RealReflect
Real-Time Visualization of Complex Reflectance Properties in Virtual Prototyping

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RealReflect

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www.realreflect.org
Participants

Vienna University of Technology, Austria
University of Bonn, Germany
UTIA Prague, Czech Republic
MPI Saarbrücken, Germany
INRIA Grenoble, France
DaimlerChrysler AG, Germany
Faurecia, France
vr architects, Austria
IC:IDO GmbH, Germany
Motivation

- Virtual Reality puts real-time demands first
  ⇒ Deficiencies in rendering quality
Motivation

- Virtual Reality uses simple Reflectance Properties like
  - Phong Model
  - Textures
  - Simple Bump Mapping
- Simple Global Illumination
  - Radiosity Solution

lit textures on gear box (Daimler Chrysler)
Goal of RealReflect

- Increase Realism in Virtual Reality
  - Accurate Materials
  - Accurate Texturing
    - Texture Mapping
    - Texture Synthesis
  - Accurate Global Light Simulation and Visualization
  - Real-Time, High-Quality Visualization

BTFs on gear box (Daimler Chrysler)
Challenges of RealReflect

- Huge amounts of Data
  - Geometry
  - Material
- High-Quality Demands
  - Quality determined by weakest link in processing pipeline
- Real-Time Demands in VR-Applications
  - Data amounts
  - High Quality Rendering
- Integration Issues
  - Port Desktop Applications into VR-System
RealReflect Pipeline

**Inputs:**
- Geometry – DaimlerChrysler, vr architects
- Material Probes – DaimlerChrysler, Faurecia
- Light Sources – DaimlerChrysler, vr architects
Light Source Acquisition

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MPI Saarbrücken
Texture Mapping

Texture Mapping

Geometry Data

Automatic Material Acquisition

BTF Analysis, Compression + Synthesis

Culling Hierarchy + LOD Generation

BTF Rendering

Real-Time Tone Mapping

Material Probe

Spectral HDR BTF data

Textured Geometry

Scene File

Global Illumination Solution

Temporary Image

Final Image

Light Source

Spectral Light Source Properties

Light Source Estimation

Accurate Global Light Simulation

SLF Rendering

Automatic Light Source Acquisition

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BTF Analysis, Compression + Synthesis

- UTIA Prague
- University of Bonn
Occlusion Culling, LOD Generation

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Vienna University of Technology
Accurate Global Light Simulation

- INRIA Grenoble
- Vienna University of Technology
BTF Rendering

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Vienna University of Technology
Real-Time Tone Mapping

- MPI Saarbrücken
- Vienna University of Technology

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Material Acquisition

- Standard material representations insufficient
- Measurement of material’s reflectance behavior (BTF)
- Automatic procedure due to large number of required measurements
Material Acquisition

- Automatic, High-Quality Acquisition System
  [Sattler et al. 2003]

Setup of Automatic Acquisition System
Material Acquisition

- RGB Measurements of Several Probes

- Frontal View of Proposette Material

- Different View of Proposette Material

- Example View of Knitted Wool
Material Acquisition

- Postprocessing Step
  - Registration
  - Normalization
  - Cutting

- Publicly available!

BTF Database Bonn
http://btf.cs.uni-bonn.de/
Material Acquisition

- Remaining Work
  - High-Dynamic Range (HDR) measurements
  - Spectral measurements
  - Accelerate measurement speed
    - Adaptive measurement procedure
  - Extend BTF database
BTF Texture Synthesis

- Automatic BTF Analysis, Compression and Synthesis
  - Measured material probes have small extend
  - Generation of large BTF textures with given appearance attributes
  - Reduce storage requirements
BTF Texture Synthesis I

- **Markov Random Field approach**
  - Model BTF as high-dimensional stochastic process
    - Minimal storage cost
    - Efficient model
      ⇒ online generation
  - Good results for standard textures
  - Preliminary results for BTFs
    - MRF combined with height map
  
  [Haindl and Havliček 2002 a]
  [Haindl and Havliček 2002 b]
  [Haindl 2002]
  [Grim 2002]
BTF Texture Synthesis II

- BTF Texture synthesis by example

- Knitted Wool
- Proposte
- Corduroy

[Meseth et al. 2003]
BTF Texture Synthesis

Remaining Work

- Improve MRF BTF models
  - Quality
  - Efficiency
- Improve Texture by Example
  - Better distance measure for BTFs
  - New approach for dimensionality reduction
Texture Mapping

