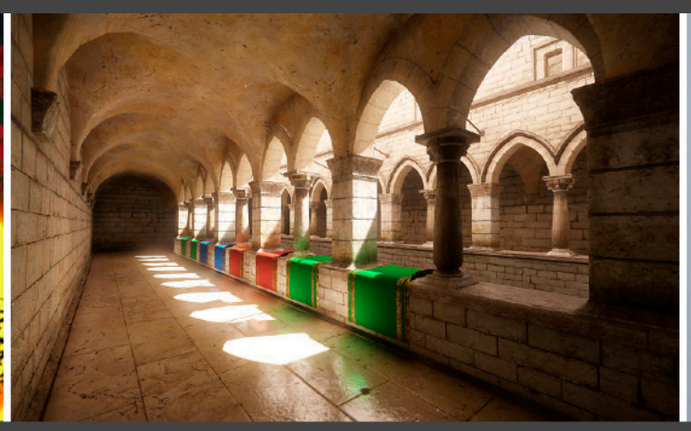
Real-Time High Quality Rendering

GAMES202, Lingqi Yan, UC Santa Barbara

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)

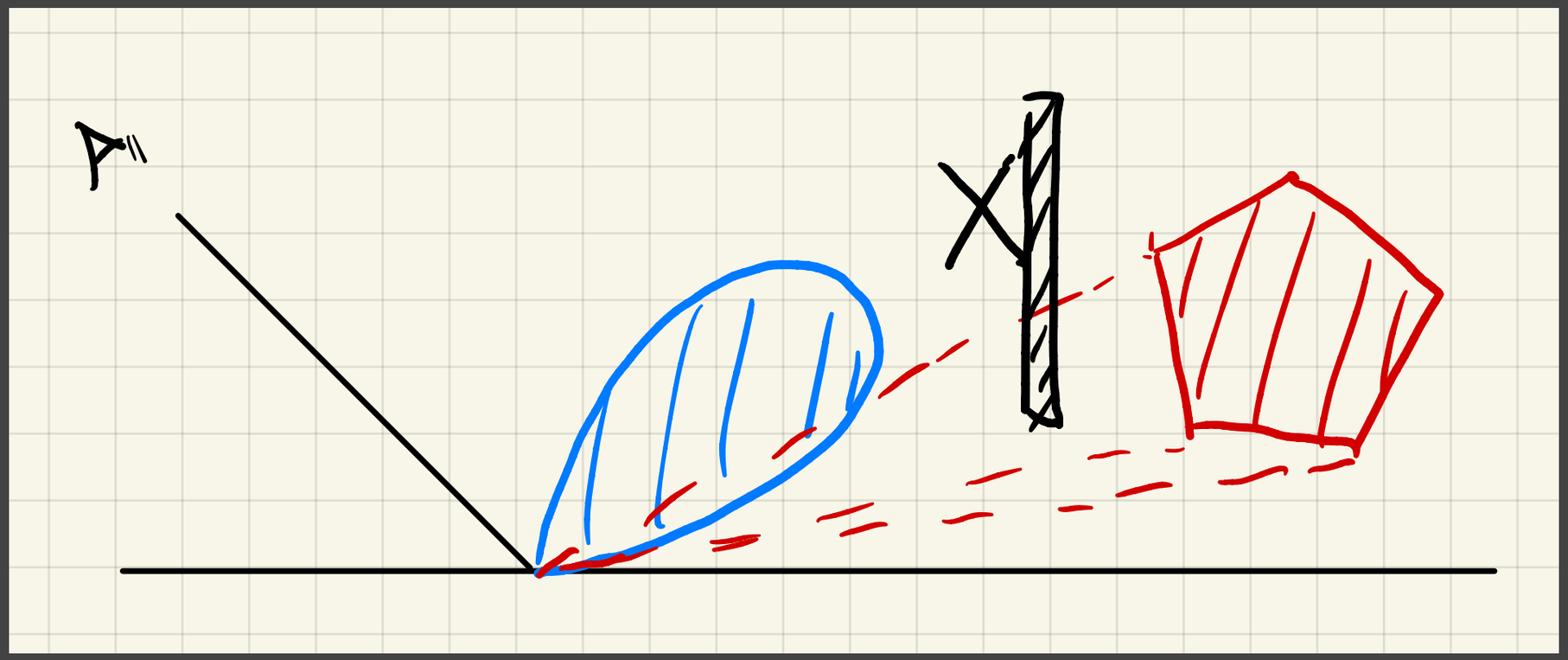
Today

- 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)

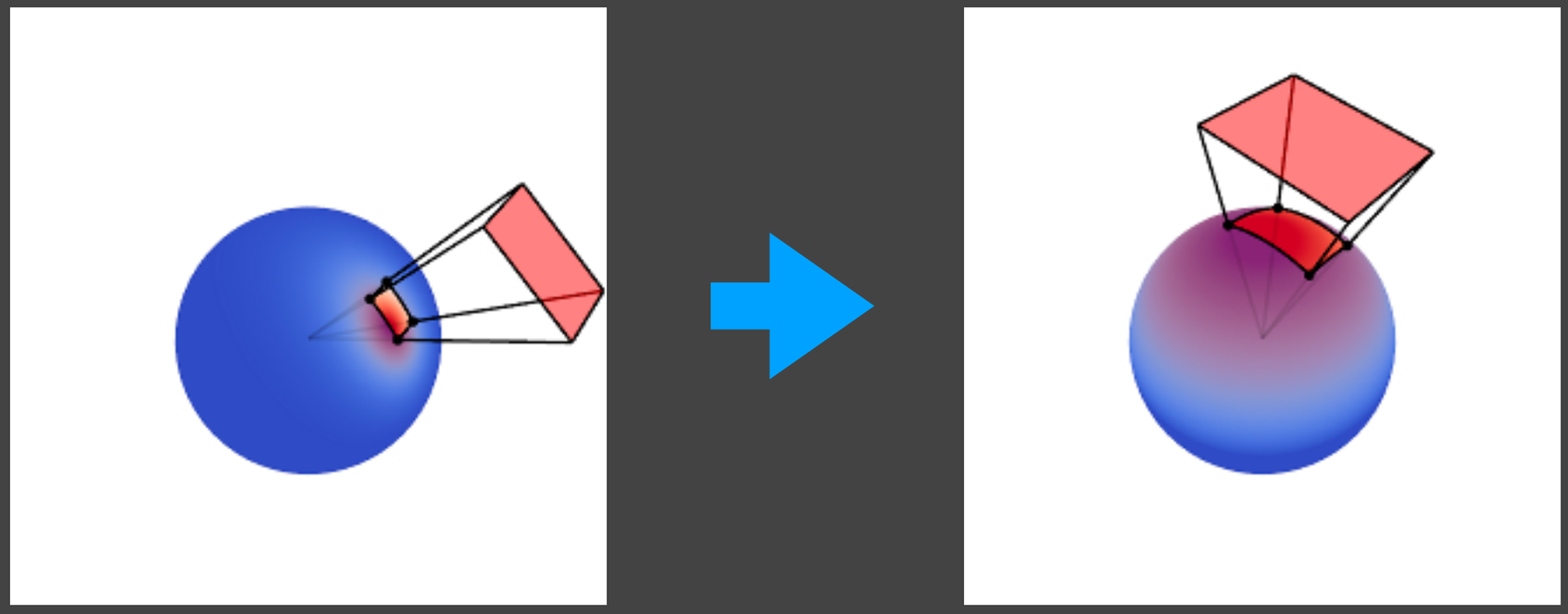
Linearly Transformed Cosines

- Solves the shading of microfacet models
  - Mainly on GGX, though others are also fine
  - No shadows
  - Under polygon shaped lighting



