COLOUR APPEARANCE OF METAMERIC LIGHTS AND POSSIBLE COLORIMETRIC DESCRIPTION

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ABSTRACT

Based on earlier [1] experiences of the colour mismatch phenomenon we investigated the colour matching with two types of visual experiments. First we confirmed the phenomenon with a white colour matching experiment using narrow band and broadband light sources illuminating white reflection patches. Secondly we made a colour matching experiment with more saturated colour stimuli. During both experiments the observers had the task to set the colour stimuli coming from the test side to that coming from the reference side of the arrangement.

Using spectroradiometric measurement data we calculated chromaticities using the CIE standard colour matching functions and using a slightly modified set of CMFs kindly received from Dr. Wold [2]. The calulations showed that using the modified colour matching functions the calculated colour differences will be smaller. This result is true in both matching situations. After the second series we came to the conclusion that the value of calculated colour difference is the function of the blue amount in the radiation.

Keywords: metamerism, LED, colour matching function, cone fundamentals.

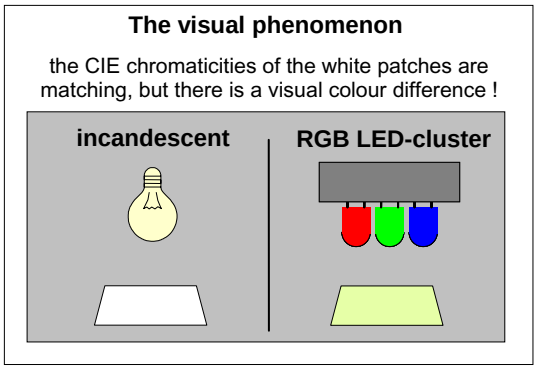

Figure 1. The visual phenomenon experienced during instrumental matching.

1. INTRODUCTION

Among the different dimensions of appearance analysis colour is one that has been studied for the longest time, but still in colour appearance analysis there are a number unsolved questions. One of the most basic one is the appearance of white. The phenomenon of white has in itself many facets, and one can discuss it from a number of viewpoints, should it be colour constancy, the white point on a scene or scaling the whiteness. But none of these can be evaluated correctly if the colorimetric determination of white is wrong.

In modern lighting one tries to use more efficient sources as the traditional incandescent lamp. Clusters of red (R), green (G) and blue (B) LEDs could be the most efficient way to set any shade of white light by adjusting the intensity of the R, G, B LEDs. Anecdotic information is available that visual investigations showed colour mismatch if e.g. an incandescent lamp set to CIE standard illuminant A is matched by the additive mixture of the light of an R, G, B LED cluster, the colorimetric match will appear to be greenish in colour as shown in Figure 1.

Thornton in his multipart paper discussed colour appearance differences of even less metameric lights[3].

2. EXPERIMENTAL SET-UP

We have set up two independent investigations at the Technical University of Ilmenau (Germany) and the University of Pannonia (Hungary), comparing visual matches between reflected lights produced by RGB LEDs and incandescent as well as high intensity discharge lamps. The photographs in Figure 2 and 3 are showing the visual fields of both arrangements. Figure 4. and 5 shows the relative spectral power distributions of the used illuminants. Instrumental matches (performed using two independently well calibrated PR-705 spectroradiometers) were judged by the

observers to have a greenish tint. If the averages of visual matches were measured colorimetrically between the RGB LED cluster and a number of light sources with more smooth spectrum we found $\Delta(u',v')$ deviations of one to two units in the second decimal place, in case of equal luminance, for two juxtaposed visual fields of approximately 2° field size.

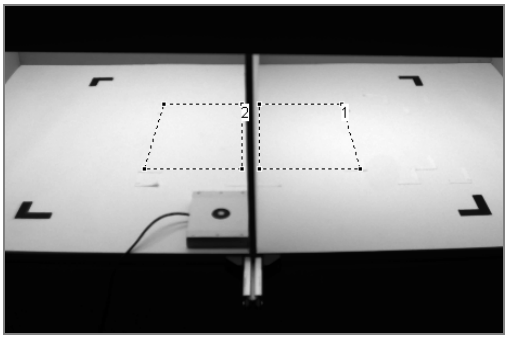

Figure 2. The visual field of experiment I.

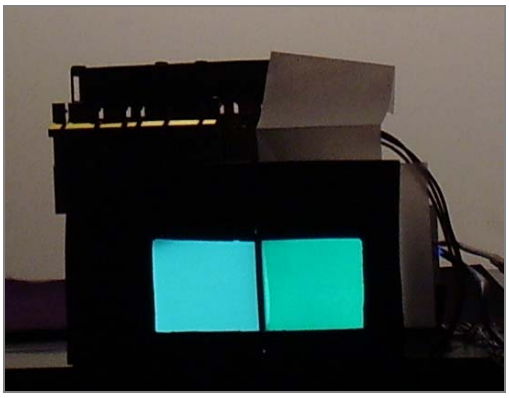

Figure 3. The visual field of experiment II.

