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42nd European Conference on Visual Perception (ECVP) 2019 Leuven

Welcome Address

We are very pleased to introduce to you the yearly issue of Perception with the abstracts of all presentations at the European Conference of Visual Perception (ECVP). The 42nd edition of ECVP was held in Leuven (Belgium), from Sunday August 25 till Thursday August 29, 2019, and consisted of 2 keynotes, 15 symposia, 33 regular talk sessions, and 8 poster sessions. In total, the program contained 273 talks and 415 posters, enough for 4 full days.

In addition, we had a series of 12 splendid tutorials focused on hot topics, techniques and research skills, we had a historical exhibition (highlighting the long and strong tradition in experimental perception research in Leuven) and a "Phenomenal Vision Night" – both open to the broader public as well. These additional components are not visible in the present set of abstracts, but you can find more information about them on the ECVP 2019 website: https://kuleuvencongres.be/ecvp2019.

We believe that this year's program contained a good mix of traditional ECVP ingredients in terms of content and approach, which were spiced up with some local Leuven flavors (perhaps some more neurophysiology, modeling, and clinical work than usual).

We have been able to put this together with the financial support from our sponsors, with the advice and help of extensive scientific and organizational committees, with the professional assistance by the Conference and Event Office of KU Leuven, and the peer reviews from 140 willing colleagues (all mentioned on the website).

In any event, we hope you find it useful to have access to this compilation of short descriptions of all the research findings and insights presented at ECVP in Leuven this year.

Johan Wagemans, on behalf of the scientific and organizing committees of ECVP 2019

Contents

How Many Component (Unique) Hues Can Dichromats See?

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According to the model of dichromatic colour vision proposed recently (Logvinenko, 2014), the dichromatic hue palette differs significantly for object and light colours. This may explain why there is no consensus on what colours dichromats see. We explored the object hue palette. A set of Munsell chips was chosen, which should be equally perceived by dichromats and trichromats. These chips clearly contain the red, green, and blue component hues. As to green, it was tinged with such an amount of white that it was hard to judge its presence even for trichromatic observers. We used the hue scaling method to evaluate the amount of all six component hues for each chip in the sample. Trichromatic observers were asked to evaluate, in percentage, how much of each component hue they saw in the chip. We found that although the amount of green was low, its presence for some chips was statistically significant. Thus, all the six component hues are present in the hue palette of dichromats. We also confirmed the opponency of black and white, which were never present together in any chip. This is contrary to the generally accepted view that grey is a mixture of black and white.

The Screening Program for Detecting Color Vision Deficiencies Based on a Color Blindness Simulator: Preliminary Study

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We have developed the screening program for color vision deficiencies. The program is based on the color blindness simulator presented earlier (ECVP, 2018). Three images—full color one, simulated "deuteranopic" and "protanopic" images—are displayed simultaneously. The task for the subject is to pick the most different image among the set of three images. Normal trichromats select the original picture as the most different one, protanopes select "deuteranopic" image, and deuteranopes select "protanopic" image. In addition, 81 children (9–17 years old, 26 males and 55 females) and 2 adults (males) were tested. We assessed color vision with Rabkin polychromatic test plates, and with our program. For the program we used ASUS UX305 with anti-glare IPS-screen. In both tests, we assessed subjects who make zero mistakes in all images as "normal," others—as "abnormal" (anomalous trichromats and dichromats). Seven subjects were identified by the Rabkin test as "abnormal." Comparing to the Rabkin test, the screening program has sensitivity—71%, specificity—100%. It seems that increasing the number of test images for each subject (we used 11) may increase the sensitivity. Our screening program seems to be a promising new method for detecting color deficiencies, though further studies on bigger samples are needed.

Perceptual Accuracy of a Spectrally and Physically Based Rendered Cornell Box Versus a Real Cornell Box

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The Cornell box has been used throughout computer graphics to show the interaction of light in computer renderings. However, it is currently unknown how this corresponds to that of a real Cornell box. In this project, test subjects will visually compare a real Cornell box to a simulated box and rate the perceived differences for the different materials in terms of brightness, colorfulness, and hue. The real Cornell box will be built based on characteristics reported in the literature, with walls and objects layered with uniformly colored paper. The real box and its materials will be optically characterized. A colorimetric accurate simulation of the box will then be rendered in Mitsuba, a state-of-the-art spectral and physical based renderer (SPBR). Colorimetric accuracy will be checked using XYZ tristimulus maps obtained with a TechnoTeam LMK-5 Color Luminance Camera and by measuring the spectral irradiance at several locations using a GigaHertz Optik BTS256E spectral irradiance meter. Considering the colorimetric accuracy, perceptual accuracy, determined in the visual experiment, will be characterized. Determining the perceptual accuracy of the current state-of-the-art SPBR could greatly advance research in lighting visualization and also other fields such as computer graphics.

