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SPECTROMETRIC INSTRUMENTATION FOR IN SITU MONITORING OF SPECTRAL COMPONENTS IN DYNAMIC LIGHTING SCENARIOS

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Abstract

We present a spectrometric instrumentation to monitor and log the spectral characteristics of the light in hospital rooms over long term periods during a trial of the effect of controlled lighting on patients. Each room has been equipped with a dynamic lighting system enabling change of correlated colour temperature of the light over the day. The objective is to estimate and document the available light exposure to the patient including the daylight through the window. The calibrated spectral measurements allows for evaluating the stimulus intensities for all five photopigments in relation to both visual and non-visual effects of the light in the rooms.

1. Motivation, specific objective

There is a growing focus on daylight and artificial light in the fields of health and psychiatry as an element that can support conventional medical treatment. In this project daylight is combined with a LED based dynamic luminaires so there is a need for documentation of the light conditions during the interventions. The objective is to provide calibrated spectral irradiance measurements in the rooms to monitor and log the spectral characteristics of the light in the long term trials and to be able to quantify the difference in lighting conditions in a dynamically controlled and not controlled room. The calibrated spectral measurements allows for evaluating the stimulus for all five photopigments as recommended by CIE using the α-opic irradiances, i.e. cyanopic, chloropic, erythropic, melanopic and rhodopic irradiances measured in W/m^2.

The applied spectral sensors needs to be small and unobtrusive not to be disturbing in the hospital room, they further need to be sensitive to low light conditions and they need to be inexpensive. Normal spectrometers do not comply with these requirements and for this setup new types of spectral sensors have been investigated and chosen for the measurement system.

2. Methods

A spectral sensor of the so-called “Pancake” configuration is used for the measurements. It consists of a linearly variable filter on top of an array detector chip and allows for spectral measurements from 380 to 700 nm. The spectral resolution is around 5-9 nm. With USB connection the sensor weighs 15 g and has a size of 10x22x38 mm^3. It is a low cost sensor, less than one fifth of price of handheld spectrometers, allowing for inexpensive multipoint measurements.

The spectral sensor itself has a narrow acceptance angle and for the ambient light measurements a cosine response is required. Therefore, the sensors has been installed in small metal boxes with a hemispherical diffuser in front of the sensor array.

Prior to the installation at the hospital these sensor boxes has been calibrated for spectral irradiance in the photometric laboratory using a 1000 W FEL standard spectral irradiance lamp at a distance of 50 cm. Further the sensors has been characterised for dark noise and specta for the used integration times has been saved. Both dark correction and calibration is applied in the pc control program.

The control program has been developed to subsequently take measurements from all the installed spectral sensors and store the measured and calibrated spectral power distributions with a timestamp and serial number for the sensor. Prior to each measurement the program automatically finds the optimal integration time for the current light conditions, ensuring no saturation and a good signal level of more than 60 % of the saturation level. The possible integration times has been restricted to 72 from 10 μs to 10 s.

In each of four rooms, three sensors has been installed to monitor the light conditions. One sensor is placed at the top of the window on the end wall measuring the daylight entering the room. The two other sensors are placed on each side wall approximately 1.5 m from the end wall with the window and at a height of 1.5 m. The three sensors in a room are connected to a USB-Ethernet hub. The sensor boxes are painted white and no wires are visible, which is essential in the hospital ward. All twelve spectral sensors are connected to a pc via an Ethernet switch. The sensors are powered through the

The spectral data logging system runs with no internet access to comply with patient data regulation.

3. Results

The sensors has been installed and will be monitoring and logging spectral data in the four hospital rooms from April 2018 an onwards. Data will be collected and presented to show the effect of the different lighting conditions in the rooms, e.g. on the α-opic irradiances. Test of the spectral sensors compared to calibrated spectroradiometers will also be done and presented.

4. Conclusions

An instrumentation system to monitor and log the spectral characteristics of the light in hospital rooms over long term during a trial of the effect of controlled lighting on patients has been described. The spectral sensors applied full fills the requirements of being small and unobtrusive, and inexpensive allowing many measurement positions and continuous logging.