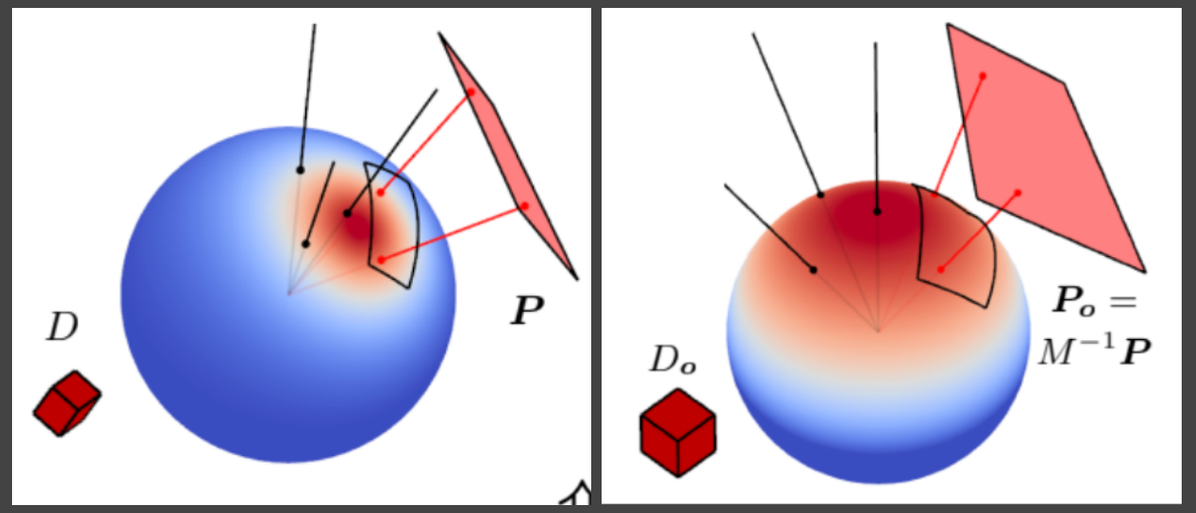
Linearly Transformed Cosines

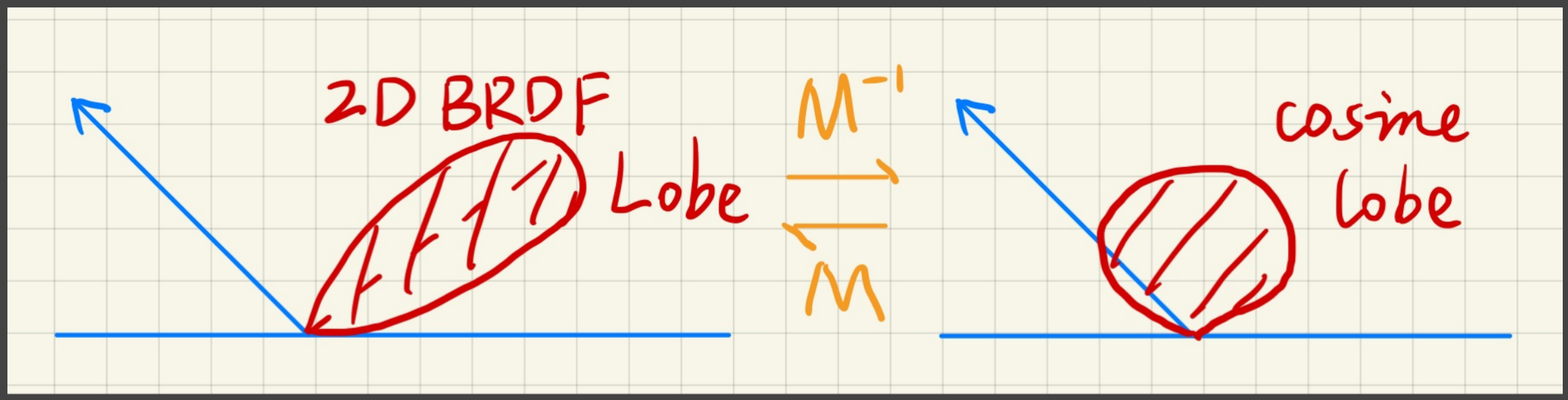
- Key idea
  - Any outgoing 2D BRDF lobe can be transformed to a cosine
  - The shape of the light can also be transformed along
  - Integrating the transformed light on a cosine lobe is **analytic**



Linearly Transformed Cosines

- Observations
  - BRDF $\xrightarrow{M^{-1}}$ Cosine
  - Direction: $\omega_i \xrightarrow{M^{-1}} \omega_i'$
  - Domain to integrate: $P \xrightarrow{M^{-1}} P'$





Linearly Transformed Cosines

- Approach
  - A simple change of variable

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

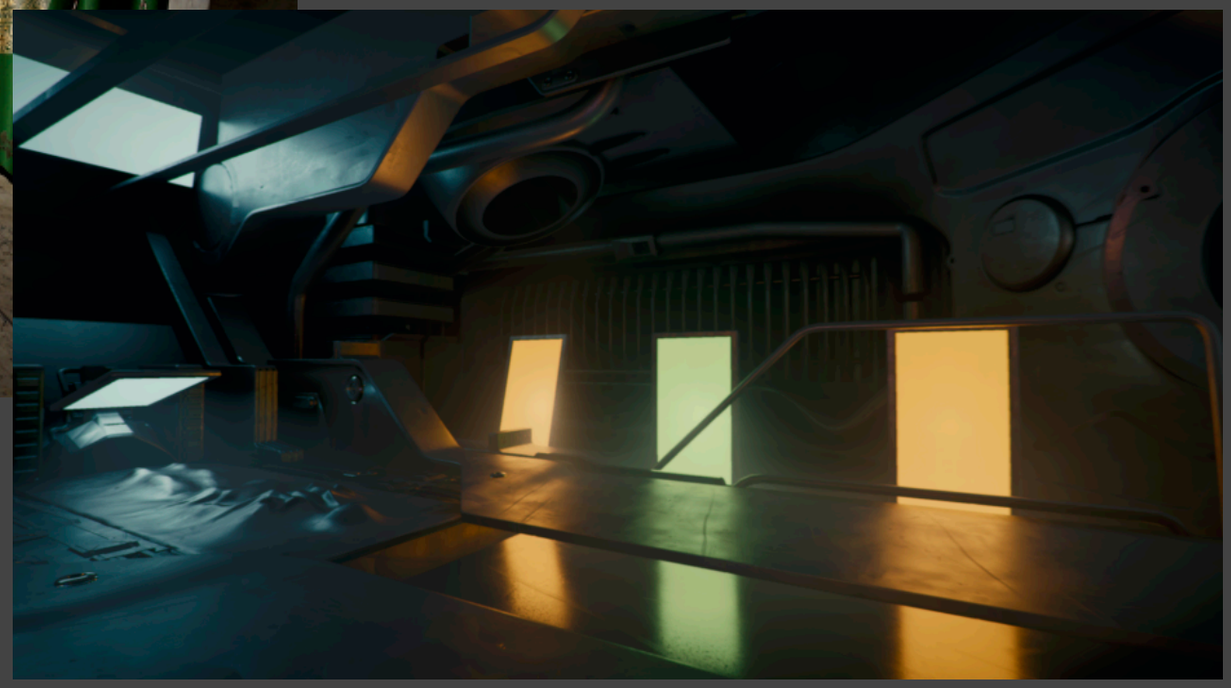
$$L(\omega_o) = L_i \cdot \int_P F(\omega_i)\,\mathrm{d}\omega_i$$

$$= L_i \cdot \int_P \cos(\omega_i')\,\mathrm{d}\frac{M\omega_i'}{\|M\omega_i'\|}$$

$$= L_i \cdot \int_{P'} \cos(\omega_i')J\,\mathrm{d}\omega_i' \quad \text{– Analytic!}$$

Linearly Transformed Cosines

- Results



Questions?

Disney's Principled BRDF

Why is it needed?

