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Which ies/eulumdat fits the given geomery of street lighting best? Selecting a luminaire from thousands of luminaire photometries

Abstract

Using our programme ies2tab and bash scripts running it, the whole world market with luminaires can be used to find the best working and least harming solution for any continuous street-lighting case – providing that their photometric files are available. For discharge lamps, thousands of files used to be available together, for luminaires from major producers present at the EU market. For LED luminaires, this is yet to be done, as has been stressed during the presentation of this paper at the Conference on Light Pollution: Theory, Modelling, and Measurements held in Smolenice, Slovakia in April 2013.

Introduction

When a street is to be lit or its lighting system reconstructed, the usual way is that the engineer takes some popular fixture[1] from his/her preferred producer. Then he/she guesses which geometry might suite the lighting task and computes the results by some proprietary software. If the result is not satisfactory, another optical configuration or another wattage for the same fixture is tried, or perhaps still another. So the geometry of poles and overhangs is optimized somehow for the selected fixture and its maybe tunable photometric properties. In a much more common case of a retrofit, when the geometry of the poles etc. is fixed, the only task may be to choose the wattage for the fixture, with the aim of reducing it compared to the previous set of luminaires[2] .

1 By *fixture*, the outdoor lighting terminology means an illuminating device with almost all its hardware, as mounted on a pole or an overhang cable: mechanic and electric parts, optical system (parts bouncing light or letting it through); the only missing component is the very light-producing unit or set of units, like discharge lamps or LEDs. Shortly, it is a "device to hold a lamp". A given fixture may provide several or many *luminaires*, depending on the chosen lamps (even for the same kind and wattage, there exist lamps from various manufacturers) and the mutual geometrical positioning of them and all the optical elements within a fixture. A fixture bears usually a brand name, easy to remember and attractive to customers (think of "lexus" or "prius" in the realm of cars).

2 *Luminaire*, in this language, is a *fixture* plus the light-producing units, like bulbs of discharge lamps or LEDs. Here, we moreover demand fixed mutual positions of optical and light-producing elements, resulting in a unique initial "photometry", that is, a unique distribution of luminous intensity of the new device. So, if the device enables several optical configurations of its hardware, resulting in differing distributions of luminous intensity, it can produce a set of luminaires. Usually, each distribution of luminous intensity is given as a computer file in some of common formats (mostly "ies" or "eulumdat"). The file is identified by a unique string in heading, or simply by its name. For the same luminaire, several such files with differing names and identifying strings may exist, being almost identical by contents and differing just by the date of measurement or by the authority who made the measurement; in this case, we consider those other designations being but aliases. If we would chose another approach, saying that a given luminaire = device with its movable optical and light-producing hardware in *any* setting, the language would become complicated, as the mutual positions of mirrors, light sources and

A better way to find the best geometry of the new installation, when one or several luminaires and their photometries are preselected, is using a programme Easy Light – Save the Sky[1], accompanied by a set of 3640 photometric files (luminaires in our parlance) from 15 manufacturers present at the Italian market in 2004. The files concern 134 fixtures, most of them fully shielded (i.e., having max. 0.49 cd/klm specific luminous intensity horizontally and above). The output of the programme shows an electric consumption per kilometre of the street and other parameters, so the most suitable luminaire can be picked up from the preselected set. To compute the impact of the chosen solution on the sky luminance, programme Roadpollution[2] is to be used[3]. Both programmes are freeware, non-commercial, with undisclosed source code, offering just a MS-windows executable.

When old luminaires are to be replaced by new ones, another task is to be solved. The geometry is maintained and a luminaire suiting excellently the lighting demands and producing minimum harm (least light outside the target area etc., least electric consumption) should be searched for. Such a software has been developed in 2007, based on a programme ies2tab[4].

ies2tab software

The programme is written in Pascal, as an open-source software under GNU public license, as all author's ones since mid 90's. Using Free Pascal (www.freepascal.org), they can be compiled for any platform. The first version of the programme from 2001 was primarily a tool to make a human-readable table out of the photometric file in a *.ies format. The table had been preceded by some common summary parameters computed from the file; the goal was, among others, to get a proper classification regarding the IESNA and CIE cutoff categories and recognizing the false zero-uplight luminaires, which might be wrongly classified just due to missing photometric data over 90 degrees. In 2002, quantities relevant for sky luminance were added, for luminaires which are not fully shielded, sending some light over 90º from nadir. An example of such summary heading:

```
# Source file: ies/35617.ies
# Luminaire flux =  5371 lm,
#                   82.6 % of the bulb flux
# between 75 and 90:  9.7 % of the luminaire flux
#  - this part causes just GLARE in case of road lighting and similar purposes
# 80deg and above:  max 370.0 cd / 1000 lm ,  3.1 % of the luminaire flux
# 90deg and above:  max   3.0 cd / 1000 lm ,  0.5 % of the luminaire flux
# CutOff Type: Non-CutOff

#  Increase of Sky Luminance due to light going
#    from the luminaire directly above horizon, as compared with the
#    luminance produced by the light dispersed from the ground:  13 %
#  Increase of Sky Luminance in Distant Places by light below 15.0 degrees
#    due to light going from the luminaire directly above horizon:  49 %
#  (for the zenith luminance such an angle suits places up to  19 km distance)
#   The increases concern the following situation:
#    Albedo = 0.10
#    Zenith Extinction = 0.30 mag (i.e., direct light remaining  76 %)
```

