VIRTUAL NIGHT DRIVE

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ABSTRACT

If one has in mind that more than 45% of all deadly accidents occur at night time or dawn, although just 25% percent of the averaged traffic occurs at night, optimal lighting devices are very important to increase traffic safety. In this paper a new night time driving simulator will be described, which allows to simulate night time scenery with the computer using virtual reality technologies. As the main point, the real light distribution is used to illuminate the scene and it is possible to perform an interactive virtual night drive even with low cost hardware. This technology is essential for the development of optimal lighting devices.

INTRODUCTION

Driving in different light and weather conditions leads principally to different perception, too. The importance of improved headlight systems becomes obvious when looking at the characteristics of accidents at night in Germany. This was examined in detail by Langwieder and Bäumler [1]. Figure 1 shows the degree and share of accidents occuring at night, resulting in slight, serious or fatal injuries. The figures show that accidents with serious consequences typically occur during darkness. Although there are less pedestrians on the road at night than during daytime, the accident statistics show that the largest number of incidents without involving vehicle occupants is still to be found among them: 60% of all accidents fatal to pedestrians happen at night [1].

This is an alarming figure, especially when considering the fact that most of fatal accidents occurring outside built-up areas happen in the dark, while the amount of traffic at night is only about 25% of the total traffic. Therefore we can conclude that perception respectively the performance of the headlamp system plays an important role in the origin of accidents [2].

HEADLAMP SYSTEMS

Static Systems

Vehicle headlamps are primarily designed to illuminate the traffic space in the direction of movement. They have to make sure that the area is sufficiently illuminated using the different light functions without dazzling oncoming traffic. In addition to this, headlamps should make the vehicle easily visible.

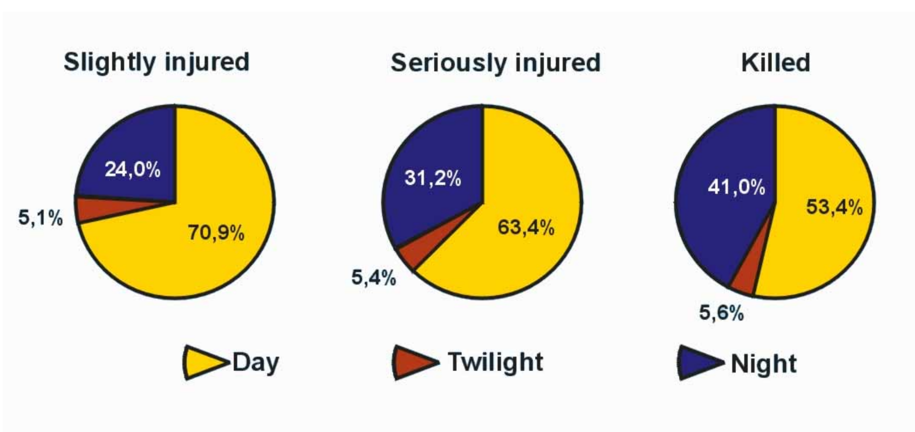

Figure 1: Degree and share of personal injuries according to night and day time and twilight situations [1].

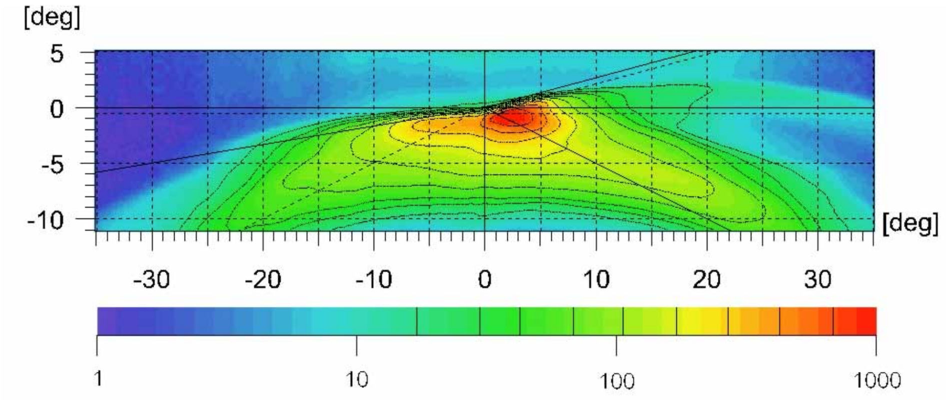

Figure 2: **False color representation in a logarithmic scale of a typical dipped beam light distribution.**

The headlamps approved in Europe today allow the driver to choose between dipped beam, main beam and fog light, depending on the individual situation. In Germany, main beams are only used in about 5 % of traffic situations, whereas dipped beams, are used around 95 % of the time. So, it is the most commonly-used light function on the road [2]. The dipped beam has a distinct light distribution (shown in Figure 2) with a well defined cut off line and a high gradient perpendicular to this cut off line. A variation of a few tenth of degrees along this gradient can cause a change of a factor 1000 in intensity.

