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VLADIMIR VASILEVICH PILYAVSKIY
Odessa National Academy of Telecommunications n. a. O. S. Popov
SE «Ukrainian Research Institute of Radio and TV»

SELECTION OF TEST MATERIAL FOR COLORIMETRIC ASSESSMENT QUALITY UHDTV VIDEO PATH

Abstract – A technique for optimal spectra for constructing the optical test patterns for Ultra High Definition Television. Shows the parameters of the spectra using the source of white type D65.

Keywords: TV colorimetry, spectral of primary color, assessment quality, error of color reproduction, spectral characteristics of TV camera, source light, primary color, triangle of color

В. В. ПИЛЯВСКИЙ
Одесская национальная академия связи им. А. С. Попова
ДП «Украинский научно-исследовательский институт радио и телевидения»

ВЫБОР ИСПЫТАТЕЛЬНОГО МАТЕРИАЛА ДЛЯ КОЛОРИМЕТРИЧЕСКОЙ ОЦЕНКИ КАЧЕСТВА ТВ ТРАКТА СВЕРХВЫСОКОЙ ЧЕТКОСТИ

Аннотация. Рассмотрена методика для получения оптимальных спектров для построения оптических испытательных таблиц для телевидения сверхвысокой четкости. Приведены параметры спектров с использованием источника белого типа D65.

Ключевые слова: ТВ колориметрия, спектр основных цветов, оценка качества, искажения цвета, спектральные характеристики камеры, источники освещения, основные цвета, треугольник цветов

The emergence of multimedia systems with an extended range of colors , such as , UHDTV, DCDM, ACES, RIMM-ROM , etc. requires a new approach to the selection of optical test images to measure color reproduction quality. Since this article focuses on television, following will only consider an ultra-high -definition television (UHDTV).

Since the system of Ultra High Definition Television [1] covers a much larger portion chromaticity diagram than a system of standard and high –definition, [2] use of a set of optimal colors, proposed [3] for systems with less coverage on the chromaticity diagram, is not possible.

The article describes the method by which the results were obtained for the construction of optical test pattern. Also shows an algorithm for the calculation of the spectral components of primary and secondary colors.

Initial data for finding optimal spectra of primary and secondary colors were taken coordinates and values equisignal white color, type D65, in the coordinate system Yxy, *see Table 1*.

To find the wavelength which corresponds to the maximum spectral energy distribution of each color, use the straight line equation in the following form,

$$y = \frac{x - x_W}{x_{color} - x_W} \cdot (y_{color} - y_W) + y_W ,$$

$$x = \begin{cases} [0:0.33] & \text{for} \quad B, C, G \\ [0.33:1] & \text{for} \quad R, Ye \end{cases} ,$$

where x_{color}, y_{color} – the coordinates of the test color in the color coordinate system Yxy , and x_W, y_W – coordinates equisignal white color, *see Table 1*.

Segment starts from the point of equisignal white (W) passes through the point of the test color and continues so it would cross the chromaticity diagram. Knowing the coordinates of the intersection point of the segment and the chromaticity diagram detect an affiliation of obtained coordinates to corresponding wavelength. The wavelengths obtained this way are shown in Table 1 and Figure 1.

Table 1

Coordinates and color values of the maximum of the spectral distribution

	R	*G*	*B*	*Ye*	*C*	*M*	*W*
x	0,708	0,17	0,131	0,4465	0,1465	0,3682	0,3333
y	0,292	0,797	0,046	0,5374	0,3446	0,1471	0,3333
$\lambda_ц$	630	531	467	571	492		

Purple color is obtained by a combination of spectral components of red and blue colors in a different proportions, the equation describing the obtaining purple color is following:

$$M = \lambda_R \cdot R_M + \lambda_B \cdot B_M ,$$

where λ_R and λ_B – wavelength corresponds to the distribution of red and blue, and R_M and B_M – coefficients expressing the quantitative relationship of red and blue in magenta , are presented in Table 2 . Finding the coefficients, R_M and B_M, is done by solving the minimization problem, i.e. determination of such values of R_M and B_M, in which ΔE will tend to zero.

