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Y. Zhang, postgraduate;
M.A. Klyavdo, graduate
(BNTU, Minsk)

COMPLEX MODEL OF THE VISUAL ENVIRONMENT FOR VIEWING DIGITAL IMAGES

The human visual system has the ability to process information in a complex visual environment. In the physiology of vision, it is customary to distinguish photopic, mesopic, and scotopic vision. Photometric quantities are grouped depending on the conditions of visual observation using appropriate descriptors and are associated with radiometric (energy) quantities by the spectral functions of light output $V_X(\lambda)$. For photopic vision with an adaptation brightness above 5 cd/m^{-2}, the following functions are used: $V(\lambda)$ for all tasks of visual observation, when objects seen by the eye are in a narrow (about 4° or less) field of foveal view [1]; $V_{10}(\lambda)$ for the field of view when the visual target is seen off-axis at a wavelength, λ_{10m} = 557 nm; V_F of a modified CIE 1988 2° observer for photopic vision research purposes [2]. The light output function V'(λ) adopted by ISO/CIE, 2005 [3] is used for scotopic vision with an average adaptation brightness of the eye L< 0.005 cd/m^{-2}. The family of luminous efficacy spectral functions $V_{mes;m}(\lambda)$ physiology-based for peripheral tasks (not applicable to foveal vision) [4, 5] is used for mesopic vision with adaptive brightness from 0.005 cd/m^{-2} to 5 cd/m^{-2}:

$$V_{mes;m}(\lambda) = \frac{1}{M(m)}\left[mV(\lambda) + (1-m)V'(\lambda)\right] \qquad (1)$$

where *m* is the adaptation coefficient 0≤m≤1 (m = 0.2; 0.4; 0.6; 0.8); *M*(m) is a normalizing function such that $V_{mes;m}(\lambda) = 1$.

As the visual environment has a huge impact on the visual processing process, there are many regulatory documents containing requirements and recommendations for creating a good light environment in various venues and residential areas. For example, SN 2.04.03-2020 establishes intervals for permissible values of indicators: natural light factor; contrast *K* to the distinction of the object on the background, safety factor, illumination pulsation coefficient, coefficient of light climate m, threshold brightness increment T_i, reflected brilliance, glare index *P*, discomfort index *M* to assess the discomfort caused by glare with an uneven distribution of light brightness according to the formula:

$$M = (L_c\Omega^{0.5}) / (\varphi_0 L_{ad}^{\;0.5}) \qquad (2)$$

where L_c is the brightness of the bright source, cd/m^2; Ω is the angular size of the bright source, sr; φ_0 is the position index of the bright source relative to the line of sight; L_{ad} is adaptation brightness, cd/m^2.

GOST 33392-2015 defines the combined indicator of discomfort UGR – an international criterion for assessing uncomfortable glare that causes discomfort with an uneven distribution of brightness in the field of view:

$$UGR = 8\lg\left[\frac{0.25}{L_a}\sum_{i=1}^{N}\frac{L_i^2\omega_i}{p_i^2}\right] \quad (3)$$

where N is the number of fixtures in the lighting installation; L_i – overall brightness of the luminous part of the i-th lamp in the direction of the observer's eyes, cd/m^2; ω_i - solid angle of the luminous parts of the i-th lamp from the observation point, sr; L_a - background brightness, cd/m^2; p_i - position index for the i-th luminaire, taking into account its placement relative to the line of sight of the observer graphically shown.

The relationship between the UGR discomfort score and the M and P scores is graphically shown in Figure 1.

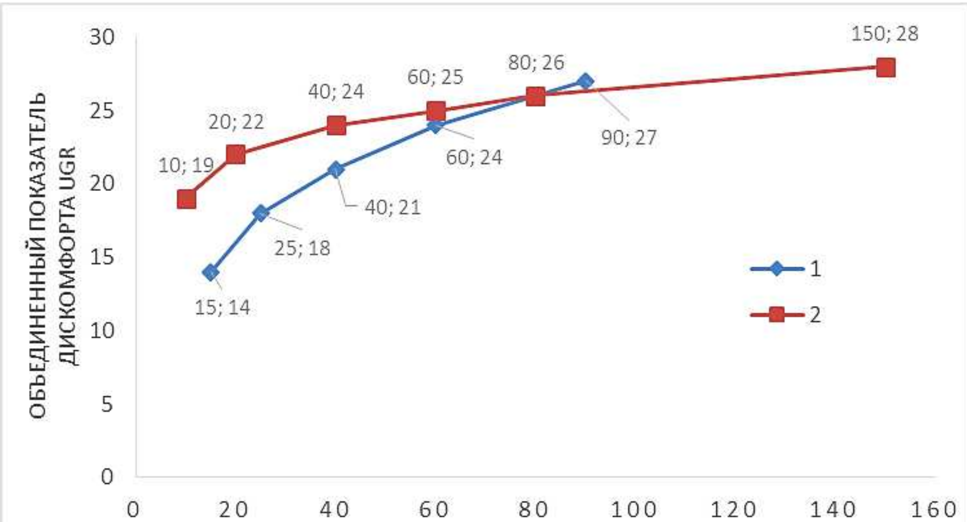

Figure 1 – The relationship of indicators UGR, M and R

Chromatic adaptation is the ability of the human visual system to maintain a color sensation when the lighting conditions of objects change [6]. So, for example, whiteness, being an important attribute in industry (when a brightness factor of more than 100% is reached, the sample may look like fluorescence). The formulas for the differential evaluation of whiteness W or W_{10} and tint T_W or T_{W10} recommended by CIE are limited by repeatability conditions and the use of D65 illuminant [7]:

$$W = Y+800(x_p-x)+1700(y_p-y) \quad (4)$$

$$W_{10} = Y_{10}+800(x_{p,10}-x_{10})+1700(y_{p,10}-y_{10}) \quad (5)$$

$$T = 1000(x_p - x) - 650(y_p - y) \quad (6)$$

$$T_{w,10} = 900(x_{p,10} - x_{10}) - 650(y_{p,10} - y_{10}) \quad (7)$$

where x_p, $x_{p,10}$, y_p, $y_{p,10}$ are the chromaticity coordinates of the reference samples; x, y, x_{10}, y_{10} - color coordinates of the studied samples.

Conclusion

The visual environment is a dynamic system characterized by a range of photobiological, technical, photometric, chromatic parameters and energy efficiency indicators. It is possible to design a model of the visual environment, which is a combination of a series of formulas, through continuous update iterations, the most appropriate light source can be selected for any given situation. When selecting a light source spectrum, other aspects that may be critical to a particular application should also be considered, such as: color recognition, color reproduction, uncomfortable glare (especially for the elderly), concentration and alertness, user Acceptability, sky glow, exposure to the natural environment, including effects on flora and fauna, human health and well-being.

LITERATURE

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