Dynamic Systems

Many research activities are going on in the field of lighting improvement in order to achieve an optimum light distribution according to driving and surrounding conditions. Brightness conditions, weather, road conditions, traffic situation, type of road, vehicle speed and acceleration behaviour must all be taken into account by new AFS (Advanced Frontlighting System) systems [3].

One example for an AFS-function is the bending light function. Such a bending light, based on a swivelling function, is well known since 1967 when it was applied to the main beam function of the Citroen DS. So far a change of the light distribution has been restricted to main beams. In the near future ECE regulations will allow the dynamic variation of the dipped beam pattern too. Nowadays the requirements for the control algorithms are much more complex than in 1967. Besides the current steering wheel angle, the behaviour of the dynamic system can depend on the actual speed of the car, its actual gear rate, its actual position (detected by GPS- or vision-systems) and many other sensor signals. It will be possible to change the illumination of the traffic environment by swivelling a function, or by adding an additional static light, or even by changing the specific characteristic of the dipped beam.

The integration of all these new functions into practice will lead to much more complex development processes. One important point for the engineer will be to figure out how the dynamic light distributions of the AFS-System influence the drivers perception and visual comfort. Validation of this technologies and the design of optimal control parameters is only possible with the help of powerful simulation techniques and with efficient virtual reality tools.

NIGHT TIME DRIVING SIMULATOR

Technical Realisation

The use of Virtual Reality technology respectively driving simulators has been well established in the automotive industry. Most of these systems are designed for dynamic daytime simulations and they are just useable on high performance computers. The usual illumination effects are based on very simple lightsources (e.g. conical light distributions), and even though the appearance is quite nice, this has nothing to do with reality. The problem is, that a night time driving simulator has to handle complex light distribution which are moving through the environment; this is not supported by OpenGL graphic adapters and the corresponding software. The simulation of the realistic illumination can be done by ray-tracing software [4], but the generation of just one picture could take up to hours (depending on the complexity). This may be fast enough for the design of static headlamp systems, but for the development of dynamic systems it is to slow.

The night time driving simulator presented in this paper fulfils all requirements for an efficient design tool for dynamic headlamp systems:

- operating system Windows 2000
- 25 frames per second (3000 € PC with OpenGL graphic adapter)
- no pre-calculations necessary
- interactive (acceleration, steering wheel)
- input data: detailed measured or simulated light distributions

