Production-accompanying measuring technique for LED and LED assembly groups

Dipl.-Ing. Christian Schwanengel, TechnoTeam BV GmbH, Germany

1 Introduction

LEDs are becoming increasingly important in different fields of the automotive industry. Because they are small and easy to combine, LED assembly groups are used very often. There are practically no restrictions concerning their design, so many different arrangements are possible.

To get photometric data of the LEDs, a well adaptable measuring system is necessary. It must be able to capture different areas of the colour space as well as different brightness/intensities. There are applications just as daytime running light, or back lights, where especially the single results of each LED compared with one another are of interest. So, it has to be checked whether all LEDs have a minimum of intensity (luminance) and also that the colour distance between the LEDs is within a predefined tolerance. All this information can be determined by means of a luminance measuring camera within fractions of a second. In addition, there are image-processing operations specially adapted to these problems (LEDs in the picture can be detected and separated automatically).

Moreover, it is possible to determine for assemblies as well as for Single-LEDs, e.g. interior symbols, intensity gradients and also the homogeneity of the symbols.

The paper describes the possible applications on the basis of various concrete examples.

2 Measuring principle

Depending on the specific application, LEDs can be measured either directly or indirectly. Figure 1 shows the measurement set-up for an indirect measurement. Here, a diffusing screen is mounted at a suitable distance to the LED assembly. The luminance can then be measured on this screen. The luminance distribution to the single LEDs contains some important information about the radiation of light. The mean luminance multiplied by the “size of the light spot“ provides information about the luminous flux or also an essential partial luminous flux. From the coordinates of the “light spot”, both the position of the LED or also a certain “squint” of the LED can be concluded.

By applying some suitable algorithms, it is now possible to derive from the spatially resolved luminance distribution all those parameters which are important for the pieces to be checked. The use of a colour camera does not only permit the brightness to be

measured, but also the colour in a spatially resolved manner. Thus, any colour differences occurring within the radiation of a single LED can be detected (e.g. in the case of white LEDs).
Here, depending on the brightness of the LEDs, the measuring time for a complete LED assembly can be shorter than one second.

Fig. 1: Measuring equipment for LED measuring

3 Possible applications

3.1 Daytime running light

For daytime running lights especially the single results of each LED compared with one another are of interest. Moreover, it has to be checked whether all LEDs have a minimum of intensity (luminance) and also that the colour distance between the LEDs is within a predefined tolerance.

