Tutorial

Bidirectional Texture Functions Modelling

Data Measurement & Representation

Michal Haindl Jiří Filip

Institute of Information Theory and Automation
of the AS CR

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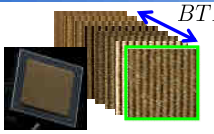
www.utia.cz

Measurement Setups Taxonomy

Sample Measurement



$BTF(\lambda, r_1, r_2, \theta_i, \varphi_i, \theta_v, \varphi_v)$

7 dimensional data ⇨
4 dimensions depend on camera, light & sample positioning

Measurement setup with **4 mechanical degrees of freedom**:

Moving Sample & Camera	sample/camera **3/1** (**1/1** + many lights)
Moving Sample & Light	sample/light **2/2**
Moving Light & Camera	light/camera **2/2**
Moving Light	light **2** + many samples (views)
Moving Sample	sample **1** + many lights & cameras
Static Measurement Setups	many lights & cameras (real/virtual)

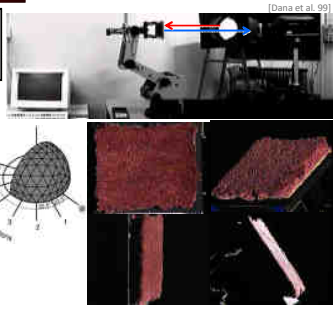
BTF Sample Acqusition

1999

Moving Sample & Camera

CURET-Columbia&Utrecht University
[Dana et al. ACM TOG99]

[Dana et al. 99]



Database: 61 samples
Illu./View directions:
55/max.205 = 215 img.
Max. illu./view elev.:
85°/85°
Rectified images:
400 x 300 pixels
Measurement time:
n/a

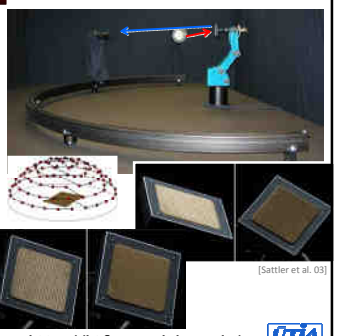
`http://www1.cs.columbia.edu/CAVE/software/curet`

BTF Sample Acqusition

2003

Moving Sample & Camera

Bonn University
[Sattler et al. EGSR 03]



[Sattler et al. 03]

Database:
10 samples (4 HDR)
Illu./View directions:
81/81 = 6 561 img.
Max. illu./view elev.:
75°/75°
Rectified images:
800 x 800 pixels
Measurement time:
~ 14 hours

`http://btf.cs.uni-bonn.de/`

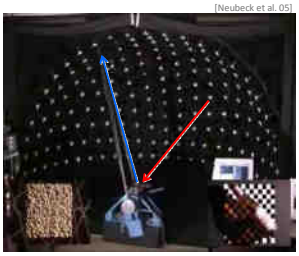
BTF Sample Acqusition

2005

Moving Sample & Camera

KULETH system
[Neubeck et al., TEXTURE 05]

[Neubeck et al. 05]



Database: n/a
Illu./View directions:
169/264 = 44 616 img.
Max. illu./view elev.:
90°/90°
Rectified images:
460 x 460 pixels
Measurement time: n/a

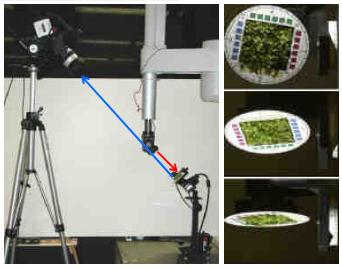
BTF Sample Acqusition

2003

Moving Sample & Light

Yale University [Koudelka et al., TEXTURE 03]

[Koudelka et al. 03]



Database: 17 samples
Illu./View directions:
120/90 = 10 800 img.
Max. illu./view elev.:
80°/75°
Rectified images:
192 x 192 pixels
Measurement time:
~ 10 hours

