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Colour Management in Virtual Reality applied to Lighting Simulations

NAME and INSTITUTION
Halina Cwierz, Francisco Diaz-Barrancas, Pedro J. Pardo , Angel L. Pérez, M. Isabel Suero
University of Extremadura (Spain)

POSTER TITLE
Colour Management in Virtual Reality applied to Lighting Simulations

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ABSTRACT
In this work, we studied the chromatic characterization of Head Mounted Displays (HMD) applied to Virtual Reality (VR) with the purpose of simulate ambient light changes. We used two of the latest commercial version of HMD through Unity, a game development platform.

It has been verified that no type of colour management is performed by default. We have made the chromatic characterization of both HMDs by measuring the spectral radiance of the HMD through its lens.

We have defined and programmed a colour management system applied just to light sources.

Results show that it is possible to apply colour management techniques to this type of display and it is also possible to simulate ambient lighting changes with a relative low error rate in real-time computing.

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INTRODUCTION

The measurement of the quality of light in both indoor and outdoor environments is a relevant topic that has gained attention due to its multiple applications. In addition to the concept of colour rendering, there are other important concepts related to the quality of a light source, such as the colour discrimination capability, colour rendering capacity, visual clarity, contrast perception, colour preference, or harmony.

Figure 1: Comparative images of real and virtual objects from a previous work. JOSA A 35 (4), B130-B135

However, the effects of using an specific light source is difficult to simulate in terms of colour reproduction. There are few computer applications that allow spectral treatment of light sources and even less in real time.

Recently, Virtual Reality (VR) has experienced a great development. In a **previous work**, the authors have stated that the **colour** is the **most significant** factor **influencing** the **quality** of the **virtual reality experience** in terms of generation of the virtual image in relation to the original one.

Therefore, it is time to wonder whether it is possible to make a simulation of different ambient lighting without a physical rendering, applying only colour management techniques.

EXPERIMENTAL

We defined a uniform colour cube whose colour can be changed freely using RGB coordinates. We made the chromatic characterization of the HMD by changing the cube's colour and measuring the spectral radiance of the HMD through its lens. After the chromatic characterization of both HMD, we have defined their ICC colour profile files. In the same 3D scene, we displayed an image with an embedded ICC profile which allowed us to easily check if the colour management had been performed by the system.

By means of a 3D model of a colour checker calibration chart (figure 2), scanned using a 3D scanner, we studied the effect of employing different real light sources (TL84, D50 simulator, A simulator) over the rendered scenes in Unity.

Starting from the SPD, we have calculated the CIE 1931 XYZ tristimulus values of the light sources and the theoretical XYZ tristimulus values of each of 24 colour patches composing the colour checker. After this, we obtained the RGB, 24 bits per sample, digital values applying the ICC Colour Profile of each VR device.

On the other hand, we captured the experimental RGB digital values of the colour checker using several virtual light sources inside Unity. Then, we calculated the XYZ tristimulus values applying the ICC Colour Profile in reverse way.

Figure 2: Virtual Light booth with colour checker calibration chart.

RESULTS

Table 1 collects the colour differences between real and expected RGB and XYZ colour values, as obtained after the chromatic characterization of two virtual reality glasses and after capturing the digital images generated by Unity for each light source.

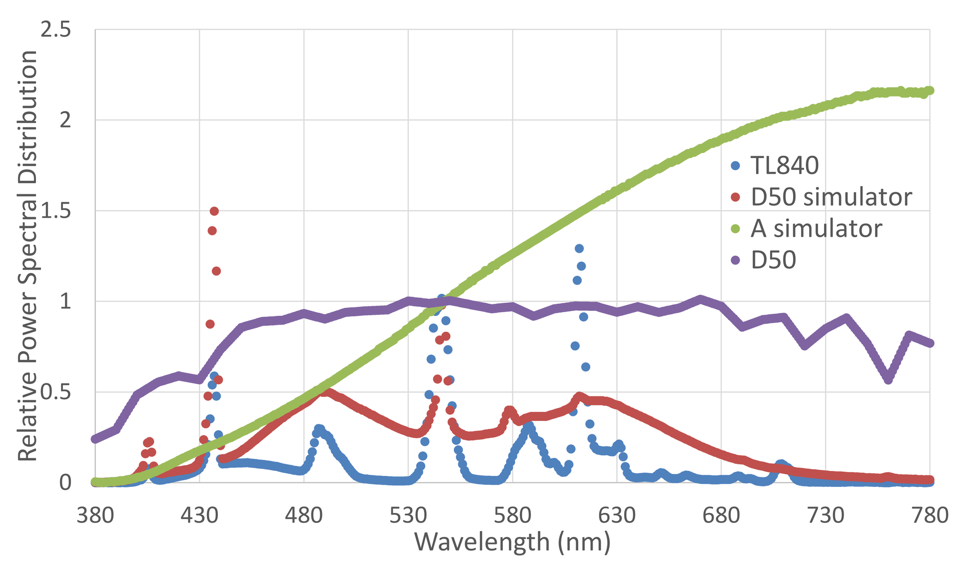

Figure 3: Spectral power distribution of light sources.

Table 1: Average difference between theoretical and measured 24 bits RGB & CIE1931 XYZ values of 24 colour checker colours calculated for four light sources.

Light Source	$\overline{\Delta RGB}$			$\overline{\Delta XYZ}$			$\overline{\Delta E_{00}}$
	R	G	B	X	Y	Z	
TL84	2.7	2.4	1.8	0.6	0.5	0.3	2.4
D50 Simulator	1.1	1.0	0.6	0.3	0.1	0.4	0.9
A Simulator	1.6	1.5	4.0	0.4	0.1	0.4	3.5
D50 Illuminant	0.6	0.4	0.3	0.3	0.2	0.2	0.5

CONCLUSION

Virtual Reality devices need a very high image refresh frequency and a very high screen resolution for a good immersive experience. These requirements make it difficult to apply spectral calculations to digital images. In this study, we made the chromatic characterization of this device and defined a colour transform library and an ICC colour profile. In this way, we have shown that it is possible to apply colour management transformations to colour images in VR devices and to simulate ambient lighting changes with a relative low error rate. A further step will be to apply spectral technics in lighting simulations in VR.