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Spatially Resolved Luminance and Color Measuring Technology in the Automobile Sector - Illustrated by Means of the Symbol and Lamp Measurement

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1 Introduction

The spatially resolved determination of light- and radiation-physical quantities is being applied in many fields of the automobile industry (development and production control). In our paper presented at the PAL2003 we dealt with the fundamentals of the spatially resolved luminance and color measurement technology.

Our follow-up paper presents some applications for which the functionality of both hard- and software has been designed to suit directly the requirements of the automobile industry. First, we will explain methods for symbol measurement in the field of the interior night design and the functional design of automotive and plane cockpits. In the second part, we will deal with the measurement of arc and filament lamps.

2 Symbol measurement for interior design

In the night design, symbols are measured and evaluated. Symbols are single signs, strings or pictograms which can contain complex or also small structures. In the following paragraph, the photometric evaluation of illuminated symbols by means of the image-resolved light and color measurement is described.

The photometric evaluation is carried out on the basis of quality parameters such as mean luminance, tristimulus value, and uniformity. Furthermore, the structure widths of the symbols and the position of the centers (photometric/geometrical) or also the position of the regions of minimum and maximum luminance play a role.

The following steps have to be carried out:

- Assembly of the camera and of the test object on an optical bench and setting up of both systems (aligning, adjustment of the object field and sharpness, etc.).
- Recording of the data by the image- resolved luminance and color measuring system.
- Preparation of the evaluation procedure and determination of the desired measuring values.

Diagram 1: Pseudocolor representation of the luminances of a symbol (palette on the right) The positions of the minimum (1.<) and the maximum (1.>) are defined by the circles drawn in the image.

Results of arc measurement:

Result	Value
Mean value	3.2 cd/m²
Minimum	1.8 cd/m²
Maximum	4.3 cd/m²
Non-uniformity	78%

For the evaluation of the symbols, those pixels must be determined which belong to the luminous surface. For this, adaptive threshold algorithms are necessary which allow a local luminance threshold to be fixed and which also allow the pixels to be classified accordingly afterwards. Thus, statistical parameters for the luminous surface established in this way can be derived.

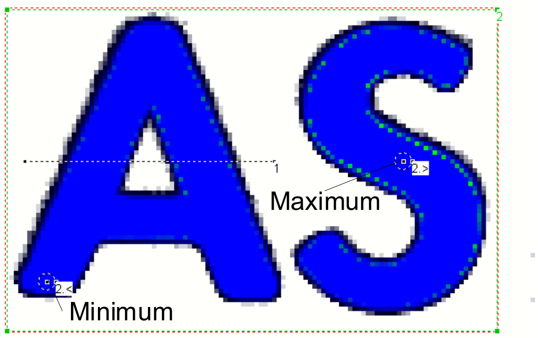

Diagram 2: Evaluated symbol represented as a label picture

In order to reduce the influence exerted by single pixels, the edges, and other less important disturbing factors, a virtual spot meter is “moved” across the luminous surface, e.g. for determining the minimum and maximum luminance.

Some further options for the evaluation procedure permit the user to fix the size of the spot. In addition, it is also possible to maintain a well-defined distance between the spot and the symbol edge so as to reduce the effects of the edges of the signs on the edges of the symbols even more.

The use of an image resolved color measuring camera does not only make it possible to perform evaluations in the field of the luminance, but also to determine the respective tristimulus values. Here, the classification of the single pixels (whether a pixel belongs to the symbol or to the edge or to the background) is effected by means of the methods described above using the luminance channel.

For the single regions (luminous surface, regions of the minimum and the maximum), the color values are determined. For this, both the tristimulus values themselves and the dominant wavelength, which is generally used as a quality parameter for determining the chromaticity, are of great importance. Because of the use of LEDs whose dominant wavelengths vary depending on the type, and due to the influence exerted by the light-conducting plastic parts, it is necessary to determine the dominant wavelength for quality evaluation.

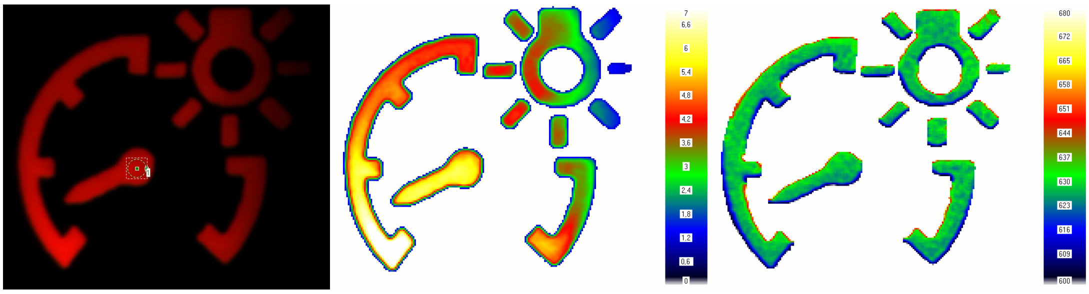

Diagram 3: *Color image of a symbol in linear representation (left); Luminance component of the symbol (middle); Dominant wavelength of the single pixels of the symbol (right)*

From the representation of the dominant wavelength, it can be seen that the evaluation, particularly in the edge regions of the symbol, may cause certain problems, which means that the evaluation must be restricted to the interior region of the symbol, using evaluation algorithms.

