# Colorimetric assessment of visual color difference between interface elements

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**Abstract**

This paper proposes an approach for the measurement of the perceived difference between two colors of an arbitrary part of a user interface based on the color difference formulas. The study analyzes different ways of measuring the difference between colors perceived by the human visual system. It is proposed to use the color discrimination threshold when selecting colors for creating user interfaces, including those in virtual and augmented reality. A method for measuring the perceived difference between colors for people with color vision deficiency is described. Based on the results, software was developed to evaluate color discrimination thresholds. A comparison of the proposed metrics with Le Courier table and contrast ratio is provided.

**Keywords**

color difference, color perception, delta E, user interface

## 1. Introduction

Nowadays, with the spread of modern high-tech devices, the use of the graphical interfaces has become an essential part of everyday life. One of the most common examples is the usability of web pages, which determines the effectiveness of software interaction with the user. A crucial factor affecting the usability of a website is its color scheme, because it is the first thing a user pays attention to when visiting a page. Therefore, developing tools that allows one to choose the right color scheme is an important issue. To select a color similar to one in an image or another interface, the appropriate software is used. For example, Kubota et al. [1] developed a model for extracting visible color from an image using a color picker.

Although this software allows you to measure color, it does not provide an assessment of the combination of two colors.

Some studies have focused on evaluating color combinations in the context of their application in user interfaces. In their study of the visual effects of web pages, Kuo et al. [2] showed that the most popular colors for web pages with black backgrounds and white backgrounds were blue and cyan, respectively. Valerie Fernandez et al. [3] developed an enhanced color scheme assessment tool that evaluates colors based on color combinations. Paper [4] showed that the assessment of color combinations is individual, the most suitable colors for interactive web pages are royal blue, gray, and dark blue, and the most suitable pair for describing web page samples is "elegant–vulgar". Despite the fact that these studies have focused on human perception of color combinations, they concentrate on subjective assessment. At the same time, insufficient attention is paid to the selection of objective criteria for choosing color combinations. This definition would help to expand the color palette, using not only pre-studied combinations. Zhu et al. [5] proposed usage of Euclidean distance between colors to evaluate the combination of background color and font color. Although the established criterion allows mathematical evaluation of color combinations, it does not correspond to the perceived difference. Instead, it is promising to use colorimetric formulas that are developed taking into account the different

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sensitivity of the human visual system in different areas of the color spectrum. This method has already been successfully used to evaluate images [6].

## 2. Methods of color difference measurement

The background of the question "How different are two colors from each other?" includes research conducted over a long period of time. One of the most important discoveries in this field is the ellipses discovered by David L. MacAdam [7]. Each of them represents an area in the CIE 1931 color space within which colors are indistinguishable to human vision.

To obtain them, a series of experiments was conducted in which the observer selected a color corresponding to the reference one. Each color in the color space under consideration is represented by two chromaticity components and luminance, which was fixed at 48 $cd/m^2$ during the experiment. It is worth noting that this color space is non-uniform, i.e., the ellipses have different sizes and orientations. A color space in which the ellipses are significantly similar in area is called equidistant or uniform.

In addition to MacAdam ellipses, other experiments were also conducted, but under different conditions [8]. It should be noted that ellipses have several significant disadvantages for measuring color differences: they vary in size and are not calculated for every color. For practical tasks of measuring the difference between colors, the International Commission on Illumination developed $\Delta E$ formulas. Significant progress in measuring the perceived difference between colors was achieved in 1976, when $\Delta E$ was defined as the Euclidean distance between points in CIELAB space. This color space is quasi-uniform, which brings color coordinates closer to the difference in their perception [7]. However, this formula does not accurately define the noticeable difference between colors, which led to the development of further standards CIE94 and CIEDE2000 [9]. These formulas were developed to represent the population average and take into account the difference of color perception in different areas of the visible spectrum.

In addition to the CIE standards, numerous other formulas have been developed. Notable among them is the use of the CAM16-UCS color appearance model. It allows the $\Delta E$ metric to be found as the Euclidean distance between three color coordinates. This formula more accurately accounts for the nonlinearity of perception and is used to adapt the image to the spectral properties of the viewing environment [10].

### 2.1. CIEDE2000 formula

The current standard is CIEDE2000 [11], so we consider it for further application. Let's take a closer look at the sequence of calculations required to obtain the color difference. Since RGB is the most common color representation in computer graphics, but does not separate chroma and luma components, we need to convert color coordinates to CIEXYZ [12]. To do this, we multiply the transformation matrix by the corresponding RGB vector using the formula:

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} 0.4124564 & 0.3575761 & 0.1804375 \\ 0.2126729 & 0.7151522 & 0.0721750 \\ 0.0193339 & 0.1191920 & 0.9503041 \end{bmatrix} \times \begin{bmatrix} R \\ G \\ B \end{bmatrix}. \tag{1}$$

