Multi-Scale Hybrid Micro-Appearance Modeling and Realtime Rendering of Thin Fabrics

Chao Xu[1] Rui Wang[1] Shuang Zhao[2] Hujun Bao[1]

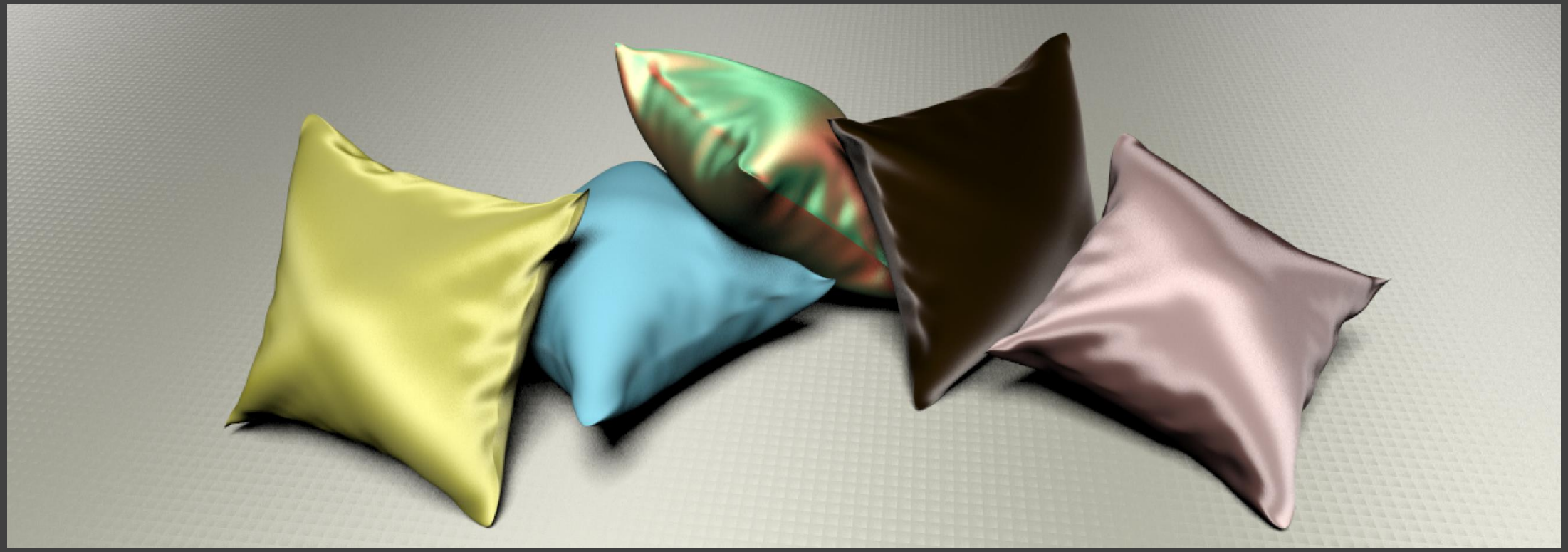
[1]Zhejiang University

[2]University of California, Irvine

织物渲染

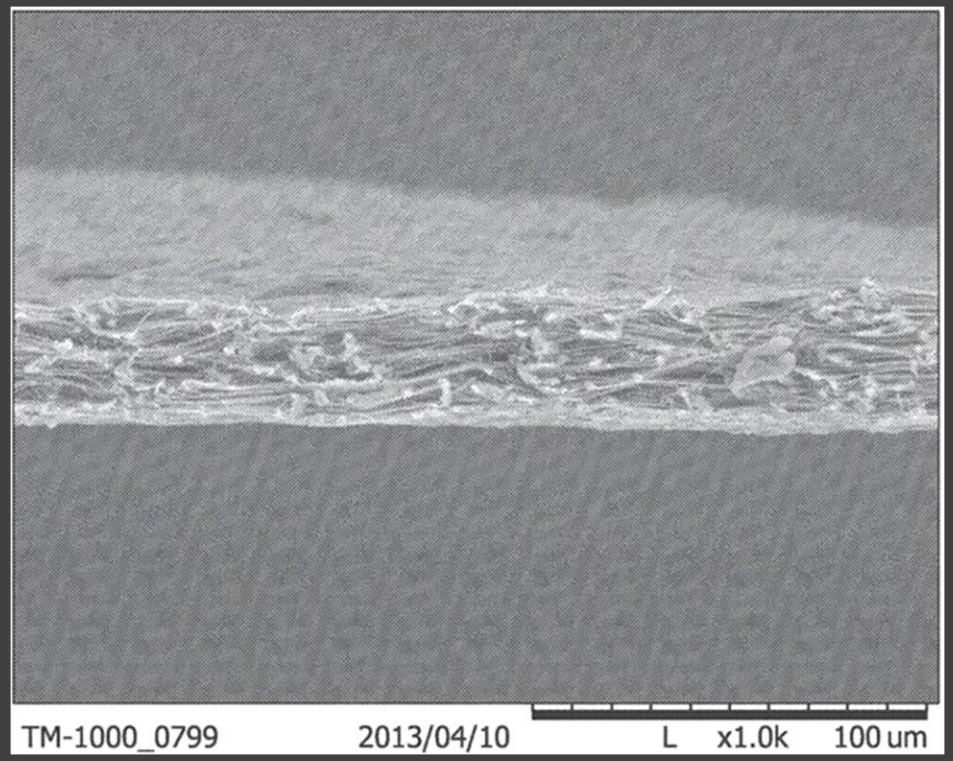
目前工业界织物渲染现状

目前工业界织物渲染现状

