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Digital measurement of road lighting

Streszczenie. *Dotychczasowe oprogramowanie współdziałające z matrycowymi miernikami luminancji nie pozwalało na precyzyjne rozmieszczenie pól pomiarowych, zgodnie z obowiązującymi przepisami normalizacyjnymi w oświetleniu drogowym. Opracowany, przez pracowników Zakładu Techniki Świetlnej, system precyzyjnego rozmieszczania pól, pozwala w znaczny sposób zautomatyzować i skrócić czasochłonny proces pomiaru rozkładu luminancji na powierzchni jezdni. W referacie zostanie przedstawiony sposób działania systemu. (**Cyfrowy system pomiaru oświetlenia drogowego**).*

Abstract. *Till today, existing software for matrix measurers of luminance did not allow for precise place of measuring points and areas (in accordance with current regulations standards) for street lighting measurers. New system, designed by employees of Lighting Technology Department in Warsaw University of Technology changed this situation. New system allow to place precise the measurement points and areas n pictures with luminance distribution. System allow to automate and shorten the time-consuming process of measuring the luminance distribution on the road surface. In paper new system will be presented.*

Keywords: lighting technology, street lighting measurements, matrix measurer of luminance
Słowa kluczowe: technika świetlna, pomiary oświetlenia drogowego, matrycowy miernik luminancji

Introduction

The importance of road lighting measurements speaks for itself. They allows for objective evaluation of the lighting installation condition, correctness of its mounting procedure, as well as the final lighting project verification.

Unfortunately in Poland the road lighting is subject to measurements on extremely rare occasions.

One of the reasons for this is the considerable work- and time consumption of such measurements [7],[8]. Luminance measurements are exceptionally difficult to perform. For instance, in case of a single 3 lane road 270 unit luminance measurements have to be made (or more depending on the measurement unit length), with a customized meter (i.e. with the measurement field 20' × 2' – in accordance with the subject standard [1],[6]). Moreover, the measurement should be taken by a group consisting of at least 3 people at night and all of the measurement team members have to be provided with safe working conditions [7]. It is not an easy task as traffic is rarely stopped on the given part of lane.

The measuring process itself is also quite challenging. At night one of the team members places a marker on the road (in the measurement grid spot), while the other member directs the measurement field (in reality it is a tiny black line visible in the meter viewfinder) of the meter towards the spot indicated by the marker. The significant distance between the meter and the measurement spot (usually from 60 to 100m), as well as the necessity to level the measurement field (small line visible in the meter viewfinder) makes performance of such measurements extremely hard.

What is more, luminance measurements cannot be planned too long in advance due to weather conditions (which are difficult to foresee in the long run). It can be easily concluded that the above-mentioned factors discourage from making such measurements – though it is a rather lame excuse.

When matrix luminance meters appeared on the market, a chance to shorten the road luminance measurement time was born. Unfortunately the software that was usually provided allowed for measuring luminance only in a certain area (e.g. the road outline). Introduction of measurement fields consistent with the standard was impossible. Calibration of the road view (observed in perspective in a trapezoid-like shape) to a rectangular area and then mapping the measurement points grid was a certain simplification. Such proceedings must have resulted in certain mistakes. It is hard to tell how calibration of the image influences the luminance distribution on the resultant image, however, it is certain that an additional, hard to estimate error must be calculated on basis of the adjacent fields' luminance values. Moreover, the measurements should be made at the measurement grid points with the measurement field 20' × 2', which is rather difficult after the image has been calibrated and its proportions have been changed.

As part of the research work done by the Lighting Division of the Warsaw University of Technology an innovative method of analyzing the results of measurements made with a matrix luminance meter (MLM) was developed. The system of precise spacing of the measurement grids, developed by the Lighting Division employees, allows for significant automation and shortening the time-consuming period of measuring the luminance distribution on the road surface.

Description of the road luminance distribution operation measurement system (the system of precise spacing of the measurement fields)

What was created out of the realized research was an application which spaces the measurement fields on the luminance image obtained during the MLM measurements in a precise and fully controlled way. The main goal of the user is to define the "outline" (fig. 2) of the road area of its interest, usually marked during the measurements with some markers (flags etc.), precisely determining the four apexes of the measurement field (fig. 1).

An exemplary application window can be seen in figure 5. It depicts the registered image and allows for defining all of the crucial calculation parameters.

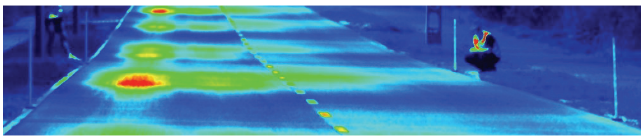

Fig. 1. The luminance distribution, registered on the road surface, registered by the MLM in the color pseudo-color scale.

Next, the developed algorithm automatically calculates the location of subsequent measurement points and maps the measurement fields in accordance with the standard.

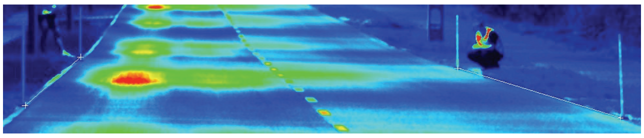

Fig. 2. Luminance distribution registered on the road surface with mapped markers defining the calculation area of the application.

Figure 3 presents exemplary measurement fields with mapped full set of measurement fields. The computer method of analyzing the luminance distribution offers numerous advantages, including:
- the possibility to refer results of measurements taken at different intervals in a precise manner (e.g. every few months),
- the possibility to map the measurement points correctly – thanks to the developed algorithm which takes into consideration incorrect leveling or non-identical aiming of the meter during the measurements.

