Image-based Modeling and Rendering

7. Advanced Topics in IBMR : Bidirectional Texture Functions

Course no. ILE5025

National Chiao Tung Univ, Taiwan

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Introduction

- Most of the image-based rendering approaches mentioned in the class requires fixed lighting conditions.
- BRDF (Bidirectional Reflectance Distribution Function) in conventional graphics.
- How to utilize image-based concepts for BRDF?

Ref:

• G. Müller, Bidirectional Texture Functions, SIGGRAPH'05 course notes: Realistic Materials in Computer Graphics.

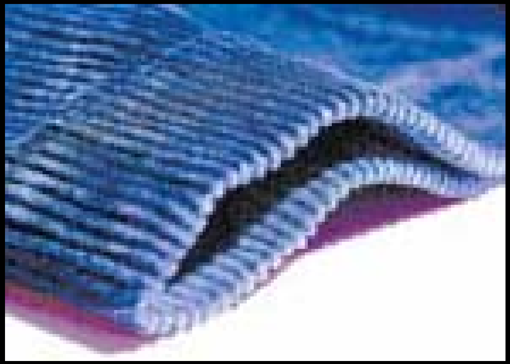
• K.J. Dana, B.V. Ginneken, S.K. Nayar J.J. Koenderink, "Reflectance and Texture of Real-World Surfaces", ACM Trans. Graphics, 18(1):1-34.

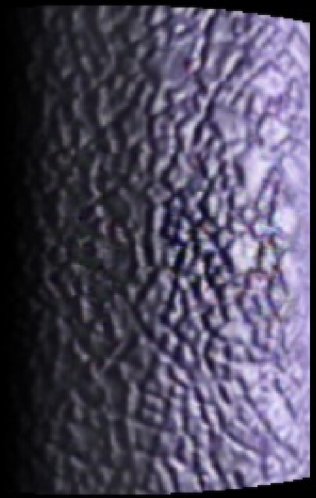
• X. Liu, Y. Yu, H.-Y. Shum, "Synthesizing Bidirectional Texture Functions for Real-world Surfaces", Proc. SIGGRAPH'01, pp. 97-106.

• X. Tong, J. Zhang, L. Liu, X. Wang, B. Guo, H.-Y. Shum, "Synthesis of Bidirectional Texture Functions on Arbitrary Surfaces", Proc. SIGGRAPH'02, pp. 665-672.

Introduction

- How to model and render objects with complex reflectance, detailed geometry, etc ... ?
  - Geometric details
  - Reflectance
    - Material
    - Lighting
    - View directions
    - ......

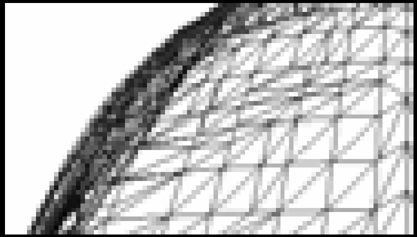


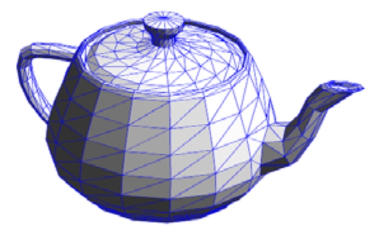


Introduction

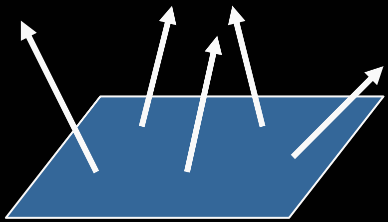
- Classic graphics approaches: Modeling on different scales

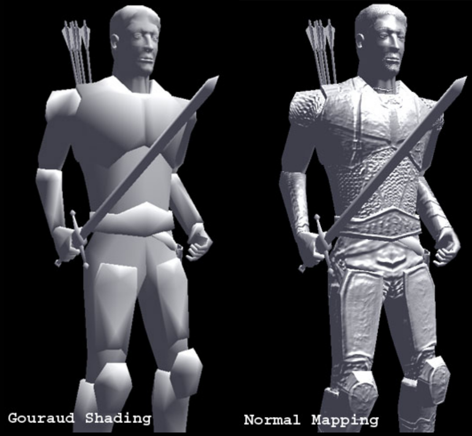
Macroscopic scale
(polygons, parameterized surfaces, etc.)