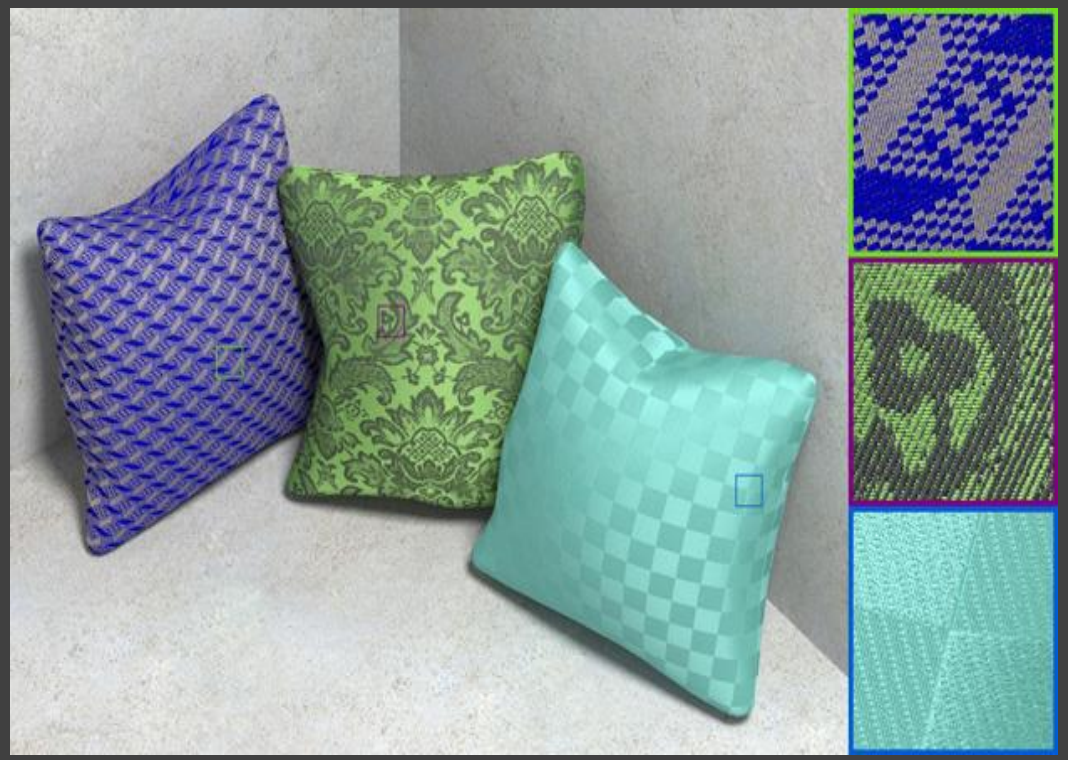


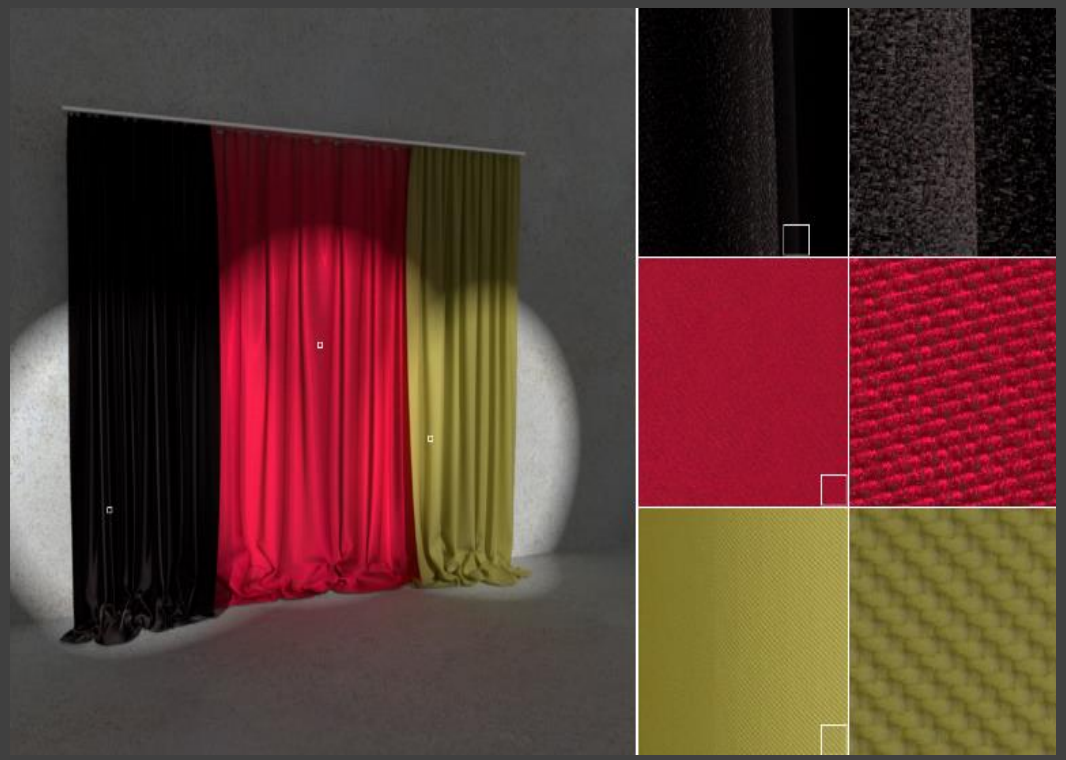
Lack of Detail！

存在的挑战



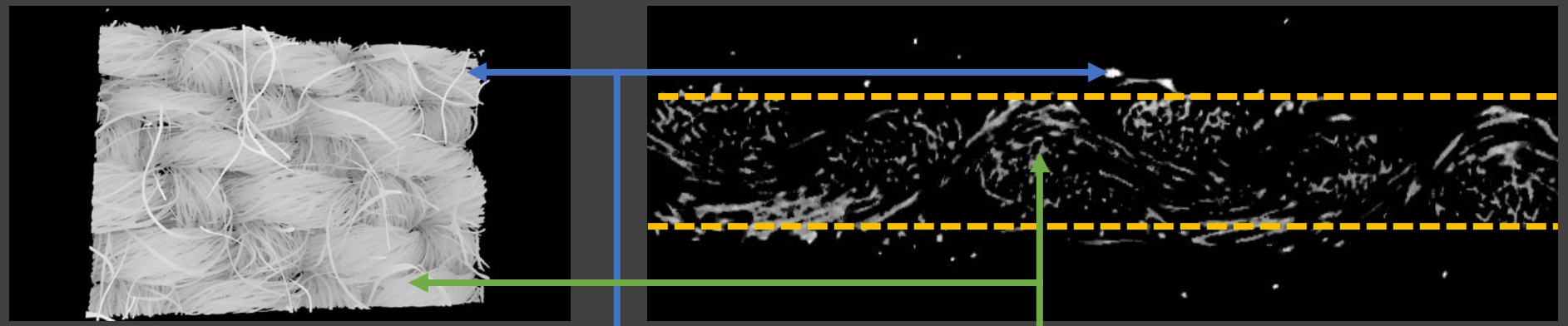
离线渲染的解决方案






ZHEJIANG UNIVERSITY
1897

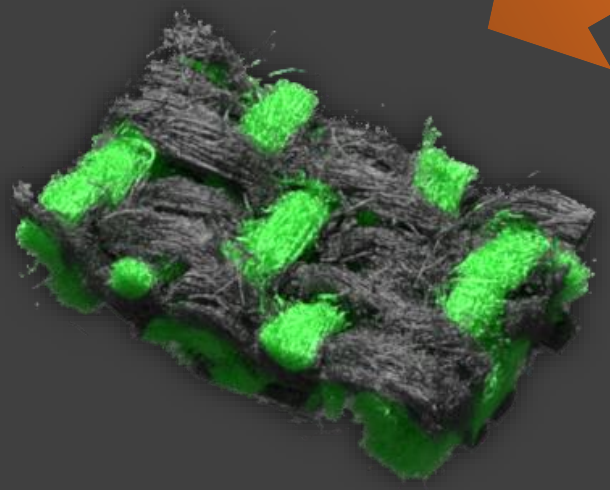
我们的实时绘制方案

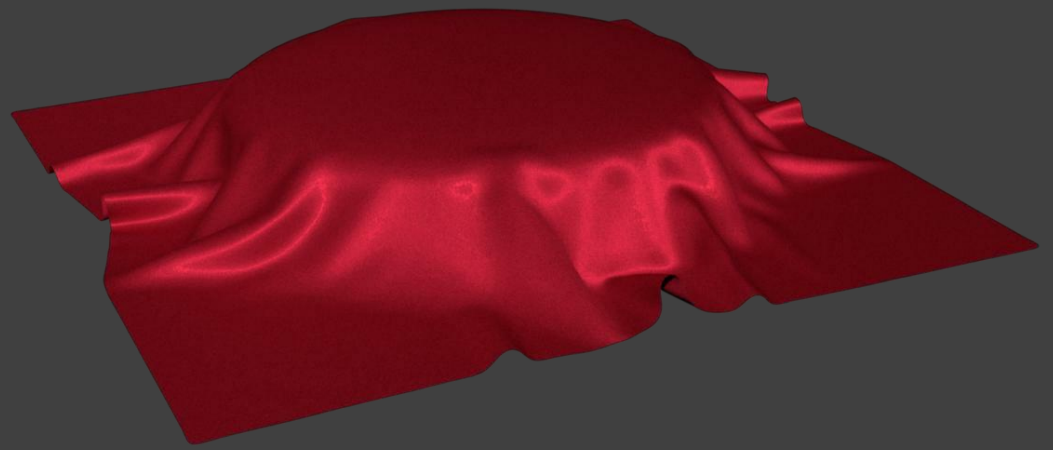


基于混合表达的复杂材质模型

