



Trends in the development of the colorimetric systems after 1830

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Abstract: The article discusses the main trends of various types and forms of colorimetric systems after 1830 used in creating and building digital images.

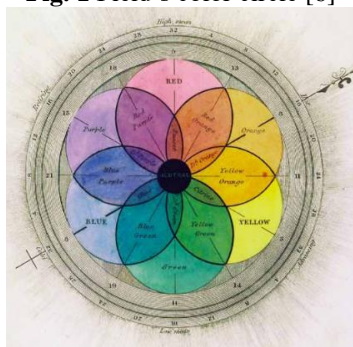
Keywords: colorimetric systems, color models, colors.

I. Development of the colorimetric systems after 1830

In 1841, George Field created a color circle that was largely influenced by the theory of Aristotle and Goethe's color circle.

In fig. 1 Field's colorimetric system is shown.

Fig. 1 Field's color circle [6]

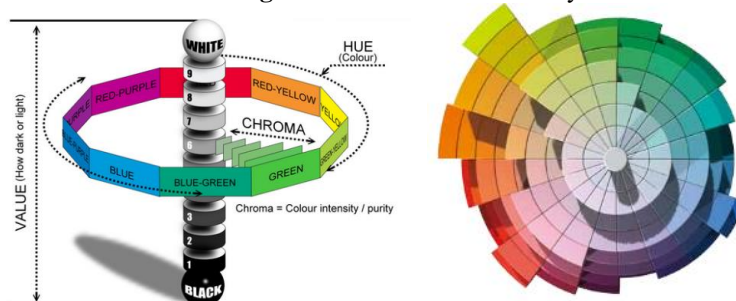


Until 1905, the trends in the development and the diversification of colorimetric systems continued, and the forms and types were very different. This year was a turning point in colorimetry, because it started to look at another way of perceiving the individual components of color - saturation, brightness and color tone.

In 1905, Albert Munsell divided the color space into areas based on saturation, color tone and brightness [7]. The color samples were originally created to be perceived in the same way and were, later cleared and adjusted on the basis of the color measurements to become a realistic color system used in the XYZ format.

In fig. 2. Munsell's colorimetric system is shown.

Fig. 2 Munsell's colorimetric system



Several years later, Wilhelm Ostwald used a reference grid in the form of a stack consisting of pure color levels, white levels and black levels of 24 color tones. The design of this system is based on the use of Hering's theory of the four colors and the law of Weber-Fechner for the relationship between perception and an exciter in the level of gray.

In fig. 3 the Wilhelm Ostwald's system is shown.

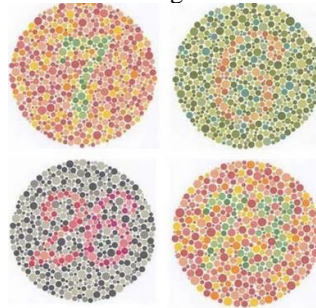
Fig. 3 Ostwald's system



In 1917, Shinobu Ishihara, Japanese professor at the University of Tokyo, created the test for red-green color blindness. This test system is widely used in medicine today, mainly for determining the color perception of individual digits by the visual apparatus of the human.

In fig. 4 the Shinobu Ishihara's system is shown.

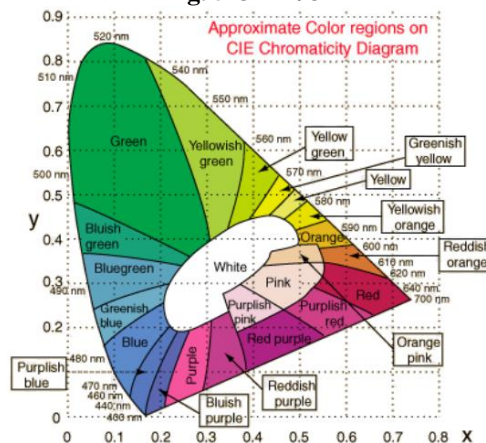
Fig. 4 The test for red-green color blindness



The CIE 1931 color spaces are the first defined quantitative links between physical pure colors (i.e. wavelengths) in the electromagnetic visible spectrum, and physiological perceived colors in human color vision. CIE 1931 RGB color space and CIE 1931 XYZ color space were created by the International Commission on Illumination (CIE) in 1931 [1]. The CIE XYZ color space is derived from a series of experiments done in the late 1920s by William David Wright [2] and John Guild [3]. Their experimental results are combined into the specification of the CIE RGB color space, from which the CIE XYZ color space is derived.

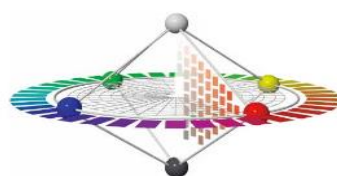
CIE 1931 is one of the most widely used color systems. In fig. 5 CIE 1931 is shown.

Fig. 5 CIE 1931



The NCS (Natural Color System [8, 9]) is a color system used in the Swedish industrial standards. The NCS color system expresses colors in terms of constituent ratios of six psychological elementary colors: white, black, red, yellow, green, and blue. The colors are divided into 10 even steps between the primary colors red, yellow, green, and blue, giving 40 hues. The shape of the color solid resembles the abacus bead shape of Ostwald's color solid, but a major difference is that the colors making up the solid are determined based on perceptive experimental data. In fig. 6 the natural color system is shown.

