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# EVALUATION OF LIGHT DISTURBANCE SOURCES AND THEIR EFFECT ON HUMAN VISION

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## Abstract

There is now an increasing emphasis on reducing the overall level of lighting in towns and villages. The priority is to reduce energy consumption thanks to energy costs and decrease a light pollution in towns, villages and general space. This has an understandable impact not only on road safety but a whole range of other situations. The main objective of this research is to develop an analytical tool to characterize the average brightness levels generated by street public lighting. Usually measuring tools are working with photopic preferences. The conversion to mesopic vision as defined by CIE norm 191:2010 - RECOMMENDED SYSTEM FOR MESOPIC PHOTOMETRY BASED ON VISUAL PERFORMANCE. Such approach tool should be able to determine the difference in the perception of the visual scene for photopic and mesopic adaptive luminance. The purpose is to test whether, as a matter of economy, street lighting could be dimmed to provide a mesopic pedestrian vision regime while maintaining adequate safety. Possible interferences from bright sources such as advertising boards were tested: in particular their ability to revert the vision mode to photopic, temporarily reducing visual gain and causing some problems with immediate perception. The transition area between the photopic and mesopic thresholds is important for drivers/pedestrians. The conventional threshold is set at  $5 \text{ cd}\cdot\text{m}^{-2}$  by the CIE. (CIE, 2010) For correct visual task, ensure safety in the area the human eye needs enough contrast in mesopic vision at reduced light level.

## Keywords

public lighting, luminance contrast, photopic vision, mesopic vision, luminaire, LED, smart lighting, Artificial Light At Night (ALAN), user safety

## Introduction

The public lighting has changed over the years. In the past we were using for illumination candles, gas lamps, halogenide sources and high-pressure sodium lamps (HPS). Nowadays LED sources are very popular. Their biggest advantage is their lower energy consumption and controllability. Thanks to that there is a transition between HPS and LED. On the other hand, inadequate lighting can be disruptive for the pedestrians, drivers of the car and residents living in houses. Advertising panels, billboards and high luminance lighting affect the visual performances of drivers and pedestrians. Different type of vision are usually used on the street – photopic and mesopic. The photopic vision needs around 2 minutes for the adaptation. If the pedestrian is in a mesopic vision and expose to photopic level (even for short direction), the vision automatically switches to photopic. Thanks to that eye will need 30 seconds to 2 minutes. That is an issue, because the pedestrian will get temporarily blinded. The main goal of this research is to characterize average luminance levels generated by street public lighting. We want to assess if the method can be generic for future use in general context. The primary task was to perform measurements on the terrain. A few typical setups were chosen: suburbs of Toulouse and town center. Secondary task was to prepare a tool, which can be helpful for the better analysis of the traffic area. A toolbox is developed permitting to apply luminance analysis in the street.

## Materials and methods

The research was performed in Toulouse city (France). Two examples of typical setups were tested: one with a road with LED luminaires using smart lighting controllers and one square in the center of the town with a fixed level and the presence of an advertising panel. The whole idea is to analyse the safety and suitability for the visual task of users. The setup comprises a tripod with the calibrated camera Canon EOS 50D. The full range of luminance is obtained using XHDR (Extra High Dynamic Range). To this end a few pictures taken with exposure time ranging from 20 s to 1 ms. The aperture was kept fixed at 5.6 and ISO 400. This ensures that each pixel is pointing to the same scene.

A spectral distribution of the luminaire was measured on the ground level with a spectra-radiometer Specbos 1201 coupled to a white calibrated reflectivity standard. Also a few control points were evaluated with luminance camera Konica Minolta Chroma Meter CS-100 targeting luminaires, ground levels and typical point of view of pedestrians.

The main objective of the analysis tool is the detection of high intensity sources and performing maps in photopic and mesopic vision. The map was classified into a mesopic and photopic levels. The program for subsequent analysis was created in MATLAB using the Image Processing and Computer Vision toolbox as standalone GUI.

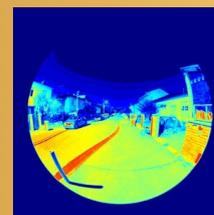
## Results

2 different setups were introduced. Setup 1 is a street equipped with smart lighting controllers using a wide-view camera. Image processing permits to detect cars or pedestrian over a 20 m range; each field of view partly overlaps between adjacent devices. The luminaire detects cars and pedestrians by 2

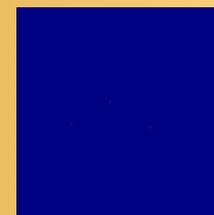
sensors. Thanks to this analysis it is established that the lighting design is adequate and ensure for comfortable visual task. There is a right compromise between good visibility (obstacles), visual comfort (no disruptive lights) and good efficiency. The output of this analysis is illustrated in Figure 1. Using our analysis, we present show this scene in photopic ( $> 5 \text{ cd}\cdot\text{m}^{-2}$ ) and mesopic ( $< 5 \text{ cd}\cdot\text{m}^{-2}$ ) view. These data are in absolute values (fixed threshold of  $5 \text{ cd}\cdot\text{m}^{-2}$ ). Thanks to that we can prove, that pedestrian or driver of the car is in mesopic vision. This is much better because he can easily see the obstacles and he is not disrupted.



Logarithmic map

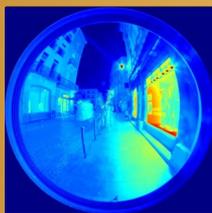


Mesopic map

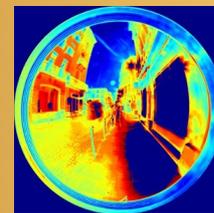


Photopic map

This measurement was taken close to the center of Toulouse in the pedestrian street with shops. On this scene it may be noticed the presence of an advertising panels and windows of brightly lit shop. Our analysis showed that the vision will be disturbed by the shop windows. The vision will be changed from mesopic into photopic. The pedestrian is going to look in the way of shop window which leads to worse adaptation and visual task. The measurement was performed around 11 PM. The shop window is uselessly overlighted. In this case the pedestrian will feel for a few minutes annoyed, uncomfortable and the visual task will be worse.



Logarithmic map



Mesopic map



Photopic map

## Conclusion

In this research 2 approaches were developed in order to analyse light scene. The measurement showed us, that street with the smart lighting system can be useful for the pedestrian. On the other hand, the measurement from the center of town showed us, that advertising panels are annoying and switch the vision into the photopic vision. This adaptation to the photopic vision can be disruptive for pedestrian and driver as well. Due to that the pedestrian/driver is not able to clearly see obstacles for a few minutes and he is glared. We found, that the photopic vision in this scene includes approximately about 40 % of FOV. It would be good to reduce the brightness of billboards and advertising panels, which can save the money and improve the visual task of the driver/pedestrian.

This research should make us think about the rules which will be capable to change the light levels of the billboards and advertising panels. This should help for the better visual task of the drivers and pedestrian in the evening or nighttime.

The main task is to determine whether the street safe and which vision mode is used. Thanks to this tool, the whole scene can be more easily analyse to identify sources and places in the scene that can be potentially distracting for pedestrians/drivers. Thanks to our MATLAB analysis tool and procedure we get a more informative description of the image.

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