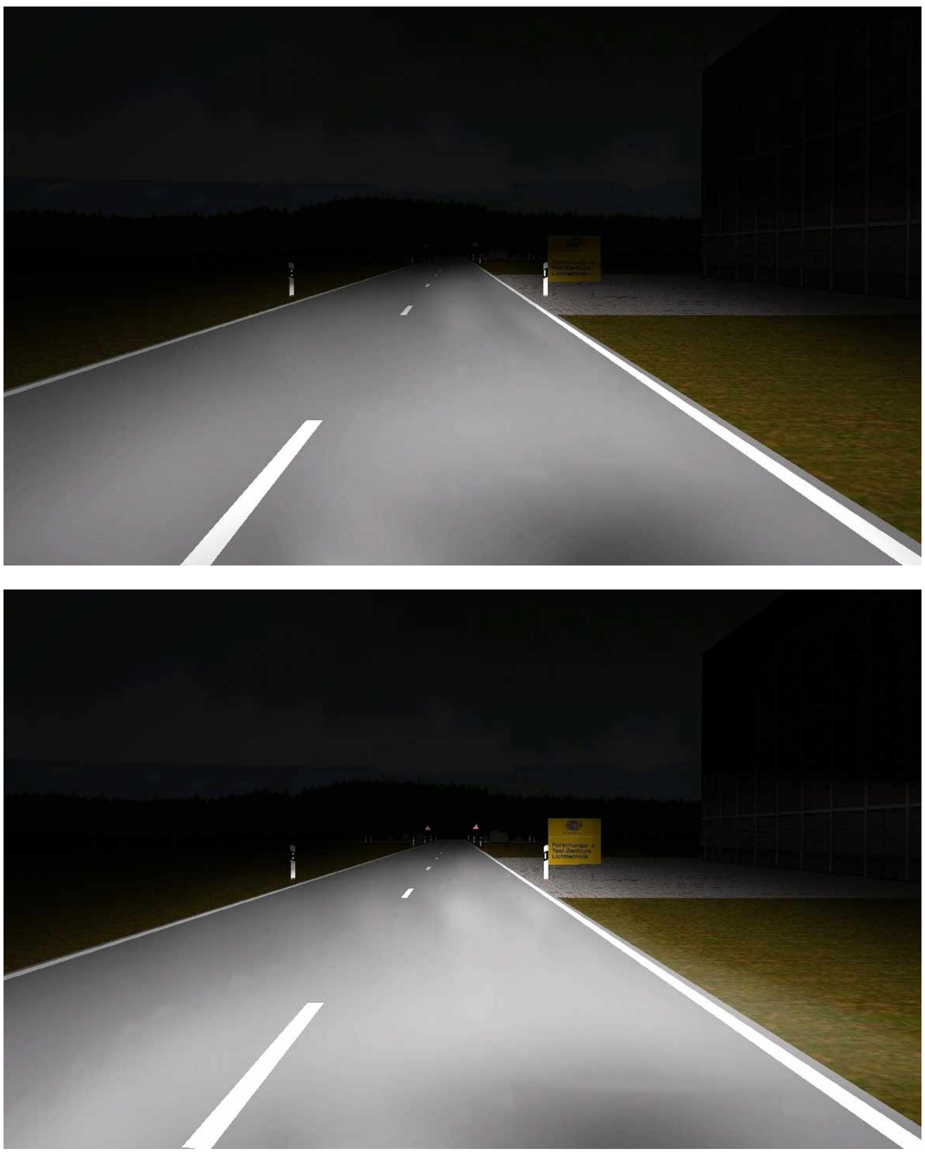

Figure 3: Realistic illuminated sceneries generated with the night time driving simulator. Top just with the dipped beam function, bottom with a combination of dipped and main beam function.

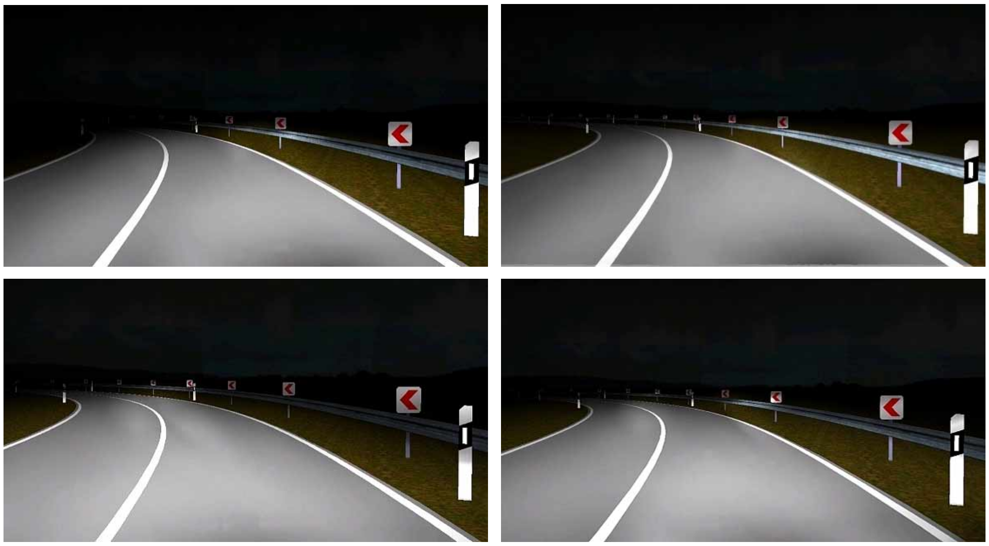

Figure 4: Curved Road with four different headlamp light distributions. Top left: static dipped beam, top right: dipped beam with a static bending light function, bottom: swivelled dipped beams, left both headlamps with the same swivelling angle, right with different angles

- dynamic change of the orientation of the light distribution (swivelling)
- instant change of the control parameters for the AFS-functions is possible
- dynamic change between different light distributions as shown in Figure 3
- luminance at the screen or wall was validated with a luminance camera

With this tool it is possible to perform a night drive simulation with headlamps that just exist on the computer or to optimize the AFS control-parameters for a headlamp system without doing a real night drive for each variation.
Due to the low-cost hardware platform each engineer can use the night time driving simulation software at his department.
The characteristics of standard monitors were measured by a luminance camera, so that the luminance values, which are the important values for perception, are realistic. The same validation was done at the simulator with a projector as visualization system. Due to the limitation of the available projection systems, the direct visualisation of glare light from oncoming traffic (more than 10000 cd/m^2) is not possible.

Examples

The effect of the variation of some AFS-control parameters is shown in Figure 4. The top left image shows the light distribution without any swivelling. The effect of a static bending light with an additional fog lamp is displayed in the top right image. The bottom left image shows both headlamps swivelled with the same angle, in the bottom right image, the swivelling angles of both headlamps are different.
The swivelling angle is calculated by an algorithm which depends on the steering angle, a speed dependent component and different parameters like the focus point on the street.
A further application is the comparison of different light distributions by toggling between them during driving. To support a realistic impression the simulator contains a measuring wall for the correct positioning of different headlamps.
The influence of dynamic vehicle movement like yaw and inclination on the light distribution can be visualised too.

CONCLUSIONS

Night time driving sessions are essential to test new headlight systems and modify it in several iterations until it suits all specifications. In order to reduce both development costs and time and simultaneously improve the quality of the headlamp strategies, the night time simulator can be used by the optical engineer for headlamp studies in an early project stage. It is possible to study several concepts and find very efficiently the optimal solution.

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