

Real-Time High Quality Rendering

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Lecture 11: Real-Time Physically-Based Materials (surface models cont.)



Announcements

- No lecture next week
 - SIGGRAPH Asia deadline
- GAMES101 resubmission
 - Have to work on it after next week

Last Lecture

- Real-Time Physically-Based Materials
 - Microfacet BRDF
 - NDF: Beckmann, GGX, GTR
 - Shadowing-masking term
 - Kulla-Conty Approximation for multiple bounces
 - Disney principled BRDF
- Shading with microfacet BRDFs under polygonal lighting
 - Linearly Transformed Cosines (LTC)

Today

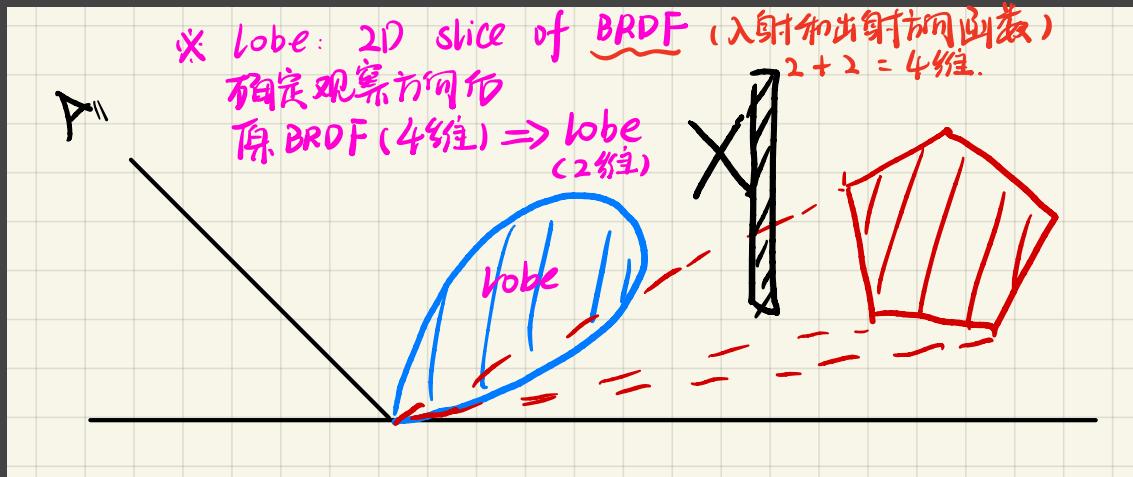
- Shading with microfacet BRDFs under polygonal lighting
 - Linearly Transformed Cosines (LTC)
- Real-Time Physically-Based Materials cont.
 - Disney principled BRDF
- Non-photorealistic rendering (NPR)

Shading Microfacet Models using Linearly Transformed Cosines (LTC)

Linearly Transformed Cosines

利用线性变换余弦对微面间模型进行着色。

- Solves the shading of microfacet models
 - Mainly on GGX, though others are also fine
 - No shadows
 - Under polygon shaped lighting 光源为多地形时的照明



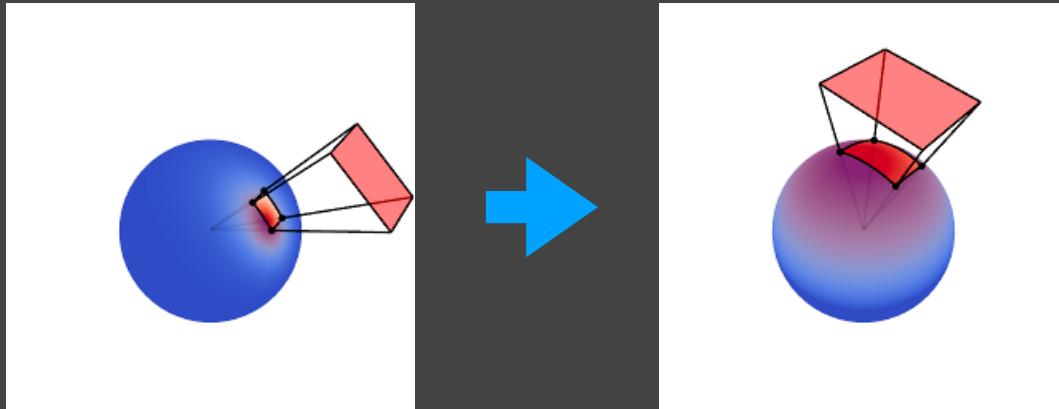
Linearly Transformed Cosines

- Key idea

任何传出的 2D BRDF lobe 都可以变换为余弦

- Any outgoing 2D BRDF lobe can be transformed to a cosine
- The shape of the light can also be transformed along
- Integrating the transformed light on a cosine lobe is **analytic**

