MAXIMUS MAXimum fidelity Interactive Multi User display Systems

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MAXIMUS

MAXimum fidelity Interactive Multi User display Systems

1. Project Overview

The aim of the project MAXIMUS is to address a **full high dynamic range visualization system** starting with **high dynamic range material and light acquisition**, providing a **high dynamic range light simulation and rendering pipeline** and finally **displaying maximum fidelity image quality with color gamut enhanced high dynamic range projection technology** to bring the total dynamic range to over 5.000.000:1.

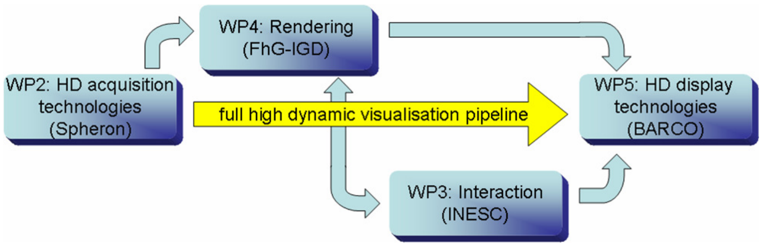

Figure 1: Enabling technologies for the MAXIMUS high dynamic range visualization system.

MAXIMUS will demonstrate these capabilities in the **professional application fields**: **car design**, especially interior car design with an emphasis on lighting effects and **architectural and industrial design** especially in-room light design. To allow professionals and customers to work together and to easily configure lights, materials and objects **new natural multi-user interaction techniques** will be developed within MAXIMUS to round off the developments into an innovative and beneficial application for the above mentioned markets.

Hardware Setup

The illustration below indicates the hardware setup considered appropriate for both user groups:

Figure 2: Setup of the MAXIMUS system.

The solution involves the utilization of two screens, one vertical (which we call the "wall") and one horizontal (which we call the "table"). The latter is primarily used for collaborative design review and the former for 3D presentation, though they can be used simultaneously.

An example usage of the system would be the review of a building. In this case the table would show 2D plans of the building while the wall presents a 3D view of the same environment. The table is touch-sensitive, allowing the user to easily navigate a camera through the building by pointing or dragging to a new location. As he or she does this, the wall updates the 3D view according to the new camera position/orientation. Re-positioning objects and light sources or changing light intensities is also possible by interacting with the table. Additionally, and in response to the architects request for a ‘creative desk’, the table will allow for modifications of plans by providing ‘redlining’ functionality, where the user can sketch over existing, scanned in drawings.

User Interface and Input Devices

The Puck

The horizontal table will utilize a ‘puck’ style of graphical menu which can be ‘thrown’ between users situated around the table. The puck acts as a toolbox from which commands can be found and applied. Crucially, although multiple users can annotate using pens, a single user is in charge of the toolbox.

Users Fingers and Pen

Since the table is touch sensitive the users will be able interact with their fingers. As additional input devices Anoto Pens are used, since the precision of a finger will not be accurate enough to draw annotations.

"Squeezy Ball"

The vertical screen will use an innovative "Squeezy Ball" style interface device which will allow users to interact with items and change their ‘quality’ i.e. objects on / off, intensity of lights. As it is tracked in 3D space, the ball essentially acts as a 3D cursor which ‘glues’ itself to objects when within reasonable proximity.

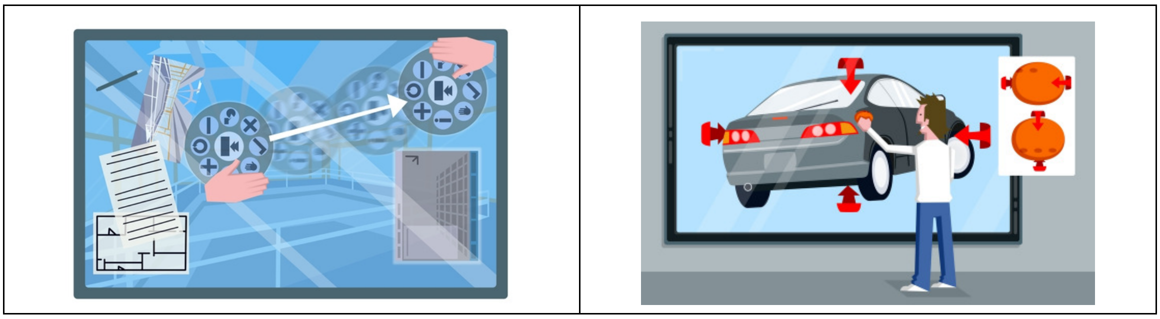

Figure 3: Left: The puck for interaction with the table: Right: Powerwall interaction with the "Squeezy Ball".

2. Current State of Development

The current state of the technological development is summarized as follows:

Multi-user Natural Interaction Techniques

The technologies relevant for the proposed interaction table have been investigated and prototypes for multi-touch and pen based interaction are available. First user tests with the new Squeezy Ball interaction device (see Figure 4) for direct interaction with large scale displays show that it is most effective when used with a point metaphor.

Figure 4: The Squeezy Ball interaction device: left: sensors, center: shell, right: final 1st prototype.