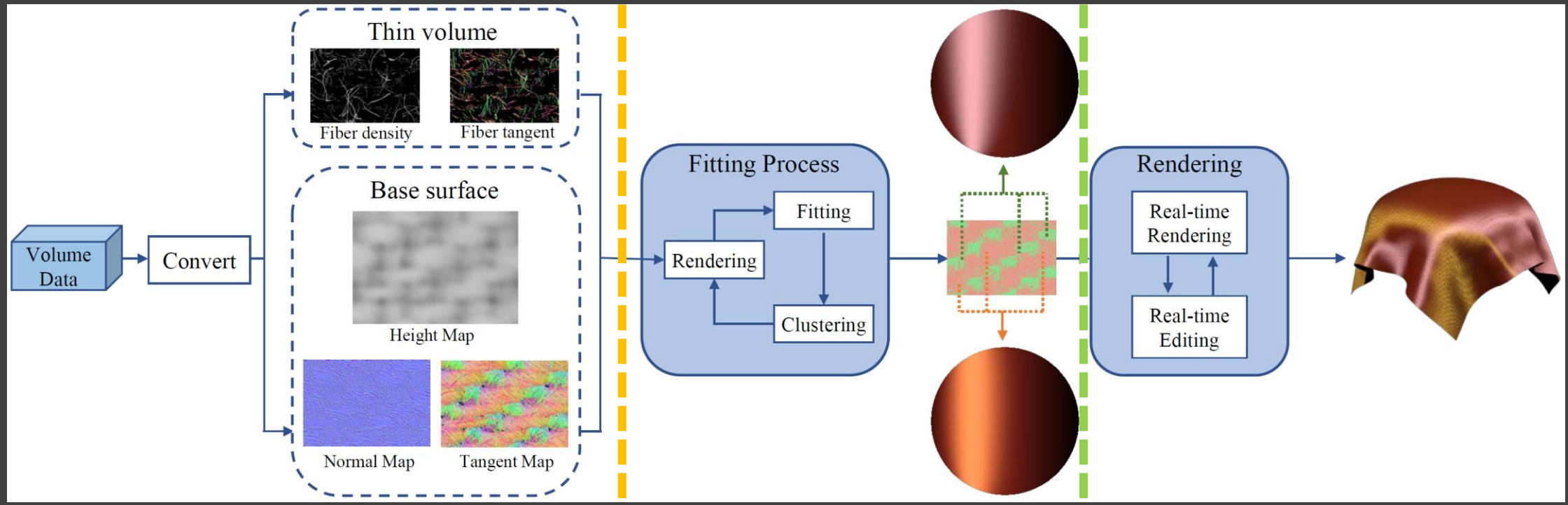
数据获取

Micro CT



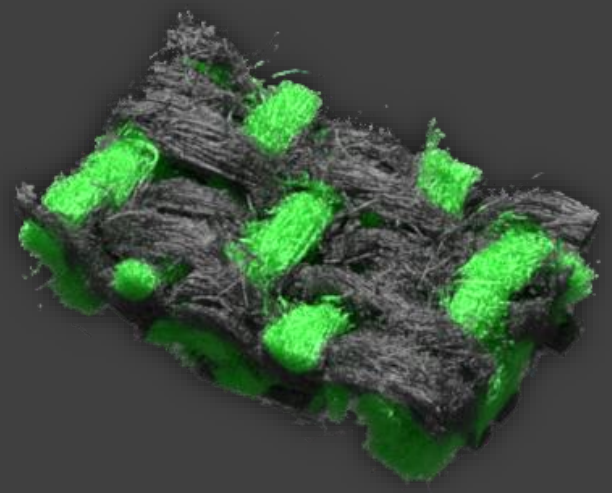


整体处理流水线



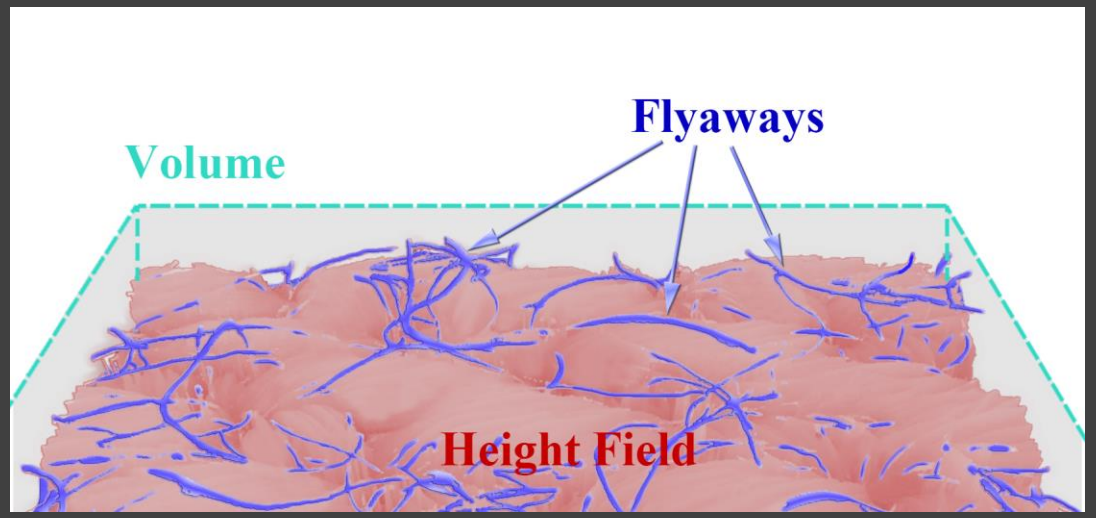
数据转换与分离　　聚类与拟合　　绘制

数据转换与分离过程



原始扫描得到的CT体数据

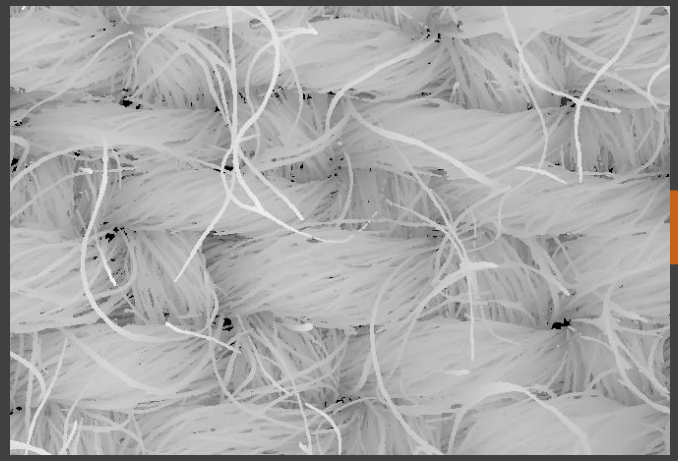
数据量巨大：1.1GB
难以在实时绘制中应用



对飞线和底层数据进行分离表达

数据量大幅降低：30MB
也能够保证表面绘制的细节

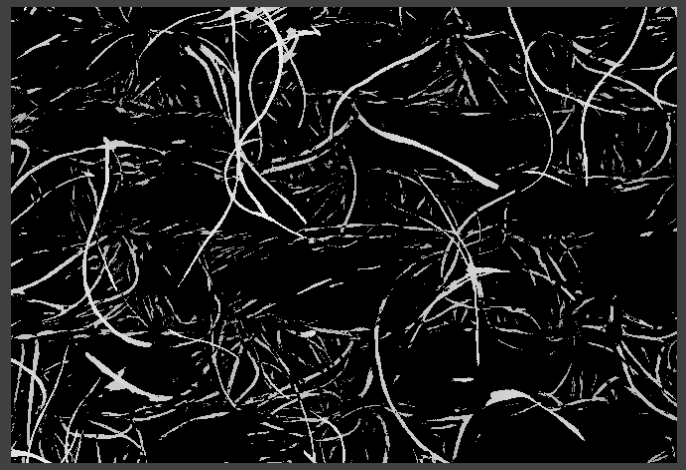
