Jungdam Won, Yunku Kang, Jonghwa Woo
Seoul National University

DEEP OPACITY MAPS

Overview

- Introduction
  - Shadow Maps
  - Deep Shadow Maps
  - Opacity Shadow Maps
  - Density Clustering
- Deep opacity Maps
  - Motivations
  - Algorithm detail
- Implementation & Results
  - Implementation issues
  - results

Shadow

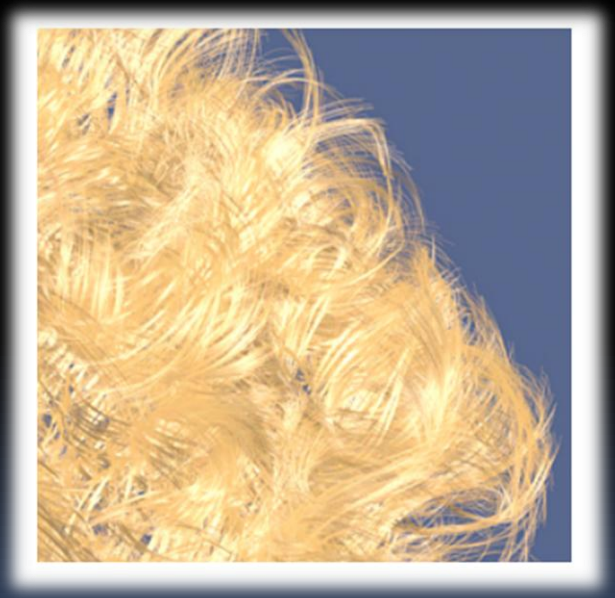
- Definition
  - [NOUN] A shadow is a dark shape on a surface that is made when something stands between a light and the surface

Shadow

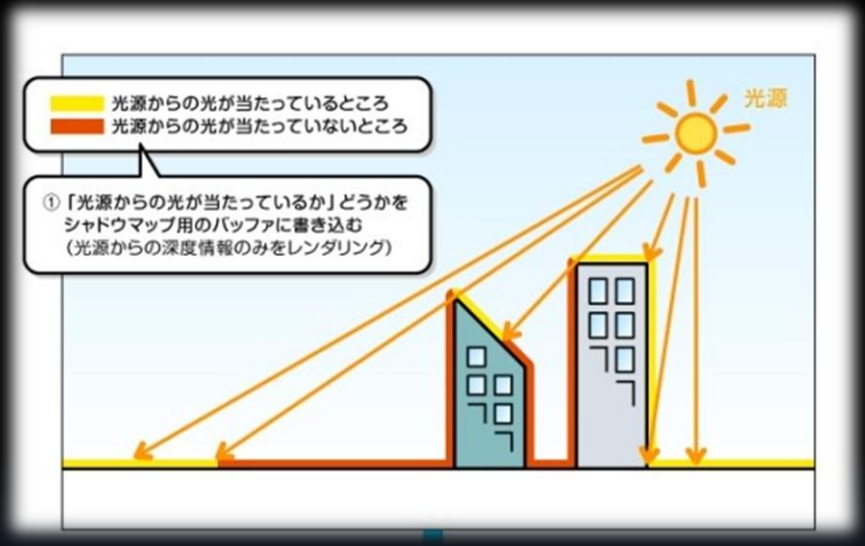
- Importance
  - Criterion of realistic three-dimensional graphics
  - Much information about the settings in a picture
    - Shape, material, location, light source

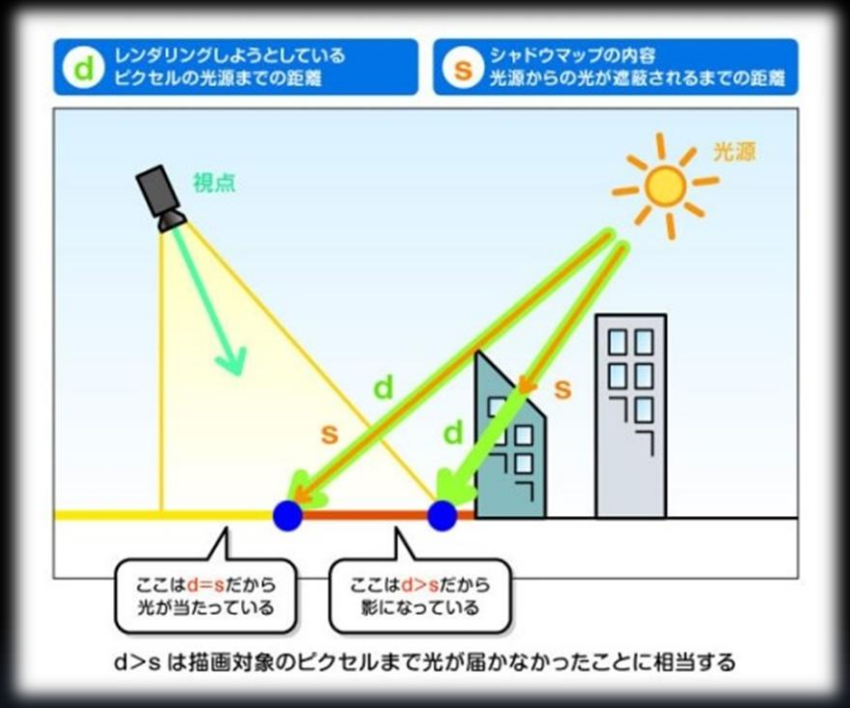
Self-Shadow

- Shadow on themselves and each other



Shadow Maps (1978)





- WILLIAMS L.: Casting curved shadows on curved surfaces. In SIGGRAPH '78 (1978), pp. 270–274.

Deep Shadow Maps (2000)

- LOKOVIC T., VEACH E.: Deep shadow maps. In Proceedings of SIGGRAPH 2000 (2000), pp. 385–392.

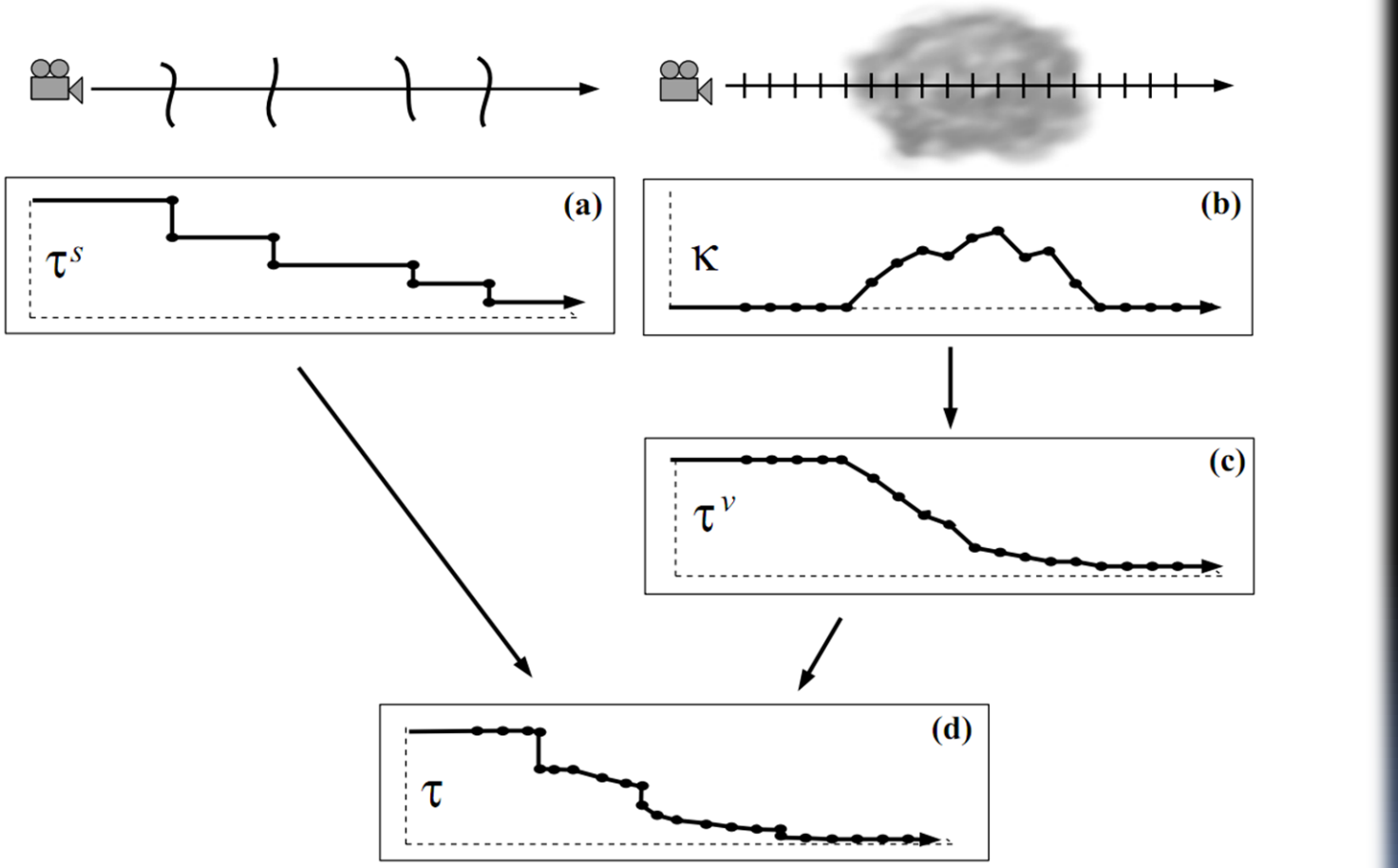
Deep Shadow Maps (cont.)

