Realistic Image Synthesis
research at MPI Informatik

Philipp Slusallek
Karol Myszkowski
Gurprit Singh
Research From Saarbrücken

• Some examples
High Dynamic Range (HDR) Imaging

Typical image and video formats (JPEG, MPEG)
HDR Imaging Pipeline

 Viewing Conditions A
Real Scene
Eye

Abstract 3D Model
CG Rendering

Image Quality Metric

Memory of Appearance

Viewing Conditions B
HDR Display

Inverse Tone Mapping

Viewing Conditions C
LDR Display

Inverse Tone Mapping
Tone Mapping

Naïve non-linear compression

Advanced contrast perception model
MPI HDR Software

**PFSTools**
For High Dynamic Range Images and Video

http://pfstools.sourceforge.net/

**PFStmo**
tone mapping operators

http://www.mpii.mpg.de/resources/tmo/

**PFS calibration**
Photometric Calibration of HDR and LDR Cameras

http://www.mpii.mpg.de/resources/hdr/calibration/pfs.html

**HDR Visual Difference Predictor**

http://www.mpi-sb.mpg.de/resources/hdr/vdp/index.html

GPL License
Overcoming Display Limitations

- Enhancing apparent (perceived) quality rather than improving technical aspects
- Take advantage of the visual system properties

120 Hz
Cornsweet Illusion
Glowing Effect

[Zavagno and Caputo 2001]
Apparent Resolution Enhancement

Increased apparent resolution
Optimization Result

Display

Predicted image on the retina

time

integration
3D Image Retargeting

Input devices
Produce different depth ranges

Output devices
Reproduce different depth ranges

Depth manipulations required
Visible Difference Metric (VDP)

• Can the human eye see the differences between two images?
Dataset of Visible Distortions

Peter Panning

Z-fighting

Shadow acne

Shadowmap downsampling

[Piórkowski et al. 2017]
Dataset of Visible Distortions

Aliasing
[Piórkowski et al. 2017]

Perception patterns
[Čadík et al. 2013]

IBR
[Adhikarla et al. 2017]

Deghosting
[Karađuzović-Hadžiabdić et al. 2017]
Label Creation
Label Creation
Neural Network Architecture
Multi-material Printing

Stratasys J750 (poly-jetting printer)

Vero Opaque materials (not actually opaque!)

Cyan
Magenta
Yellow
black
White
3D Appearance Printing

Goal: Visually Reducing Light Diffusion in the 3D Printed Material
3D Appearance Printing

Without correction (MC simulation)

Target texture

With correction (MC simulation)
3D Appearance Printing

Volumetric MC global illumination simulation

intrinsic material parameters

target appearance

current solution (proxy RGB)

solution refinement

prediction

RGB → CMYKW conversion

3D material distribution

Volumetric MC global illumination simulation
despite the non-linearity of the appearance, it changes monotonically
→ simple residual energy minimization
3D Appearance Printing

520 px (≈5 cm)

550 px

Target  Standard print  Our print
Varifocal Displays

Membrane AR – Dunn et al.
Deformable Beamsplitter

Dynamic focal depth: objects at any depth
Wide field of view
Optics are simple

Membrane AR – Dunn et al.
Deformable Beamsplitter
Multi-focal Plane Display

1.4 D  Back virtual plane

2.0 D  Front virtual plane

LCD1  LCD2  LCD3  LCD4

ET  BS  BS  ET

15cpd, 40 deg, 1200x1200 pixels
Multi-focal Plane Display

Temporal coherency

Captured

Mask
Saccade in Foveated Rendering

Estimated gaze location by the eye tracker

Latency

Actual gaze location

Saccade Landing Position Prediction for Gaze-Contingent Rendering
Saccade in Foveated Rendering

Saccade Landing Position Prediction for Gaze-Contingent Rendering
Eye Tracking: Saccade Landing Prediction

- Anchor point
- Eye tracker’s sample point
- Target
- First Prediction
- Confidence Interval
Eye Tracking: Saccade Landing Prediction
Eye Tracking: Saccade Landing Prediction

Anchor point

Latest Prediction

Eye tracker’s sample point

Target
Eye Tracking: Saccade Landing Prediction

Latest Prediction
Eye tracker’s sample point
Target
Anchor point
Eye Tracking: Saccade Landing Prediction
Eye Tracking: Saccade Landing Prediction
Eye Tracking: Saccade Landing Prediction
Luminance-Contrast-Aware Foveated Rendering

Less Visible

More Visible
Luminance-Contrast-Aware Foveated Rendering

Standard Foveation
(adaptive rate of resolution reduction in periphery)

Content-Aware Foveation
Sampling Patterns

Random

Jitter

Poisson Disk
How error in MC integration is affected by different sampling patterns?

Spatial domain statistics: Pair Correlation Function / Discrepancy

Fourier domain statistics

Define Error in terms of Spatial and Fourier domain statistics
Learn to Render: Path to Neural Networks

Bako et al. [2017]
Our Focus: Learn to Render

• ML/NN algorithms for denoising
• CNNs/GANs (unstructured)
• Learning Light Transport the Reinforced Way
• Learning to Importance Sample