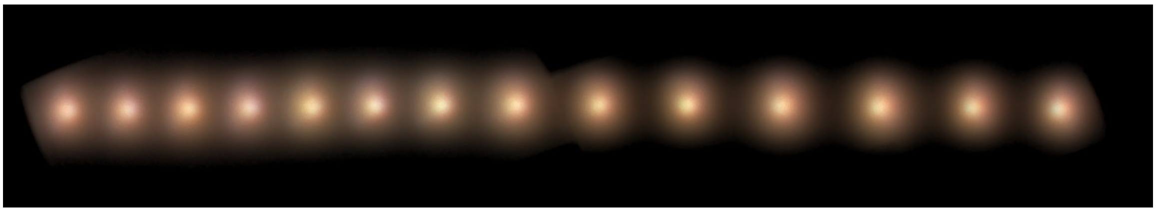

Fig. 2: Colour image of a daytime running light on the diffuser glass

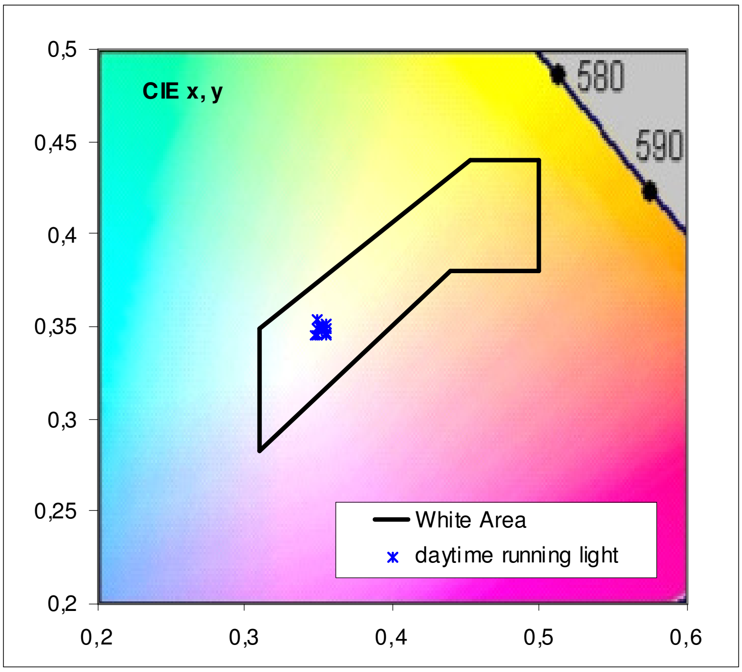

Fig. 3: CIE x,y colour coordinates of a daytime running light

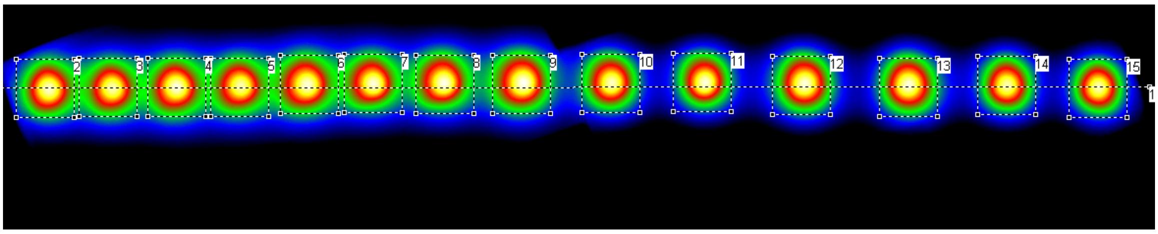

Fig. 4: Intensity distributions of a daytime running light on the diffuser glass with regions

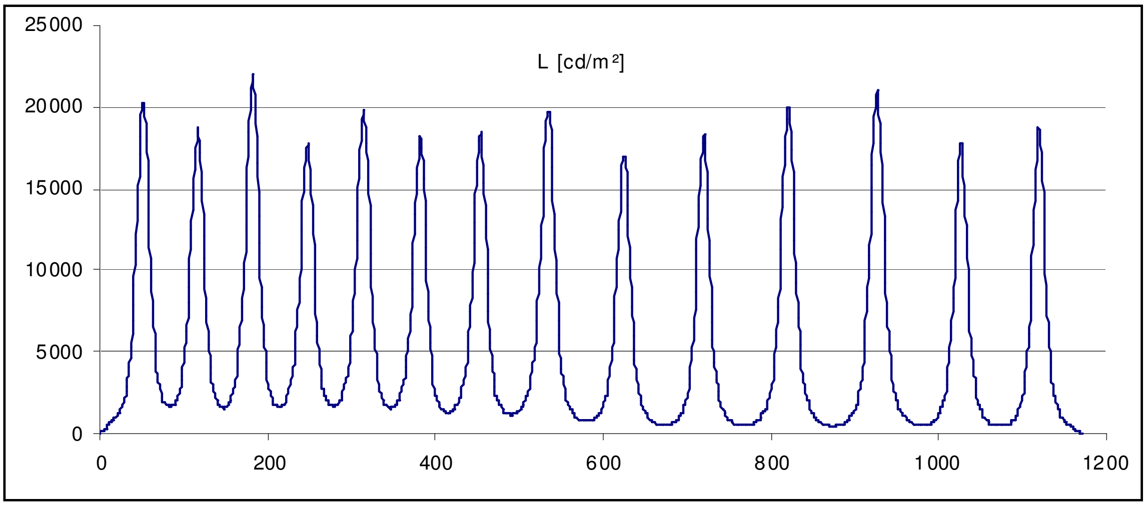

Fig. 5: Course of the intersection through the intensity distributions in Fig. 4

3.2 Back lights

The following example shows the captures of an LED back light. The evaluation options are equivalent to those of the daytime running light.

