A practical Microcylinder Appearance Model for Cloth Rendering

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Overview

Introduction

Cloth rendering

Outline

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Introduction

$$L_o(\mathbf{p}, \boldsymbol{\omega_o}) = L_e(\mathbf{p}, \boldsymbol{\omega_o}) + \int_\Omega f(\mathbf{p}, \boldsymbol{\omega_o}, \boldsymbol{\omega_i}) L_i(\mathbf{p}, \boldsymbol{\omega_i}) |\cos\theta_i| d\boldsymbol{\omega_i}$$

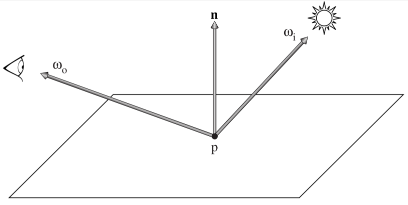
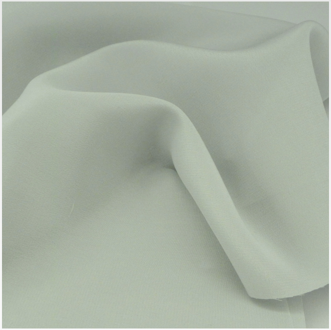


Diagram of light emitted from **p**, image taken from [PH10].

where L_o is the outgoing radiance, L_i incoming radiance, L_e emitted radiance, f BRDF function, **p** surface point, $\boldsymbol{\omega_i}$ incident light, $\boldsymbol{\omega_o}$ outgoing light, Ω hemisphere above **p**, θ_i angle of incidence.

The problem

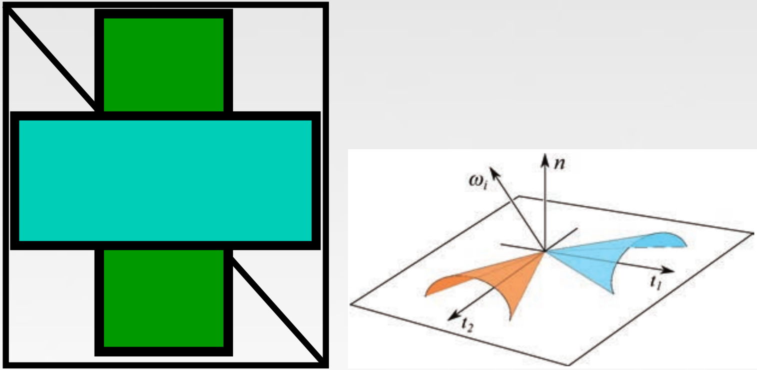
- Render cloth fast and realistically
  - Small threads
  - Weaving patterns



Left shows a close up view of fabric, right shows a picture of cloth, images taken from [SBD*13].

Appearance model

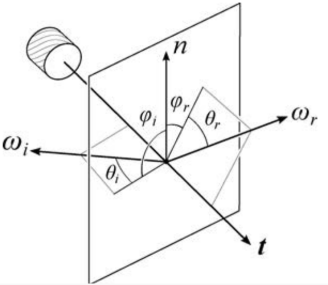
- Two microcylinders [SBD*13]



Left shows model in a triangle mesh, right shows scattering cones in a patch, images taken from [SBD*13].

Appearance model

$$\text{BRDF: } f(t, \omega_i, \omega_r) = \frac{\text{Reflection term} + \text{Volume scattering term}}{\text{Normalization factor}},$$

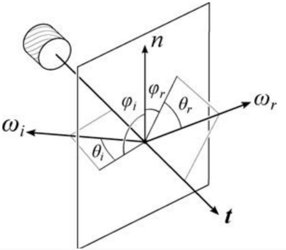


Angle definitions for a single thread, image taken from [SBD*13].

where f is the BRDF function, t is the thread direction, ω_i is the ray incoming direction, ω_r is the ray outgoing direction.

BRDF

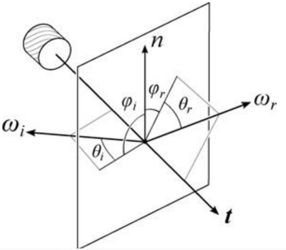
$$\text{BRDF: } f(t,\omega_i,\omega_r) = \Bigg(\overbrace{F_r(\eta,\omega_i)\cos(\phi_d/2)g(\gamma_s,\theta_h)}^{\text{Reflection term}} + F_t(\eta,\omega_i)F_t(\eta',\omega_r')\frac{(1-k_d)g(\gamma_v,\theta_h)+k_d}{\cos\theta_i+\cos\theta_r}A\Bigg) \Big/ \cos^2(\theta_d),$$



where f is the BRDF function, t is the thread direction, ω_i is the ray incoming direction, ω_r is the ray outgoing direction, F are Fresnel terms, η are Fresnel coefficients, g is a Gaussian lobe, k_d is a scattering constant, γ are Gaussian widths, $\theta_h = (\theta_i + \theta_r)/2$ and $\phi_d = \phi_i - \phi_r$.