- Compute visibility function

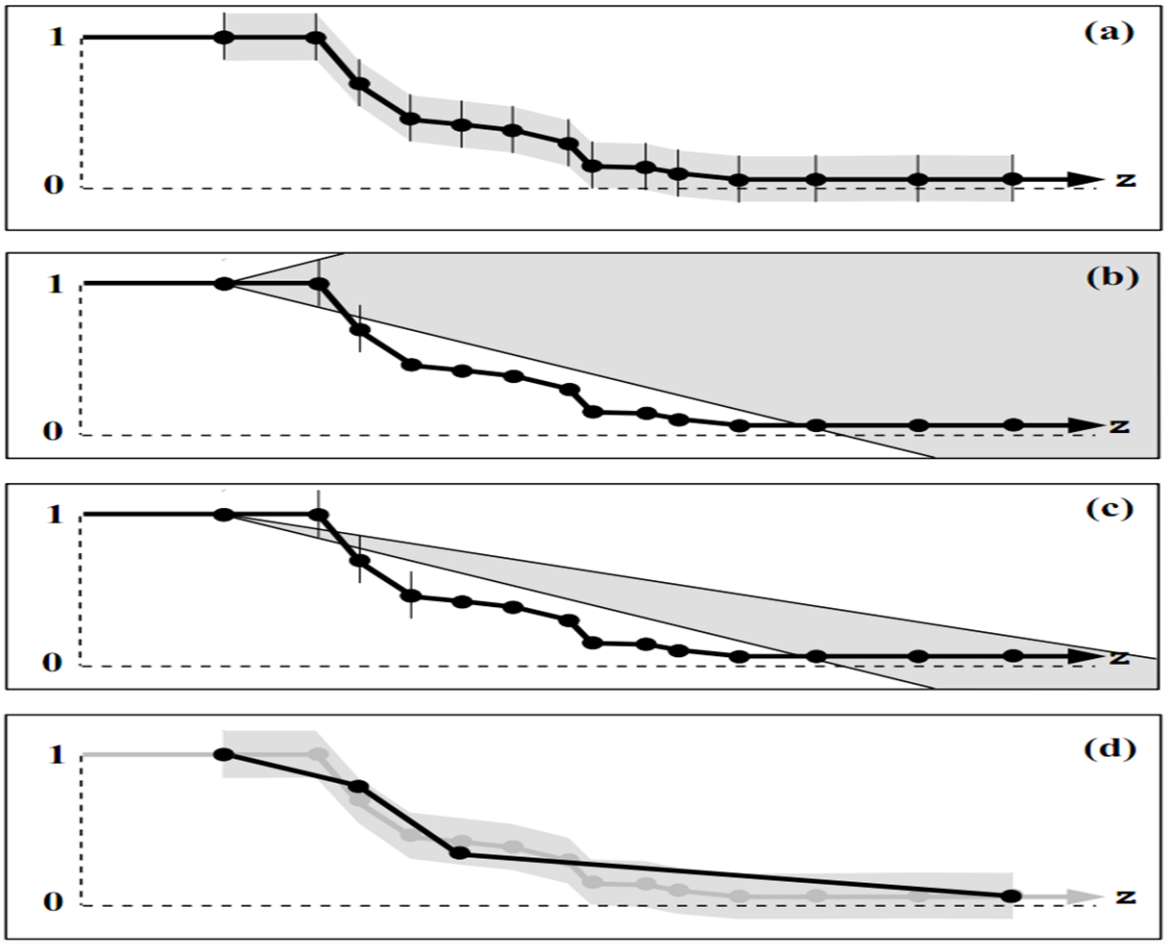
$$\tau(p) = \exp(-\Omega), \text{ where } \Omega = \int_0^l \rho(l')dl'$$

$$V_{i,j}(z) = \int_{-r}^{r}\int_{-r}^{r} f(s,t)\,\tau(i+\tfrac{1}{2}-s, j+\tfrac{1}{2}-t, z)\,ds\,dt\ ,$$

Deep Shadow Maps (cont.)



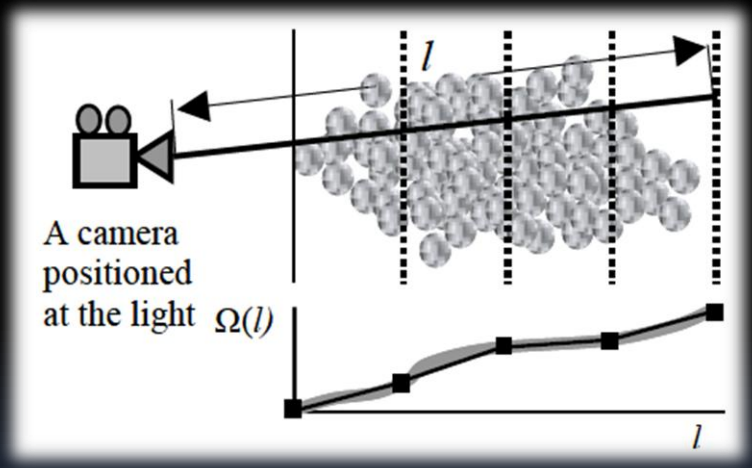
Deep Shadow Maps (cont.)



Opacity Shadow Maps (2001)

- Computing visibility function is heavy!

