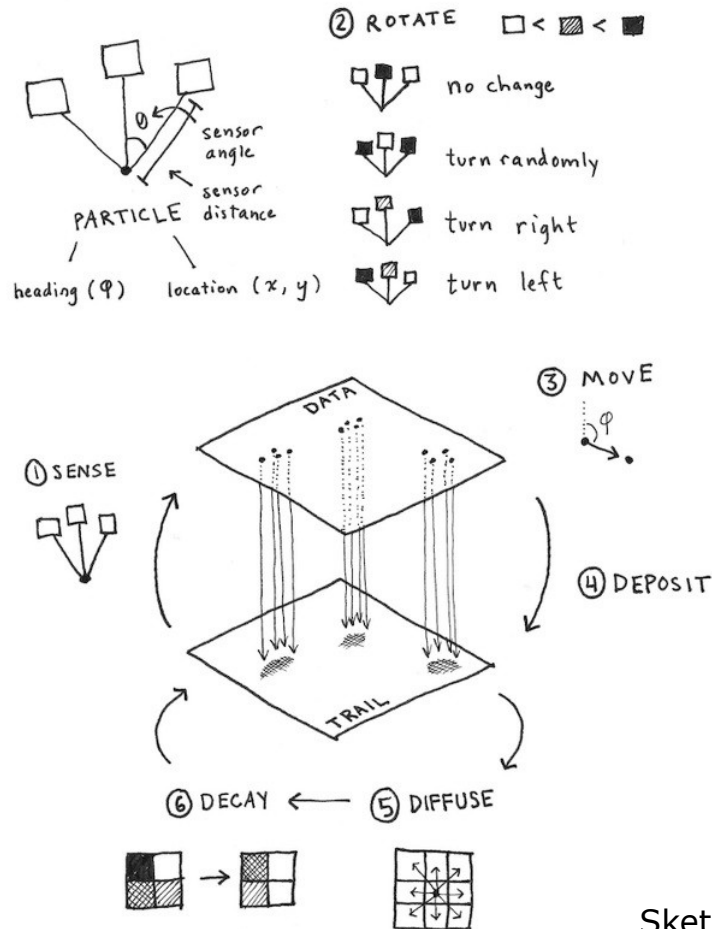


Particle Simulations on 2D Manifolds: Implemented for Physarum Models on the Surface of Objects in a dynamic 3D Environment



