Depth-Dependent Halos: Illustrative Rendering of Dense Line Data

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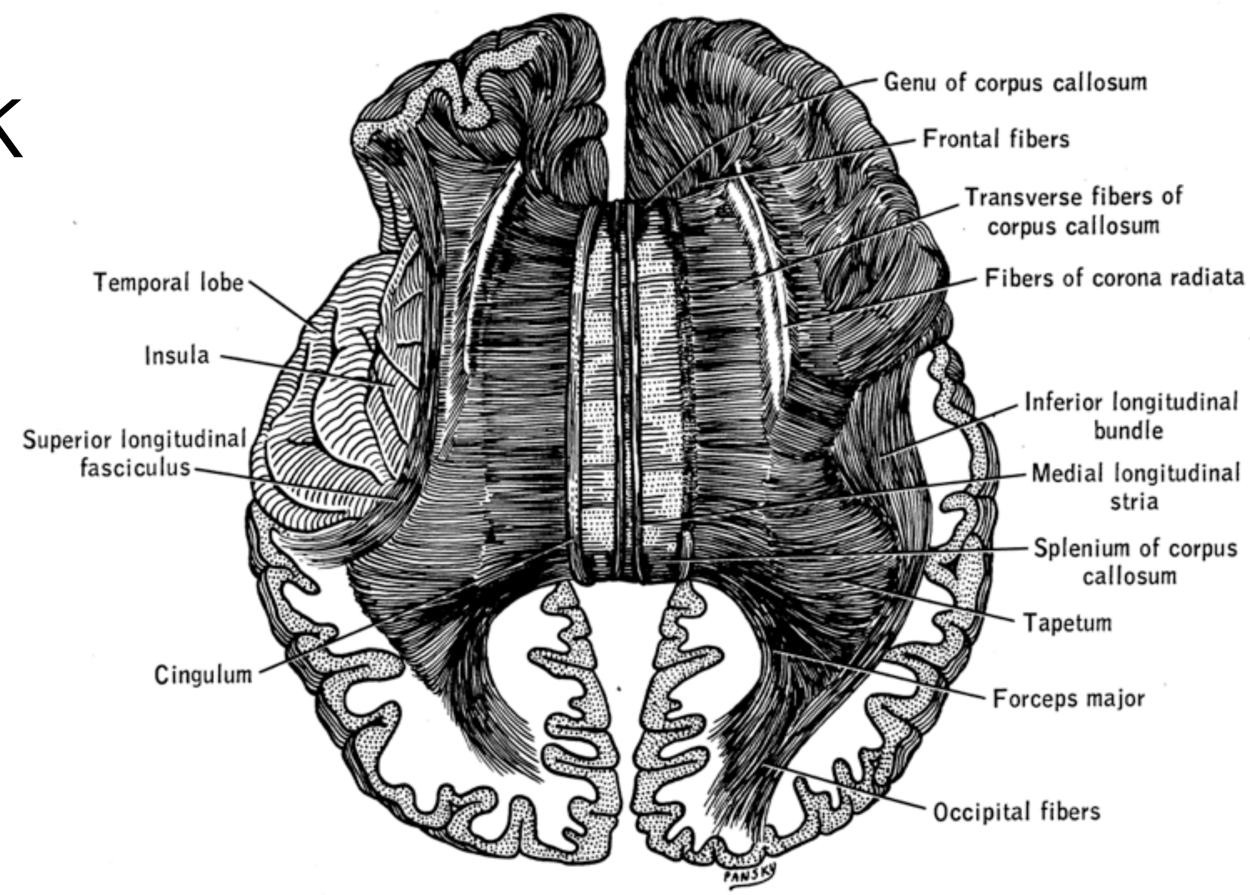
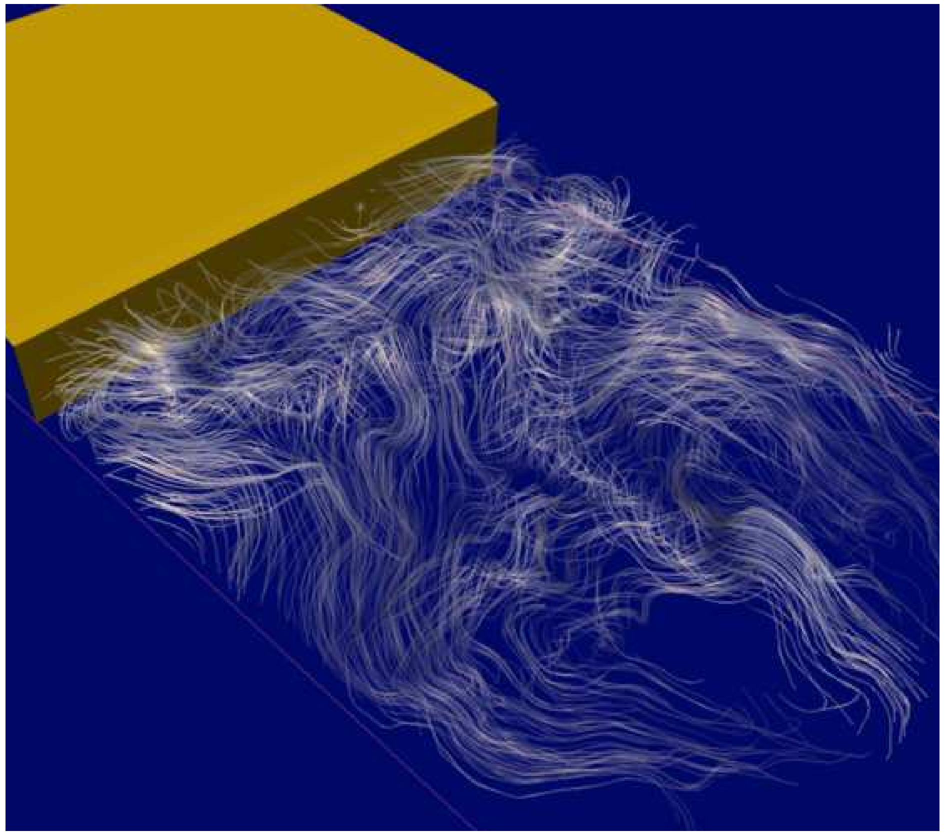
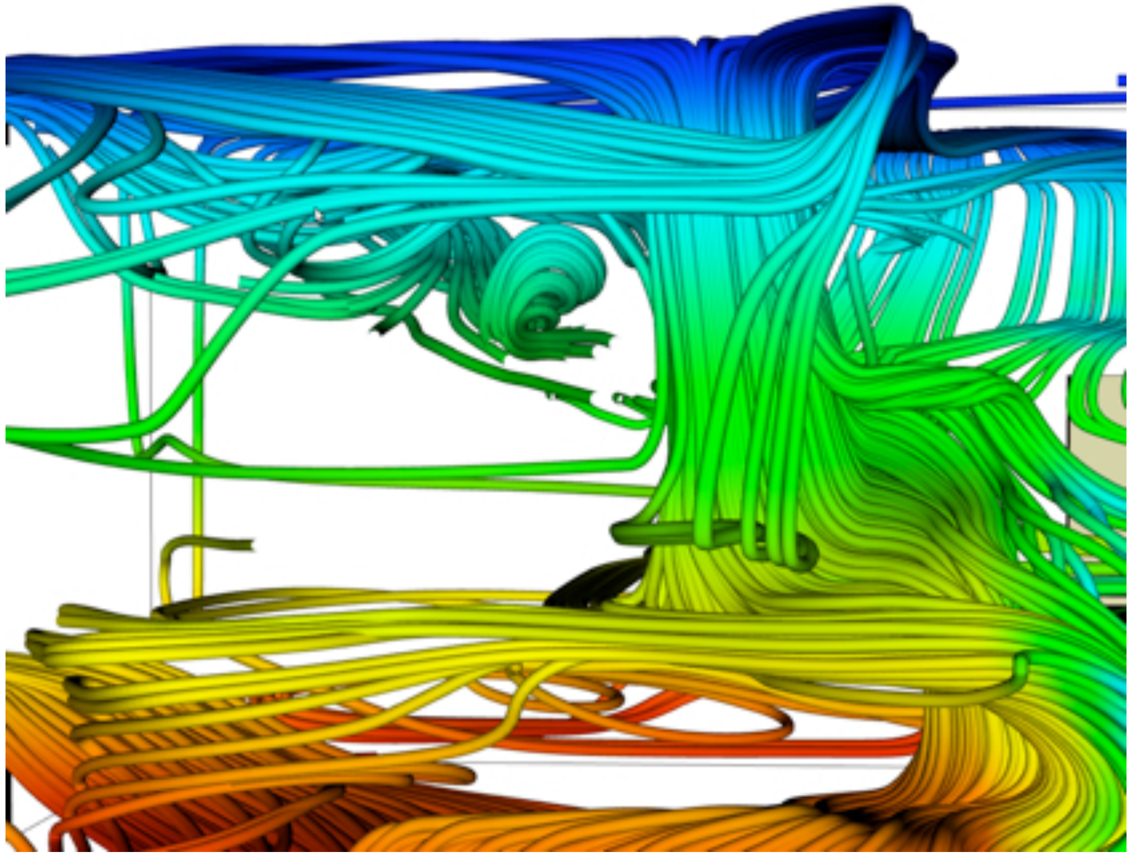
Motivation & Related Work



Visualization of dense line data

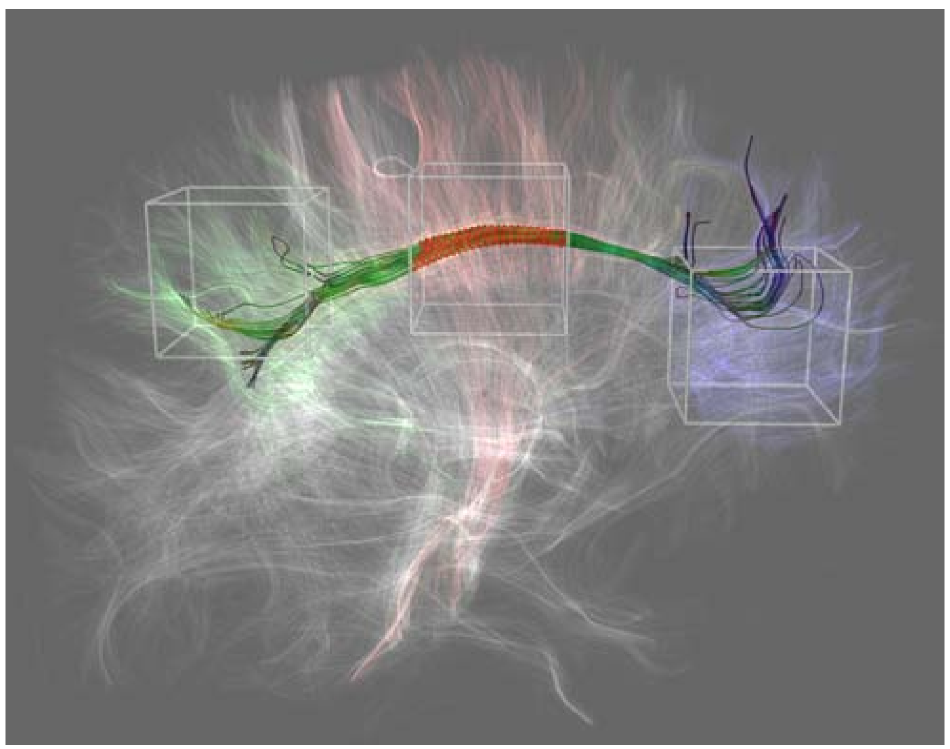


[Zöckler et al., 2007]



created with VTK

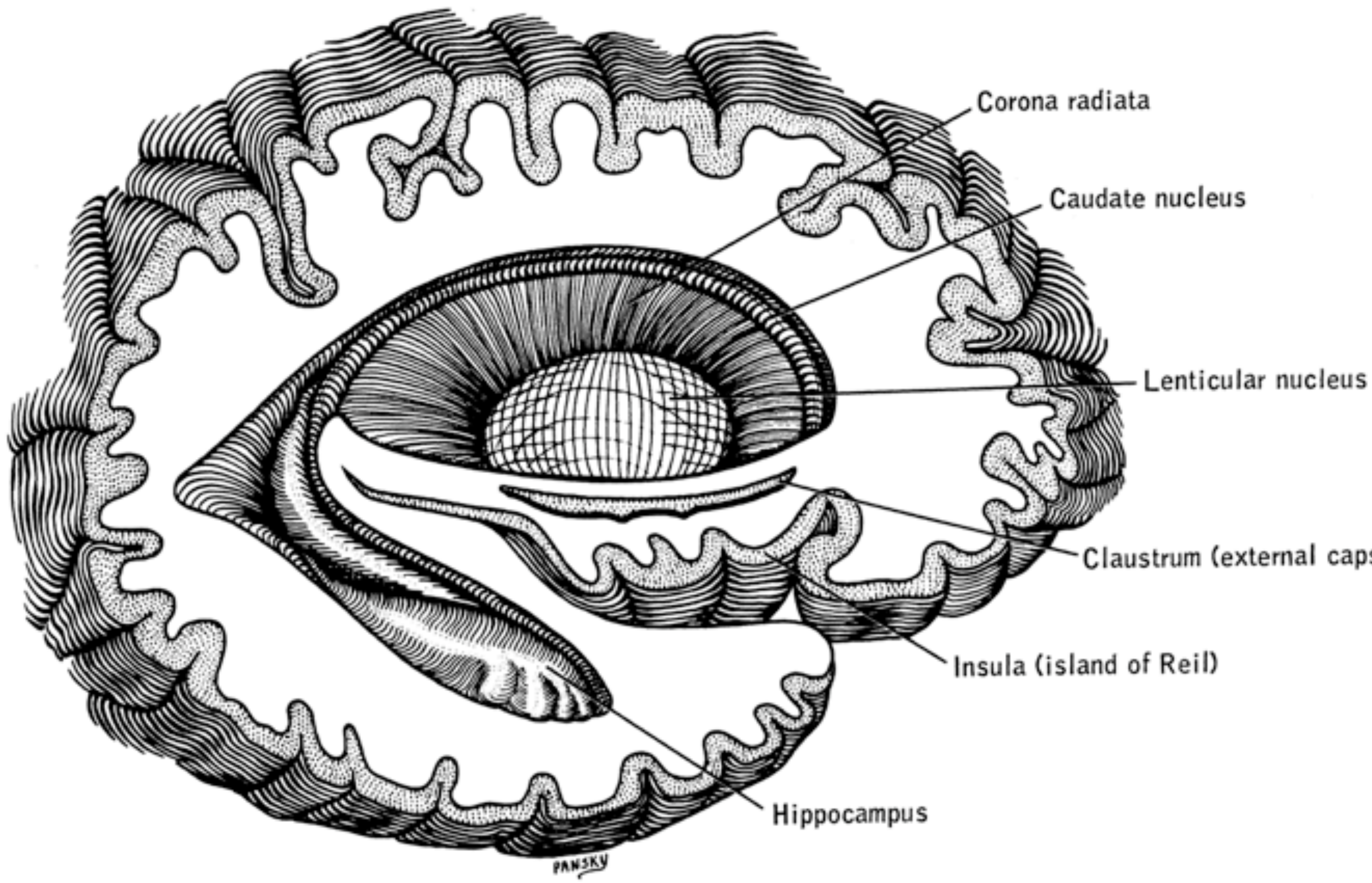
Visualization of dense line data



[Blaas et al., 2005]

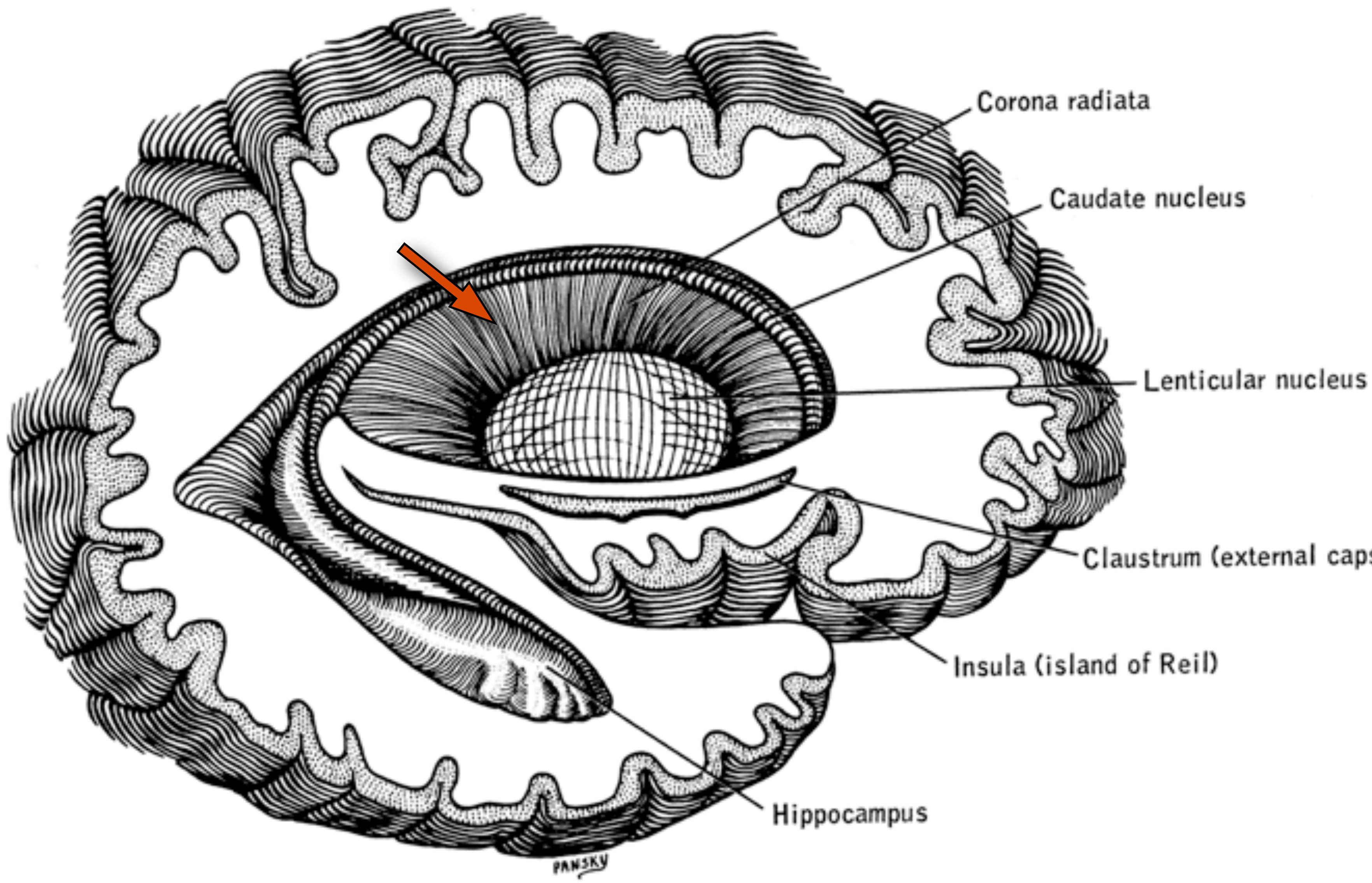
[Petrovic et al., 2007]

Hand-drawn black-and-white illustrations



[House and Pansky, 1960]

Hand-drawn black-and-white illustrations



[House and Pansky, 1960]

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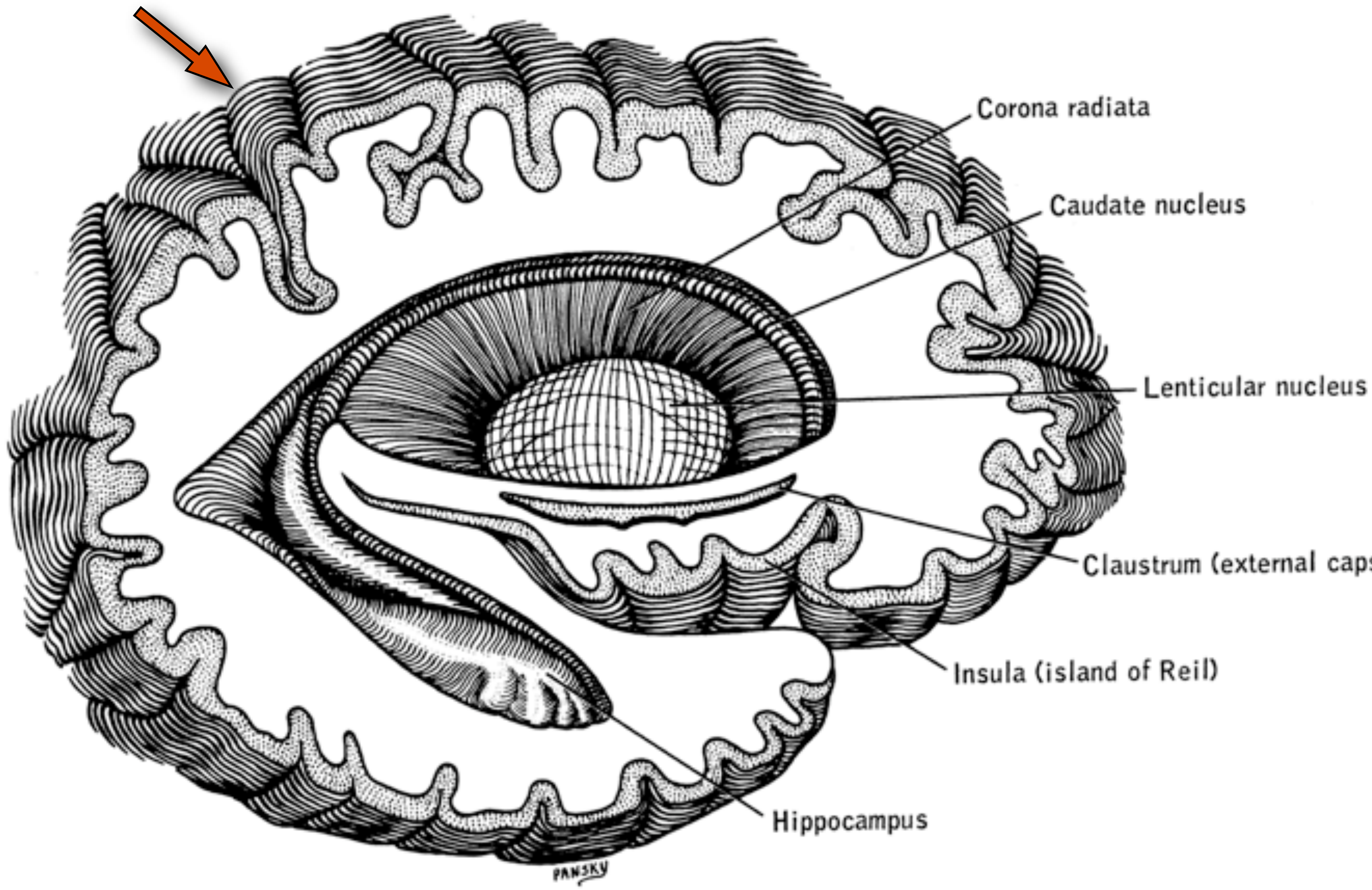

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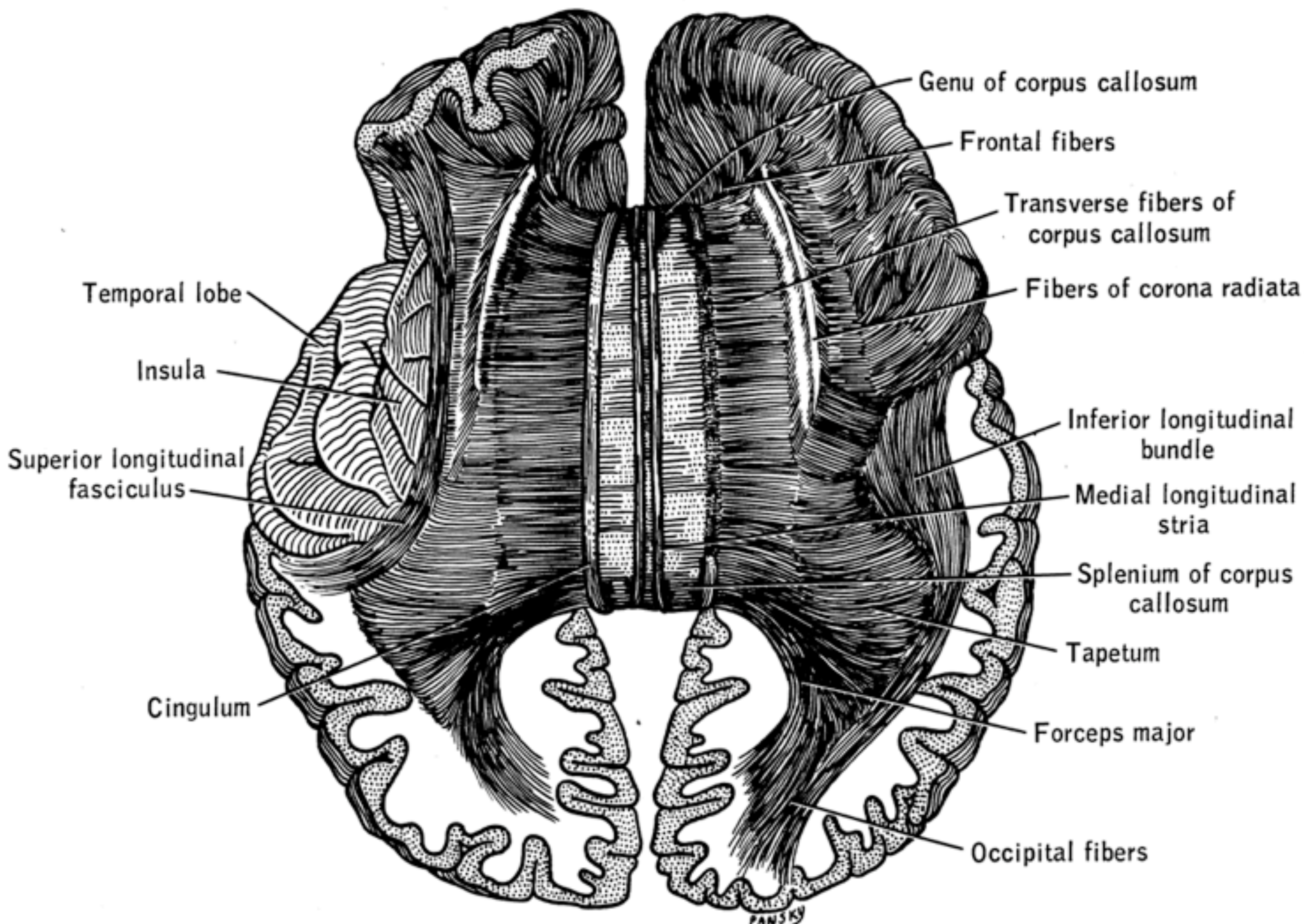