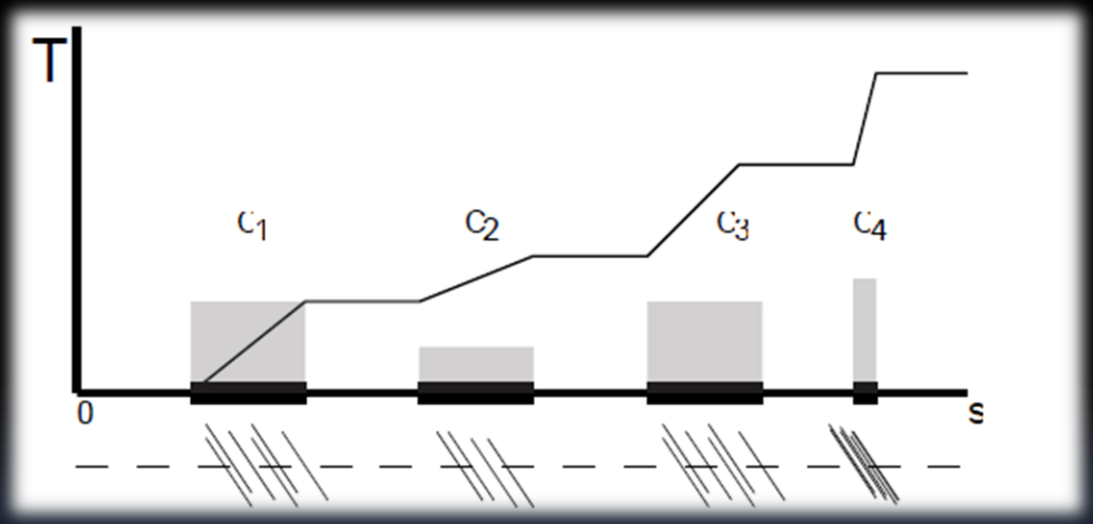
  -> compute only few visibility value and interpolate



- KIM T.-Y., NEUMANN U.: Opacity shadow maps. In 12th Eurographics Workshop on Rendering Techniques (2001), pp. 177–182.

Density Clustering (2004)

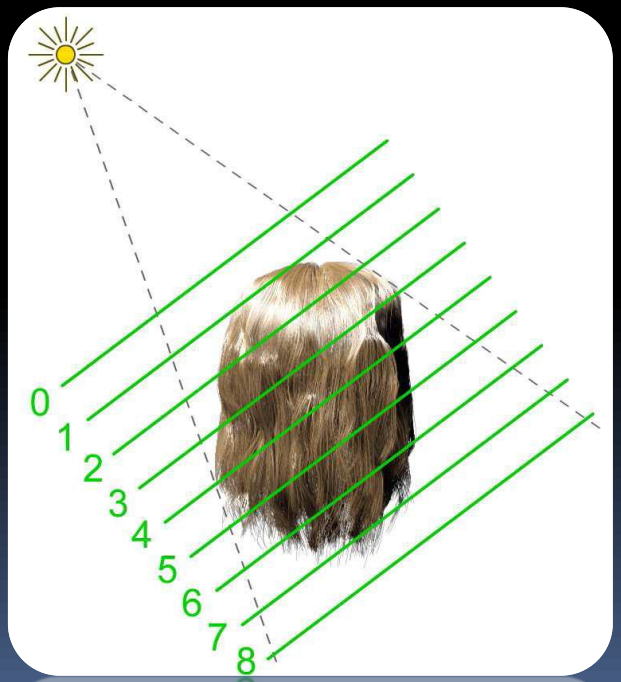
- Compute visibility function simply using clustering



- MERTENS T., KAUTZ J., BEKAERT P., VAN REETH F.: A self-shadow algorithm for dynamic hair using clustered densities. In Proceedings of Eurographics Symposium on Rendering 2004 (2004), pp. 173-178.

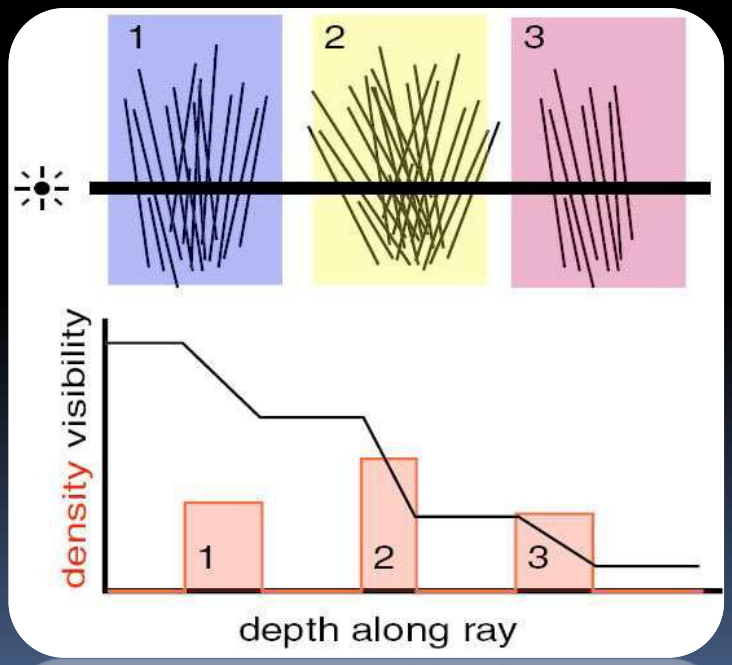
Motivation

Opacity Shadow Maps
- Layering Artifacts!



Motivation (cont.)

Density Clustering
- Inaccuracy Artifacts!



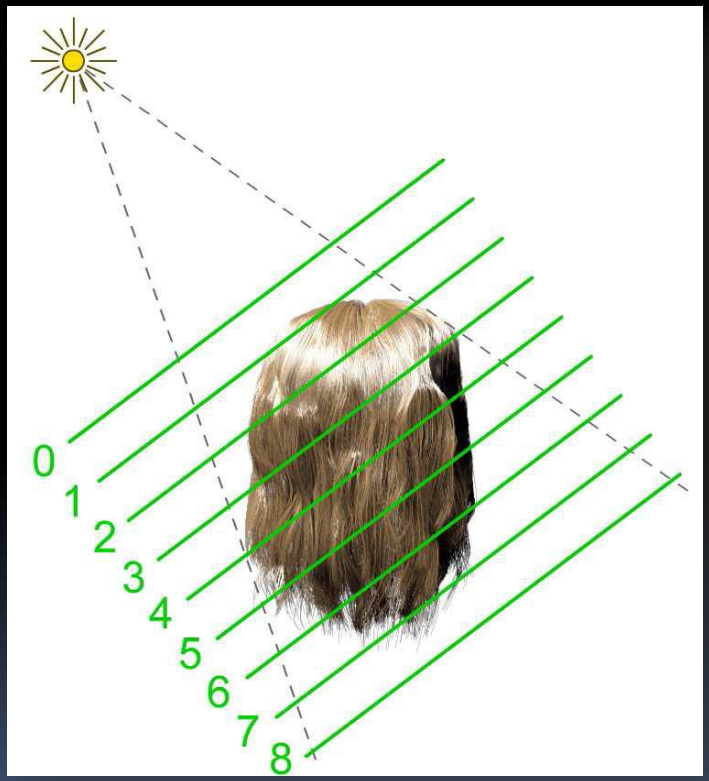
Motivation (cont.)

Deep Opacity Maps

- Artifact Free!