3 Characterization of lamps and filaments

The measurement of arc and filament lamps is very important for the development and production control of lamp suppliers and the manufacturers of headlights and luminaries. The application of the image-resolved light and color measurement just as of a specially designed software permits us to evaluate several parameters needed for evaluating lamps.

3.1 Measurement of arc lamps

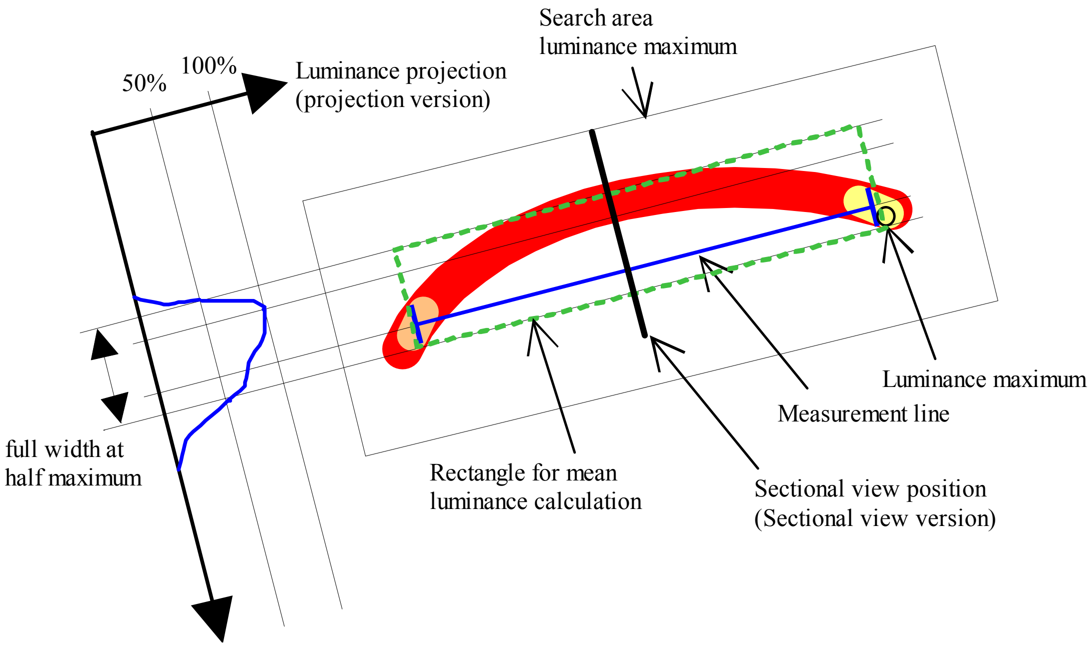

Diagram 4: Specification of arc parameters according to ECE 99

The arc measurement can be used for evaluating arcs according to ECE 99 in order to determine certain measuring values of the arc.

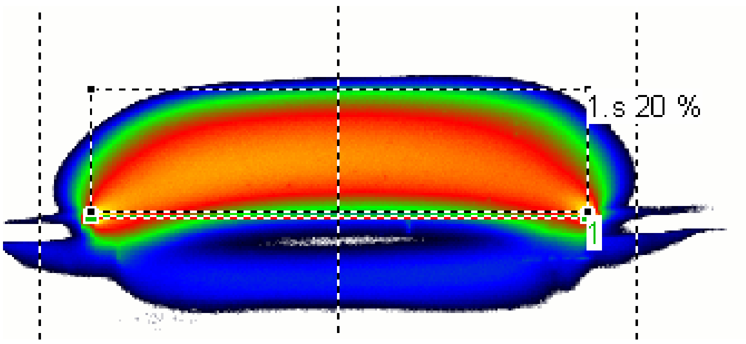

Diagram 5: Luminance image with measuring regions (false color, logarithmic representation)

Results of arc measurement:

r (mm)	s 20% (mm)	L 20% (cd/m²)	L_{max} (cd/m²)	L_{mess} (mm)
0.503	1.01	60.75e6	210.3e6	4.10

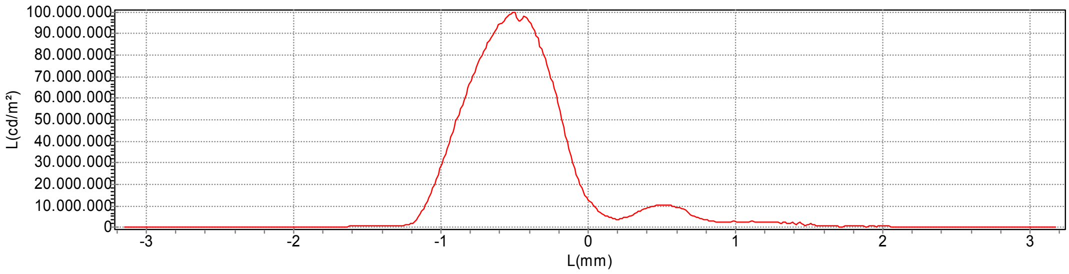

Diagram 6: Projection of arc profile (parallel to line 1 in the area 1.s 20%)