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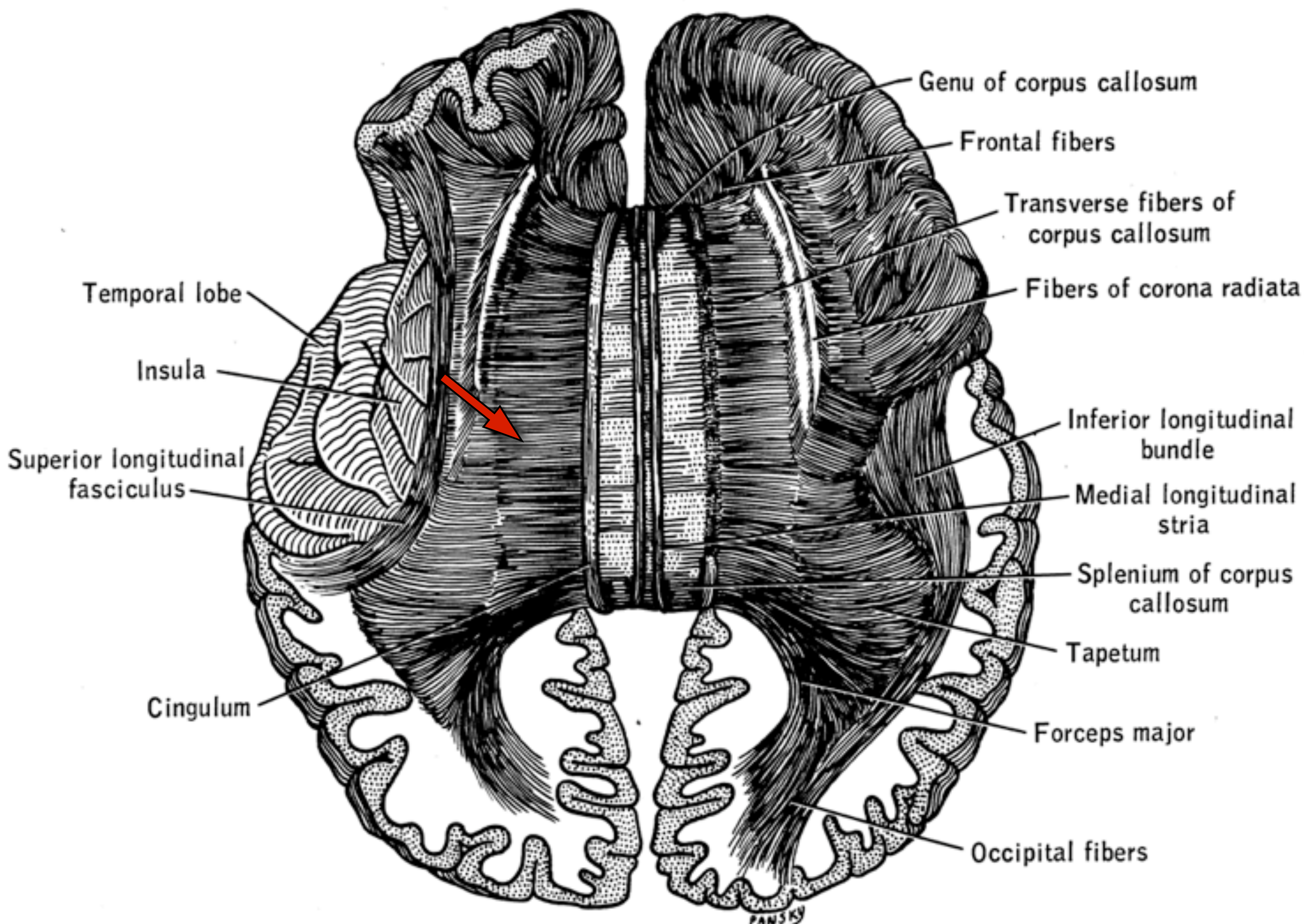
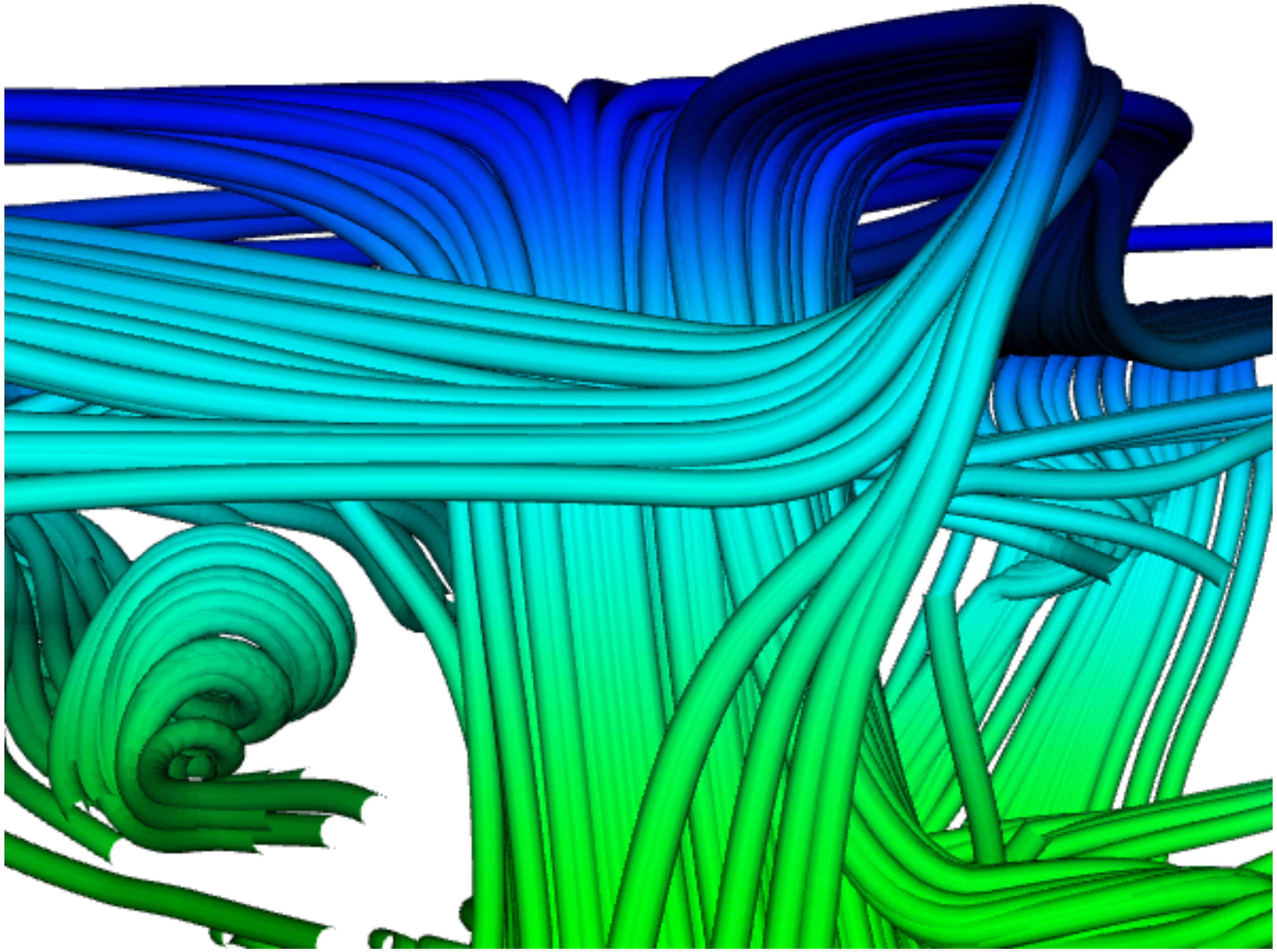
Hand-drawn black-and-white illustrations



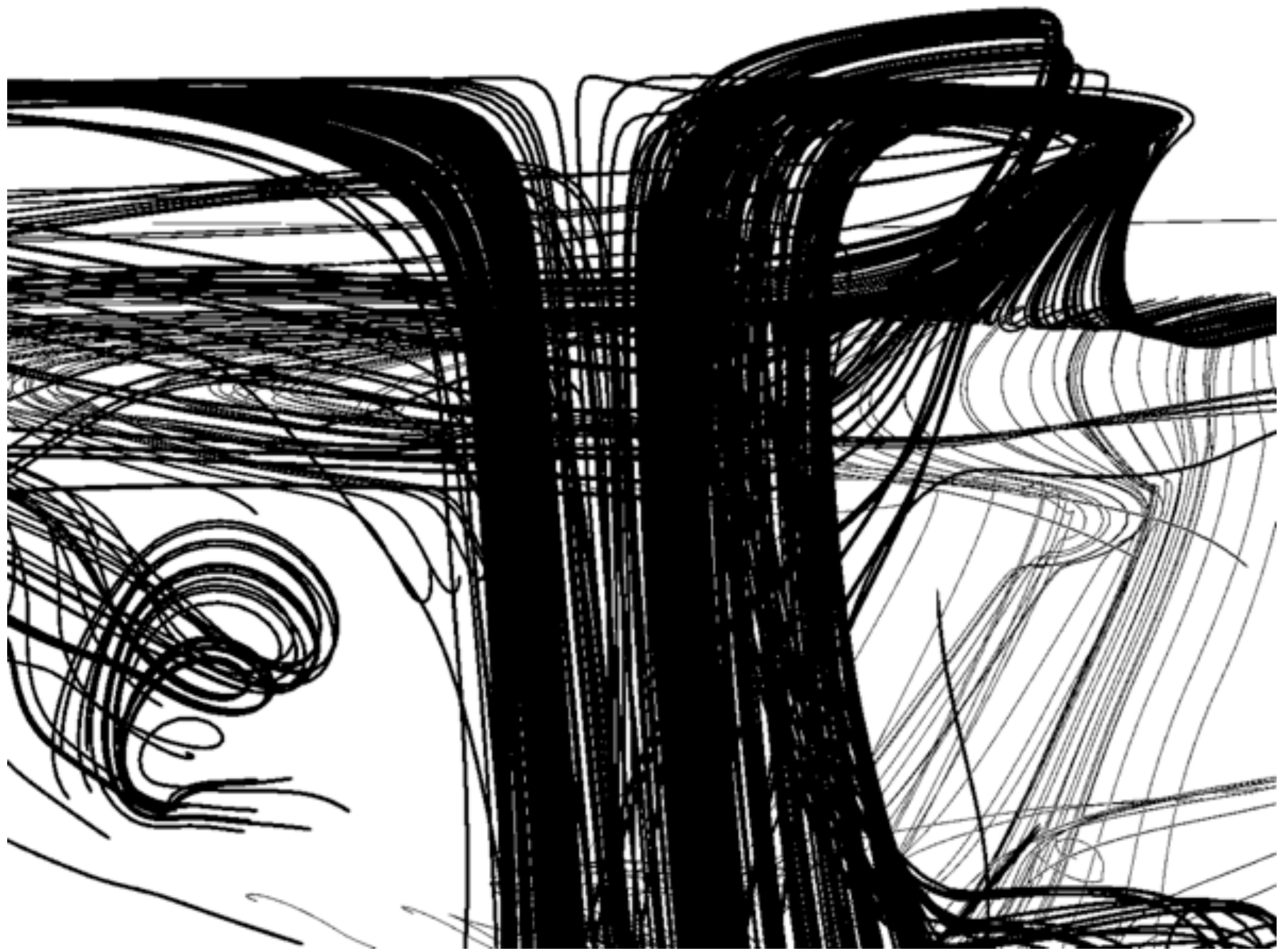
[House and Pansky, 1960]

From tubes to depth-dependent halos



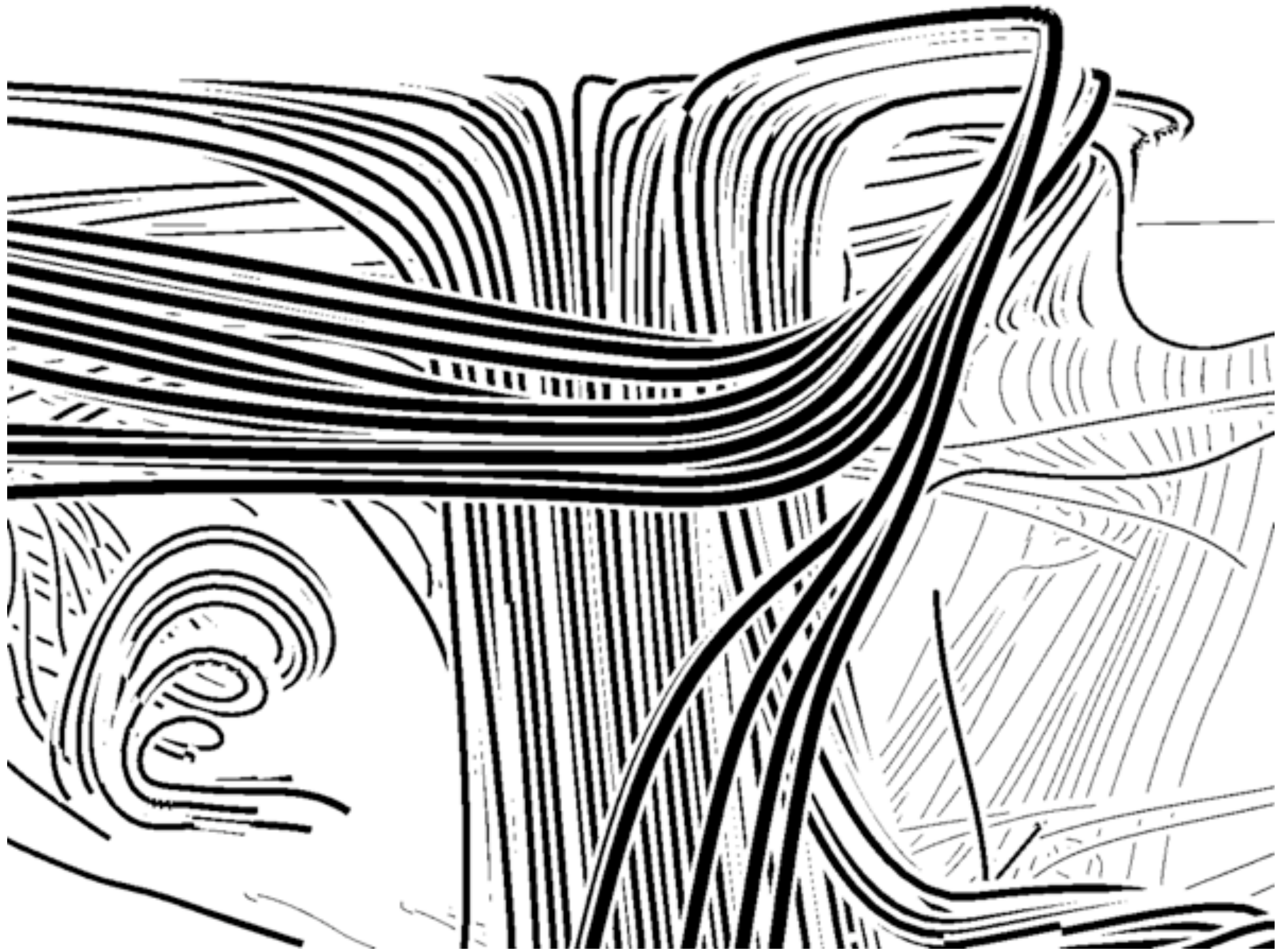
tubes

From tubes to depth-dependent halos



black lines

From tubes to depth-dependent halos

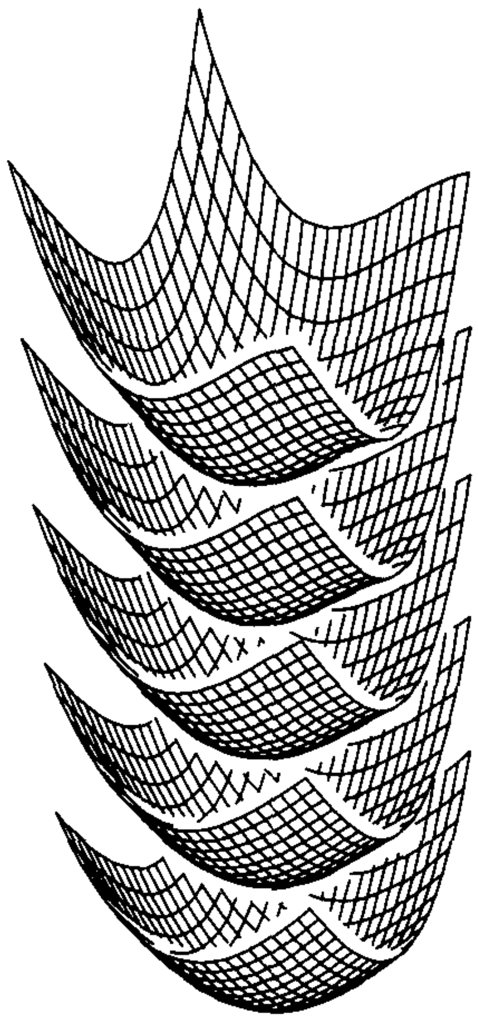


black lines with halos

From tubes to depth-dependent halos

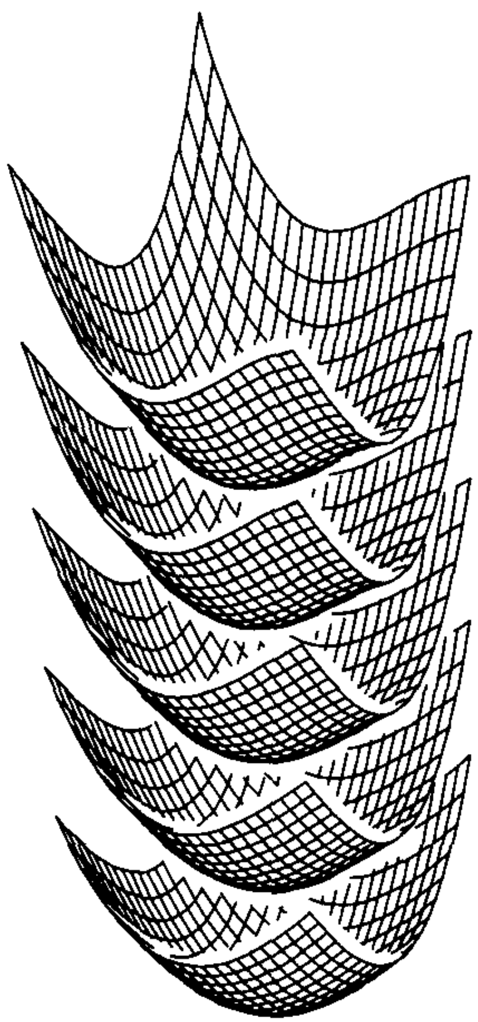
black lines with depth-dependent halos

Halos in illustration and visualization



[Appel et al., 1979]

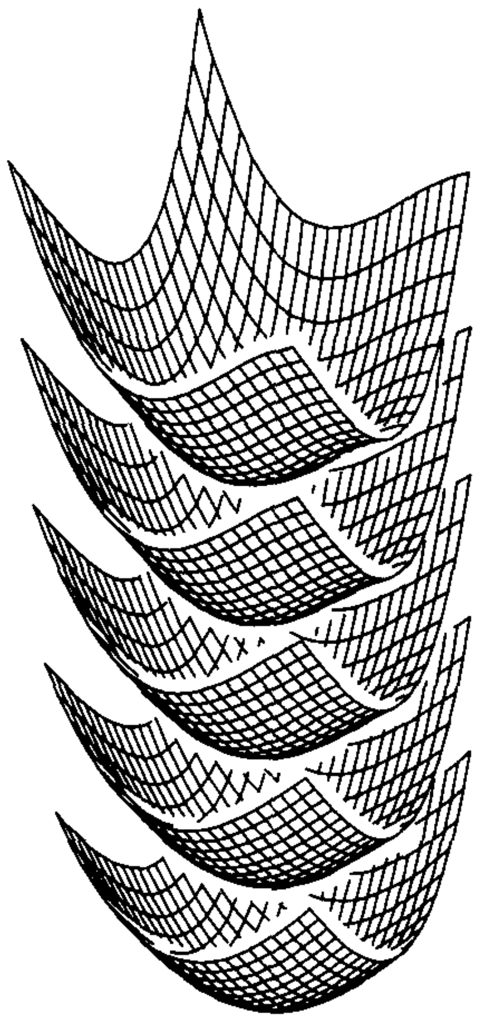
Halos in illustration and visualization



[Appel et al., 1979]

[Bruckner et al., 2007]

Halos in illustration and visualization



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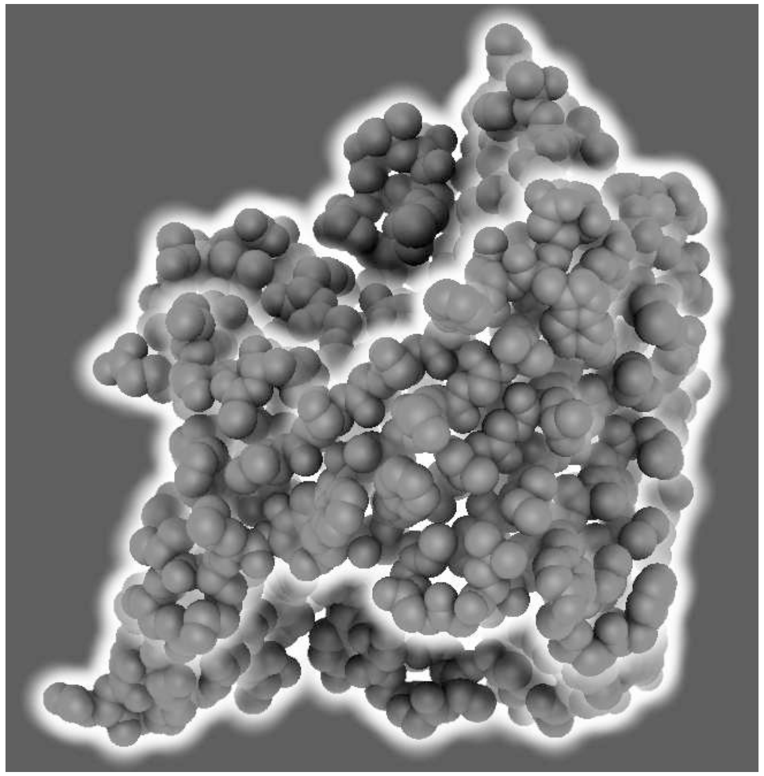
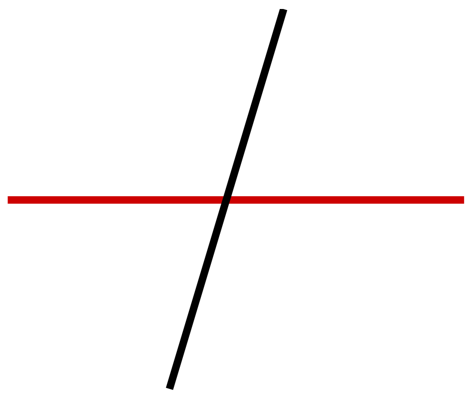


[Tarini et al., 2006]

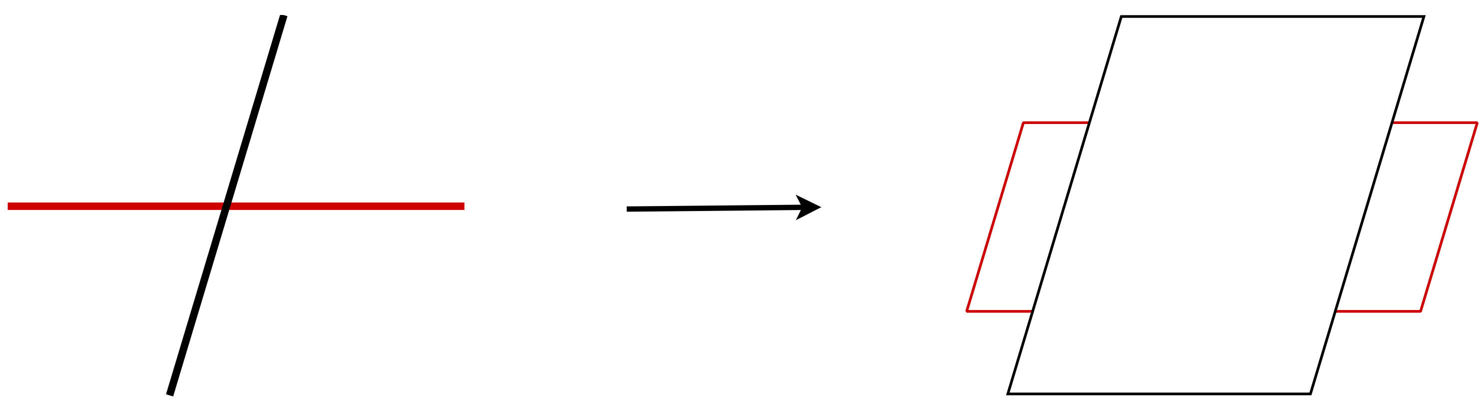
Depth-Dependent Halos

Depth-dependent halos — overview



lines

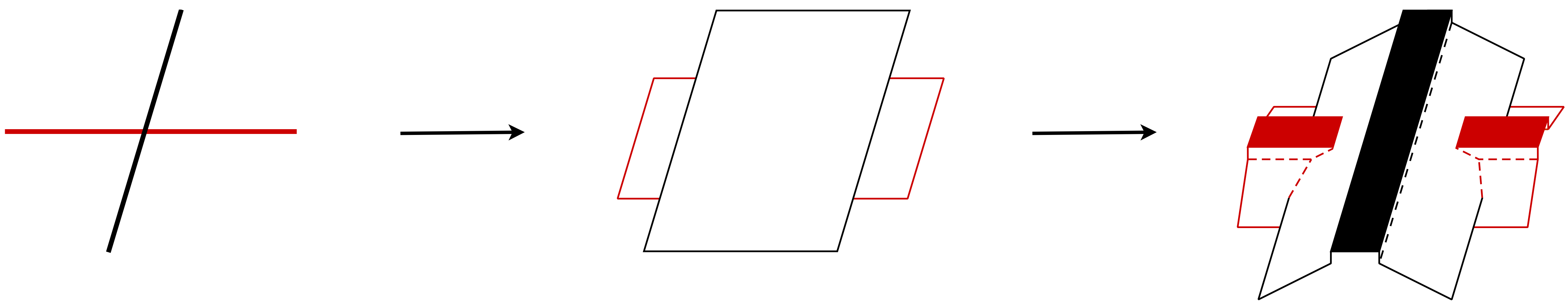
Depth-dependent halos — overview



lines

view-oriented triangle strips

Depth-dependent halos — overview

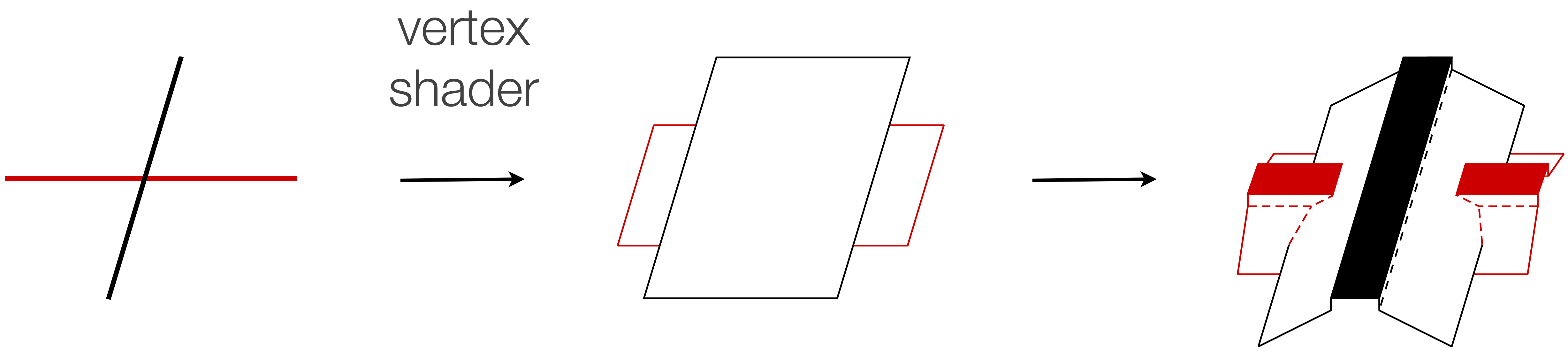


lines

view-oriented
triangle strips

depth
manipulation,
coloring

Depth-dependent halos — overview



lines

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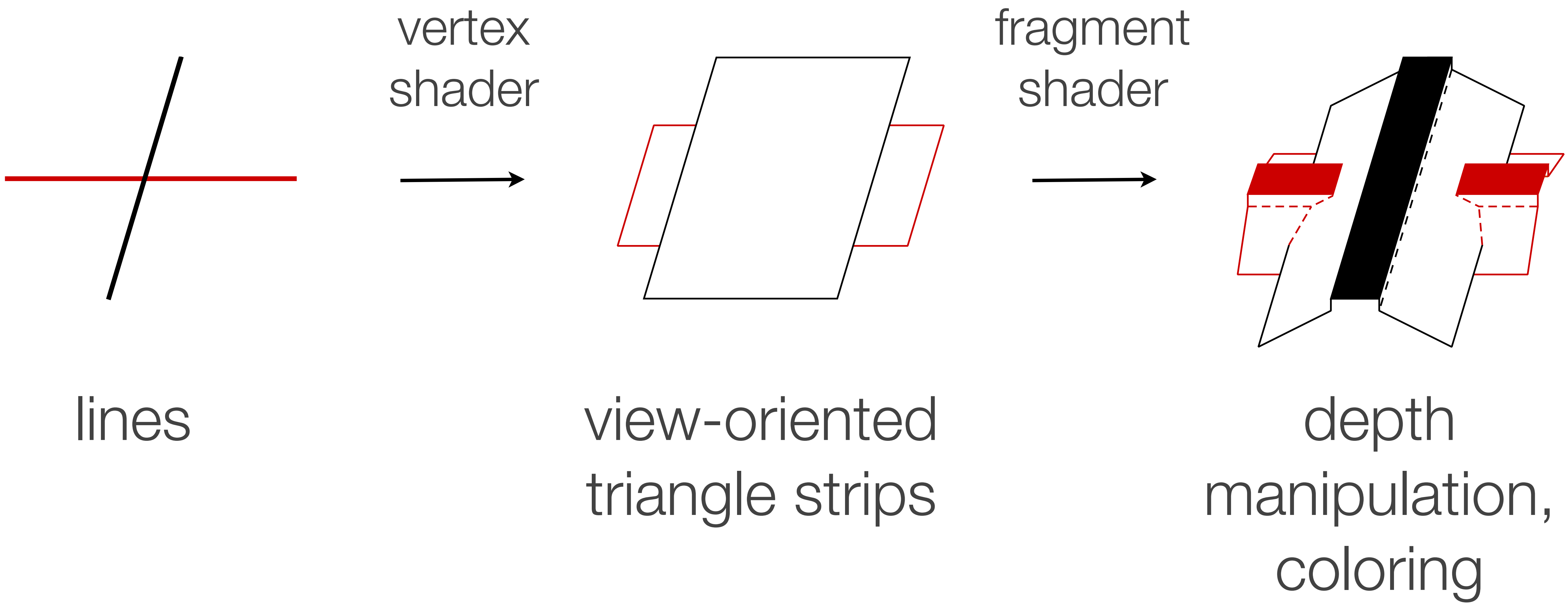
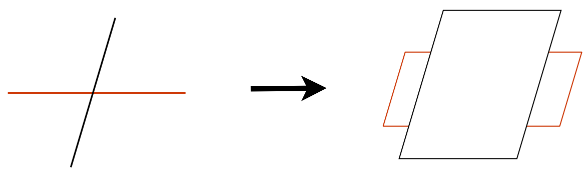
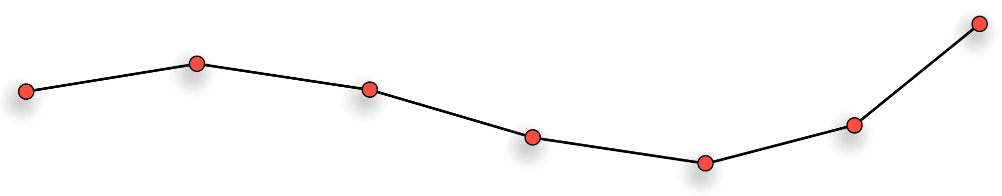
Depth-dependent halos — overview



