DMD Based Automotive Lighting Unit

Alexander Wolf, Gerolf Kloppenburg, Roman Danov, Roland Lachmayer
Institute of Product Development, Leibniz University of Hannover
mailto:wolf@ipeg.uni-hannover.de

In this paper we present a DMD based automotive lighting unit. In order to generate a suitable light distribution a strongly distorting optical system is developed, offering a Hot Spot of $193\,lx$ and a horizontal opening angle of $\pm 39°$

1 Introduction

Today's upper class vehicles are often equipped with matrix beam front lighting systems to generate adaptive light distributions. A next step in this development is the use of DMD modules as beam shaping technology. This increases not only the number of individually controlled pixels, but also reduces the system's complexity by far.

The advantage of DMD-based light modules is that they do not require mechanical actuators and thus have no macroscopically moving parts. The light is directed by many micro-mirrors onto the desired areas on the road. The luminous intensity of an automotive light distribution shows high gradients. This required the generation of many dimmed pixels, which are realized by absorbing a large amount of the light so that the system efficiency is lowered significantly. Thus a high luminous flux of the light source is necessary to achieve an automotive light distribution.

2 System concept

In order to overcome this problem Kauschke suggests an inhomogenious illumination of the DMD with an increased intensity in the middle [1], [2]. Since the operating temperature of a DMD module is limited the maximum light intensity on the DMD is restricted.

In contrast to this idea our system is based on a redistribution of the luminous flux after the DMD. The imaging lens system which projects the DMD into the traffic space shows a strong pincushion distortion (Fig. 1).

Using an optical system without distortion each pixel of the DMD would appear with the same size on a wall normal to the optical axis. With an ideal system and assuming that the micromirrors are homogeniously illuminated each pixel on the wall would show the same illuminance.

Using a system with a pincushion distortion the pixel in the middle become smaller with increased illuminance compared to an optical system without distortion. At the same time the pixel at the edges of the projected image are enlarged so that their illuminance is reduced.

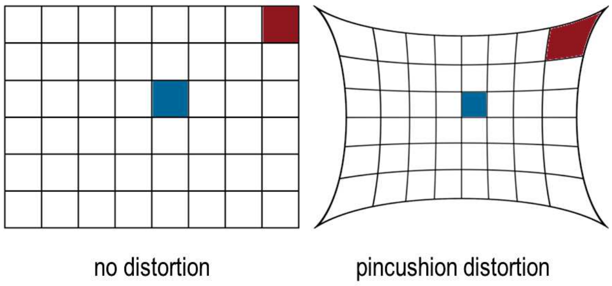

Fig. 1 *Pincushion distortion.*

3 Measurement results

Our headlamp prototype is based on a commercial video projector. In combination with the distorting optical system a luminous flux of $1960\,lm$ is generated. The hot spot of the light pattern shows an illuminance of $193\,lx$ in a distance of $25\,m$ which is equal to a luminous intensity of approximately $120.000\,cd$ (Fig. 2). The opening angle of the generated light pattern is $\pm 39°$ in horizontal and $\pm 6°$ in vertical direction.

The sharpness of the prototype system is limited. Therefore it is neccesary to swich a subset of pixels instead of individual micromirrors in order die generate significant contrasts.

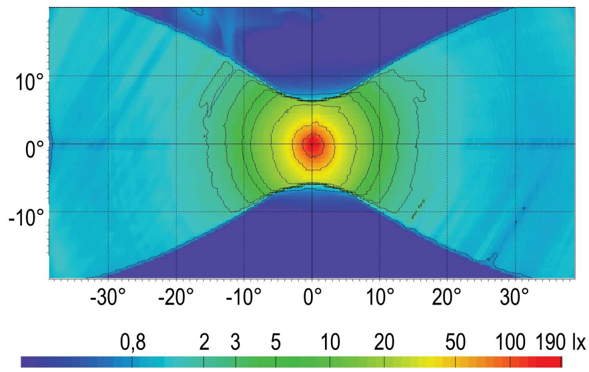

Fig. 2 *Light distribution of the system.*

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4 Functions of high-resolution headlamps

A high-resolution headlamp allows the implementing of various functions [3]. With todays matrix beam systems a glare free highbeam can be realised. But the increased number of individual pixels allows in addition the projection of navigation information or stop lines onto the road (Fig. 3). In combination with a camera self glare from traffic signs can be detected and reduced by decreasing the illuminance on the sign [4].

Fig. 3 *Exemplary functions of high-resolution headlamps (renderings). Top picture: Projection of stop line, bottom picture: Projection of navigation information.*

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