# The Arbitrary Road from Reality to Virtual Reality

Monica Billger*, Beata Stahre* and Ilona Heldal**

*Design & Media, School of Architecture, Chalmers Univ. of Technology, Sweden
** Dep of Technology and Society, Chalmers Univ. of Technology, Sweden

## Introduction

Virtual Reality has great potential to become a usable design tool for the planning of light and colour in buildings. The problem of lighting scenes is the central conceptual and practical problem of computer graphics, due to the complex interaction between light and objects, [1, p.73-74]. In most computer graphics today, the goal is to make visualizations that look good and enough natural [1, 2]. At present, light and colour cannot be simulated in a realistic and reliable way in Virtual Reality (VR), as was shown experimentally [3,4]. In real rooms, differently painted surfaces affect each other by reflections, causing colour variations on equally painted surfaces that are not reproduced in virtual rooms. Existing software for light calculation, such as Lightscape™ and 3dsmax 6.0, use radiosity to calculate how much light that strikes back from a surface. A colour bleeding scale is used to define how much the colour of the surface should change the colour of the "bouncing" light. The scale is arbitrary, since there are no recommendations built upon knowledge on how coloured surfaces reflect upon each other.

Our research project deals with the problems of lighting scenes and to gain knowledge on how to make light and colour phenomena more realistic, not just to "look good". The goal is to develop VR as a design tool. Such a tool can enable us to create reliable virtual rooms to pedagogically display various colour phenomena and to communicate colour appearance during the design process.

In a previous study [Phase I; 3,4], we made comparisons between (1) a real room, (2) a digital model (3D-studio/Lightscape) on a desktop PC, and (3) a VR simulation (Division Mock-Up dVise 6.0) in an Immersive/CAVE based system. Here, we report from phase II, a complimentary study where we added stereographic and monographic VR[1] models on the desktop. A comparison with Lightscape models was also included. We investigated colour and light appearance, and sought to understand how the different virtual environments affect the experience of the room as a whole. The latter is the focus of the present paper. We give a preliminary overview of the experience of the different applications, such as the use of technical devices, possibilities to explore space, ways to move around and the sense of involvement and presence.

[1] In the present paper, we separate the three desktop models from each other, by not referring to the Lightscape model as a VR model. This is in contrast to our previous papers.

## Experimental design

### The real room

The real room studies were carried out in a specially designed 25 m2 experimental room. The result presented here includes studies of two light situations: fluorescent 3000K and incandescent light. The room was designed to get clear examples of how simultaneous contrast and reflections cause different appearances of two yellow hues in two nuances. In total, 47 participants were involved, 63 observations of the two light situations were made, 43 in fluorescent and 20 in incandescent light.

### From paint to digital colours

The process to translate real colours into their digital counterparts is described in [4]. Briefly, real world paints are described in NCS (Natural Colour System) terms and translated into their digital counterpart by the NCS Palette™. In a reiterative process, the digital colours are adjusted in order to represent the real world paints. Since the translation is complex and prone to artefacts, it is important to find an acceptable level of robustness and correctness. Most importantly, the relations between differently coloured surfaces must be as truthful as possible. By contrast, small translocations of the colour scale can be accepted. These translocations are the results from our adaptation to the surrounding light and the light from the computer screen.

### Virtual environments

The model room from the phase I study [3,4] was exported to 3D studio Max 6.0. Monographic and stereographic VR were displayed on a desktop PC with a 21" calibrated CRT. A game pad was used for navigation. Light calculations were made for fluorescent light (3000K) and for incandescent light. We used a plug-in to 3D studio [5] for the export to VR. For the stereographic studies, we used Chrystal Eyes shutter glasses. The incandescent room was used for most of the observations. In total, 27 observers participated, making 45 observations.

For phase II Desktop PC/Lightscape, two models were used; one with incandescent and one with fluorescent light. Directly after the assessment of one of the VR models (mono or stereo), the participants made a comparison between this one and the other VR model and the Lightscape model. 45 observations were made, 10 of the room with incandescent and 35 of the room with fluorescent illumination.

### Evaluation methods

Data were collected from video recorded interviews and questionnaires. The correspondence between the evaluations made in the different virtual environments and the real room, rather than, the participants' evaluation of this particular experimental room is of interest. In the project, several methods for evaluating the room models have been used. In the present study, the methods described below have been used.