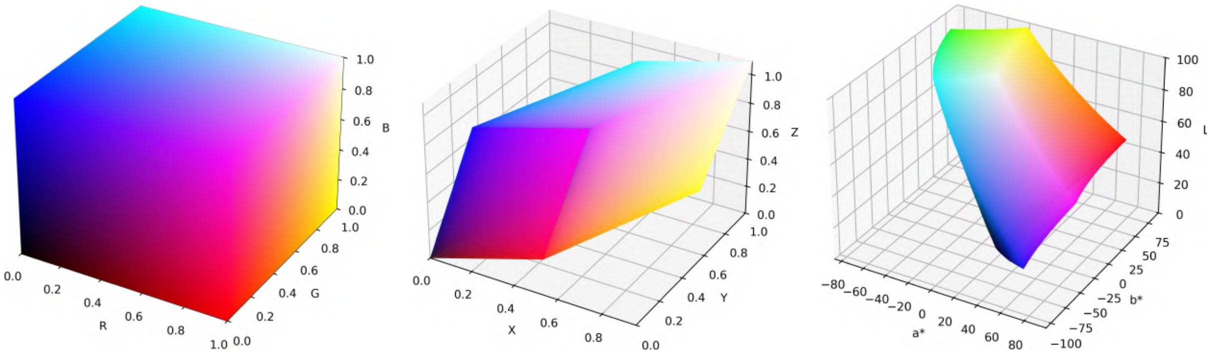
Since the CIEXYZ space is not uniform, it is necessary to convert the coordinates to the CIELAB space using equation:

$$\begin{cases} L^* = 116\, f\left(\dfrac{Y}{Y_n}\right) - 16 \\ a^* = 500 \left[ f\left(\dfrac{X}{X_n}\right) - f\left(\dfrac{Y}{Y_n}\right)\right] \\ b^* = 200 \left[ f\left(\dfrac{Y}{Y_n}\right) - f\left(\dfrac{Z}{Z_n}\right)\right] \end{cases} \tag{2}$$

In the formula (2), $X_n$, $Y_n$, $Z_n$ are the coordinates of white point defined in [12]. The function $f(x)$ provides nonlinearity. It is described as follows:

$$f(x) = \begin{cases} x^{1/3}, & \text{if } x > \left(\dfrac{6}{29}\right)^3, \\ \dfrac{841}{108}x + \dfrac{4}{29}, & \text{otherwise.} \end{cases} \tag{3}$$

The geometry of the color spaces considered for the sRGB gamut, which is widely used in computer graphics, is shown in figure 1. It can be seen that the CIELAB space has a more complex shape.




(a) (b) (c)

**Figure 1:** sRGB gamut in different color spaces: RGB (a), CIEXYZ (b) and CIELAB (c).

Next, having obtained the coordinates in the required space, let us consider the calculation of the actual distance CIEDE2000. The equation is as follows:

$$\Delta E^*_{00} = \sqrt{\left(\frac{\Delta L'}{k_L S_L}\right)^2 + \left(\frac{\Delta C'}{k_C S_C}\right)^2 + \left(\frac{\Delta H'}{k_H S_H}\right)^2 + R_T \left(\frac{\Delta C'}{k_C S_C}\right)\left(\frac{\Delta H'}{k_H S_H}\right)}, \tag{4}$$

where

$$\begin{aligned} \Delta L' &= L'_2 - L'_1, \\ \Delta C'_{ab} &= C'_{ab,2} - C'_{ab,1}, \\ \Delta H'_{ab} &= 2\sqrt{C'_{ab,2} C'_{ab,1}} \ \sin\left(\frac{\Delta h_{ab}{}'}{2}\right), \quad \Delta h'_{ab} = h'_{ab,2} - h'_{ab,1}. \end{aligned} \tag{5}$$

The chroma ($C^*_{ab}$) in the CIELAB space is defined as

$$C'_{ab} = \sqrt{a'^2 + b'^2} \tag{6}$$

while the hue angle ($h_{ab}$) is given by

$$h_{ab} = \tan^{-1}\left(\frac{b^*}{a^*}\right) \tag{7}$$

In formula (4) $k_L, k_C, k_H$ are the correction coefficients for lightness, chromaticity, and hue, respectively, $S_L, S_C, S_H$ are the weighting functions for lightness, chromaticity, and hue, respectively, $R_T$ is the rotation function. Their calculation is shown in detail in [7]. A visual comparison of MacAdam ellipses and those obtained using the CIEDE2000 formula is shown in figure 2. For illustrative purposes, all ellipses have been enlarged.

It can be seen that the direction in which both types of ellipses are elongated coincides in most cases. This is not true for the blue-magenta region, which is noted in the literature and is a disadvantage not only of the formula under consideration [13].