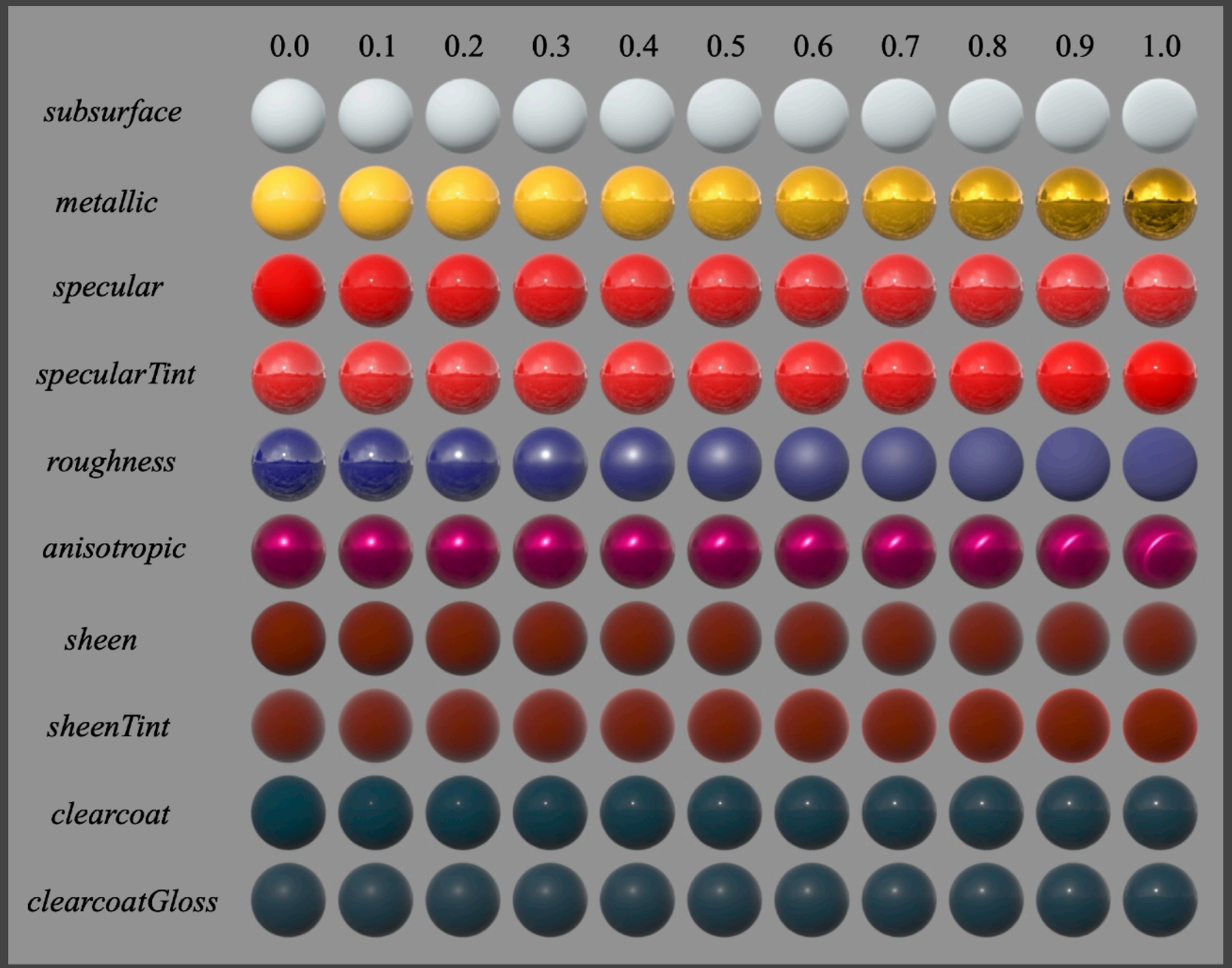
- Motivation
  - No physically-based materials are good at rep. all real materials
    - e.g. lacking diffuse term in most microfacet models
  - Physically-based materials are not artist friendly
    - e.g. “the complex index of refraction n-ik”
- High level design goal
  - Art directable, not necessarily physically correct
  - But again, referred to as PBR in real-time rendering…

What is “principled”?

- The BRDF is designed with a few important principles
  - Intuitive rather than physical parameters should be used.
  - There should be as few parameters as possible.
  - Parameters should be zero to one over their plausible range.
  - Parameters should be allowed to be pushed beyond their plausible range where it makes sense.
  - 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
- A wide range of materials in a single model
- Open source implementation is available
- Not physically based
  - But is it a big problem?
  - Academia vs. industry
- Huge parameter space

Questions?

Non-Photorealistic Rendering (NPR)

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stylization

In real-time rendering,

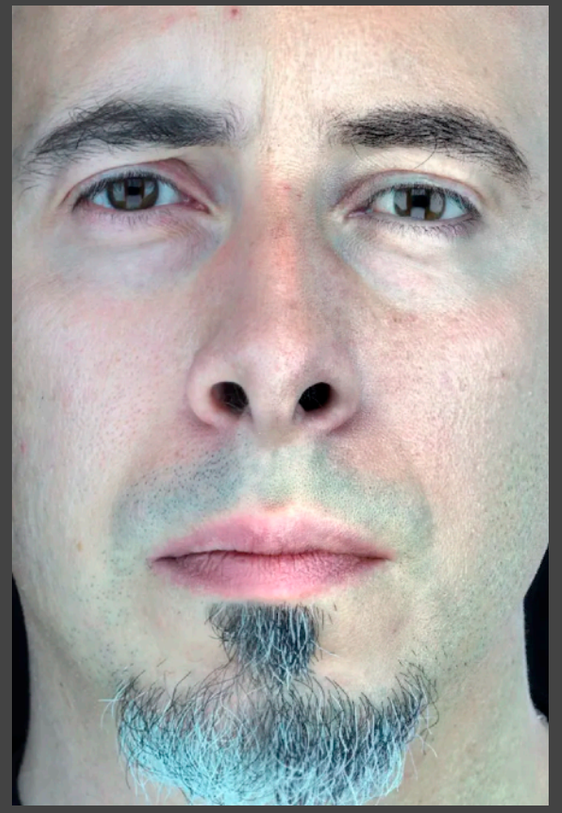
Non-Photorealistic Rendering (NPR)

==

(fast and reliable) stylization

Photorealistic Rendering

- Goal
  - Indistinguishable from photos
  - Focus: lighting, shadows, materials, etc.



Non-Photorealistic Rendeirng (NPR)

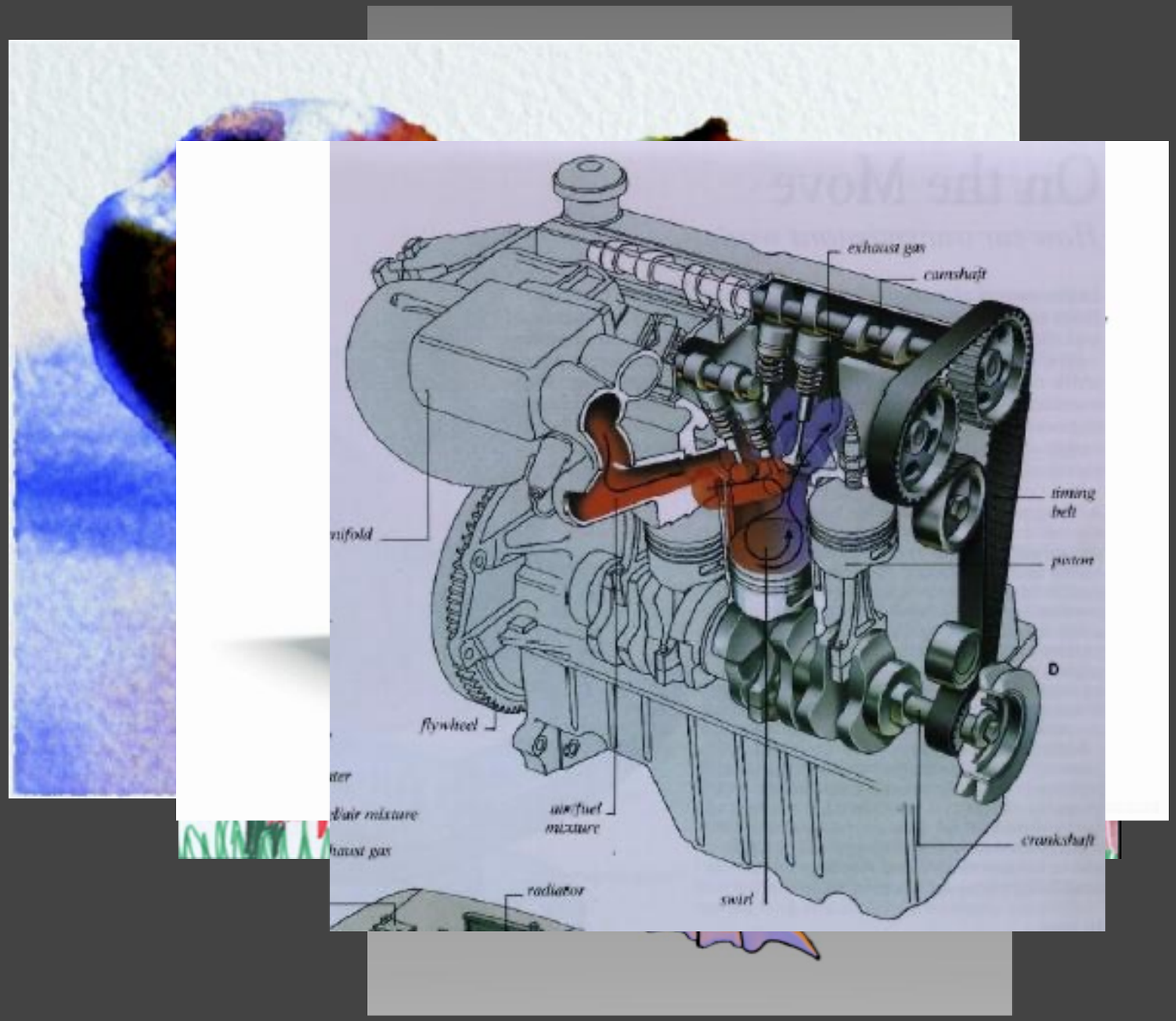
- Goal
  - Producing artistic appearances