lenses would have to be identified by another means than just by a name of the photometric file or a longer string within the file. For us, such string denotes the very luminaire as well. We should be aware, however, that over the years, photometric properties of the luminaire are evolving due to dirt and corrosion, which are smoothing the distribution of luminous intensity, and to due reduced output of its light sources, or due to increased luminous output of newly inserted light sources. Photometries of such worn luminaires are scarcely published.

```
#    Indicatrix type =0 (0: acc. to P.Cinzano, 4..6: CIE sky types)
#   (the downward-scattered part of lambertian uplight is 0.1108 then)

# 62.5 deg to <67.5 deg:   max   398 cd / 1000 lm,
# 67.5 deg to < 76  deg:   max   997 cd / 1000 lm,
# maximum spec. lum. intensity   997 cd / 1000 lm
```

2003/2004, eulumdat photometric format and the conversions between these two formats have been added. In its time, it was probably the only standalone converter, moreover platform independent (as regards platforms for which it was compiled, DOS executable production has been discontinued, just linux binaries, and later also Win32 executables were made).

In 2007, an option to produce an illuminance plot has been added, using the same logarithmic colour scale as used by our another programme, raw2lum[5] (software making all possible radiometric evaluation of images made in a raw mode by digital cameras, via a *.pgm produced by dcraw[6]). And an option to evaluate illumination of a rectangle. All possible rotations of the luminaire are possible, this being necessary not because of tilts along slopes (good to improve uniformity and reduce glare), but also for accounting for changing choices of the main axes for the photometry files. Fraction of light falling there, maxima, minima, averages and their ratios are computed.

The final improvement has been an option to compute illuminance by a continuous row of equidistant luminaires. For most outdoor lights, this is the most common situation.

The programme is a command-line one with the photometry file name as a obligatory parameter, controlled by 29 optional parameters. It may seem complicated, so to make the programme usable for everybody, an online use has been enabled, via a short php and several scripts (written in bash under linux)[7] . It might be a good aid for anybody interested in lighting and light pollution computations, when wishing to know most about a single luminaire (or convert its photometry to the other format).

Running it on thousands of photometries

Such a command-line programme is quick. A natural follow-up was running it on many photometries (luminaires) to get their overview. This has been done, using a series of scripts for the Easy Light – Save the Sky database by Diego Bonata[1], and for several other producers or newer fixtures, including some LED-based ones, see the results and a lecture on in at [4], where a directory “scripts_bat” offers all those scripts. A typical work is like: in a directory with any ies/eulumdat files, changing blanks in file names to dots, computing images and tables, and creating html overviews for spacing 5 and either 6 or 4 (spacing: distance between luminaires / luminaire height above the ground) – lighting a way well and most efficiently may be no easy task in a such configuration. Thumbnail overviews may ease picking up the right luminaire visually, from hundreds of them. We don't publish the original *.ies or *.ldt files (if the producer does not recommend that), but offer just the human-readable information from them – summary information, tables, plots, so no producers should be shy to submit their data to us.

Another script, rect_il.sh, picks up the best performing luminaire for the given place to be lit. To do that, rotations of 90º (or 270º or even 180º) of the coordinate system around a vertical axis are to be tried, as esp. within the eulumdat format, the proper orientation of the coordinate system for reporting the luminous intensities is often confused.

The most powerful script can be used to select the best-fitting luminaires for an long linear area with luminaires in predefined positions of uniform spacing. A bash script rect_ilc.sh[8] has been written for this purpose. It sorts the luminaires according to the minimum illuminance in a strip representing the street (the higher the minimum illuminance, the better). Using it several times, with more and more strict requirements, can select a reasonably small set of the best performing luminaires for the given geometry of the street and lighting infrastructure. An example of results of such a search is given within [9], for more discussion see [10].