Rendering

The rendering work performed in MAXIMUS is concerned with physically based image synthesis utilizing measured material and light data. The goal is to generate realistic images for design review with a quality close to current off-line rendering systems but at significantly improved speed. To achieve this we developed the concept of Hybrid Rendering to fuse diffuse global illumination results generated using Precomputed Radiance Transfer (PRT) and specular effects generated by Ray Tracing. Support for dynamic objects and local light sources is achieved by further development of the Precomputed Shadow Fields algorithm. Initial CPU-based implementations of all relevant algorithms are available. The concept of Hybrid Rendering using PRT and Ray Tracing has been verified (see Figure 6). The method to produce 16-bit output for the HDR projector has been validated. Figure 5 shows a rendering of the MAXIMUS PRT renderer.

Figure 5: Rendering of Mustang model provided by Italdesign-Giugiaro using our static PRT engine (left) and reference photograph (right). The light probe and reference HDR photograph was provided by Spheron. The rendering is done at 45 fps on a Geforce GTX 260.

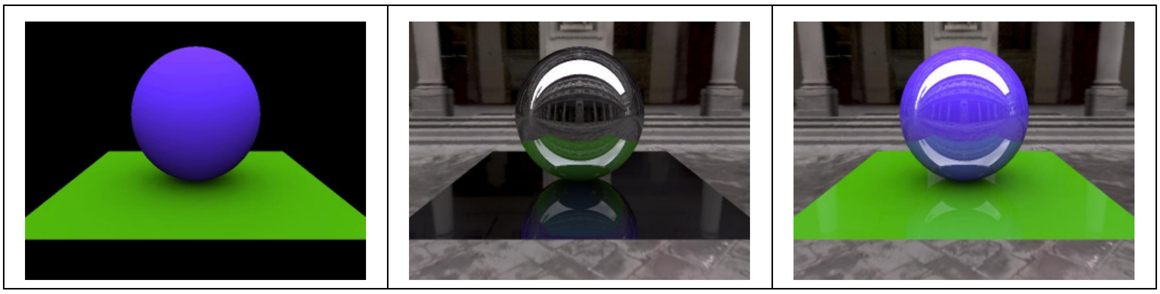

Figure 6: Hybrid PRT / Ray Tracing in the MAXIMUS Renderer. Left: Diffuse component rendered using PRT. Middle: Specular component rendered using our OpenSG-based Ray Tracer. Right Hybrid (composed) image showing PRT and Ray Tracing effects

HDR Acquisition Technologies

The aim in HDR acquisition is to further develop a HDR sensor that is used to measure BRDFs (material properties) and light fields (environment lights / light probes) that are used for physically based image synthesis. A HDR sensor and its dynamic range (DR) capabilities have been re-evaluated in the context of an experimental HDR goniometer and a full spherical HDR camera (in full production) in order to identify all opportunities to improve on the DR-performance of the two devices. First measurements of BRDFs and light fields have been performed and an interchange fileformat for the BRDF data has been defined. Figure 7 shows an example of the diffuse part of a measured BRDF.

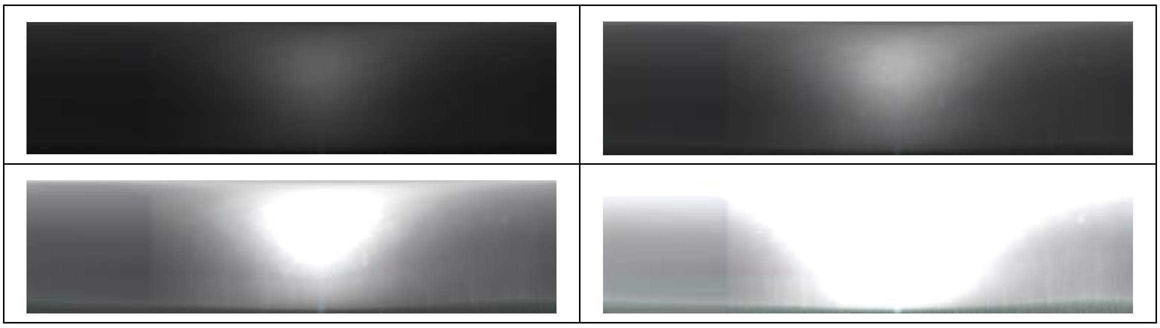

Figure 7: Diffuse part of a BRDF measured using the HDR Goniometer. Direct reflection peaks have been separated into another file.

HDR Display Technologies

The HDR display technologies are concerned with increasing the dynamic range, accuracy and color gamut of existing projectors. The expected increase in dynamic range to 5.000.000:1 using a combination of dimming systems has been validated. To enable communication of HDR image data from the image generator (rendering PC) to the projector, 16 bit gamma encoded input and the 23 bit equivalent processing path have been integrated into a projector. The (relative) accuracy of the proposed external spectrometer based color maintenance system was verified. For white point a maintenance accuracy of better than 0.005 in CIE 1931 x,y can be expected. Furthermore, it has been verified that a 30% color gamut expansion over EBU is achievable on a projector at the expense of max. 15% of the light output.