数据转换与分离过程



原始高度图

对上层飞线进行分离

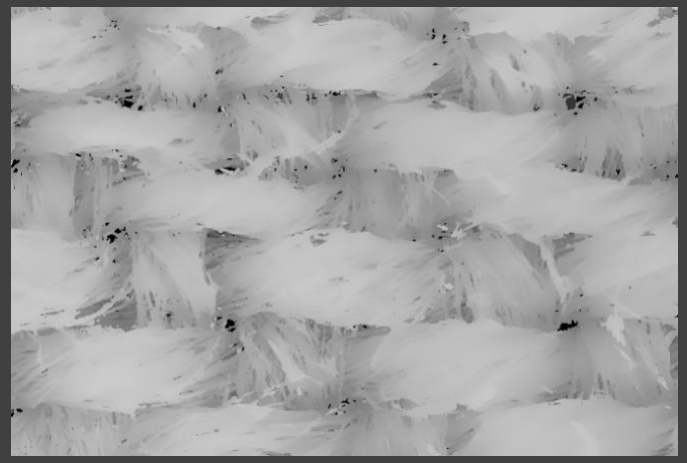
上层高度图



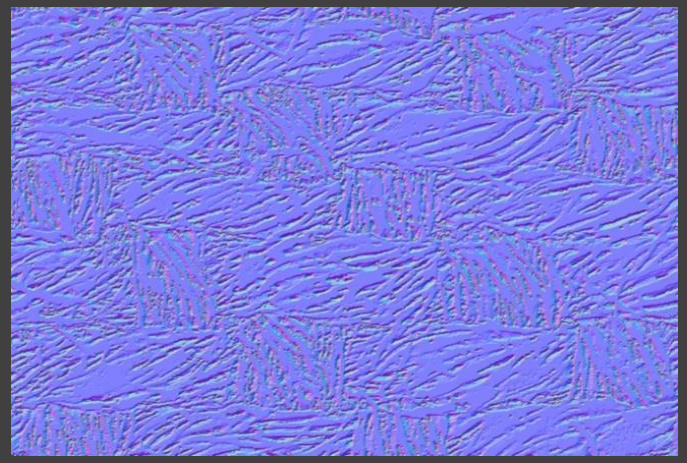
底层高度图

数据转换与分离过程

Height Field



Prefiltered Height Field

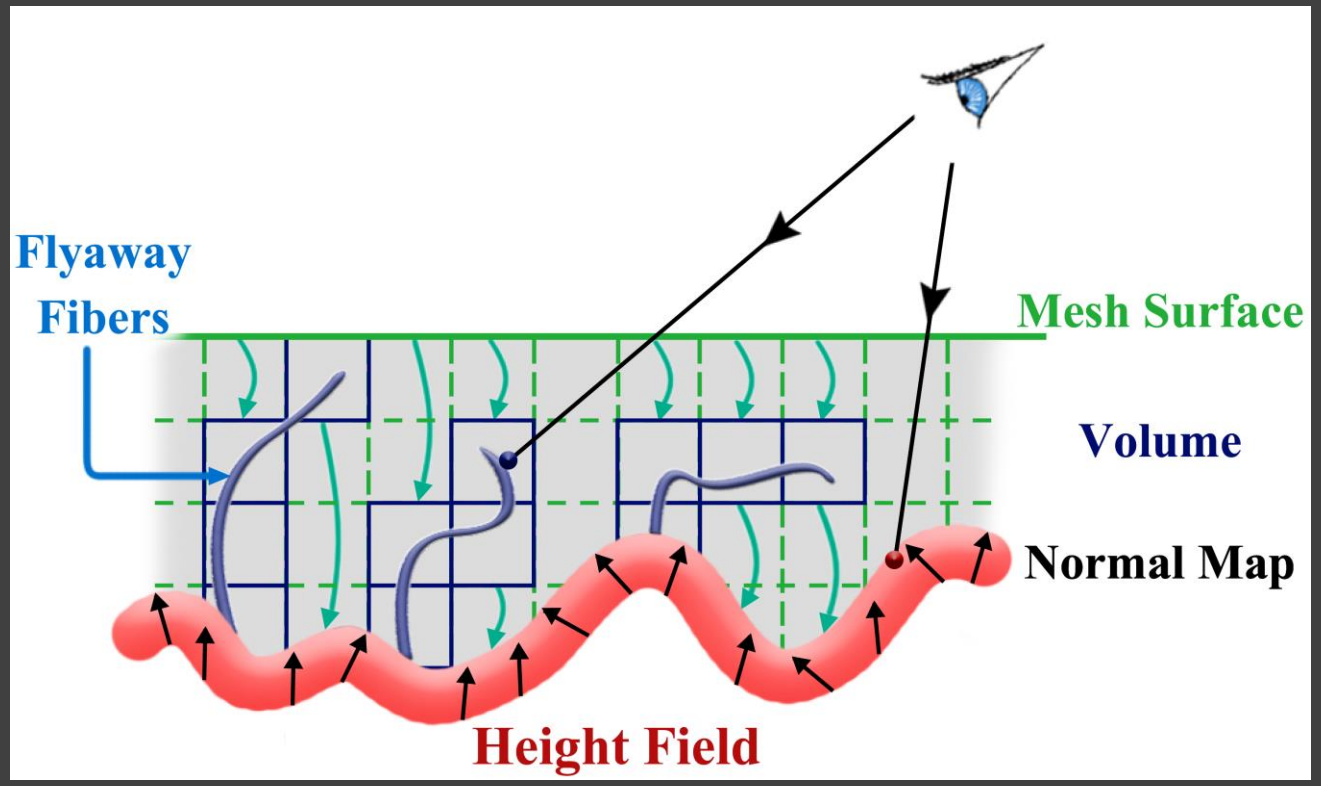


Detailed Normal Map

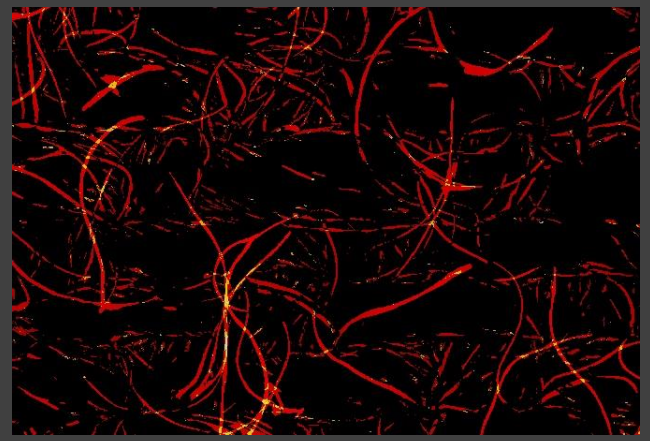
Easy
TO
LOD!