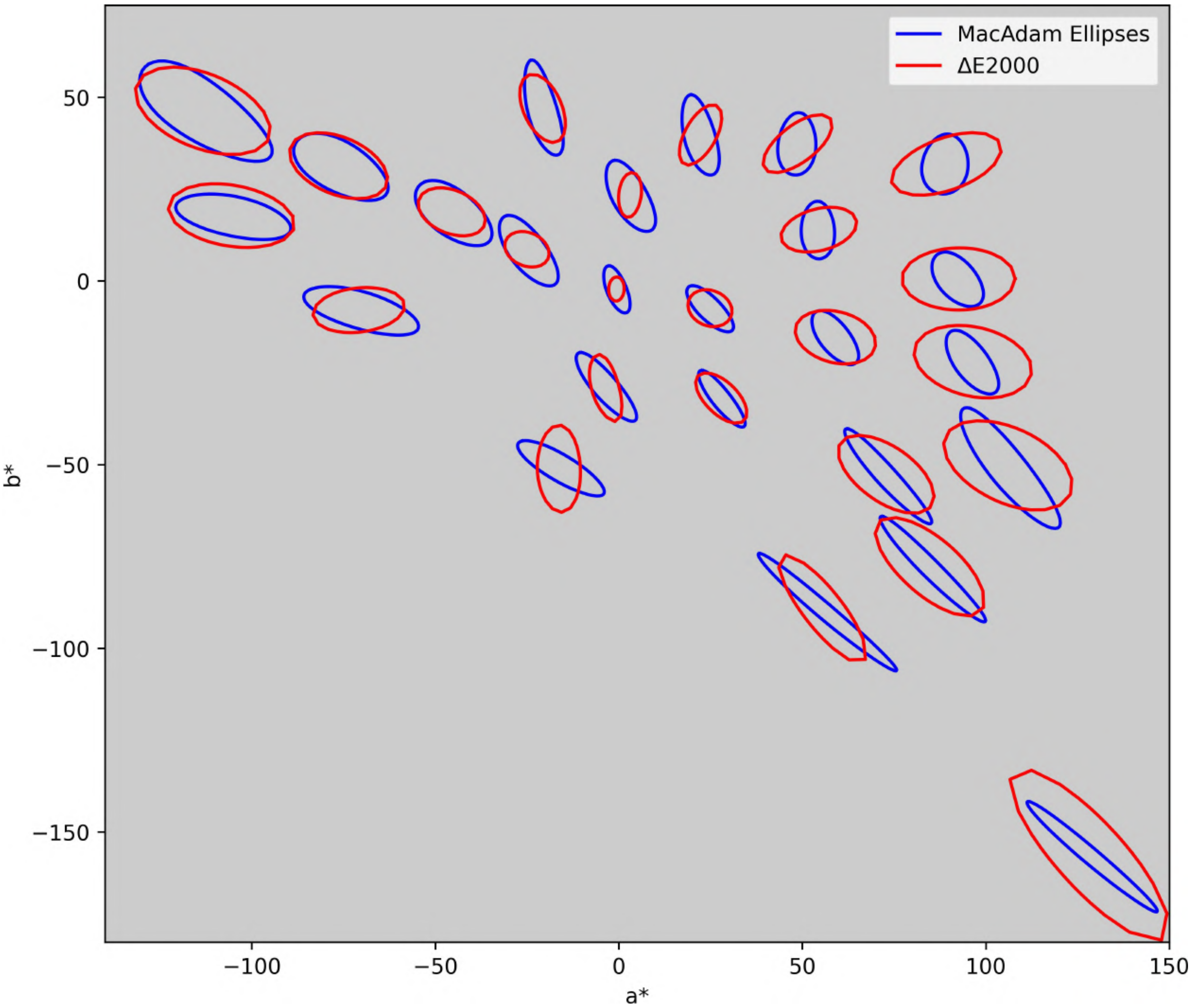



**Figure 2:** CIELAB color space with MacAdam (blue) and CIEDE2000 (blue) ellipses.

## 2.2. CAM16-UCS $\Delta E$ formula

Now let's take a closer look at calculating color distance using the CAM16-UCS color space. Today, it is considered the main tool for evaluating color reproduction in video [14]. To convert to it, we first need to calculate the parameters lightness J, colorfulness M, and hue angle h using the forward CAM16 model [15] and color coordinates in CIEXYZ, and then use the equations [16]:

$$\begin{aligned} J' &= \frac{1.7J}{1 + 0.007J}, \\ M' &= \frac{\ln(1 + 0.0228M)}{0.0228}, \\ a' &= M' \cos(h), \\ b' &= M' \sin(h), \\ h' &= h \end{aligned} \tag{8}$$

The geometry of this space for the sRGB gamut is shown below (figure 3).