View-oriented strips (vertex shader)





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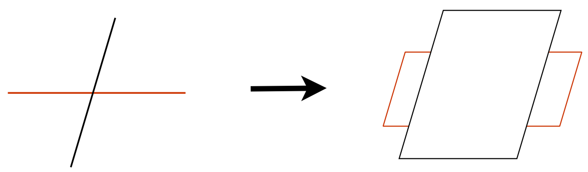
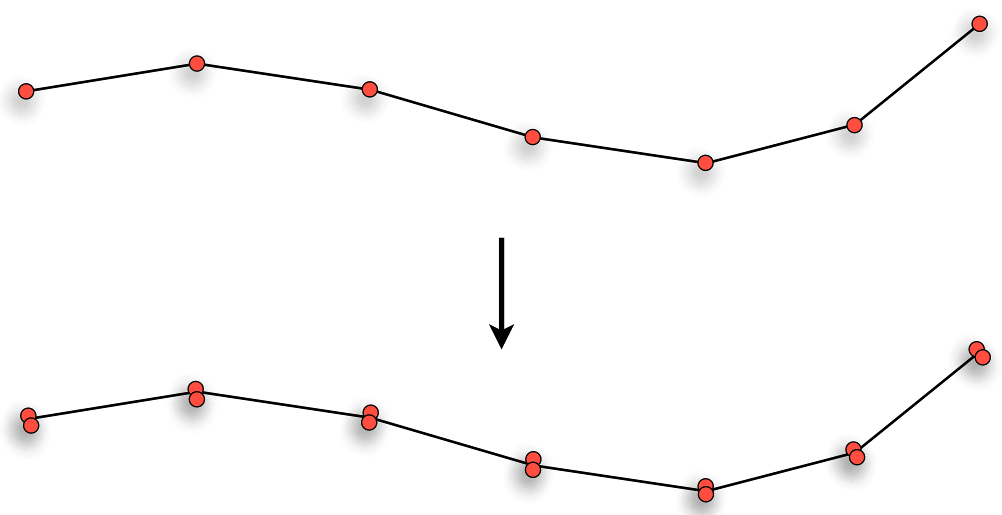
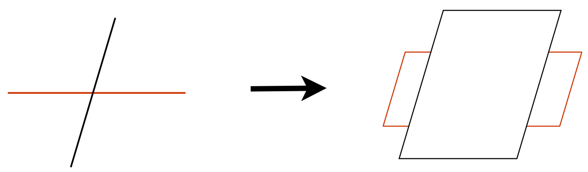
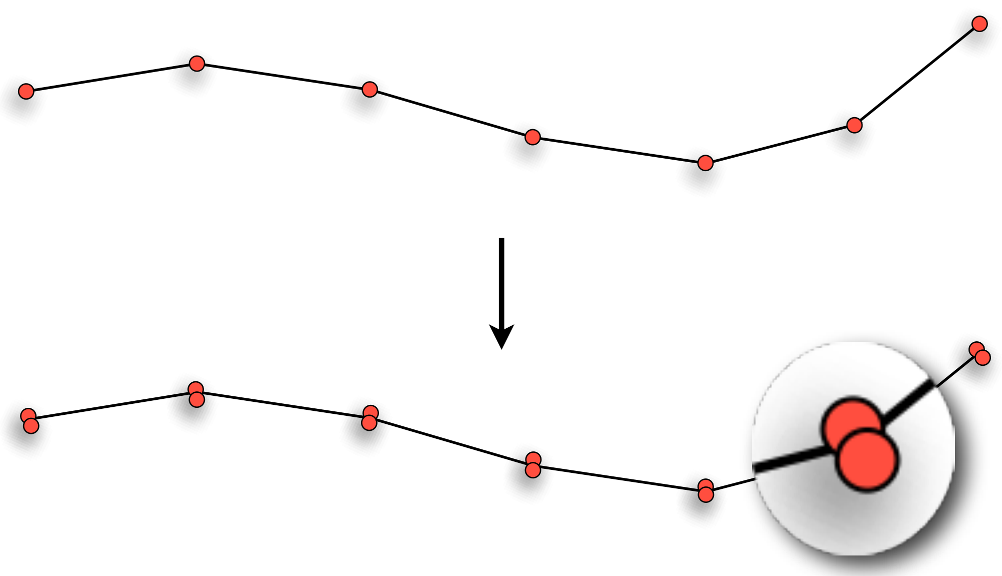




- duplicate each vertex
- add texture coordinates (u, v)
- add average direction vector $\mathbf{D}$

View-oriented strips (vertex shader)





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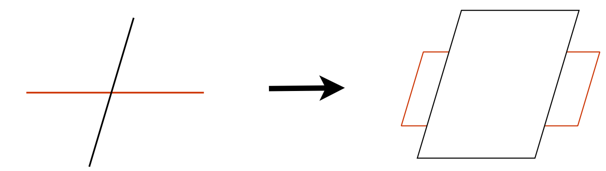

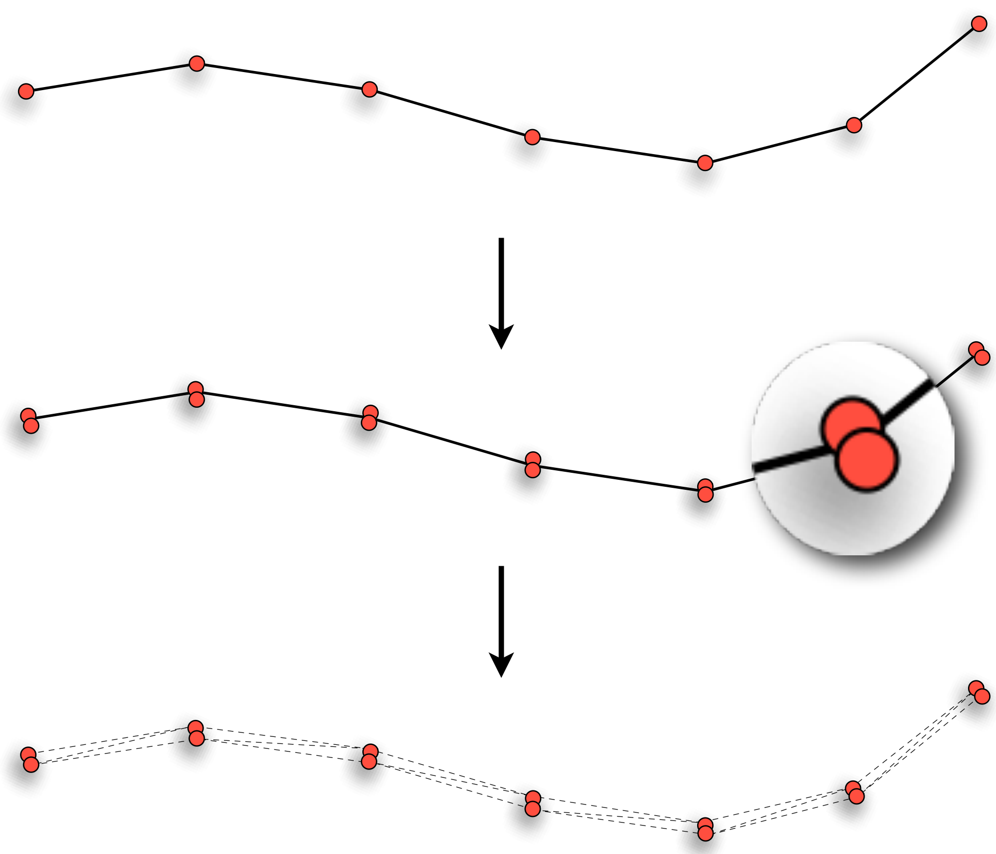

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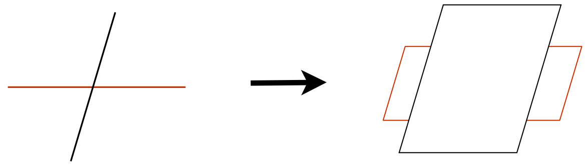

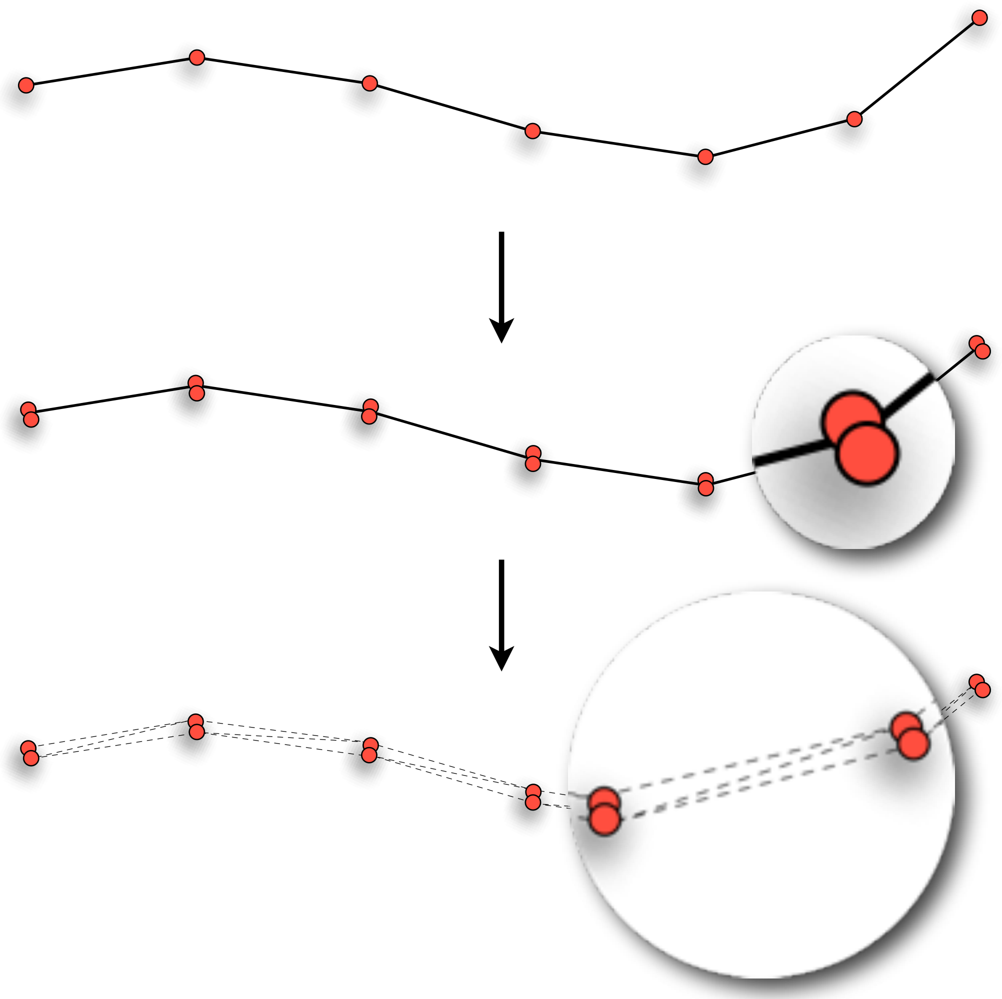

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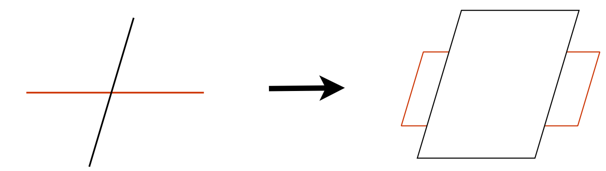

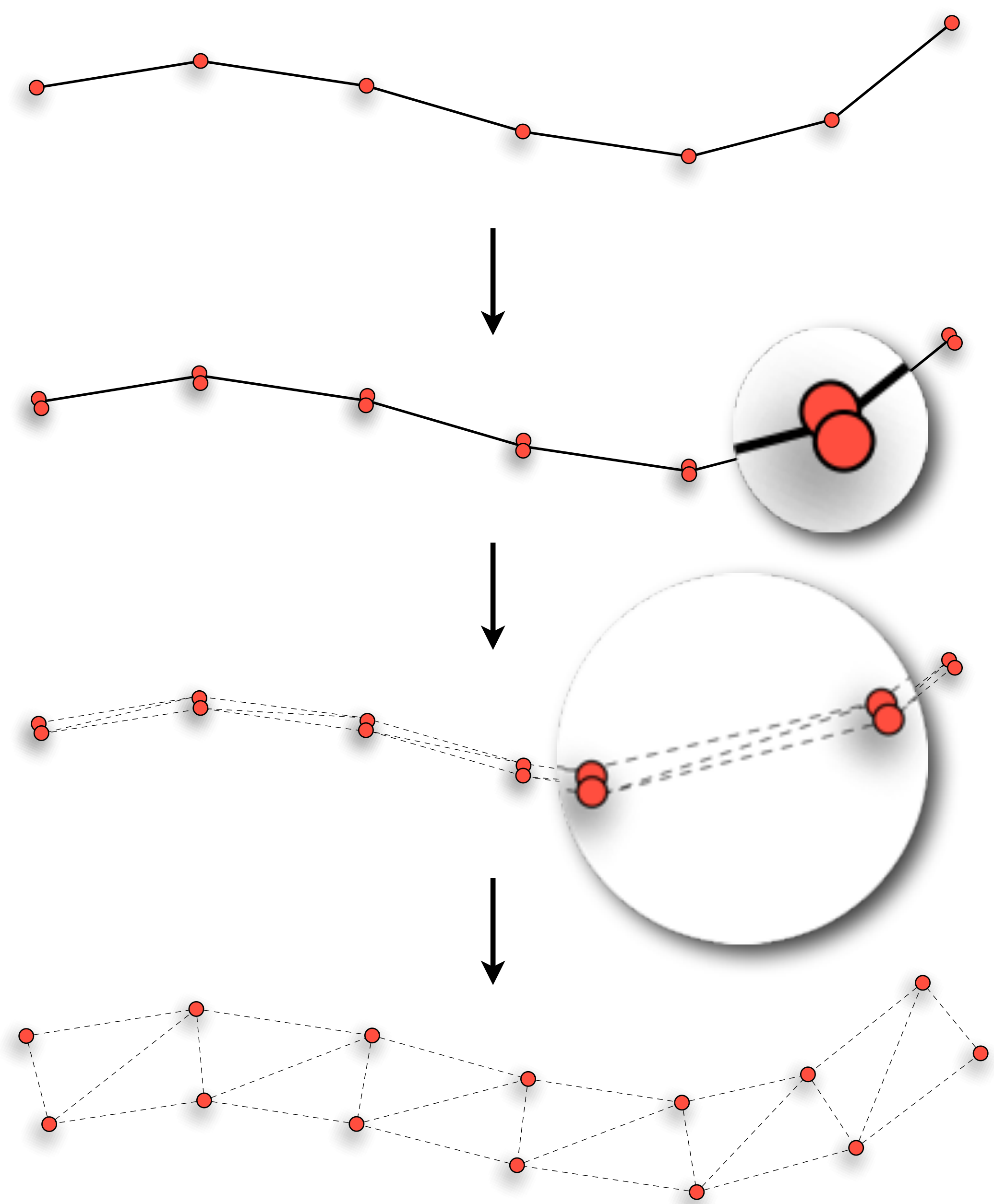

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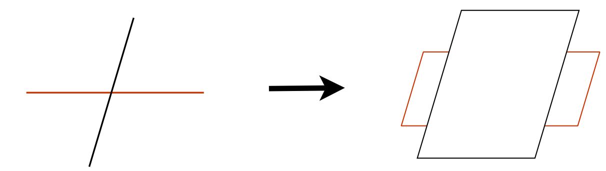
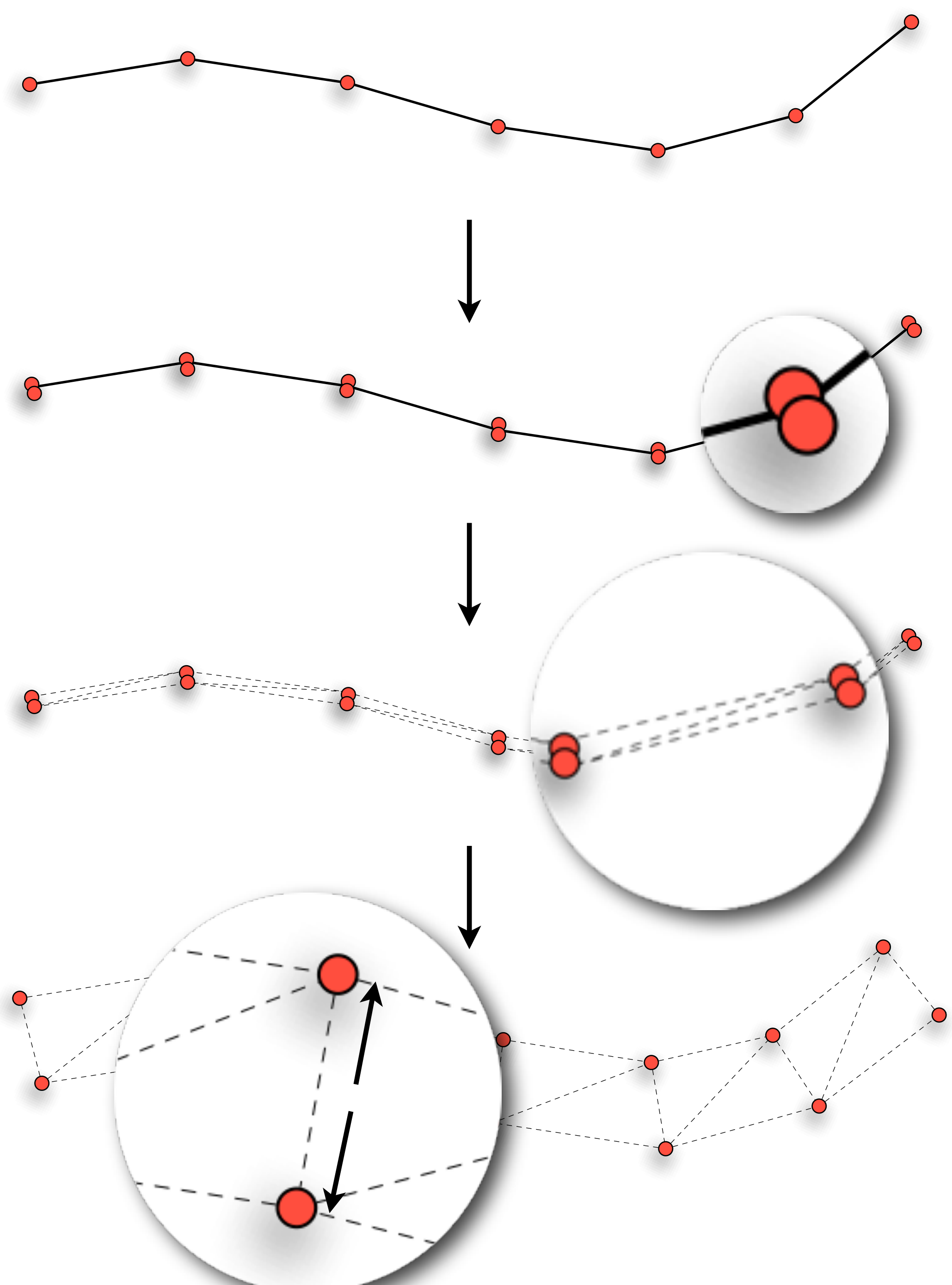
- change vertex position:

$$p_{\text{out}} = p_{\text{in}} + \|\mathbf{V} \times \mathbf{D}\|(v - 0.5)w_{\text{strip}}$$

View-oriented strips (vertex shader)





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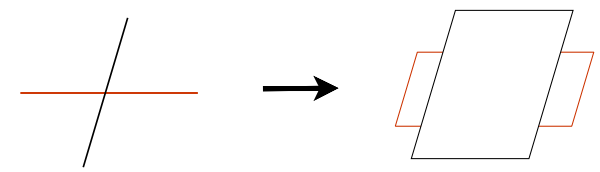

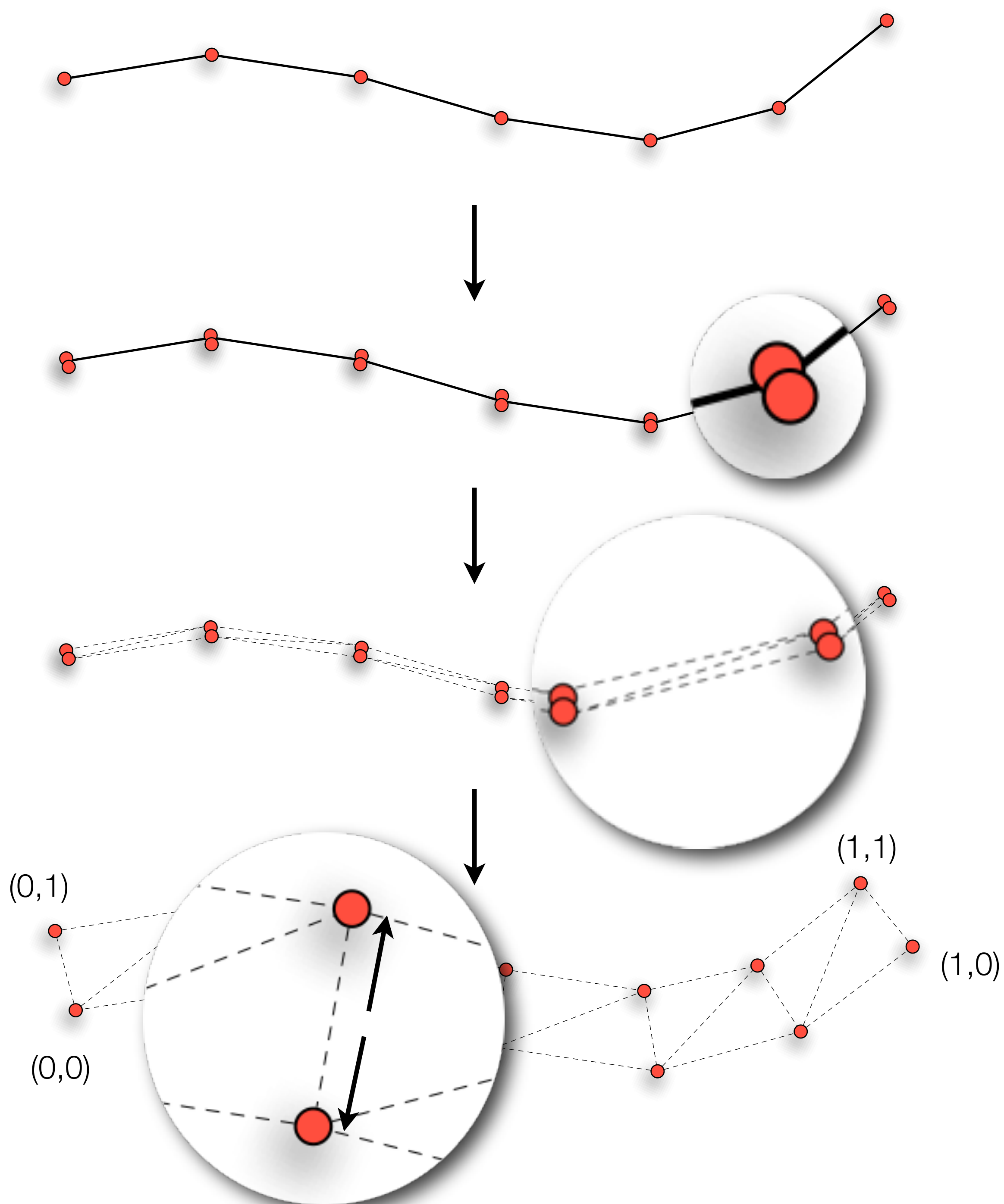

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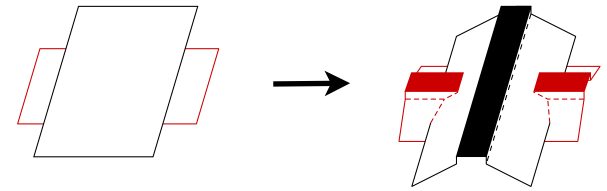
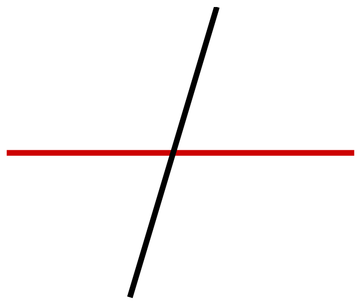
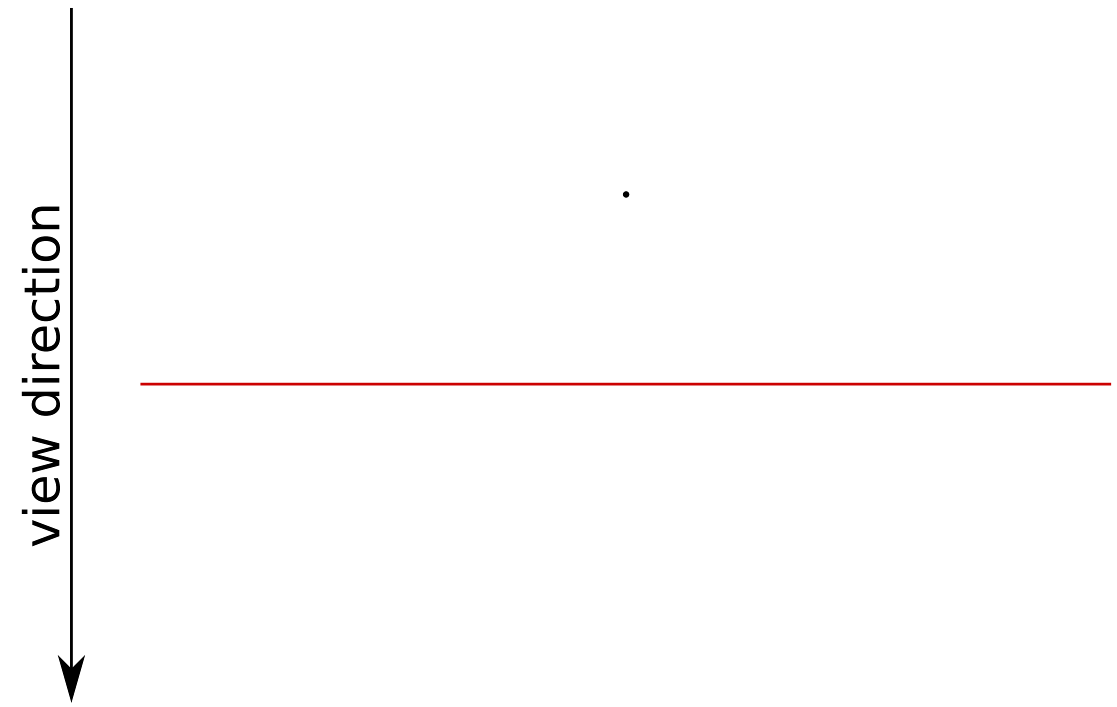
Depth manipulation (fragment shader)







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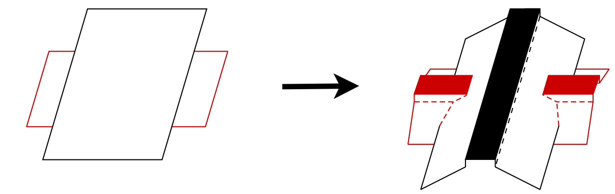

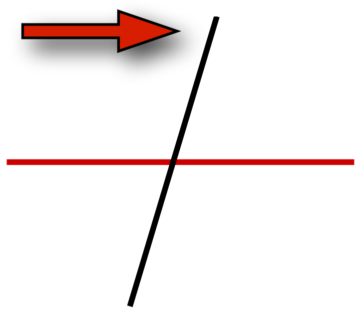

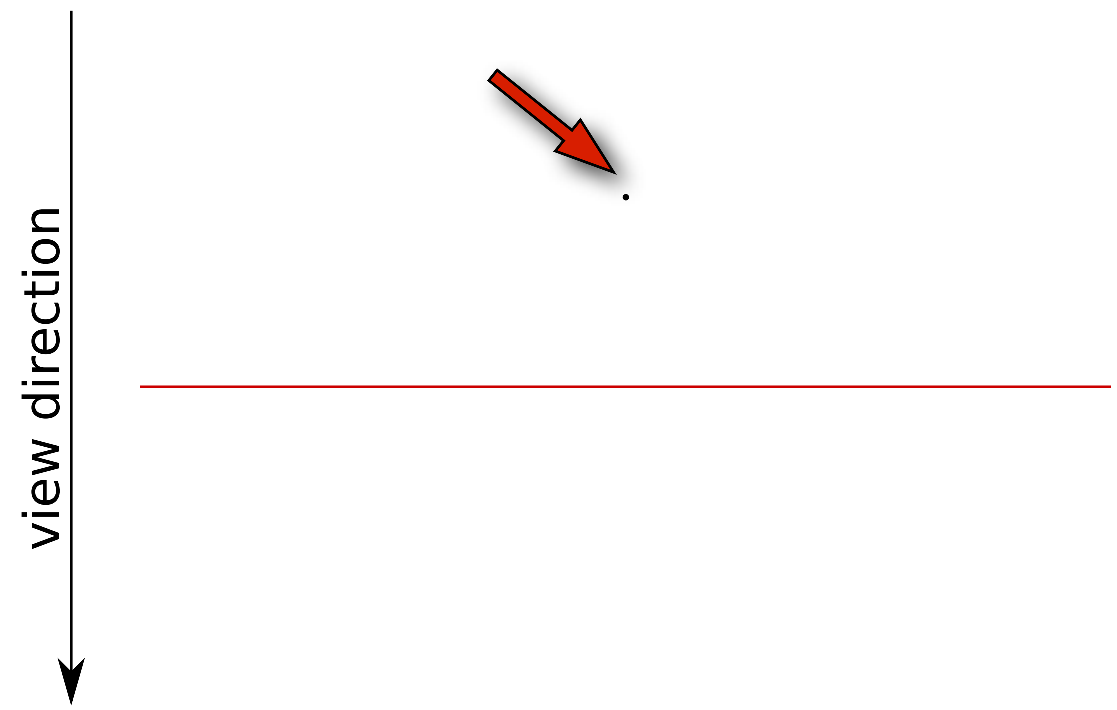

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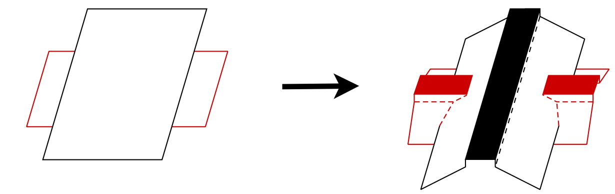

