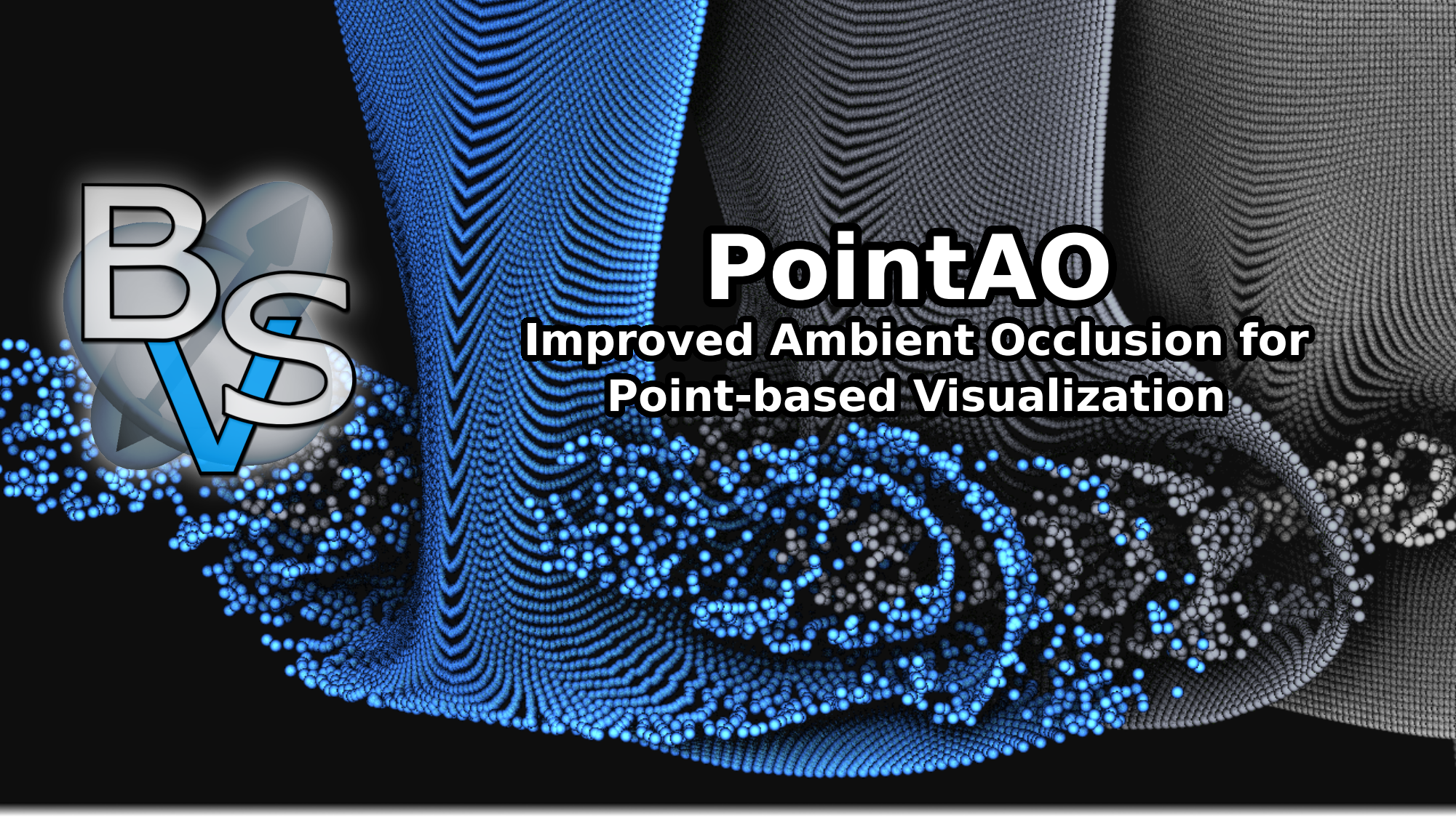

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[1] Image and Signal Processing Group, Leipzig University, Germany
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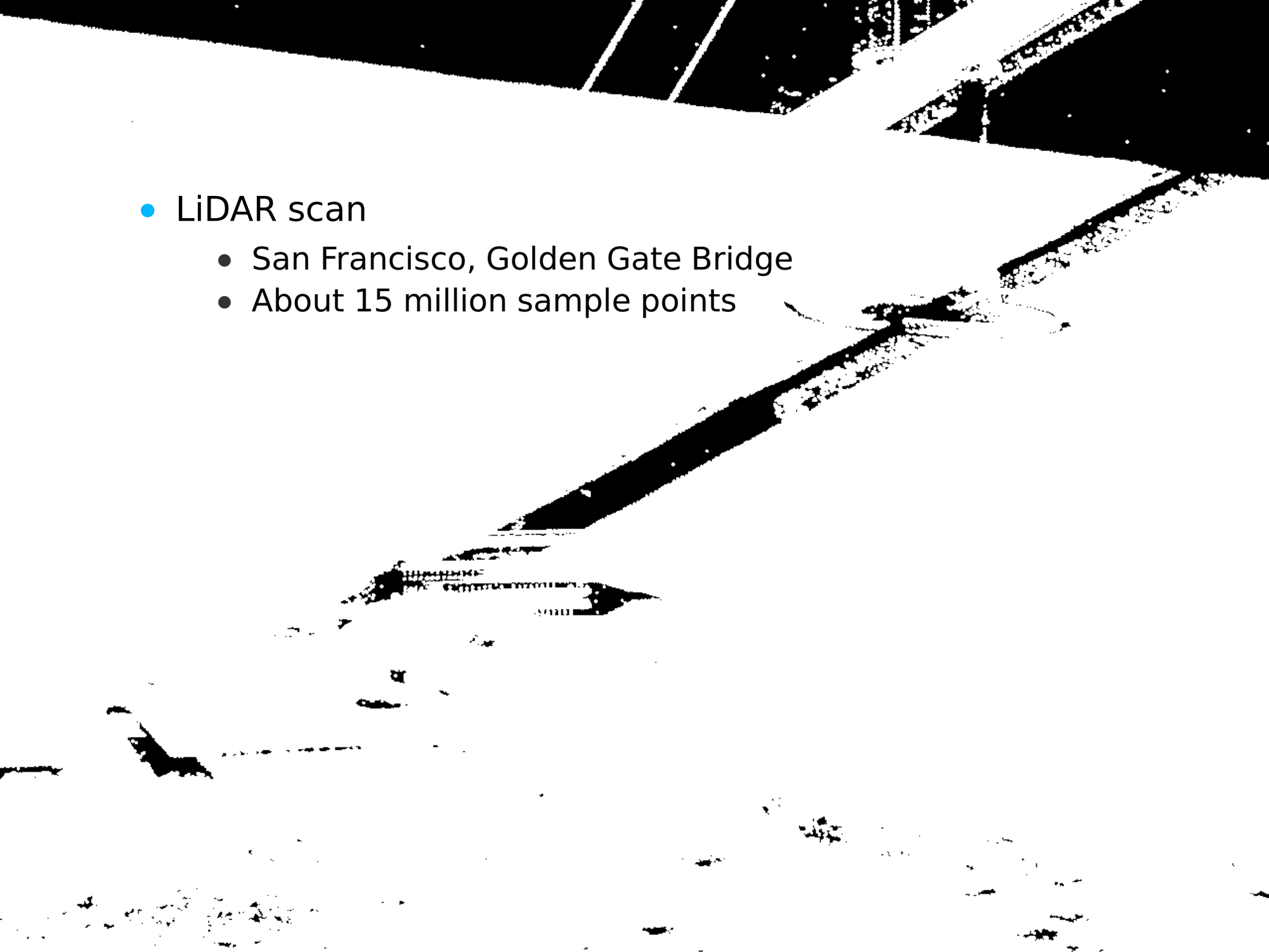
Why?

- Isn’t plain point and glyph rendering sufficient for visualization?