在余弦 lobe 上积分变换后的光是解析的。



Linearly Transformed Cosines

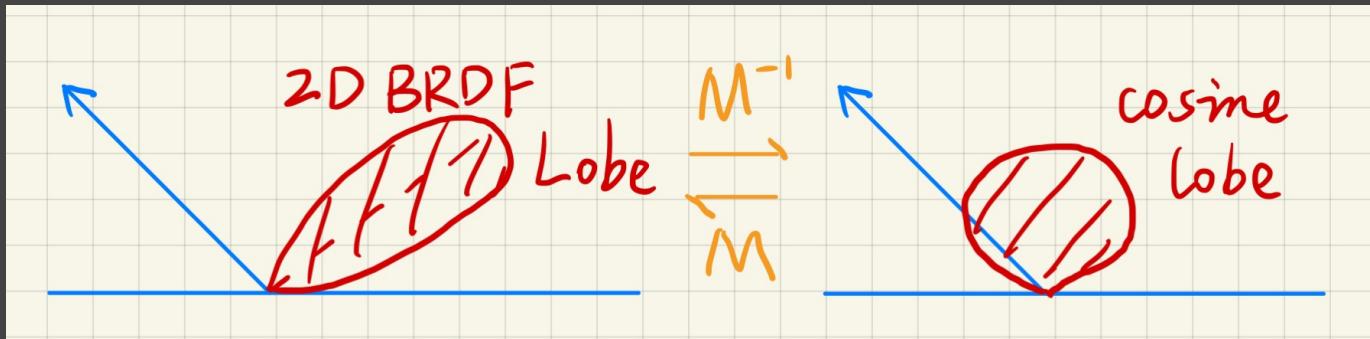
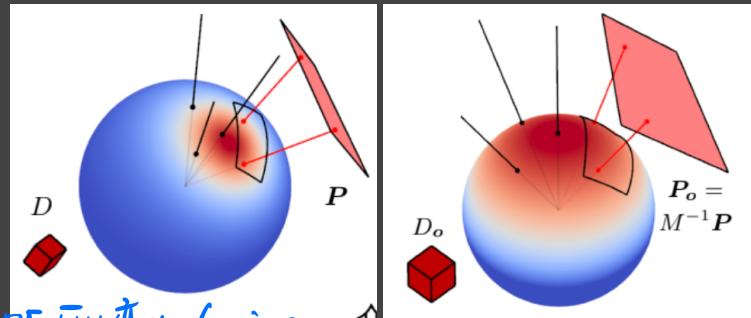
- Observations

- BRDF $\xrightarrow{M^{-1}}$ Cosine

- Direction: $\omega_i \xrightarrow{M^{-1}} \omega'_i$
对所有方向都 $\xrightarrow{M^{-1}}$ w_i 使得 BRDF 可以变为 Cosine

- Domain to integrate: $P \xrightarrow{M^{-1}} P'$

原有的地形光源所覆盖的方向也会发生变换 \rightarrow 原有积与域也会发生变换.



Linearly Transformed Cosines

- Approach

- A simple change of variable

$$\begin{aligned} L(\omega_o) &= L_i \cdot \int_P F(\omega_i) d\omega_i \\ &= L_i \cdot \int_P \cos(\omega'_i) d\frac{M\omega'_i}{\|M\omega'_i\|} \\ &= L_i \cdot \int_{P'} \cos(\omega'_i) \underline{J} d\omega'_i \end{aligned}$$

$$\omega_i = \frac{M\omega'_i}{\|M\omega'_i\|}$$

↑ 直接代入
← 方向 ← 单位长度 → 旧 - 新

对于常见 BRDF
从不同方向看过去
可以导引 2D BRDF table \rightarrow cosine
这么一个变换矩阵。
通过统计方法。
— Analytic!
有解析解。

Linearly Transformed Cosines

- Results



Questions?

Disney's Principled BRDF

Why is it needed?