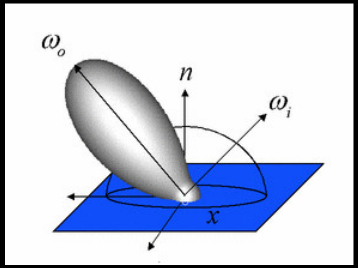


Mesoscopic scale
(normal or bump maps, etc.)





Microscopic scale
(BRDF modeling)



Introduction

- Classic approach: Modeling on different scales
  - Extremely optimized hardware available
  - Artistic freedom to model almost everything
  - Interaction and dynamics possible

- BUT extremely difficult and artistic task to model realistic meso- and micro-structure
  - Unintuitive material parameters
  - Complex interaction between meso- and microscale
  - ...

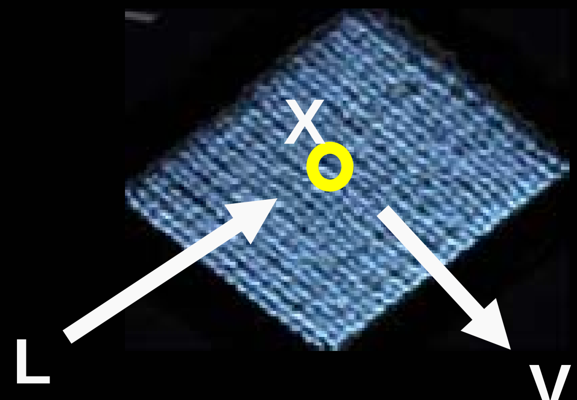
Introduction

- Previously mentioned image-based approaches
  - Lightfields
  - Primitives + view-dependent textures
  - Surface lightfields
  - ....
- How to extend these concepts for bidirectional reflectance problems ?

Bidirectional Texture Functions

- BTFs deal with both meso- and micro-scales.
- Measured 6D-slice of a materials reflectance field parameterized over planar surface S
- 6D: 2D texture + 4D BRDF

$$T(x, y, \theta_i, \phi_i, \theta_r, \phi_r)$$



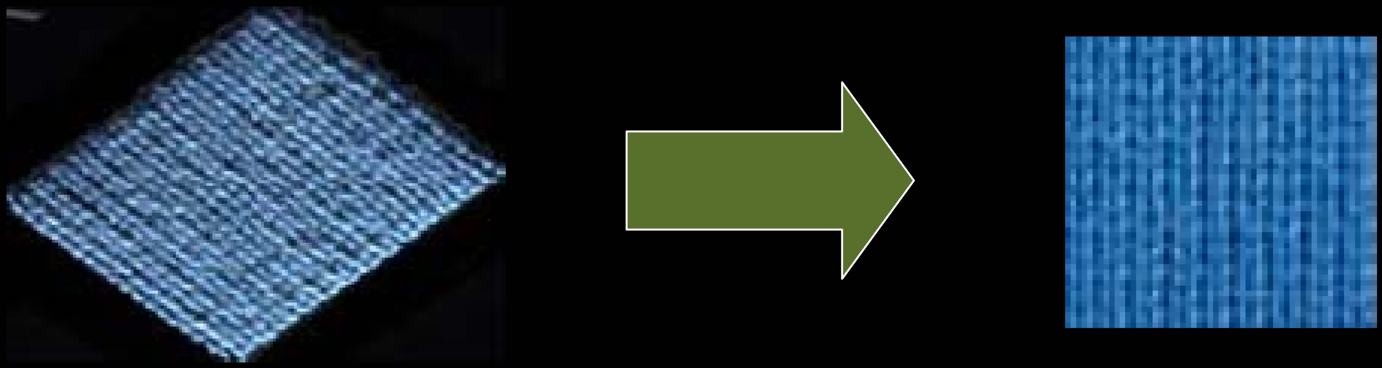
- Integrates:
  - Occlusions (shadowing, masking)
  - Inter-reflections and subsurface
  - scattering from neighboring positions