Physarum Simulation

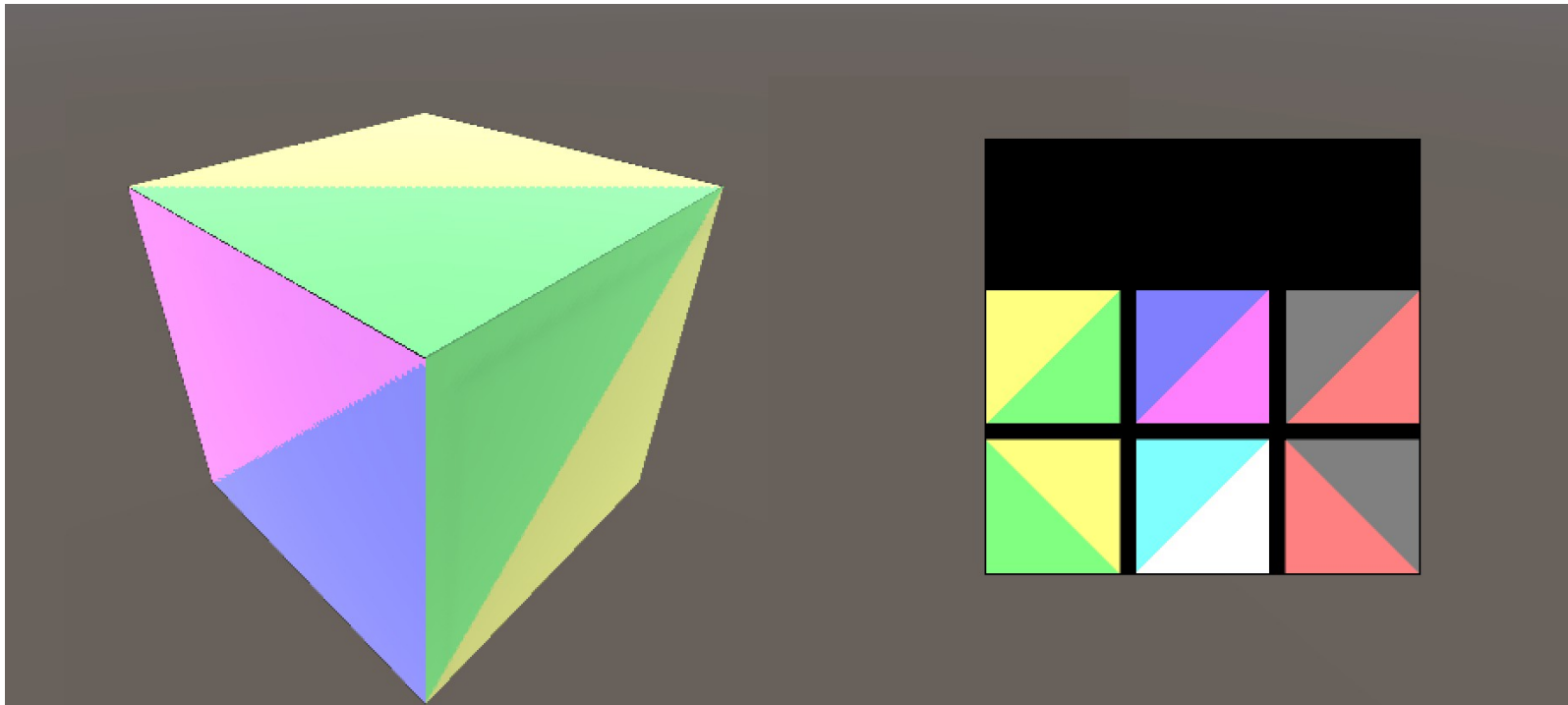


Sketch by Sage Jenson

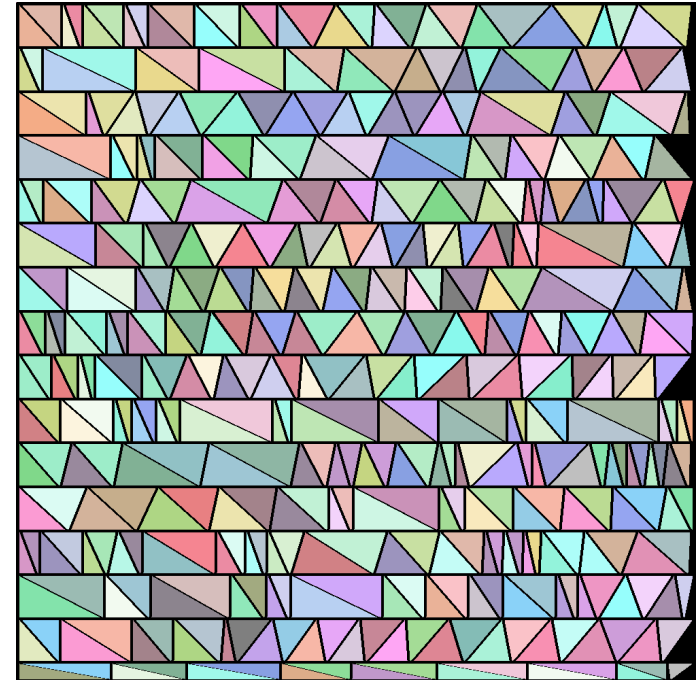
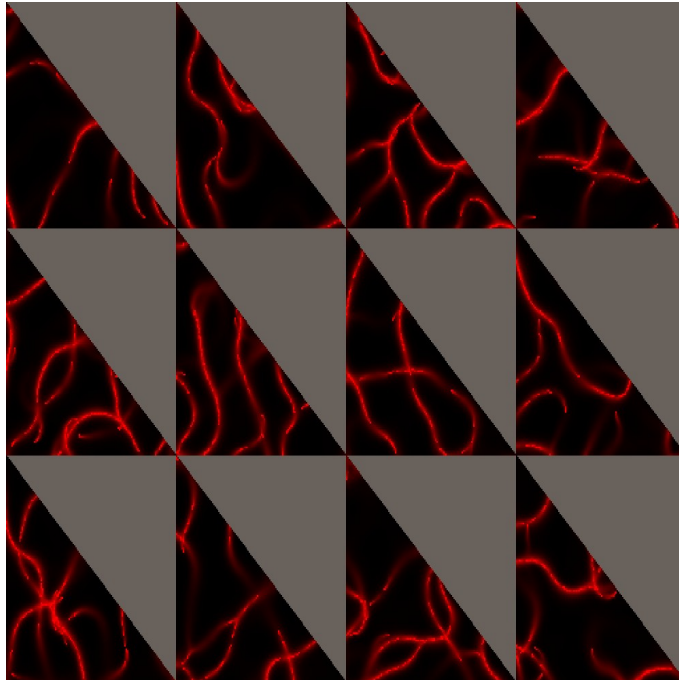
Transfer to the third Dimension