当大面积铺设后，由于细节非常多，导致远处会产生大量的图形走样

数据转换与分离过程

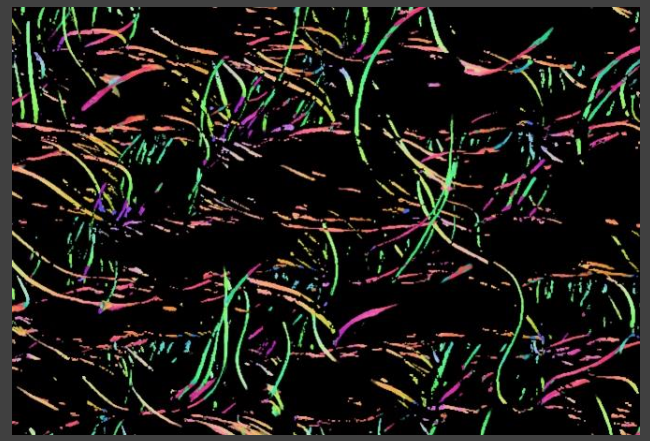


链式存储飞线（大幅降低冗余空间占用）



RG：第一和第二层的起始高度

BA：第一和第二层的持续高度

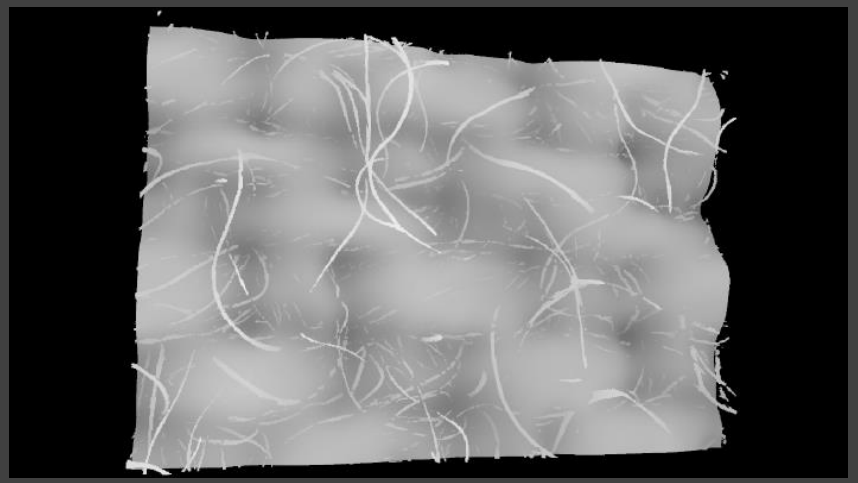


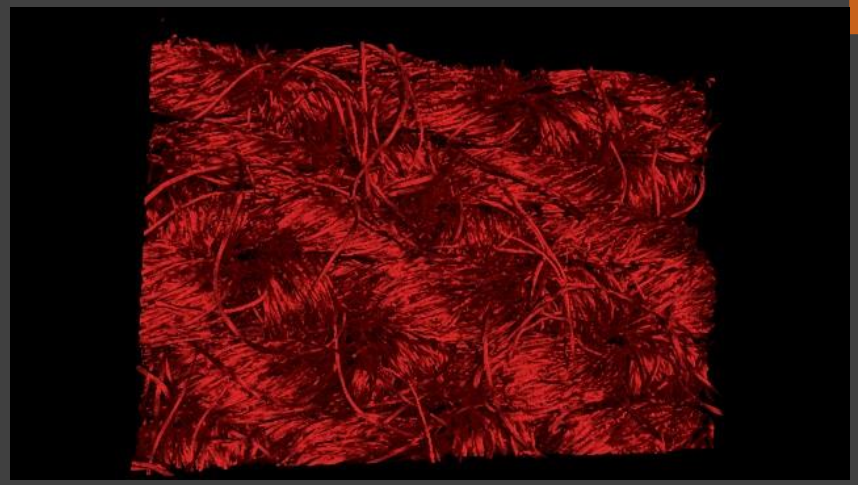
RGB：第一层的tangent方向

A：第一层density值

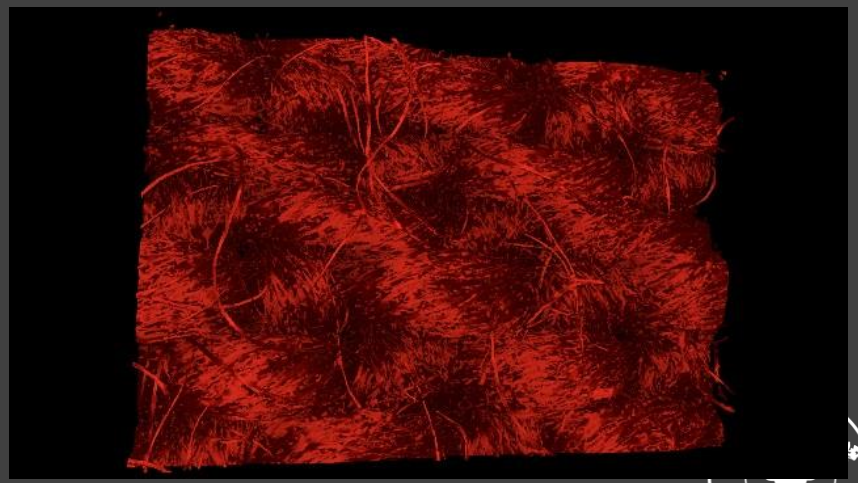
数据转换与分离过程

使用高度场对底层
低频数据进行表达



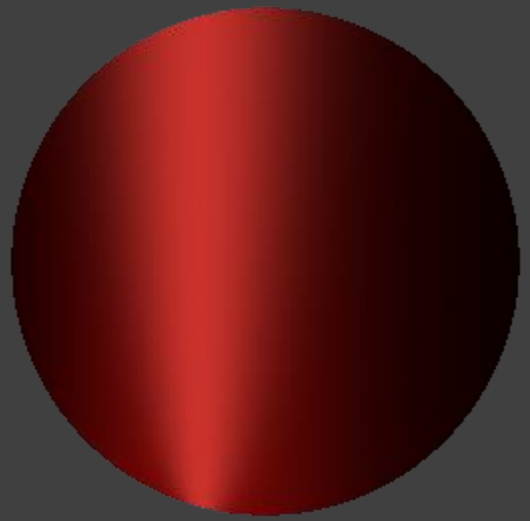


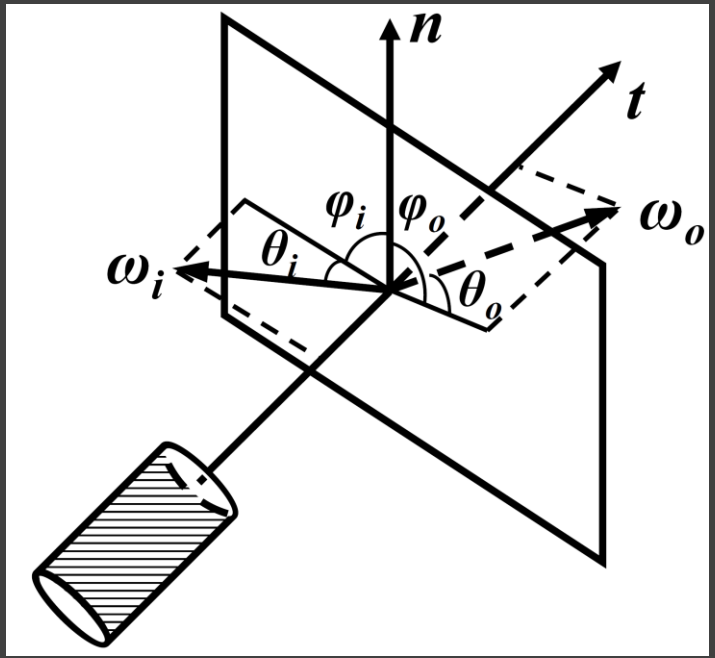
使用链结构对飞线
高频数据进行表达



聚类与拟合

- 我们提出的BRDF模型





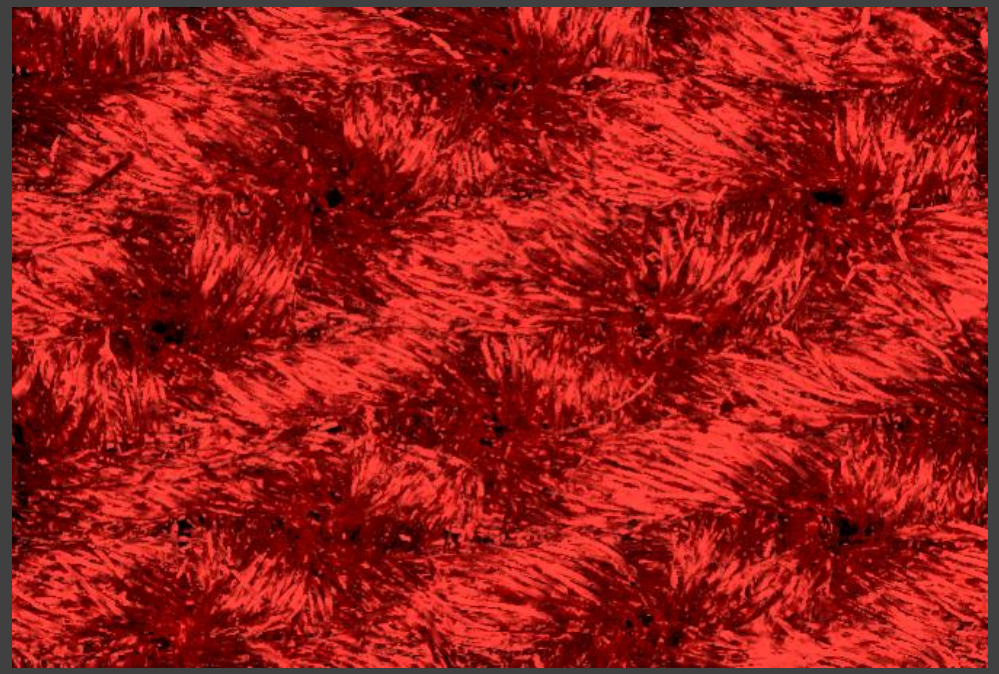