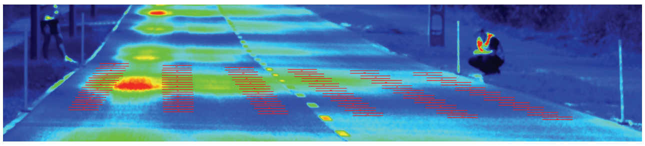

Fig. 3. Results of the automatic mapping of measurement points with mapped measurement fields with dimensions 20' x 2'.

The paper includes saved parts of the screen images from the draft version of the application. The program is developed constantly and now it allows for presenting the minimal, maximal and average luminance within each measurement field and defining the area or set of measurement fields (fig. 4). Basing on these data, the program calculating all of the parameters which form part of the standard (average luminance, overall luminance uniformity, longitudinal luminance uniformity [1],[3],[6]). What is now the subject of research is the possibility to introduce output data export to Excel documents and directly to a printer (according to the adopted format). Introduction the possibility to compare the results of a few subsequent measurements, ran in order to evaluate the road lighting condition, will be introduced into the next versions of the application, providing a complete tool that considerably limits the time necessary for road measurement and their analysis.

LP	Lmin	Lmax	Lavg	wsp. X	wsp. Y
0	1,09	1,74	1,38	434	743
1	1,21	2,06	1,55	429	750
2	1,34	2,83	2,00	423	757
3	1,48	3,01	2,22	418	763
4	1,45	3,55	2,37	413	770
5	1,12	2,83	1,87	408	777
6	0,86	1,93	1,33	402	784
7	0,84	1,50	1,11	397	791
8	0,79	1,33	0,98	392	797
9	0,85	1,15	0,96	387	804
10	1,32	1,68	1,48	530	745
11	1,50	2,20	1,73	531	752
12	1,98	2,90	2,33	531	759
13	2,29	3,02	2,50	531	766
14	2,31	3,24	2,57	531	773
15	1,62	2,90	2,11	532	780
16	1,16	1,94	1,45	532	787
17	1,01	1,42	1,15	532	794
18	0,91	1,19	1,01	532	801
19	0,93	1,11	1,02	533	808
20	1,21	1,49	1,39	627	747
21	1,46	2,06	1,68	633	754
22	1,92	2,52	2,30	638	761
23	2,02	2,62	2,40	644	768
24	1,90	2,66	2,31	650	775
25	1,39	2,17	1,79	656	783
26	1,01	1,52	1,24	661	790
27	0,88	1,09	0,98	667	797

Fig. 4. The numerical presentation of luminance calculations for few subsequent measurement fields is depicted in figure 3.

All of the measurements were made with the matrix luminance meter, using a lens with focal length 50mm. Application of a lens with long focal length – selected so that the measurement field covered the road area registered by the matrix meter as fully as possible, would allow for extension of the calculations precision.

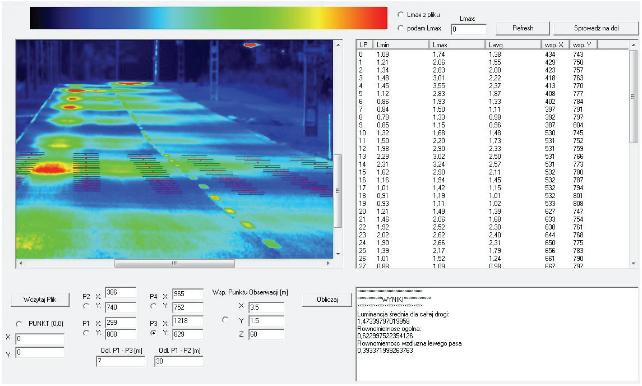

Fig. 5. Window of the application developed for the purpose of road measurements – application state for September 2011.

Comparison of the obtained results with the measurement made in the conventional way

The first measurement results made using the developed system show that the results obtained with both methods are similar. However, what is noteworthy is the considerable reduction of the measuring time. Moreover, the number of employees performing the measurements is also limited. A detailed comparison of the numerical data obtained using both methods (the standard way and the currently developed one) will be presented in further publications.

The application also allows for considerable reduction or elimination of the human involvement (the possibility of a human error in e.g. incorrect aiming of the meter at the measurement field). A registered luminance distribution can be analyzed multiple times and the results of subsequent analyses will not change. This is not the case with the conventional equipment, where obtaining an almost 100% similarity of results of different measurements (made at different times by various people) is extremely hard or even impossible.

Conclusions

Application of the matrix luminance meter in the measurements considerably shortens the measurement time. Basically, only unit measurements are necessary (the number of measurements equals the number of road lanes), as compared to the few dozen or even few hundred of measurements made in the conventional way. Next, the obtained luminance distribution images undergo analysis in the developed application. Thanks to precise arrangement of the measurement fields in the analyzed image, the average luminance, the overall luminance uniformity and the longitudinal luminance uniformity can be estimated – in accordance with the standard requirements [1], [6]. This shortens the time and work consumption of the measurements. Moreover, their precision is enhanced, which makes them unique, as compared to the standard measurements. The same measurements performed in the conventional manner by two different people may vary slightly (when it comes to precision of aiming the measurement field at the measurement grid spot).
All in all, the matrix luminance meter combined with the developed application is a quick and precise system of measuring the luminance distribution on roads.

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