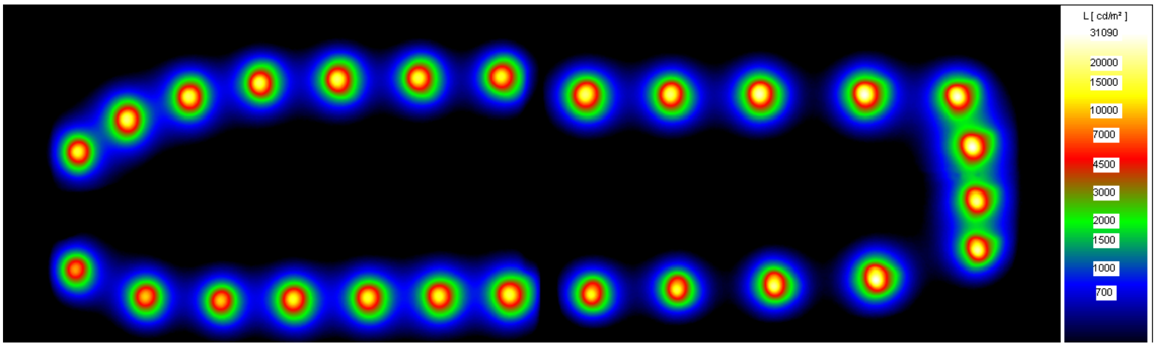

Figure 6: Intensity distributions of a back light on the diffuser glass

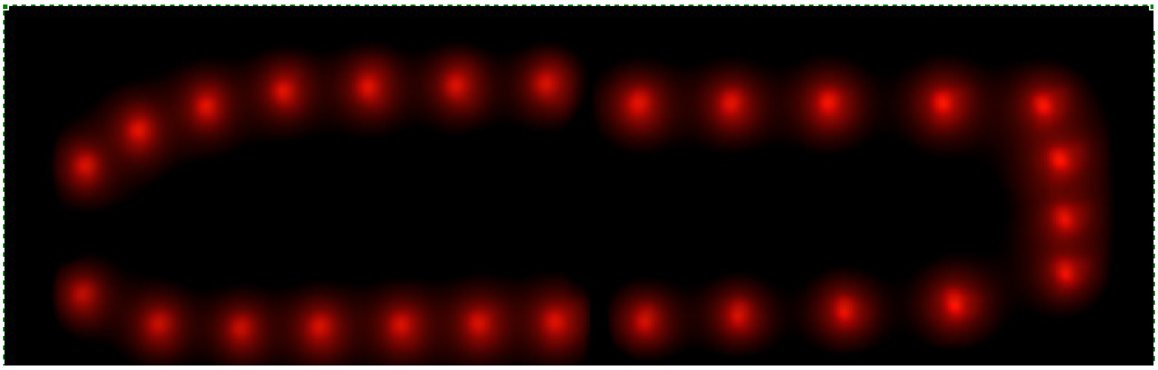

Figure 7: Colour image of a back light on the diffuser glass

3.3 Direct measurements made on RGB-LED-modules

In contrast to the indirect measurement, no additional diffusing screen is mounted between the LED and the photographic system. When capturing the LED modules with the colour camera, the chips themselves and also the light scattered by the covering become visible. Thus, the images of the LED are greatly inhomogeneous (see linear representation – in the case of a logarithmic representation, this is no longer perceivable).

