Robustness of light color perception for LEDs with different spectra relating to age, sex and other criteria

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1. Experimental approach

LEDs with identical color temperatures or chromaticity coordinates do not always appear the same for a human observer. This is due the fact, that the known color matching functions are not fully appropriate for most of the people. The majority of color measurement devices use the CIE 1931 tristimulus values for the 2° visual angle observer [1]. However, other color matching functions exist, for example the CIE 1963 (10°) values [2] or the functions published by CIE in 2006 [3]. These are based on research of Stiles and Burch [4], as well as Stockman and Sharpe [5, 6]. In addition, there are recent investigations from Csuti [7] and Polster [8] resulting in better fitting curves. They postulate that the curve for S-cones has to be moved 6 nm or 3 nm to shorter wavelengths. These are just a few of many possible different color matching functions. But why does every researcher determine its own curve by fitting just his own experimental data? This might be due to the small amount of subjects and the unknown tolerance in individual visual functions. But what size is the tolerance and which differences exist between people of different sex, age and other individual criteria like culture or training?

If LEDs are used for lighting applications, they should have the same color for all people at all viewing field sizes and all illuminances. There are spectra, which are robust with respect to color shifts toward changes in observer type and field size and there are other non-robust spectra. The aim of this work is to create an index for the evaluation of the spectrum robustness. Related to the metamerism of one spectrum concerning changes in field size an index already exists [8]. This index can be modified for inter- and intraobserver metamerism. Several such indices have to be combined in order to reach a robustness index.

To achieve this aim I want to find out how large these differences between the individual groups are. I want to investigate which color matching functions are the best for special types of subjects. Maybe some set of curves are best for older people, or for people with blue eyes or some other mutuality. Important as well is the influence of the viewing field size (2° or 10°).

2. Experimental set-up

The subject has to evaluate the color difference between two semicircles with equal color coordinates [9]. During the experiment the subject is placed in front of a uniformly illuminated field building a surrounding of equal color coordinates which can be mixed out of different white LEDs. The subject looks at a circular test symbol, which is divided into two semicircular areas. Each semicircular area has another spectrum, but nearly the same color coordinates. During the experimental procedure one semicircular area remains steady as a reference and the other changes its color within a narrow pattern of about 100 chromaticity points. The chromaticity points from the pattern are very close to one another, so that hardly any color difference is noticeable. The shown colors change randomly. In this way different combinations of spectra can be investigated by the subjects depending on their age, sex and other individual criteria. Also intraindividual differences between the two eyes of one subject can be investigated.

The experimental set-up already exists [10]. It is a box, positioned on a table with dimensions of about 1 m x 1 m and a depth of 2 m. The subject's head is fixed on a head rest and the test person is looking inside the box monocularly. The subjects look through an aperture of 2° or 10° at the test symbol. The test symbol color can be mixed out of a large gamut, since nine different colored LEDs are used. So the same color coordinate can be shown generated by a lot of different spectra. The provided LEDs are white (color temperatures 2700 K, 4100 K, 6560 K) and colored (dominant wavelengths 655 nm, 627 nm, 505,5 nm, 530 nm, 447,5 nm and 470 nm).

3. Interpretation of data

After the test there will be a cloud of colors with color coordinates for each spectrum which look visually identical as the reference color (Figure). This cloud will be different for each subject, even for every eye. From this cloud the barycenter and variance of each spectrum and subject can be calculated. The smaller the differences between the barycenter of the people within one spectrum, the more similar these spectra appear to the people. In this case we can postulate that the spectrum has a high robustness factor. Hence, for each spectrum it can be found how robust it is against changes of the viewer type. The aim of this thesis is to find a possibility to rate the robustness for unknown spectra out of the robustness of these known spectra.

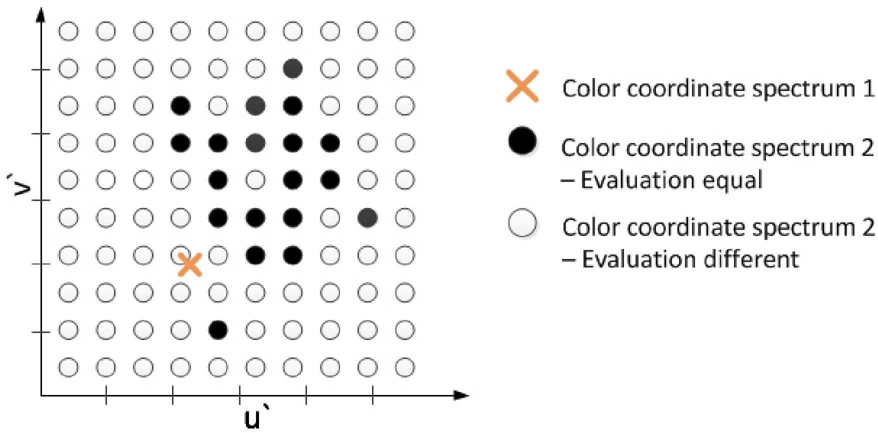

Fig.: Color coordinates for evaluation

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