- LiDAR scan
  - San Francisco, Golden Gate Bridge
  - About 15 million sample points


Depth-Colormap
only available for LiDAR

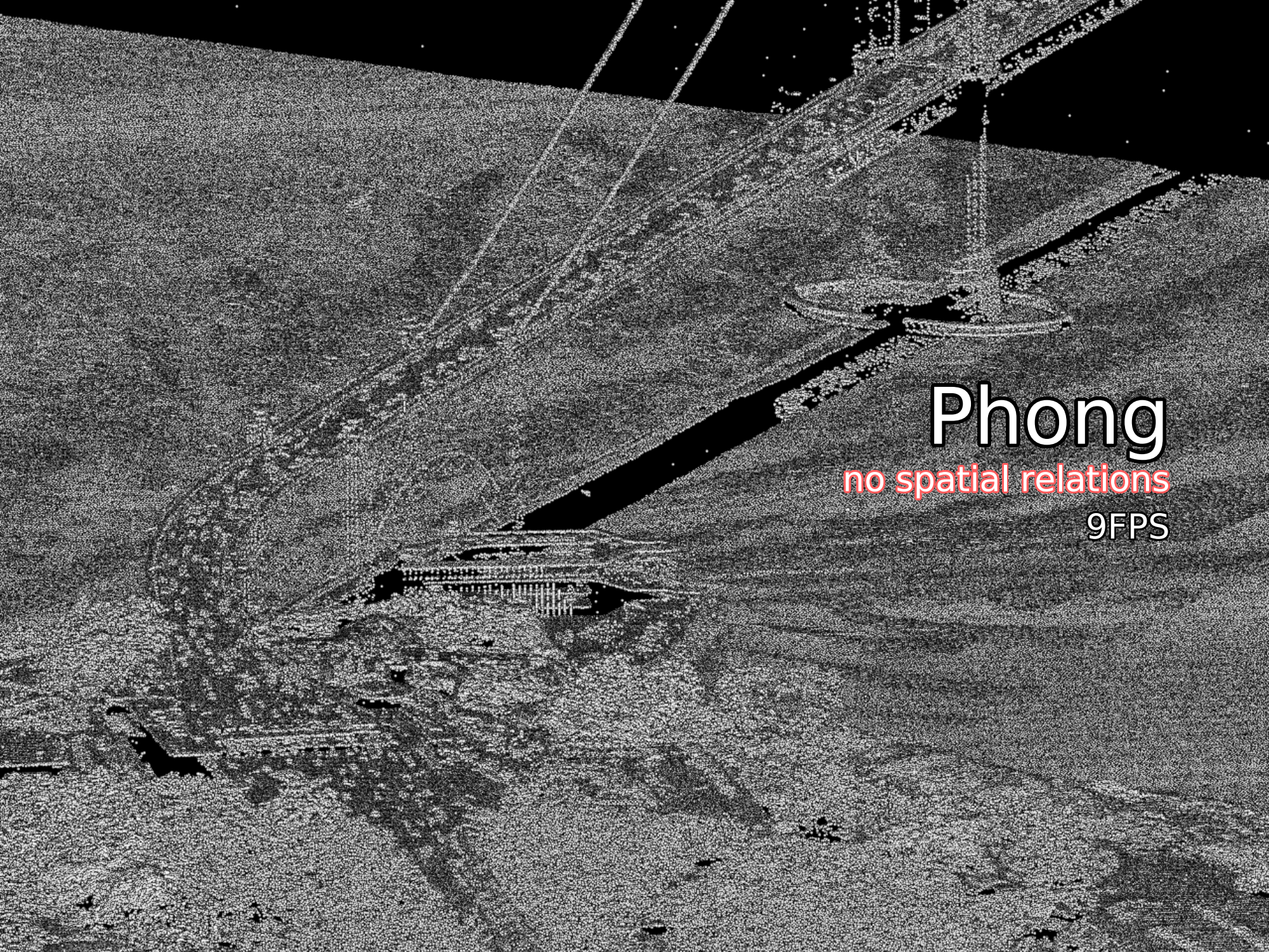
Why? — The Problem

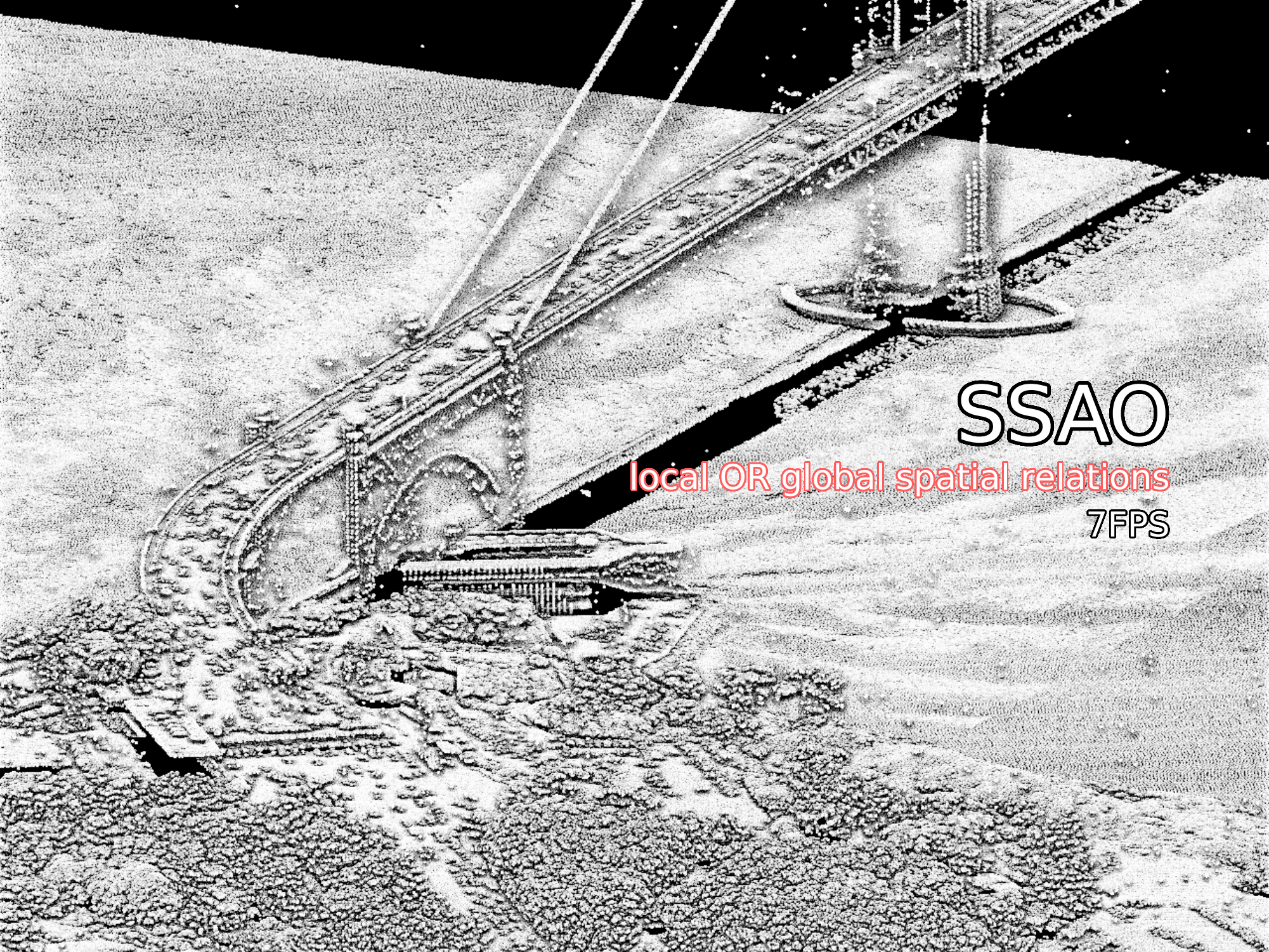
- Possible solution: shape from shading.
  - See Ramachandran et al.
  - Shading in computer graphics?
    - local illumination provides structure
    - global illumination provides relative, spatial information