Using the coordinates obtained above, we can calculate $\Delta E$ as the Euclidean distance between them:

$$\Delta E = \sqrt{(J'_2 - J'_1)^2 + (a'_2 - a'_1)^2 + (b'_2 - b'_1)^2} \tag{9}$$

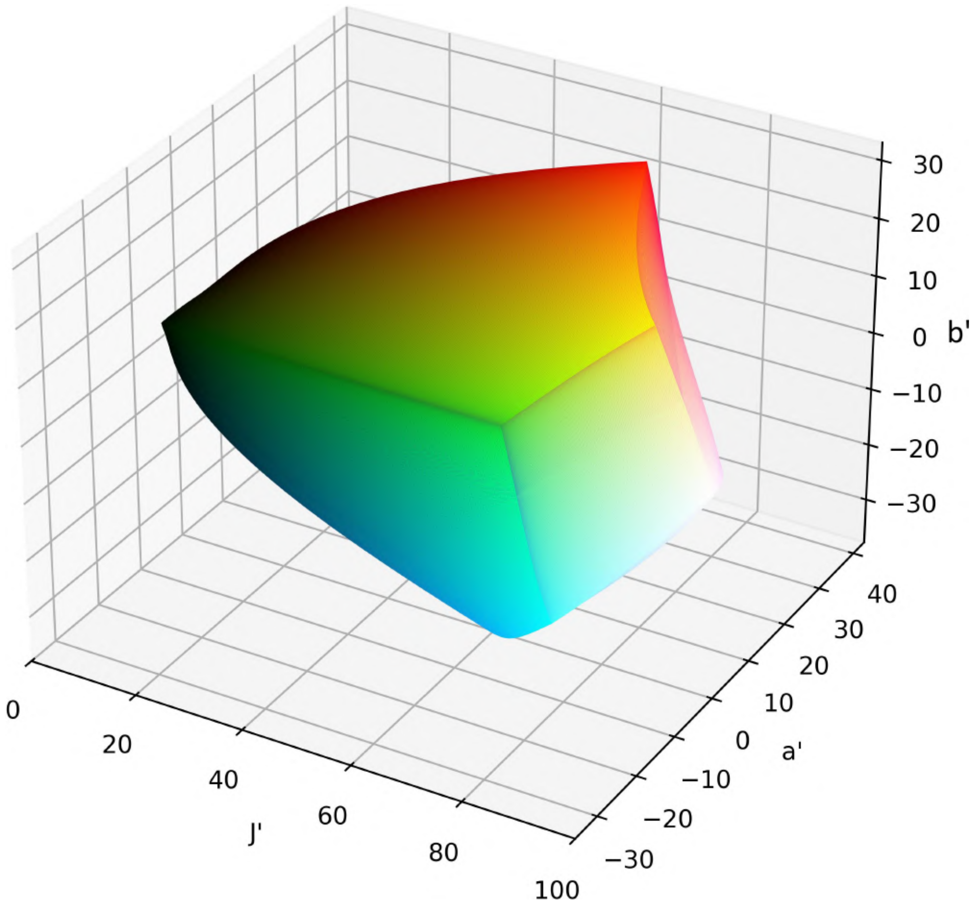



**Figure 3:** sRGB gamut in CAM16 uniform color space.

### 2.3. Formula comparison

To measure the performance of color difference formulas, the STRESS metric is typically used [7]. It is calculated using the $\Delta V$ measured during the experiment and computed $\Delta E$, as defined in the next equations (10)–(11):

$$\mathrm{STRESS} = 100 \times \sqrt{\frac{\sum(\Delta E_i - F_1\,\Delta V_i)^2}{F_1^2 \sum \Delta V_i^2}} \tag{10}$$

$$F_1 = \frac{\sum(\Delta E_i)^2}{\sum \Delta E_i\,\Delta V_i} \tag{11}$$

Table 1 provides a brief overview of the results [17] for the two formulas that were discussed. It can be seen that the STRESS metric differs for large color difference (LCD) and small color difference (SCD) on the display. The lower is its value, the better is the formula.

**Table 1**
Overview of CIEDE2000 and CAM16-UCS $\Delta E$.

| Formula | Color space required for calculation | Mean STRESS for LCD | Mean STRESS for SCD |
|---|---|---|---|
| CIEDE2000 | CIELAB | 25.3 | 30.6 |
| CAM16-UCS $\Delta E$ | CAM16-UCS | 21.9 | 28.7 |

## 3. Color vision deficiency simulation

Color vision deficiency limits users' ability to interact with software and affects both functionality and aesthetics [18]. In order to improve the accessibility of the graphical interface, it is necessary to choose colors correctly. Since there are no specific color difference formulas for this case, it is worth using color vision deficiency simulation.

Let us consider models of color vision anomalies in detail. The condition of shifting the perceived color to another range of the spectrum is called anomalous trichromacy and is divided into protanomaly, deuteranomaly, and tritanomaly [19].

Dichromacy is caused by the absence of one of the three types of functional cones and, similarly, can be classified as protanopia, deuteranopia, or tritanopia. Dichromats cannot recognize colors that can only be distinguished by the reaction of the type of cones they lack. Confusion lines represent specific colors that are indistinguishable for a given type of dichromat. These lines are described by equations of straight lines passing through the plane of chroma channels of the CIE 1931 color space via confusion points. These points are defined by coordinates $(x = 0.747, y = 0.253)$ for protanopes, $(x = 1.40, y = -0.40)$ for deuteranopes, and $(x = 0.171, y = 0)$ for tritanopes [19]. Figure 4 shows the visible light spectrum with the corresponding confusion lines.

