Complementary Colour Harmony in Different Colour Spaces

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ABSTRACT

This research investigates hue complementarity in different colour spaces namely CIELAB, CIELUV, Kuehni LAB, OSA-UCS, and Hunter Rd_{ab} colour spaces. A psychophysical experiment has determined the hue of colours that are deemed complementary to twenty standard fixed hues. The data were then analysed in CIELAB space and the other applied ones to explore in which colour space opposite hues best describe visual complementary relationships. In each space the opposite hues were calculated as 180 degrees from the standard fixed hues and compared with the psychophysically derived complementary hues. The results show that none of the five colour spaces can exactly predict complementary relationships; however, OSA-UCS colour space performed better than the other four colour spaces. For OSA-UCS colour space, apart from a few hues, each complementary hue was within 1.0±4.5 degrees of the opposite hue. The computations were carried out under CIE illuminant D65 and for the 1964 standard observer. Previous investigations (Mahyar et al. 2011) was carried out in the other colour spaces, namely CIELAB, Munsell and Kuehnie LAB, under different conditions of CIE illuminant C and 1931 standard observer. Psychophysical experiment in CIELAB colour space were presented at a previous AIC meeting (Mahyar et al. 2007).

1. INTRODUCTION

Complememntarity in different colour spaces has been already examined under CIE illuminant C and 1931 standard observer condition among three colour spaces by the authors (Mahyar et al. 2011). This research is a trail of the previous work on hue complementarity in order to introduce any possible colour space which can represent complementary hue relationship, as well as finding any possible distortion from the opposite colours in the complementary hue relationship in each colour wheel.

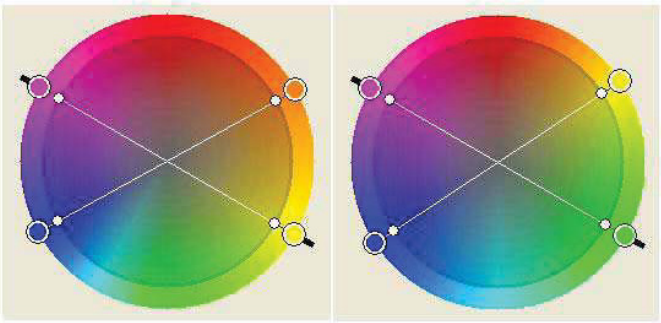

Figure 1: Colorant mixing (left) and visual (right) colour wheels show inconsistent complementary relationships (reproduced from Pacific-Business-Centre 2010).

The idea of this work originally comes from the fact that there is a lack of consistency in introducing the complementary hues if different colour wheels are considered. For example, as shown in Figure 1, in colour wheels that represent colorant mixing, yellow is placed op-

posite to purple and orange is placed opposite to blue. In colour wheels that represent visual relationships, on the other hand, yellow is placed opposite to blue and green is placed opposite to purple.

2. EXPERIMENTAL

A psychophysical experiment was performed in CIELAB colour wheel in constant lightness and chroma values. Figure 2 shows a screenshot of the display during the experiment. Observers were asked to find a maximally contrasted combinations of colours as a total of twenty colour pairs. The details of the experiment has been published in the previous work of the authors (Mahyar et al. 2007).