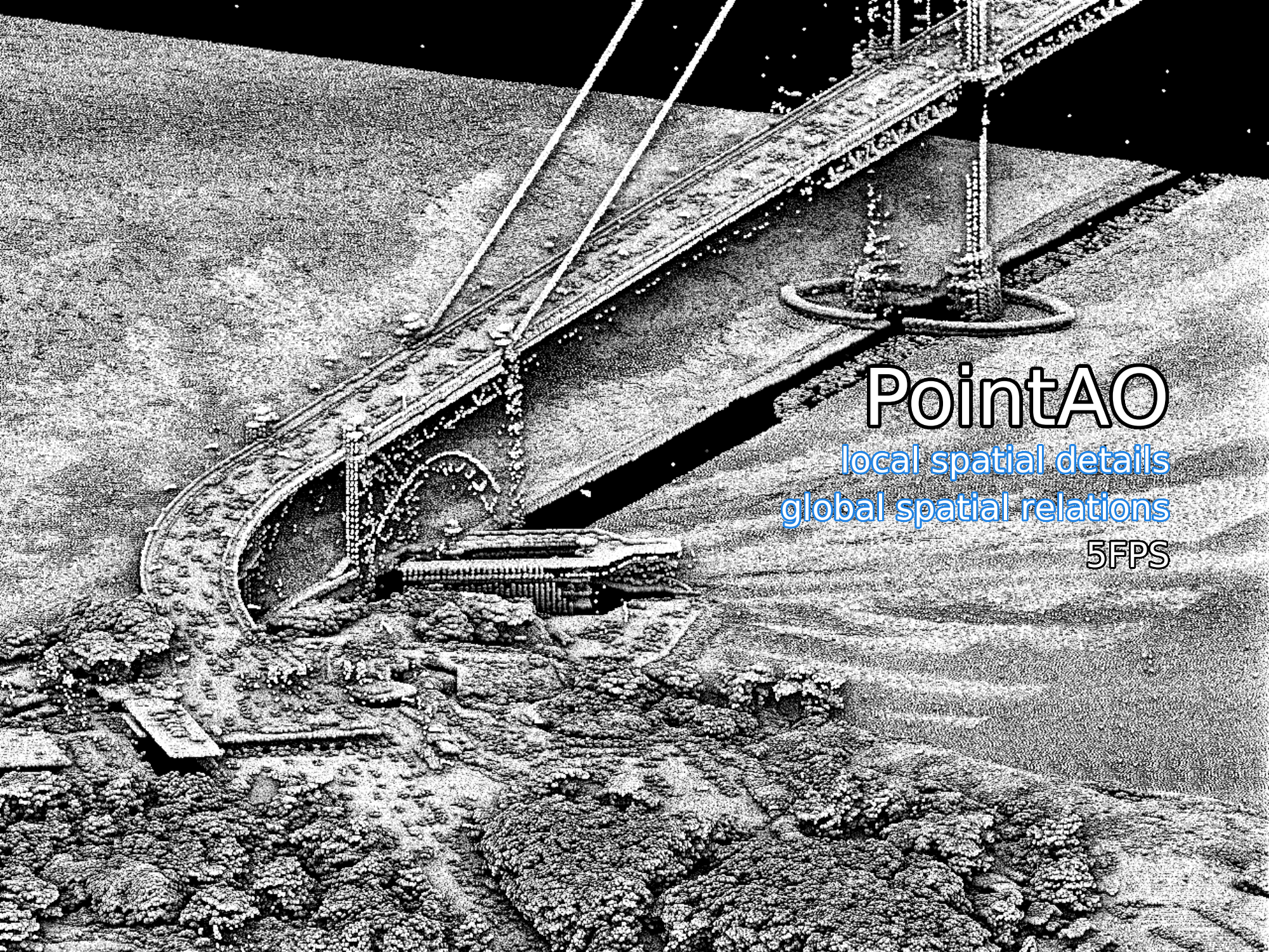
    → Let’s try!