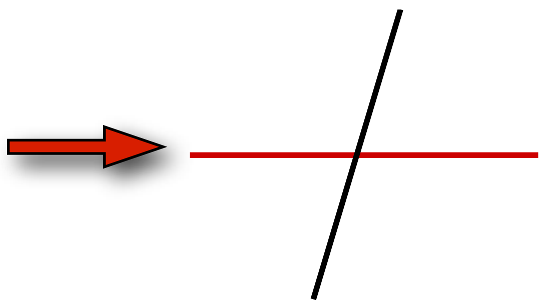

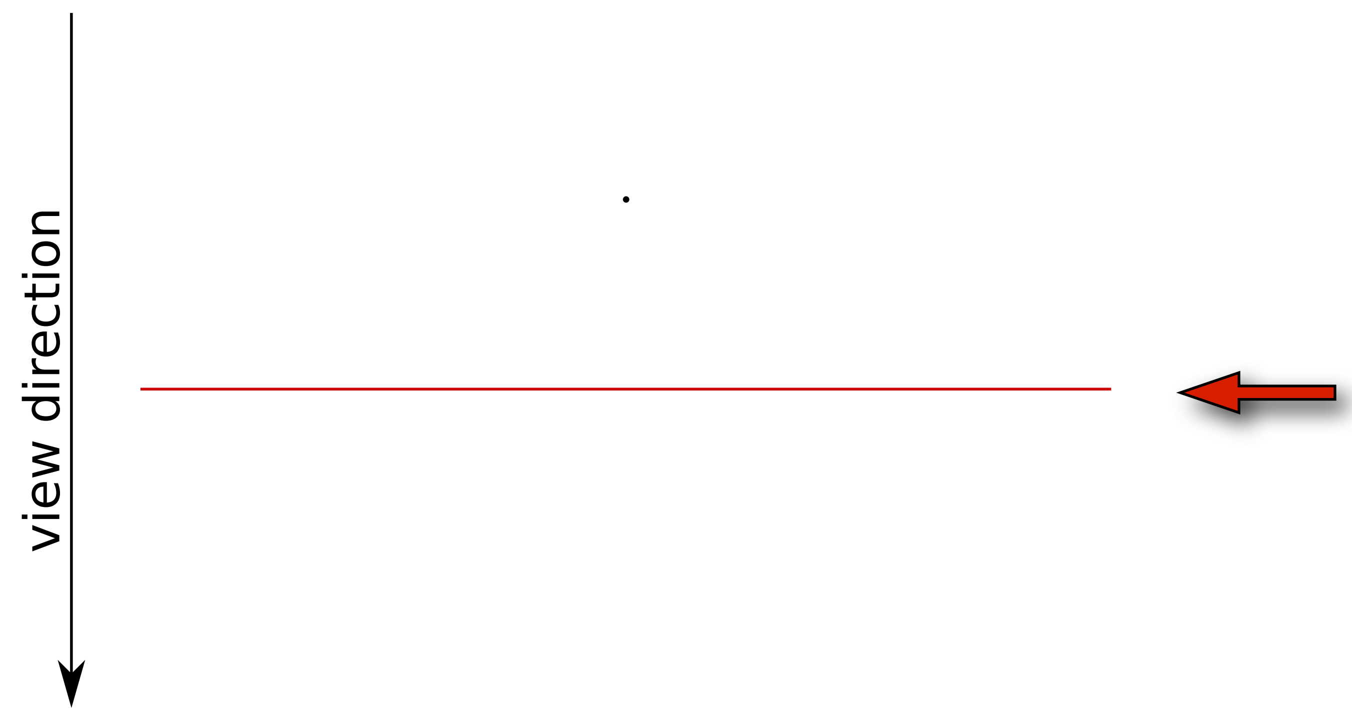

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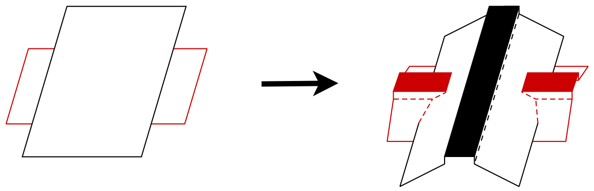

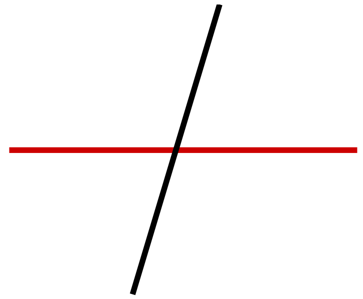

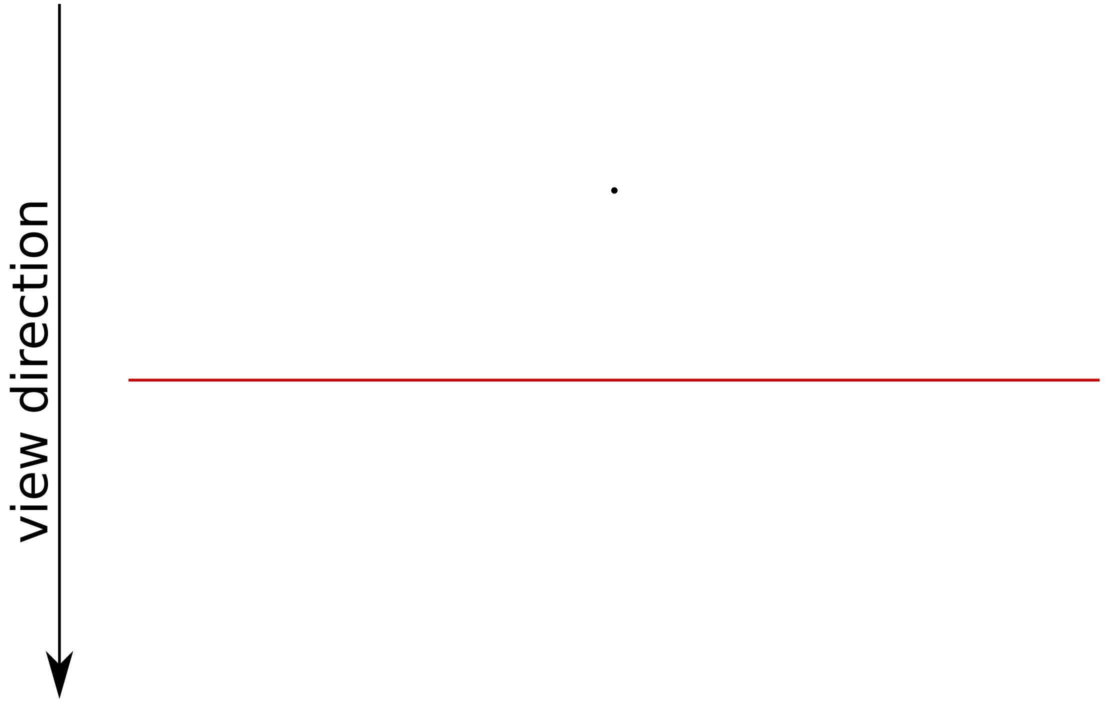

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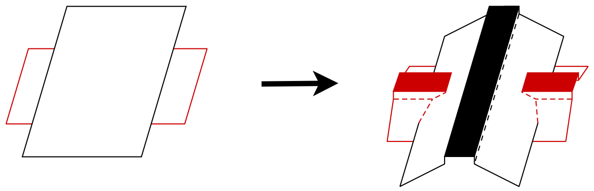

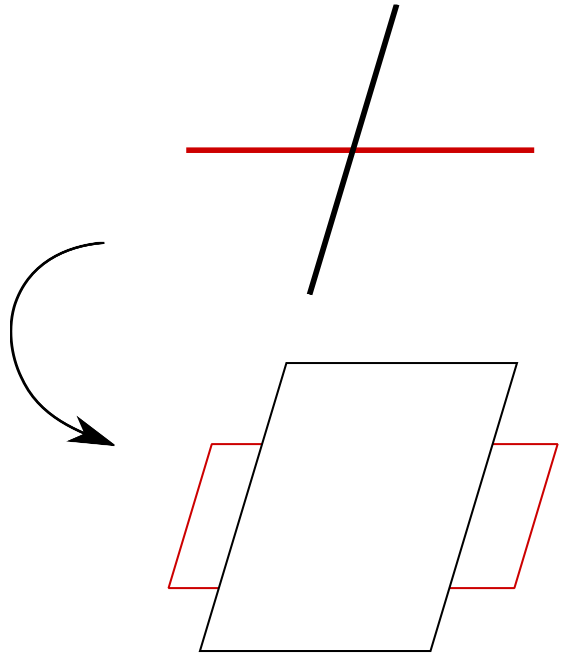

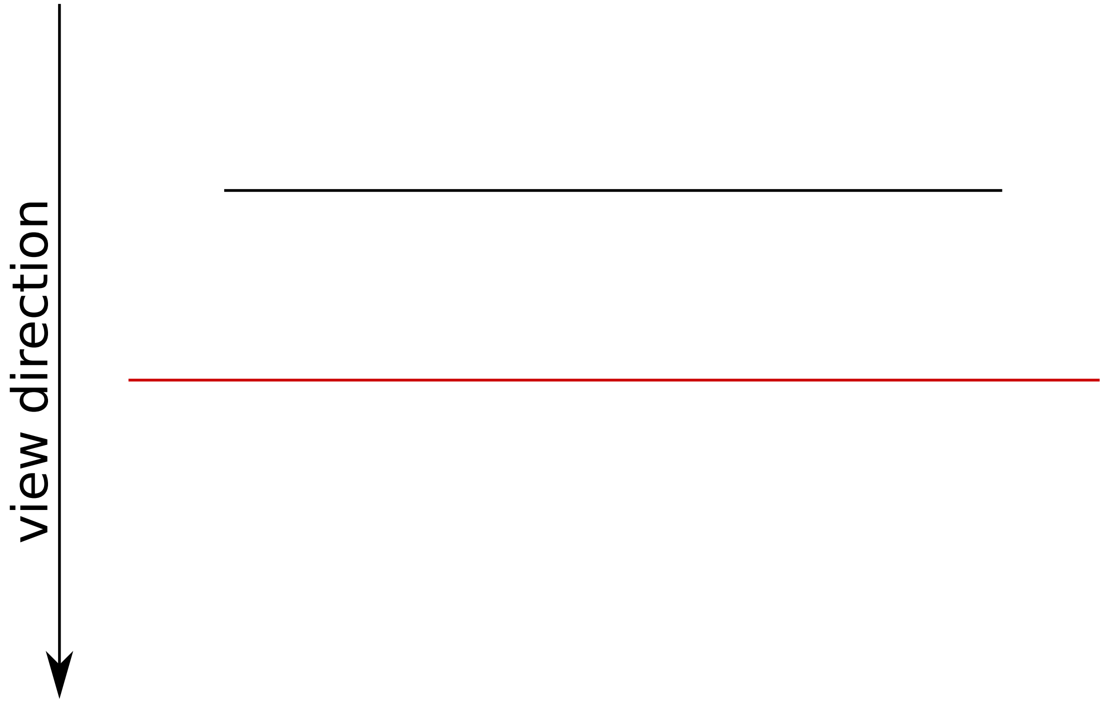

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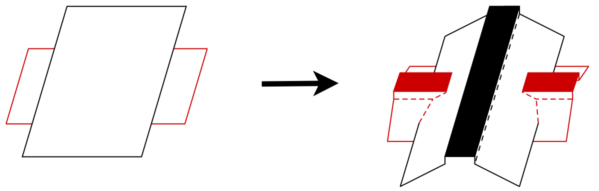

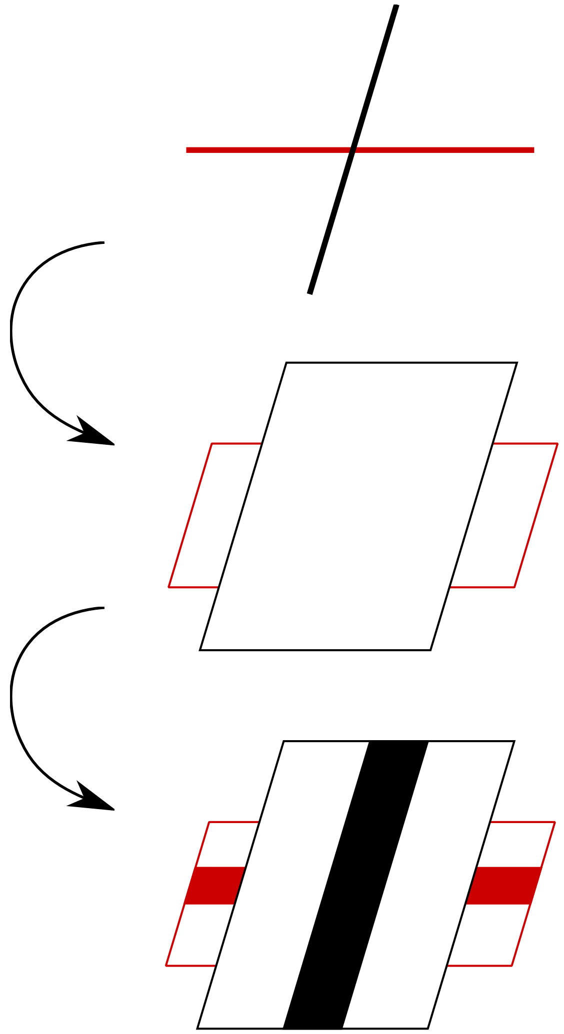

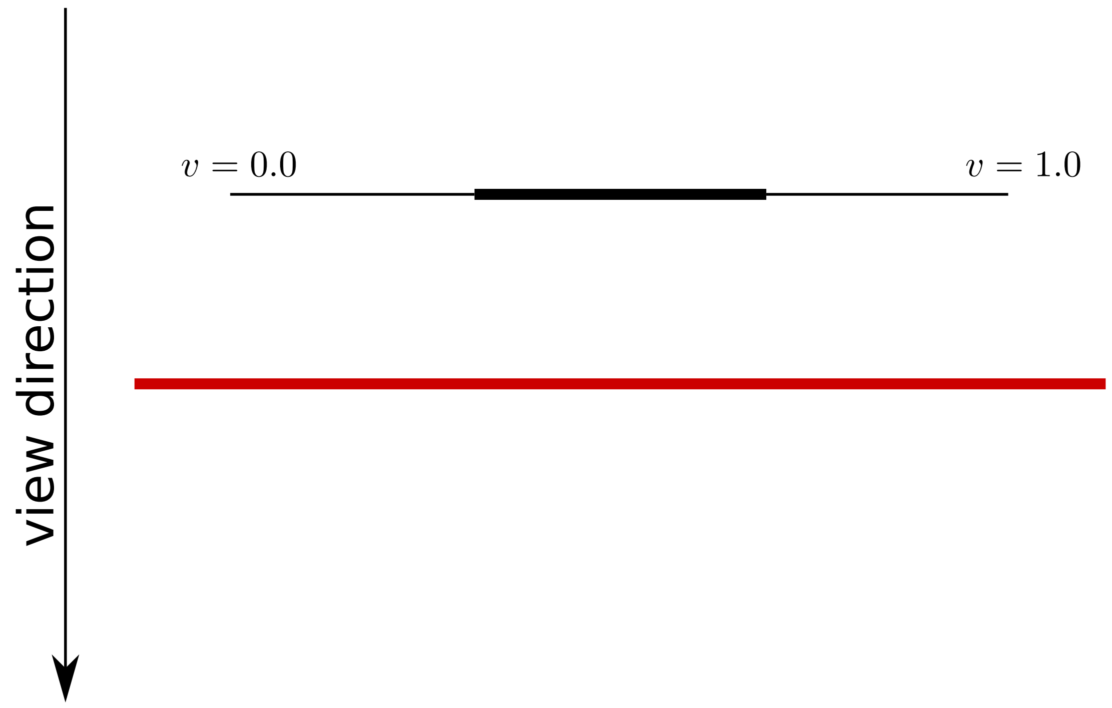

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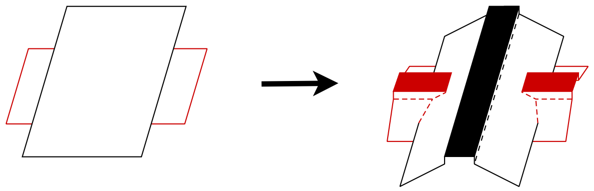

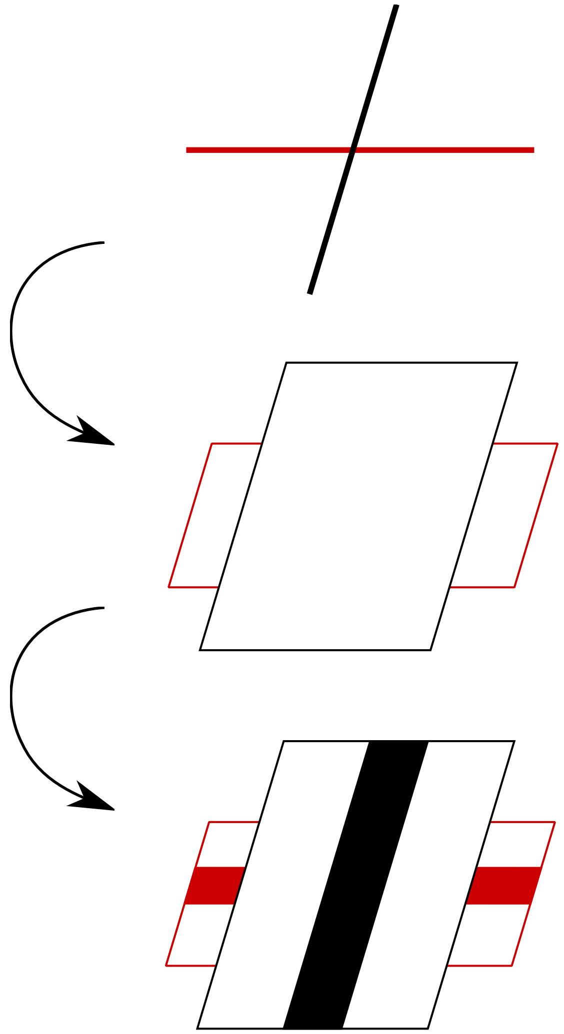

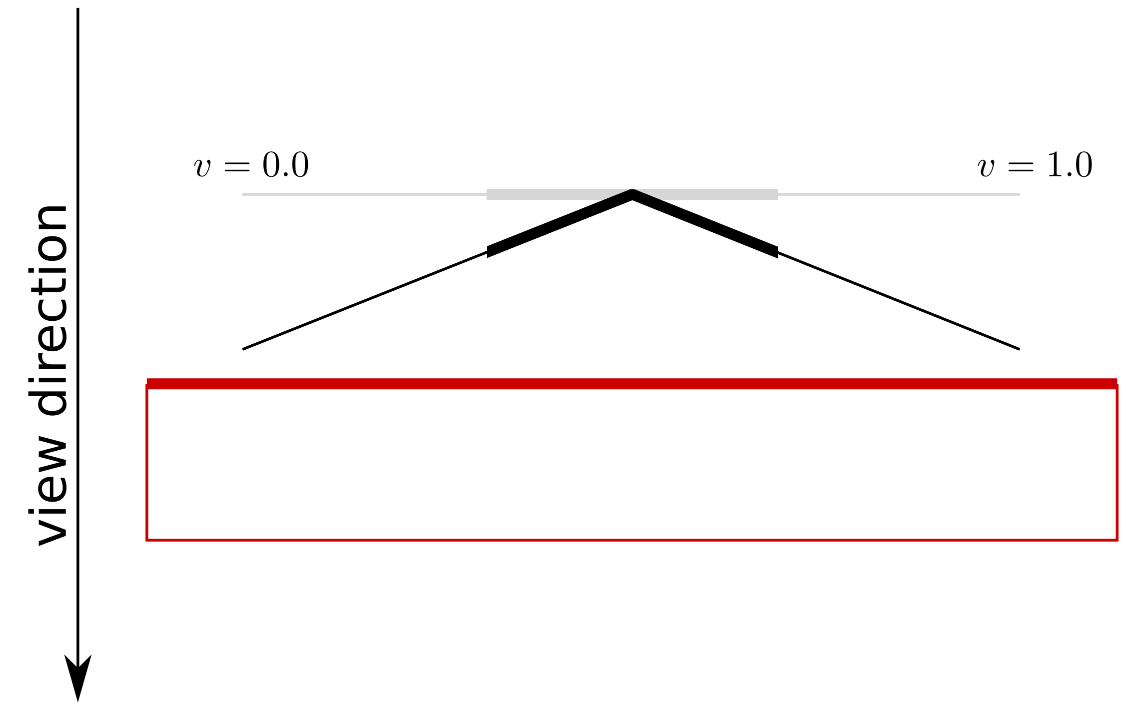

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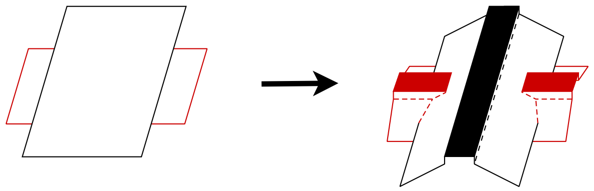
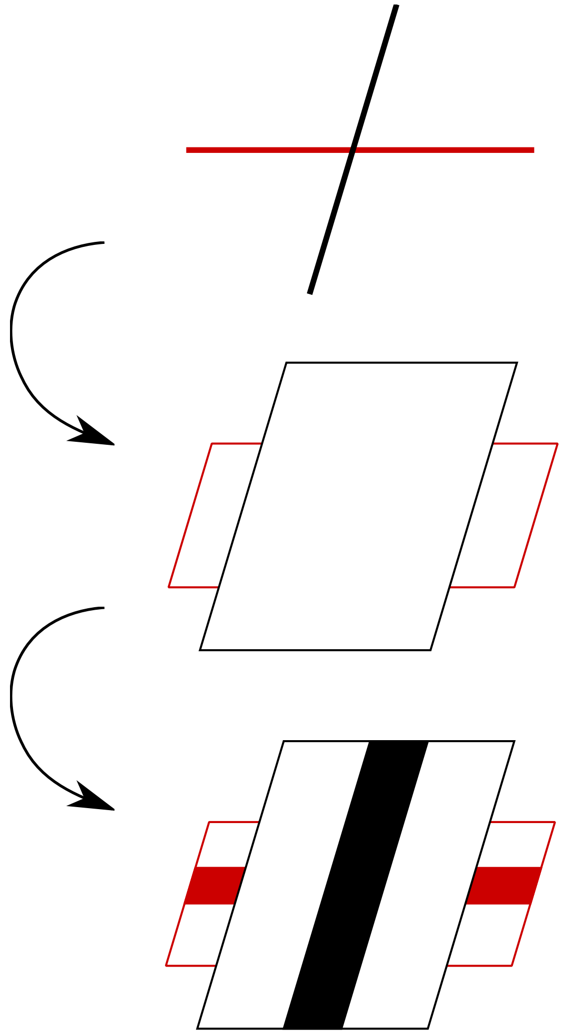
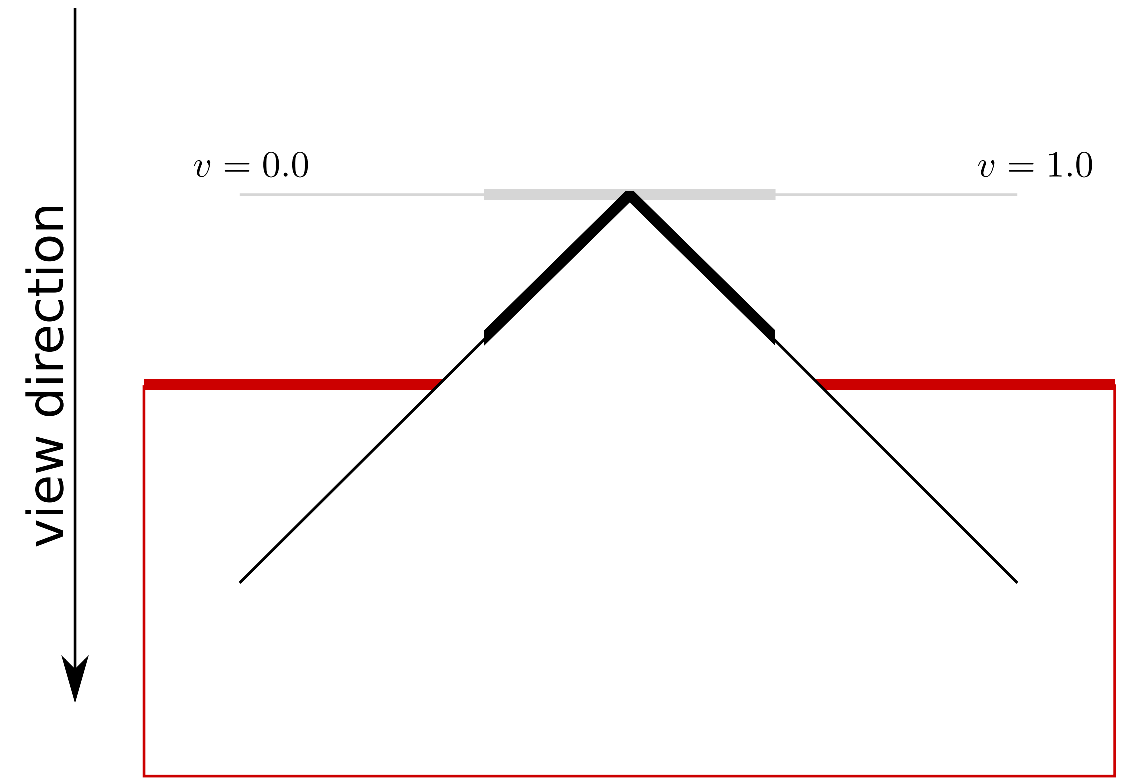
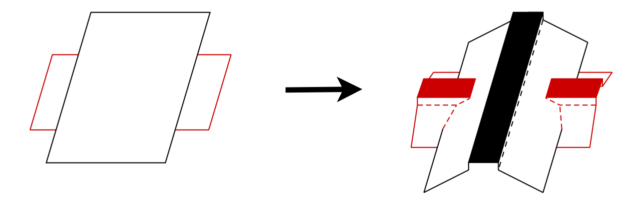