$$\text{BRDF: } f(t,\omega_i,\omega_r) = \left(F_r(\eta,\omega_i) \overbrace{\cos(\phi_d/2)}^{\text{Cylinder reflection}} g(\gamma_s,\theta_h) + \right.$$

$$\left. F_t(\eta,\omega_i)F_t(\eta',\omega_r') \frac{(1-k_d)g(\gamma_v,\theta_h)+k_d}{\cos\theta_i+\cos\theta_r} A \right) / \cos^2(\theta_d),$$



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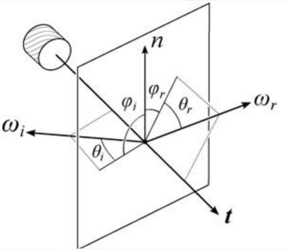
BRDF

$$\text{BRDF: } f(t,\omega_i,\omega_r) = \left(F_r(\eta,\omega_i)\cos(\phi_d/2) \overbrace{g(\gamma_s,\theta_h)}^{\text{Cylinder roughness}} + F_t(\eta,\omega_i)F_t(\eta',\omega_r')\frac{(1-k_d)g(\gamma_v,\theta_h)+k_d}{\cos\theta_i+\cos\theta_r}A \right) / \cos^2(\theta_d),$$



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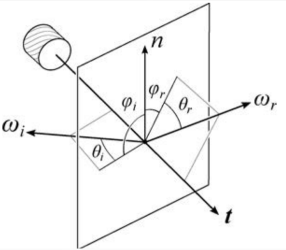
BRDF

$$\text{BRDF: } f(t,\omega_i,\omega_r) = \Bigg(\overbrace{F_r(\eta,\omega_i)}^{\text{Attenuation factor}} \cos(\phi_d/2) g(\gamma_s,\theta_h) + F_t(\eta,\omega_i) F_t(\eta',\omega_r') \frac{(1-k_d) g(\gamma_v,\theta_h) + k_d}{\cos\theta_i + \cos\theta_r} A \Bigg) / \cos^2(\theta_d),$$



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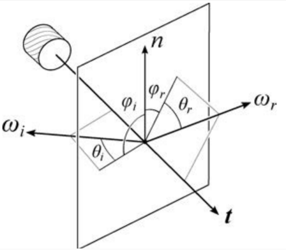

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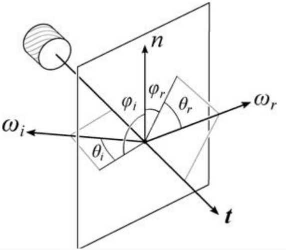

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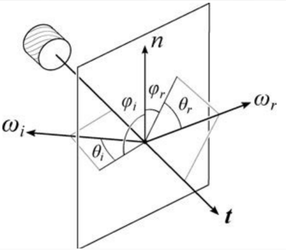

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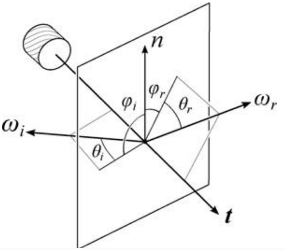

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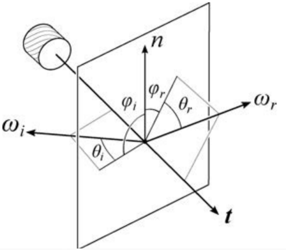

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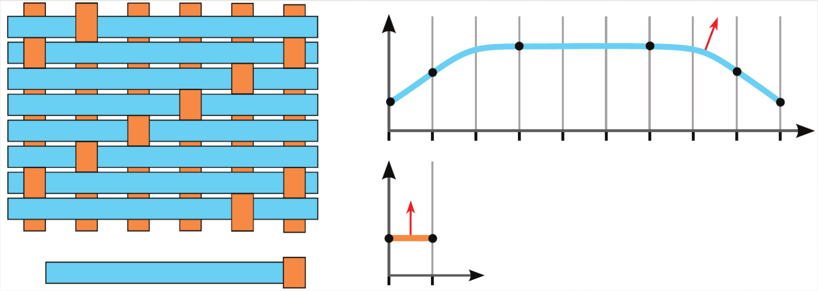
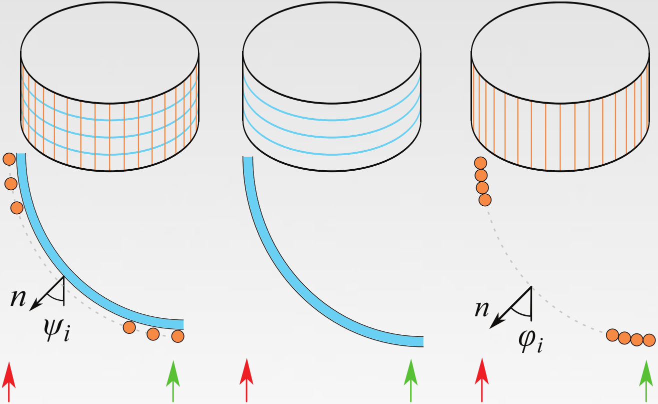
Shading Model 1



Normal sampling, (top-left) cloth patch, (bottom-left) smallest cloth patch, (top-right) blue thread tangent curve, (bottom-right) red thread tangent curve, image taken from [SBD*13].

