

Riemannian Formulation of the CIEDE2000 Colour Difference Formula

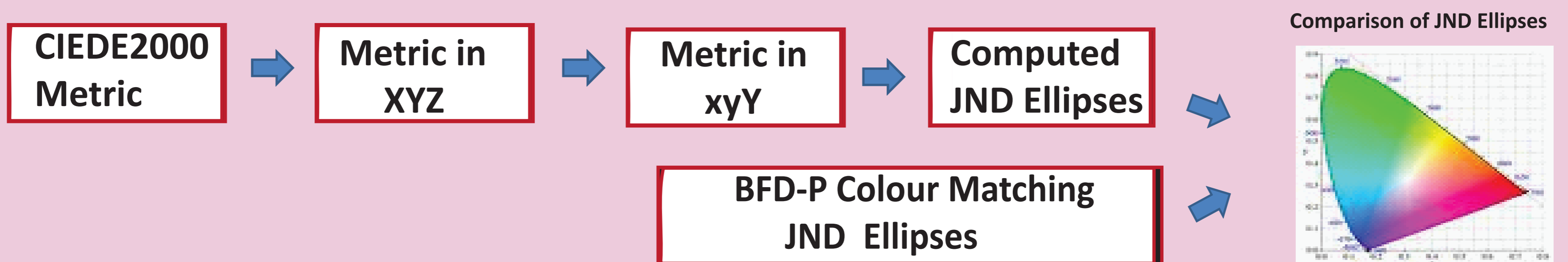
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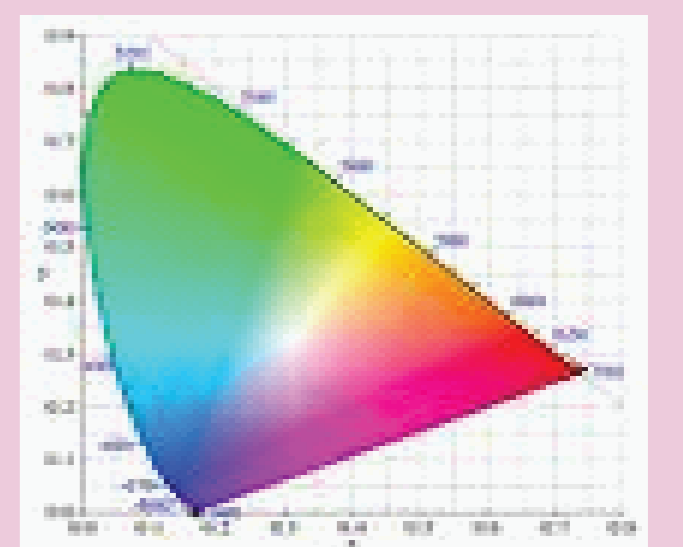
ABSTRACT:

The CIELAB based CIEDE2000 colour difference formula to measure small to medium colour differences is the latest standard formula of today. It incorporates different corrections for the non uniformity of the CIELAB space. In this paper, the authors present a mathematical formulation of the CIEDE2000 by the line element to derive a Riemannian metric tensor in a color space. The coefficients of this metric give Just Noticeable Difference (JND) ellipsoids in three dimensions and ellipses in two dimensions. The authors also show how this metric can be transformed between various colour spaces by means of the Jacobian matrix. Finally, the CIEDE2000 JND ellipses are plotted into the xy chromaticity diagram and compared to the observed BFD-P colour matching ellipses by a method described below.