The screening program for detecting colour vision deficiencies based on a colour blindness simulator: preliminary study

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Introduction

The main pathologies of color vision – dichromacy and anomalous trichromacy – are caused by the malfunction of one of the cone types. There are three types of dichromacy: protanopia – the absence of a long-wave photopigment, deuteranopia – the absence of a middle-wave photopigment, and very rare tritanopia – the absence of a short-wave photopigment, while anomalous trichromacy is caused by the shift of the spectral sensitivity curve of one of the cone types from its normal position along the axis of wavelengths.

In this work we present the algorithm for simulation of dichromatic perception and the diagnostic computer program for color vision deficiencies based on this algorithm. We compare our program with the Rabkin test, a common diagnostic means for color vision disorders in Russia (Rabkin, 1971). In addition, we theoretically predict the impact of incorrect monitor settings on the quality of diagnostics by our program.

Algorithm description

The work of the simulator is based on direct and inverse transformations between monitor pixel values (R, G, and B) and relative cone excitations (L, M, and S). Relative spectral sensitivities of human cones were deduced from the CIE XYZ colorimetric system basing on the set of three copunctal points: protanopic (x_p=0.75; y_p=0.25; z_p=0.0), deuteranopic (x_d=1.7; y_d=−0.7; z_d=0.0) and tritanopic (x_t=0.17; y_t=0.0; z_t=0.83) (Nyberg, Yustova, 1957):

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix} = \begin{pmatrix} x_p & x_d & x_t \\ y_p & y_d & y_t \\ z_p & z_d & z_t \end{pmatrix} \cdot \begin{pmatrix} w_L \cdot L \\ w_M \cdot M \\ w_S \cdot S \end{pmatrix} \qquad (1)$$

To convert pixel RGB values to XYZ color values the following data is required:
1) the chromaticities of primary monitor colors (red, green and blue): $x_R, y_R, x_G, y_G, x_B, y_B$;
2) the chromaticity of the monitor white light: x_W, y_W (or correlated color temperature);
3) the gamma value of the video system, which describes the nonlinear relationship between pixel values and intensities.

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix} = \begin{pmatrix} x_R & x_G & x_B \\ y_R & y_G & y_B \\ z_R & z_G & z_B \end{pmatrix} \cdot \begin{pmatrix} a_R \cdot R_{lin} \\ a_G \cdot G_{lin} \\ a_B \cdot B_{lin} \end{pmatrix}, \text{ where } R_{lin} = \left(\frac{R}{255}\right)^{\gamma};\quad G_{lin} = \left(\frac{G}{255}\right)^{\gamma};\quad B_{lin} = \left(\frac{B}{255}\right)^{\gamma}; \qquad (2)$$

The weighting factors w_L, w_M, w_S in (1) and a_R, a_G, a_B in (2) were calculated so that the brightest white pixel (255, 255, 255) corresponded to XYZ color with unity lightness and to LMS values of (1, 1, 1):

$$\begin{pmatrix} x_W/y_W \\ 1 \\ z_W/y_W \end{pmatrix} = \begin{pmatrix} x_R & x_G & x_B \\ y_R & y_G & y_B \\ z_R & z_G & z_B \end{pmatrix} \cdot \begin{pmatrix} a_R \\ a_G \\ a_B \end{pmatrix} \qquad \begin{pmatrix} x_W/y_W \\ 1 \\ z_W/y_W \end{pmatrix} = \begin{pmatrix} x_p & x_d & x_t \\ y_p & y_d & y_t \\ z_p & z_d & z_t \end{pmatrix} \cdot \begin{pmatrix} w_L \\ w_M \\ w_S \end{pmatrix}$$

The algorithm works as follows. For each pixel of the original image:
1) the LMS values for the normal trichromate are calculated;
2) the value of the omitted photopigment (L for protanopes and M for deuteranopes) is substituted with the linear combination of other LMS values: $L_p = p_p \cdot M + q_p \cdot S$, $M_d = p_d \cdot L + q_d \cdot S$;
3) these modified LMS values are transformed back to the R_{lin}, G_{lin}, B_{lin}, and then to pixel RGB values.
It is highly probable that for an arbitrary chosen image some of the values of R_{lin}, G_{lin}, or B_{lin} for some pixel may exceed the range [0, 1], which indicates that the color range of the simulated image exceeds the monitor gamut and the simulated image can not be correctly displayed. To be able to work with any image the program should contain a preprocessing procedure, which, if necessary, reduces brightness and/or saturation of the image before conversion.

Program description

The program is intended for diagnostics of protanopia and deuteranopia (not tritanopia). In the program the conversions from the pixel RGB values to LMS values and vice versa were made with the assumption that the monitor was set up to the color temperature of 6500 K (x_W=0.3127, y_W=0.3291) and had the gamma value of 2. We assumed the following chromaticities of monitor primary colors: x_R=0.625, y_R=0.342; x_G=0.307, y_G=0.587; x_B=0.156, y_B=0.069. We suppose these chromaticities not to differ much among the monitors (Golz, MacLeod, 2003).