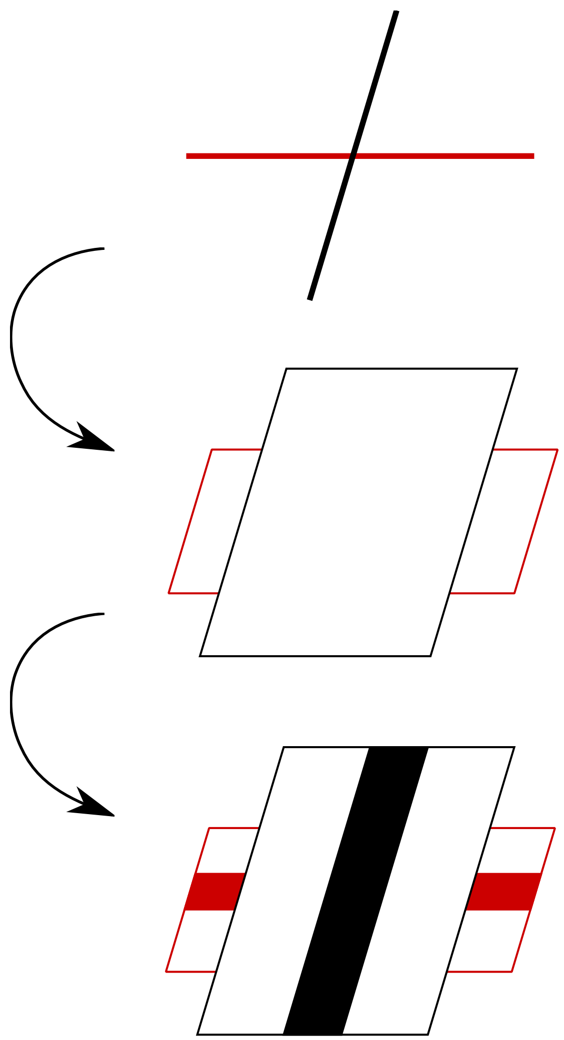


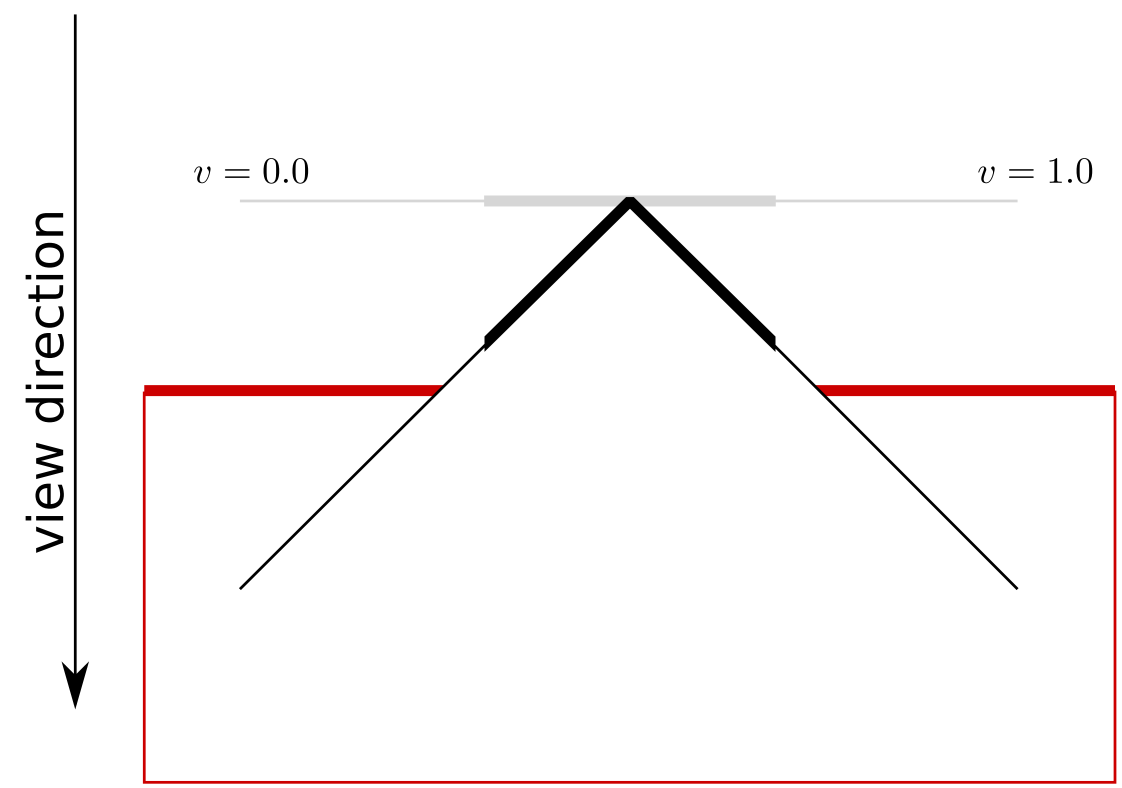


$$d_{\text{new}} = d_{\text{old}} + d_{\max} f_{\text{displacement}}(2|v - 0.5|)$$

Depth manipulation (fragment shader)







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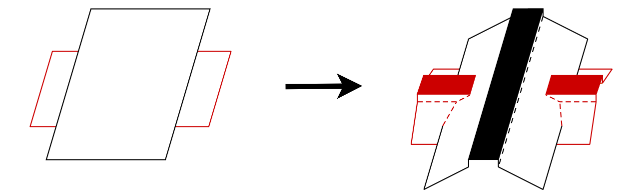
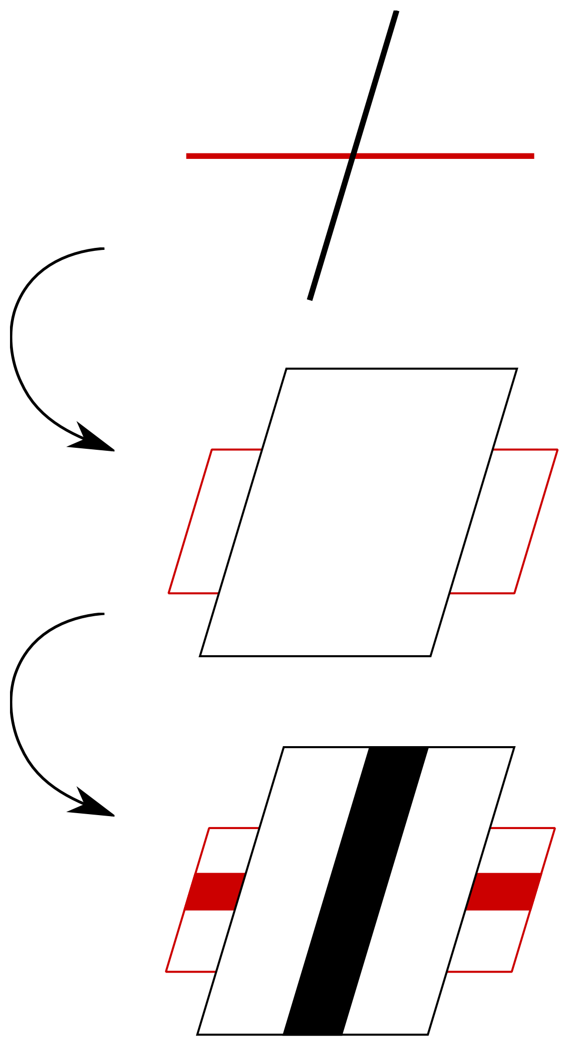
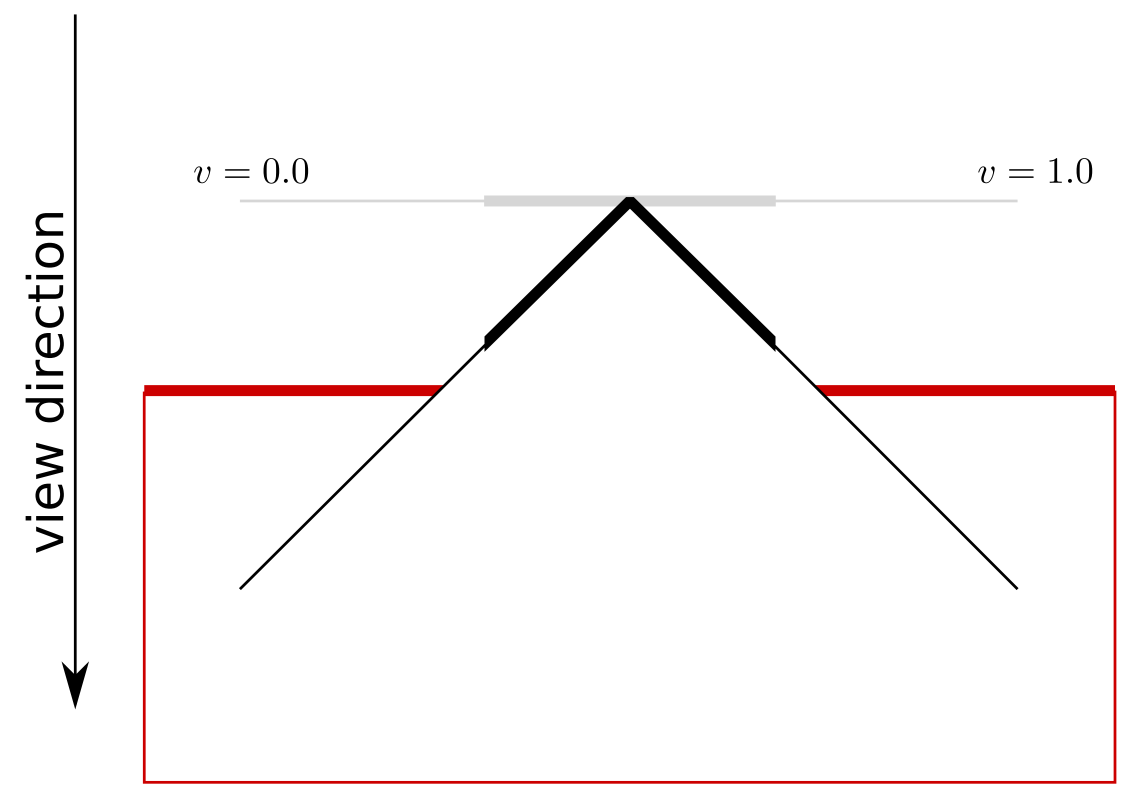
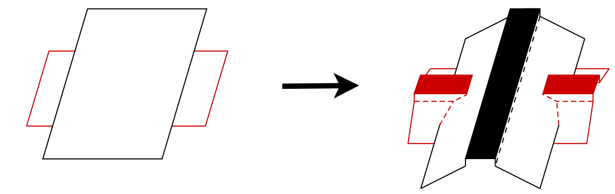
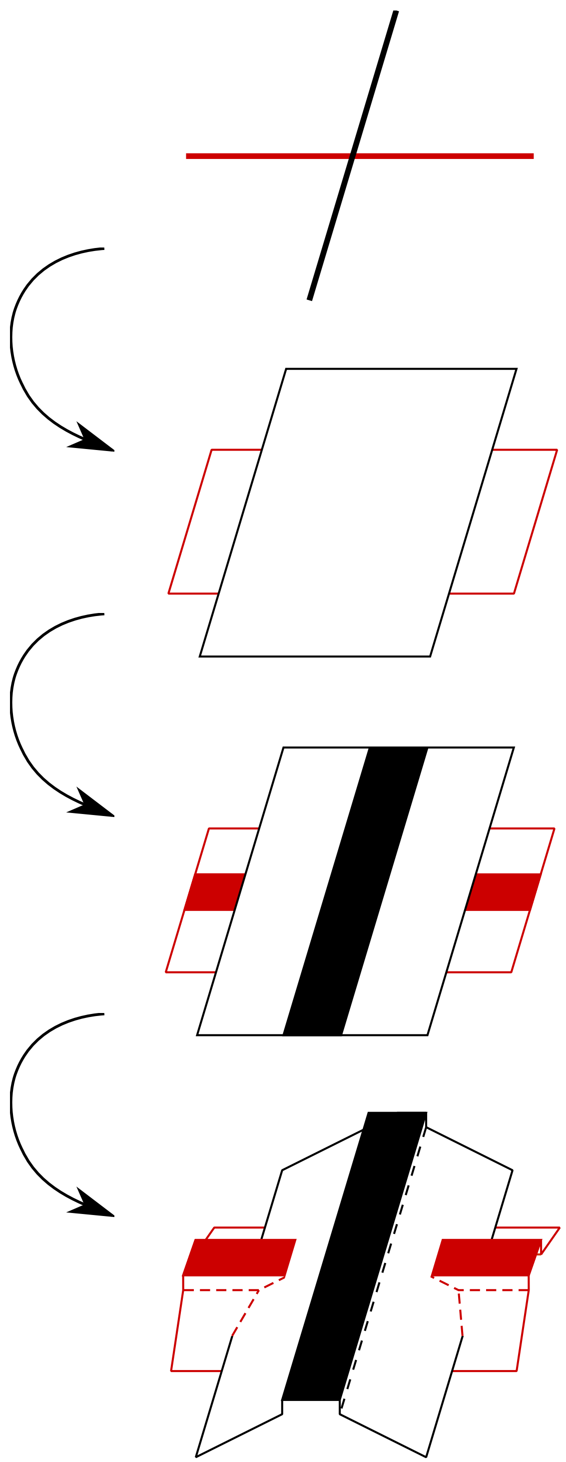


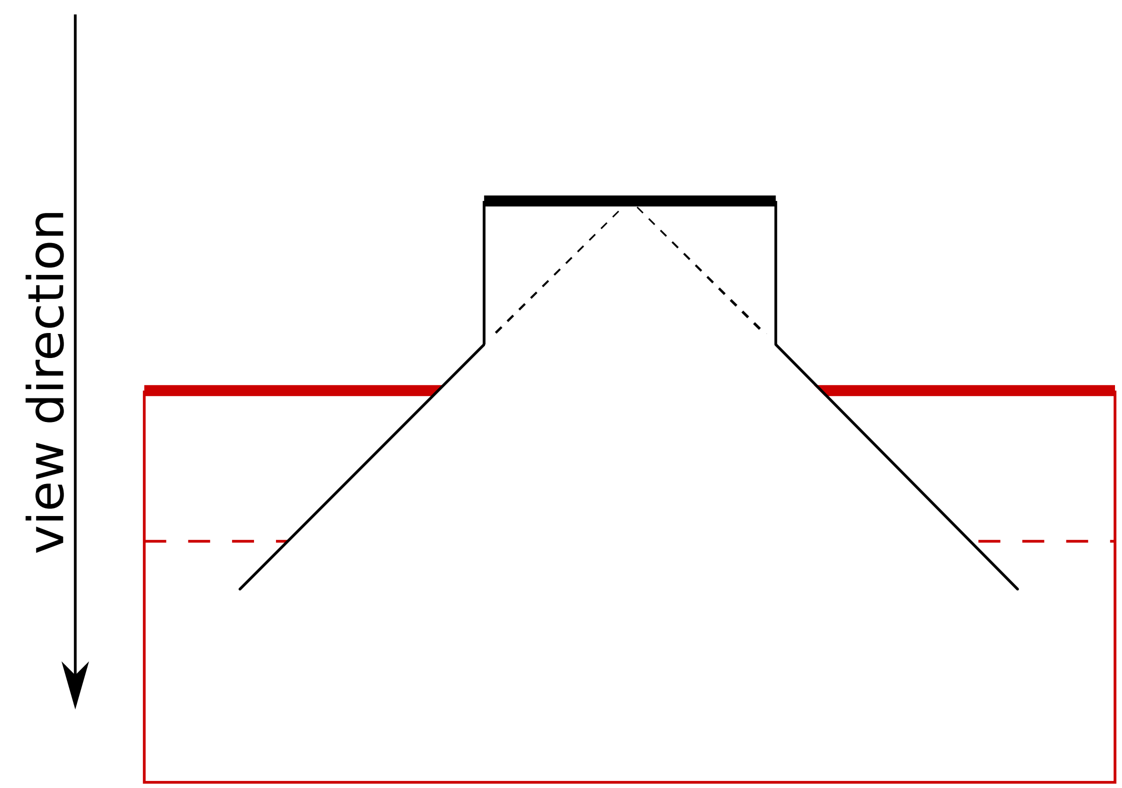




$$d_{\text{new}} = d_{\text{old}} + d_{\max} f_{\text{displacement}}(2|v - 0.5|)$$

Depth manipulation (fragment shader) 





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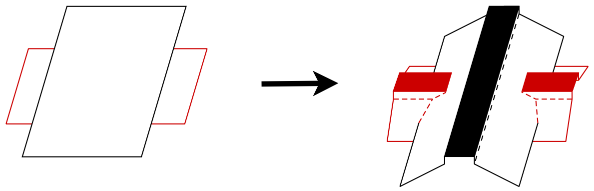

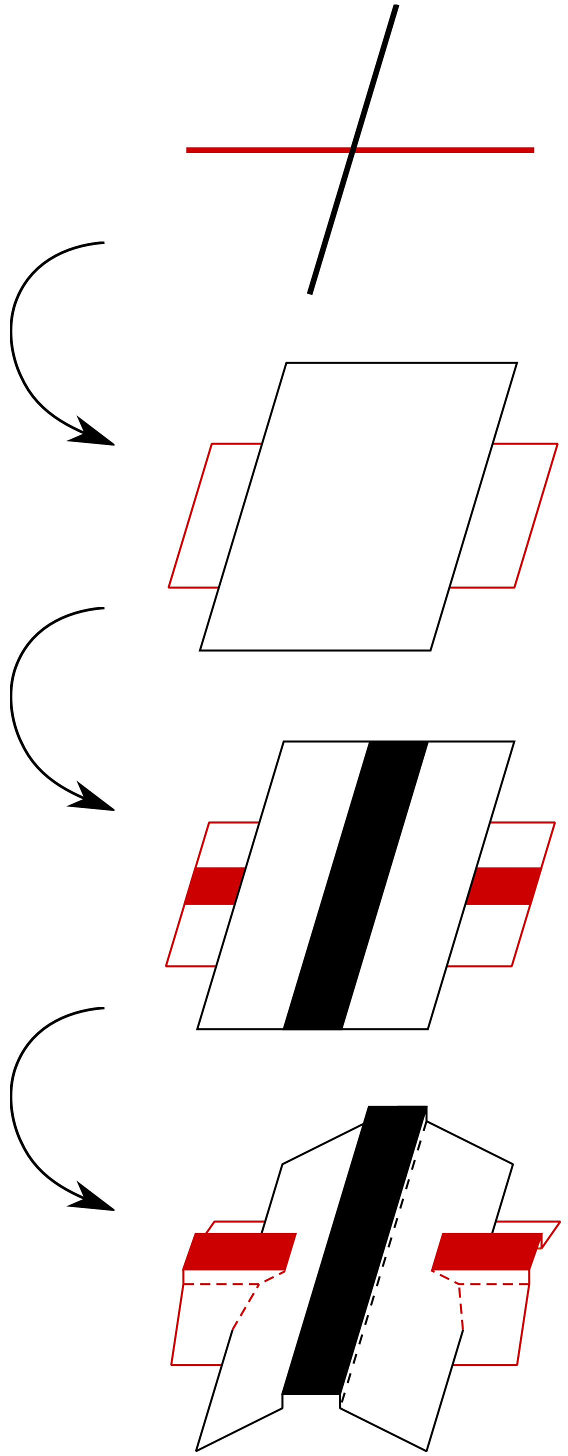

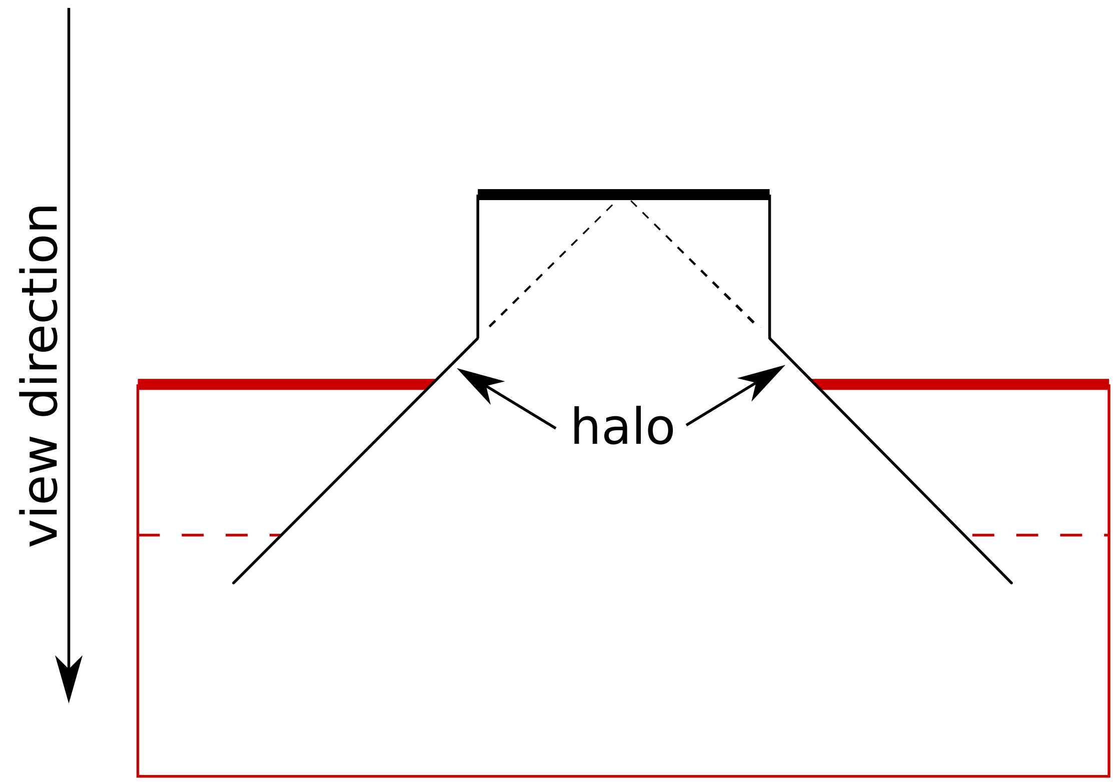

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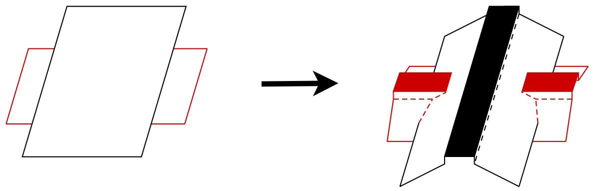

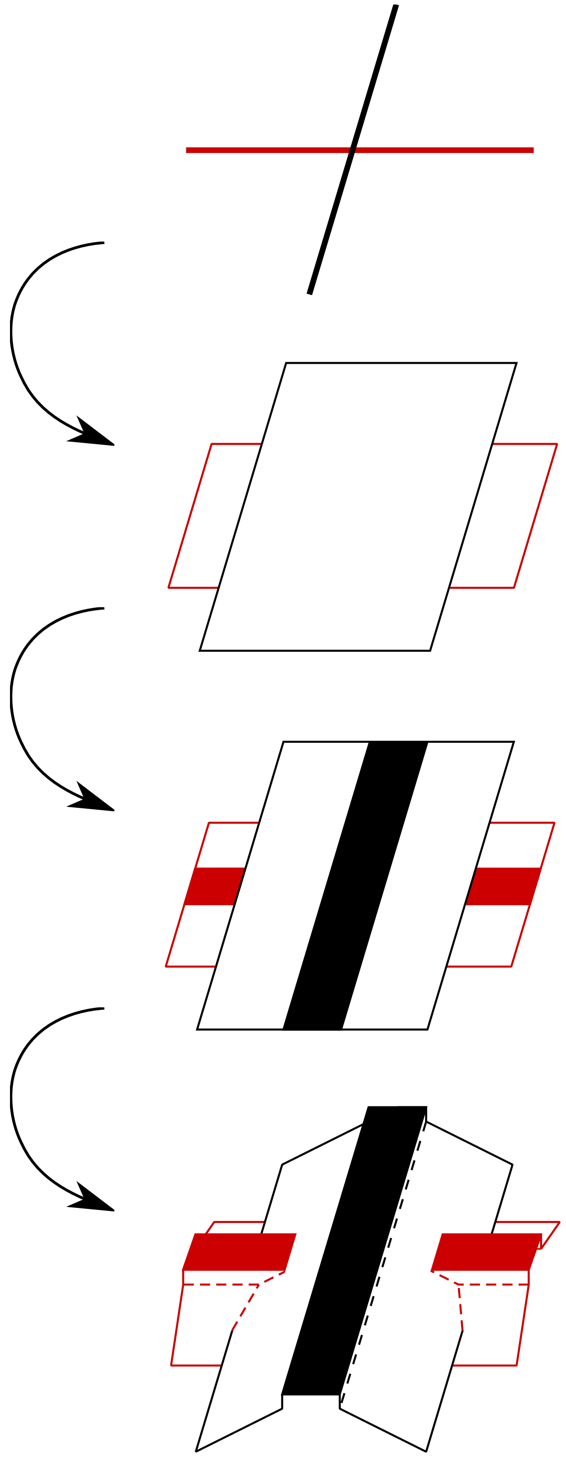

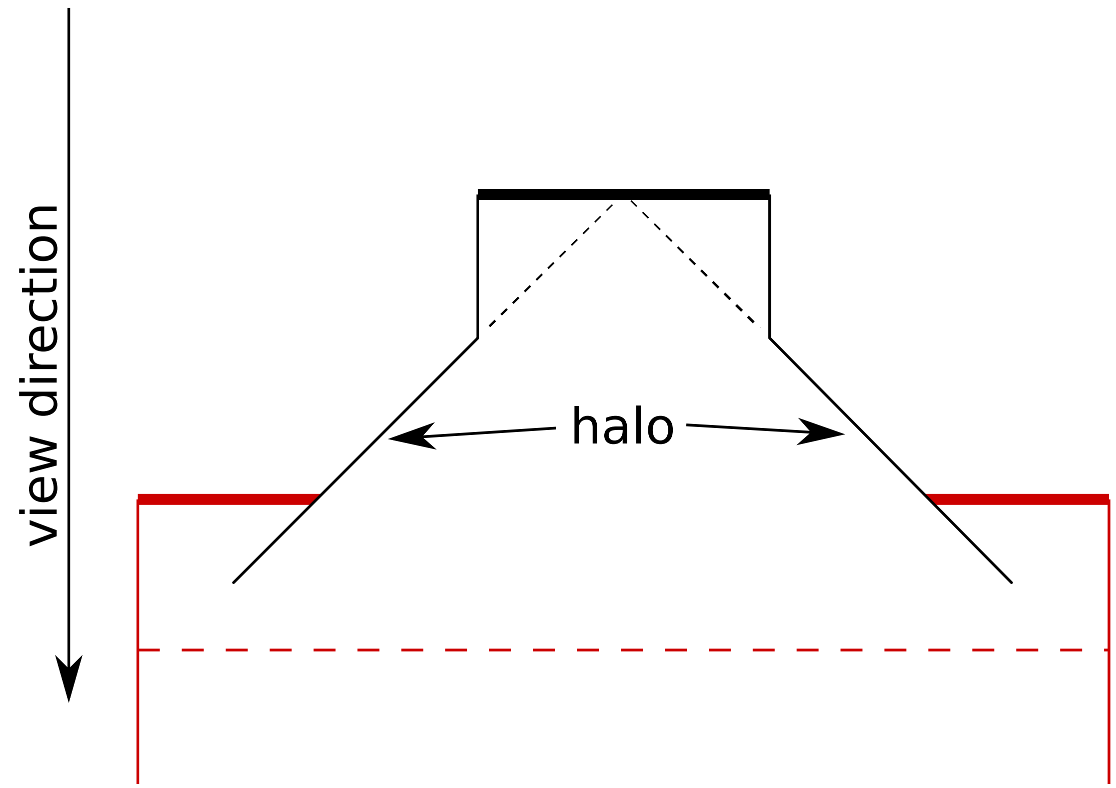

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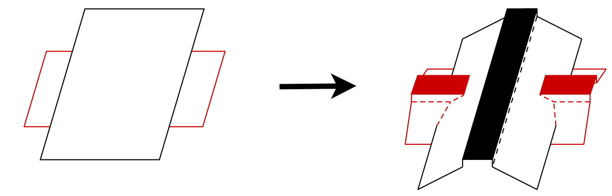