The practical use of confusion lines to simulate color vision deficiency is limited by several factors

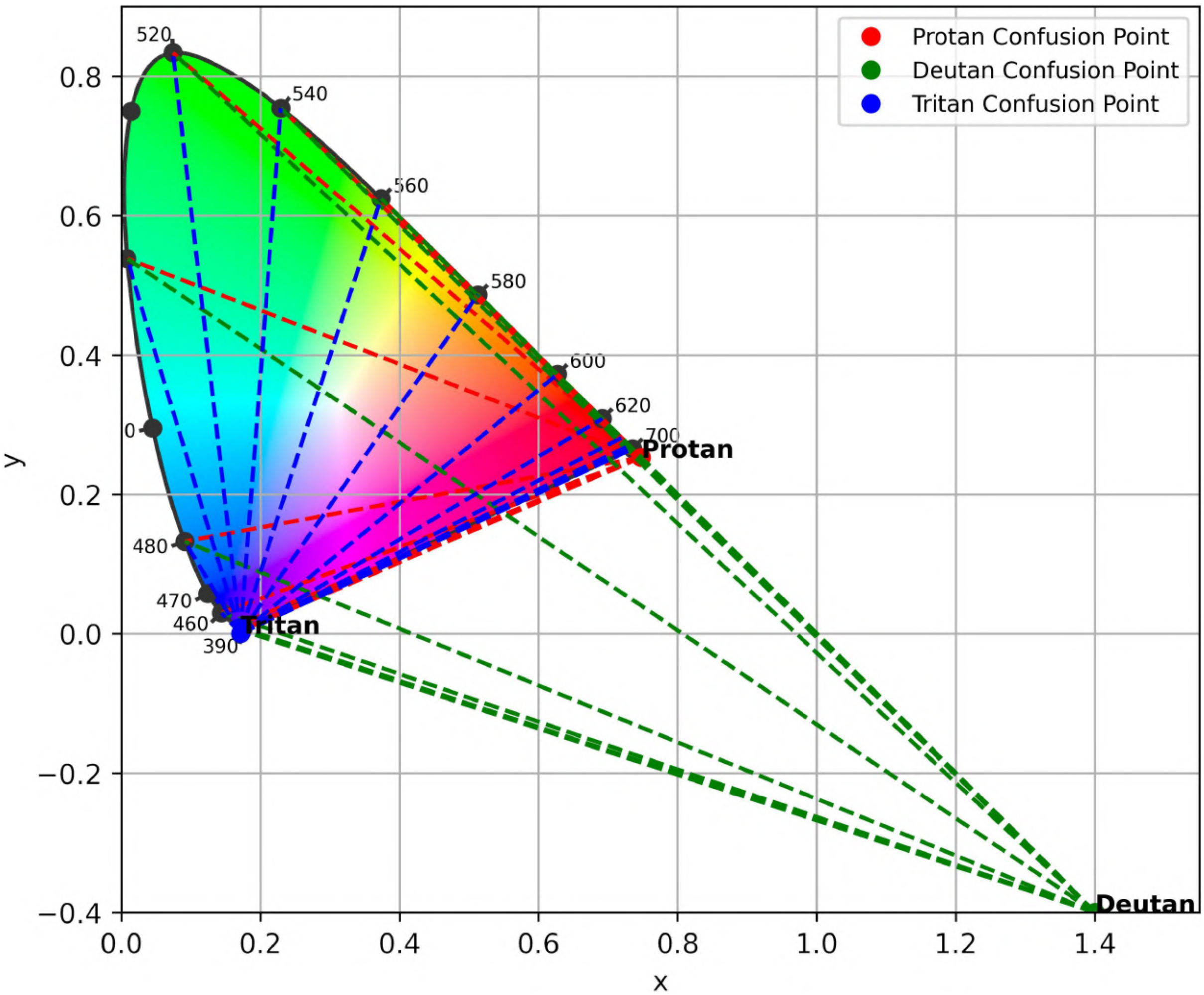



**Figure 4:** Confusion lines for protanopia (red), deuteranopia (green) and tritanopia (blue) in CIE 1931 color space.

[19]. Instead, a model for converting color coordinates using equations of the following form is used:

$$\begin{bmatrix} R_S \\ G_S \\ B_S \end{bmatrix} = M_{CVD} \times \begin{bmatrix} R \\ G \\ B \end{bmatrix}. \tag{12}$$

where $RGB$ is the reference color vector, $R_S G_S B_S$ is the simulated color vector, $M_{CVD}$ is the transformation matrix. Matrices for several degrees of severity of color vision abnormalities are given in [20]. To obtain the others, it is necessary to interpolate values from two matrices with values closest to the selected ones. Thus, to measure the perceived difference between colors in conditions of color vision deficiency, it is proposed to simulate it by recalculating the color coordinates and then substituting the obtained values into the corresponding $\Delta E$ formula.