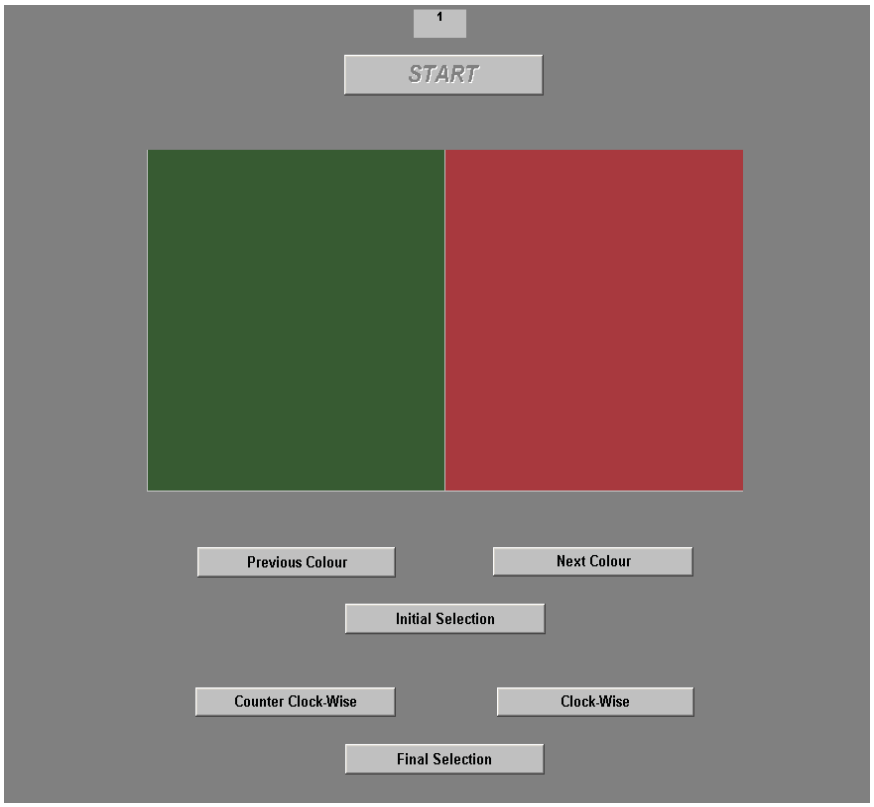

Figure 2: A screenshot of the psychophysical experiment.

3. RESULTS AND DISCUSSION

The results of the psychophysical experiment, in which complementary colour harmony in CIELAB colour space was investigated, were transformed into the corresponding values in other colour spaces. As mentioned earlier, CIELUV, Kuehni LAB, OSA-UCS, and Hunter Rdab colour spaces were considerd in this research. Obviously, opposite hues are located in 180 degrees interval of each fixed hue. The angle differences between each complementary hue and the relevant opposite hue (Δh) were calculated too. In each fixed hue, the average of all selected complementary hues (h_{ave}), by the observers, and the hue angle of the opposite colour (h_{opp}) are calculated. Equation 1 calculates the Δh values in each colour space.

$$\Delta h = h_{ave.} - h_{opp} \quad (1)$$

Figure 3 compares the Δh values in different colour spaces where all the twenty fixed hues were displayed. The fixed hues alter clockwise from yellow to red, blue and green in the figure. The numbers of one to twenty in the figure show the number coding for all the fixed hues. For instance, number 1 shows the fixed hue of 90 degrees in the CIELAB colour wheel which is a yellow colour. It is notable to mention that due to the fact that each fixed hue in CIELAB colour space were converted to the appropriate values in the other colour space, each number of the fixed hues in the figure demonstrates various fixed hue angles in different colour spaces.The values of the hue angle differences (see Equation 1 for Δh) between each opposite hue and the hue which was chosen as the maximally contrasted hue with the fixed hue by the observers are illustrated in the figure.The black circle shows the Δh equal to zero, that obtained when the observers select the opposite hues as maximally contrasted hues of each fixed hue. As seen in Figure 3, there is possibly no colour space, among investigated colour spaces, which can define a regulation between complementary relationships and the opposite hues for all hues around the colour wheel.