Opacity Shadow Maps

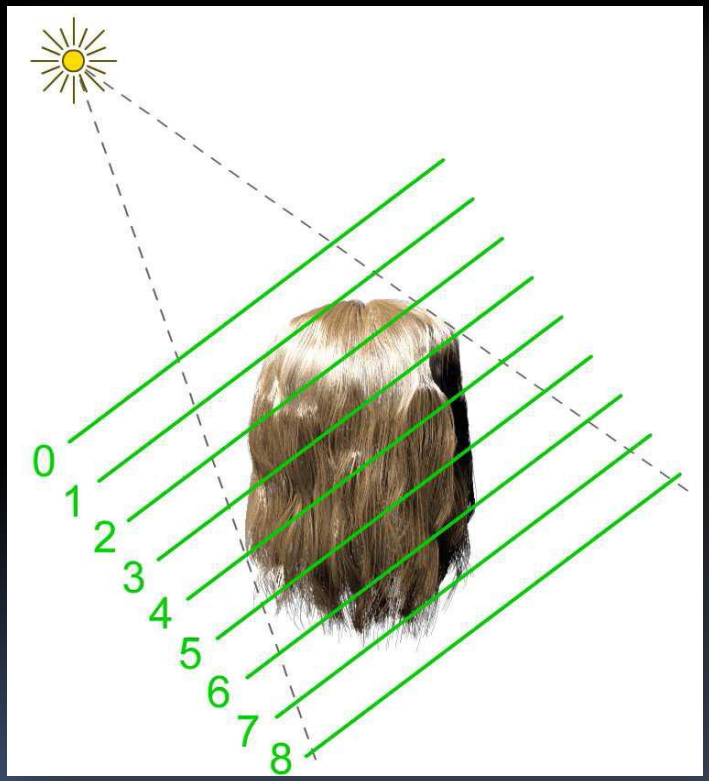
- Overview



Opacity Shadow Maps

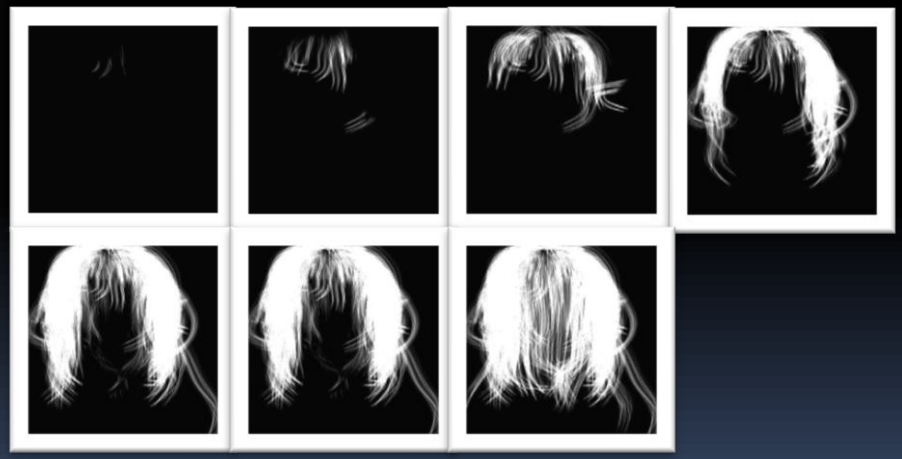
Opacity Shadow Maps

- Overview



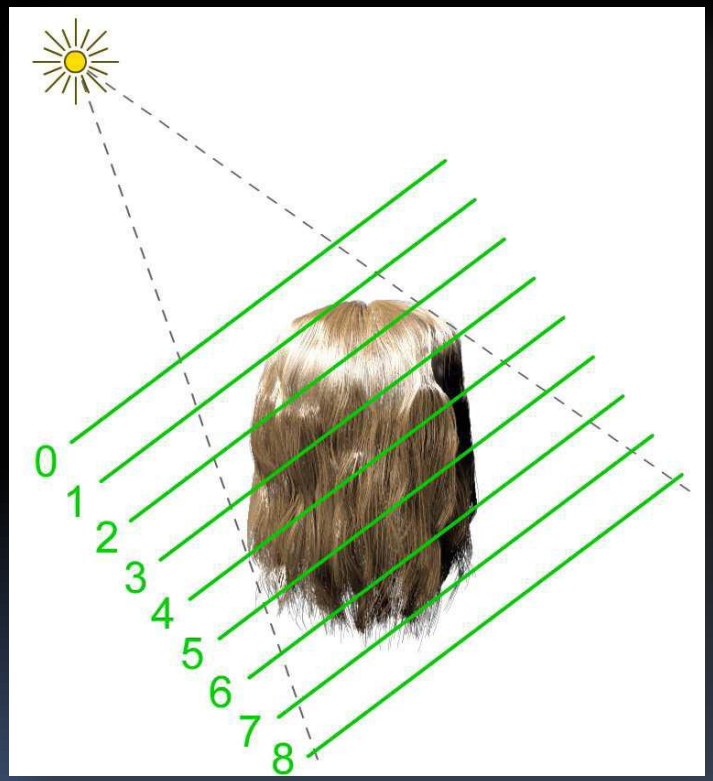
Opacity Shadow Maps

- Pass 1~n: Opacity Map
- Final frame rendering

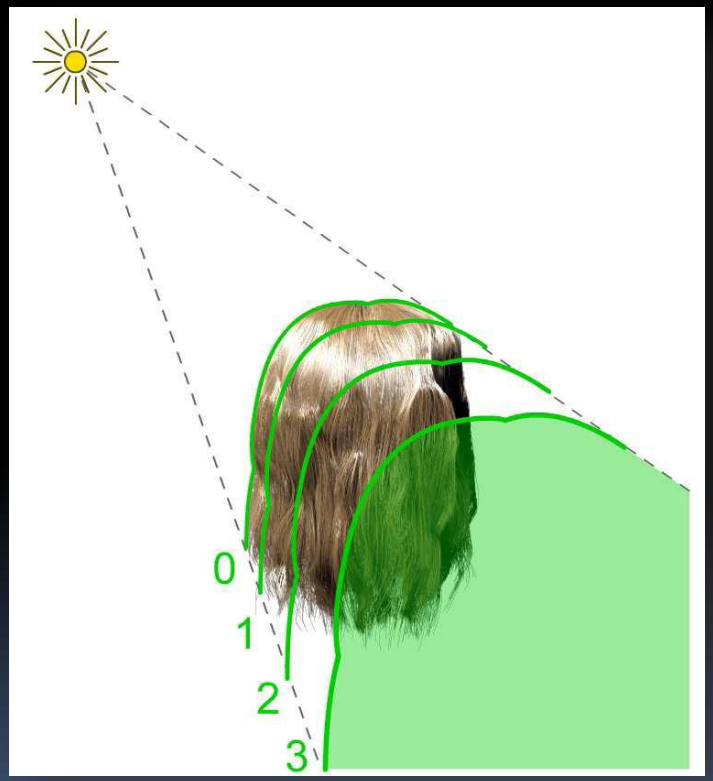


Deep Opacity Maps

- Overview



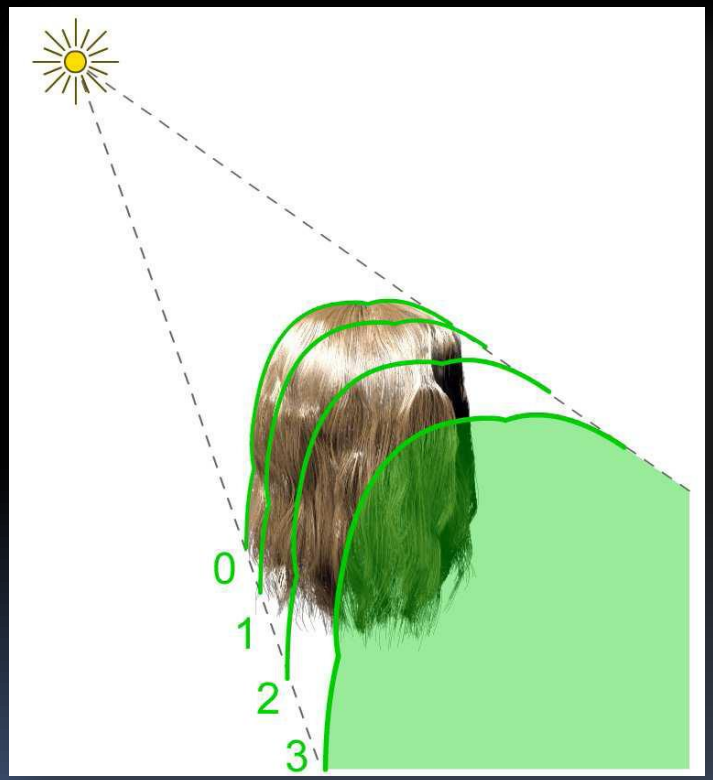
Opacity Shadow Maps



Deep Opacity Maps

Deep Opacity Maps

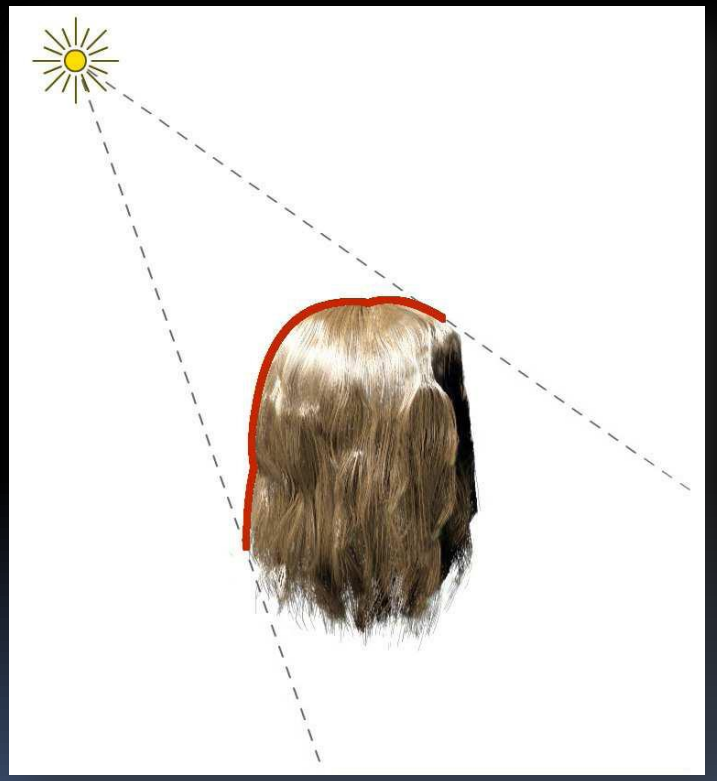
- Overview
  - Pass 1: Depth Map
  - Pass 2: Opacity Map
  - Final frame rendering



Deep Opacity Maps

Deep Opacity Maps

- Pass 1: Depth Map
  - Calculate z_0 per pixel



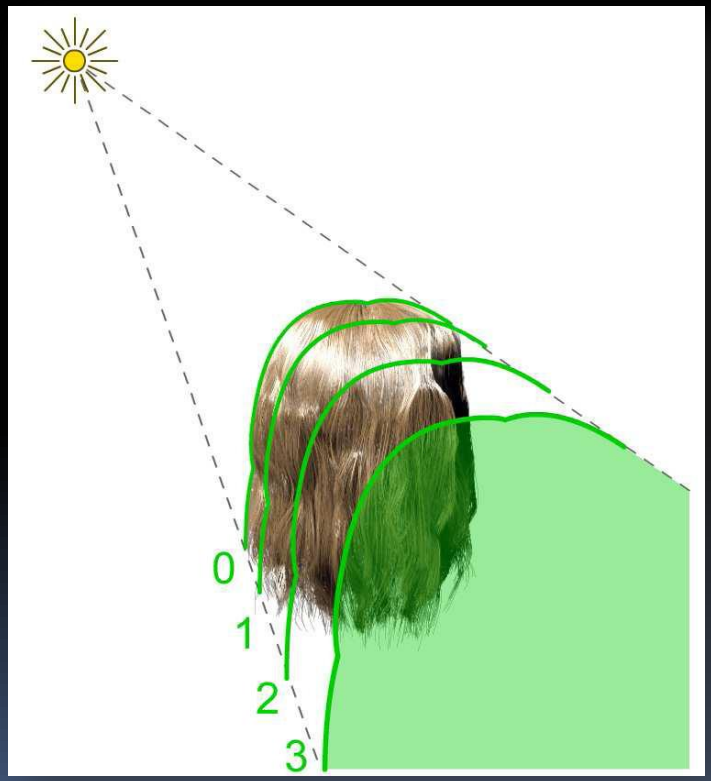
Deep Opacity Maps