`http://vision.ucsd.edu/kriegman-grp/research/vst`

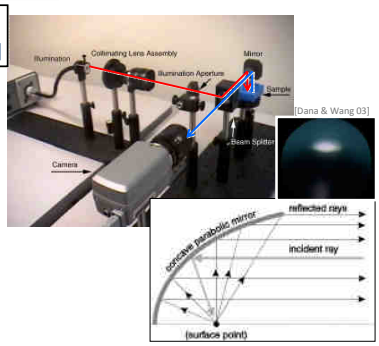
BTF Sample Acqusition

2004

Moving Sample & Light

Rutgers University
[Dana & Wang, JOSA 04]

Database: n/a
Illu./View directions:
continuous
Max. illu./view elev.:
23-37°/23-37°
Rectified images:
~ 200 x 200 pixels
Measurement time:
~1 hour



[Dana & Wang 03]

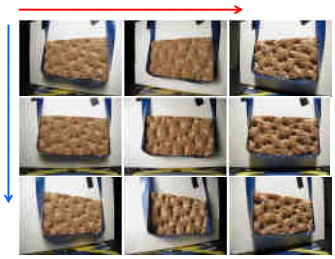
BTF Sample Acqusition

2004

Moving Light & Camera

KTH TIPS, TIPS2
[Hayman et al., ECCV 04]

Database: 11
Illu./View directions:
3/4/9 scales = 108 img.
Max. illu./view elev.:
45°/22.5°
Rectified images:
~ 200 x 200 pixels
Measurement time:
n/a



[Hayman et al. 04]

`http://www.nada.kth.se/cvap/databases/kth-tips/`

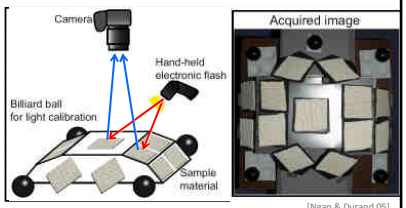
BTF Sample Acqusition

2005

Moving Light

MIT System
[Ngan & Durand, ESGR 05]

Database: n/a
Illu./View directions:
13-100/13 = 1 300 img.
Max. illu./view elev.:
60°/60°
Rectified images:
~ 512 x 512 pixels
Measurement time:
~1 hour



[Ngan & Durand 05]

BTF Sample Acqusition

2009

Moving Sample

Amsterdam Library of Textures (ALOT)
[Burghouts & Geusebroek 09]

Database: 250
Illu./View directions:
6/4/4 rot. = 100 img.
Max. illu./view elev.:
80°/80°
Images resolution:
1536 x 1024 pixels
Measurement time:
n/a

[Burghouts & Geusebroek 09]

`http://staff.science.uva.nl/~mark/ALOT/`

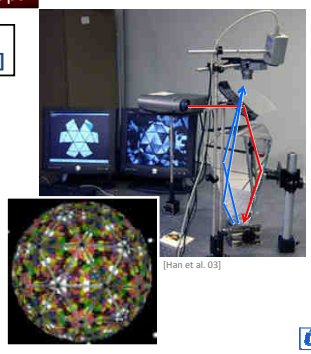
BTF Sample Acqusition

2003

Static Measurement Setups

New York University
[Han et al., ACM TOG 03]

Database: n/a
Illu./View directions:
22-79/22-79 =
484 – 6241 img.
Max. illu./view elev.:
76°/76°
Rectified images:
~ 200 x 200 pixels
Measurement time:
~1 hour



[Han et al. 03]

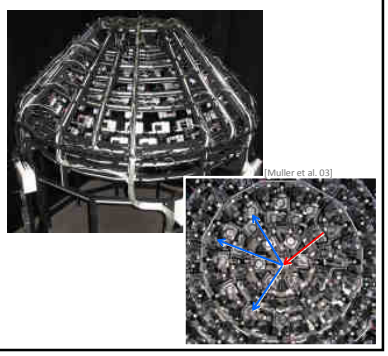
BTF Sample Acqusition

2005

Static Measurement Setups

Bonn University
[Müller et al. 05]

Illu./View directions:
151/151 = 22 801 img.
Max. illu./view elev.:
n/a
Rectified images:
1024 x 1024 pixels
Database: n/a
Measurement time:
~1 hour



[Muller et al. 03]