Method:



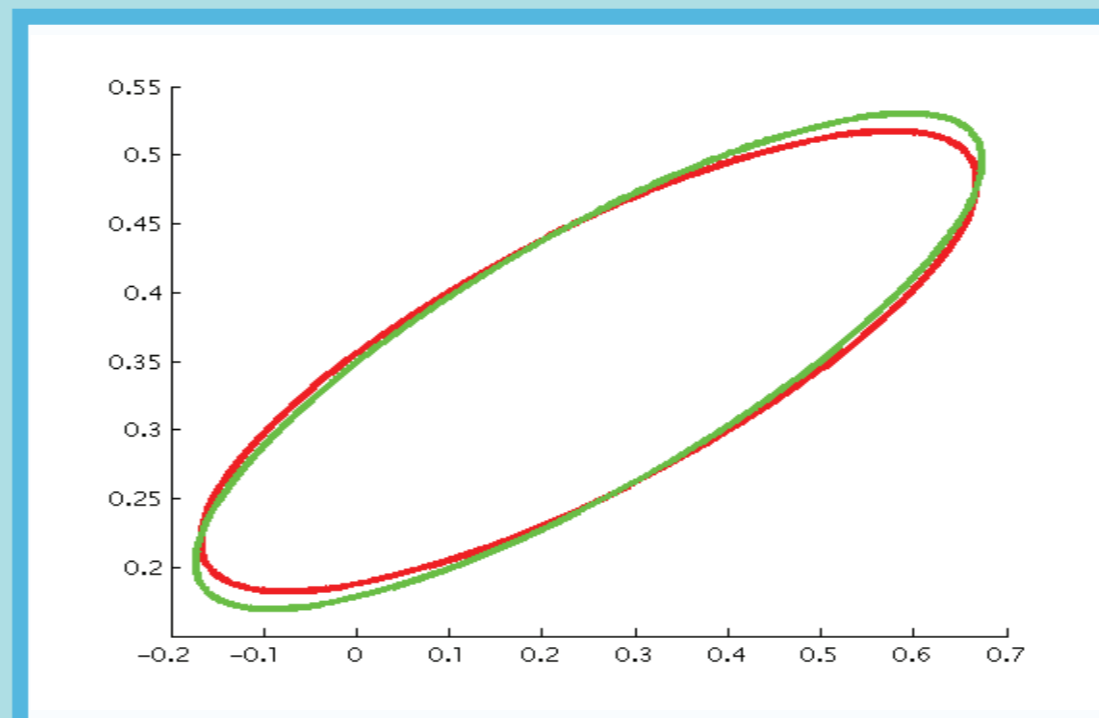
Comparison of JND Ellipses



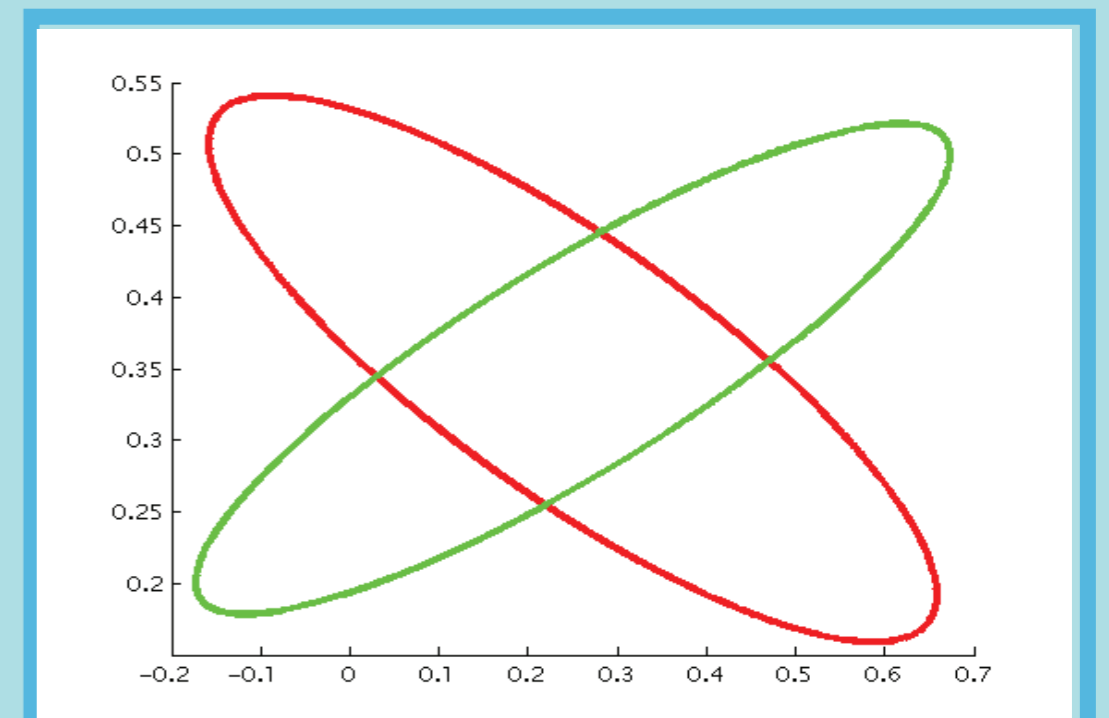
Ellipse Comparison:

We can compare the similarity between a pair of ellipses by using the principle of union - intersection. The technique works by calculating the ratio of the area of intersection and the area of union of a pair of ellipses. The ratio value lies in the range of $0 < x < 1$. High value of the ratio gives strong evidence that two ellipses are closely matched and vice versa. This method takes account of variations in size, shape and orientation for a pair of ellipses simultaneously.

Highly matched ellipse pair with match ratio .92



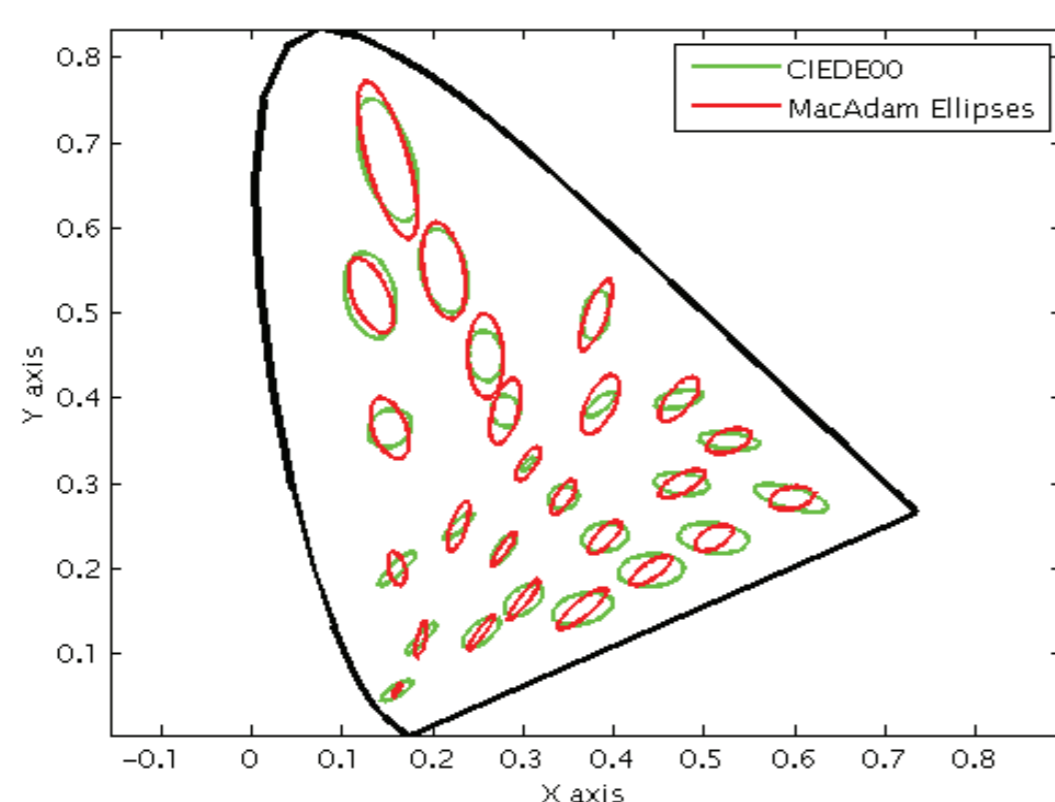
Poorly matched ellipse pair with match ratio .24