Characteristics of NPR

- Starts from photorealistic rendering
- Exploits abstraction
- Strengthens important parts

Applications of NPR

- Art
- Visualization
- Instruction
- Eduation
- Entertainment
- …



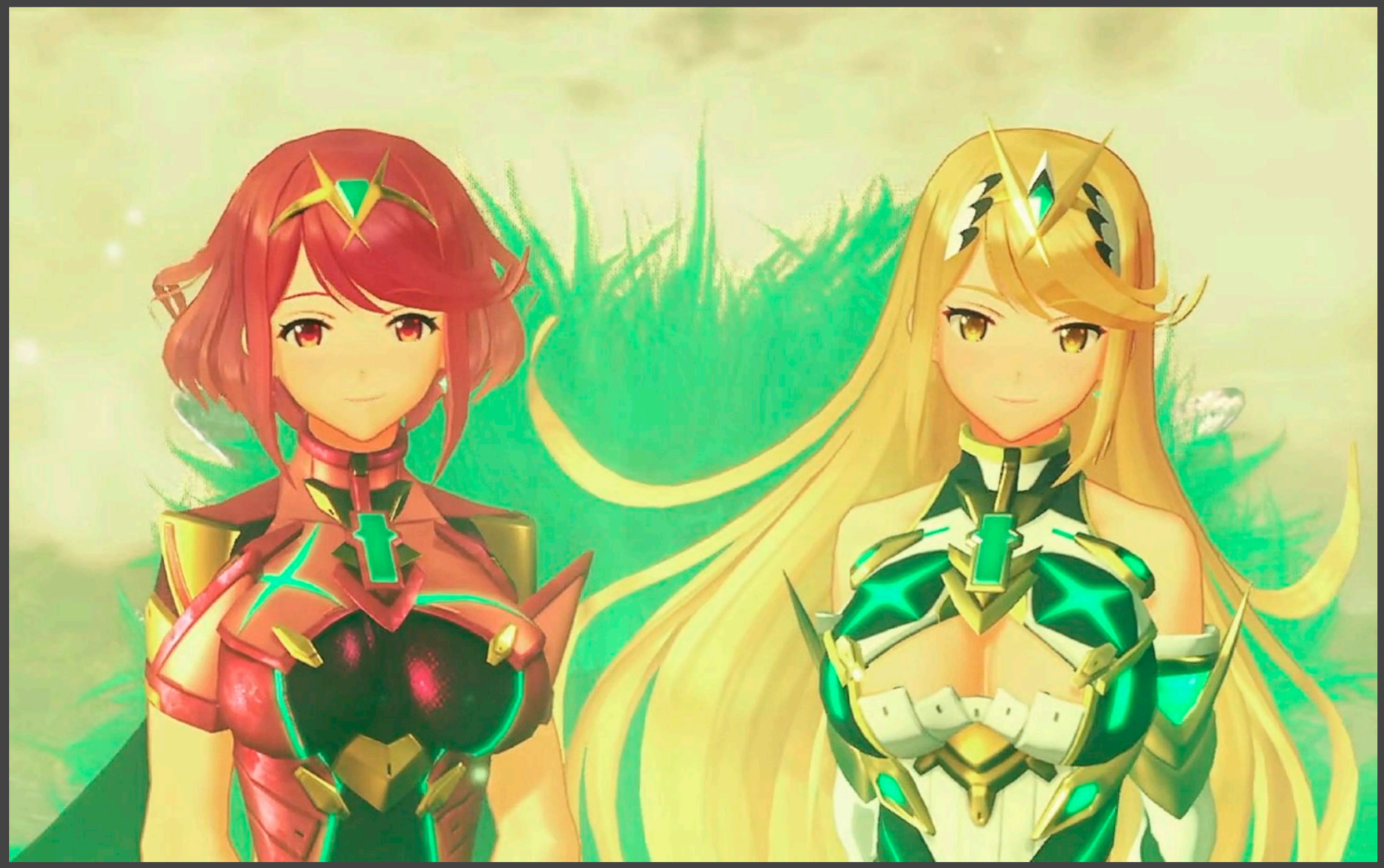
Applications of NPR

[Atelier Ryza 2: Lost Legends & the Secret Fairy]

[Attack on Titan, Season 4]

What are Styles?

- Can we summarize styles from this image?



[Xenoblade Chronicles 2]

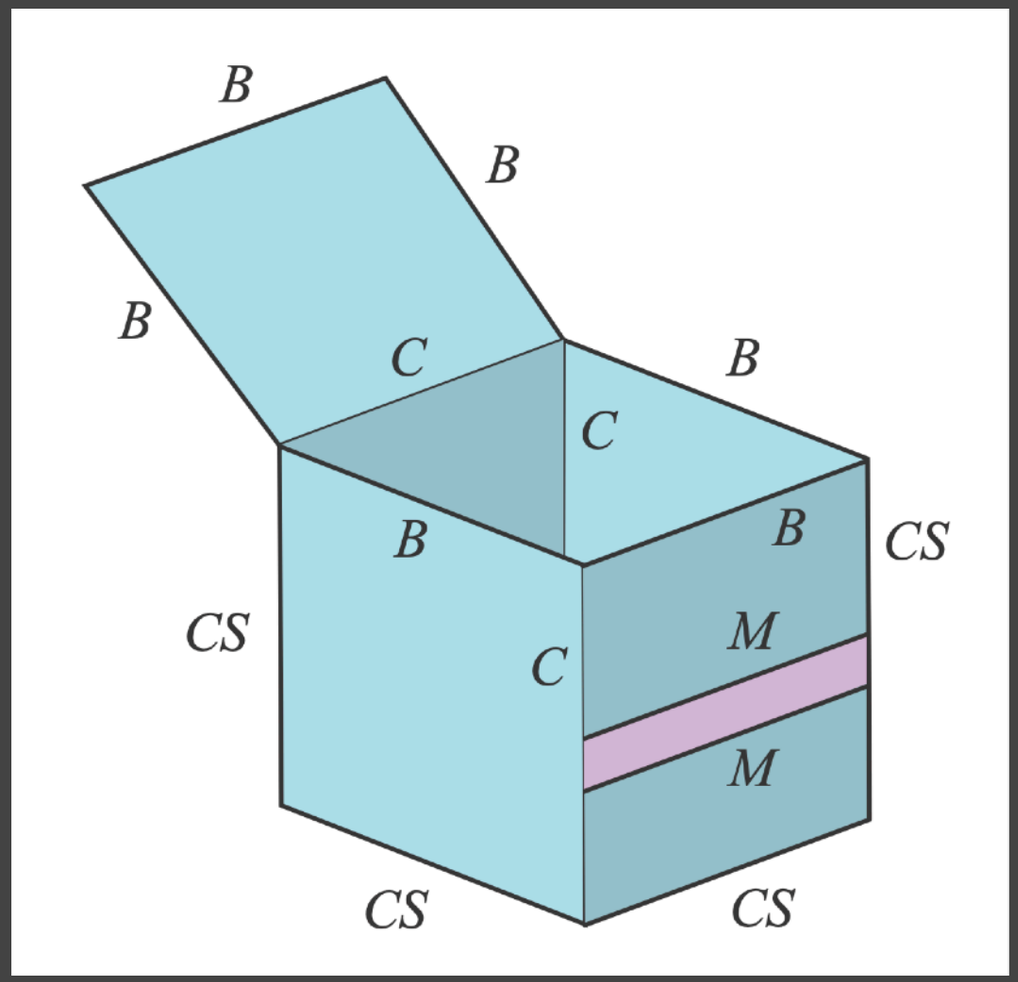
What are Styles?