- **Automatic Texture Mapping**
  - Achieve suitable mapping of material to trimmed NURBS models or triangular models
    - Orientation constraints
    - Distortion constraints
    - Placement constraints
Texture Mapping

- Texture atlas generation for trimmed NURBS models

Minimizing Angle- and Area Deformation

[Texture Atlas]

Textured Result

[Guthe and Klein, 2003]
Texture Mapping

Parameterization of triangular models

- Single parameter trades off angle and area preservation
- Guaranteed avoidance of face flips

[Degener et al. 2003]

horse model parameterized using different angle/area preservation tradeoff factors
Texture Mapping

Remaining Work

- Parameterization of huge models
  - Run-Time efficiency
  - Out-of-Core solutions?
- Include orientation constraints into our texturing algorithm for triangular meshes
- Development of intuitive user interface
- Plugins for commercial modelling software
LOD and Culling

- Occlusion Culling, LOD Generation
  - Reduction of amount of rendered data
  - Out-of-Core data handling
  - Appearance preservation
  - Handle both trimmed NURBS and triangular models
LOD and Culling

- High-quality, real-time trimmed NURBS rendering
  - Integration of Normal Maps
  - Image Based Lighting
  - About 20 fps

[Balázs et al. 2003]
LOD and Culling

Out-of-Core rendering of huge triangular models
  - High-Quality
  - Real-Time
  - About 100 fps

[Guthe et al. 2003]
LOD and Culling

Remaining Work

- Integration of occlusion culling mechanisms
- Appearance preserving LOD generation
- Run-time optimized simplifier
- Integration into scenegraph API (OpenSG)
Light Source Acquisition

- **Automatic Light Source Acquisition**
  - Required for Accurate Light Simulation
  - Captures Spectral Light Emission

- **Light Source Estimation**
  - Required for Real-Time BTF rendering
Light Source Acquisition

- Unfortunately neglected in the project proposal
- Important work done already
  - Acquisition of real light sources [Goesele et al. 2003]
  - Rendering with acquired light sources
  - Goniometric diagram mapping [Havran et al. 2003]
Accurate Light Simulation

- Simulates global effects
- Important for safety relevant simulations
- Inclusion of accurate material representations (BTFs)
- Spectral data handling
- Generates SLFs for real-time rendering
Accurate Light Simulation

- Current version
  - Achieves high-quality results
  - Includes spectral effects

Purgathofer, Wilkie et al.
Accurate Light Simulation

Remaining Work

- Photon Tracer for triangular and trimmed NURBS based models
- Inclusion of BTFs
- Conversion of results to real-time renderable format
SLF Rendering

- **Surface Light Field (SLF) Rendering**
  - Real-time visualization of light simulation results
  - Large amounts of material data
    - requires out-of-core scheme
  - Few previous research results
BTF Rendering

- Bidirectional Texture Function (BTF) Rendering
  - High-quality preview of scenes
    - Includes all local effects like inter-reflections, self-shadowing, subsurface scattering and self-occlusion
  - Lacks global effects
  - Large amounts of material data

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BTF Rendering

- Local PCA based BTF renderer

Gear box (DaimlerChrysler) with lit textures: the surface structure of the material appears flat

BTF textured gear box (DaimlerChrysler): the surface structure of the material becomes visible

[Müller et al. 2003]
BTF Rendering

Remaining Work

- Handling of large scenes with many materials
- LOD representations
- Integration with LOD and culling
- Integration into Scenegraph API (OpenSG)
Tone Mapping

- Mapping of HDR rendering results to LDR display devices
  - Account for Human Visual System (HVS)
  - Account for display device characteristics
- Real-time requirements
Tone Mapping

- Tone Mapping operator
  - Based on evaluation of existing operators
  - Log compression of luminance values
  - Efficiently implementable in hardware
  - Achieves real-time frame rates

[Drago et al. 2002]
[Drago et al. 2003]
Tone Mapping

- **Real-time Tone Mapping framework**
  - Real-time application of arbitrary global tone mapping operators
  - Evaluation mainly in a fragment program

Original operator vs. speed-up version

[Artusi et al. 2003]
Tone Mapping

- Remaining Work
  - Integration of time dependency of the HVS
  - Integration of defects of HVS
    - Glare effect
    - Visual acuity
  - Integration with real-time renderers
Integration

- Integrate RealReflect Pipeline into VR system IDO:Base (IC:IDO)
  - Enhance existing Scene Editor
  - Integrate OpenSG into IDO:Base
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