- Pass 2: Opacity Map

Layers:

0: z0 ~ z0 + d1
1: z0 + d1 ~ z0 + d2
2: z0 + d2 ~ z0 + d3
…

d1, d2, d3… are user defined



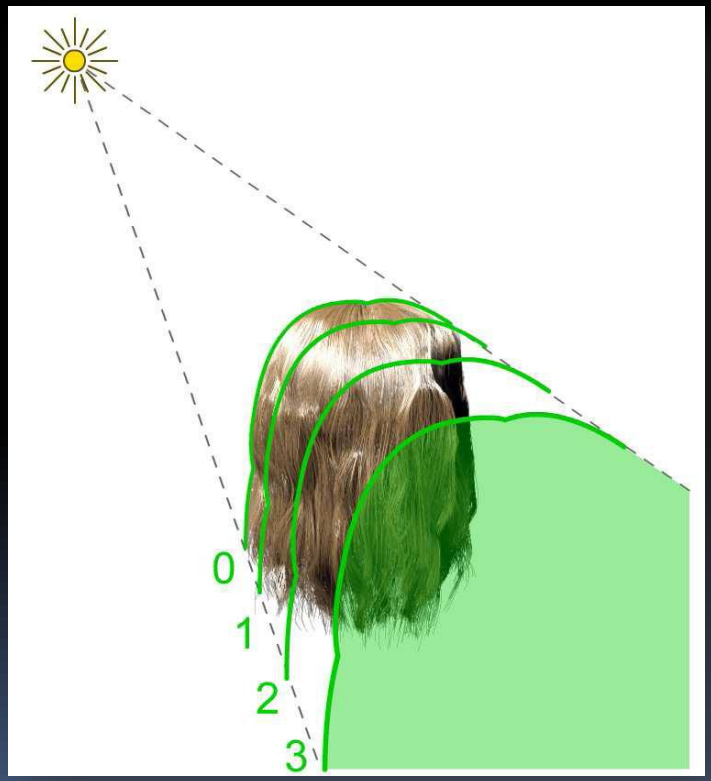
Deep Opacity Maps

- Pass 2: Opacity Map

s = d1

Alternatives:

- s, s, s, s, …(constant)
- s, 2s, 4s, 8s, …(powers of 2)
- s, s, 2s, 3s, 5s, .. (Fibonacci)
- **s, 2s, 3s, 4s, …(linear)**



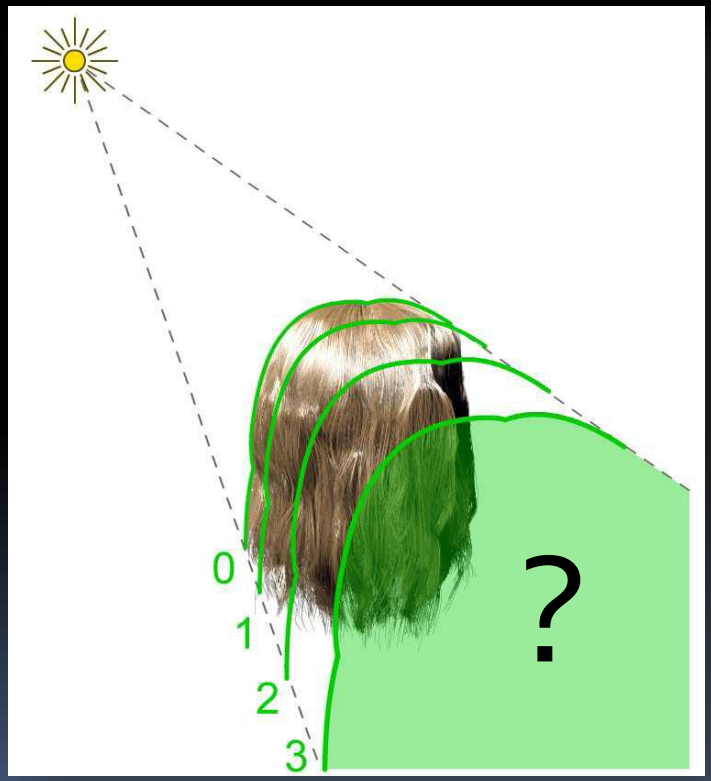
Deep Opacity Maps

- Beyond the last layer

Ignore?
- Won't cast shadows

Add to the last layer?
- Casts shadows on themselves

Increase the last layer size?
- Reduces accuracy



Implementation

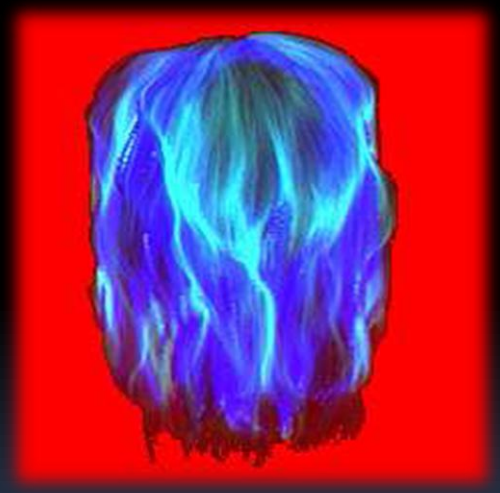
- Depth Map
  - can be 8-bit, 16-bit, or 32-bit
- 3 opacity layers
  - Single Texture

