

Building Volumetric Appearance Models of Fabric using Micro CT Imaging

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Challenging to model and render



Silk satin



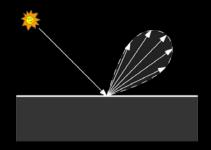


Gabardine wool

Velvet

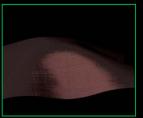


Surface-based



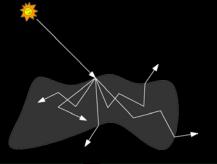


[Ashikhmin et al. 2000]



[Irawan 2008]

Volumetric





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[Xu et al. 2001]

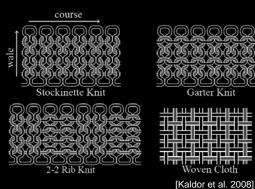
[Jakob et al. 2010]

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Building Volumetric Models

- A procedural process
- Requires significant manual effort

Knit





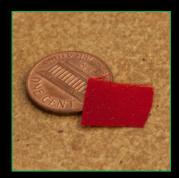
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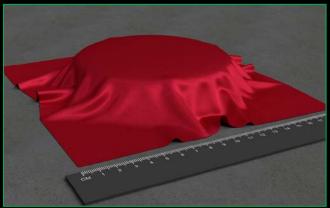


Building high-quality volumetric models automatically



Material sample





Volumetric appearance model

Prior Work

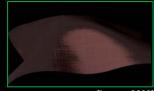
- Appearance modeling
 - [Dana et al. 1999], [Wang et al. 2008], …
 - [Kajiya and Kay 1989], [Jakob et al. 2010], ...
- Cloth reflectance models
 - [Irawan 2008], ...
- Cloth structure
 - [Shinohara et al. 2010], ...



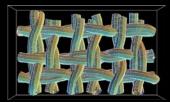


[Wang et al. 2008]

[Jakob et al. 2010]





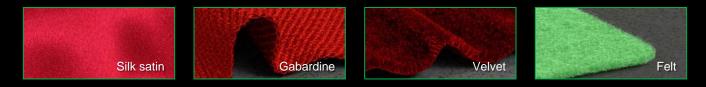




Our Contribution



 A new way of building high-quality volumetric appearance models for fabrics

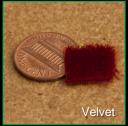


- Model Construction
 - End-to-end pipeline

- Rendering
 - New sampling strategy

X-ray Computed Tomography

Micro CT scanner in UTCT



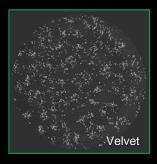


Material sample

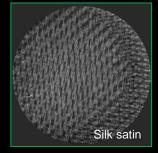




Desktop micro CT scanner



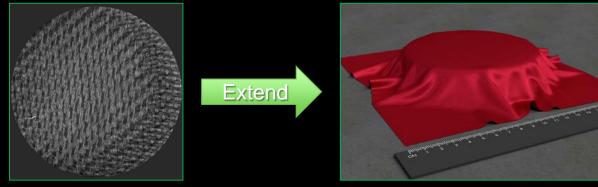
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Volumetric Appearance Model





Micro CT image

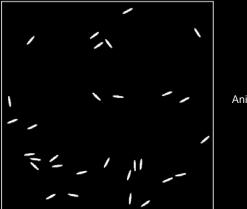
Volumetric appearance model

Micro-flake Model



Isotropic

model



Anisotropic model [Jakob et al. 2010]



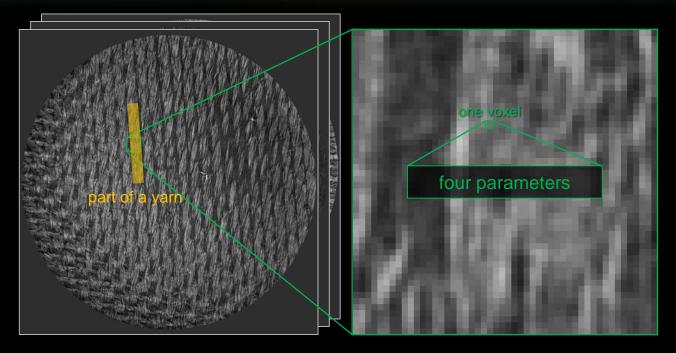
Rendered image

Anisotropic medium

Crucial for cloth rendering

Micro-flake Model: Description



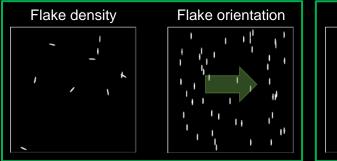


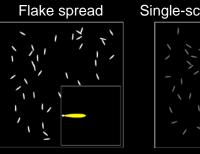
Micro-flake Model: Parameters



Fiber arrangement

Fiber appearance

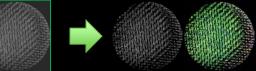




Single-scattering albedo

CT image processing

ssing Appearance matching









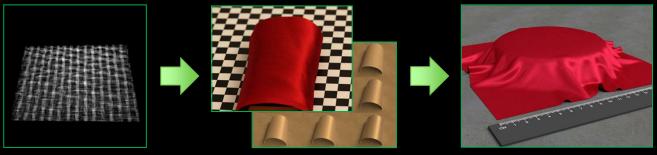




Input:



Micro CT images

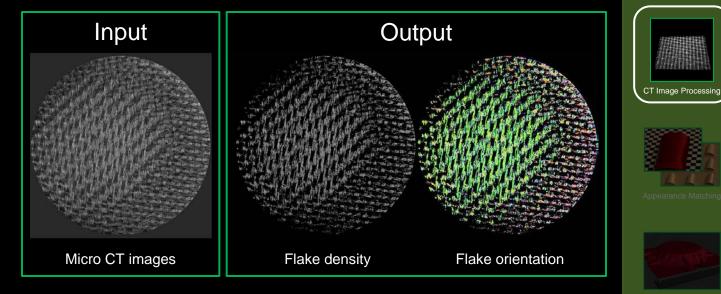


Rendering

CT image processing

Appearance matching

CT Image Processing: Goal



Rendering

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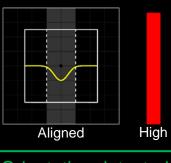
Outline

CT Image Processing

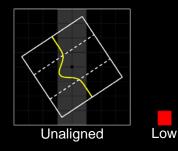


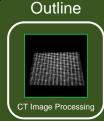
Fiber orientation detection





Orientation detected







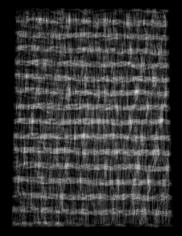
Appearance Matching



Rendering

Denoising

CT Image Processing: Result





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Appearance Matching



CT Image Processing



Flake density (per-pixel scalar)



Denoised density field





Flake orientation (per-pixel vector)





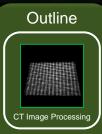


Flake spread (global scalar)



Single-scattering albedo (global per-channel scalar)

To be solved in the next stage



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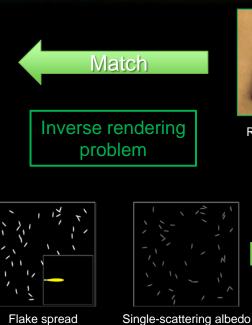
Appearance Matching

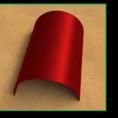


Appearance Matching: Goal



One photo (measured appearance)





Rendered image



Outline

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CT Image Processing





Appearance Matching



(measured appearance)

What to match?



Rendered image



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CT Image Processing





Rendering

Two statistical measures



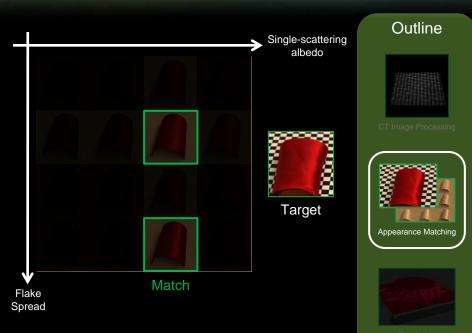
Single-scattering albedo

Flake spread

Appearance Matching

How to find the match?

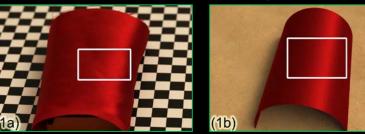
- Binary Search
 - Match mean
 - Match standard deviation



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Appearance Matching: Result

Appearance matching pair



Validation pair (rotated sample, same lighting)







Outline



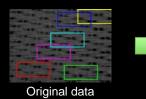
CT Image Processing

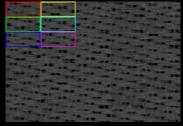




Rendering

- Before rendering...
 - Data Replication





Tiled data

- Shellmap [Porumbescu et al. 2005]
- Monte Carlo volume path tracing
 - New sampling strategy







CT Image Processing



Appearance Matching





Experimental Results

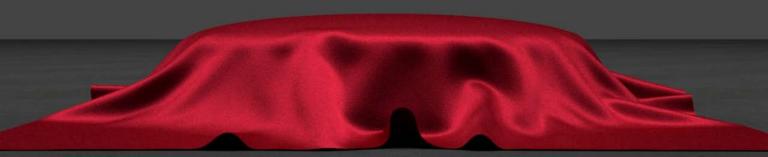
Building Volumetric Appearance Models of Fabric using Micro CT Imaging



Rendering: silk satin

Volumetric Data Size: 800MB Rendering time: 470 core-hours 500G effective voxels

Rendered video: silk satin



Area lighting

Rendering: gabardine

Volumetric Data Size: 2.70GB Rendering time: 350 core-hours 1500G effective voxels

Rendered video: gabardine

Environment lighting

Rendering: velvet

Volumetric Data Size: 4.65GB Rendering time: 240 core-hours 3000G effective voxels

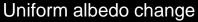
Rendering: felt

Volumetric Data Size: 7.26GB Rendering time: 240 core-hours 4500G effective voxels

Edited Results





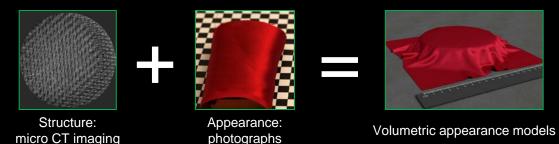




Orientation-based albedo change



- SIGGRAPH2011 VAN(OUVER
- A new way of building volumetric appearance models



- The power of structural information
- Future work
 - Multicolored fibers, synthesis-based data replication
 - Beyond fabrics and CT

Acknowledgements

- Jessie Maisano
- Piti Irawan

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- Autodesk



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