V. S. Ramachandran. Perception of shape from shading. *Nature*, 331:163–166, 1988.

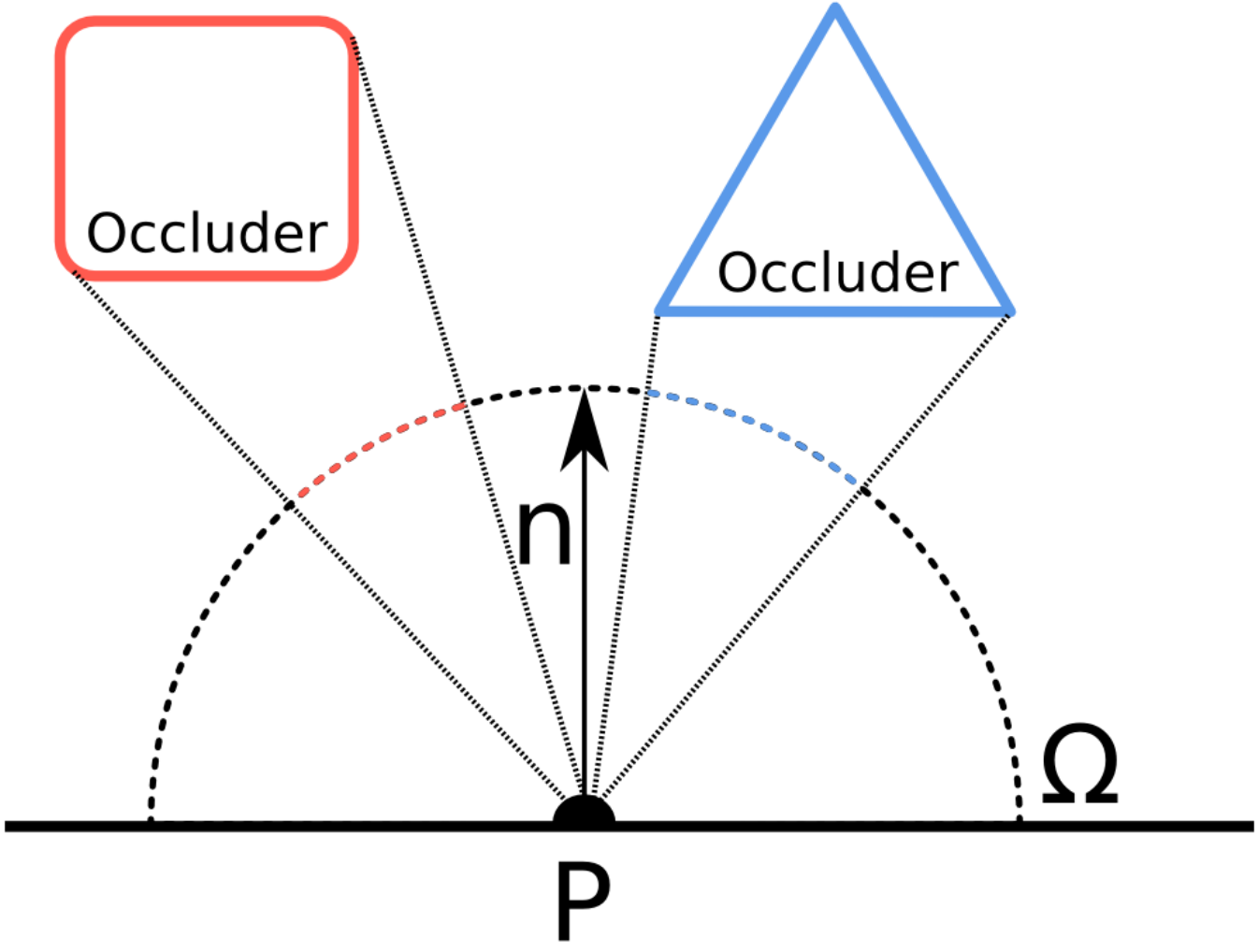

No Shading


Phong
no spatial relations
9FPS

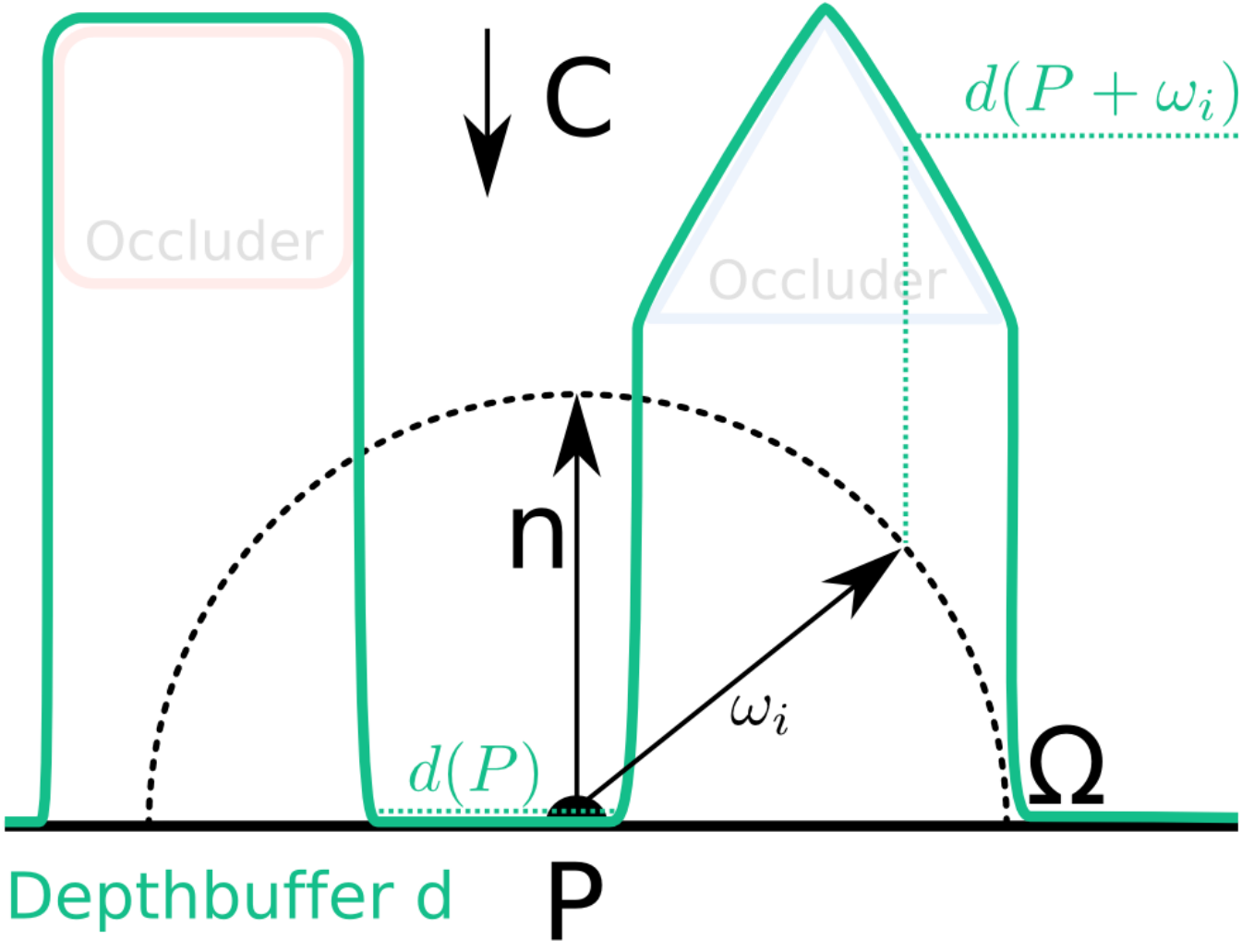

SSAO