$$f_r(\omega_i, \omega_o) = k_d + F(\eta, \theta_i)\ \cos(\varphi_i)^a\ f_{r,s}(\omega_i, \omega_o)$$

$$f_{r,s}(\omega_i, \omega_o) = \sum_j \frac{k_j}{\sqrt{2\beta_j \pi}} \exp\left(-\frac{(\theta_i + \theta_o)^2}{2\tilde{\beta}_j^2}\right)$$

$$\tilde{\beta}_j = \exp\left(-\frac{(\varphi_i + \varphi_o)^2}{2\gamma_j^2}\right)$$

聚类与拟合

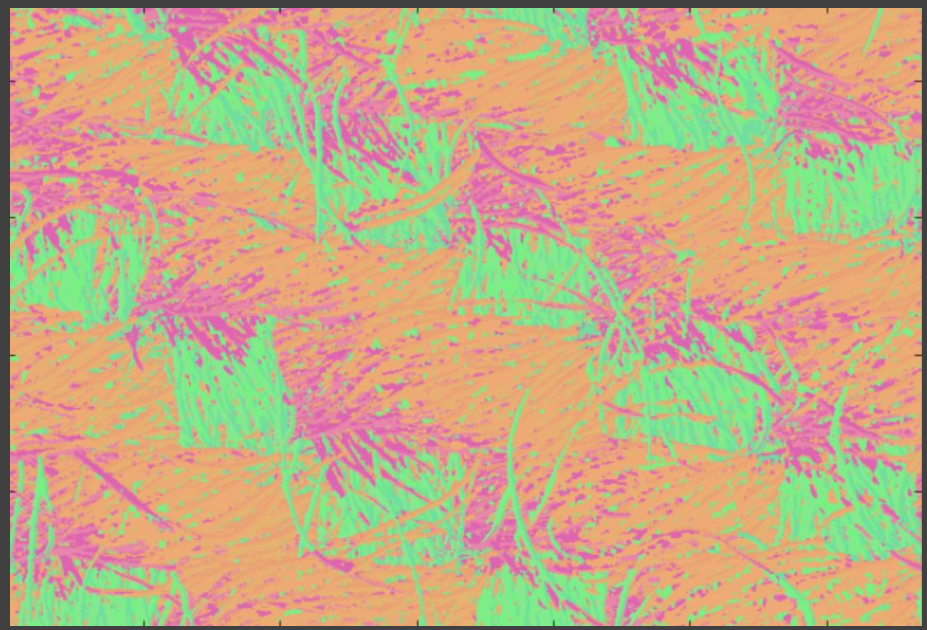
- 拟合过程-预采样
  - 较为稀疏的遍历入射光与视角方向。
  - 每一组方向进行全图绘制
  - 基于normal，tangent，以及绘制结果建立特征向量: [N, T, f]