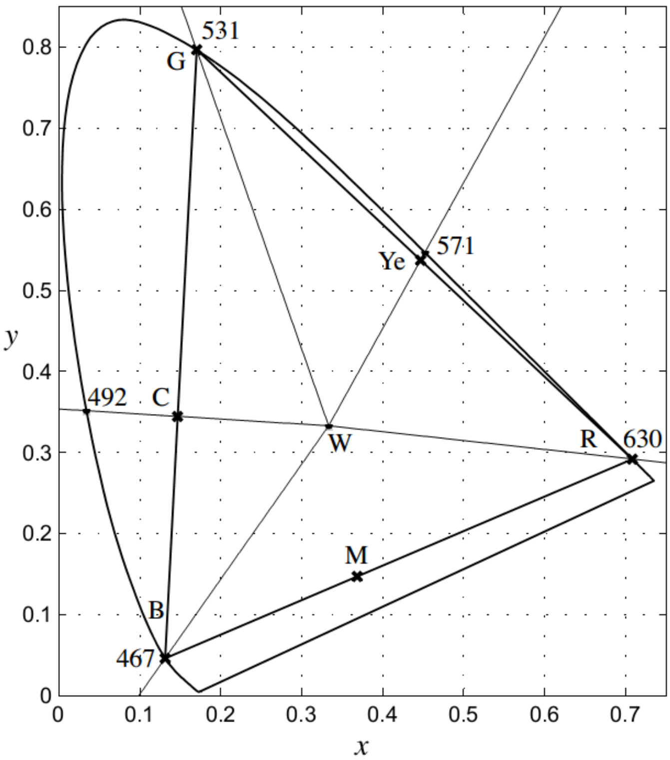

Figure 1. Finding the maximum of the spectral distribution for each color

Coefficients are different for different light sources and depend on the power spectral distribution of the light source. For example, shown below the values of the coefficients for fluorescent light sources which are as close as possible to the standardized spectral distribution of the light source type D65, Table 2

Table 2

Leveled ratios of red and blue in magenta

	R_M	B_M
D65	0,6225	1,3461
FL 3.15	0,5881	1,3369
FL 1	0,6112	1,3582

Use of the data obtained in this form is difficult because to implement such narrowband spectra for the main and additional to them colors is not always possible. The spectra of the primary colors, red, green and blue, are narrowband because the points of the primary colors located on the boundary of the chromaticity diagram, ideally it is monochromatic radiation such as a laser. For additional colors were taken normal distribution of the Gaussian in the following form ,

$$y(x) = 1 \big/ \sqrt{2\pi}\xi \cdot e^{-\frac{(x-\lambda_ц)^2}{2\xi^2}},$$

where $y(x)$ – the value of the level of the spectral distribution $x = (360:1:720)$, and $\lambda_ц$ - value of the wavelength with the maximum level of the spectrum ξ – the distance from $\lambda_ц$ to the point of inflection characteristics . Solving the problem of finding the minimum of the function $error(\lambda_ц, \xi) = \sqrt{(x_0 - x)^2 + (y_0 - y)^2}$ where x_0, y_0 the coordinates of the test color, see Table 1, x, y the coordinates obtained after the selection of parameters $\lambda_ц, \xi$. The results are shown in Figure 2.