local OR global spatial relations
7FPS


PointAO
local spatial details
global spatial relations
5FPS

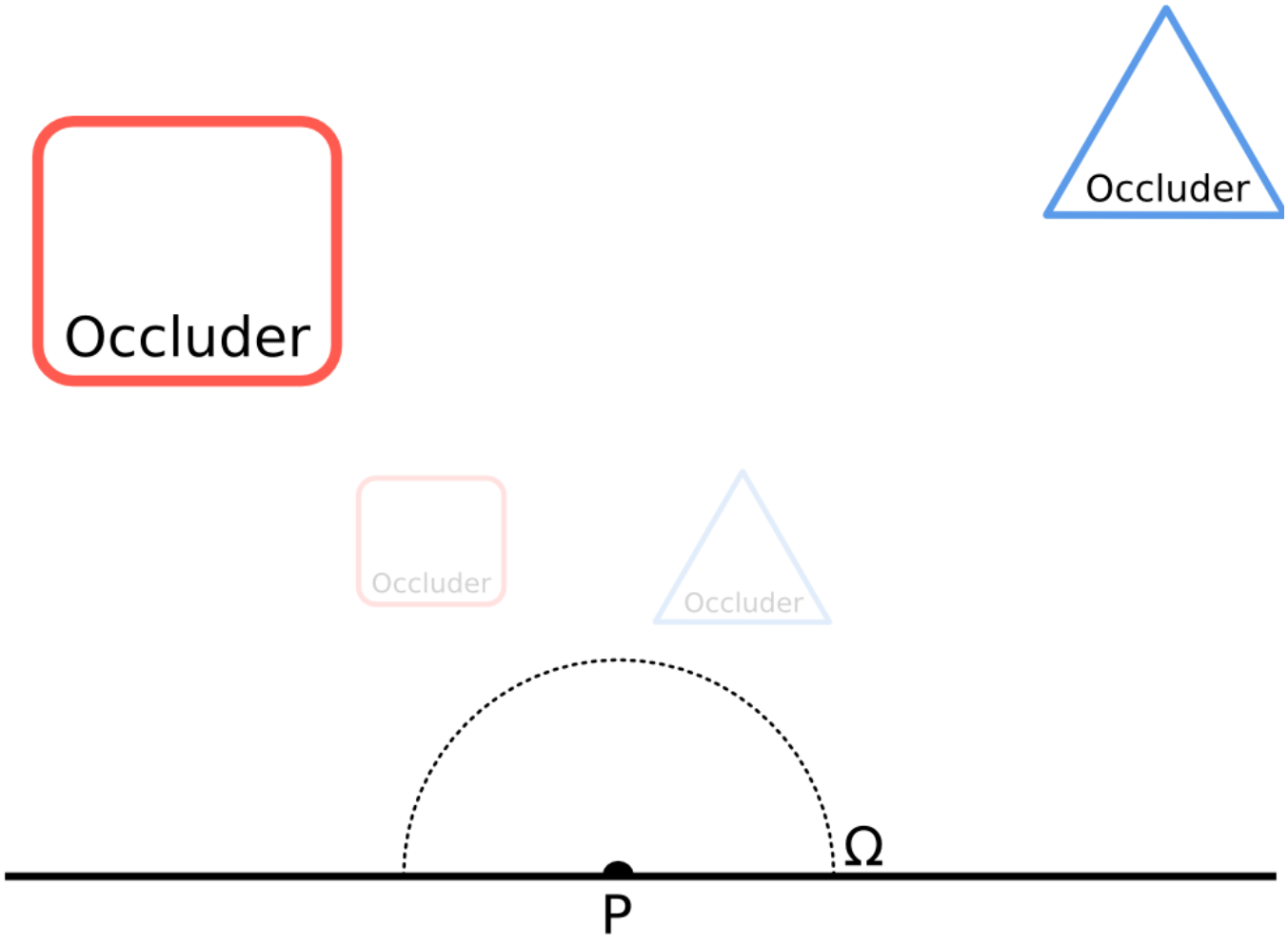
How? — Ambient Occlusion



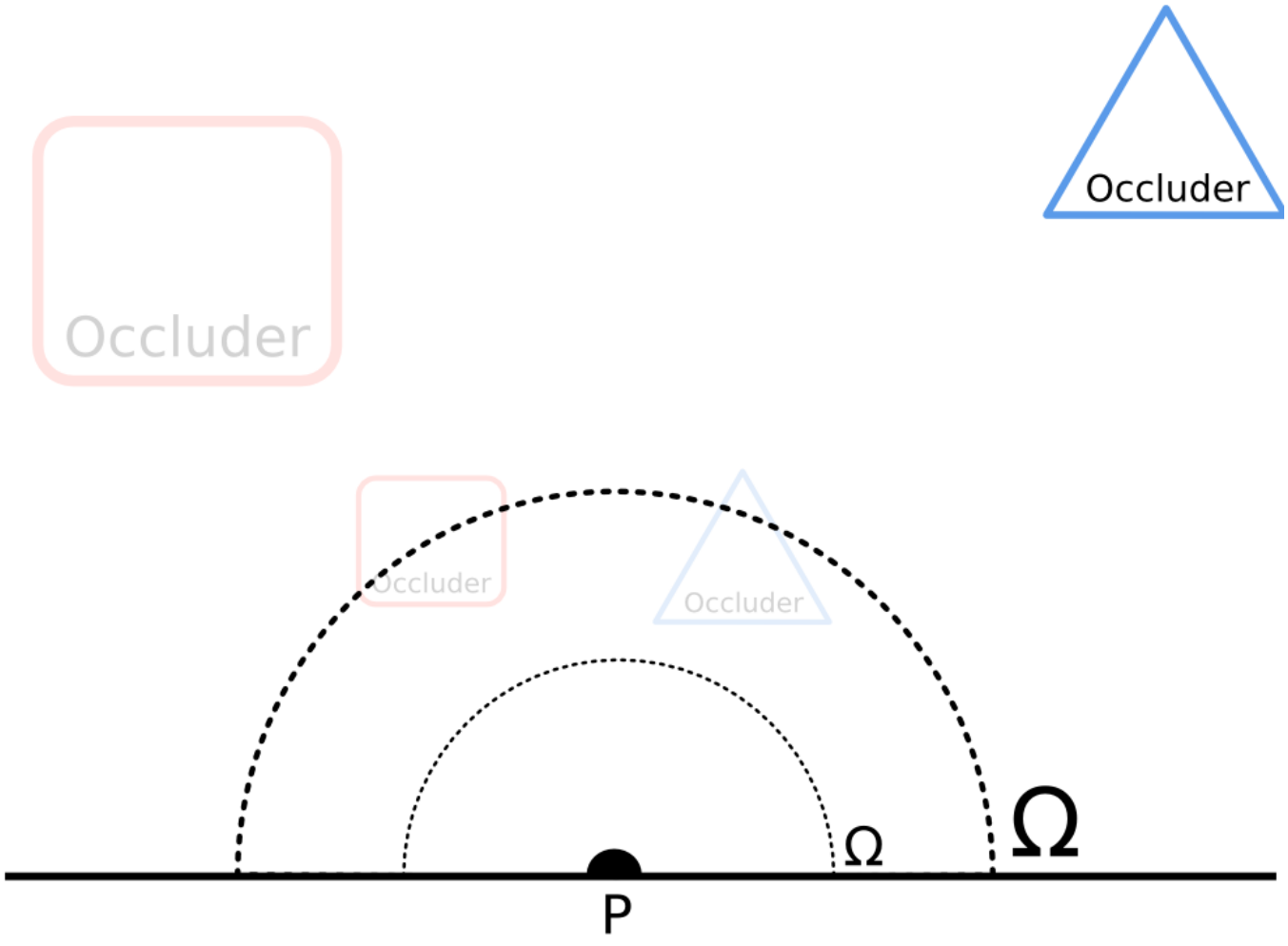
How? — SSAO



