Chromatic diversity of indoor scenes rendered with CIE illuminants and white LEDs for normal and colour deficient observers

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The colour quality of a light source is typically evaluated by the colour rendering index (CRI), a quantity that measures how much the colours under the light source differ from the colours under daylight. The goal of this work was to evaluate the quality of lighting by estimating instead the chromatic diversity light sources produce in indoor scenes for normal and colour deficient observers. Reflectance spectra of objects typically found in indoor scenes (like books, coloured fabrics, children toys, fruits, indoor plants, among others) were obtained using an hyperspectral imaging system with a low-noise cooled digital camera with a spatial resolution of 1024 (H) x 1344 (V) pixels and a fast tunable filter with an infrared filter in front of the lens. Images were acquired from 400 to 720 nm in 10 nm steps. Care was taken to avoid shadows and multiple reflections. Chromatic diversity was estimated for 60 illuminants, 55 CIE illuminants and 5 LED light sources (Luxeon, Philips Lumileds Lighting Company, USA), by computing the CIELAB colour volume of the objects and by counting the number of non-empty unitary cubes of the segmented CIELAB volume. A large variation in chromatic diversity was found across illuminants, with the best illuminant producing about 50% more colours than the worst. A weak correlation between the number of discernible colours obtained with a particular illuminant and its correspondent CRI was also found. For normal observers, the best illuminant was CIE FL3.8, producing about 7.5% more colours than CIE illuminant A and 8% better than D_{65}. For colour deficient observers, increases in relation to illuminant A of about 12% (CIE FL3.7), 7.6% (CIE HP2), 17.8% (LED LXHL-BW02), 8% (CIE HP1) and 6% (CIE FL3.14), for protoanomalous, deuteroanomalous, protanopes, deuteranopes and tritanopes observers, respectively, were found. These results suggest that both normal and colour deficient observers may benefit with a careful choice of the illuminant to maximize the chromatic diversity perceived in indoor scenes and this choice is not necessarily based on the CRI.

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