NON-ADDITIVITY ERRORS IN MESOPIC PHOTOMETRY

Zoltán Vas, János Schanda, Géza Várady and Péter Bodrogi

University of Pannonia, Virtual Environments and Imaging technology Laboratory, Veszprém, Hungary

In the mesopic luminous range –between the photopic and scotopic- both the rods and cones are active. Typical applications in the mesopic luminance range are e.g. street lighting, car headlamp lighting, emergency lighting, lighting for security purposes. Present day standards are based on the photopic spectral luminous efficiency function $V(\lambda)$, which describes the luminous spectral sensitivity of the cones under photopic lighting conditions. This results under mesopic conditions in differences between measured or calculated values and visually observed ones. For proper evaluation of mesopic visibility, a new, more adequate model for the mesopic vision is needed.

One major consideration in developing a new mesopic model is the question of additivity (CIE 1978). It is known, that there are visual tasks for which additivity does not hold. Such a task is e.g. threshold contrast sensitivity, an important factor in street lighting.

A new chromatic model (called CHC from the abbreviation of chromatic conspicuity) was formulated to predict the mesopic increment detection at threshold value, with relevance to retinal physiology. The main goal of the CHC model is that it solves the problem of spectral non-additivity of visual performance based methods. The conventional photometric models overestimate the visual detectability. The CHC model can be a step toward an advanced (detection based) system of mesopic photometry.

Until the mid fifties of the last Century high pressure mercury lamps were used in street lighting, followed by high pressure sodium lamps. At present a tendency can be observed to change to metal halide lamp lighting, with a more bluish light – that based on some preliminary mesopic models should provide better visibility. Recently LEDs have been introduced in street lighting applications. The spectral power distribution (SPD) of the LEDs could be optimized, only industry still misses the guidance for this SPD.

We have performed experiments to prove the predictions of the CHC model. An achromatic background, a large projection canvas illuminated by a lamp at 0.5cd/m^2 (chromaticity coordinates are x=0.32; y= 0.34, CCT=6000K), built from white phosphor LEDs was used. We used LEDs, because one can expect that in the future such spectral power distribution will provide the practical street lighting adaptation. The size of this canvas was 80°x60° to ensure a homogenous achromatic adaptation field.

Target lights were projected by two further projectors, the light of which was monochromatized by interference filters. Threshold contrast was measured for a monochromatic yellow light ($\lambda_{max=}$ 570 nm) and for a yellow light of the same dominant wavelength, but produced by the superposition of two monochromatic lights ($\lambda_{1,max}$= 540 nm, $\lambda_{2,max}$=620 nm). Results show, that in the mesopic range, one can use the spectral responsivity functions determined using monochromatic measurements as simply as in the photopic range. Abney's law does not hold.

The CHC model that we have developed predicts this non-additivity and enables the determination of real threshold contrast sensitivity, which is higher as predicted by the current mesopic models. This is of major importance in street lighting, as the current models will underestimate the visibility threshold by several tens percents.