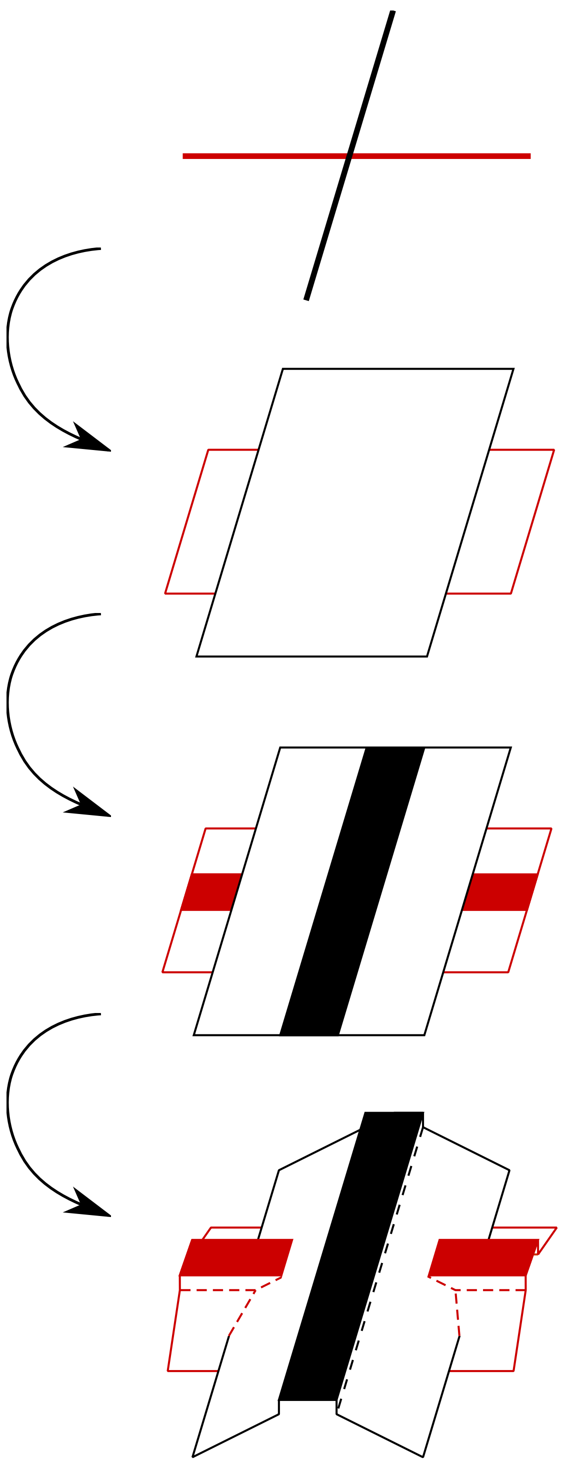

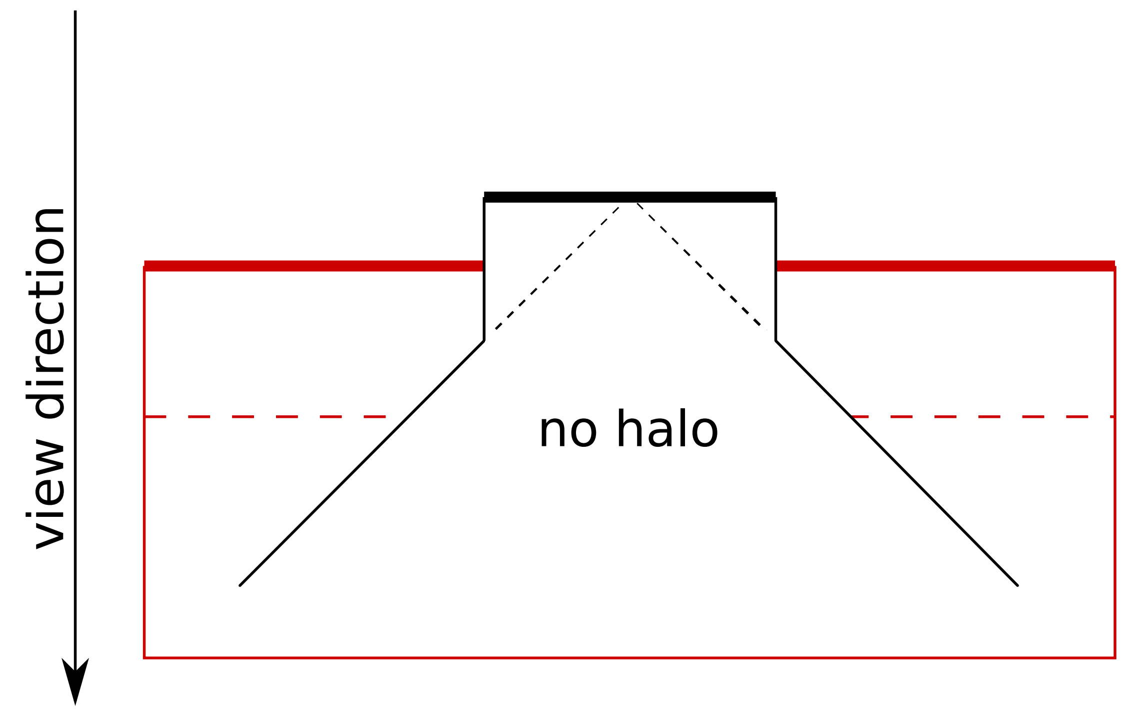

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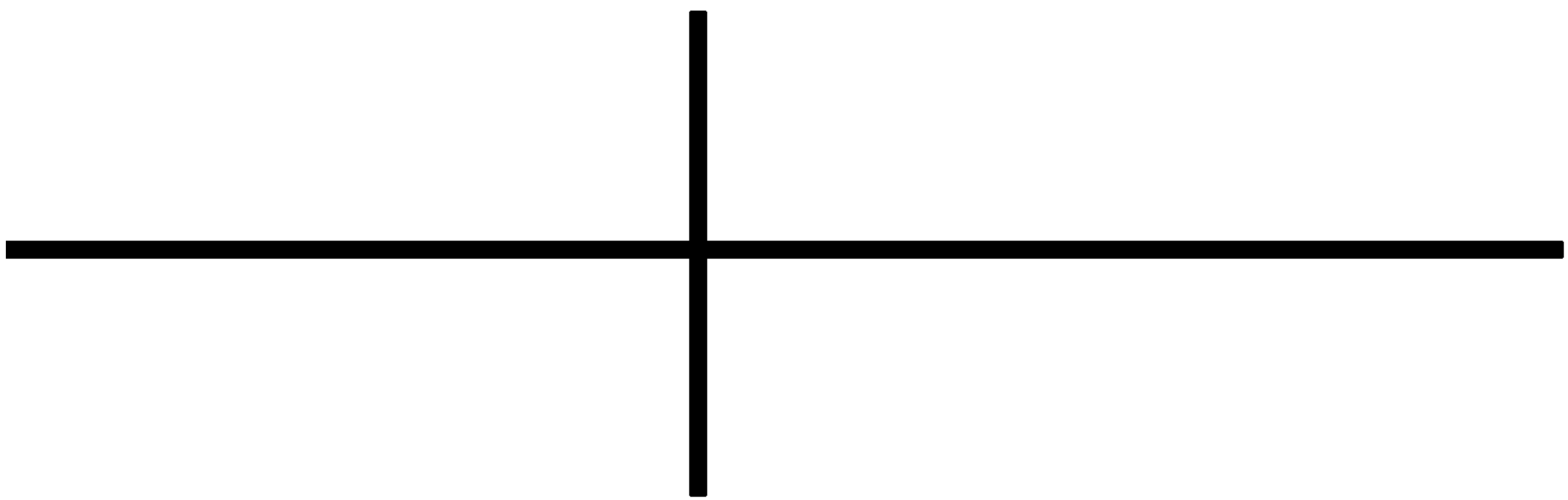
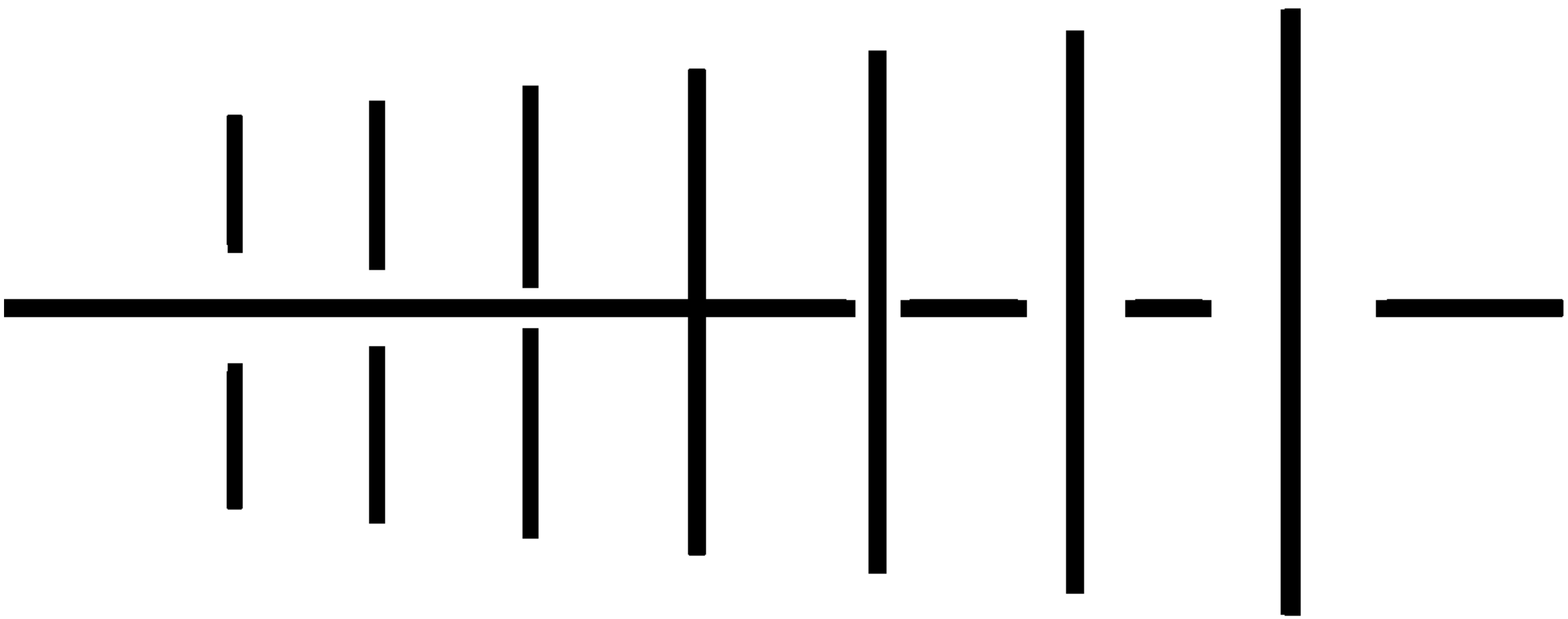
Depth-dependent halos



Depth-dependent halos



Depth-attenuated line width

Depth-attenuated line width

Tapering

Tapering

Image quality

- Screen: anti-aliasing and anisotropic filtering
- Print: high resolution black & white images

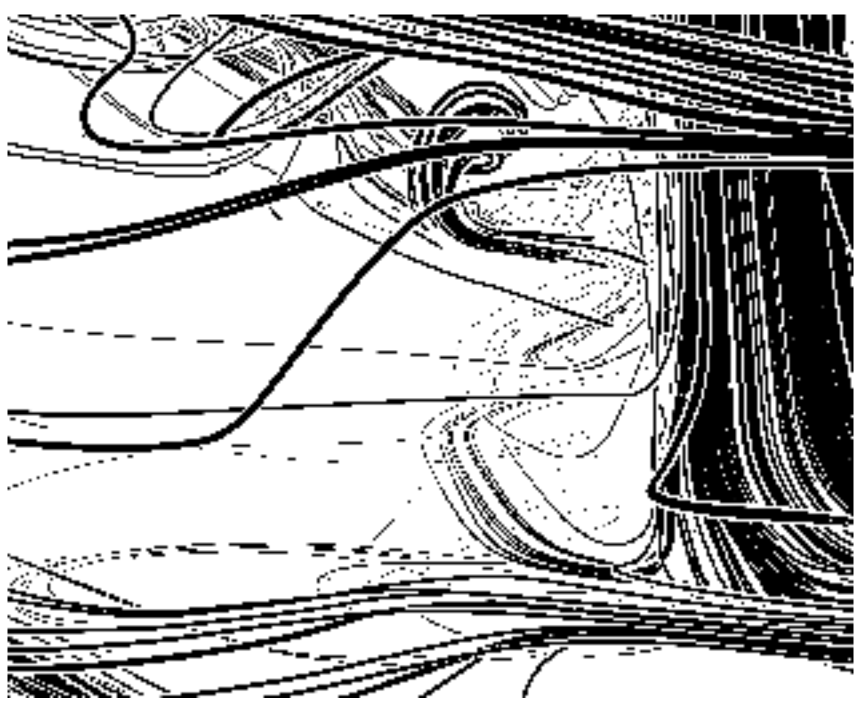


Image quality

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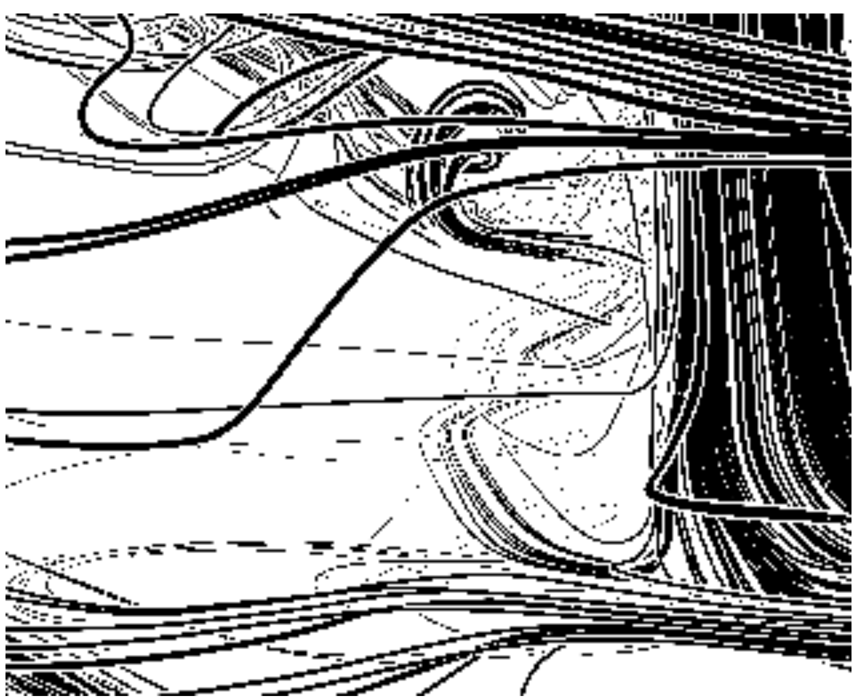


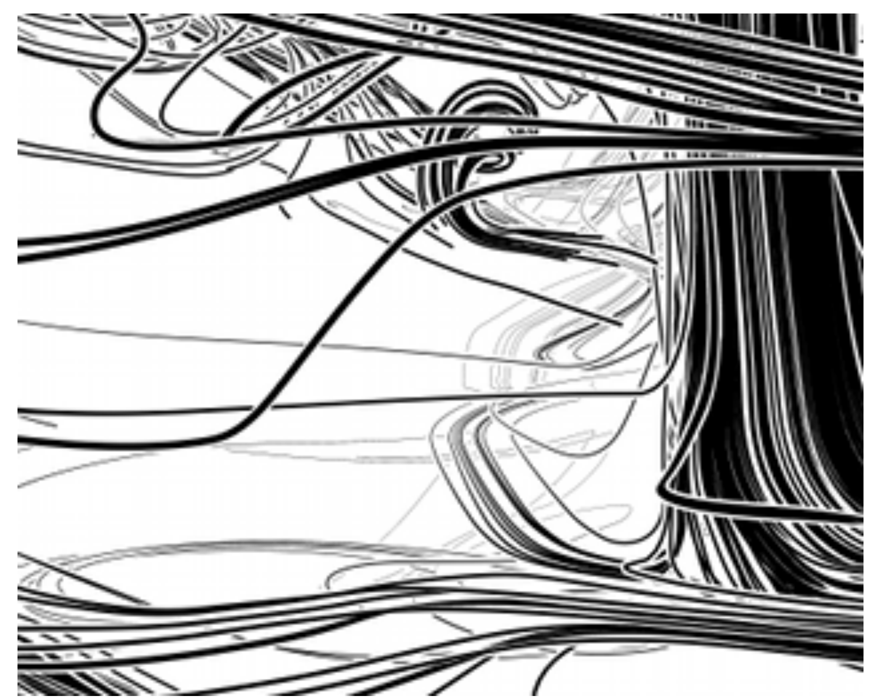
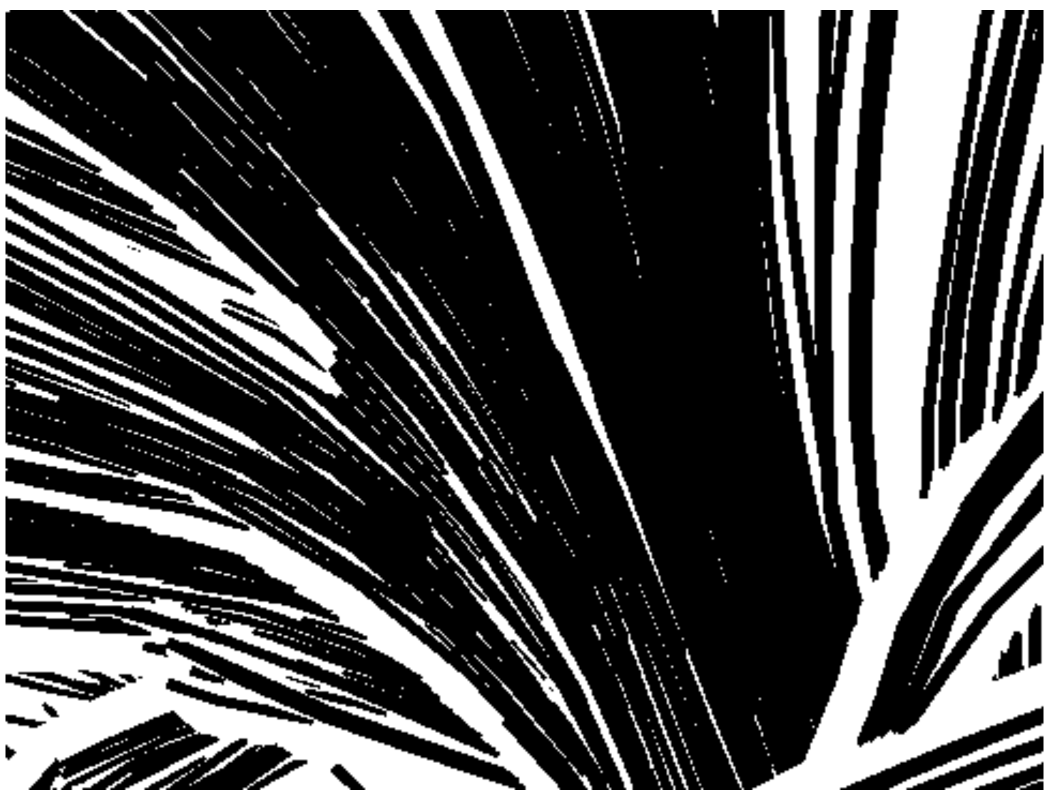
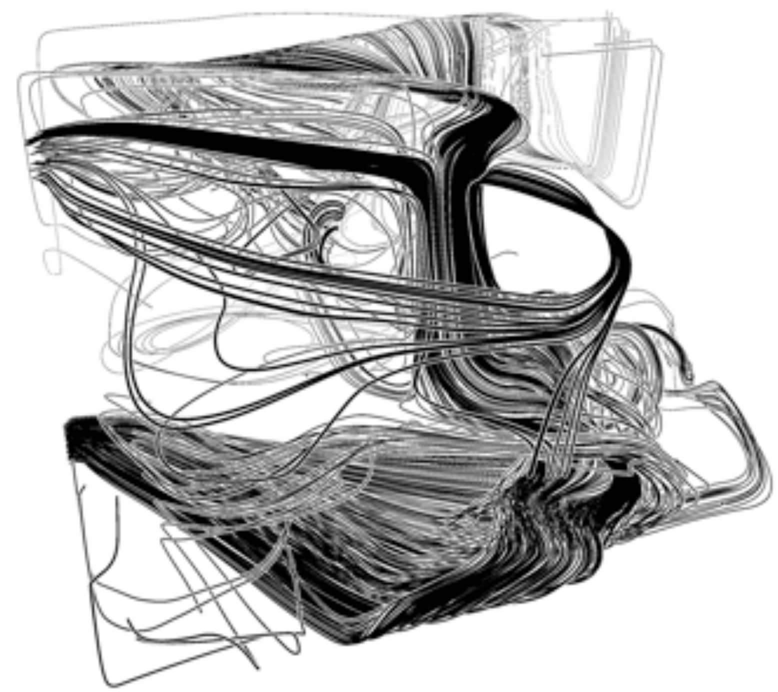


Illustration principles



emphasis

de-emphasis/
abstraction



Results

Results: DTI fiber tracts

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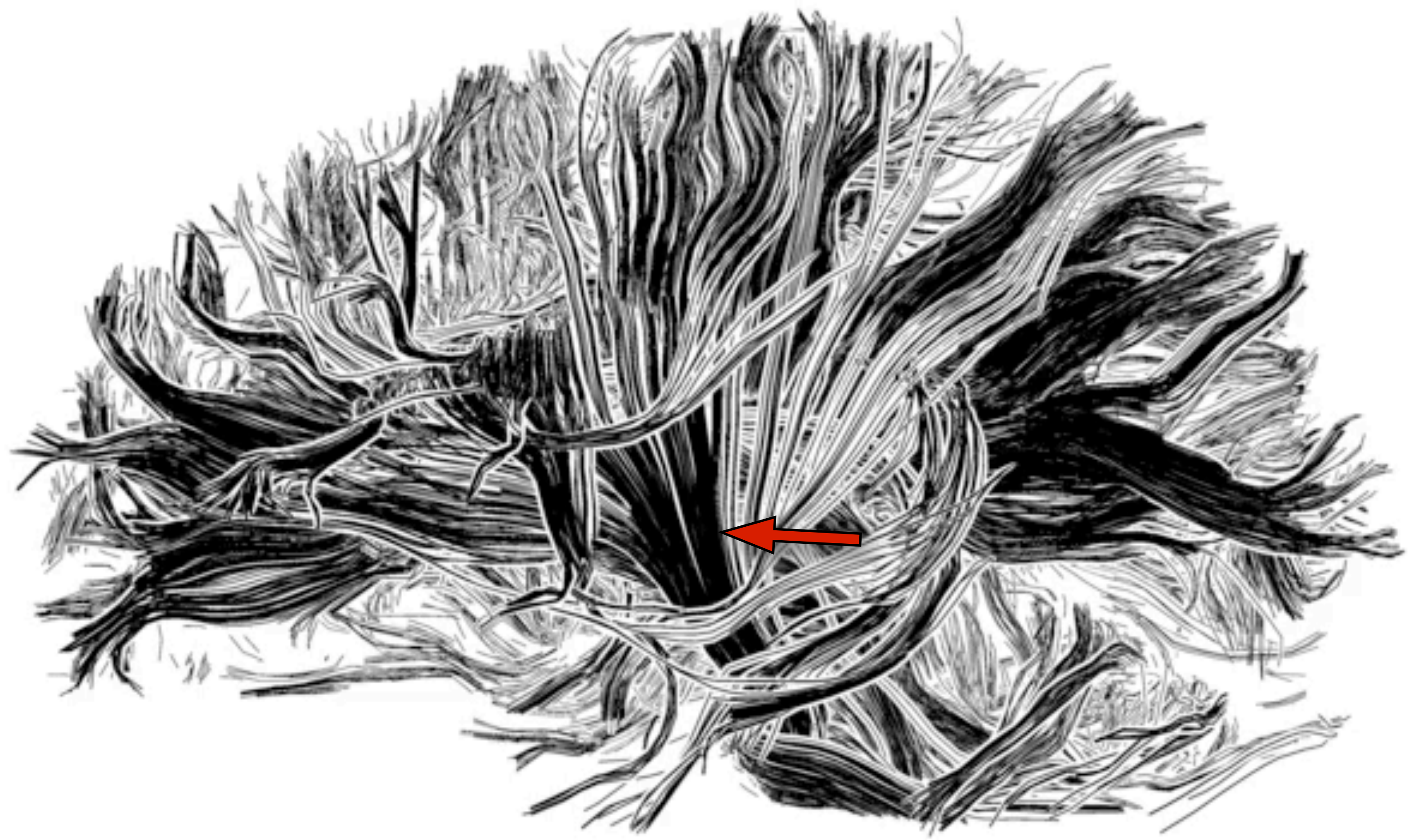
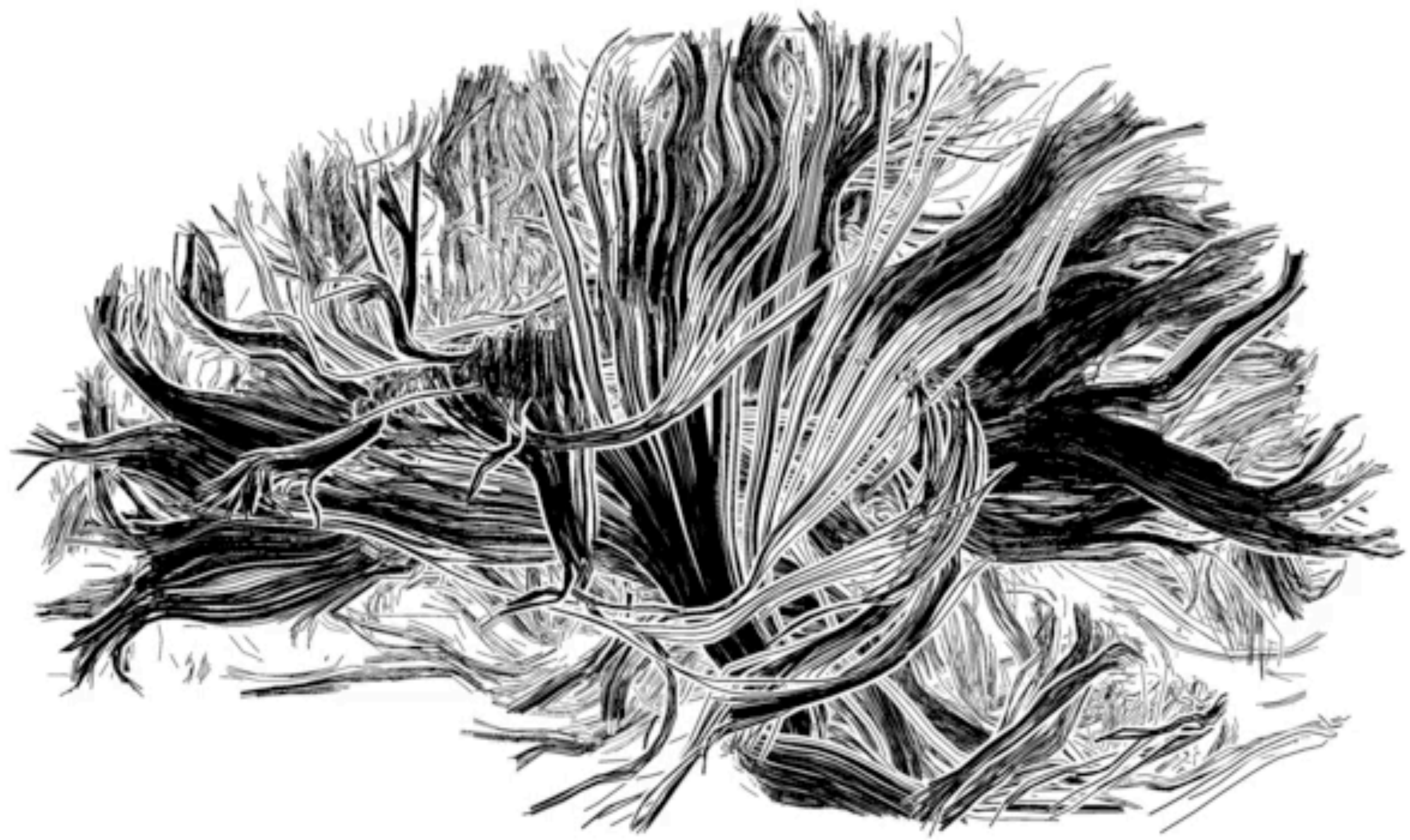


Results: DTI fiber tracts



Results: flow visualization (1)

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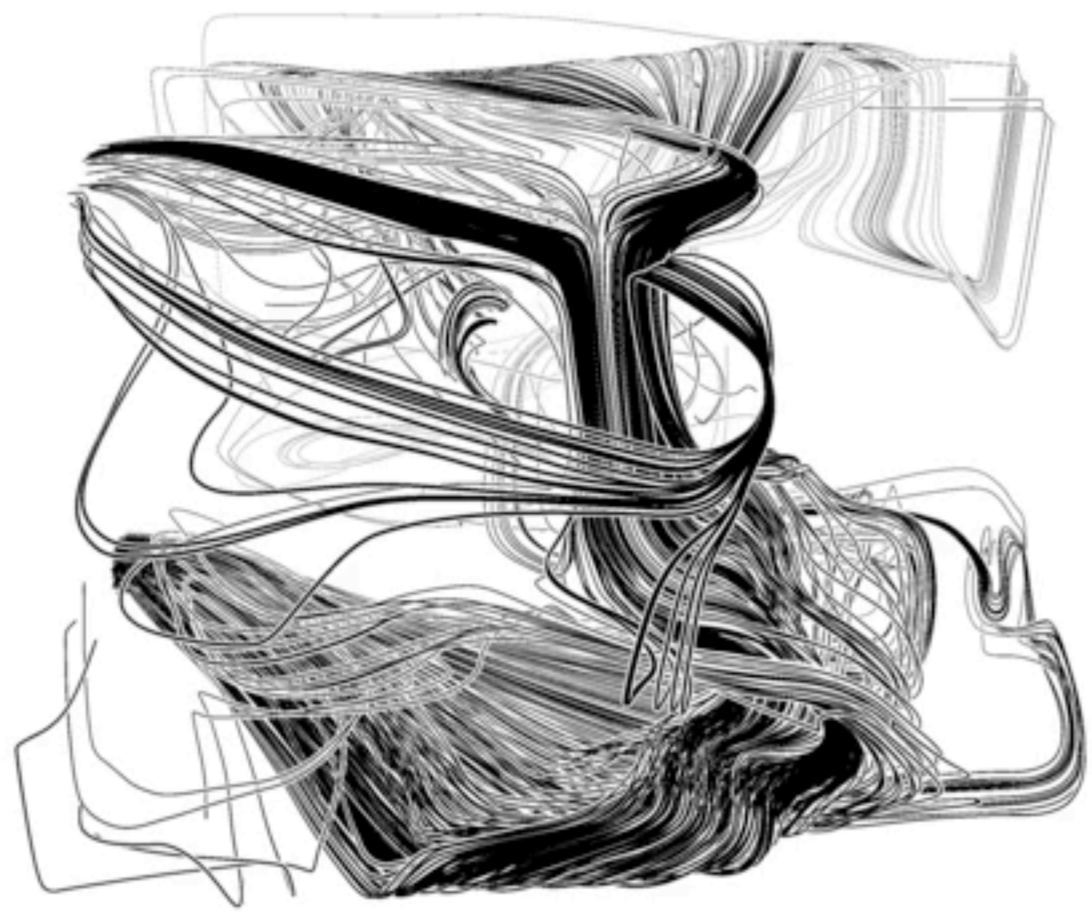