## 4. Implementation of software and experiment

### 4.1. Design of the application

Since the software being developed must be suitable for any type of program interface, it was decided to implement it as a separate application, as proposed in [21]. This allows one to pick color from any area of the screen, regardless of the type of content. The application was implemented in the Python programming language in the PyCharm integrated development environment. The standard Python library, the matplotlib library for visualizing the position of colors in the CIELAB color space, numpy, and colour [22] were used to calculate the difference between colors. The PyQt5 framework was used to create the graphical interface.

Figure 5 shows the interface design.

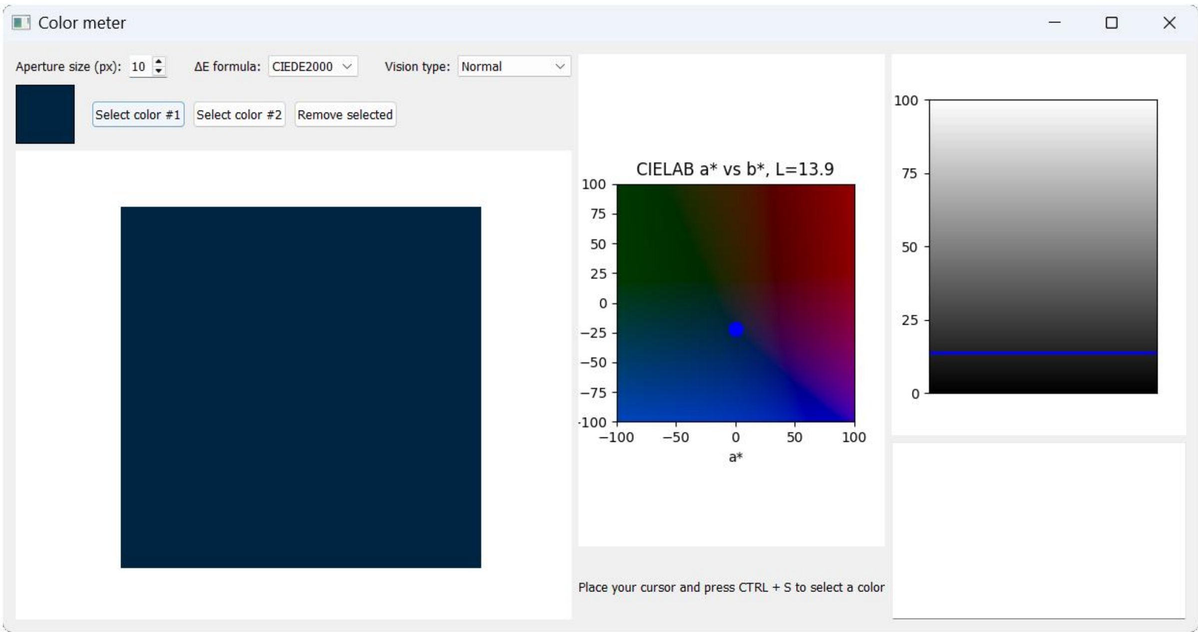



**Figure 5:** Interface of the developed application.

Since the color of a single pixel can be difficult to distinguish, the application allows users to select the size of the aperture, and the final color is averaged within it. The selected pixels are shown in detail. Buttons for selecting colors and drop-down lists for selecting the desired color difference formula and color vision type were provided. Text with the color difference value and the values of the selected colors in the RGB color space in decimal and hexadecimal notation is shown after successful measurement. Since it is difficult to visualize color coordinates in three-dimensional space, one was chosen where lightness is separated from chroma – CIELAB. The plane of color difference channels is demonstrated at a given lightness of the selected color, which is marked on a gradient from white to black for clarity. Colors are marked with identical dots, as their order does not affect the distance between them.

### 4.2. Practical evaluation of color combinations

The developed application is suitable both for measuring small color distances, where it is important to assess whether the difference will be noticeable, and for large color differences, where it is important to assess the contrast. Due to the lack of data on color combinations with small distances, it was decided to measure large ones. Color combinations from Le Courier table [3, 5] were taken for evaluation, where the higher the combinations are rated, the better they are. This table is shown in figure 6, where the combinations are ranked from best (black on yellow) to worst (red on green) among those considered.

| |
|---|
| BLACK ON YELLOW |
| GREEN ON WHITE |
| RED ON WHITE |
| BLUE ON WHITE |
| WHITE ON BLUE |
| BLACK ON WHITE |
| YELLOW ON BLACK |
| WHITE ON RED |
| WHITE ON GREEN |
| WHITE ON BLACK |
| RED ON YELLOW |
| GREEN ON RED |
| RED ON GREEN |

**Figure 6:** Le Courier table.

Since the proposed method does not take into account the order of colors (which one is the background), only unique combinations were evaluated. For comparison, their contrast was also measured using the Luminosity Contrast Ratio algorithm [3]. Contrast is defined by the following equation:

$$\text{Color contrast} = \frac{L_1 + 0.05}{L_2 + 0.05} \tag{13}$$

where $L_1$ is the brightness of the lighter color, $L_2$ is the brightness of the darker color. Brightness is calculated using the corresponding color coordinates R, G, B as follows:

$$L = 0.2126\left(\frac{R}{255}\right)^{2.2} + 0.7152\left(\frac{G}{255}\right)^{2.2} + 0.0722\left(\frac{B}{255}\right)^{2.2} \tag{14}$$

For each color combination were measured their RGB values in the hexadecimal system, CIEDE2000 and CAM16-UCS $\Delta E$ color difference, contrast. Table 2 provides a brief overview of the results of measurement.