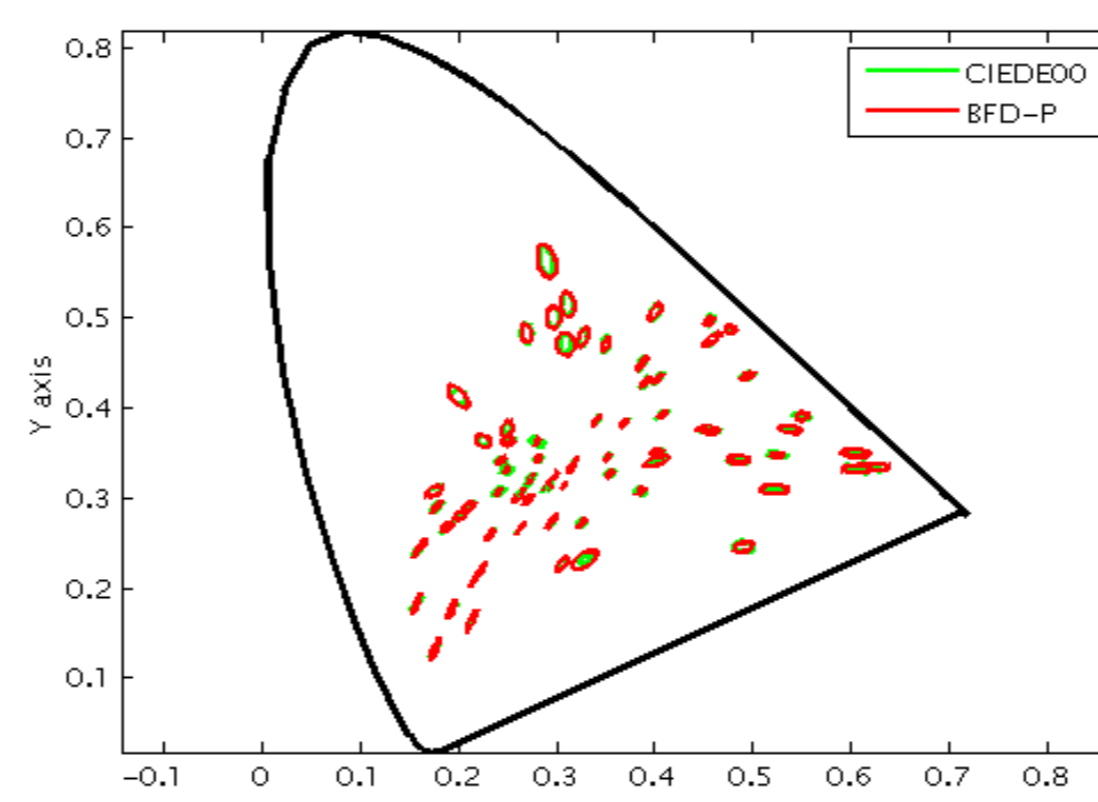
The CIEDE2000 Metric:

$$(dE_{00}^*)^2 = \begin{bmatrix} dL' & dC' & dH' \end{bmatrix} \begin{bmatrix} (k_L S_L)^{-2} & 0 & 0 \\ 0 & (k_C S_C)^{-2} & \frac{1}{2}(k_C S_C k_H S_H)^{-1} \\ 0 & \frac{1}{2}(k_C S_C k_H S_H)^{-1} & (k_H S_H)^{-2} \end{bmatrix} \begin{bmatrix} dL' \\ dC' \\ dH' \end{bmatrix}$$