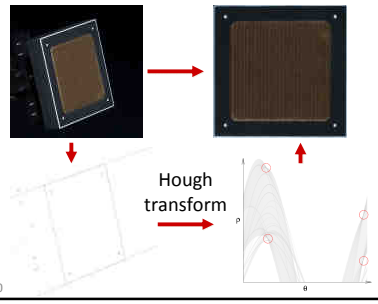
BTF Spectral Measurement

- Most system measure data in 8-bit/colour channel
- Materials appearance depends on light's spectrum ⇨ need for full spectral measurements.
- University Bonn Database (UBO) – 4 HDR architectural samples
- [Lyssi 09] (UBO) – full spectral BTF measurement and calibration on [Sattler et al. 03] setup.
  - Spectral Filter ⇨ 30 wavelength bands (430 – 720 nm)
  - 30 x 81 x 81 images ⇨ enormous measurement times (3 days)
  - sample in OpenEXR = **1 TeraByte**
- [Rump et al. 10] – GT data for multispectral BTF
- [Rump & Klein 10] – spectralization

[Sattler et al. 03]

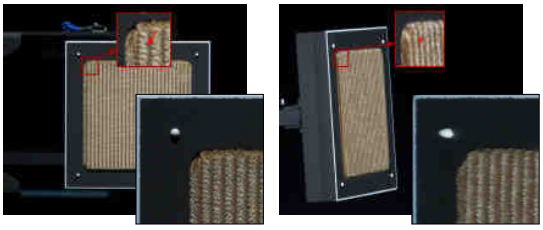
Measured Data Rectification

- Registration and resampling images of different views ⇨ same size images, surface normal aligned with camera axis



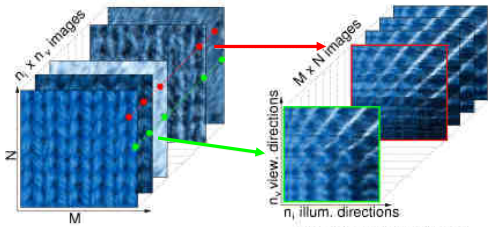
Measured Data Representation

Different views = Pixel-wise misalignment



Courtesy of University of Bonn

Measured Data Representation



Texture representation

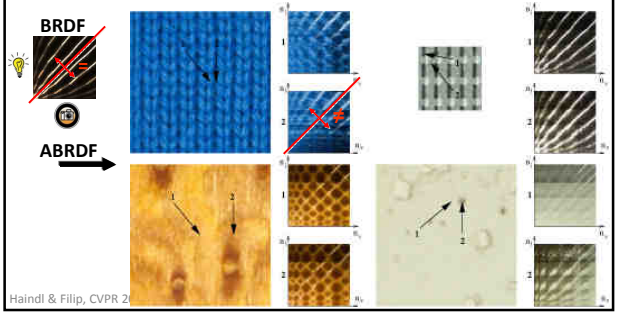
- Only images for the same view are correctly registered
- Shadows/occlusion compensation required prior to processing

ABRDF representation

- Illuminations/views aligned
- Highlights positions fixed
- Easier pixel-wise comparison.

Apparent BRDFs

Apparent BRDF ≠ BRDF (masking, occlusions, shadowing, etc..)
possible violation of: Helmholtz reciprocity & energy conservation



Conclusions on BTF Measurement

- Measurement **setup design depend on** the required **application ⇨ accuracy & time & price & spatial /spectral resolution**.
- **High** rectification **accuracy ⇨ no moving parts** or simple mechanical elements (DOF < 3).
- Data-consistency-critical applications ⇨ non-uniform sampling strategies.
- Images rectification and registration ⇨source of errors.
- Maximum **sample size** ⇨ influences distance of light & camera.
- Maximum **sample height** ⇨ influences selection of measurement technique.

References

Moving Sample & Camera

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- A. Neubeck, A. Zalesny, and L. Gool, *3D Texture Reconstruction from Extensive BTF Data*, Texture 2005, pp. 13-18, Oct. 2005.

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- A. Ngan and F. Durand, *Statistical Acquisition of Texture Appearance*, Proc. Eurographics Symp. Rendering '05, pp. 31-40, Aug. 2006.

Moving Sample

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Static Measurement Setups

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Spectral Measurement

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- Martin Rump and Reinhard Klein, *Spectralization: Reconstructing spectra from sparse data*, In proceedings of EGSR 2010, to appear, June 2010