    R: depth (z0)

    G: layer 1 opacity

    B: layer 2 opacity

    A: layer 3 opacity



Implementation (cont.)

- 7, 11, 15…opacity layers
  - Multiple Draw Buffers

R_1: depth (z0)
G_1: layer 1 opacity
B_1: layer 2 opacity
A_1: layer 3 opacity

Texture 1

R_2: layer 4 opacity
G_2: layer 5 opacity
B_2: layer 6 opacity
A_2: layer 7 opacity

Texture 2

OSM
16 layers
81 fps

OSM
128 layers
2.3 fps

DC
4 layers
79 fps

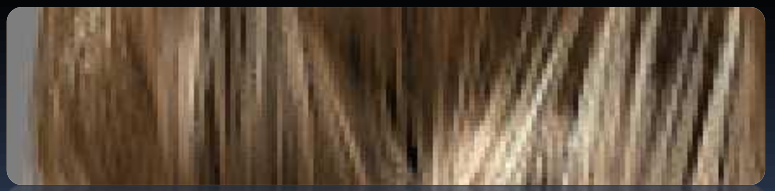
DOM
3 layers
114 fps

OSM
8 layers
88 fps

OSM
256 layers
0.6 fps

DC
4 layers
47 fps

DOM
3 layers
74 fps



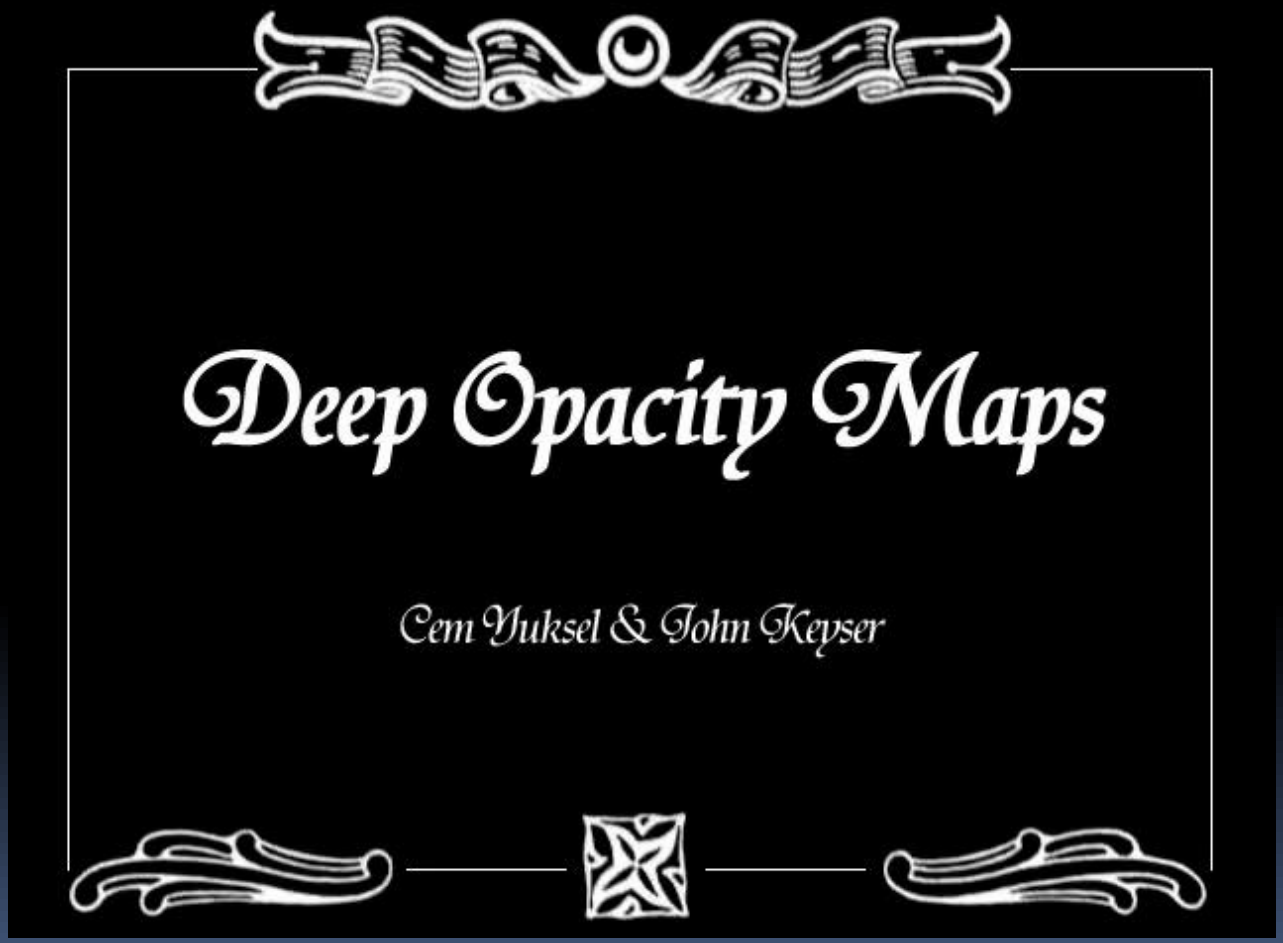
OSM
8 layers
65 fps

OSM
256 layers
0.5 fps

DC
4 layers
37 fps

DOM
3 layers
50 fps

OSM vs DOM

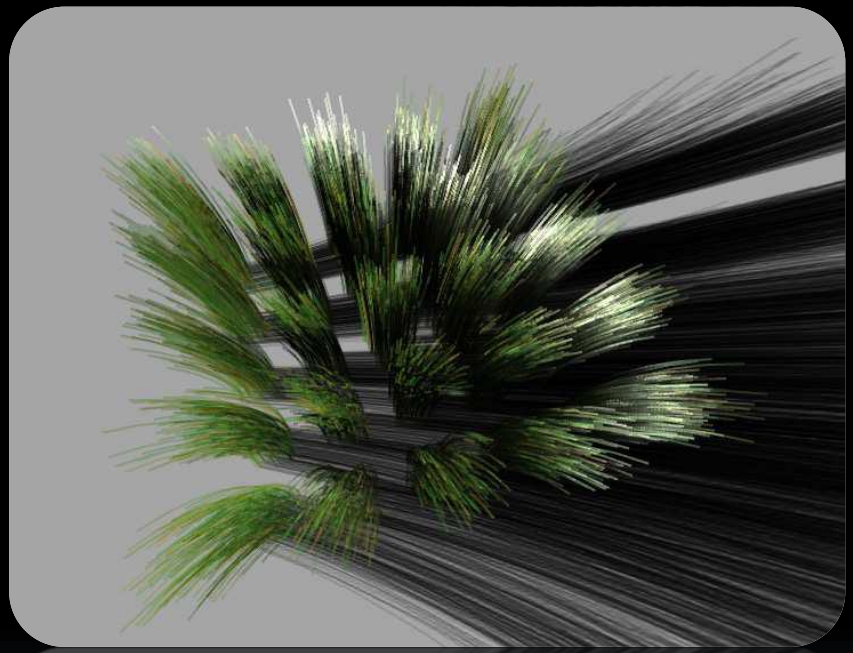


OSM vs DOM

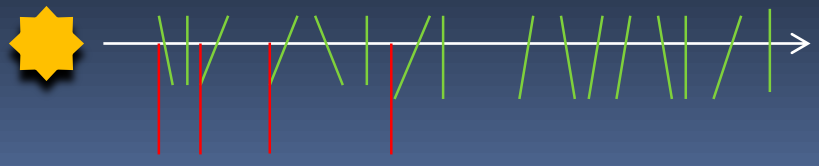

Opacity Shadow Maps
128 layers
Deep Opacity Maps
3 layers
~ 5.6 FPS
~ 127 FPS

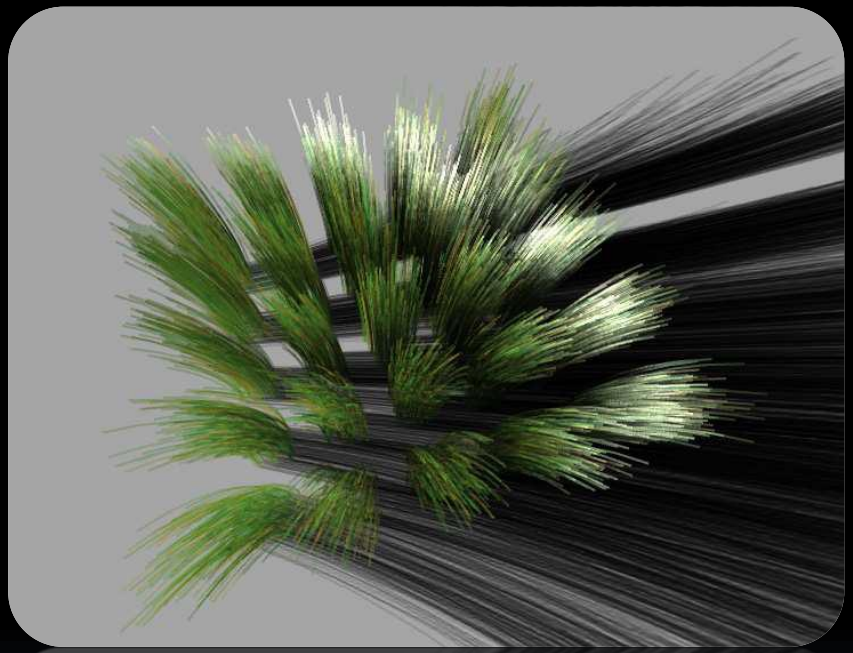
DC vs DOM


