A colour rendering metric based on memory colours (MCRI)

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ABSTRACT: A colour rendering index based on memory colours (MCRI) is described. The performance of the MCRI was assessed by calculating the correlation with 3 sets of visual data. Comparing the performance of the MCRI with the performance of the CIE CRI, it was found that the MCRI was significantly better ($p < 0.1$) at predicting the visual ranking of the 3 data sets.

1. INTRODUCTION: The CIE colour rendering index [1] is widely used as a standard for assessing the quality of white light sources. It's applicability to narrow-band sources, such as LEDs, is being debated as there has been increasing evidence from visual experiments that the CIE Test Colour Method can fail to predict the actual visual rendering abilities of such sources [2; 3; 4; 5]. Several new metrics (NIST CQS [6], Philips CRI [7], Colour Category Index [8], Darmstadt RCRI [9], Feeling of contrast [10], CRI-CAM02UCS [11] and MCRI [12; 13]) have been proposed during the last few years, especially within the framework of the CIE technical committee TC1-69 dealing with colour rendering of white light sources. Like the CIE CRI, most of these metrics use an illuminant as a reference, which is (usually) set up as the optimum light source. But what is the optimum reference source?

2. COLOUR RENDERING BASED ON MEMORY COLOURS:

2.1 Idea and Method: The MCRI has no need for a reference illuminant, because all referencing is done to the memory colours of a set of familiar objects. The basic idea is simple: the more similar a test source renders the object colours to their memory colours the higher the colour rendering. The similarity is calculated based on the data obtained by Smet et al. [13]. In a series of visual experiments Smet et al. investigated the colour appearance rating of a set of nine familiar real objects . The chromaticity of the objects spanned the entire hue circle. In the experiments each object was presented to a group of observers who were asked to rate the colour appearance of the presented object with respect to what they thought the object looked like in reality. For each object, the pooled ratings were modeled by a modified bivariate Gaussian distribution in IPT colour space [14]. These distributions, describing the similarity between any apparent object colour and its memory colour, are the basis of the MCRI. The general calculation scheme is as follows. First, determine the chromaticties of all the objects under the test source in IPT space. Next, calculate the degree of similarity with the memory colour using the similarity distributions (=special MCRI indices). Finally, take the geometric mean of the set of calculated similarities. This number, the general MCRI index, describes the general colour rendering properties of a light source.

2.2 Validation: To assess the performance of the MCRI and of the CIE CRI, i.e. their ability to predict the visual ranking of a set of test sources, the Spearman correlation coefficient was calculated with 3 sets of visual data. Two sets were obtained at the University of Lyon by Jost-Boissard et al. [15; 16]. Another one was obtained in a series of visual experiments at the Light and Lighting Lab by Smet et al.*(paper to be published)*.

The Jost-Boissard data sets consisted of the Thurstone scaling [17] for attractiveness of a set of nine 3000K and eight 4000K light sources, which were almost exclusively LED sources. The Smet et al. data set consisted of Scheffé scaling [18] for preference, attractiveness, naturalness and fidelity for as set of six 2700K light source. The light sources were an equal mixture of both broad- (e.g. halogen, Nd incandescent) and narrow-band (LEDs) sources.

The CIE CRI and the MCRI had respectively a Spearman correlation of 0.03 and 0.88 with the Jost-Boissard 3000K data set. For the Jost-Boissard 4000K data set, the CIE CRI and MCRI had Spearman correlations of respectively 0.17 and 0.90. The statistical significance of these findings was verified with the method of Meng, Rosenthal and Rubin for comparing correlated correlation coefficients [19]. It was found that the MCRI was significantly better at the $p < 0.05$ level. More details can be found in a paper by Smet al.[12].

For the Smet et al. 2700K data set, Spearman correlations of 0.49 (CIE CRI) and 0.94 (MCRI) were found between the metrics and the Scheffé scalings for preference, attractiveness and fidelity. The results were statistically significant at the $p < 0.1$ level. For naturalness, no significant differences were observed, as the Spearman correlation was 0.60 for both the CIE CRI and the MCRI. The experiments, as well as the validation of the MCRI will be described in more detail in an upcoming paper.

3. CONCLUSION:

The MCRI was found to be significantly ($p < 0.1$) better than the CIE CRI at predicting the visual appreciative ranking of the 3 sets of light sources.

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