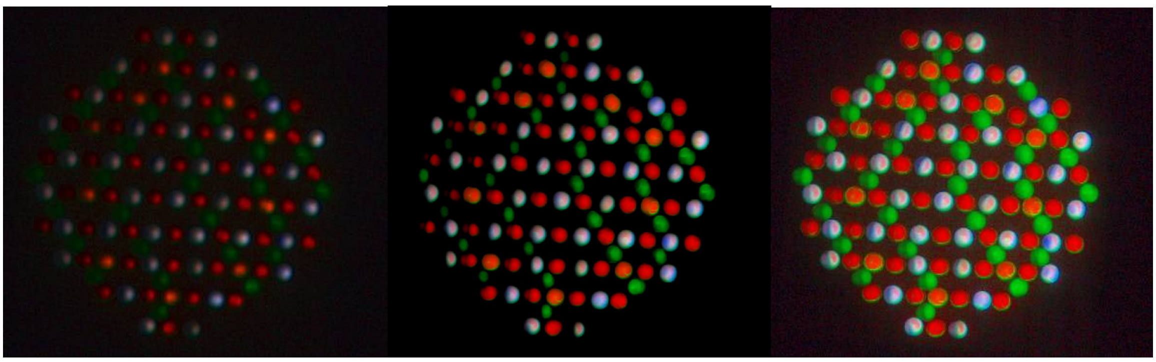

Fig. 8: Colour image, linear, 2 times logarithmic and 4 times logarithmic

The components can be extracted from the colour images. In what follows, L, x and y are shown as examples:

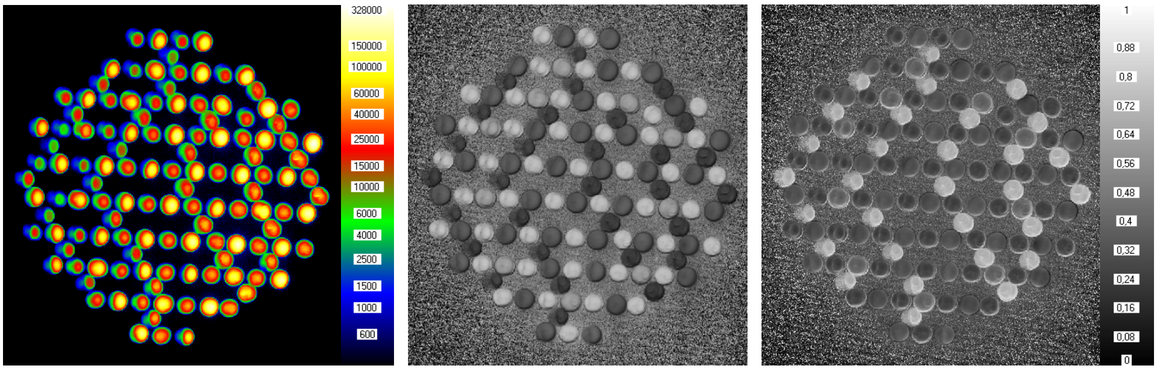

Fig. 9: luminance, x and y

For assessing the homogeneity of the luminance and the colour, it is useful to establish mean values over suitable areas. For the following evaluation, circular areas have been used for averaging. The position of the areas (regions) is indicated in the images. The mean values of the luminance L and the colour coordinates x,y related to the respective areas are shown both in the form of a table and as a graphic.

To determine suitable sizes of the areas for averaging, two measuring areas of different sizes have been used (diameter of 100 pixels and diameter of 150 pixels, respectively).