3. RESULT OF EXPERIMENT I.

Figure 6. shows that by applying of the fundamental colour matching functions calculated by Wold [2] using the L, M, S cone fundamentals now suggested by CIE TC 1-36 [4] we got a better colour match. If the modified colour matching functions are used the difference between the chromaticity of the reference (incandescent) and matching (RGB LED) stimuli become smaller then using the original CIE 1931 CMFs.

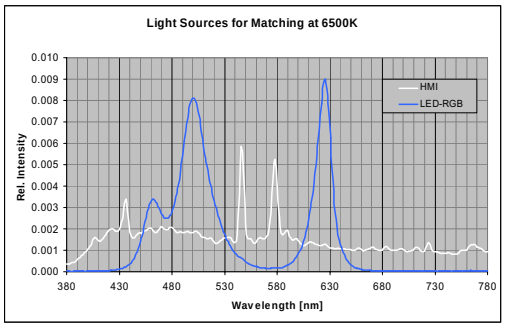

Figure 4. The SPDs of the used illuminants in Experiment I.

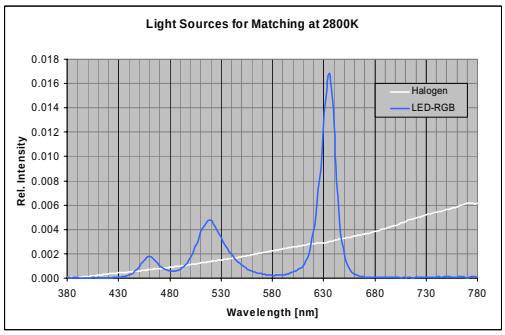

Figure 5. The SPDs of the used illuminants in Experiment II.

In the 2nd experiment the observed patches were primary light sources. Both sides were radiated from the backside. The reference radiation was produced by a halogen incandescent lamp filtered with colour glass filters (the right side of the visual field) and the test field was radiated with RGB-LEDs (the left side of the visual field). The observers had the task to set the same chromaticity on the test side as they perceived it from the reference side. The observers could change three - not perfectly independent - parameters of the test radiation: the hue, the brightness and the saturation.

4. RESULT OF EXPERIMENT II.

We can see in Figure 7 that the chromaticity differences between the filtered halogen reference radiation and the RGB-LED matching stimuli depend on the amount of blue light in the radiation.

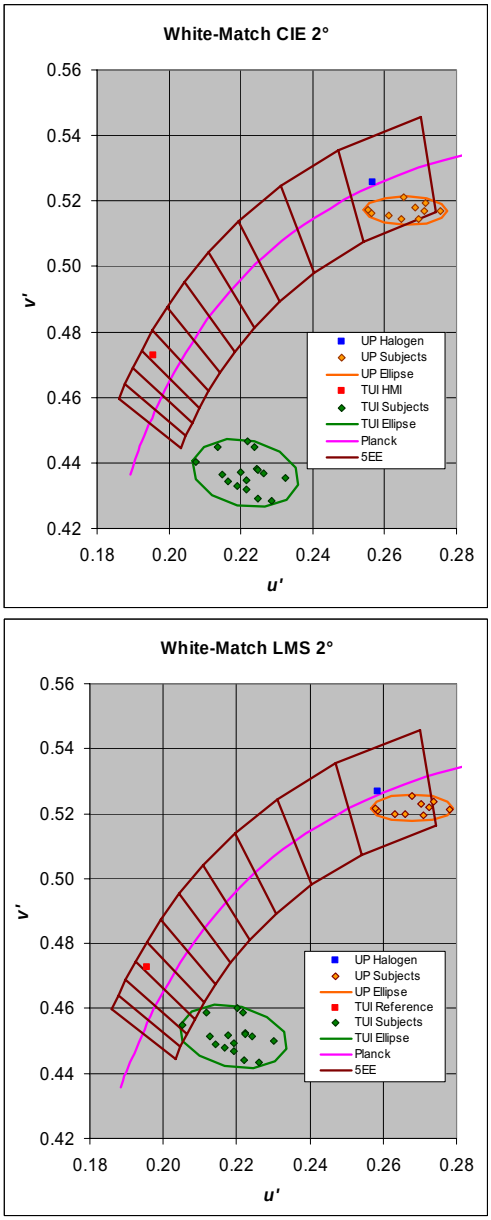

Figure 6. Chromaticities of matching white secondary light sources.

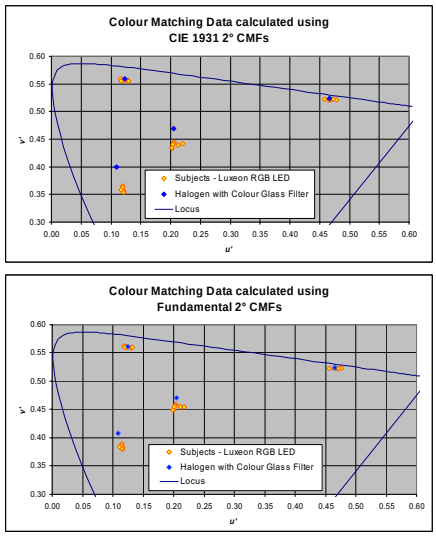

Figure 7. Results of matching colour primary light sources.

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