- Can we summarize styles from this image?
  - Bold contours (actually, outlines)
  - Blocks of colors
  - Strokes on surfaces

Borderlands 3 (2019)

Outline Rendering

- Outlines are not just contours
  - [B]oundary / border edge
  - [C]rease
  - [M]aterial edge
  - [S]ilhouette edge

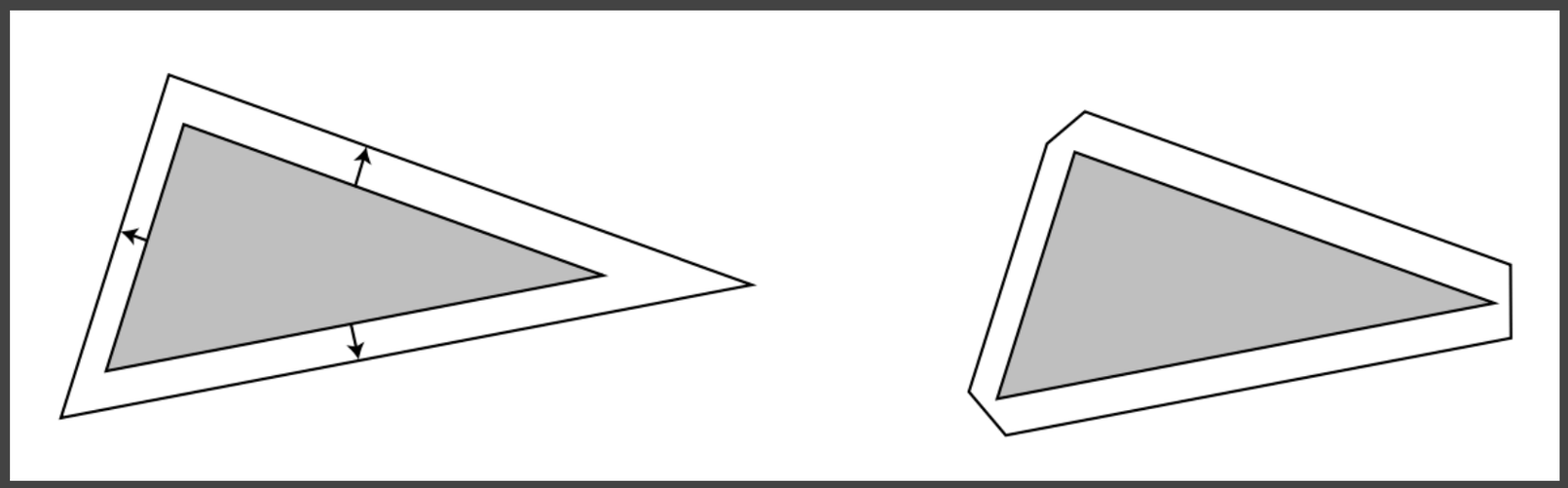


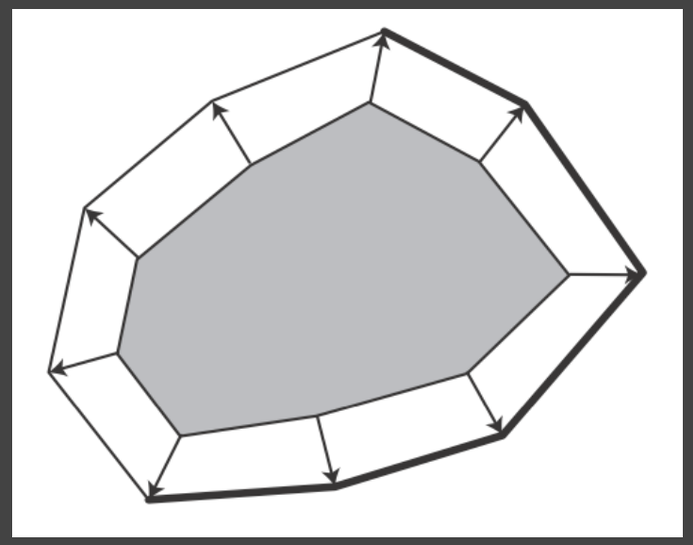
Outline Rendering -- Shading

- Shading normal contour edges
  - Darken the surface area where the shading normal is perpendicular to viewing direction

Outline Rendering -- Geometry

- Backface fattening
  - Render frontface normally
  - “Fatten” backfaces, then render again
  - Extension: fatten along vertex normals