聚类与拟合

- 拟合过程-聚类
  - 基于特征向量进行聚类

K=2

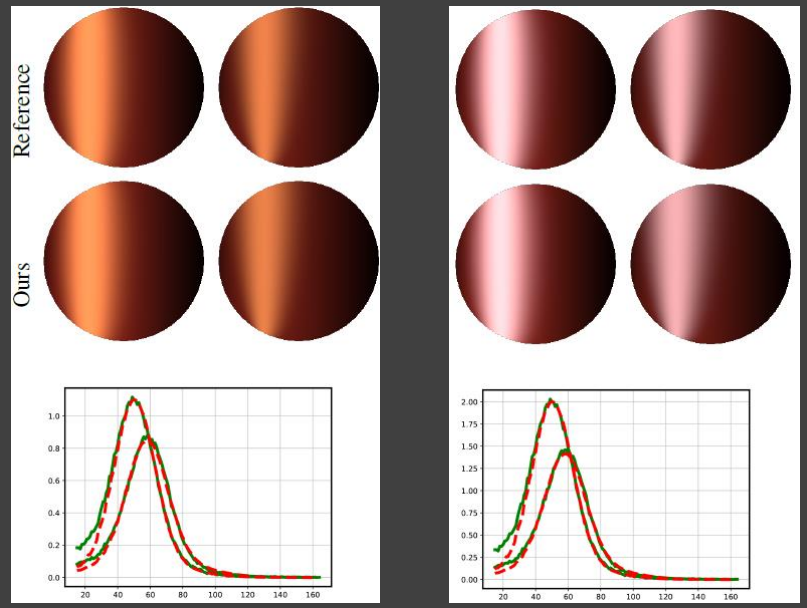


K=8

聚类与拟合

- 拟合过程-BRDF拟合
  - 基于聚类结果，对每个类的中心方向进行局部精密采样
  - 基于采样数据进行BRDF拟合。

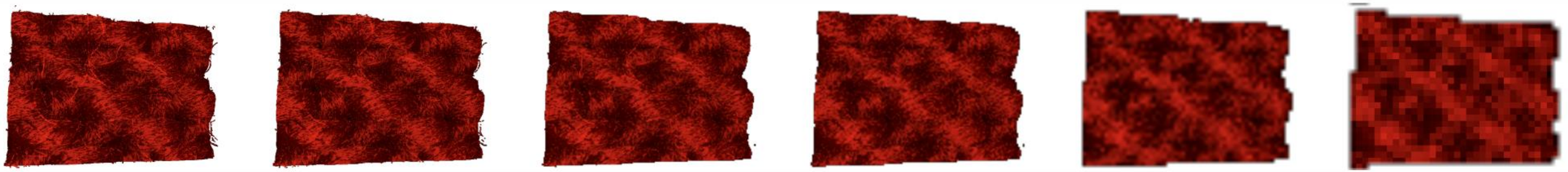
K=2时候的聚类结果



BRDF拟合结果

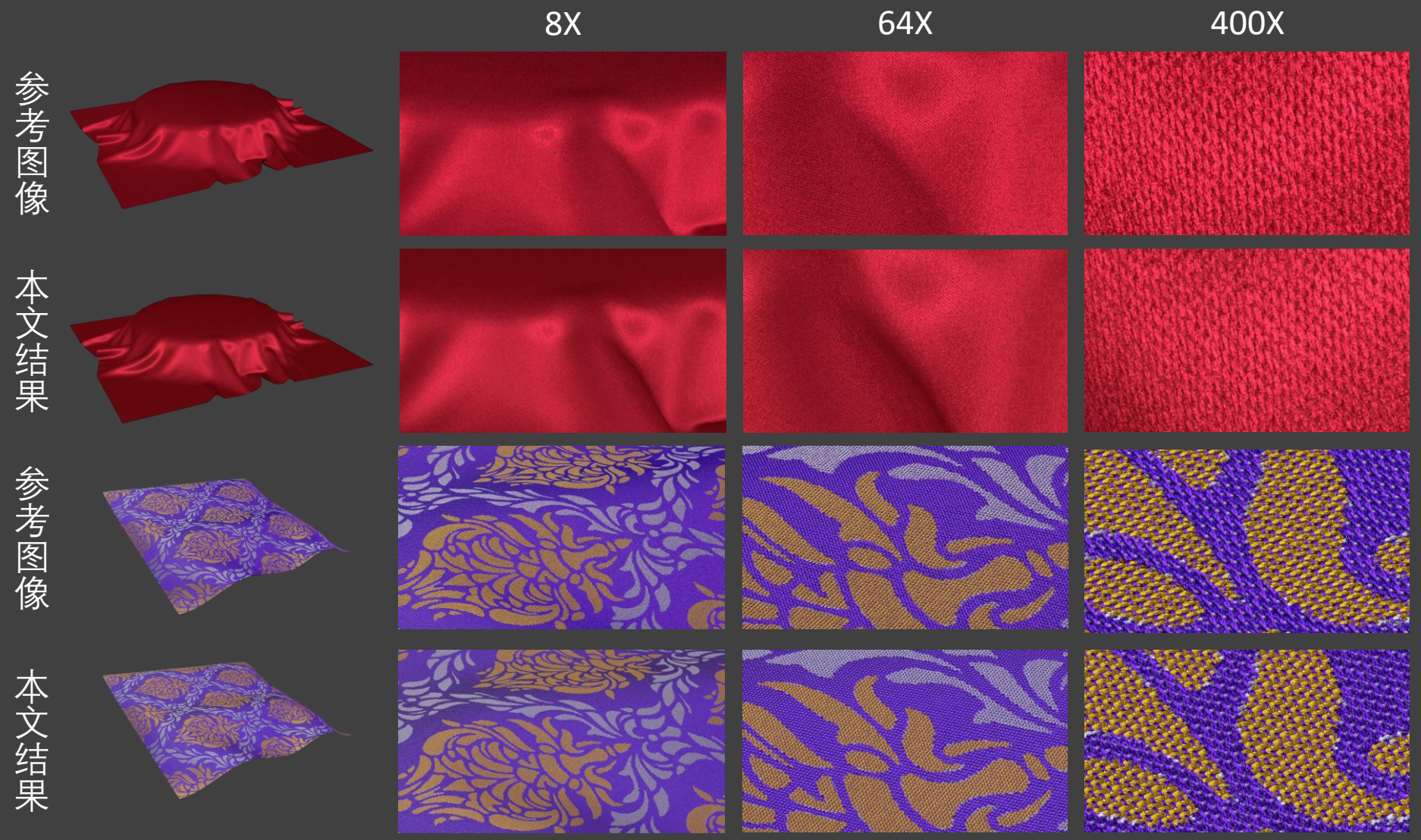
绘制过程

- LOD

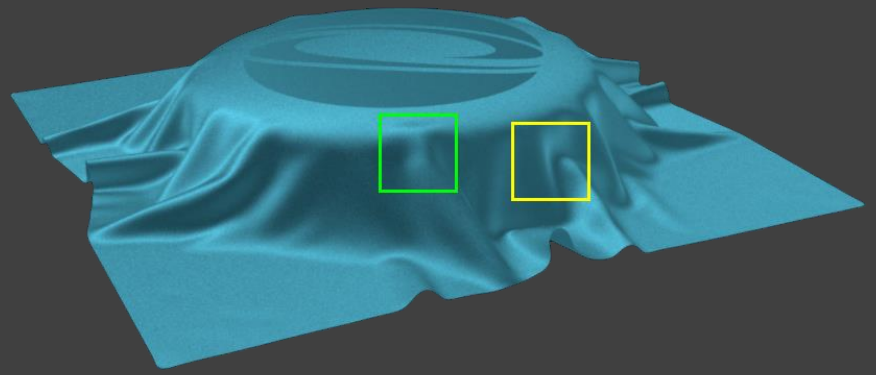


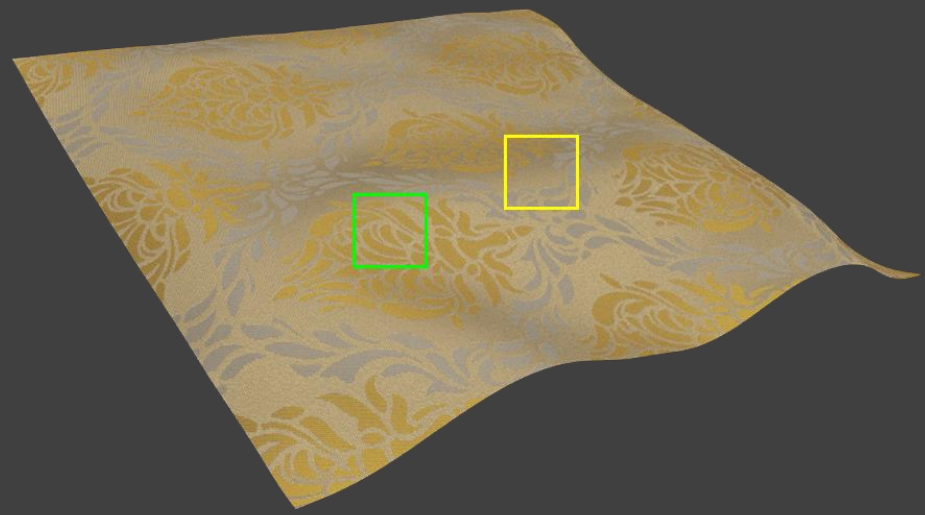
(a) Level 0 (b) Level 1 (c) Level 2 (d) Level 3 (e) Level 4 (f) Level 5