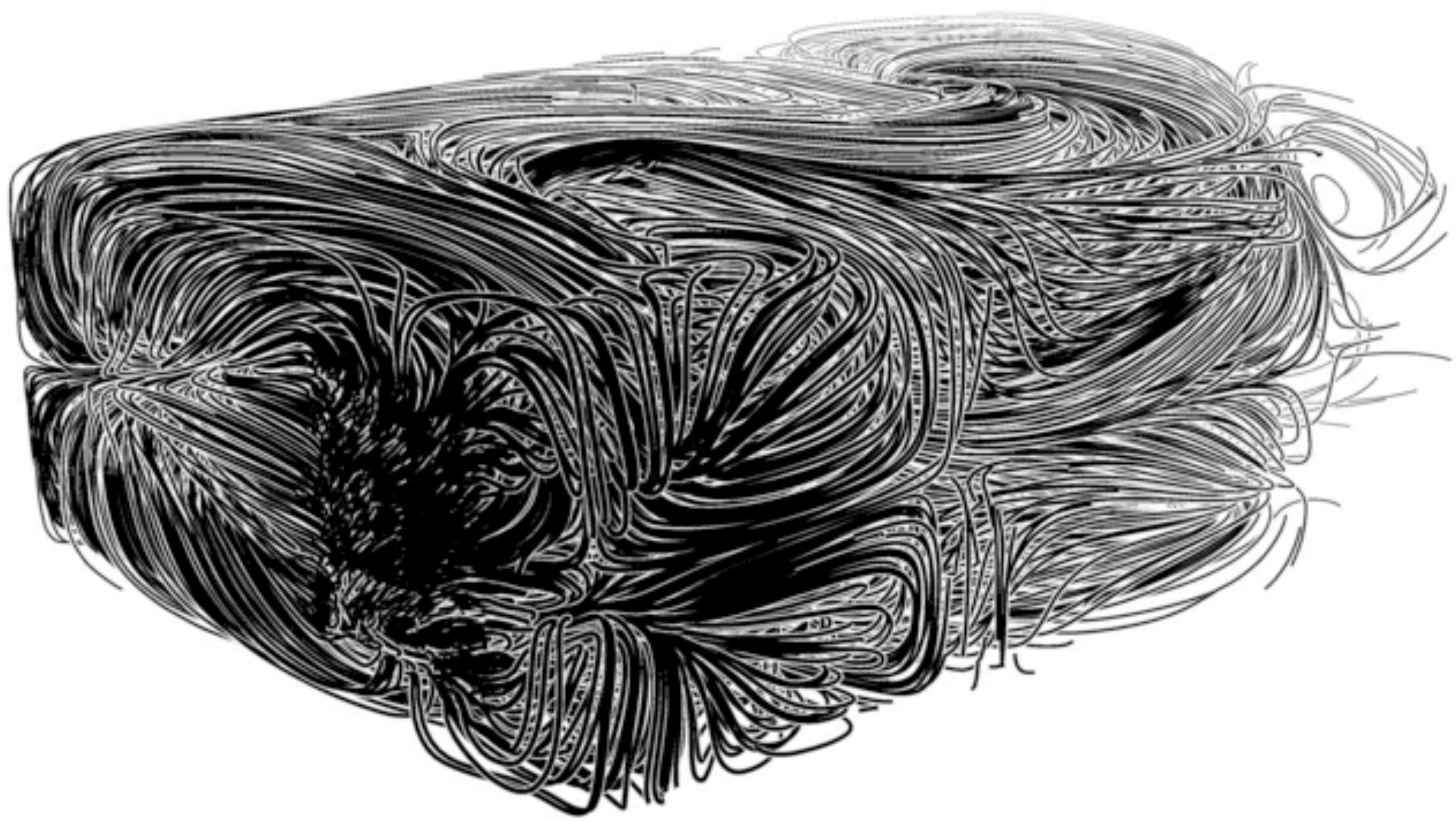
Results: flow visualization (2)

Results: flow visualization (2)

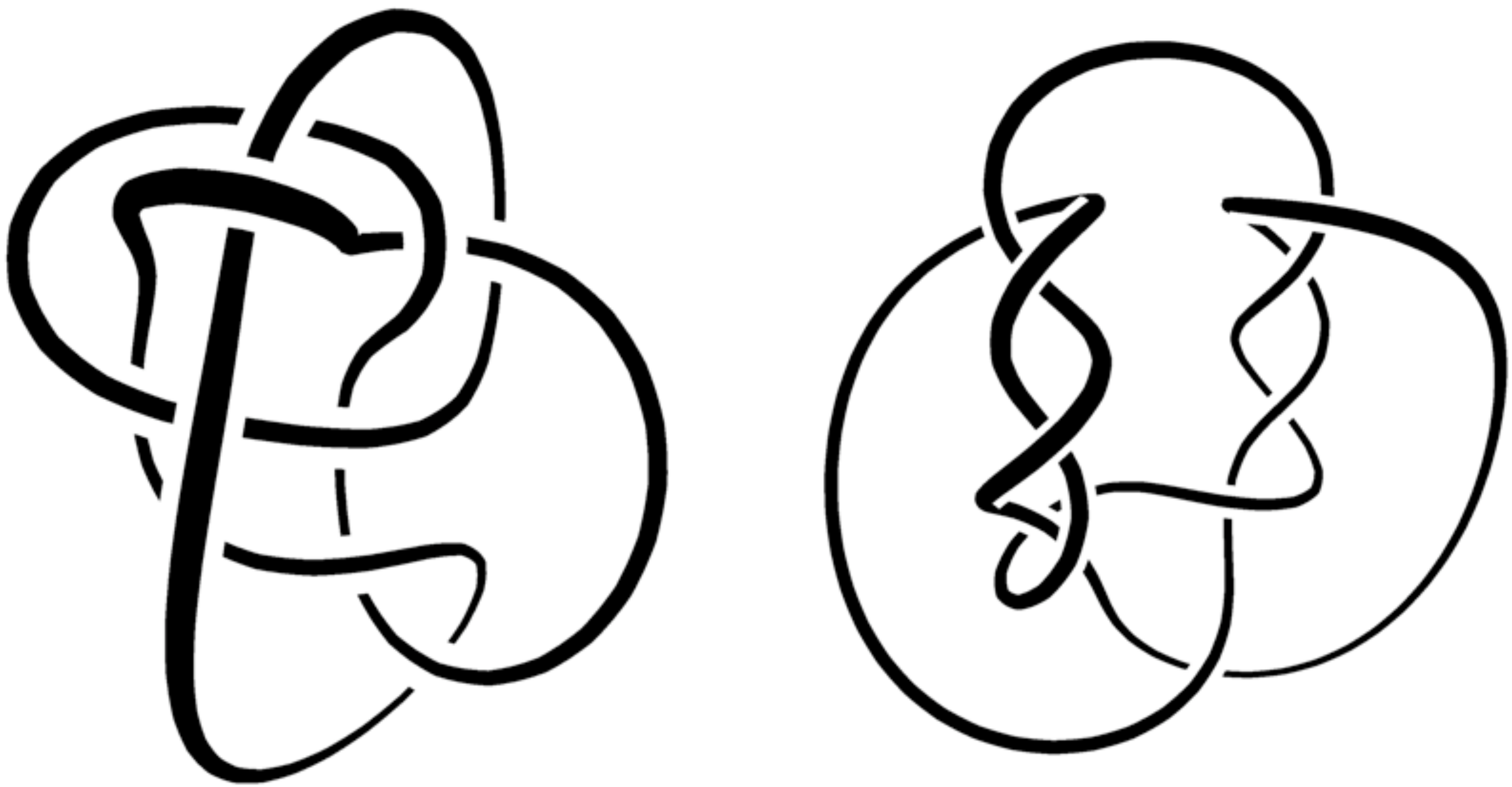
Results: flow visualization (2)

Filtering

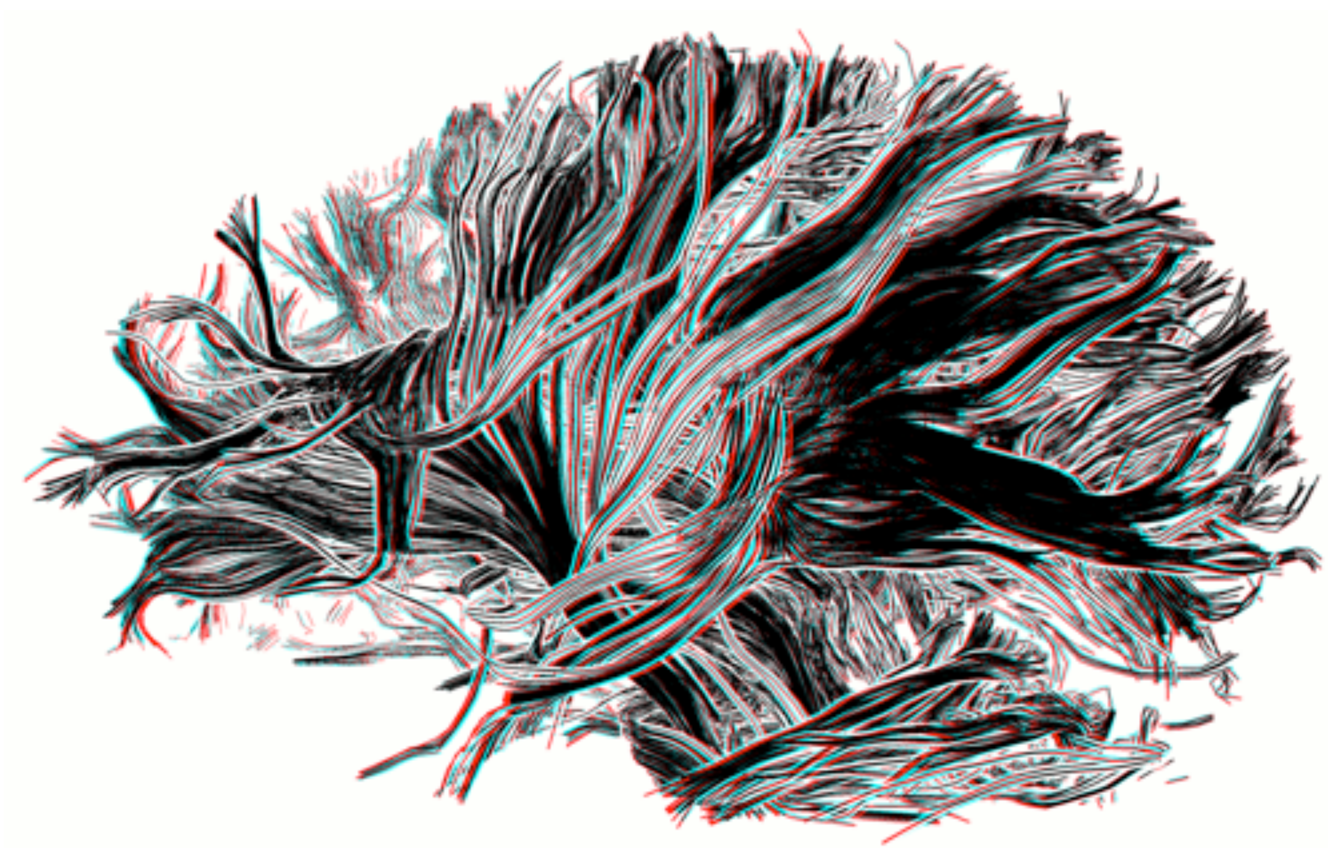
Filtering

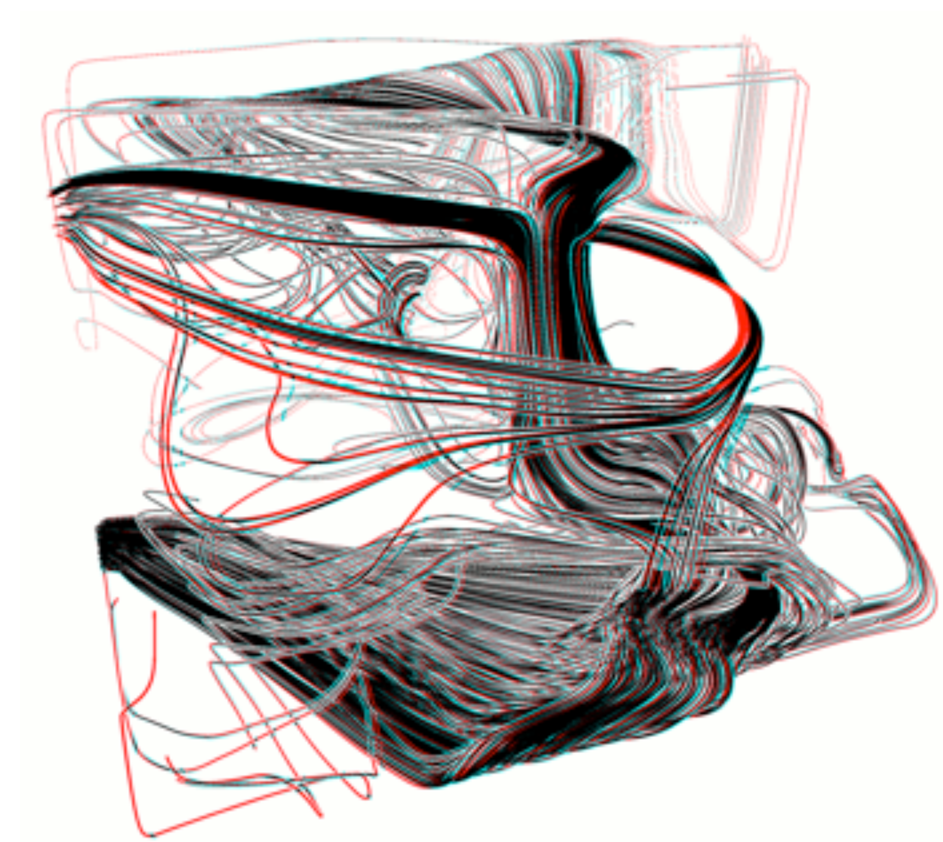


Results: simple shapes (knots)