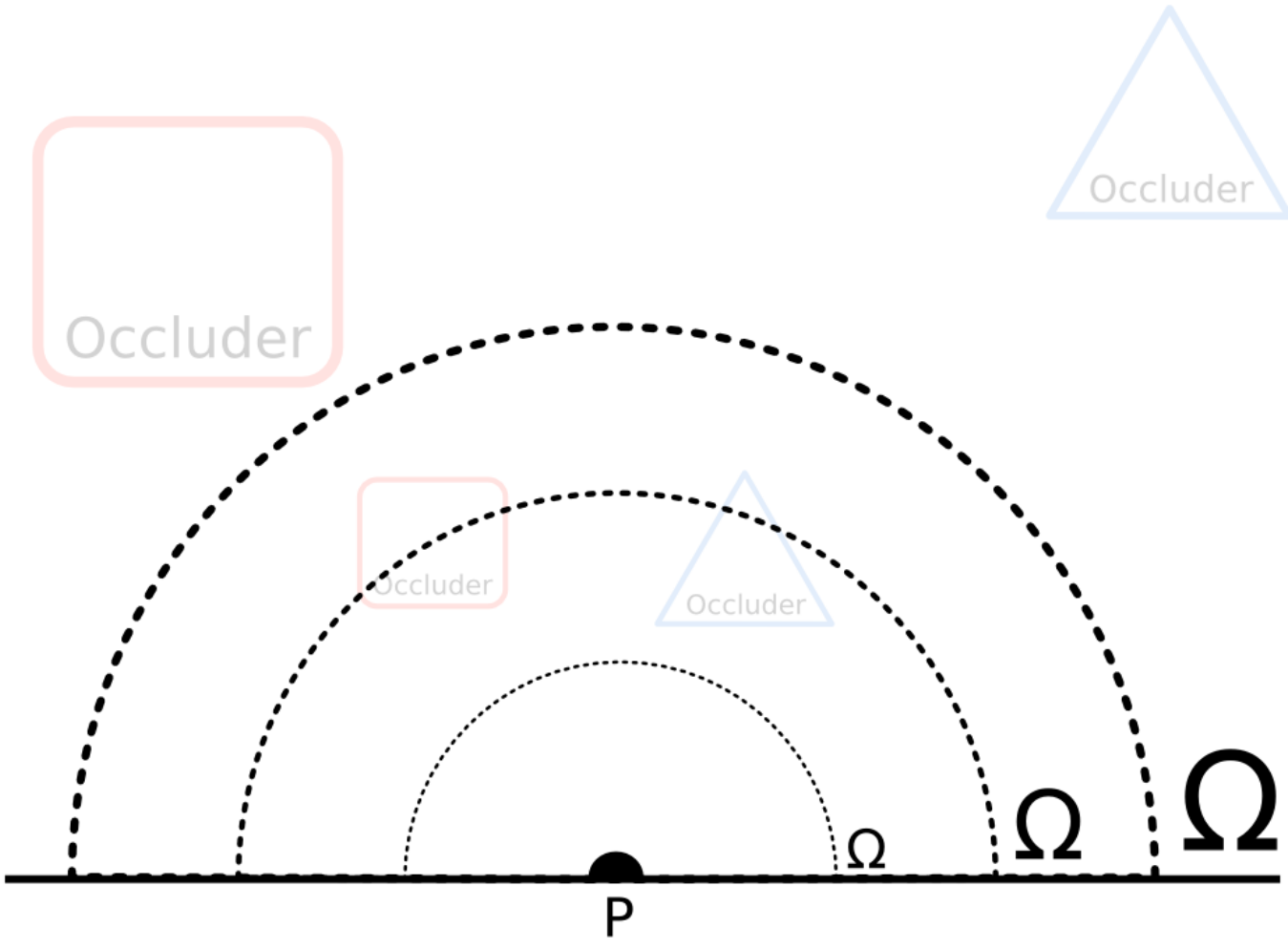
How? — From SSAO to PointAO



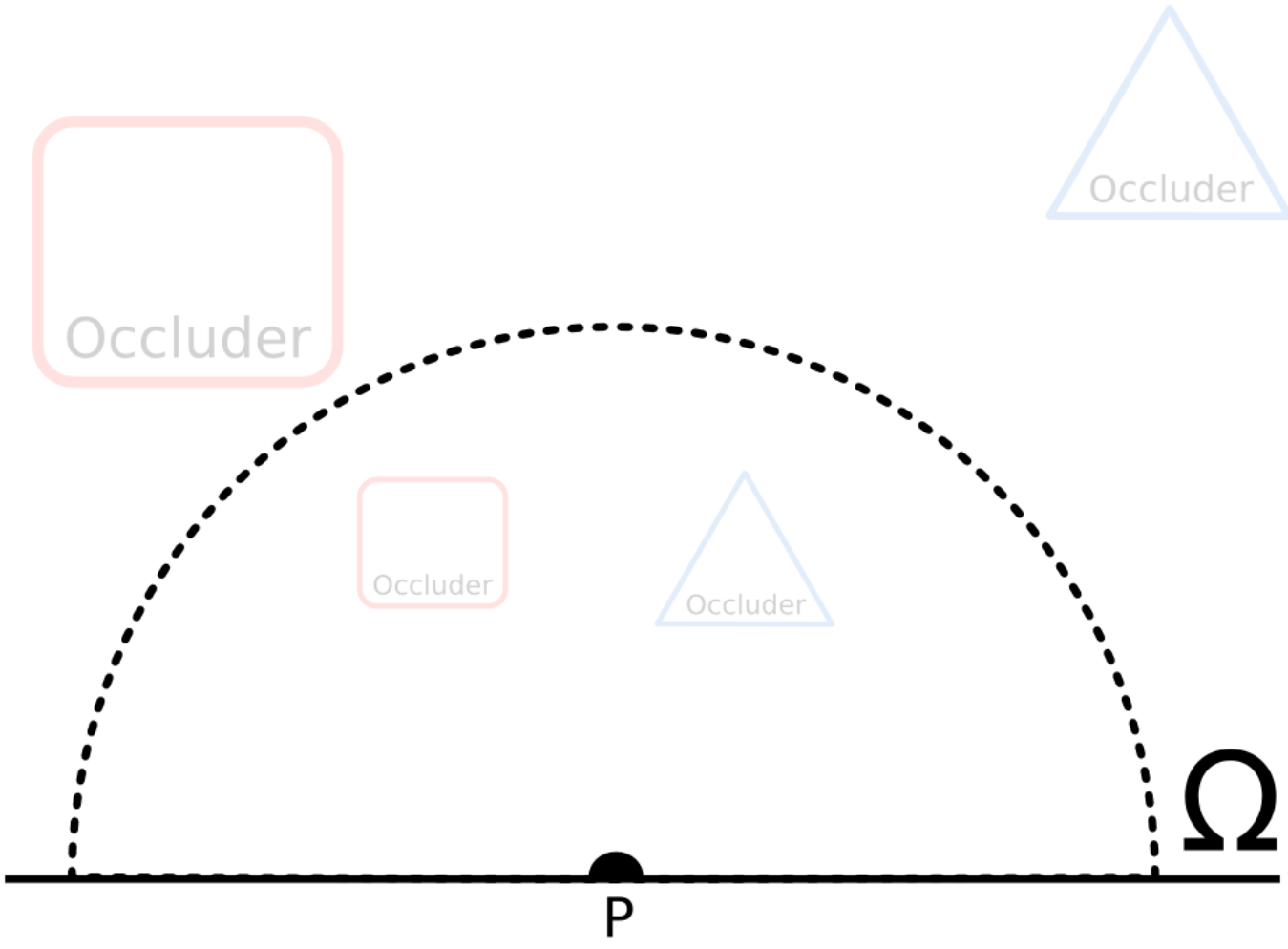
How? — From SSAO to PointAO



How? — From SSAO to PointAO



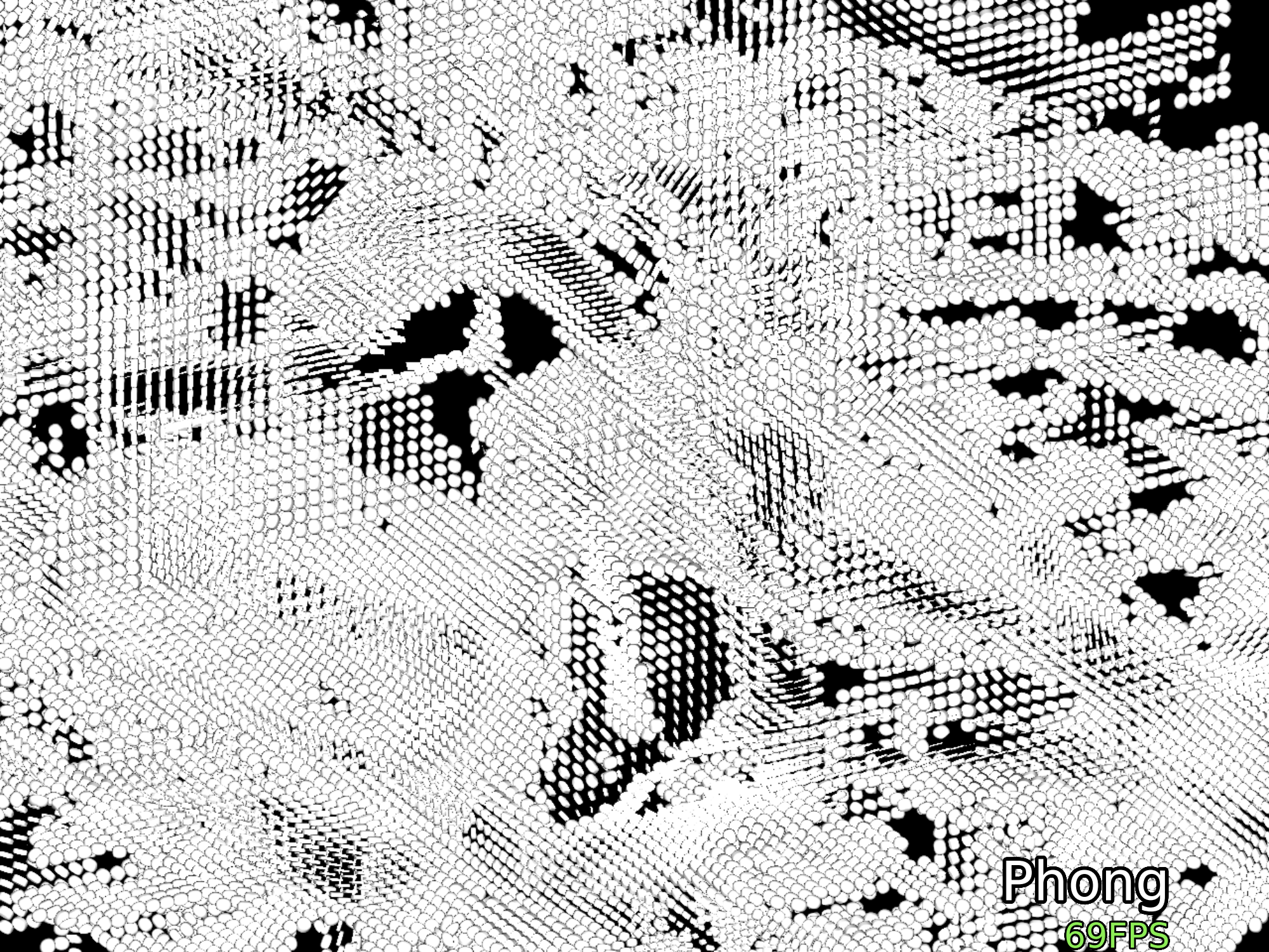
Why not a single, large hemisphere?

