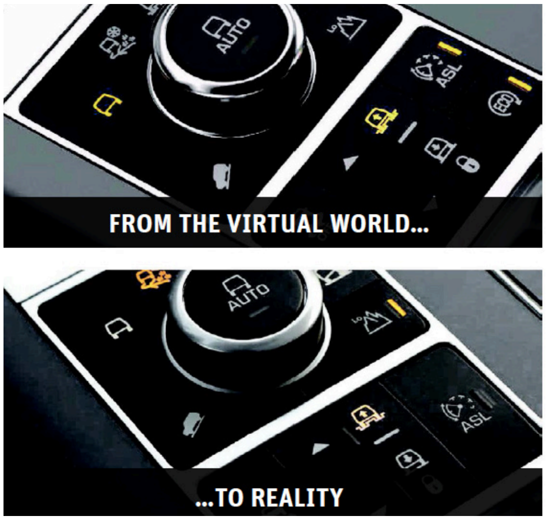
WHITE PAPER

Is Physics-Based Virtual Prototyping the Future of Automotive Interior Lighting Validation?

What is physics-based virtual prototyping and why is it such a topic of interest for automotive interior design? The design process of a vehicle interior is complicated and subjected to many parameters. A significant amount of the potential issues, as annoying reflections due to lighting systems inside the vehicle, is only identified during the physical prototyping phase, which means, too late in the process. Physics-based simulation enables to design more efficiently around virtual prototypes, to optimize and validate a vehicle interior early in the development process. However, are these virtual prototypes lifelike enough to make reliable decisions – and even to replace a real prototype? This white paper will show, through a series of comparisons, how a virtual prototype is similar to an actual prototype, enabling to create a virtual, yet entirely reliable, automotive interior lighting validation process.

Introduction

The dream of any team involved in automotive interior is to anticipate and solve design and process-related issues as early as possible in the design process. Vehicle design, and more specifically interior design, is critical regarding quality assurance. Predicting, even before building the first physical prototype, potentially dangerous phenomena such as veiling glare, reflections of the sun on glossy or metallic materials in the windshield, or even annoying reflections due to lighting systems inside the vehicle (ambient lighting, roof lamps, buttons, screens...), would let car manufacturers anticipate and optimize the design very early in their design process. A virtual evaluation of these risks is possible only by modeling the virtual prototype of the car with physical parameters and by defining measurable target criteria (metrics), which sometimes come from subjective items.



Courtesy of Jaguar Land Rover.

Challenge: Visualizing Illumination within Complete Interior Vehicle at an Early Stage

The design process of a vehicle interior is complicated because subject to many parameters. The proportions, shape, placement, surfaces, for the interior, are developed, emphasizing ergonomics and the comfort of the passengers. From the integration of new technologies, such as driving assistance and autonomous driving, to the validation of ergonomics for the future driver and passengers, each step of the interior is analyzed and validated. An important and challenging part to detect all the optical reflections in the passenger compartment, the design procedure goes from sketches, to digital model and then physical clay models, used to create full-sized mock-ups of the final interior and evaluate the design.

Nevertheless, a significant amount of the problems is only identified during the physical prototyping phase, which means, too late in the process. This dramatically impacts the validation cycle:

- It generates feedback loops between teams that can be very heavy.
- It increases the duration of the project, delaying the time-to-market.
- It increases the cost of the project.

Car manufacturers and their subcontractors are aware of this problem; they are also continually seeking to optimize their tools. One of the most efficient methods to optimize interteam feedback loops and to reduce times to market and their cost is virtual prototyping. The ability to visualize a product and integrate it into a realistic virtual environment makes it possible to make reliable decisions in the upstream phases, drastically reducing the number of problems during the validation phase. It also makes it easier to compare several configurations and variations of a future product to pick the best design. Several virtual prototyping solutions exist, many of them are powerful enough to provide and good quality rendering, but without taking a physical approach of the design into account. However, integrating the computation of optical phenomena (and the interaction between light and materials and how we perceive it) is essential when it comes to validating the look and lighting of the vehicle interior. We are now going to see how to physics-based virtual prototyping help create and qualify interior design through a series of comparative studies.