The experiment revealed that the rankings for the proposed metrics do not match. It has already been noted that the Le Courier table was created for paper and may not correspond to the perception of color on displays [5]. The differences may be caused by the different shapes of the ellipses for the corresponding formulas and the accuracy of floating point calculations. In order to establish the most appropriate metric, it is necessary to analyze a larger number of different combinations.

## 5. Conclusions and future work

The proposed method for evaluating color combinations based on colorimetric formulas can be useful for determining whether the colors of an interface are distinguishable. The developed software can

**Table 2**
Experiment results.

| Color 1 | RGB 1 | Color 2 | RGB 2 | CIEDE2000 | CAM16-UCS $\Delta E$ | Contrast |
|---|---|---|---|---|---|---|
| White | FFFFFF | Green | 0F605B | 53.96 | 64.60 | 7.43 |
| White | FFFFFF | Red | F6020E | 46.70 | 63.66 | 4.26 |
| White | FFFFFF | Blue | 0002FC | 64.51 | 74.55 | 8.72 |
| White | FFFFFF | Black | 000000 | 100 | 100.02 | 21 |
| Yellow | FEF01C | Black | 000000 | 95.21 | 99.41 | 17.74 |
| Red | F6020E | Yellow | FEF01C | 60.91 | 62.92 | 3.6 |
| Red | F6020E | Green | 0F605B | 55.78 | 65.85 | 1.75 |

be used for this purpose. The results of this work can be used when creating plugins for design tools. Further improvements to the proposed algorithm are possible by integrating methods for extracting the perceived dominant color of an area instead of averaging.

Promising areas for further research include comparison with other color difference formulas, including those that take into account individual visual characteristics, the creation of such formulas for people with color vision deficiency without the need to recalculate colors, and the creation of automated systems for selecting color combinations.

The task of determining the aesthetically best range of distances between colors requires conducting experiments taking into account the statistics of a significant number of respondents.

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## Data availability statement

The parameters required for the formulas, as well as the coordinates of the MacAdam ellipses, are available in the Python package published on Zenodo [22].

## Conflicts of interest

The author declares no conflict of interest.

## Declaration on Generative AI

During the preparation of this work, the author used ChatGPT-5 for formatting assistance. After using this tool, the author reviewed and edited the content as needed and takes full responsibility for the publication's content.

## References

[1] Y. Kubota, S. Yoshida, M. Inami, Apparent color picker: color prediction model to extract apparent color in photos, Frontiers in Signal Processing 3 (2023) 1133210. doi:10.3389/frsip.2023.1133210.

[2] L. Kuo, T. Chang, C.-C. Lai, Visual effect and color matching of dynamic image webpage design, Color Research & Application 46 (2021) 1321–1331. doi:10.1002/col.22662.

[3] S. Valerie Fernandez, M. Abdul Majid, N. Akma Abu Bakar, M. Fakhreldin, Enhanced Colour Scheme Assessment Tool (COSAT 2.0) for Improving Webpage Colour Selection, in: 2021 International

Conference on Software Engineering & Computer Systems and 4th International Conference on Computational Science and Information Management (ICSECS-ICOCSIM), 2021, pp. 459–464. doi:10.1109/ICSECS52883.2021.00090.

[4] L. Kuo, T. Chang, C.-C. Lai, Affective psychology and color display of interactive website design, Displays 71 (2022) 102134. doi:10.1016/j.displa.2021.102134.

[5] W. Zhu, Z. Cheng, Q. Wang, J. Du, Y. Lin, Font and background color combinations influence recognition efficiency: A novel method via primary color Euclidean distance and response surface analysis, Displays 85 (2024) 102873. doi:10.1016/j.displa.2024.102873.

[6] S. A. Alwash, A. I. Alanssari, V. Pyliavskyi, O. Osharovskaya, M. Bermas, A. Taran, Assessment Quality of Modify Images by CIECAM02, CAM16, CAM20u Models, in: 2022 29th International Conference on Systems, Signals and Image Processing (IWSSIP), 2022, pp. 1–4. doi:10.1109/IWSSIP55020.2022.9854391.

[7] R. Shamey, Encyclopedia of Color Science and Technology, 2 ed., Springer International Publishing, Cham, 2023. doi:10.1007/978-3-030-89862-5.