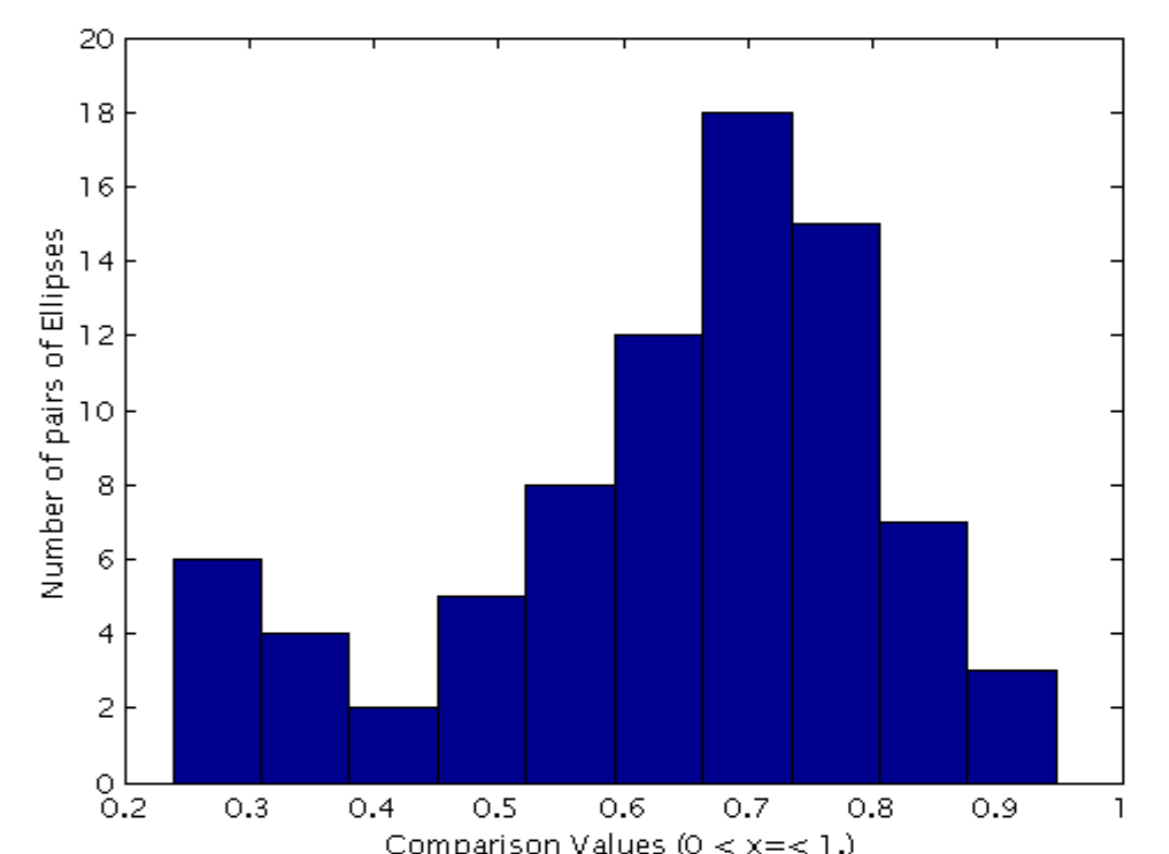
Result:



MacAdam and CIEDE2000 ellipses plotted on the CIE1931 chromaticity diagram



BFD-P and CIEDE2000 ellipses plotted on the CIE1931 chromaticity diagram



Histogram of comparison values between CIEDE2000 and BFD-P ellipses

Conclusion:

The presented method in this paper can be used for comparing the performance of the CIEDE2000 color difference formulae in terms of JND ellipses. On the basis of our findings, the authors can say that the CIEDE2000 significantly measures the visual color differences. However, orientation problem is seen in CIEDE2000 ellipses compared to BFD-P and MacAdam ellipses in the blue region as well as in the red region. This indicates further improvement of the colour difference metrics in general is necessary.

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