/ Solution: Physics-Based Virtual Prototyping for Vehicle Interior

THE UTILITY OF PHYSICS-BASED VIRTUAL PROTOTYPING

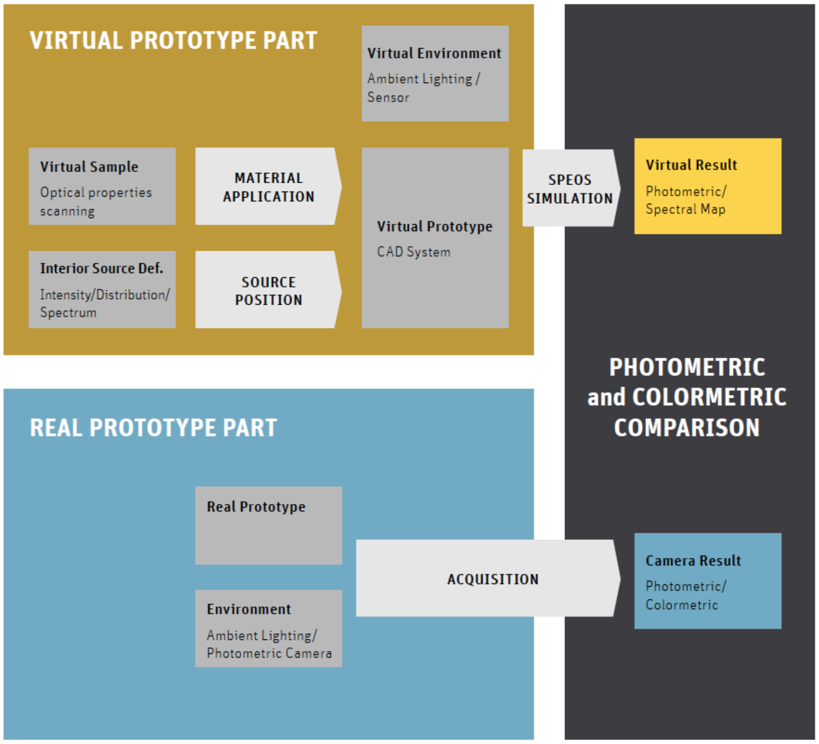
Vehicle lighting innovations that are changing the driving experience need to be accurately tested, validated and optimized before being introduced to the market. To meet this need, a physics-based solution for integrated virtual prototyping and testing has been developed. Functional virtual prototypes of different lit and lighting systems, such as driver information and multimedia systems, can be easily tested in a driving simulator through a rapid prototyping approach. The virtual prototyping technology does not require hardware to physically make a prototype and consequently involves less cost. This technique thus works towards the CAE (computer-aided engineering) goals of maximizing quality and efficiency and minimizing time and cost.

RESULTS FROM PHYSICS-BASED VIRTUAL PROTOTYPING VALIDATION

We are now going to show, through several comparative examples, that virtual prototyping based on physics makes it possible to detect errors in the same way as realizing measurements on a real prototype – but of course much earlier in the process. We will compare realistic simulation results with reality, regarding luminance and colorimetry. Reality corresponds to photometric measurements performed on a car, with a color camera (LMK photometric camera from Technoteam), providing luminance maps. Realistic simulations are performed using the CAD data of this same vehicle, virtually, using SPEOS Visual Ergonomics features, on which physical materials, measured on samples with the material scanner of Ansys OPTIS, the OMS², are applied.

We will compare:

- Light source reflections in the windows.
- Illumination and color rendering of the instrument panel.



/ Setting Up the Virtual Prototype

VIRTUAL SAMPLES AND MATERIAL APPLICATION

We have measured all materials of the interior of the car with the OMS^2. These measurements provide physical data for light distribution which we apply to the CAD geometries of the vehicle.