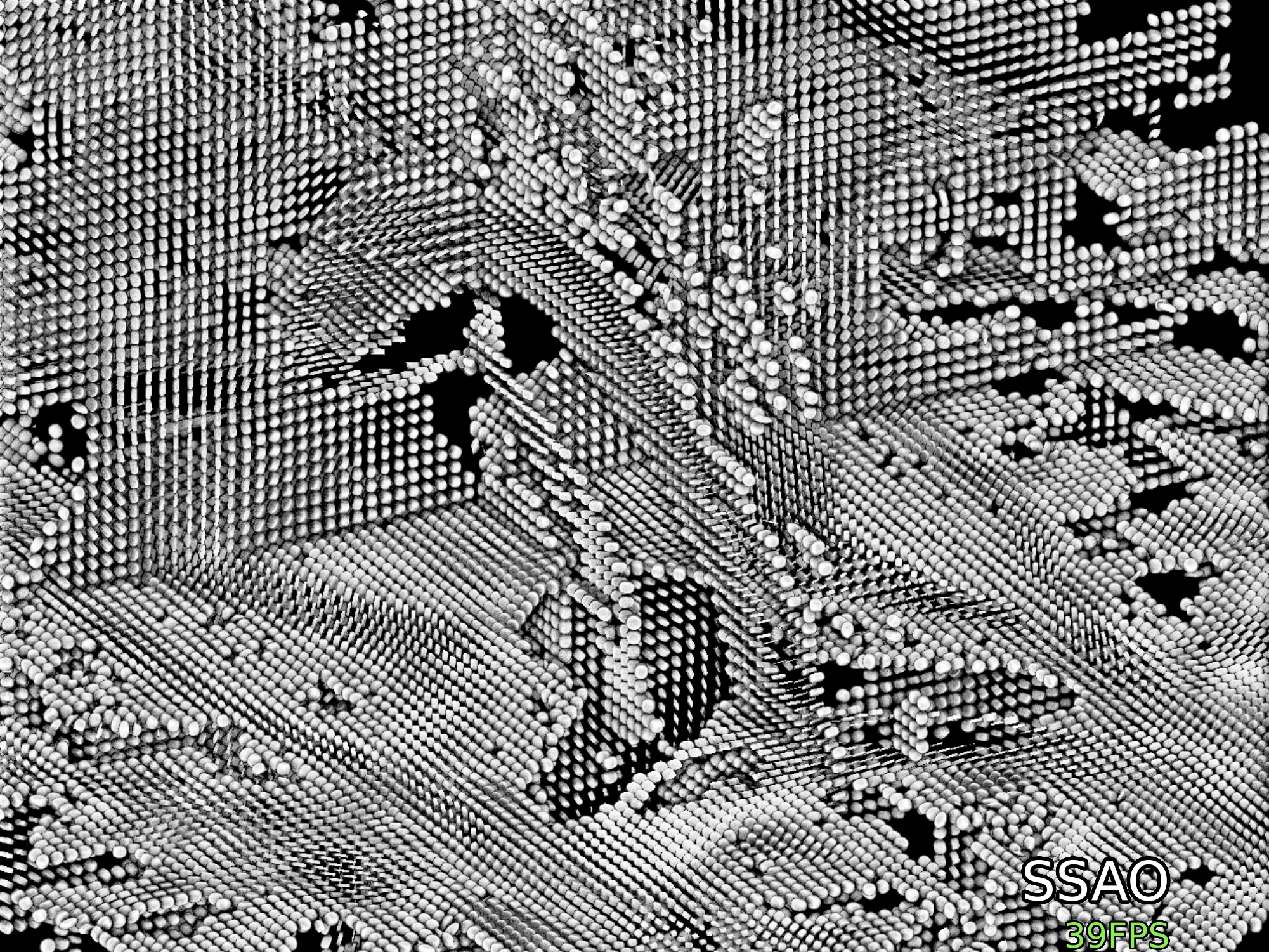


How? — PointAO

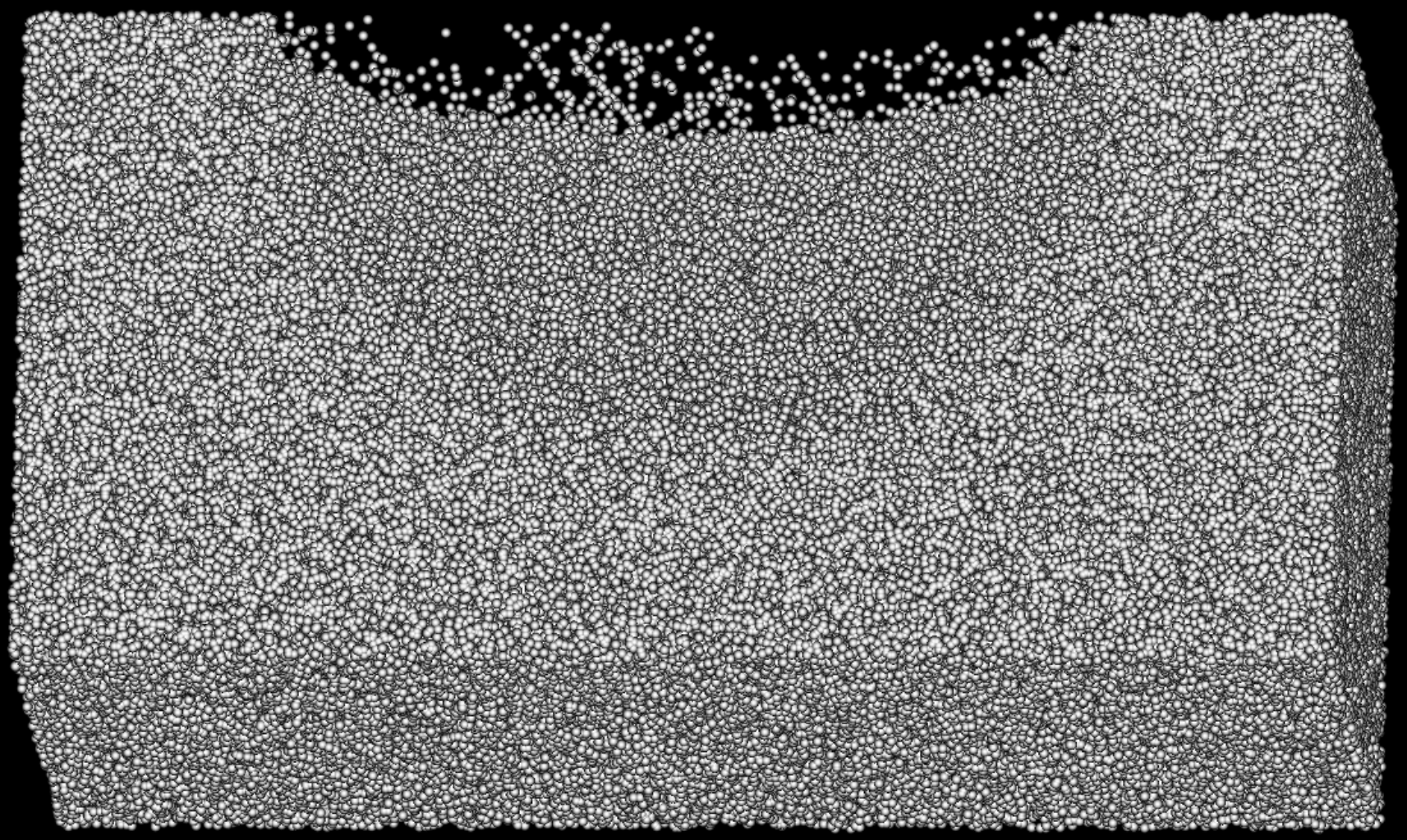
- Similar to LineAO
- Modified:
  - Sampling Scheme
  - Radius Scaling Scheme
  - Weighting Function

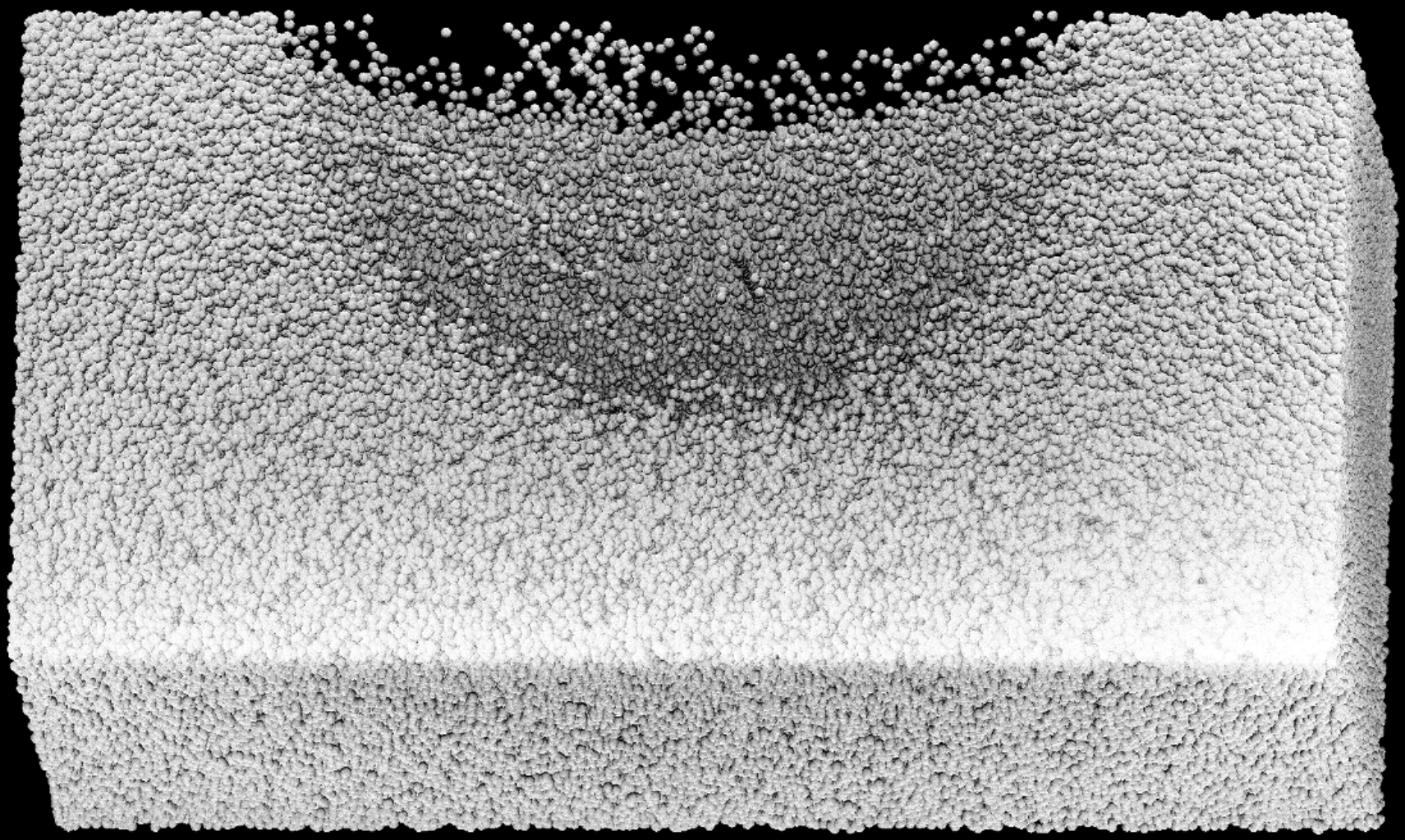
Eichelbaum et al.:, LineAO – improved three-dimensional line rendering. IEEE Transactions on Visualization and Computer Graphics 19, 3 (2013), 433–445