The default illuminance plots are for (unrealistic) “unit” case that luminaires would have lamps producing 1 klm, would be point-like and just 1 m over the terrain. For a real luminaire height and a real lamp, see an example for a 9 W LED array in a directory referenced in [11].

A missing database of photometries

Ten years ago, the mentioned database[1] had been almost sufficient, if a couple of missing manufactures would be added, who have the photometric data on the web. However, with the emergence and quick development in LED outdoor lighting, we are no more able to advice municipalities, which luminaire would fit their case best. This is really a pity, as LEDs with lenses can distribute light much better then discharge lamps with mirrors. Even narrow paths can be efficiently illuminated by diodes.

Our software can easily pick up the winners or at least finalists from the whole world market. However, if the basic luminaire properties (photometries) are kept rather confidential, demanding tremendous effort from anybody to get data from all manufacturers, no proper comparison between the products which might be suitable for any lighting task can be done – there is no world market at all, just niches of manufacturers and “their” lighting engineers. This is a pronounced market failure, motivating for corruption.

Establishing a world-wide repository of outdoor luminaire photometries would be the right cure. Any linux computer can do that, with the manufacturers having accounts on it, being able to put their files there and replace them as needed. Or, conversely, if the manufacturers would give stable URLs for the files, their files could be mirrored there. Overviews as mentioned above could be then made from them, updated once a month or so. Also, a zip file with all the photometries could be renewed, so that anybody could select the best-performing luminaire for each basic lighting task, a spot-one or a linear one. An incentive for manufacturers to participate would be at hand: they get promotion this way. If they would be reluctant, then a recommendation from expert institutions should follow – don't use any luminaire outside this database, it is suspect...

Using the whole world market instead of adhering to the same manufacturers for decades could reduce not only light pollution, but even power consumption a lot. We have no sustainable, no-regret electricity for lighting, not even is it in sight... We have to bear in mind that current electricity consumption is immoral, destroying the planet to future generations.

Discussion: limitation of our software – no luminances

In our opinion, outdoor lighting serves primarily pedestrians and cyclists. Motorized vehicles have their headlamps, which are rather strong nowadays. Standards demanding some minimum luminances of the road are promoting quick driving at night, what is surely nothing to wish. Those luminances are namely computed for a view into the far distance, not appropriate for

streets where non-motorized traffic coexist, calling for cars to go slowly. And quite inadequate for weather when the traffic is least safe, like during rain or snow. So, illuminance should be a better metrics, independent of a position of the observer, easy and reliable to compute. We object even to standards recommending some lower limit of average illuminance – if less light is enough in spots with less then average, then it is enough everywhere. Anything more than that is counterproductive, not beneficial. This is what our software can optimize: the lower the maximum/minimum and average/minimum ratio of illuminances, the better.

Conflict of Interest Statement

None Declared

References

1. Bonata D. Easy Light - Save the Sky 4.0 - inglese. 2008. Available at http://tinyurl.com/stsen

2. Cinzano P. Roadpollution: a software to evaluate and understand light pollution from road lighting installations. 2004. Available as http://www.lightpollution.it/roadpollution/roadpollution_turin.pdf

3. Cinzano P. Roadpollution User Manual. 2006. Available at http://www.lightpollution.it/roadpollution/

4. Hollan J. ies2tab programme: photometric properties of luminaires. 2001-2007. Available at http://amper.ped.muni.cz/light/ies2/

5. Hollan J. Luminance and Radiance measurement using raw formats of common cameras. 2006. Available at http://amper.ped.muni.cz/light/luminance/

6. Coffin D. Decoding raw digital photos. 2008. Available at http://www.cybercom.net/ dcoffin/dcraw

7. Hollan J. Online computing of summary results from photometric files of luminaires and of plots of ground illuminance by them. 2007. Available at http://amper.ped.muni.cz/light/ies2/online/

8. Hollan J. A bash script sorting the luminaires according minimum illuminance of the road. 2007. Available as http://amper.ped.muni.cz/light/ies2/scripts_bat/rect_ilc.sh.txt

9. Hollan J. The selection of best performing luminaires for a street in Ostopovice. 2007. Available as http://amper.ped.muni.cz/light/ies2/EasyLight-SaveTheSky/ostopovice.htm

10. Hollan J. Choosing the best-suiting outdoor luminaire. 2007. Available as http://amper.ped.muni.cz/light/ies2/EasyLight-SaveTheSky/ch_best.htm

11. Hollan J. Re: Batlamp - the ultimate LED streetlight for protecting the night sky? 2012. Available as http://amper.ped.muni.cz/darksky/2012/000092.html