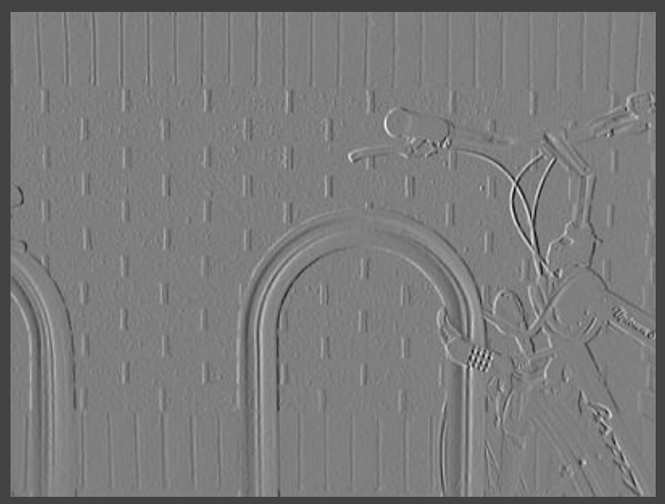


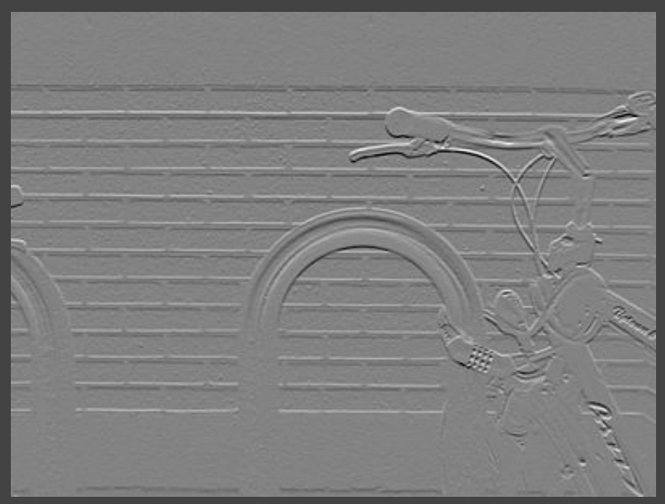
Outline Rendering -- Image

- Edge detection in images
  - Usually use a Sobel detector

1	0	-1
2	0	-2
1	0	-1

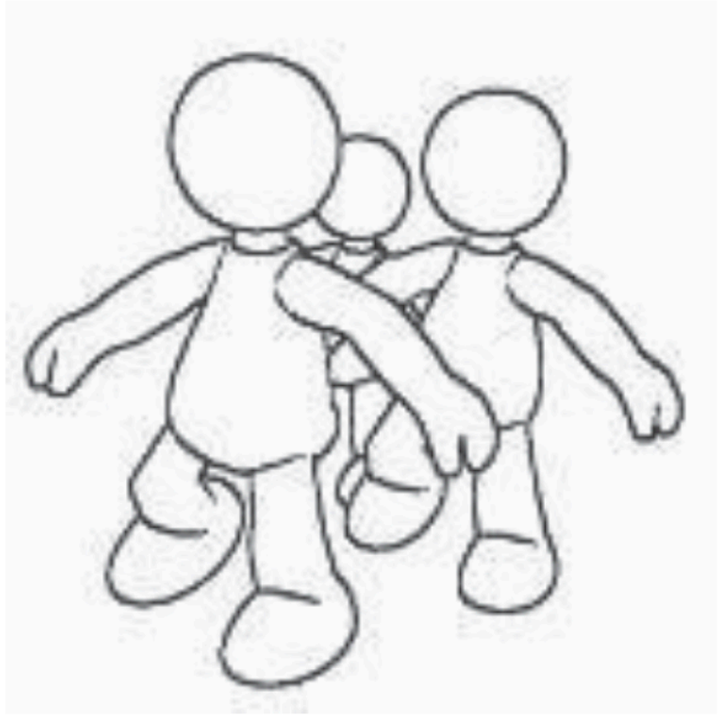
-1	-2	-1
0	0	0
1	2	1





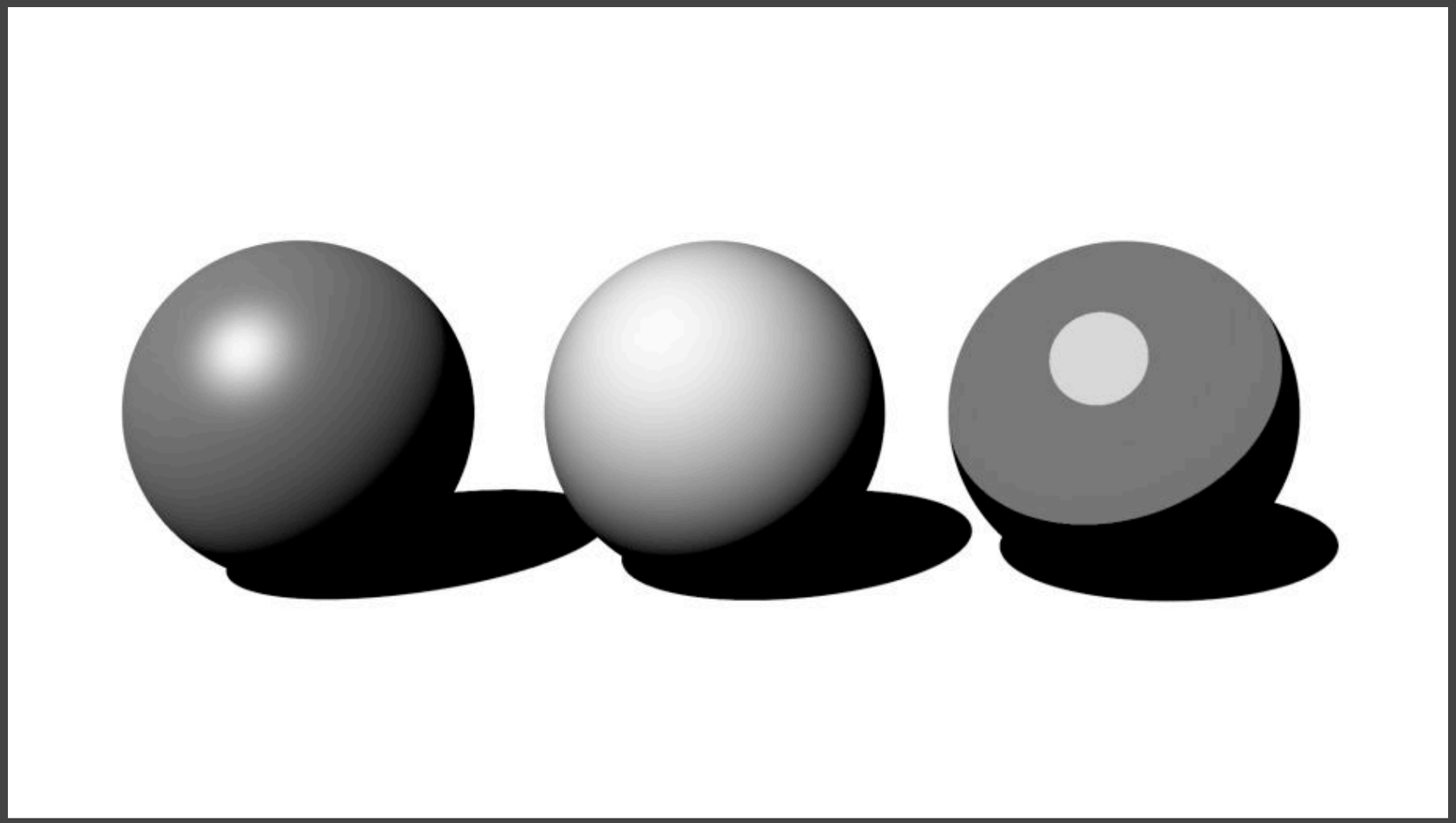
Outline Rendering -- Image

- Edge detection in images
  - May work on different information



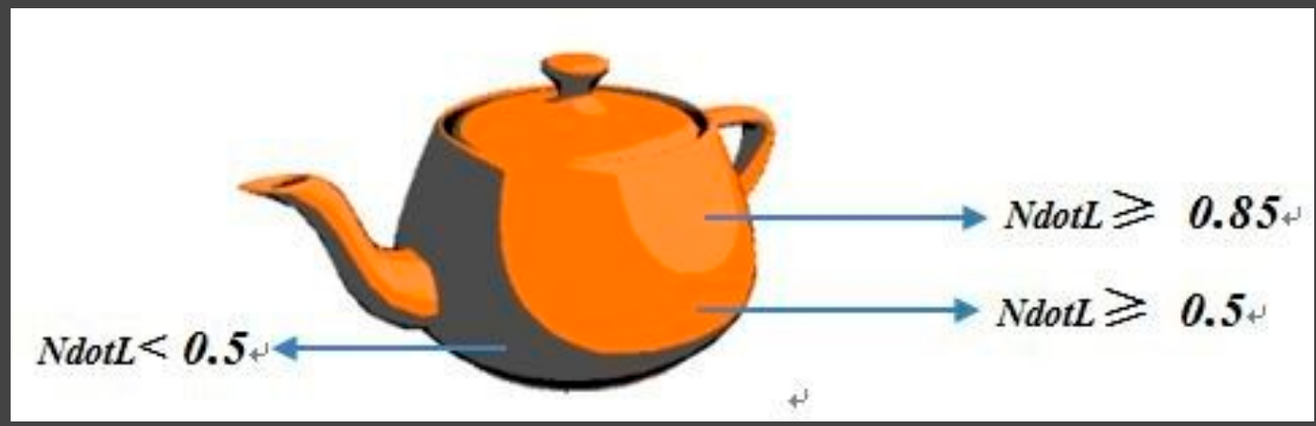
Color blocks

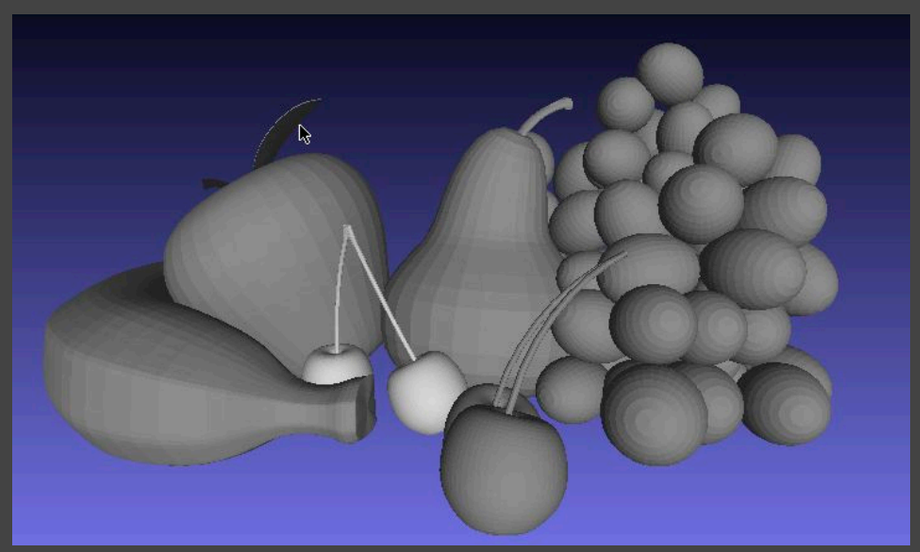
- Two different ways
  - Hard shading: thresholding on shading
  - Posterization: thresholding on final image color