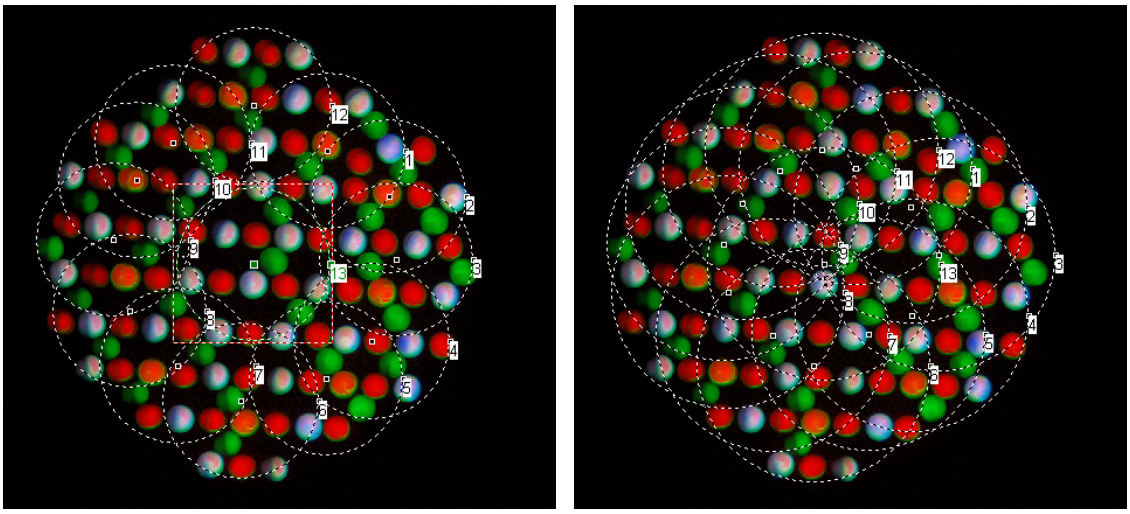

Fig. 10: Colour image, 3 times log., 2 circles with a diameter of 100 and 150 pixels, resp.

Table 1: Determination of the mean values for L, x, y for a diameter of 100 pixels

Region	1	2	3	…	11	12	13
L/cd/m²	16970	19410	17390	…	7282	10350	13630
x	0.415	0.412	0.416	…	0.440	0.445	0.412
y	0.405	0.419	0.435	…	0.416	0.398	0.395

Table 2: Determination of the mean values for L, x, y for a diameter of 150 pixels

Region	1	2	3	…	11	12	13
L/cd/m²	13830	16660	18480	…	10180	11530	13050
x	0.422	0.420	0.408	…	0.426	0.435	0.409
y	0.411	0.415	0.426	…	0.412	0.401	0.405

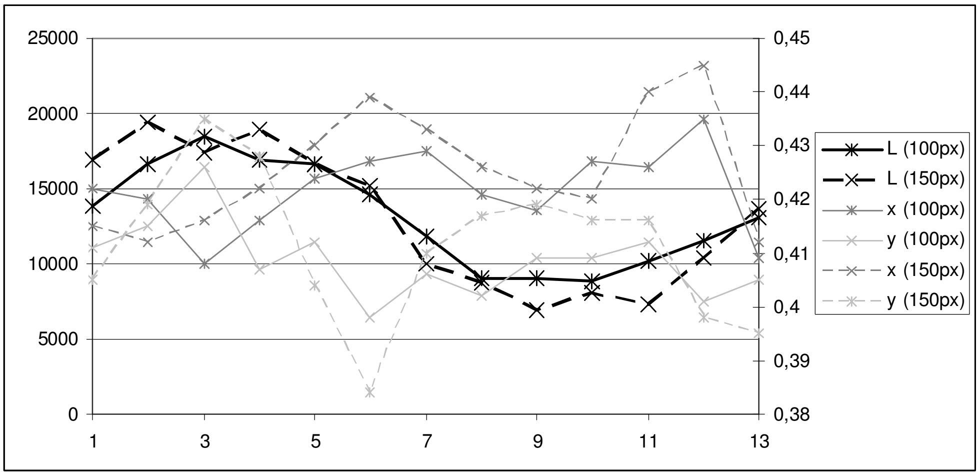

Fig. 11: Mean values of regions 1 to 13 for a diameter of 100 and of 150 pixels

3.4 Measurements made on modules with high-power LED

Also in these cases, when the LED modules are captured by the colour camera, the chips themselves and the light scattered by the covering become visible.

