Realistic Simulation of Human Contrast Perception after Headlight Glares in Driving Simulations

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Abstract

The aim of this work is to enable the simulation of the experience of short-time glare effects in a driving simulator by adjusting the display contrast according to human perception.

The simulation is displayed on a standard LDR-monitor under office conditions and the prevailing illumination is incorporated. As contrast perception is highly subjective, a psychophysical experiment was performed under realistic night driving conditions, including background illumination as well as a representative driving situation to permit realistic driving behavior.

Keywords: Human Contrast Perception, Tone Mapping, Glare, Driving Simulation

1 Introduction & Related Work

Tone mapping from a given HDR-dataset to a standard LDR-monitor has been a research topic over the last two decades [Ledda et al. 2005]. Yet, the simulation and visualization of human eye re-adaptation after being dazzled is a rather novel subject.

A few approaches have been presented during the last years, dealing with similar problems. Based on subjective test results of different experiments, both Ledda [Ledda et al. 2004] and Pattanaik [Pattanaik et al. 2000] visualize the adaptation process for humans under changing illumination levels by adjusting the displayed perceivable contrast. As they only consider the perception of fully adapted subjects, their test results are not applicable for the simulation of short-time glares.

Ritschel [Ritschel et al. 2009] and Yoshida [Yoshida et al. 2008] deal with the visualization of glares and focus on visualizing the perception of the light source itself. The simulation of the contrast perception after short-time glares has not yet been addressed in realistic rendering.

2 User Study

We perform a novel user study with 18 participants under realistic environmental conditions for the measurement of subjective contrast perception. This includes both the integration of the natural avoidance behavior of the driver as well as the reconstruction of authentic lighting conditions.

While driving in a night drive simulator, the subjects are dazzled for short time periods. The glare stimulus is generated by an automobile headlight and is parametrized by its duration (2.5, 5 and 10 seconds) and intensity (by simulating a distance of an oncoming vehicle of 10, 25 and 50 meters). The background illumination is kept constant at 0.1 lux, corresponding to a starlit night with a half moon and falls under mesopic vision.

After the glare, the contrast perception of the subject is measured. For this purpose, the driving simulation freezes and a square of approximately one degree angle of sight (roughly corresponding to critical obstacles, as animals) is projected on the (black) traffic lane of the subject. Whenever the subject is able to distinguish the square from the black background, he has the task to lower its brightness. Since the optical system of the subject recovers from the glare, the contrast perception increases until the adaptation state is reached. Hereby the projected square becomes recognizable for the subject again, whereupon he re-darkens it. The gained test data yield generalized contrast perception curves over time, for varying glare durations and intensities.

3 Conclusion

We present an explorative approach to simulate the individual re-adaptation of the human visual system after short-time glares. This simulation is based on subjective test results, collected by a psychophysical experiment with 18 subjects under authentic night driving conditions.

Using the obtained contrast perception curves, we are now able to adjust the display contrast on a LDR-monitor to match the human contrast perception over time. The minimal perceivable brightness in reality is tone-mapped to the one on the monitor, depending on the prevailing office lighting conditions. Integrated into the visualization of a night driving simulator, this allows the analysis of critical traffic situations including glare effects under defined laboratory conditions without the need to reconstruct authentic background illumination conditions.

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