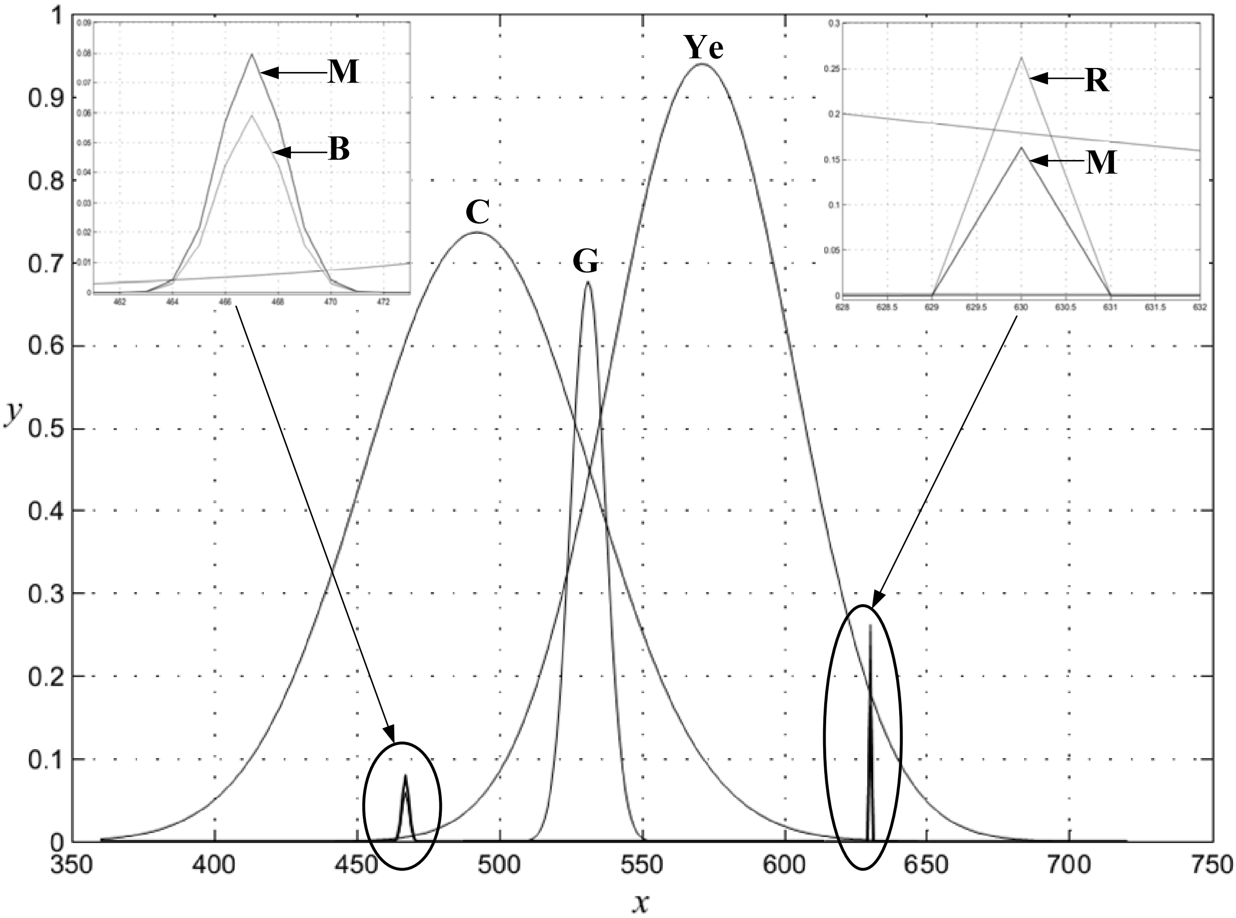

Figure 2. The spectral composition of primary and secondary colors are presented to them for SDTV

Values range of optical samples , shown in Fig. 2 built for the reference of the light source type D65. The change in the values of color rendering when using real or industrial light sources are presented below. For this illustration were selected light sources, which have the best similarity to the standardized light source D65, it is a type of fluorescent light sources FL 3.15 and FL 1.

Since the effect of different light sources on color is obvious, because of unique spectrum of each light source, it would be useful to objectively evaluate these distortions. All estimates are given in uniform color space coordinate system CAM02-UCS [4] and as such it allows to take into account all the peculiarities of human eye sight adaptation. The results are shown in the chromaticity coordinates in the color space Yxy see Table 3 and in terms of the CIE see Table 4 expressed in units of ΔE the formula

$$\Delta E = \sqrt{\left(\Delta J'\right)^2 + \left(\Delta a'_M\right)^2 + \left(\Delta b'_M\right)^2}\ ,$$

where $\Delta J' = J'_{\mathrm{D65}} - J'_{\mathrm{FL1,\ FL3.15}}$, $\Delta a'_M = a'_{M_{\mathrm{D65}}} - a'_{M_{\mathrm{FL1,\ FL3.15}}}$, $\Delta b'_M = b'_{M_{\mathrm{D65}}} - b'_{M_{\mathrm{FL1,\ FL3.15}}}$, where J', a'_M, b'_M – in the chromaticity coordinates CAM02-UCS system

Table 3

Color coordinates obtained when the sample is illuminated by different light sources

	FL 1			FL 3.15			D65		
	x	y	z	x	y	z	x	y	z
R	0,7079	0,2920	0,0001	0,7079	0,2920	0,0001	0,7079	0,2920	0,0001
G	0,1714	0,7915	0,0371	0,1698	0,7924	0,0378	0,1664	0,7950	0,0386
B	0,1314	0,0460	0,8226	0,1313	0,0461	0,8226	0,1314	0,0460	0,8226
Ye	0,4431	0,5441	0,0128	0,4383	0,5450	0,0167	0,4399	0,5435	0,0166
C	0,1636	0,3031	0,5350	0,1507	0,3031	0,5462	0,1504	0,3004	0,5492
M	0,2984	0,1173	0,5843	0,3522	0,1403	0,5075	0,3328	0,1320	0,5352

The evaluation was conducted under the following viewing conditions – luminance adaptation $L_A = 20, 50, 200\ \mathrm{cd/m^2}$, which corresponds to the brightness of white $Y_W = 100, 250, 1000\ \mathrm{cd/m^2}$ and middle-condition for the observation, with stimulus intensity equal $Y = 100\ \%$. The results of evaluations are listed in Table. 3.

Table 4

Error values of color

	R	G	B	Ye	C	M
L_A=20 cd / m^2						
FL 3.15	0,01	0,548	0,01	1,117	2,295	7,858
FL 1	0,01	0,359	0,07	0,413	0,550	3,964
L_A=50 cd / m^2						
FL 3.15	0,01	0,570	0,01	1,151	2,374	8,140
FL 1	0,01	0,373	0,08	0,433	0,572	4,105
L_A=200 cd / m^2						
FL 3.15	0,01	0,605	0,01	1,198	2,496	8,590
FL 1	0,01	0,395	0,08	0,463	0,607	4,318

The results show how much the selected light source influence on each color. If you apply the definition of the metric signature color distortions presented in [5], we can say that the noticeable color distortion falls down only on purple color, for all the other colors , color distortion is not noticeable .

Obtained results set the standards for building optical test materials for UHDTV, and also are ideal base line colors. The practice should maximally correspond with the mentioned above spectral characteristics.

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