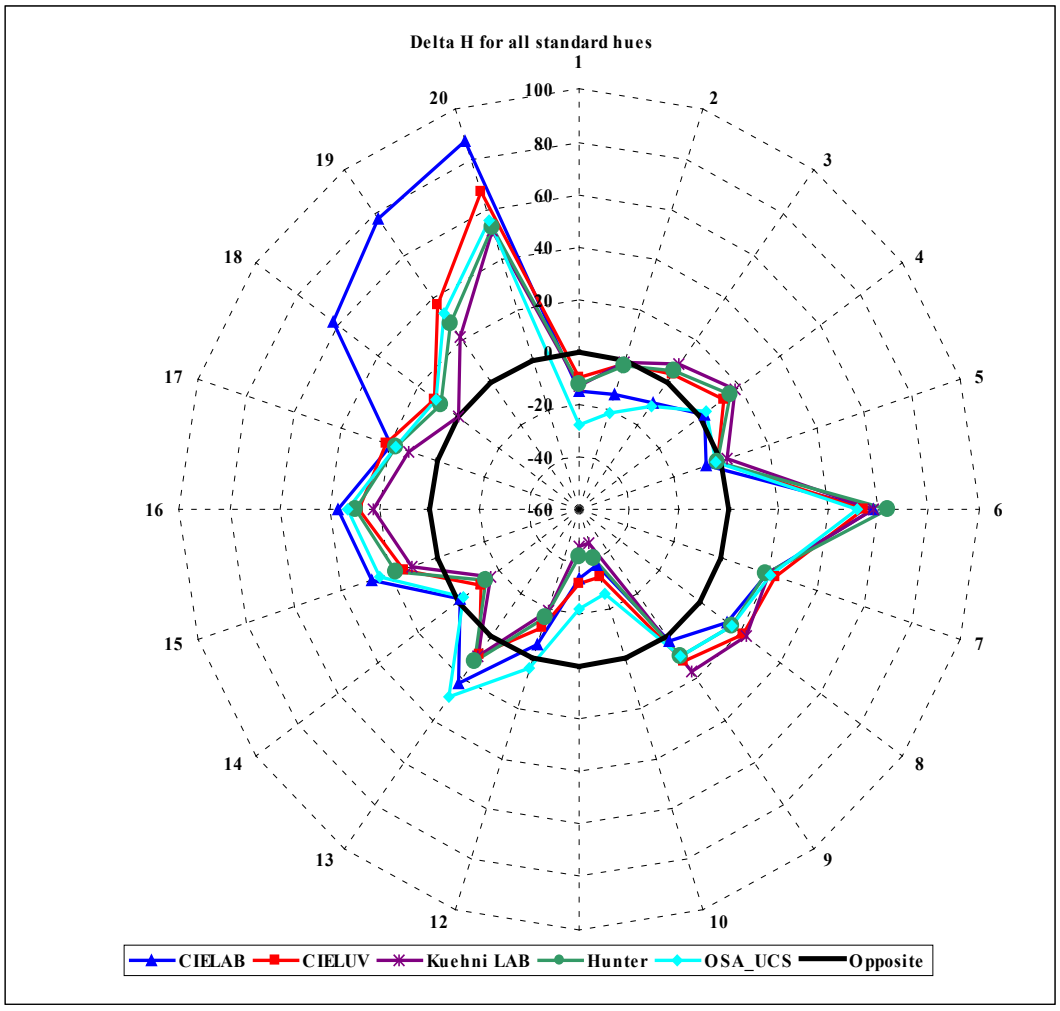

Figure 3: Hue differences between each opposite hue and maximally contrasted hue.

The intervals between the complementary and the opposite hue angles of each fixed hue indicate as 'Interval', which is 'average of Δh values ± standard error'. Table 1 shows the Interval values in all five applied colour spaces.

Table 1: Measured intervals between complementary and opposite hues.

Colour Space	Interval values
CIELAB	3.9±4.07
CIELUV	7.64±3.32
Kuehni LAB	6.86±3.45
OSA-UCS	7.74±3.5
Hunter Rd_{ab}	1.04±4.54

There seems to get no good agreement between the complementary and the opposite hues in CIELAB colour space. OSA-UCS colour space shows better agreement between the complementary and the opposite hues in comparison to the other colour spaces. In fact, in OSA-UCS colour space the average of Delta H values is almost 1 degree.

4. CONCLUSIONS

Five colour spaces, namely, CIELAB, CIELUV, Kuehni LAB, OSA-UCS, and Hunter Rd_{ab}, were applied to study complementary relationships between hues. Comparison among the colour spaces show that OSA-UCS colour space is better than the other colour spaces in order to find an agreement between complementary and opposite relationships. Apart from a few colours in the colour wheel, each complementary colour looks to be in interval of 1.04±4.5 degrees under CIE Illuminant D65 and the 1964 standard observer conditions.

ACKNOWLEDGEMENTS

The authors would like to thank all observers who participated in the experiment.

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