BTF Acquisition

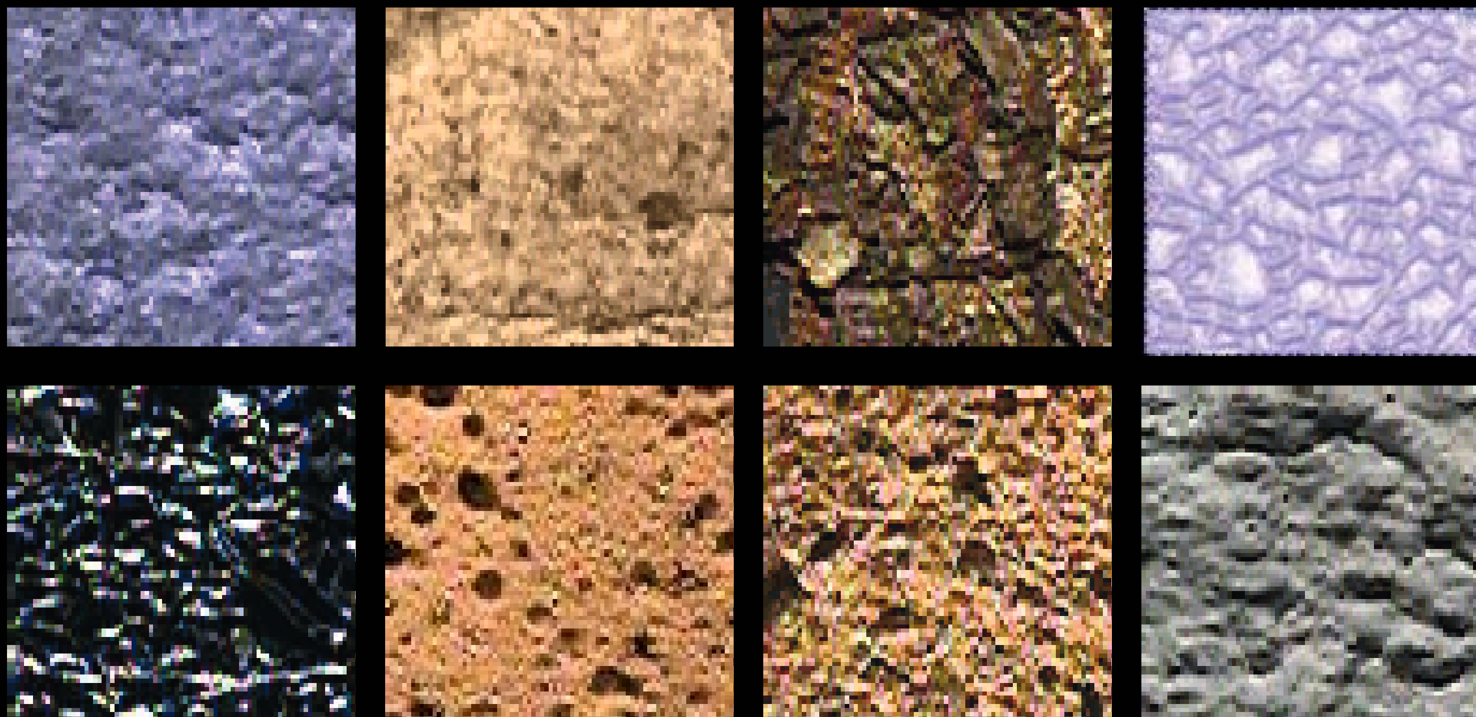
- Sampling a 6D-function
  - Take pictures (spatial dimension)
  - under various view and light directions (angular dimensions)