Color blocks

- May not be binary
  - Quantization



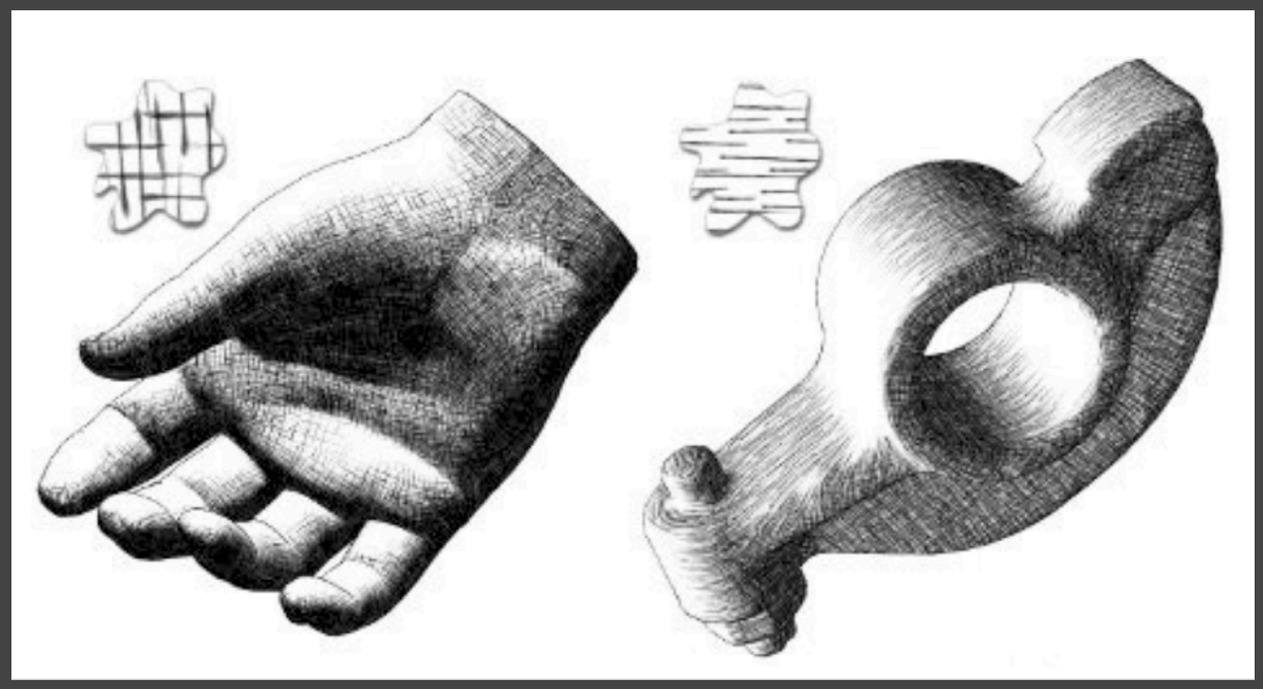


Color blocks

- Different styles on different components

Strokes Surface Stylization

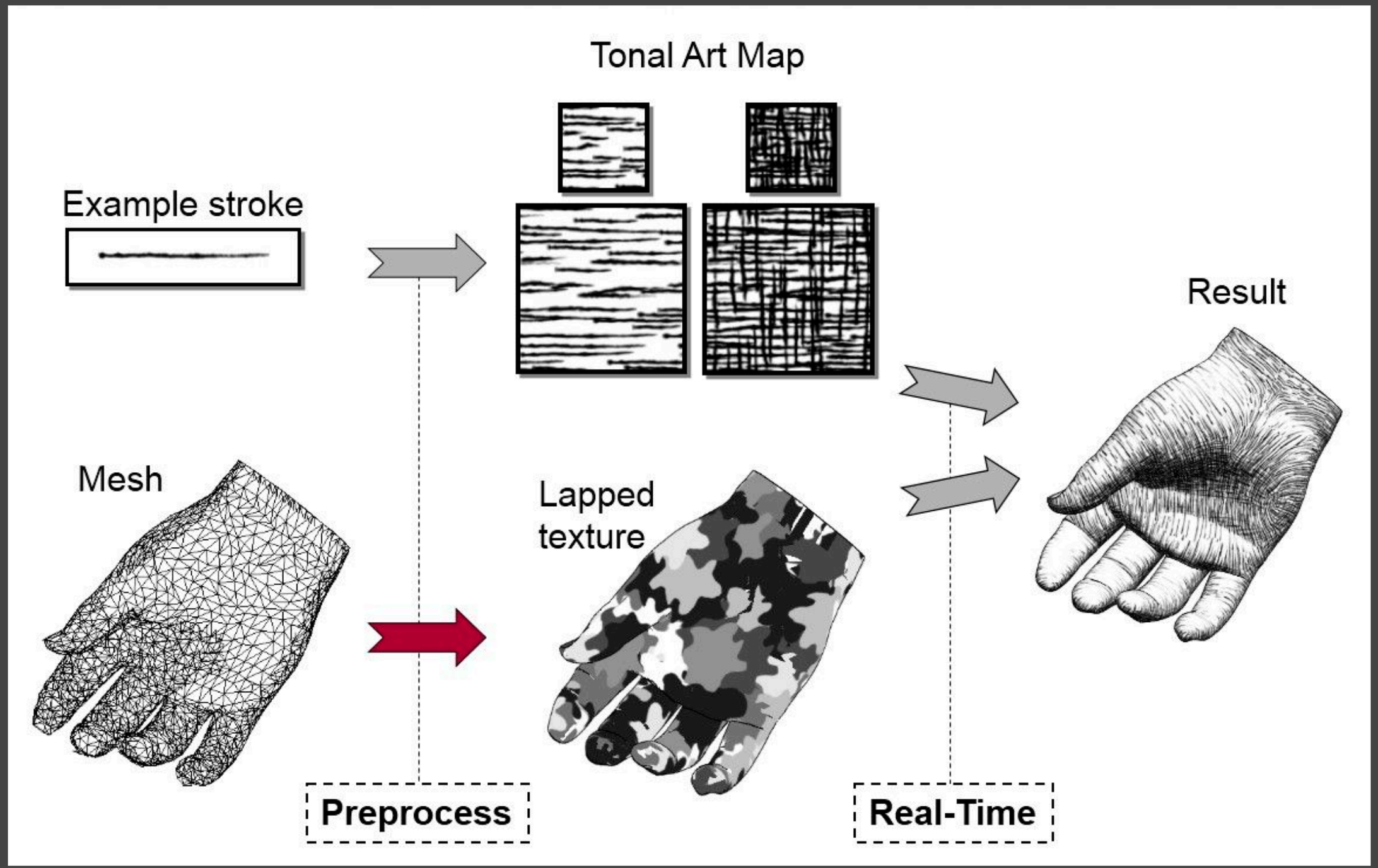
- Sometimes you do not want color blocks
- Instead you want to mimic sketching
- Idea
  - Replace point-wise shading with pre-generated stroke textures
  - Density?
  - Continuity?