INTERIOR LIGHT SOURCE DEFINITION AND POSITION

We define light sources' distribution, intensity, and spectrum from specifications and place them at the right location into the virtual car.

VIRTUAL ENVIRONMENT

We define an ambient lighting, corresponding to the environment where the car is in reality. We place a virtual camera sensor where the LMK camera is, to provide the same point of view.

SIMULATION

Once we have done the data preparation, we can launch the simulation and see the results!

/ Setting Up the Real Prototype

REAL PROTOTYPE

The car, placed in a room, is covered up with black fabric to prevent any annoying light from entering.

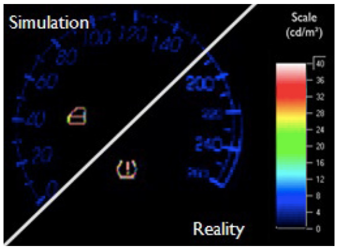
ENVIRONMENT

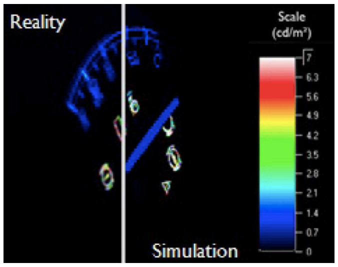
A directional light source (white tungsten lamp) is positioned on the left of the car to enlighten the dashboard via the driver's window. The photometric camera is placed to take a picture close to the driver's point of view.

/ Comparing the Real and Virtual Prototype

We will examine the cluster's needle and the cluster's icons of the vehicle's dashboard, from two different angles:

- From the driver's point of view, looking at the cluster directly. This will let us check the readability and legibility of the information.
- Still from the driver's point of view, but this time looking at the cluster's reflection on the driver's window. This way, we will check if the reflection in the window is annoying in driving situations.





PHOTOMETRIC COMPARISON FROM A DRIVER POINT OF VIEW

We first compare the simulation to the reality acquired by the camera, at the same scale representation (40cd/ m^2), from the driver's point of view. The luminance difference on icon is > 2% The luminance is equivalent in the simulation and reality. The information is bright enough in both cases to ensure an optimal readability without being annoying.

PHOTOMETRIC COMPARISON IN REFLECTION

In the reflection this time, we will compare the simulation to reality the same scale representation (7cd/m^2). The luminance difference on icon >1.5% The luminance is equivalent in the simulation and reality. The reflection is not too critical in either case and is not annoying in a driving situation.

COLOR RENDERING

Finally, we now compare the color aspect of the cluster's needle, in the simulation and reality. The results are expressed in xyY and the result of the comparison in ΔExy.

The colorimetric data of the simulation is similar to the colorimetric data of the real world. The color is bright and homogeneous enough for an optimal aspect, in both cases.

/ Impact: If the Virtual World is Equivalent to Reality, Why Bother with Physical Prototypes?

With this automotive interior validation process, the results we obtained show that the virtual world is very close to reality:

- The luminance of the internal light source, such as that of the cluster, and their reflections that we measured is equivalent in reality and the simulations. The rendering images, with the surfaces measured with the OMS², provide results equal to the measurement performed with the LMK camera regarding luminance
- The colorimetric data of the rendering images of the simulation is similar to the colorimetric data of the real world obtained w ith the LMK camera.

NEEDLE'S COLOR:

Simulation	Reality
x: 0.667	x: 0.685
y: 0.332	y: 0.308

ΔExy= 0.123

Develop this easy and fast validation at the virtual prototyping stage, and many errors associated with light and its reflection on the various parts of the car interior can be avoided. Physics-based simulation thus enables automotive OEMs and their Tier-1 suppliers to create vehicle interior together and more efficiently. By merely collaborating around accurate and functional virtual prototypes, they can try various design options, optimize and validate them, and communicate decisions early in the development process. Virtual prototypes accelerate the development and deployment times, reduce the risk of over-design and under-design, and enable to start engagements earlier, simplify delivery and support, improve satisfaction, and accelerate time to revenue.

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