HDR SIMULATION OF INTELLIGENT LED ROAD STUDS

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Abstract – A simulation of intelligent road studs using a High Dynamic Range (HDR) display technology, recently developed at LEPSIS, IFSTTAR, is presented. A combination between HDR rendering algorithm and HDR display device technology was adopted for this specific simulation. This HDR simulation of LED road studs, already been used in psycho-visual evaluations and behavioural studies of road users, will allow studying a number of new road developments through driving simulators.

Key words: HDR, LED road stud, driving simulation.

1. Introduction

Driving simulation is a powerful and cost-effective tool allowing the implementation of complex driving tasks as well as testing new road designs. Good immersion of drivers in virtual environments, known as an important factor for having a plausible driving behaviour in a simulated situation, relies mainly on the realism of the visual scene of the driving simulation.

In order to improve the visual features of its driving simulators, IFSTTAR has developed a new graphics rendering engine, integrating various effects such as tone mapping [Petit 2010], static and dynamic shading, weather effects, realistic vegetation, etc. Recently, high dynamic range (HDR) rendering has been integrated to this software development so as to respond to the demands of the FP7 project INROADS which focuses on the development of an intelligent LED road stud system (see http://www.fehrl.org/index.php?m=320).
Intelligent LED road studs are devices which are anchored within the road surface for lane marking and delineation for night-time visibility. They are self-sustained thanks to integrated renewable energy (e.g., solar photovoltaic, piezoelectric, etc.) and activated/deactivated following the vehicle position.

The key issues of this software development are to reproduce the *working mechanism* of those road studs and to provide a *realistic night driving condition* where a high visual fidelity of those LEDs in terms of colour, contrast in interaction with other light sources (road lightning, car headlights, etc.) is required. The two following sections detail our technical choice and design to address those issues.

2. HDR imaging technology for realistic simulated night driving conditions

The night condition in a driving context contains a high luminance range since bright and dark areas are present at the same time in the scene. The bright ones come from public lightings and vehicles in traffic whereas the dark ones are originated from the night. The fidelity in presenting this high luminance range is essential for psycho-visual evaluations and behavioural studies in simulated visual environments, in particular those including the intelligent LED road studs in the context of the INROADS project. This luminance range issue is the origin of our choice of HDR imaging technology for this software development, since HDR images can represent a high range of luminance levels found in real-world scenes.

The main challenge was the guarantee of a high performance of the real-time simulation and the realism of those LED road studs, which is always a compromise. Results issued from different studies at the IFSTTAR LEPSIS Lab in terms of HDR rendering algorithm was previously used to simulate accurately different lighting sources from public lighting and vehicles in traffic [Petit 2013]. Besides, HDR display devices, providing a wider luminance range than LCD screens [Seetzen 2004] was also used in the INROADS project's driving simulation experiment [Shahar 2014].

Figure 1. LED road studs' simulation

3. Simulation of the LED road stud system's working mechanism

Three main elements were taken into account for a LED simulation:

- The *automaton* which controls a LED stud section (colours, display frequency, activation or deactivation). An example of the automaton is provided Figure 1: three stud sections (1, 2 and 3) are turned on/off automatically following the position of the vehicle (the blue arrow).
- The *photometric characteristics* of LED road studs.
- The *interaction between LEDs and other dynamic lighting sources* in the scene such as the driver's vehicle headlights, and headlight of oncoming vehicle.

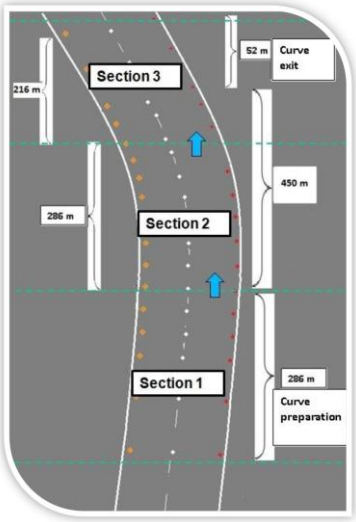

Figure 2. Automaton of the LED stud sections

4. Applications in behavioural studies and perspectives

This HDR simulation was used in an investigation of the Active Lane Delineation application as potential applications of intelligent LED road studs [Shahar 2014]. The focus of this study is on the visibility, the readability and in general terms the benefits of such LED-based systems in night-time driving conditions compared to those with or without road lighting.

One key feature of this virtual reality simulation was a large number of LED light sources which could be simultaneously simulated, while keeping a high frame rate (around 60 fps). We hope the HDR simulation of LED road studs allows us to increase the number of new road developments which will be likely tested on driving simulators.

5. Acknowledgements

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