物理表面模型无法模拟多层材质。

- Motivation

（没有一种基于物理的材质能够很好地表示所有真实材质）

- No physically-based materials are good at rep. all real materials
 - e.g. lacking diffuse term in most microfacet models
 - Physically-based materials are not artist friendly
 - e.g. “the complex index of refraction $n\text{-}ik$ ”

- High level design goal

- Art directable, not necessarily physically correct
 - But again, referred to as PBR in real-time rendering...

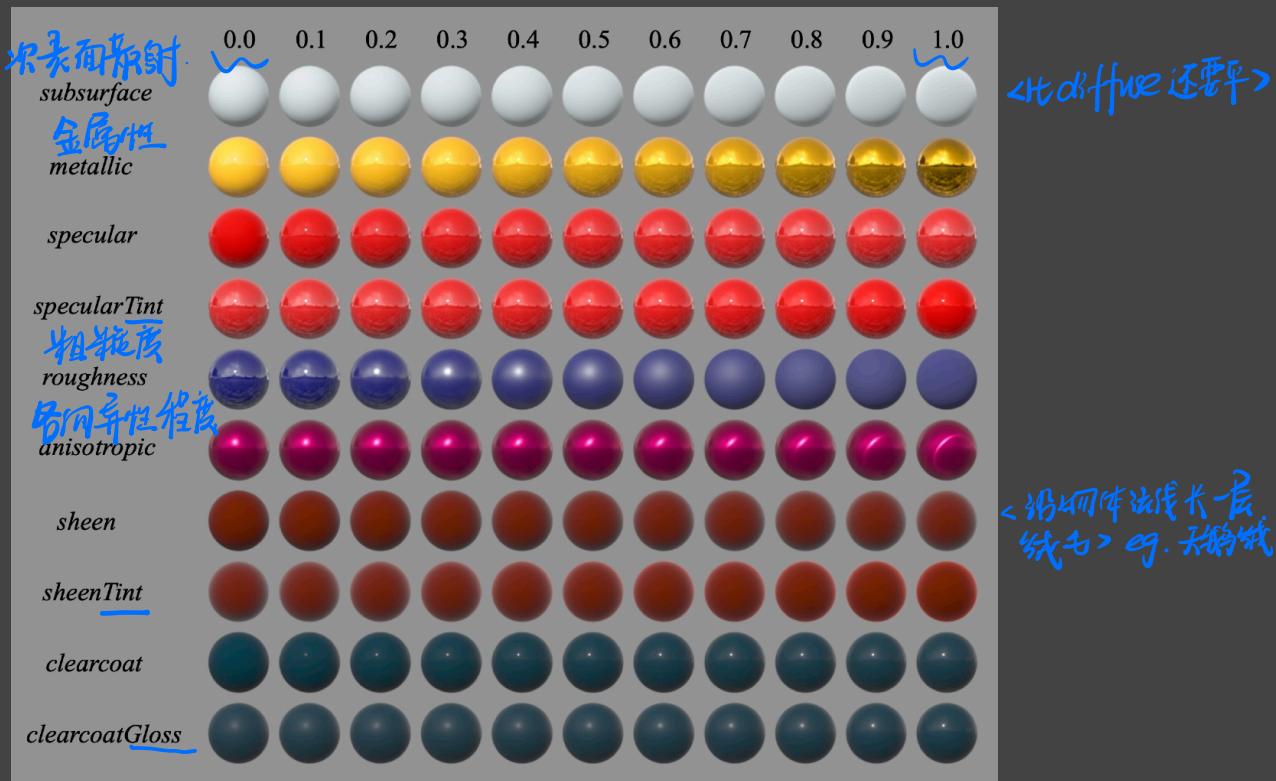
What is “principled”?

有几个重要原则。

- The BRDF is designed with a few important principles
 - Intuitive rather than physical parameters should be used.
参数尽可能少.
 - There should be as few parameters as possible.
参数应在其合理范围内 介于 0 到 1 之间
 - Parameters should be zero to one over their plausible range.
参数应允许参数推到合理范围以外.
 - Parameters should be allowed to be pushed beyond their plausible range where it makes sense.
参数组合尽可能健壮和合理.
 - All combinations of parameters should be as robust and plausible as possible.

How does it work?

- A table showing the effects of **individual** parameters



Pros and Cons

- Easy-to-understand / control
 _{單一模型的多種材質}
- A wide range of materials in a single model
- Open source implementation is available
- Not physically based
 _{非基於物理. 但卻叫做 PBR (in RT)}
 - But is it a big problem?
 - Academia vs. industry
- Huge parameter space
 _{巨大的參數空間}

Questions?