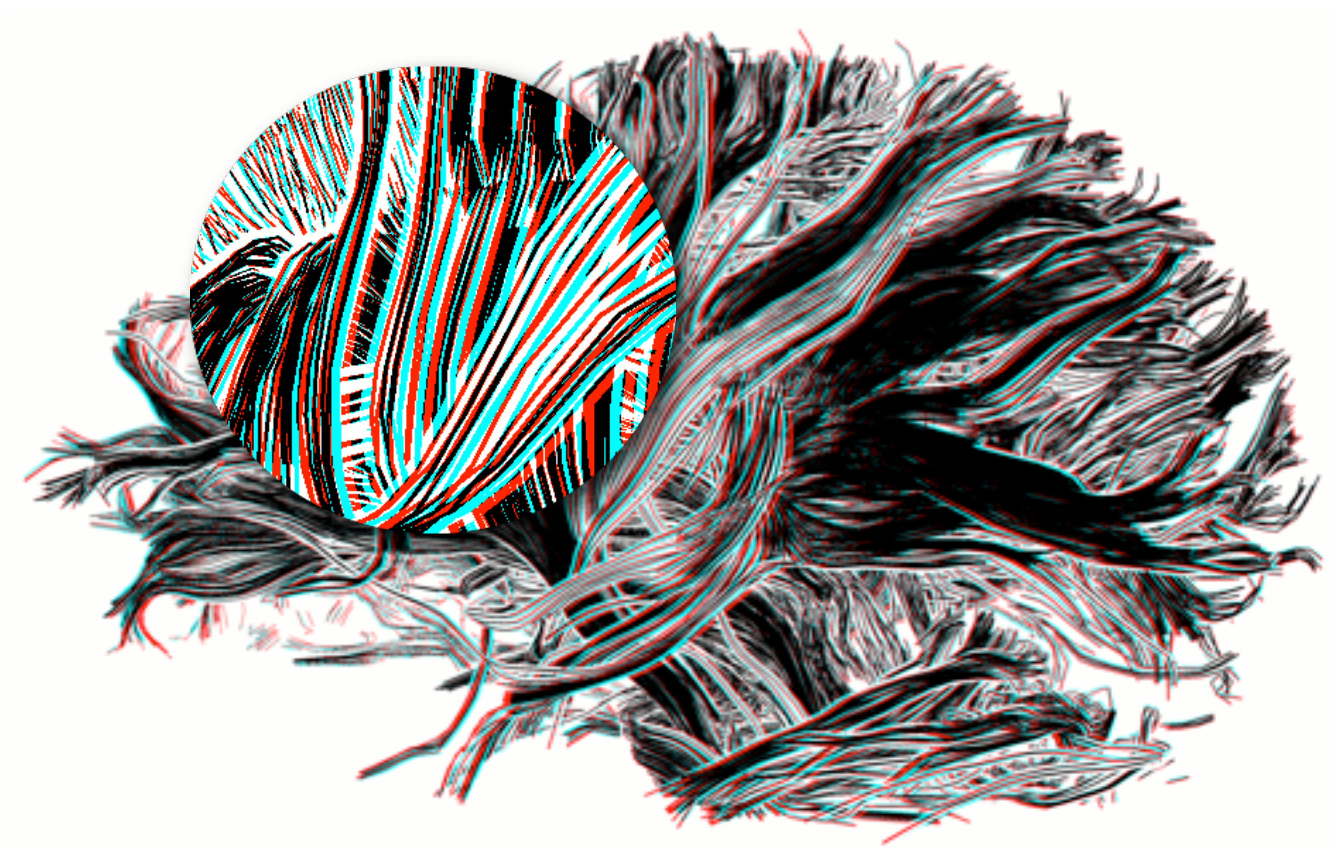


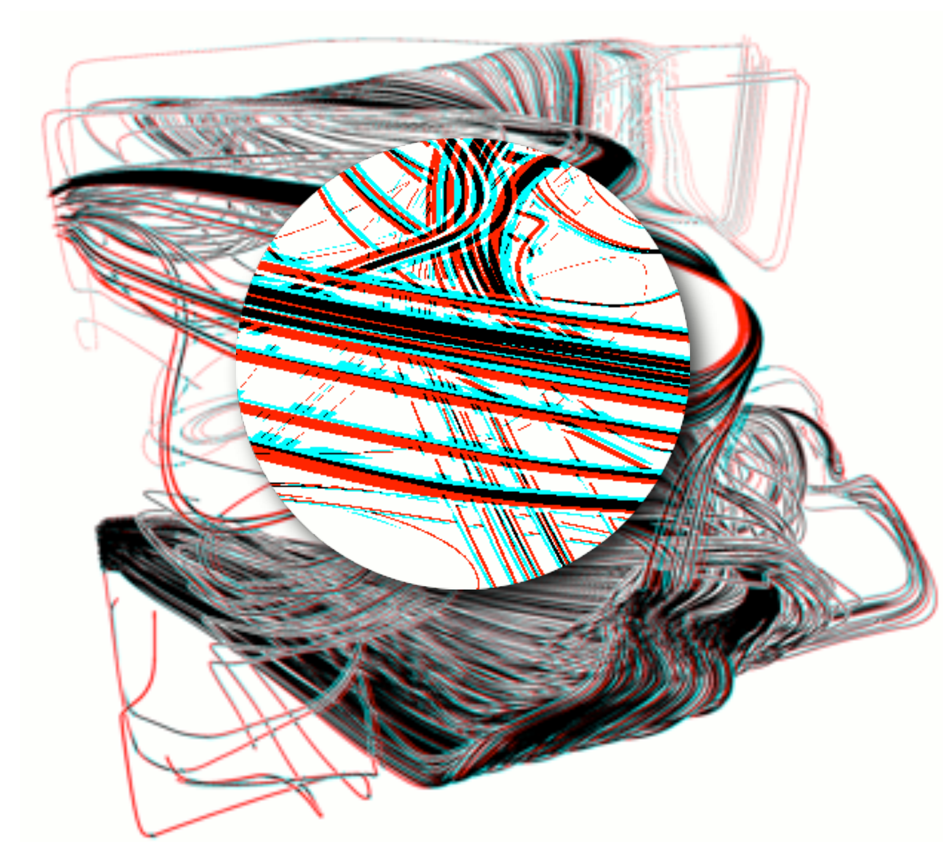
Anaglyphic rendering



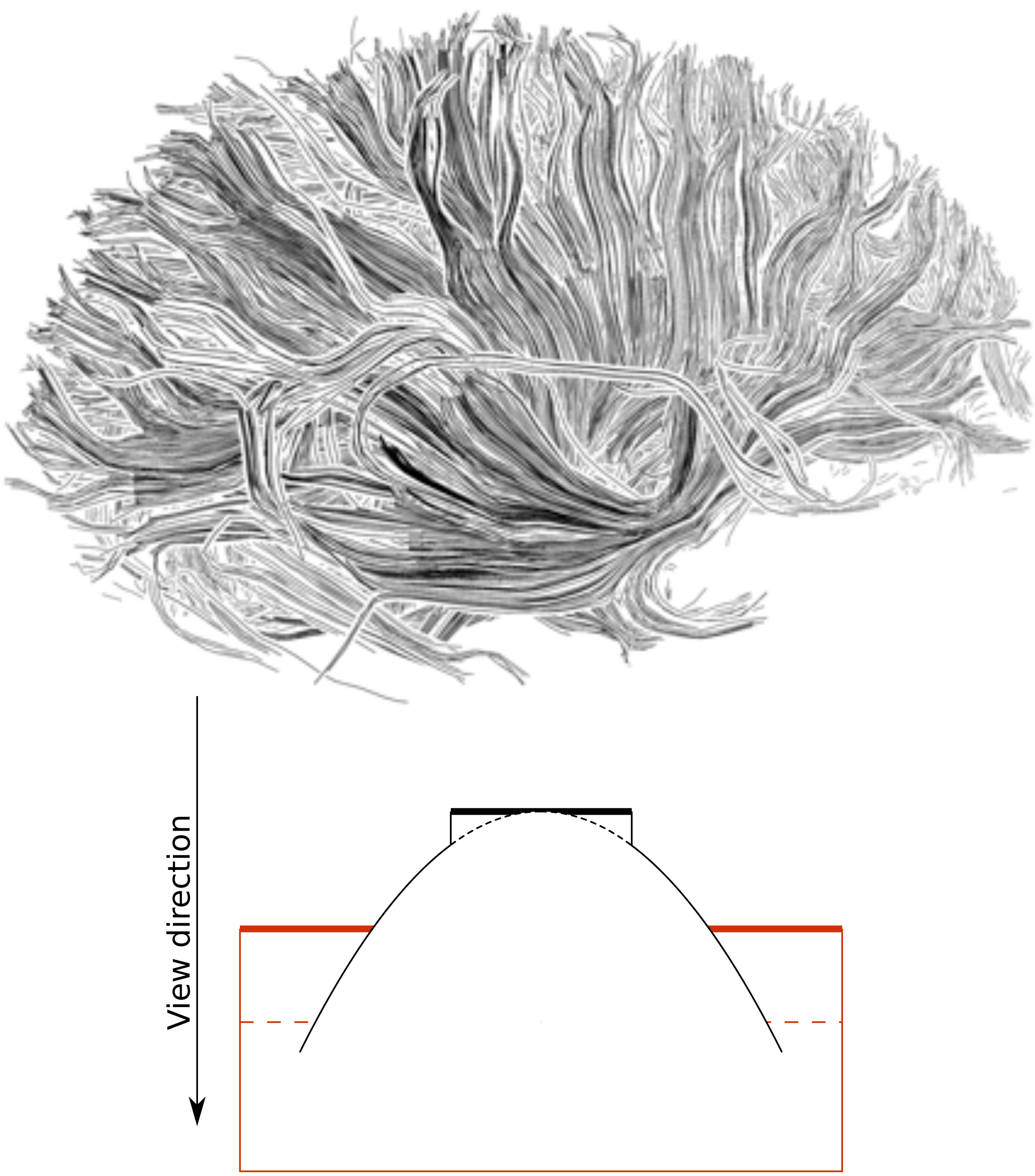


Anaglyphic rendering

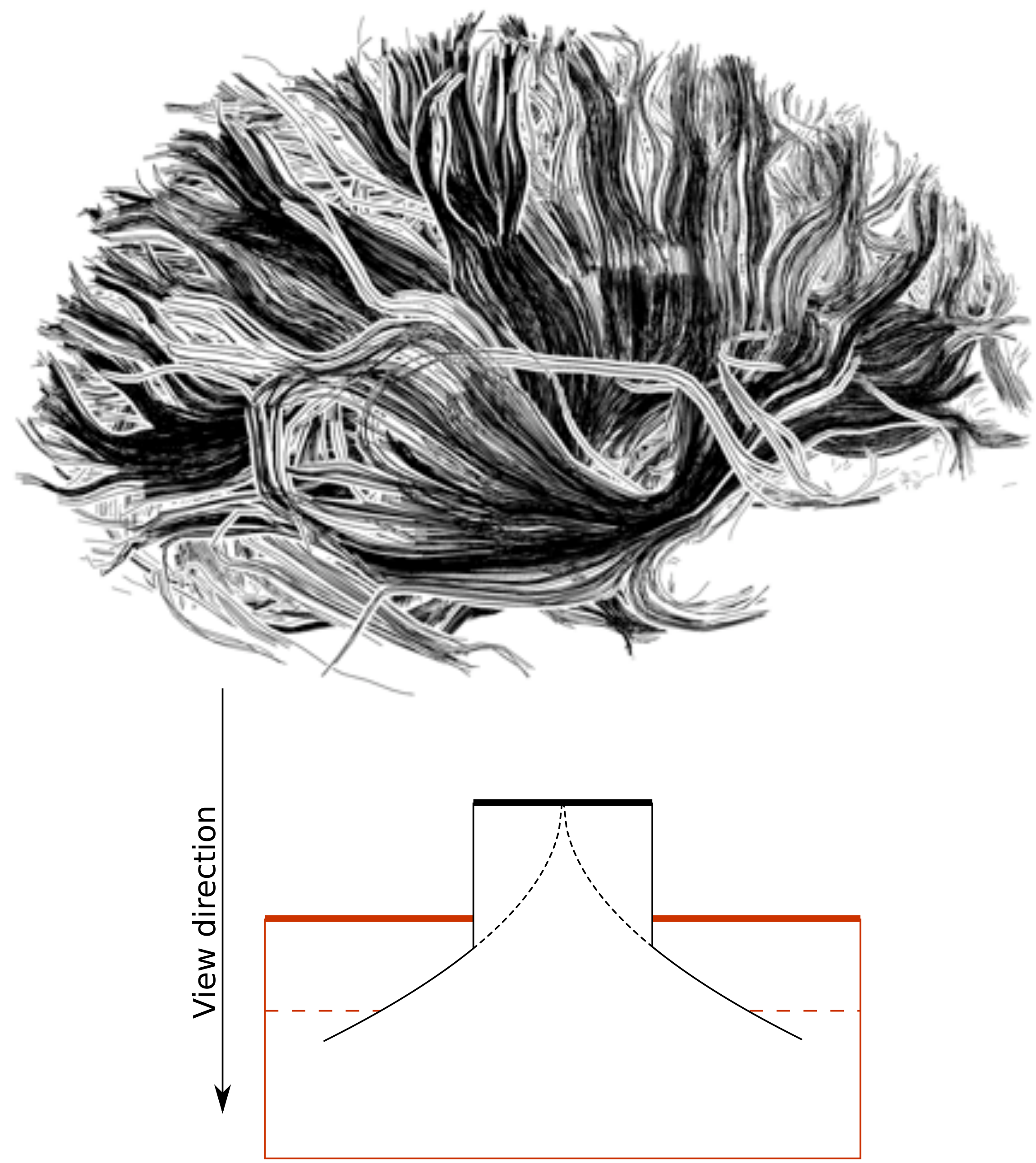




Displacement function

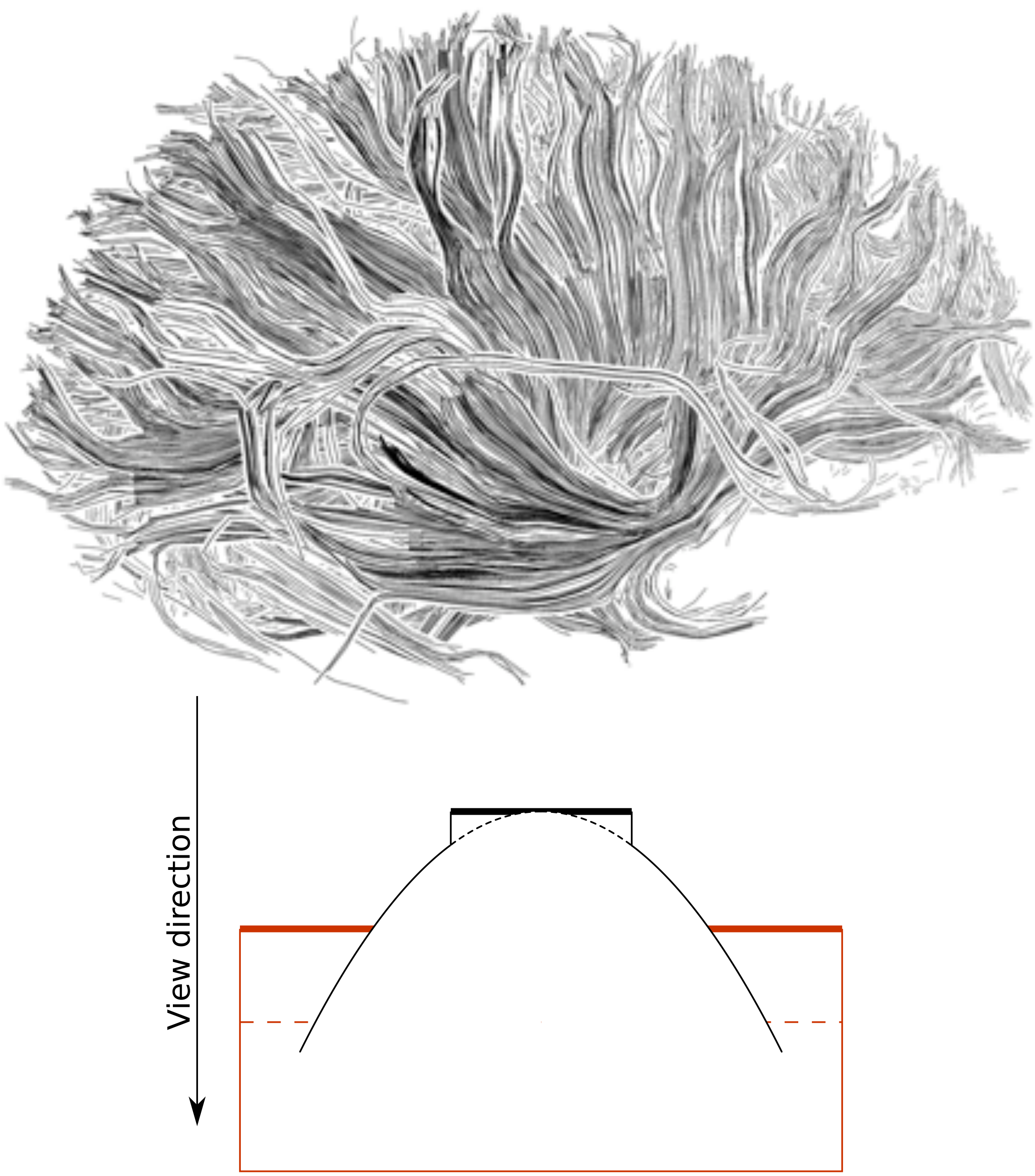


$$f_{\text{displacement}}(x) = x^2$$



$$f_{\text{displacement}}(x) = \sqrt{x}$$

Displacement function



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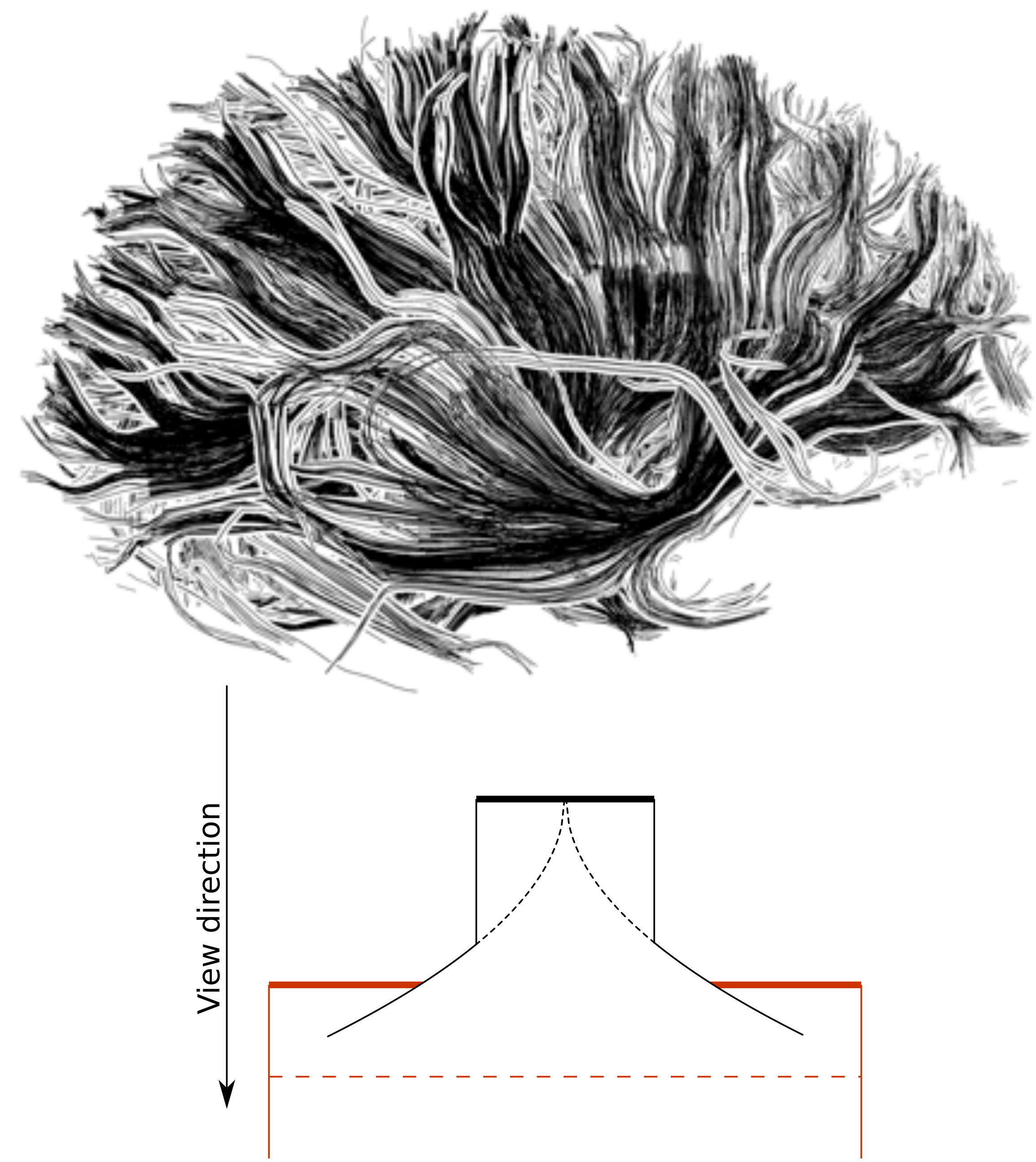
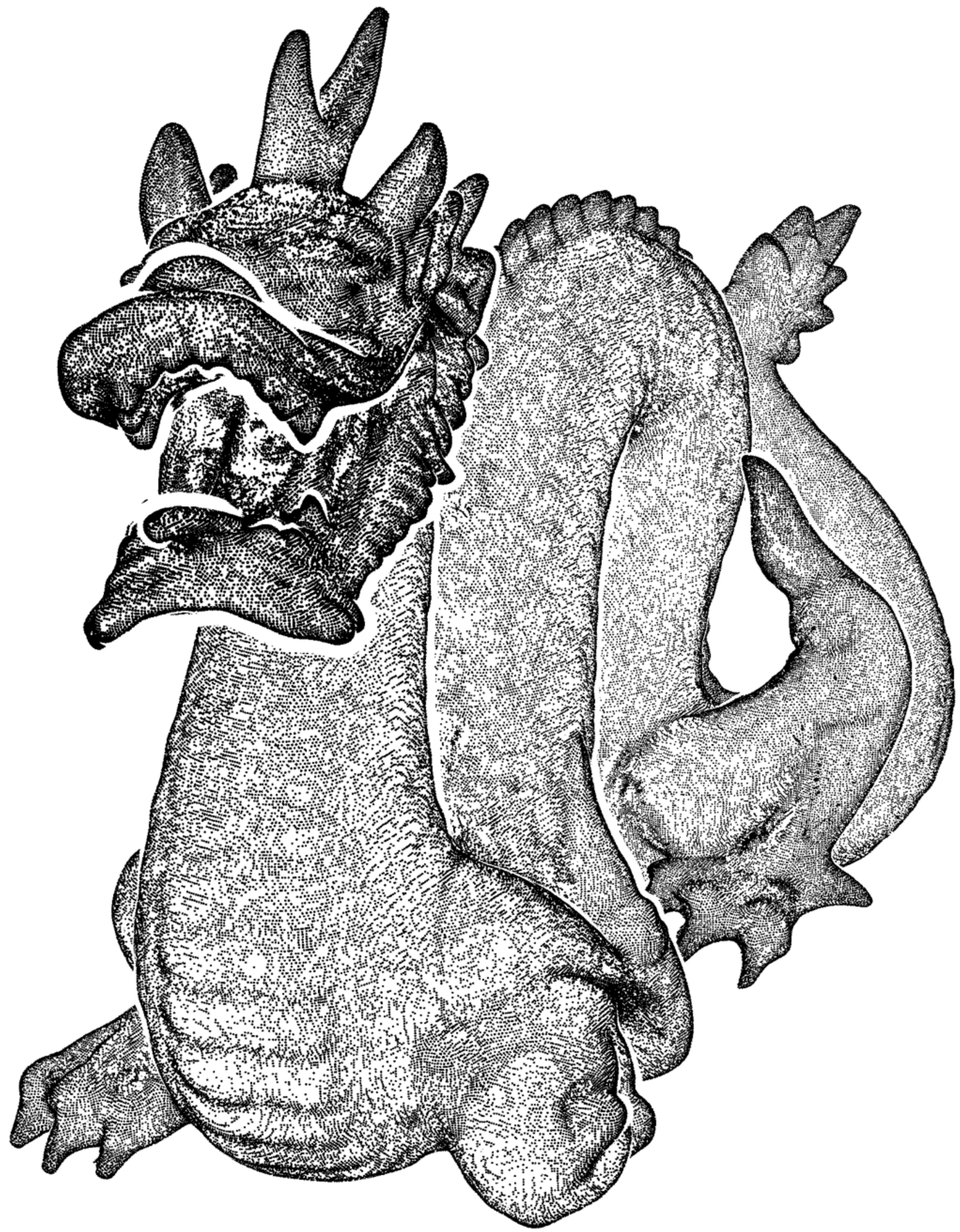
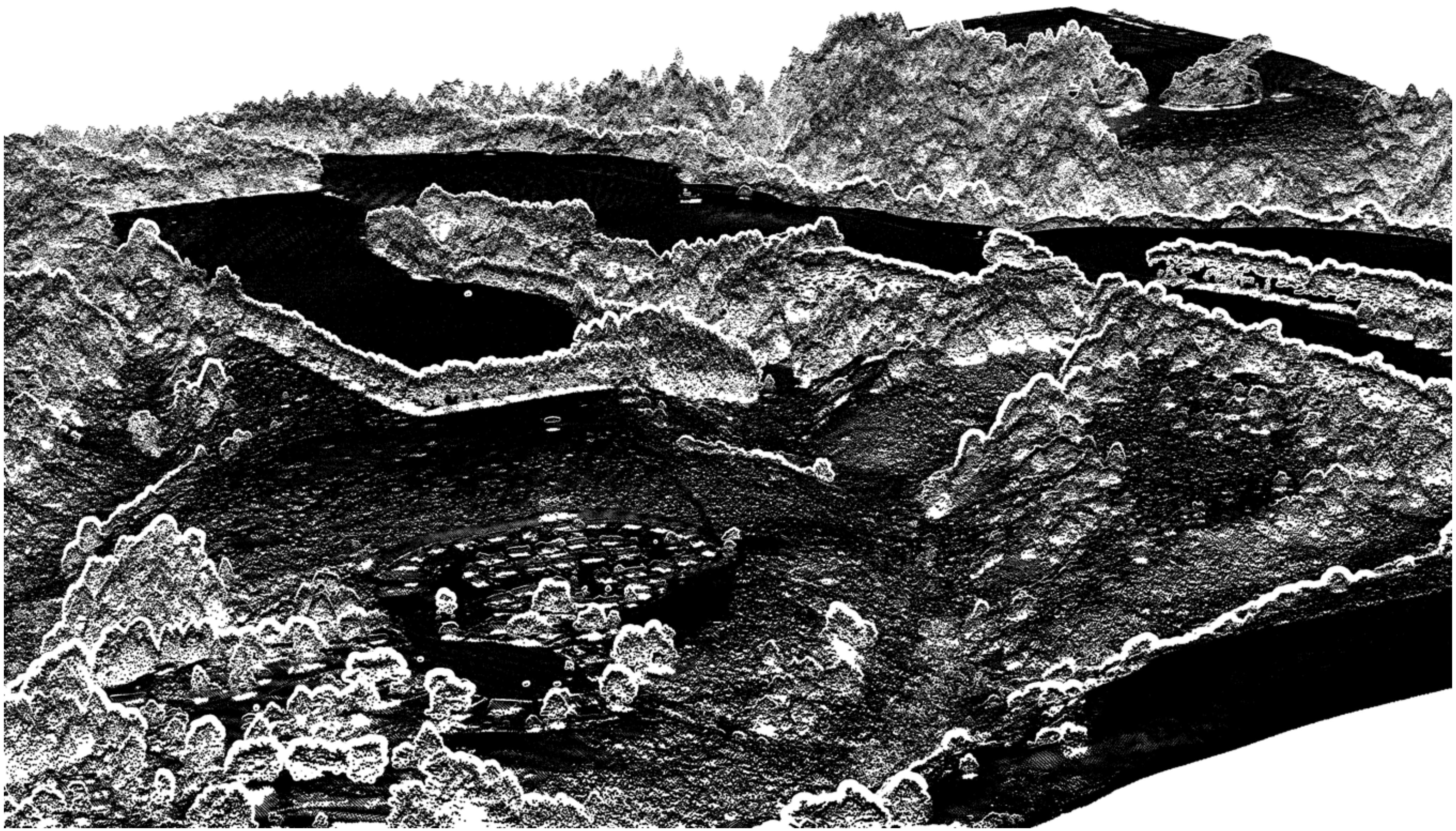


$$f_{\text{displacement}}(x) = \sqrt{x}$$

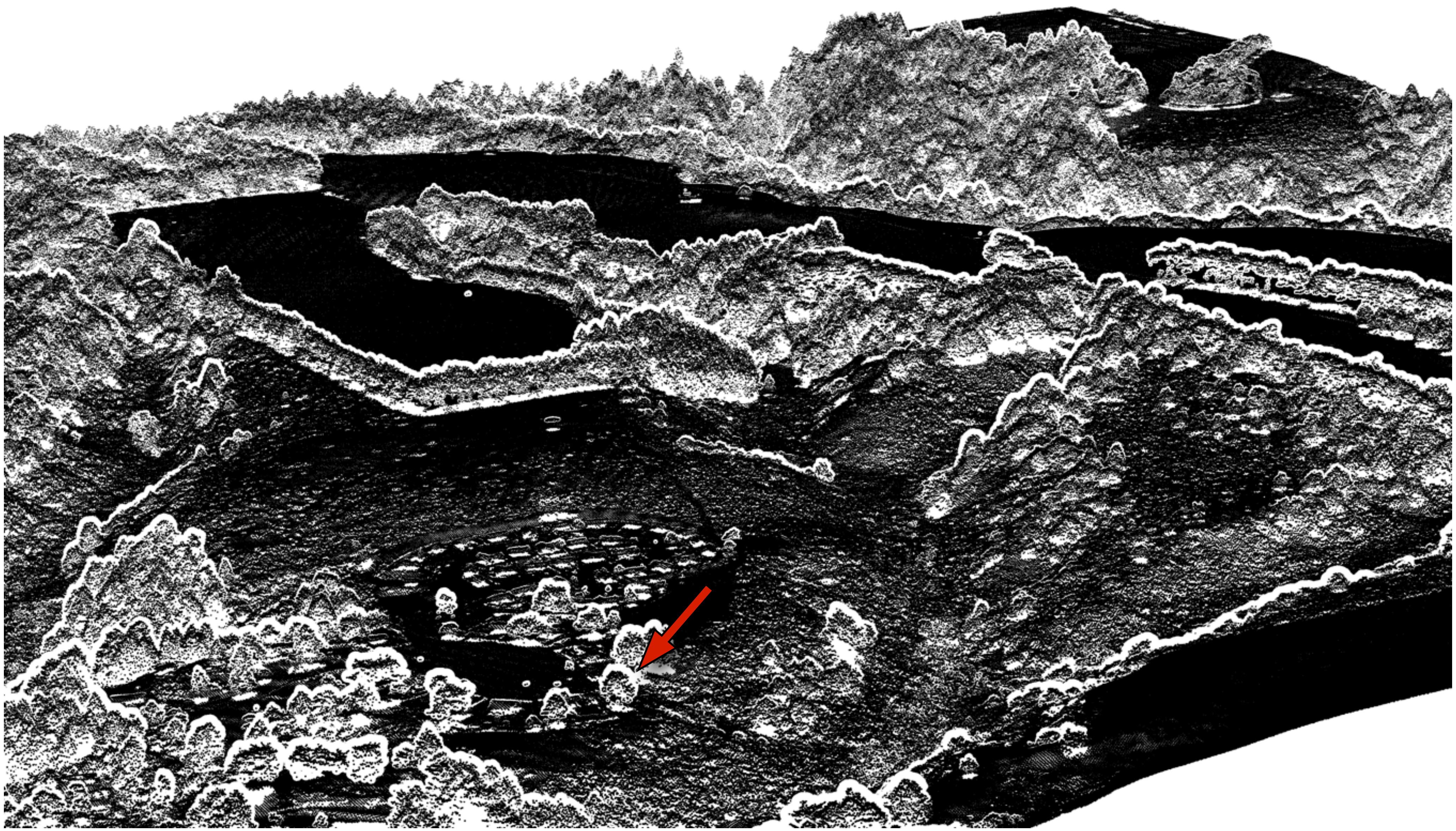
Application to point data



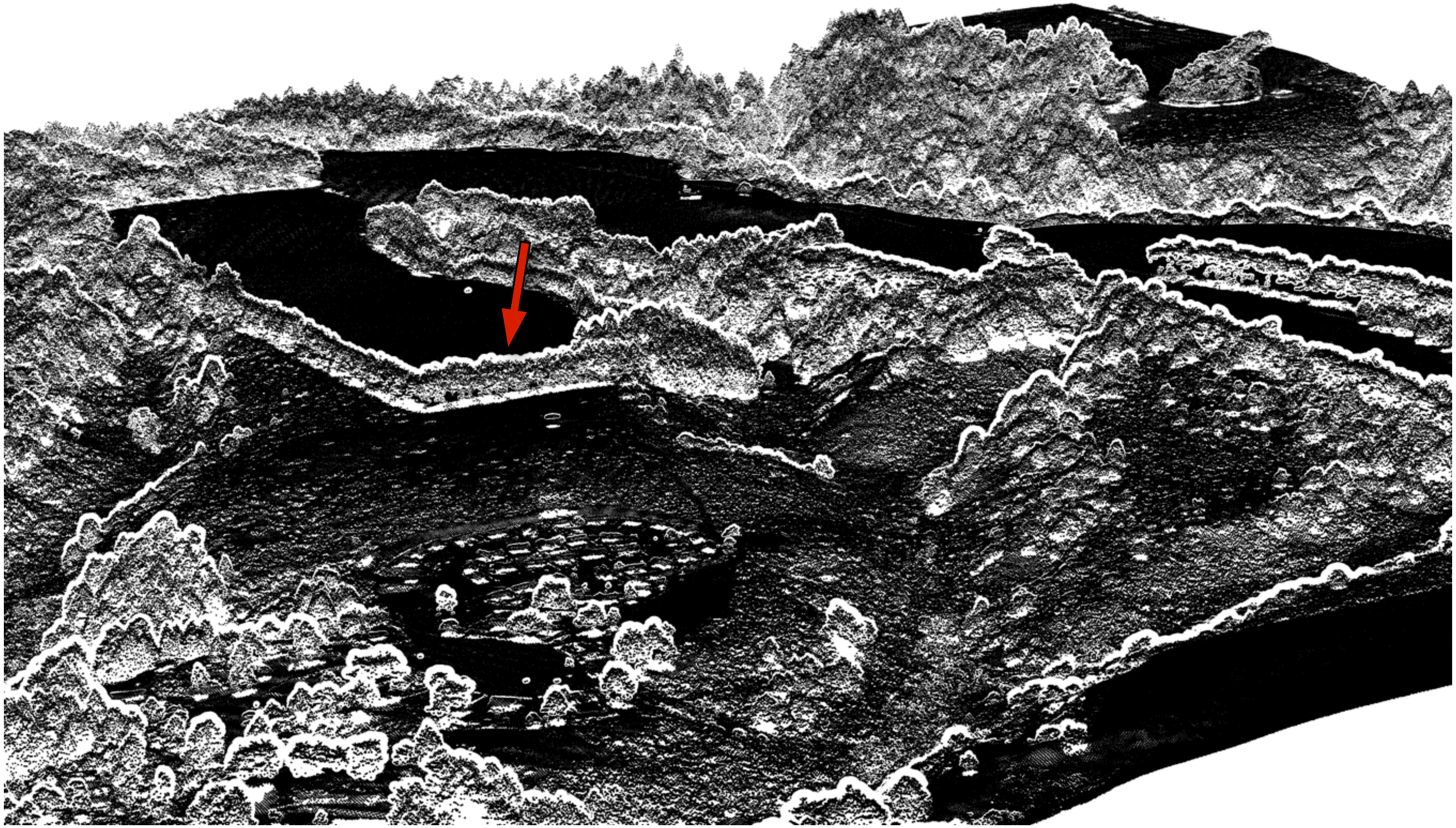
Application to point data



Application to point data



Application to point data



Performance

Machine specs:

- 3 GHz Intel Core2 Extreme
- 4 GB RAM
- NVIDIA 8800 GTX

# lines:	11 306
# vertices:	260 836
frame rate:	123 fps

Performance

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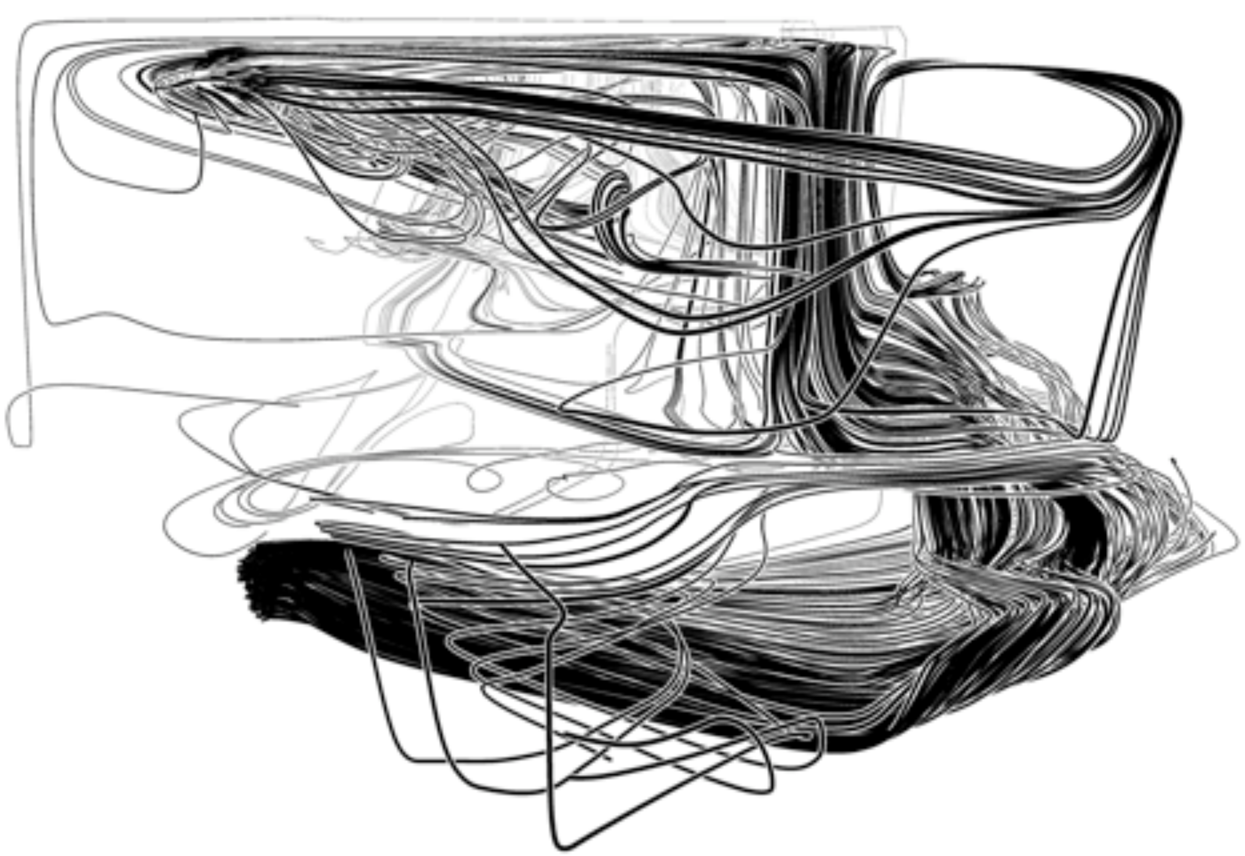
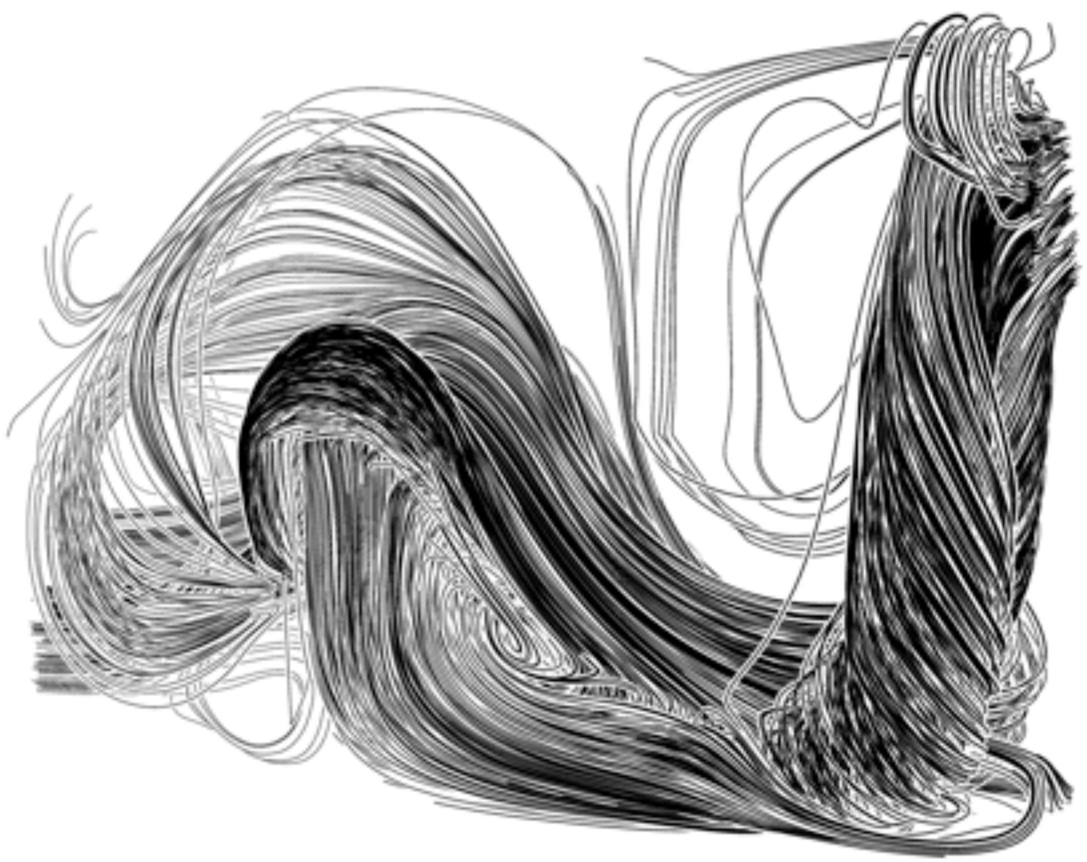


# lines:	786
# vertices:	278 849
frame rate:	290 fps

Performance

Machine specs:

- 3 GHz Intel Core2 Extreme
- 4 GB RAM
- NVIDIA 8800 GTX



# lines:	1 400
# vertices:	2 603 605
frame rate:	43 fps

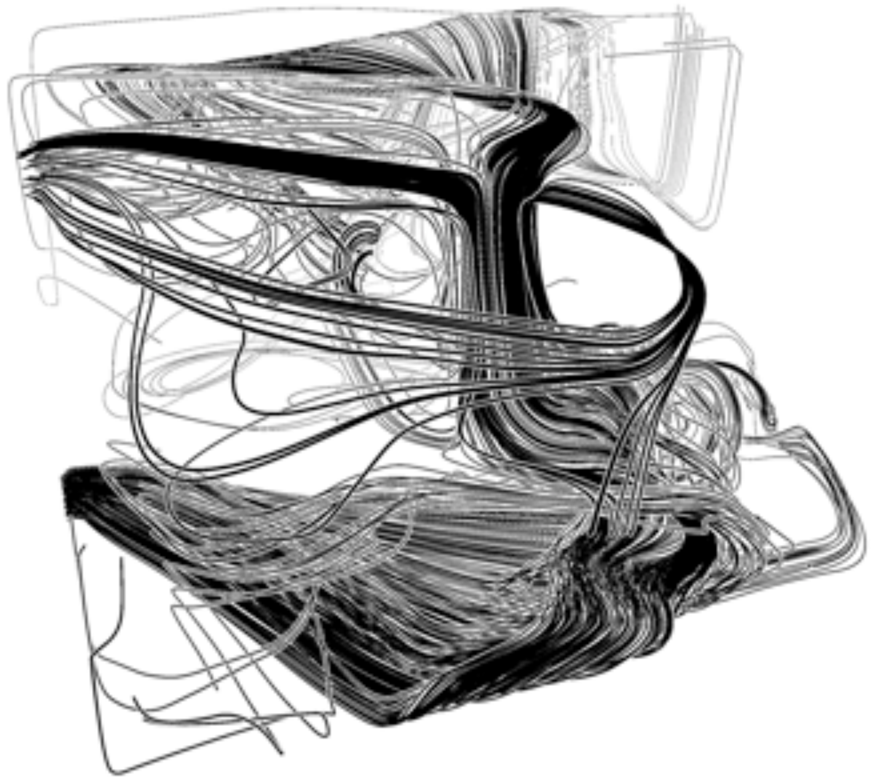
Informal evaluation with medical domain experts

- All experts were impressed.
- Compared to the tract visualization they used, our illustrative visualizations "show better depth relation and structure."
- Very suggestive.
- Requests for more interactivity.

- Suggestions to combine with other visualization methods to show context.

Conclusion

- A new technique for illustrative visualization of dense line data.
- Emphasis and abstraction through depth-dependent halos around lines.
- Simple method that easily maps to the (hardware) graphics pipeline.
- Interactive frame rates and high quality print reproduction.
- Positive feedback from informal evaluation.

Depth-Dependent Halos: Illustrative Rendering of Dense Line Data

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http://www.cs.rug.nl/svcg/to/halos