BTF Acquisition

- Post-processing
  - Texel-to-texel correspondence
  - Compensation for non-directional light source and non-orthographic projection



BTF Data



CUReT database 205 images under 205 different viewing and lighting conditions

BTF Database Bonn www.cg.cs.uni-bonn.de/btf

Applying BTF

- Discrete sample images → continuous BTF
  - Weighted combination (Interpolation) according to view/lighting configuration, e.g.

$$\frac{\exp(-\sigma, dist(C_T, C_{R_i}))}{\sum_{k=1}^{M} \exp(-\sigma, dist(C_T, C_{R_k}))}$$

$$dist(C_1, C_2) = \sqrt{\|V_1 - V_2\|^2 + \lambda \|L_1 - L_2\|^2}$$

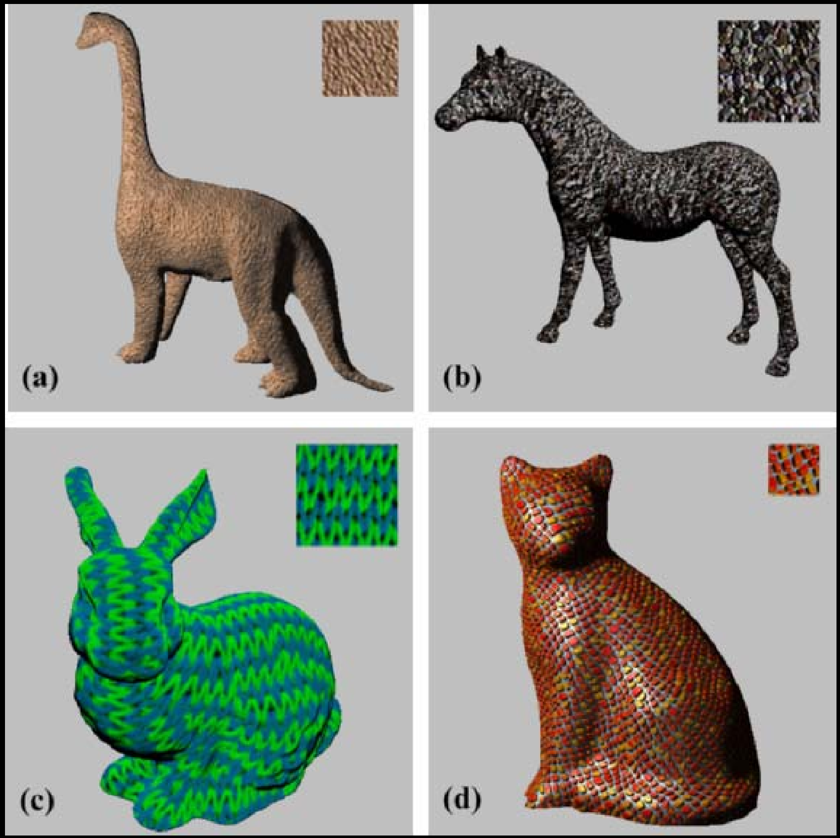
For isotropic material

$$dist_{iso}(C_1, C_2) = \min_r \left\{ dist(C_1, C_2(r)), dist(\hat{C}_1, C_2(r)) \right\}$$

Applying BTF

Applying BTF

- Considering the surface geometry, meso-structure of textures, etc.
- Using texture synthesis techniques.



Compression

- More view/light → larger data
- Preferable properties:
  - fast (real-time), random access decompression
  - preservation of visual important features
  - maximum of a few MBs
- PCA, VQ, CPCA, Tensor, …