Shading Model 2



Masking examples, Green arrow points view from above, red arrow points view at grazing angle, image taken from [SBD*13].

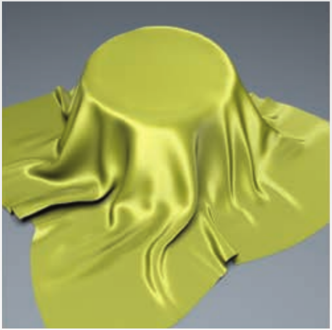
Shading Model 3

$$L_r(\omega_r) = Q(t) \sum \int L_i(\omega_i) f(t, \omega_i, \omega_r) M(t) P(t) \cos\theta_i d\omega_i,$$

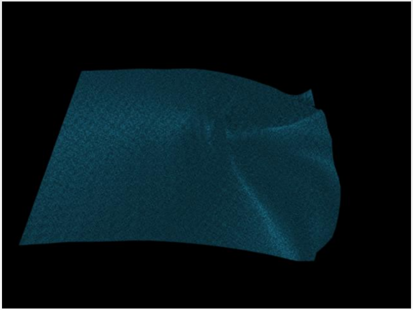
where f is the BRDF function, t is the thread direction, ω_i is the ray incoming direction, ω_r is the ray outgoing direction, θ_i is the incoming ray angle, $Q(t)$ is a normalization factor for samples and non watertight patches, $M(t)$ is the masking term and $P(t)$ is a view-projection normalization factor.

Cloth rendering: My work vs state of the art

- Results



Cloth render result from [SBD*13].



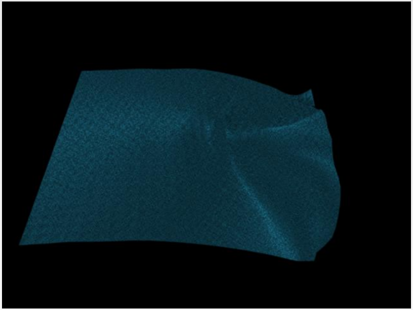
Cloth render with our code.

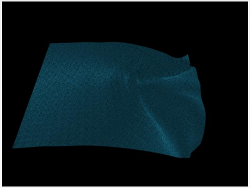
Cloth rendering: Possible improvements

- Fixed close up with hybrid model
- BRDF modifications for speed or quality
- Estimate good values for parameters
  - Picture of target cloth
  - 2D Manifold of parameters space

Previous work: EngD first year

- Appearance model for cloth
- Skin rendering





Left shows cloth rendering scene, right shows skin rendering scene.

Future Work

- Implement full model
- Importance sampling extensions by [MI] and [WXK]
- Improve model

Thank you

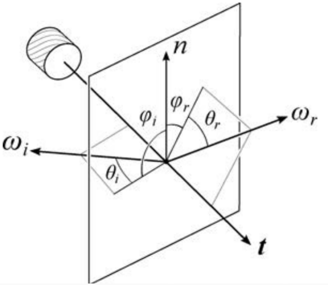
Questions?

References

[SHD15] Simon, F. et al. Rich-VPLs for Improving the Versatility of Many-Light Methods. Computer Graphics Forum, 2015
[SBD*13] Sadeghi, I. et al. A practical microcylinder appearance model for cloth rendering. ACM 2013
[PH10] Pharr, M. et al. Physically based rendering: From theory to implementation, Morgan Kaufmann, 2010
[MI] Mizutani K. et al. Importance Sampling for Cloth Rendering under Environment Light, Mathematical Progress in Expressive Image Synthesis I, 2014
[WXK] Wang J. et al. Importance Sampling for a Microcylinder Based Cloth Bsdf, SIGGRAPH Talks, 2014

Cloth rendering: Technical

$$\text{BRDF: } f(t,\omega_i,\omega_r) = \Bigg(F_r(\eta,\omega_i)\cos(\phi_d/2)g(\gamma_s,\theta_h) + F_t(\eta,\omega_i)F_t(\eta',\omega_r')\frac{(1-k_d)g(\gamma_v,\theta_h)+k_d}{\cos\theta_i+\cos\theta_r}A\Bigg) \Big/ \cos^2(\theta_d),$$



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