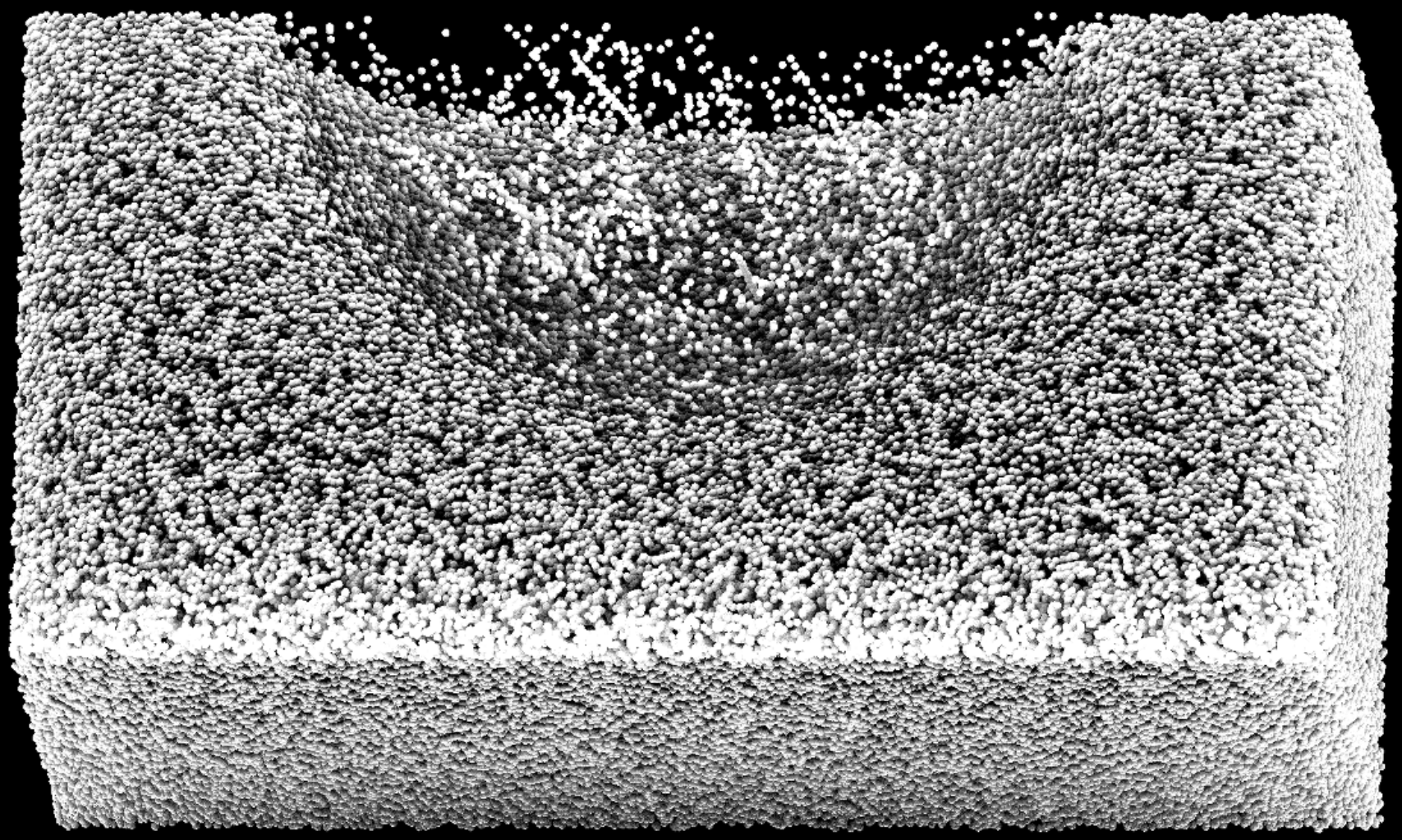

Phong
69FPS


SSAO
39FPS


PointAO
32FPS


Phong
30FPS


SSAO
19FPS


PointAO
12FPS

Results — Features

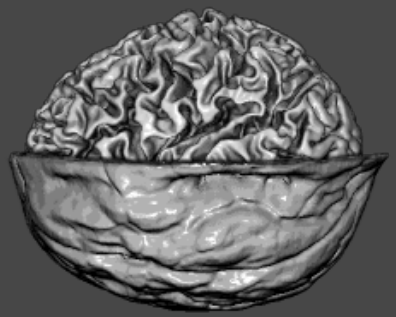
- Greatly improved structural and spatial perception
- Simultaneous depiction of local and global structures
- Renders in real time without pre-computation
- Consistency under modification and interaction

Results — Limitations

- Not suited for coarse data
- Does not work for two dimensional and quasi two dimensional data

Future Work

- Combination with other visualization paradigms



OpenWalnut

Visualization in a Nutshell

Details – Math

$$PointAO_{s_r,s_h,r_0}(P) = \sum_{j=0}^{s_r-1} AO_{s_h,j}(P, \frac{1}{1-d(P)} * z(P) * (j^2 + j * r_0))$$

$$AO_{s,l}(P,r) = \frac{1}{s}\sum_{i=1}^{s}\left[(1 - V(r\omega_i, P))g_l(r\omega_i, P)\right]$$

$$V(\omega, P) = \begin{cases} 1 & \text{if } d(P) - d(P+\omega) < 0 \\ 0 & \text{else,} \end{cases}$$

$$g_l(\omega, P) = g_l^{depth}(\omega, P) \cdot g^{light}(\omega, P)$$

$$\Delta d_l(\omega, P) = d(P) - d(P+\omega) \in [-1, 1]$$

$$\delta(l) = \left(1 - \frac{l}{s_r}\right)^2 \in (0, 1]$$

$$h(x) = 3x^2 - 2x^3, \forall x \in [0,1] : h(x) \in [0,1]$$

$$g_l^{depth}(\omega, P) = \begin{cases} 0, & \text{if } \Delta d(\omega, P) > \delta(l) \\ 1, & \text{if } \Delta d(\omega, P) < \delta_0 \\ 1 - h(\frac{d(\omega,P) - \delta_0}{\delta(l) - \delta_0}), & \text{else.} \end{cases}$$

$$g^{light}(\omega, P) = 1 - \langle \omega, n(P) \rangle$$

- Scale radius according to depth of pixel.
- Weight each occluder with $g(r\omega_i, P)$
- Classify and weight according to distance and used hemisphere
- Incorporate local light to retain shape of rendered objects (especially useful for glyphs)

LineAO vs. PointAO

- Sampling Scheme
  - No Gaussian pyarmid
  - No reduction of samples

→ more details

LineAO vs. PointAO

- Radius Scaling
  - No linear scaling
  - Instead: $\frac{1}{1-d_j(P)} * z(P) * (j^2 + j * r_0)$
    - include depth of pixel

    $\rightarrow$ more near pixels use smaller sampling radii for more detail

    $\rightarrow$ far away pixels use larger sampling radii for smooth shadows when behind others

    $=$ darken holes/cracks

LineAO vs. PointAO

- Weighting Function
  - Ignore scattered light of far away occluders
  - Instead: use local BRDF to emphasize shape

    $\rightarrow$ Retains shape of glyphs