[8] M. Georgoula, G. Cui, R. Luo, A revisit of the MacAdam colour discrimination ellipses, Color and Imaging Conference 24 (2016) 121–121. doi:10.2352/ISSN.2169-2629.2017.32.121.

[9] K. Hovorova, Y. Hryhorieva, B. Harmash, S. Gulevskyy, I. Malkova, E. Diumin, The determination of colour differences when calculating the colour rendering index, Ukrainian Metrological Journal 4 (2024) 43–47. doi:10.24027/2306-7039.4.2024.319180.

[10] V. Pyliavskyi, Development of the algorithm of video image adaptation to spectral power distribution of illuminants, Eastern-European Journal of Enterprise Technologies 1 (2019) 58–67. doi:10.15587/1729-4061.2019.156491.

[11] ISO/CIE 11664-6:2022(E), Colorimetry – Part 6: CIEDE2000 Colour-Difference Formula, ISO/CIE 11664-6:2022(E), International Organization for Standardization (ISO) / Commission Internationale de l'Éclairage (CIE), 2022.

[12] IEC 61966-2-1:1999, IEC 61966-2-1:1999 – Multimedia systems and equipment – Colour measurement and management – Part 2-1: Colour management – Default RGB colour space – sRGB, Standard, International Electrotechnical Commission (IEC), 1999.

[13] Q. Xu, B. Zhao, G. Cui, M. R. Luo, Testing uniform colour spaces using colour differences of a wide colour gamut, Optics Express 29 (2021) 7778–7793. doi:10.1364/OE.413985.

[14] N. Raheem, A. Q. Taher, A. I. Alanssari, V. V. Pyliavskyi, B. S. Bashar, M. M. Ismail, Color appearance models CAM16, ZCAM and CAM20u for video applications, Semiconductor Physics, Quantum Electronics & Optoelectronics 25 (2022) 342–347. doi:10.15407/spqeo25.03.342.

[15] C. Gao, K. Xiao, M. Pointer, C. Li, The development of the CIECAM16 and visualization of its domain and range, Color Research & Application 50 (2025) 144–160. doi:10.1002/col.22959.

[16] C. Li, Z. Li, Z. Wang, Y. Xu, M. R. Luo, G. Cui, M. Melgosa, M. H. Brill, M. Pointer, Comprehensive color solutions: CAM16, CAT16, and CAM16-UCS, Color Research & Application 42 (2017) 703–718. doi:10.1002/col.22131.

[17] M. R. Luo, Q. Xu, M. Pointer, M. Melgosa, G. Cui, C. Li, K. Xiao, M. Huang, A comprehensive test of colour-difference formulae and uniform colour spaces using available visual datasets, Color Research & Application 48 (2023) 267–282. doi:10.1002/col.22844.

[18] A. Jamil, G. Denes, Investigating Color-Blind User-Interface Accessibility via Simulated Interfaces, Computers 13 (2024). doi:10.3390/computers13020053.

[19] H. Moreira, L. Álvaro, A. Melnikova, J. Lillo, Colorimetry and Dichromatic Vision, in: C. M. Travieso-Gonzalez (Ed.), Colorimetry and Image Processing, IntechOpen, London, 2017. doi:10.5772/intechopen.71563.

[20] A. Zeileis, J. C. Fisher, K. Hornik, R. Ihaka, C. D. McWhite, P. Murrell, R. Stauffer, C. O. Wilke, colorspace: A Toolbox for Manipulating and Assessing Colors and Palettes, Journal of Statistical Software 96 (2020) 1–49. doi:10.18637/jss.v096.i01.

[21] A. O. Doroshuk, Vymiriuvannia spryimaiemoi vidstani mizh koloramy interfeisu [Measurement of the perceived distance between interface colors], in: S. V. Kivalov (Ed.), Advanced Technologies in Information and Communication Engineering (ATICE'2025), Helvetica Publishing Group, Odesa,

2025, pp. 24–28. doi:10.32837/11300.30175.

[22] T. Mansencal, M. Mauderer, M. Parsons, N. Shaw, K. Wheatley, S. Cooper, J. D. Vandenberg, L. Canavan, K. Crowson, O. Lev, K. Leinweber, S. Sharma, T. J. Sobotka, D. G. Moritz, M. Pppp, C. Rane, P. Eswaramoorthy, J. Mertic, B. Pearlstine, M. Leonhardt, O. Niemitalo, M. Szymanski, M. Schambach, S. Huang, M. Wei, N. Joywardhan, O. Wagih, P. Redman, J. Goldstone, S. Hill, J. Smith, F. Savoir, G. Saxena, S. Chopra, I. Sibiryakov, T. Gates, G. Pal, N. Tessore, A. Pierre, F.-X. Thomas, S. Srinivasan, T. Downs, K. Rusching, X. Chen, B. Herb, T. A. Caswell, L. Collod, B. Brummer, mesvam, X. Zhaozhen, C. Müllner, J. Hammudoglu, M. Li, L. R. Peeters, Jackchou00, L. Schmidt, Colour, 2025. doi:10.5281/zenodo.17837391.