First, a measuring line (reference line) is inserted in the arc by the user. For calculating the results, one can decide whether the following evaluations shall be carried out according to the projection method or according to the sectional view method. Using the projection method, the mean luminance in the direction of the reference line is determined for various lines running parallel to the reference line. Using the sectional view method, the luminance is determined along a line which is perpendicular to the reference line in the middle of it. In both cases, the first result obtained is a one-dimensional function behavior along the section or also the projection.

The maximum (luminance L_{max} and the distance r from the measurement line) of this function is determined. Various threshold values X% (e.g. 50, 20, 10%) can be fixed on the basis of which the program calculates the width of the arc. The mean luminance is determined within a rectangle whose width results from the length of the measuring line drawn by the user. The height as well as the position of the rectangle are defined by the arc widths calculated.

In a larger search rectangle, the luminance maximum is additionally searched for. Averaging is effected over an N_{max} x N_{max} - pixel environment in order to reduce the influence of measuring uncertainties due to noise.

After the calculation of the arc object, further regions are drawn in the image next to the original line marked at the beginning of the calculations (see Diagram 5).

3.2 Measurement of filament lamps

The filament object can be used for evaluating filaments. The algorithms presented here are a first step towards the acquisition of these data. Further automatic evaluations are imaginable, any suggestions in connection with this are welcome.

The user draws a rectangle around the filament, with this rectangle surrounding the filament completely. Then, a filament object for this rectangle must be calculated. The user can decide whether the following evaluations shall be carried out either according to the projection or to the sectional view method. If the Projection method is used, the behavior of the mean luminance in the direction of the longer side of the rectangle is determined. If the Sectional view method is applied, the luminance is determined along the center line of the rectangle. In both cases, the first result obtained is a one-dimensional function behavior along the section or also the projection.

Up to three more rectangles X% can be drawn whose sizes result from a default percentage of the surface area of the rectangle drawn by the user. The mean luminance and the surface area of the rectangles additionally drawn as well as of the originally marked rectangle (100% and X%) are determined.

In the measuring rectangle, the luminance maximum is additionally searched for. Averaging is effected over an N_{max} x N_{max} -pixel environment in order to reduce the influence of measuring uncertainties due to noise.

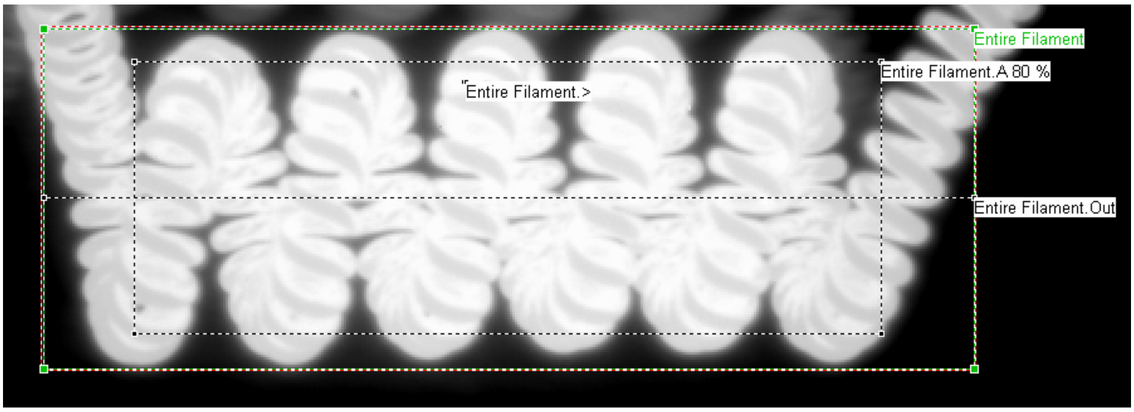

Diagram 7: Luminance image of a filament

Results of filament measurement:

Mean (cd/m²)	Area (mm²)	L 80% (cd/m²))	A 80% (mm²)	L_{max} (cd/m²)	L_{mess} (mm)
20.3e6	5.1	26.0e6	3.2	42.9e6	4.74

4 Conclusion

In our paper, we have shown example applications of the image-resolved light and color measurement in the automobile sector. The measuring technique just as the software are well able to allow applications in various fields such as luminance and color measurements in the interior design and direct "side on" measurements for lamps. Further applications in the field of headlamp measurements and for ray data measurements as basic measurements used for simulation purposes will be reported in the articles mentioned at this conference.

5 References

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