Density Clustering
4 layers
Deep Opacity Maps
3 layers
~ 81 FPS
~ 127 FPS

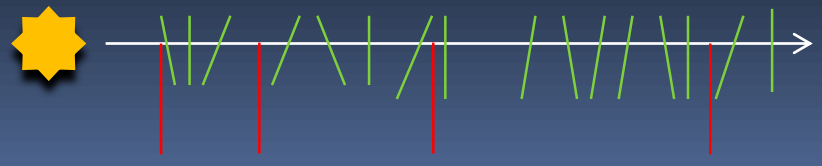


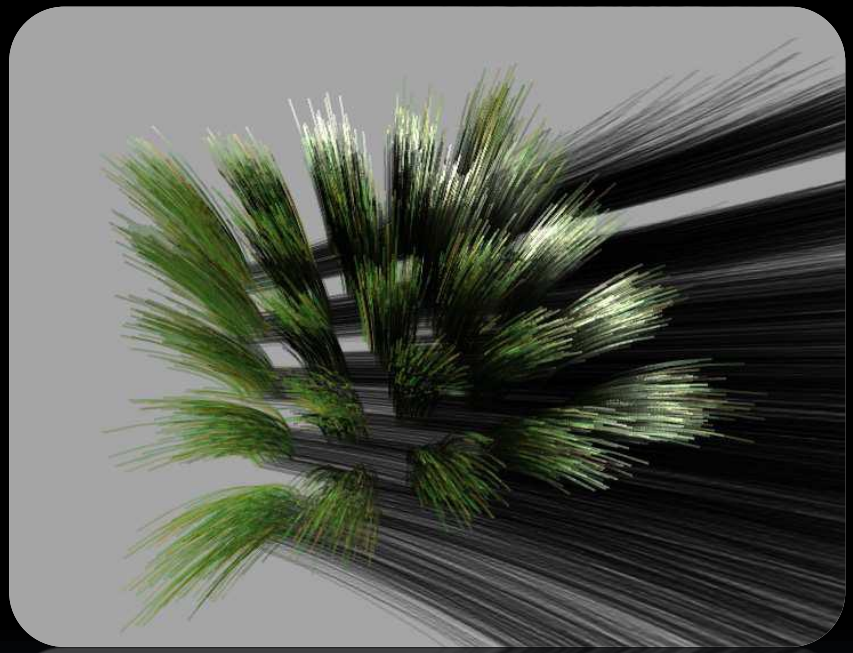
3 layers



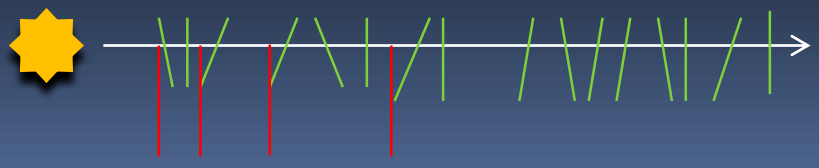


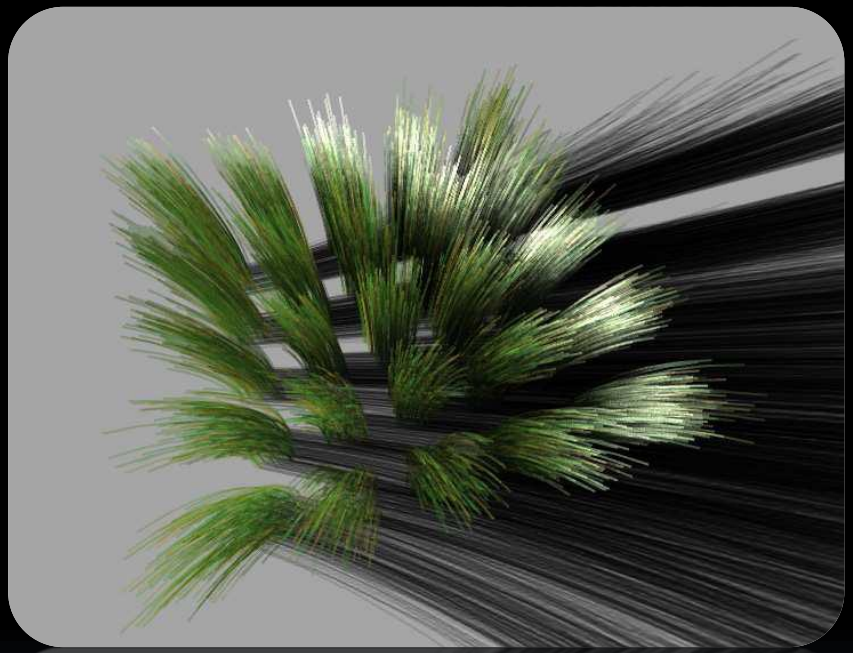
3 larger layers



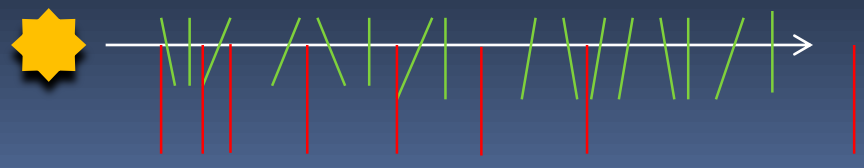


3 layers

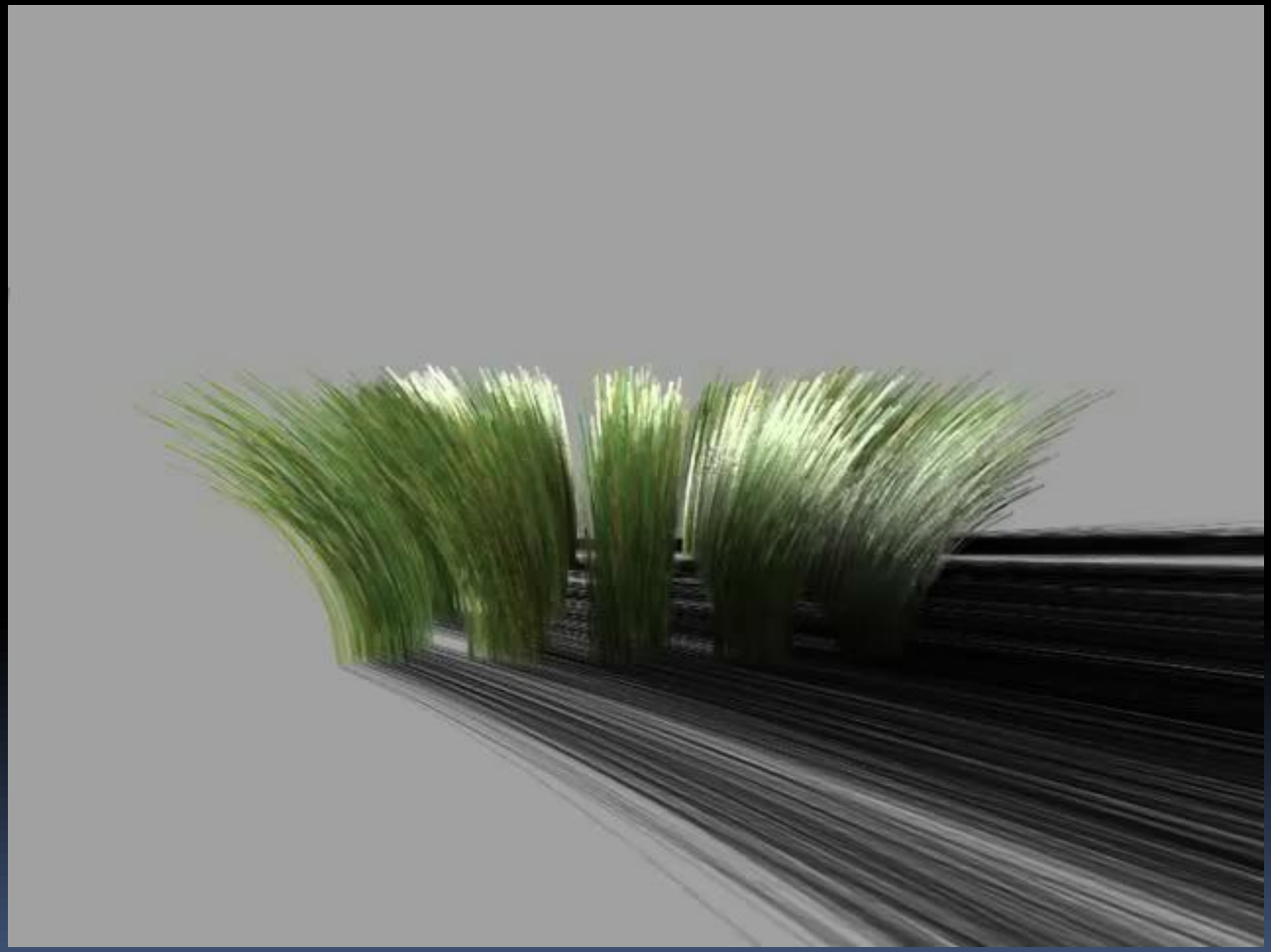




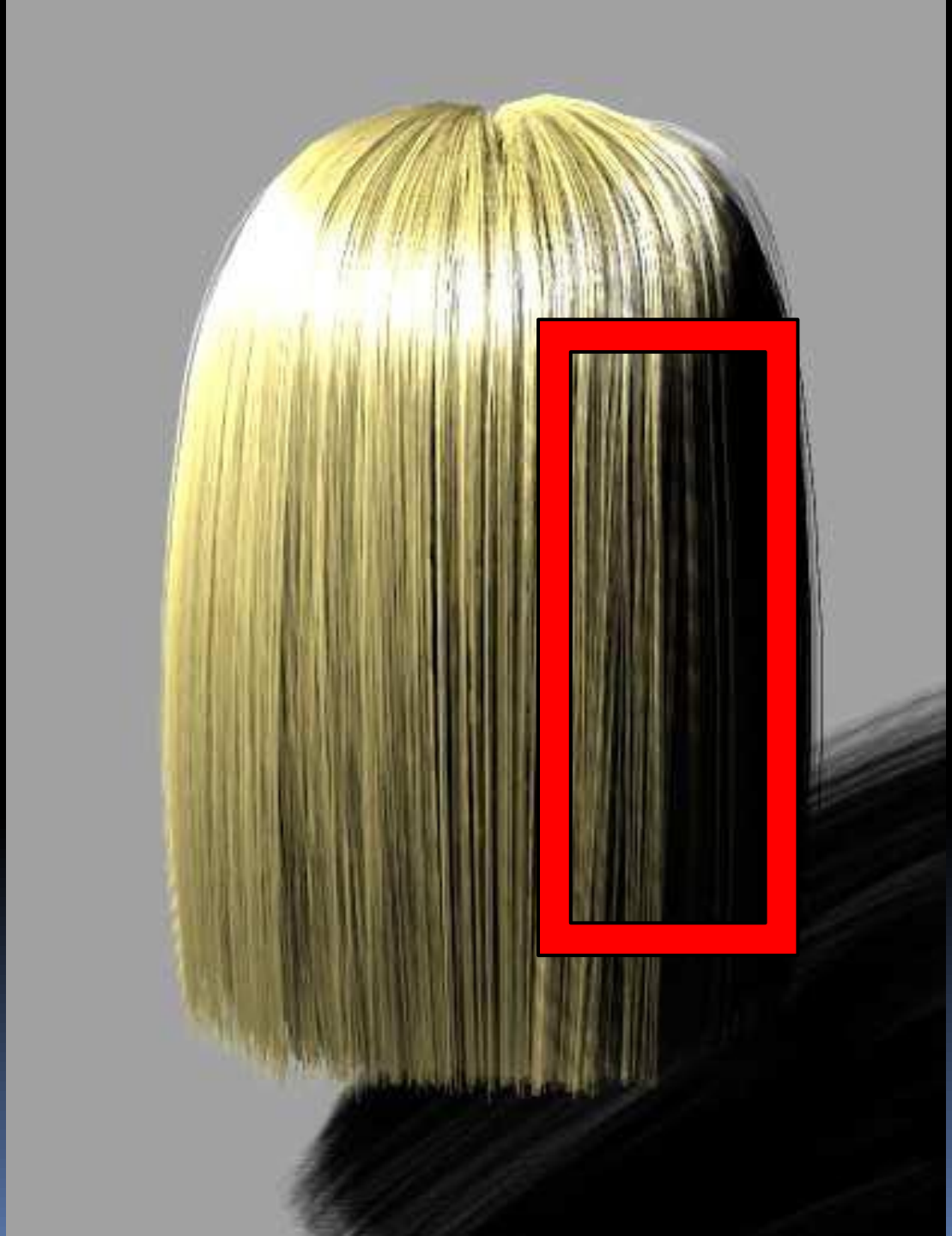
7 layers



Clustered Strands



A hairy teapot



Thank you