- Free description of the room and size estimation.
- Memory matching. In applicable cases, the participant describes differences and similarities between one situation assessed directly after the other.
- Presence questionnaire, modified [6, 7]
- Presence discussion. The participant graded and discussed his/hers sense of presence during the interview.

## Experienced differences between the models

### Size and scale

Most of the participants (19 of 22) estimated the size of the real room to be within 5 m2 of the nominal size of 25 m2. The range was between 14 and 35 m2.

Twenty-eight participants made in total 77 size estimations in the desktop VR (mono and stereo). The estimates ranged from 8 to 56 m2. 62 estimates were between 15 and 25 square meters, and 35 estimates were within 5 m2 from the nominal size.

In phase I, the participants expressed problems in estimating then room size in the Lightscape model. They could not use their own body as a reference and felt distanced to the room. When they were entering the room and trying to get an inside view, they found the narrow field of view unsatisfying. Six of 10 gave an estimation that was within 8-25 m2, and the other 4 could not give size estimation at all. In phase II, 15 of 22 estimated the Lightscape model room to be smaller than the VR models (mono and stereo).

In the real room and in the Lightscape model, all participants recognised that the room was rectangular. In VR (both desktop and cave-based system), the rectangular room was estimated by several participants to be quadratic or slightly elongated. The walls appeared closer, which may have had affected the perception. In Lightscape, the room shape was perceived instantly. The ease and speed of zooming in and out in Lightscape may explain this difference.

The scale was experienced differently. The VR (both mono and stereo) appeared to be in full scale (i.e. 1:1). By contrast, the Lightscape model was perceived as a small model room.

### Interacting with the room models

The observers moved differently in the desktop, the cave-based system and in the real room. In real rooms, one can walk around and take close looks at different locations and still keep a general conception of the room as a whole. Obviously, this is not possible when interacting with the virtual environments.

*Cave-based system and desktop VR*: The model in the cave-based system shares several advantages with the real room. One is surrounded by the room and is physically able to walk around and examine the room. The way of moving is different from the real room and the best illusion is perceived when one is standing still, letting the room move around [3]. Compared to desktop VR, the advantage of the cave-based system is that one gets an embodied experience. A great difference with the desktop VR room, compared to the other model rooms, is that one must lean forward to see the floor.

The level of detail, the light quality and the physical sensations of direct contact with object are absent in the cave-based system [4]. The colour quality is low and the colours appear greyish and weak. The room is more transparent, the screen walls shines through and are always present. In desktop VR stereo/mono, the model room appears more realistic regarding colour, light and the way the room is defined.

*Mono and stereo*: The stereographic model had a jaggedness that reduced the sense of presence. In addition, the shadows (i.e. double silhouettes) in the glasses distorted the 3D experience. Some participants experienced more presence in the monographic room, since they were free to move about without hindering. Some experienced the difference to be minimal, while most found the stereographic model to give the highest sense of presence, due to the 3D effect.

*Lightscape- VR:* There was a clear difference between the sense of presence in the VR and the Lightscape models. In the VR model, the participant is inside the model and experiences a realistic room, although the height of the eyes is undefined, and one does not bounce on the walls, but move through them.

After the VR experience, the Lightscape room is perceived as more artificial and more like a model that is observed from the outside. In the Lightscape model the participants expressed their frustration for the difficulty to take a closer look in the model. When one gets closer, the overview is lost and the object becomes very abstract. It is also much more difficult to relate one's body to the desktop model, which is observed from "the outside". The game pad engaged more of the body than the mouse. The graphic user interface of the Lightscape software was confounded by screen menus and controls, emphasizing that it is a computer model. By contrast, the VR-model filled out the screen, and therefore did not split the attention.

## Final reflections

To sum up, we have overviewed results concerning one part of a larger study. The focus was on experienced differences between three desktop models. Most interesting was the differences between the desktop Virtual Reality models and the Lightscape model. We also found very small differences between the stereographic and the monographic model.

The desktop VR was described with adjectives commonly used for real rooms, while Lightscape was described in terms of a model. The Lightscape model was perceived as more realistic and attractive in itself, compared to desktop VR. However, desktop VR had a more realistic environment to move around in. Hence, it seems important also to consider the purpose for modelling.

The surprising result showing size, and especially scale differences, between the desktop VR models and Lightscape needs to be investigated further.

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