- Wrapping Trail Texture around Object
- Continuous Particles Movement across Triangle Borders
- Interaction between Multiple Objects

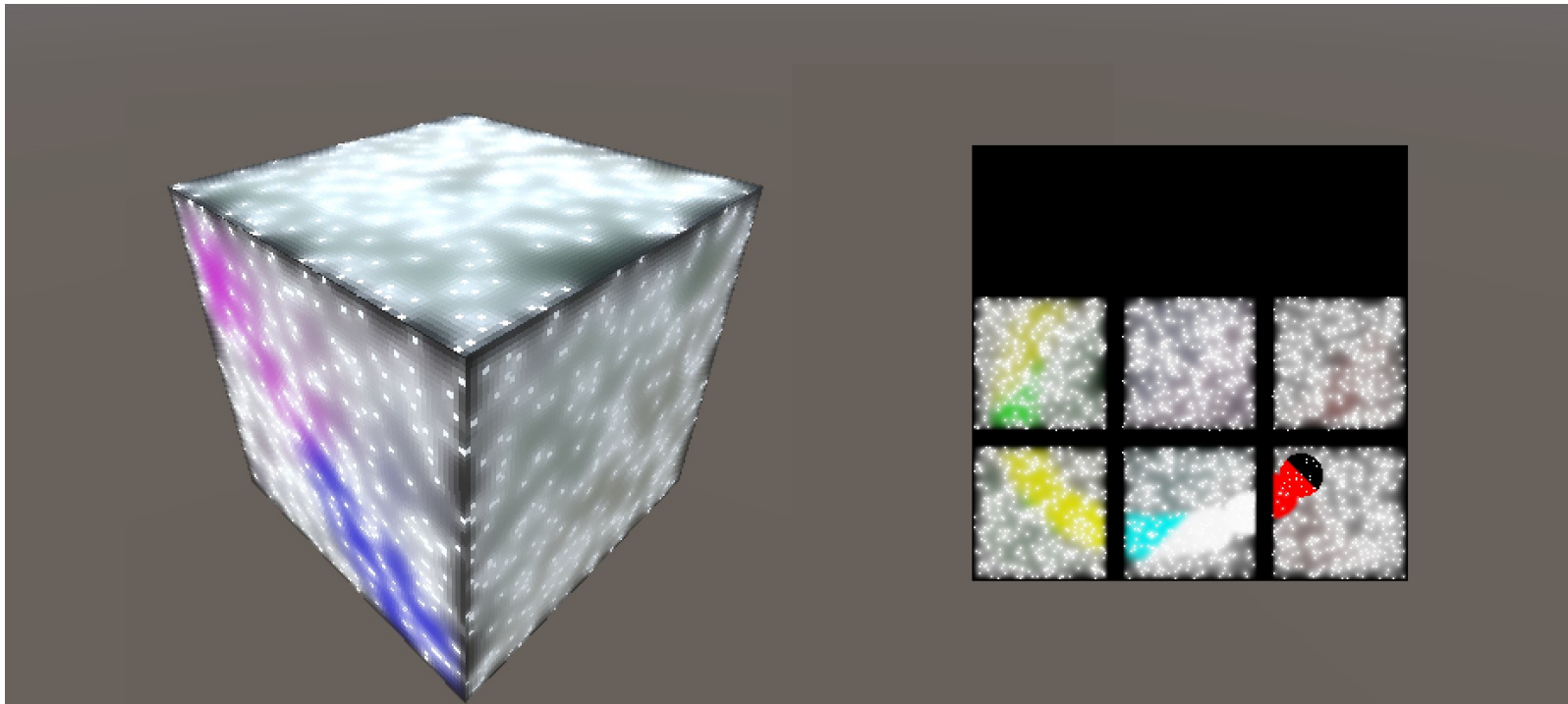
UV Mapping



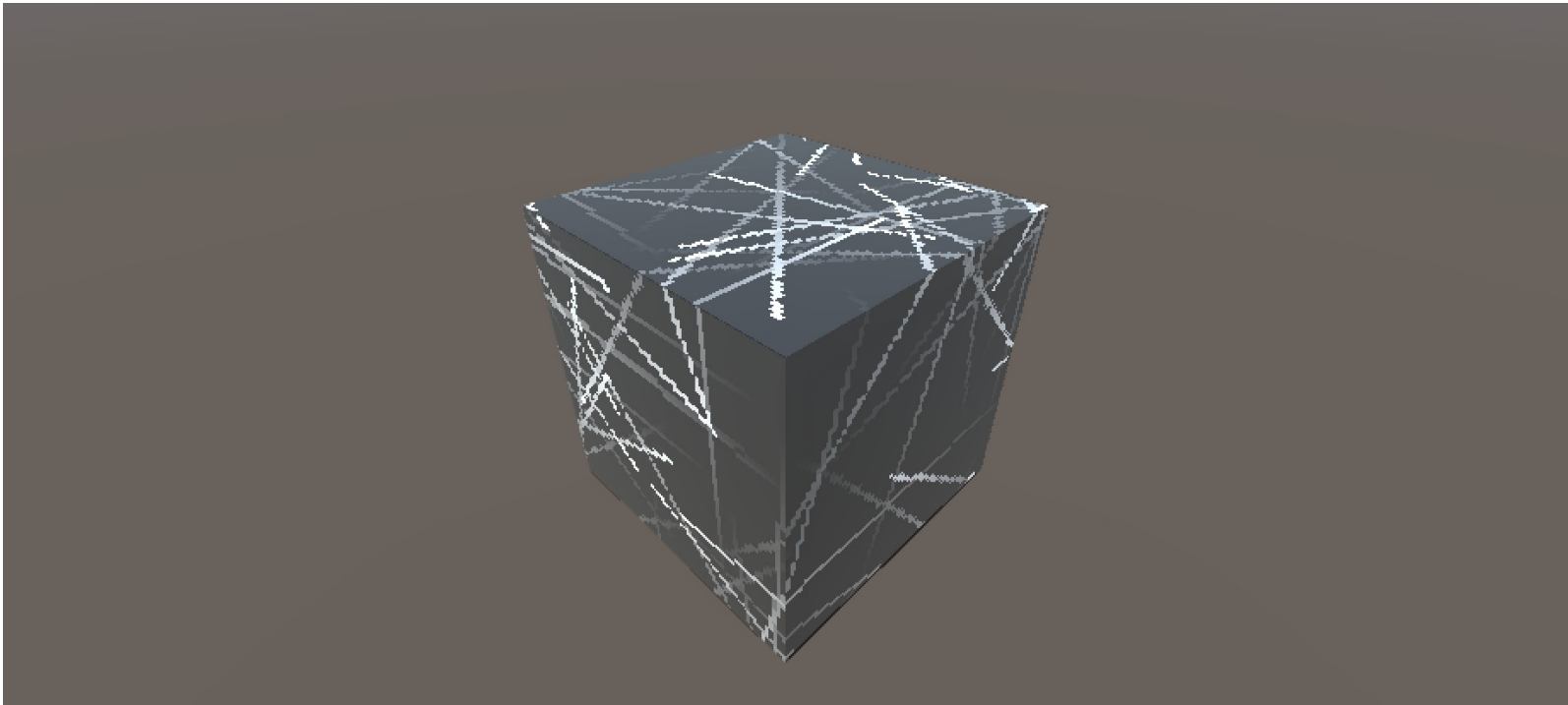