Fig. 6 Natural color system



The development and the improvement of already existing colorimetric systems continued in the next few years. In the modern world, several colorimetric systems or color models are the most widely applied. These are: RGB, CMYK, CIE LAB etc.

II. Basic color models

It was Maxwell, who expressed the idea of the existence of three basic colors for the first time - in the color theory of color vision.

RGB is the abbreviation of Red (red), Green (Green), Blue (blue) and is an additive color system (abstract model for quantitative determination of the colors) [5].

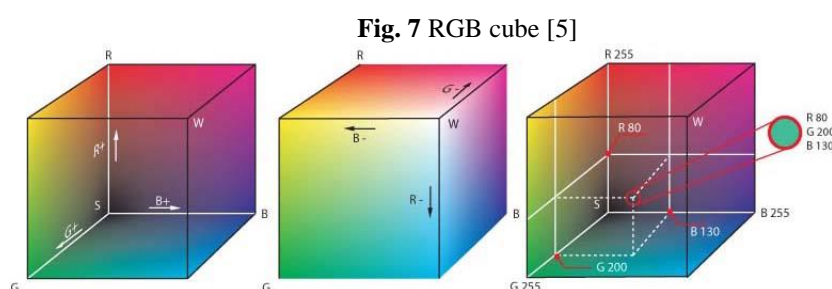
All hues of the color of the visible spectrum can be obtained through the combination of the three primary monochromatic radiations - red, blue and green. Upon mixing of the two basic colors, as well as the mixing of two fundamental (basic) and adding a third primary color, the result is the production of a different color.

This model is presented in three-dimensional space, and each coordinate reflects the "weight" at a primary color in the resulting color and this weight ranges from zero to maximum value. The result is a cube, which contains all the colors that form the color space (model) RGB (Fig. 7).

It turns out that a sufficiently large part of the visible spectrum can be represented by mixing the red, green and blue lights in different proportions and intensities. When two or three of these colored lights overlap, they produce the complementary colors cyan, magenta, yellow and white.

It is the most widely applicable system of color reproduction in color monitors and TVs, and for each pixel of the screen there are three emitting diode transitions or three types of phosphors which emit red, green and blue light.

This color system can be represented schematically in the form of a cube, with each of the possible colors located within this cube (fig. 7).



It is important to note the main points of this model. In the first cube at the beginning of the coordinates, all of the constituents are zeros or there is no radiation, i.e. this is the point of black. Second, where all constituents components have a maximum value and it is the point of white. On the line joining these points the achromatic colors are located (these are shades of gray) – i.e. from white to black. This is because the three basic (constituents) are the same and are in the range from zero to the maximum value.

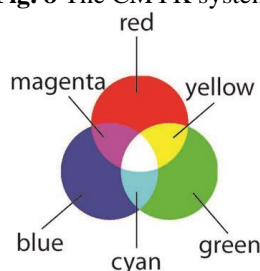
In computer systems and technologies 256 gradations (shades) of gray are most commonly used (there are scanners that recognize and encode up to 1024 shades of gray).

Image scanners use this model to encode images and to display color on the monitor. Modern television also works on this principle.

In practice, RGB is the most widespread color system (model) for computer images. In a 24 bit version 256 values for each of the three primary colors are possible in this system, resulting in derivative combinations in the range of 16,777,216.

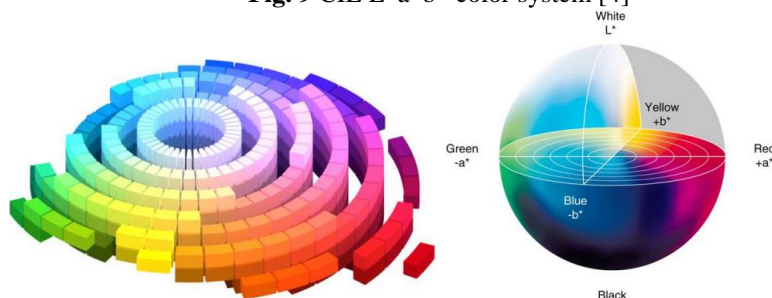
The CMYK color system has found practical application mainly in photo printers and other printing systems. In them for each point on the white sheet there are four to six types of inks colored in magenta (light or dark), cyan (light or dark), yellow and black. The CMYK system has the form shown in fig. 8.

Fig. 8 The CMYK system



The CIELAB color space is a uniform color space recommended in 1976 by the International Commission on Illumination (CIE), written as CIE $L^*a^*b^*$. This color space (figure 9) is relatively uniform perceptually and conforms closely to the red-green and blue-yellow scales. CIELAB is widely used in areas involving reflective and transparent products, such as printing and graphic arts.

Fig. 9 CIE $L^*a^*b^*$ color system [4]



III. Conclusion

The variety of colorimetric systems is of exclusive importance for the development of computer and communication systems in the modern world. Without these systems the development of the cinema, cartography, medicine, caving, architecture and other application areas of the rapidly developing technological world would not be possible.

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Acknowledgments

The authors would like to acknowledge the support of the "Research & Development" division of Plovdiv University in the project: НН15-KC-016/24.04.2015.