Strokes Surface Stylization

- Tonal art maps (TAMs)
  - Strokes of different densities
  - Each density has a MIPMAP

Strokes Surface Stylization



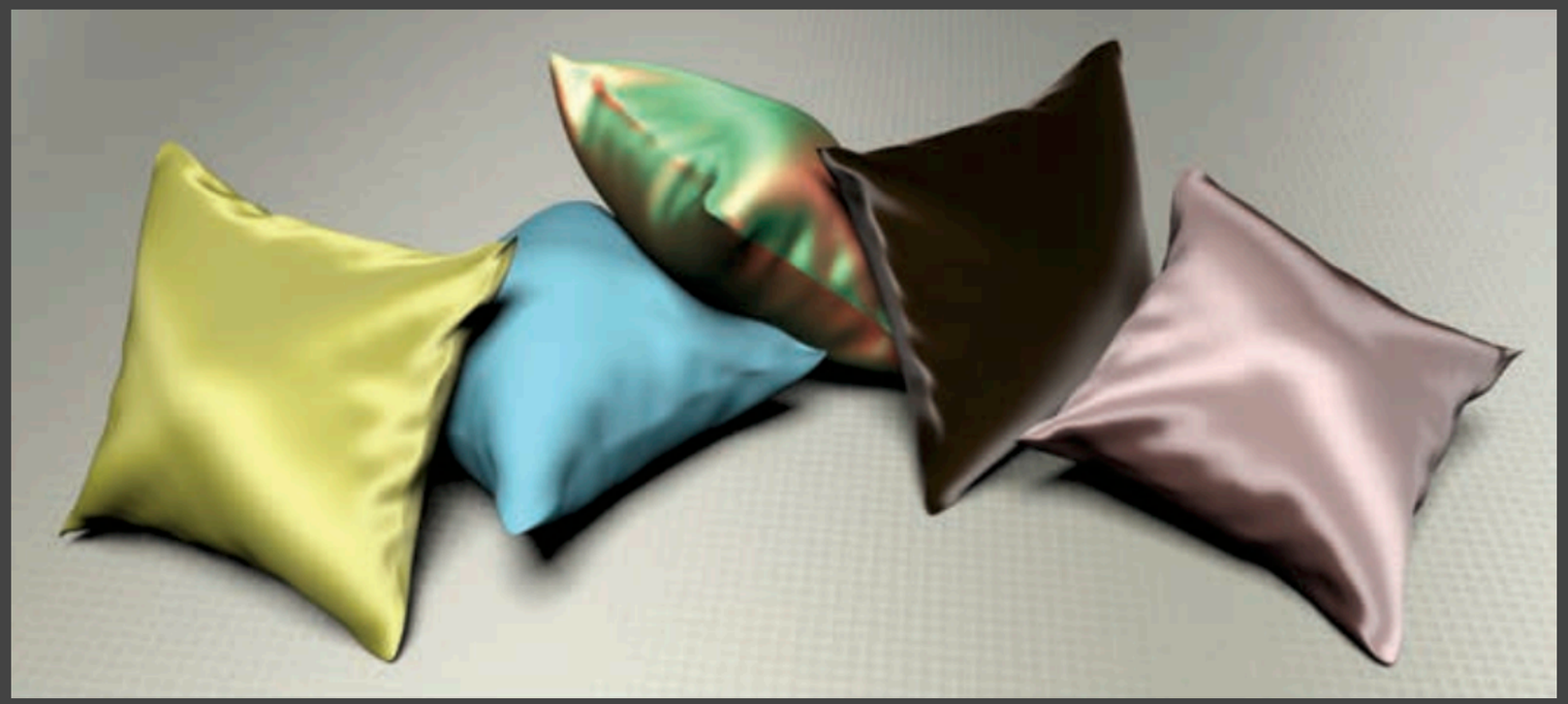
Some Notes

- NPR is art driven
- But you need the ability to “translate” artists’ needs into rendering insights
  - e.g. edge
- Communication is important
- Sometimes, per character, even per part

Key Observations

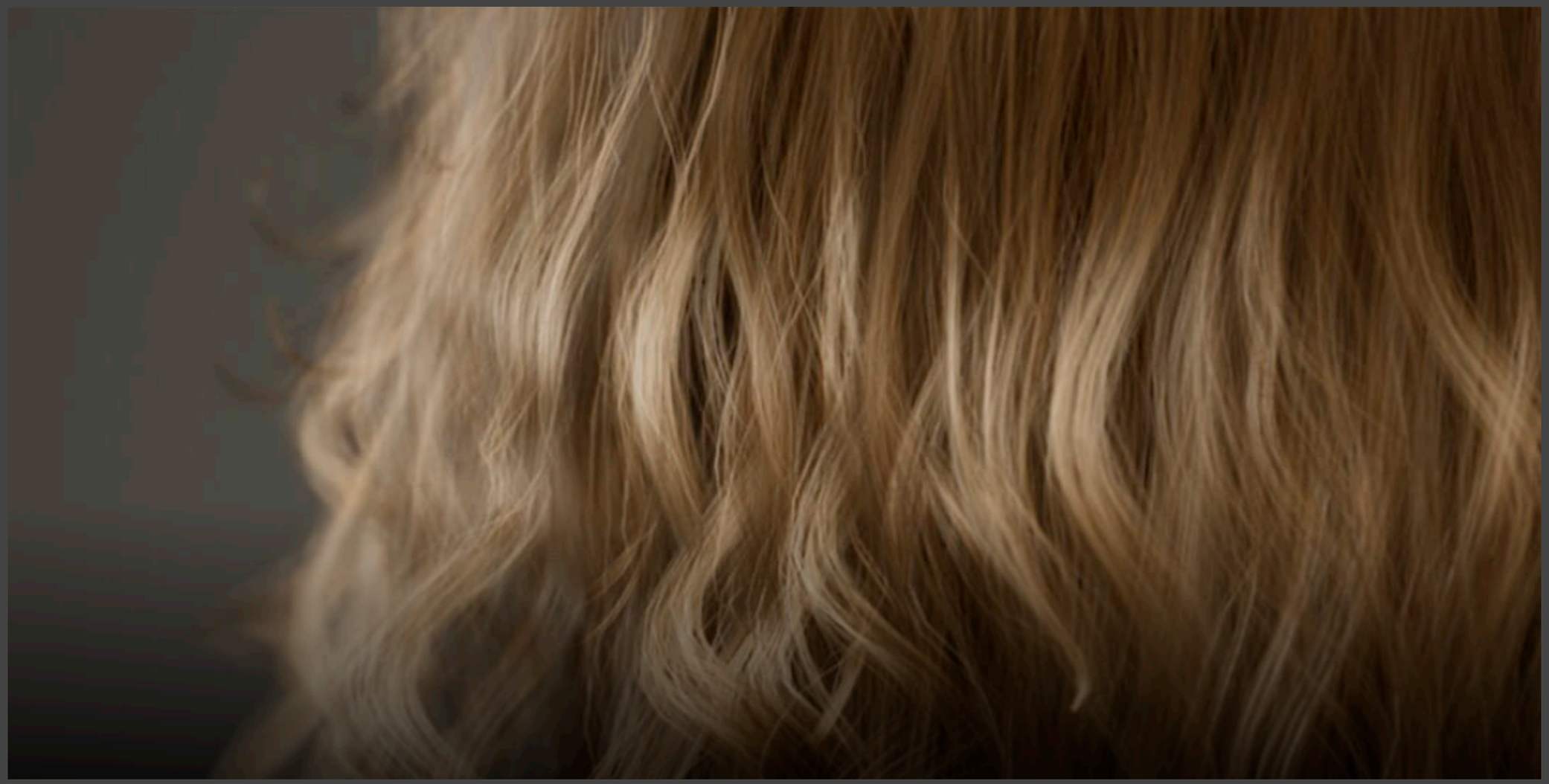
- Something people still haven’t paid much attention to
  - Photorealistic models are super important in NPR
- Example: cloth

[Sadeghi et al.]



Next Lecture

- Real-Time Physically-Based Materials (scattering models)



https://docs.unrealengine.com/en-US/WorkingWithContent/Hair/index.html

Thank you!

(And thank Prof. Kun Xu for some of the NPR slides)