UV Mapping Automation



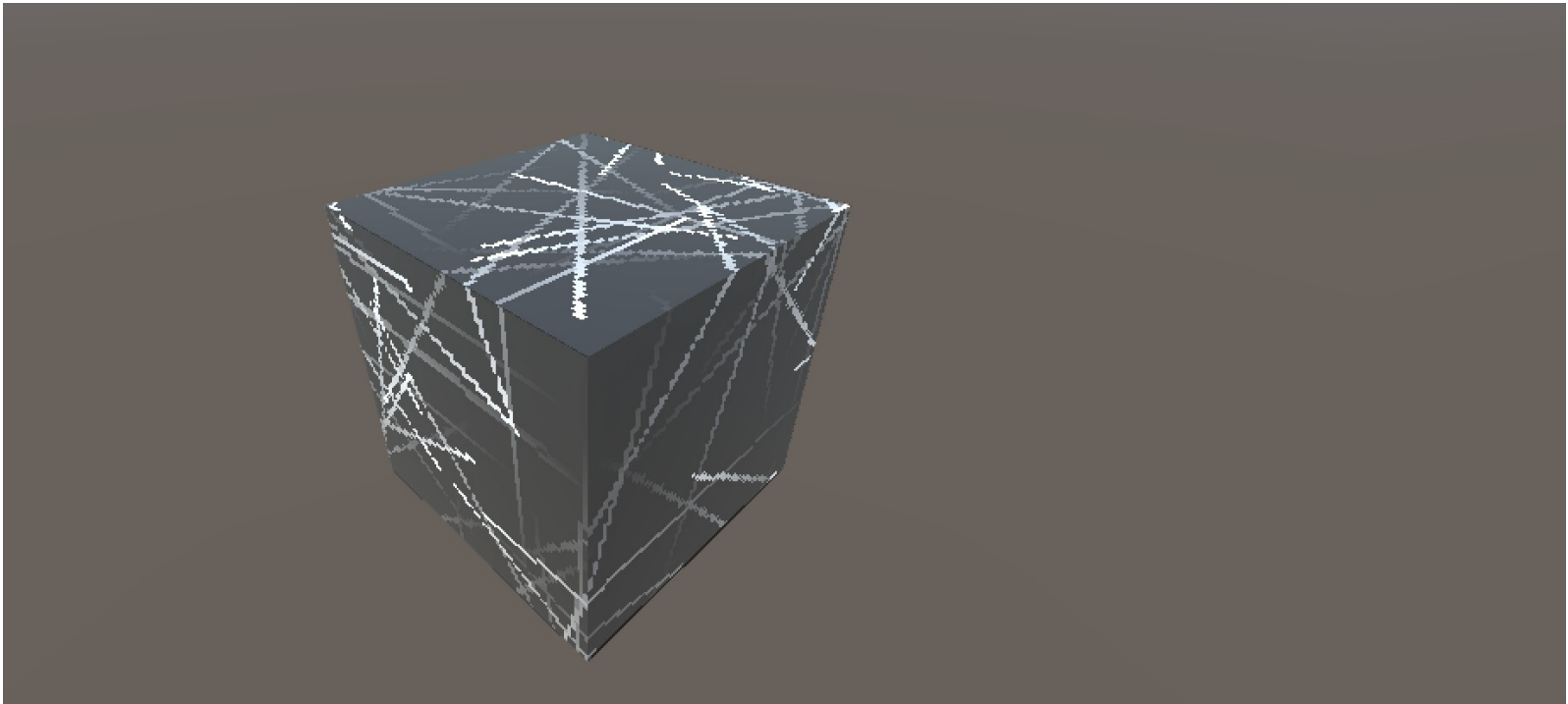
Trail Deposition and Diffusion