The subject is being sequentially presented with triples of images: a "trichromatic" one, and two images simulating color perception of protanopes and deuteranopes. The order of presentation of the triples as well as the positions of images in each triple are pseudo-random. The task of the subject is to select the image standing out color-wise. Normal trichromates select the "trichromatic" image as the most different one, protanopes select "deuteranopic" image, and deuteranopes select "protanopic" image. The selections made by the subject are recorded to the log file.

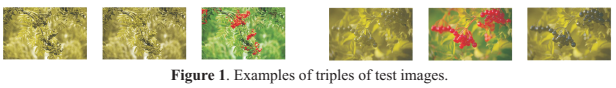

Figure 1. Examples of triples of test images.

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Program approbation

The aim of approbation: to compare the program with pseudo-isochromatic plates – the Rabkin test (similar to the Ishihara test).
Subjects. 81 schoolchildren (8-17 years old) and two adult dichromats.
Methods. Viewing distance for pseudo-isochromatic plates was 40 cm; viewing distance for computer program - 50-60 cm. Ambient lighting was 300 lux. Each subject was tested by computer program ant then by pseudo-isochromatic test.
The approbation was conducted in three sessions:
in the first session we used 3 test images in computer program (53 subjects),
in the second session we used 11 test images (28 subjects),
in the additional session we tested 2 adults with known dichromacy.
Results. In the first session 2 subjects from 53 were diagnosed as dichromats by pseudoisochromatic plates; only one of them was diagnosed as dichromat by computer program.
We supposed, that three images might be not always enough for correct testing.
In the second session 4 subjects from 28 were diagnosed as dichromats by pseudoisochromatic plates; three of them were strictly diagnosed by computer program as dichromats, and the fourth gave ambiguous responses: 1 response – as a deuteranope and 10 responses – as a normal trichromat; we attributed him to the deuteroanomalous trichromat.
In the additional session two adult subjects were correctly diagnosed as dichromats by both tests.
By approbation we can conclude that all subjects were able to understand the task. The program appears to be suitable for testing even in younger group (8-9 years old).

Figure 2. Color vision testing procedure.

The influence of the monitor parameters on the quality of simulation

The parameters of the monitor used for screening – color temperature, chromaticities of primary colors and gamma value – should correspond to those used in the algorithm.

Figures 3 shows the predicted influence of the real monitor gamma value on the shifts of color coordinates of test image colors in the LMS color space. It can be seen that when the gamma value of the monitor is 3, the position of purple colour on the MS plane is closer to position of color simulated for deuteranope than to the position of color simulated for protanope. In this case the protanopes will be diagnosed as deuteranopes. At the same time the position of that purple color on the LS plane is far from its simulations for protanopes and deuteranopes, which in turn are close to each other. In this case deuteranopes could be diagnosed as normal trichromats.

Figure 4 shows the predicted shifts in positions of test image colors in the LMS color space caused by incorrect color temperature setting of the real monitor. Surprisingly, this setting proved to be not so critical as gamma value for correct diagnostics by the program.

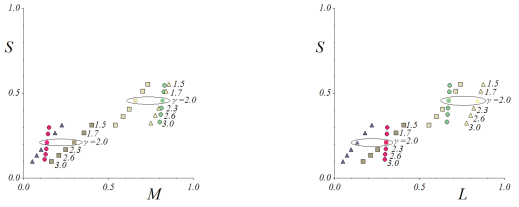

Figure 3. Two monitor colors, green (0,255,160) and purple (255,0,120), and their simulations for deuteranopes and protanopes in the human LMS color space. The simulator was set up for the monitor with color temperature of 6500 K and gamma value of 2. Circles denote the calculated positions of these colors in the color space with the assumption that real monitors has gamma values from 1.5 to 3. Squares represent the positions of colors simulated for deuteranopes, triangles represent colors simulated for protanopes.

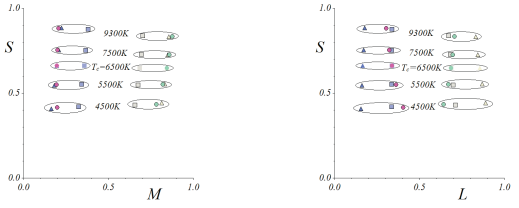

Figure 4. Two monitor colors, cyan (0,255,200) and magenta (255,0,220), and their simulations for deuteranopes and protanopes in the human LMS color space. The real monitor is assumed to be set up for color temperatures from 4500 K to 9300 K. Other conventions are the same as in Figure 3.

Conclusion

1. The data of preliminary examining (83 subjects) demonstrated the usefulness of our color vision testing software.
2. The computer program proposed seems to be a promising substitution for pseudoisochromatic plates, because (1) the program is not affected by photodegradation, and (2) it is harder to cheat the program.
3. The mismatch between the gamma of the real monitor and the gamma specified in the algorithm can significantly affect the accuracy of diagnostics.