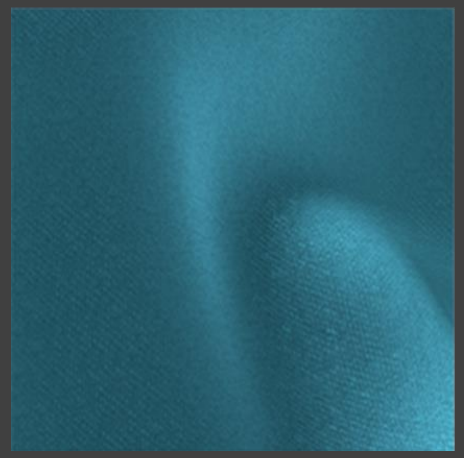
结果：绘制结果及比较

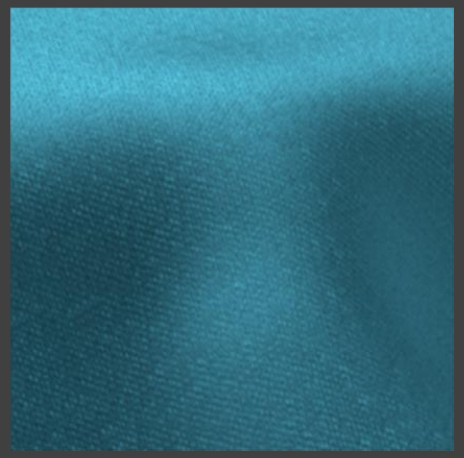


结果：绘制结果及比较







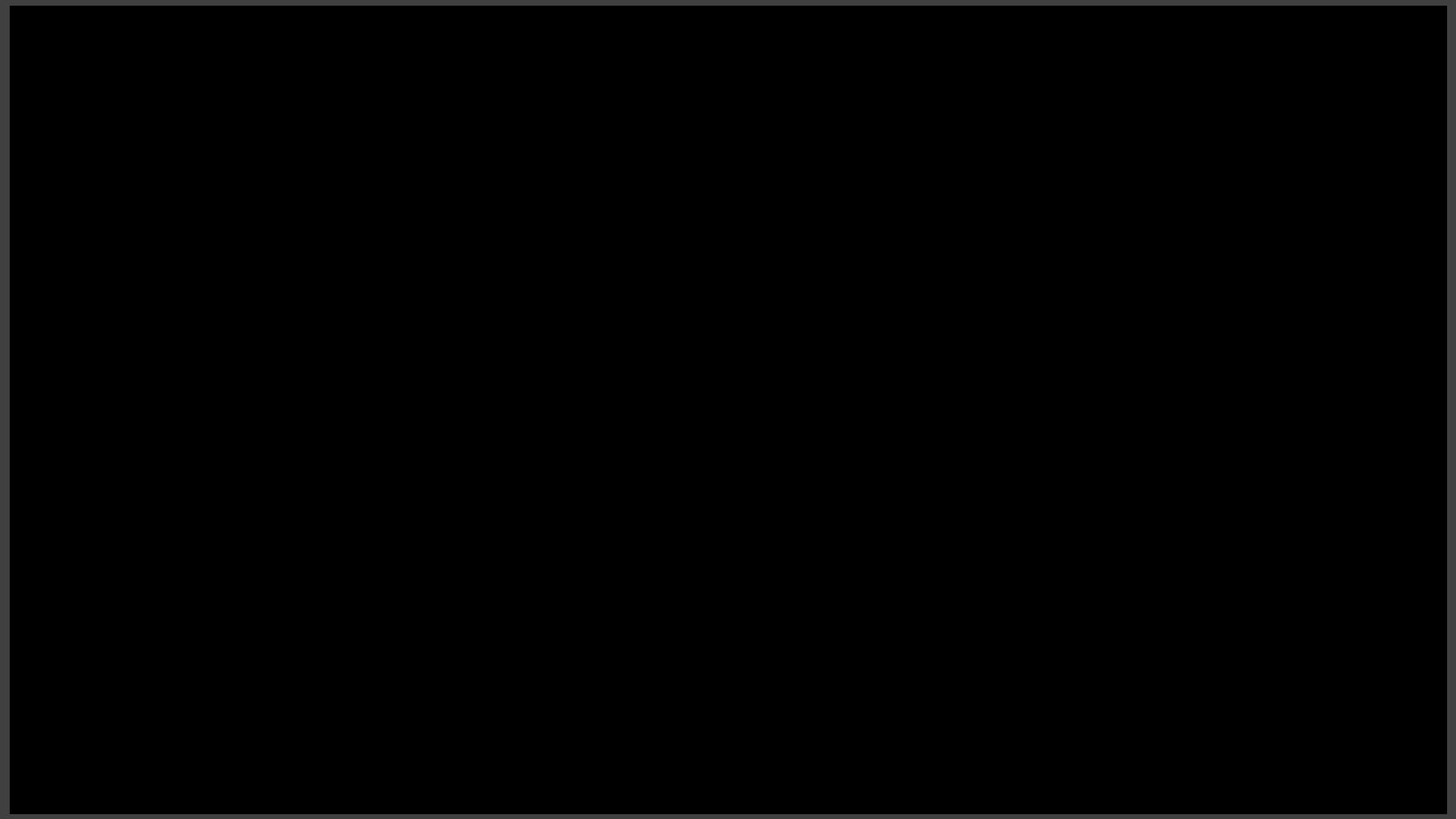


结果：绘制结果及比较

Model	Training 1 (for clustering)	Training 2 (for fitting)	K	BRDF fitting	Filter size (x / y)
Silk	16 h (324)	4 h (129 K)	8	3 h	18 / 37
Twill 1	13 h (324)	2 h (65 K)	16	7 h	26 / 21
Twill 2	23 h (648)	2 h (65 K)	16	7 h	26 / 21
Satins	29 h (648)	3 h (65 K)	32	12 h	18 / 12
Felt	21 h (648)	2 h (65 K)	32	12 h	28 / 33

Model	Model size (input)	Model size (ours)	Render time (input)	Render time (ours)
Silk	1.9 GB	25 MB	72 min	24 ms
Twill 1	1.1 GB	31 MB	54 min	25 ms
Twill 2	0.5 GB	29 MB	52 min	27 ms
Satins	1.5 GB	41 MB	106 min	28 ms
Felt	1.8 GB	37 MB	94 min	31 ms

结果：绘制结果及比较



Q&A

Multi-Scale Hybrid Micro-Appearance Modeling and Realtime Rendering of Thin Fabrics

Chao Xu[1] Rui Wang[1] Shuang Zhao[2] Hujun Bao[1]

[1]Zhejiang University

[2]University of California, Irvine