Hessisches Kompetenzzentrum
für Hochleistungsrechnen

Optimization of Multi-Channel LED Spectra



Project Manager
Babak Zandi

Principal Investigator
Prof. Dr.-ing. habil. Tran Quoc Khanh

Project Term
2018 - 2019

Clusters
Lichtenberg Cluster Darmstadt

Software
MATLAB

Institute
Department of Electrical Engineering and Information Technology

University
Technische Universität Darmstadt

Introduction

Multichannel LED systems are a powerful tool to generate custom spectra, adaptable to the psychological and physiological human needs. Since the discovery of intrinsically photosensitive ganglion cells, it has been found that distinct spectral light distributions can positively affect the hormonal balance of humans. The more LED channels a light system has, the greater the degree of freedom of changing a spectral power distribution over time. In a fixed multichannel LED system, the spectrum can be varied through an additive mixture of individual LED colour channels. The intensity of each channel is adjustable via the duty cycle. In this project, we have calculated such spectra for different research purposes by using mathematical optimization procedures.

Methods

Before an optimization can be performed, the multichannel LED system has to be characterized for simulating the luminaire in a final step. We measured the spectra by using a spectroradiometer at the laboratory of lighting technology. Based on the measured spectral data, a simulated luminaire was built, which we used in an optimization workflow as a part of the main objective function. The goal was to generate spectra that match specific chromaticity points in the CIExy-2° colour space along the Planckian locus. Additionally, we generated metamer spectra, which were capable of triggering photoreceptors in the outer retina in different ways. The result of the optimization was the individual duty cycle of a respective LED channel. With these optimized duty cycle values and the simulated luminaire, we

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were able to reconstruct the desired spectra. We performed the optimization procedures in MATLAB and the simulation of the luminaire in Python.

Results

We were able to calculate multiple spectra along the Planckian locus with a custom optimization procedure. The special feature was that for each CIExy-2° chromaticity point, we could calculate several spectral power distributions to test the brightness perception and pupil light response in empirical studies. We found that the human pupil diameter can be changed by varying the spectrum at a constant luminance with different CIExy-2° chromaticity points.

Discussion

Light spectra of multi-channel LED-luminaires can be calculated by using classical optimization procedures. These polychromatic spectra are of high interest in empirical research studies and automated lighting systems for smart interior lighting. Additional spectra are required since multi-channel LED systems will probably become a standard in interior lighting. We were able to calculate the necessary spectra with classical optimization procedures, but the calculation time was time-consuming. For future applications, more efficient methods need to be developed, making the calculating of spectra even without high-performance computers possible.

Publications

Zandi, B.; Kunst, K.; Khanh, T.Q.: "Einfluss der melanopsinhaltigen Ganglienzellen auf die kurz- und langzeitige Pupillenlichtreaktion", 120. Jahrestagung der DGaO in Darmstadt, Darmstadt, 11. Bis 15. Juni 2019 https://tubiblio.ulb.tu-darmstadt.de/115914/

Zandi, B., Klabes, J. & Khanh, T.Q.: "Prediction accuracy of L- and M-cone based human pupil light models", Sci Rep 10, 10988, 2020 https://doi.org/10.1038/s41598-020-67593-3

Last Update: 2022-06-14 20:19