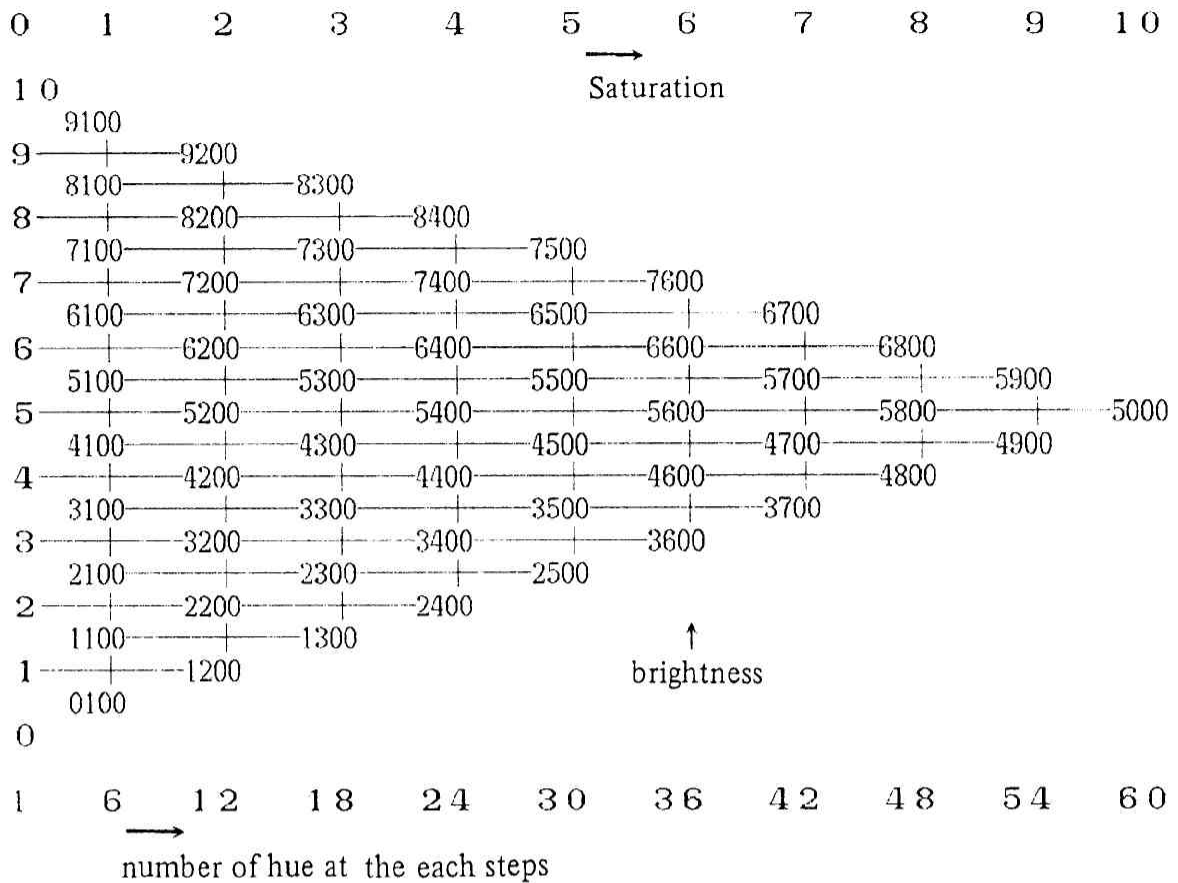


Figure-4 Cording of digital color



○ Encoding Method

One main requirement in encoding is that the colors and hues must be easy to understand and also manipulatable by machine. Therefore, they are respectively numbered in the order of brightness, saturation, and hues. For example, if $N = 11$, the encoding would be as follows.

Brightness: Bright colors are arranged at the upper part, and dark colors at the lower part. The white color at the top is assigned brightness 10, and the black color at the bottom is given brightness 0.

Saturation: The uncolored central axis is assigned saturation 0, and while spreading outside the saturation increases, reaching 10 at the most vivid part.

Hues: Hue of R = 10 levels, Y = 20 levels, G = 30 levels, C = 40 levels, Bv = 50 levels, & M = 60 levels are arranged in clockwise direction on the outer periphery of color space.

- Table 1 below shows an example of encoding brightness 5, saturation 10, and hues 20.

[CMY] %

No.	5020	5021	5022	5023	5024	5025	5026	5027	5028	5029
C	0	0	0	0	0	0	10	20	30	40
M	50	40	30	20	10	0	0	0	0	0
Y	100	100	100	100	100	100	100	100	100	100

[RGB] %

No.	5020	5021	5022	5023	5024	5025	5026	5027	5028	5029
R	100	100	100	100	100	100	90	80	70	60
G	50	60	70	80	90	100	100	100	100	100
B	0	0	0	0	0	0	0	0	0	0

- **How to Identify the 4-Digit Color Codes?**

For example color code 5825 indicates brightness 5, saturation 8, and hue 25. In this case, the dot percentage of printing ink would be composed of C10%, M10%, Y90%; while its emitted color light would be composed of R90%, G90%, B10%.

The color code of brightness 1 stage higher than 5825 is 6825, and the color code of brightness 1 stage lower than 5825 is 4825.

The color code of saturation 1 stage higher than 5825 is 5925, and the color code of saturation 1 stage lower than 5825 is 5725.

And, the hue of 5825 changes respectively to 5815 (red) and 5835 (green).