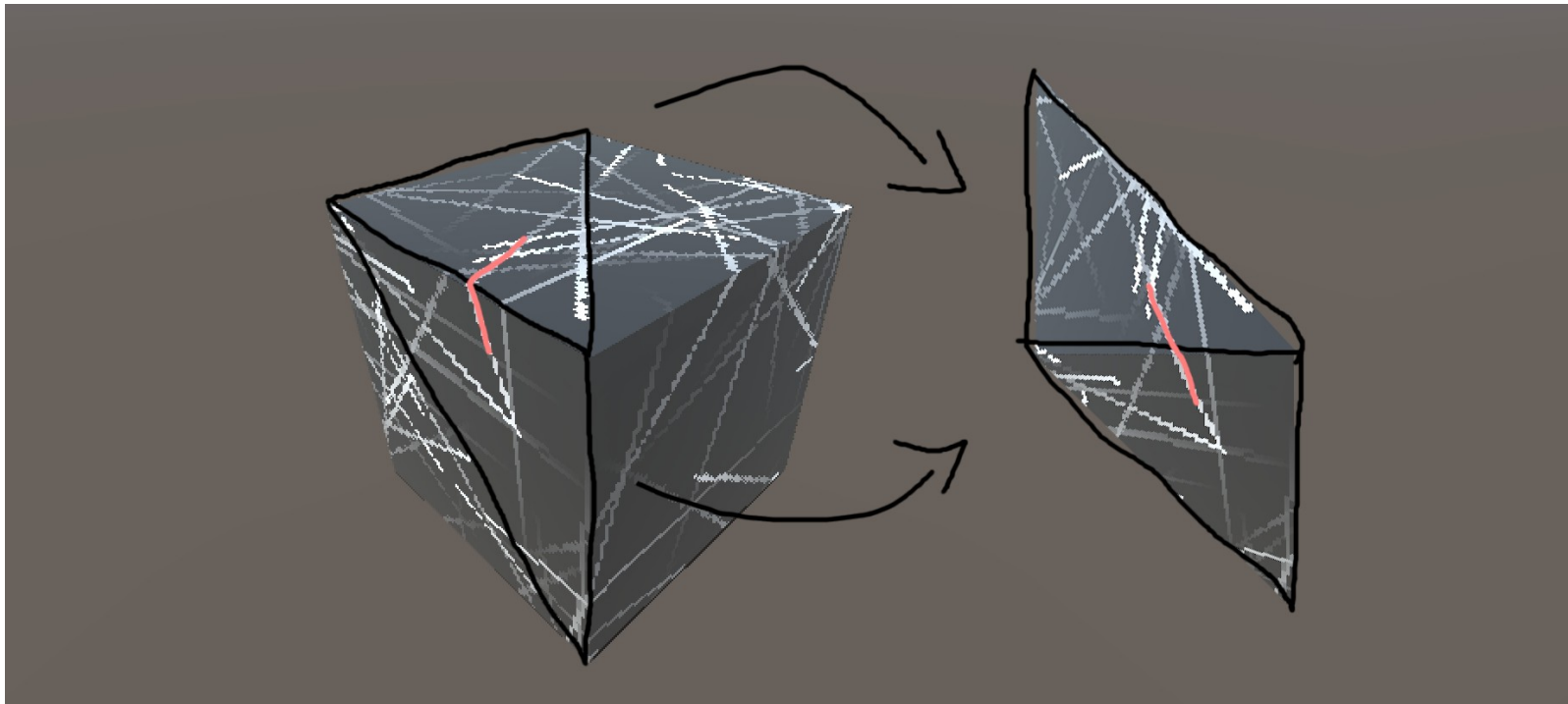
Crossing Edges



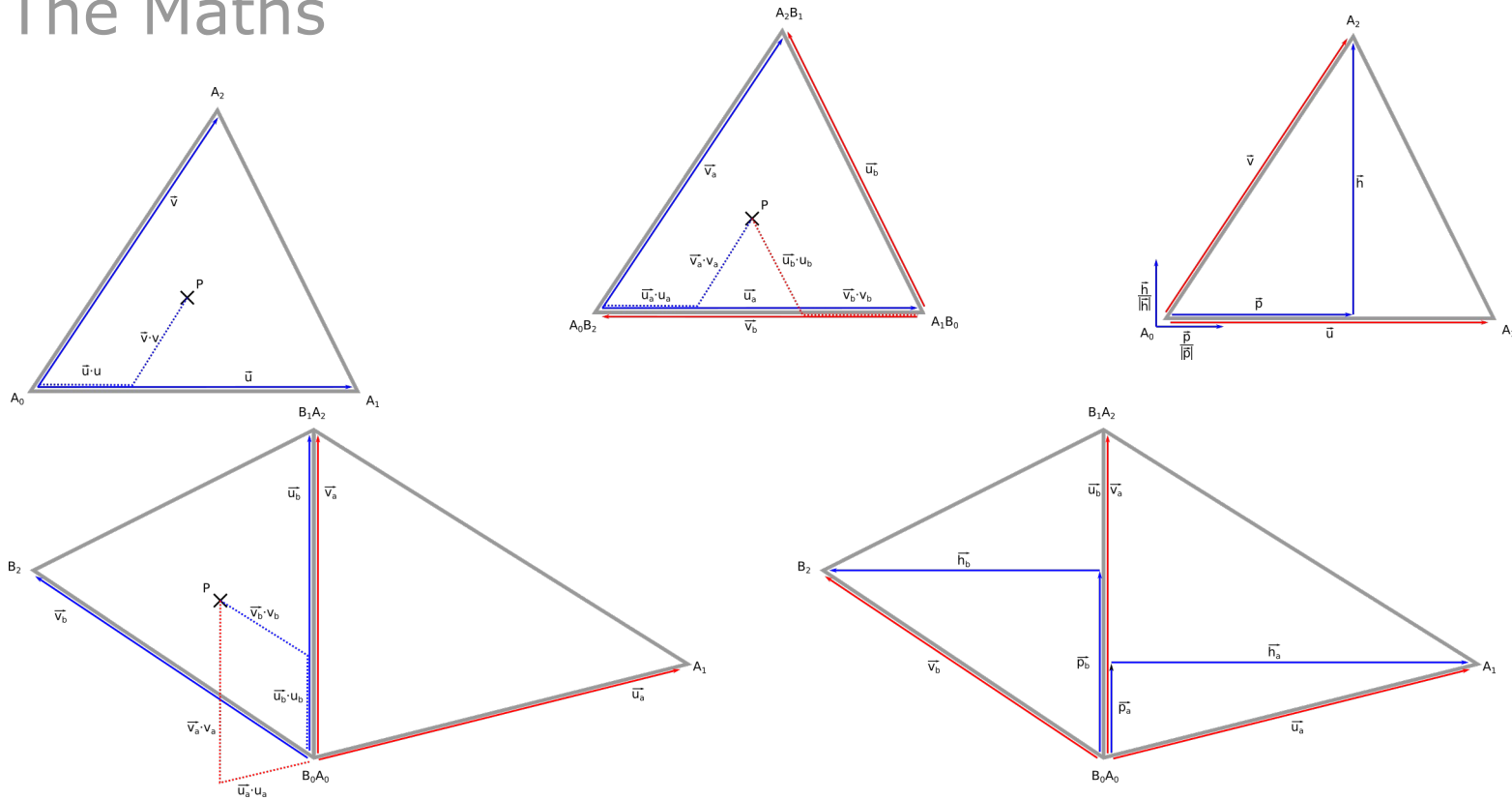
Crossing Edges



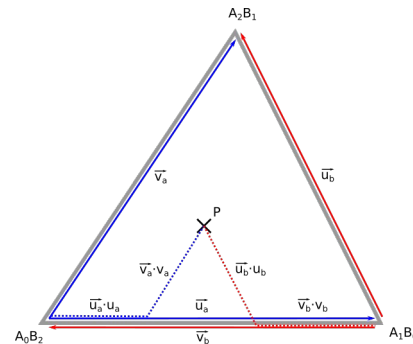
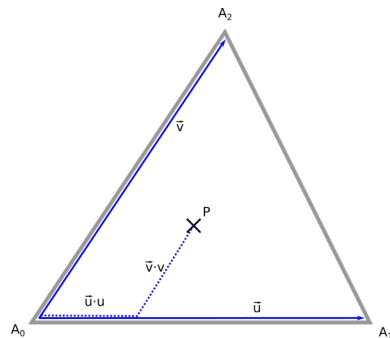
Crossing Edges