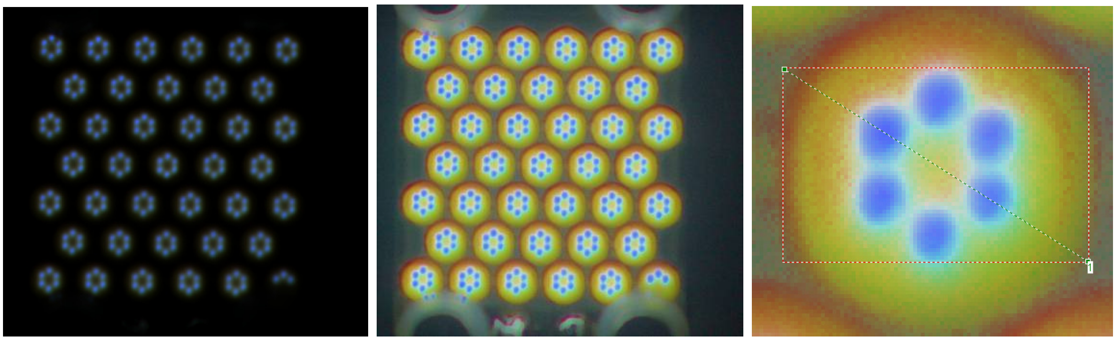

Fig. 12: Colour image, linear, 4 times logarithmic and one LED zoomed

The components can be extracted from the colour images. In what follows, L, x, y as well as the colour scale along the intersection (cf. LED zoomed) are shown as examples:

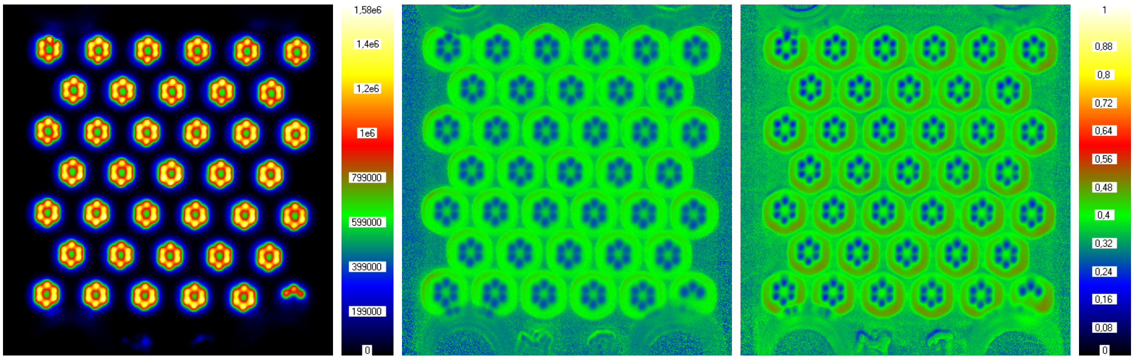

Fig. 13: Luminance, x and y

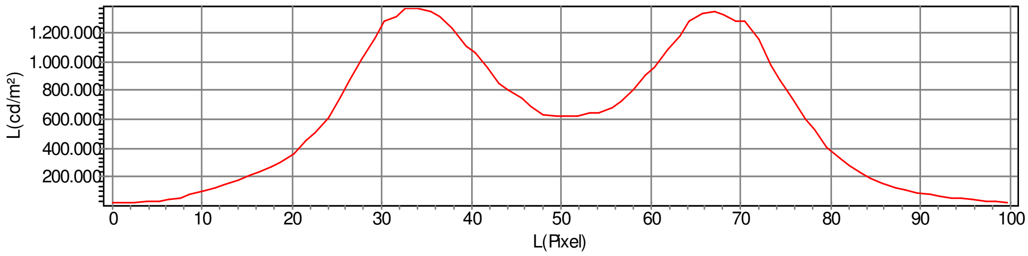

Fig. 14: Course of the intersection through the colour distributions in Fig. 12

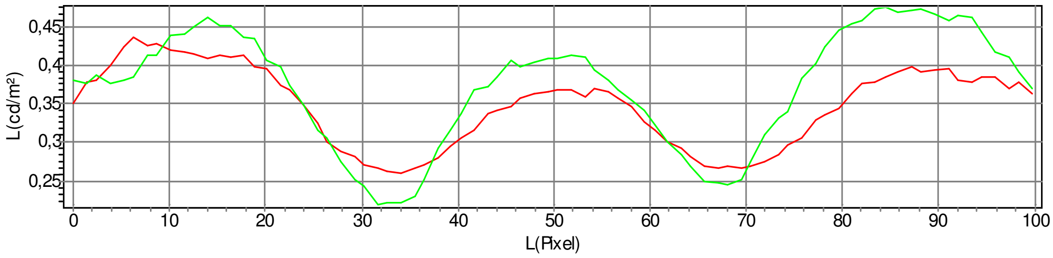

Fig. 15: x, y along intersection through the colour distributions in Fig. 12

3.5 SymbolChecker

Not only does the measuring equipment have to meet high requirements, but also the image processing software, which must be adapted to the very special conditions of the automobile supply industry. In many cases, production takes place in Eastern Europe, and the production facilities mostly run in 3 shifts. Particularly as far as more complex devices are concerned (such as car radios, air conditioning operating systems, navigation systems), a large number of equipment versions are on the market, which are all subject to modifications during the product life cycle. Thus, the software must be able to manage this variety and to allow operators to make any changes or extensions on the spot. Specifically for this purpose, the software package “SymbolChecker” has been developed by the TechnoTeam BV company.

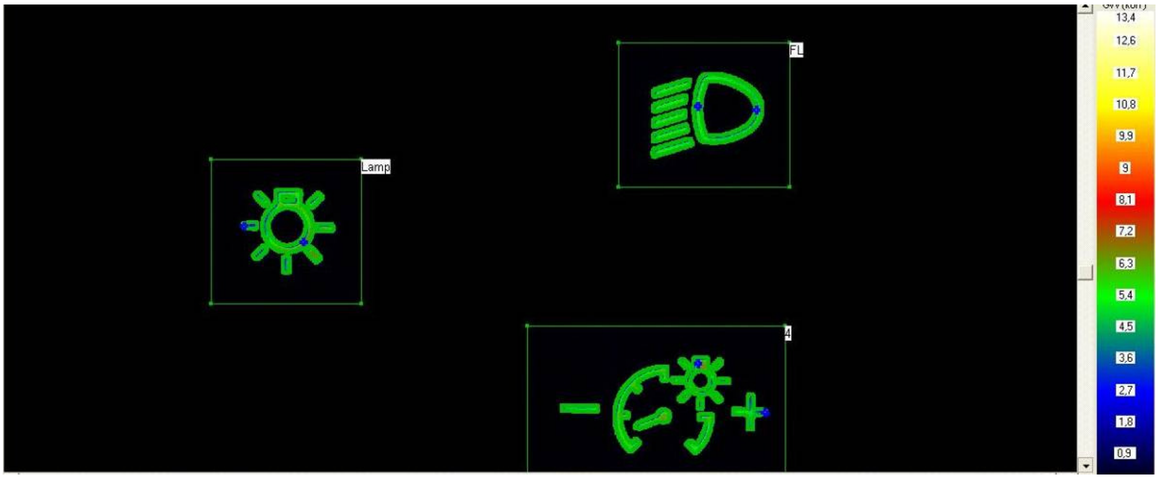

Fig. 16: Detected symbols in the symbol checker software

The image processing system can be incorporated into the manufacturing process via a multitude of interfaces (Dll, Digital-IO, TCP/IP, RS232, Profibus-DP). The integrated diagnostic functions (automatic storage of faulty images, measurement during off-line operation, processing of image series) allow the operator to react quickly to any kind of manufacturing problems. Depending on the required resolution, cameras of 1.5 megapixels up to 16 megapixels can be employed. Even in the case of high resolutions, only few pixels are available for symbols because of the typical bar widths of a few tenths of a millimetre. In order to guarantee a precise luminance measurement under these conditions, some special algorithms have been developed. The software is able to check not only the light (mean luminance, homogeneity) and the colour (CIE-colour coordinates, dominant wavelength), but also the quality of the symbols by carrying out pattern matching. For checking not back-lit symbols, there is the option to integrate an LED circular light into the camera.

Typical cases of application are the testing of switches (steering wheel switches, headlight levelling controller,) and control elements (rotary light control switch, roof control element), dial-type instruments, displays and printed circuit boards with LEDs (flexboards for rear-light, daytime running light). The application of diffusing screens (cf. Fig. 1) allows luminances and colours to be determined just as derived parameters like luminous flux and partial luminous flux, in a very simple way, and also some geometrical parameters like “squint”.