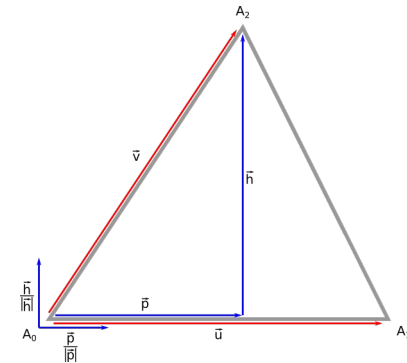
The Maths



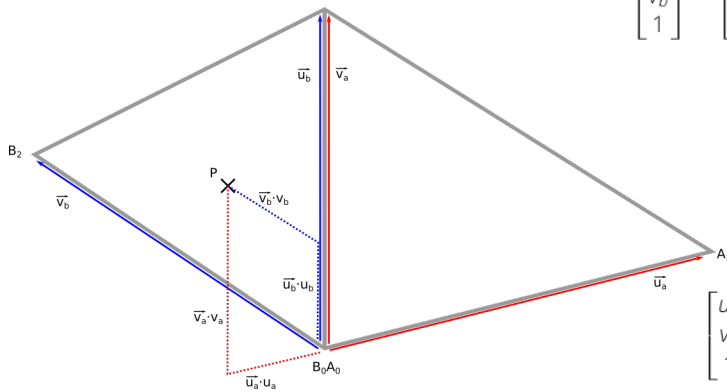
The Maths



$$\begin{bmatrix} u_b \\ v_b \\ 1 \end{bmatrix} = \begin{bmatrix} 0.0 & 1.0 & 0.0 \\ -1.0 & -1.0 & 1.0 \\ 0.0 & 0.0 & 1.0 \end{bmatrix} * \begin{bmatrix} u_a \\ v_a \\ 1 \end{bmatrix}$$



$$\begin{bmatrix} p_n \\ h_n \end{bmatrix} = \begin{bmatrix} |\vec{u}| & |\vec{p}| \\ 0 & |\vec{h}| \end{bmatrix} * \begin{bmatrix} u \\ v \end{bmatrix}$$

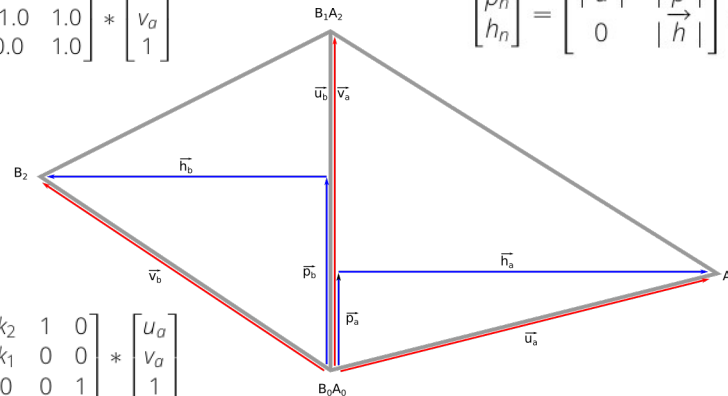


$$\begin{bmatrix} u_b \\ v_b \\ 1 \end{bmatrix} = \begin{bmatrix} k_2 & 1 & 0 \\ k_1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix} * \begin{bmatrix} u_a \\ v_a \\ 1 \end{bmatrix}$$

where

$$k_1 = -\frac{|\vec{h}_a|}{|\vec{h}_b|}$$

$$k_2 = \frac{|\vec{p}_a| - k_1 |\vec{p}_b|}{|\vec{u}_b|}$$



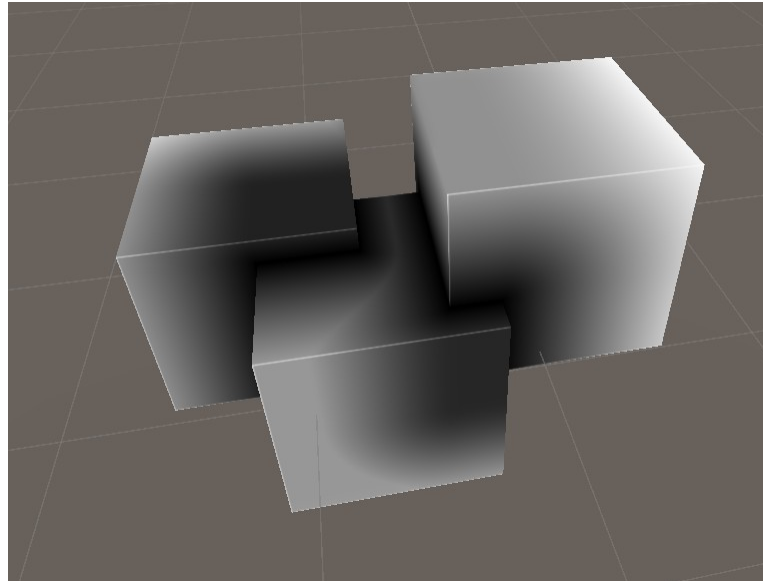
Live Demo!

Loading

Live Demo!

Loading...

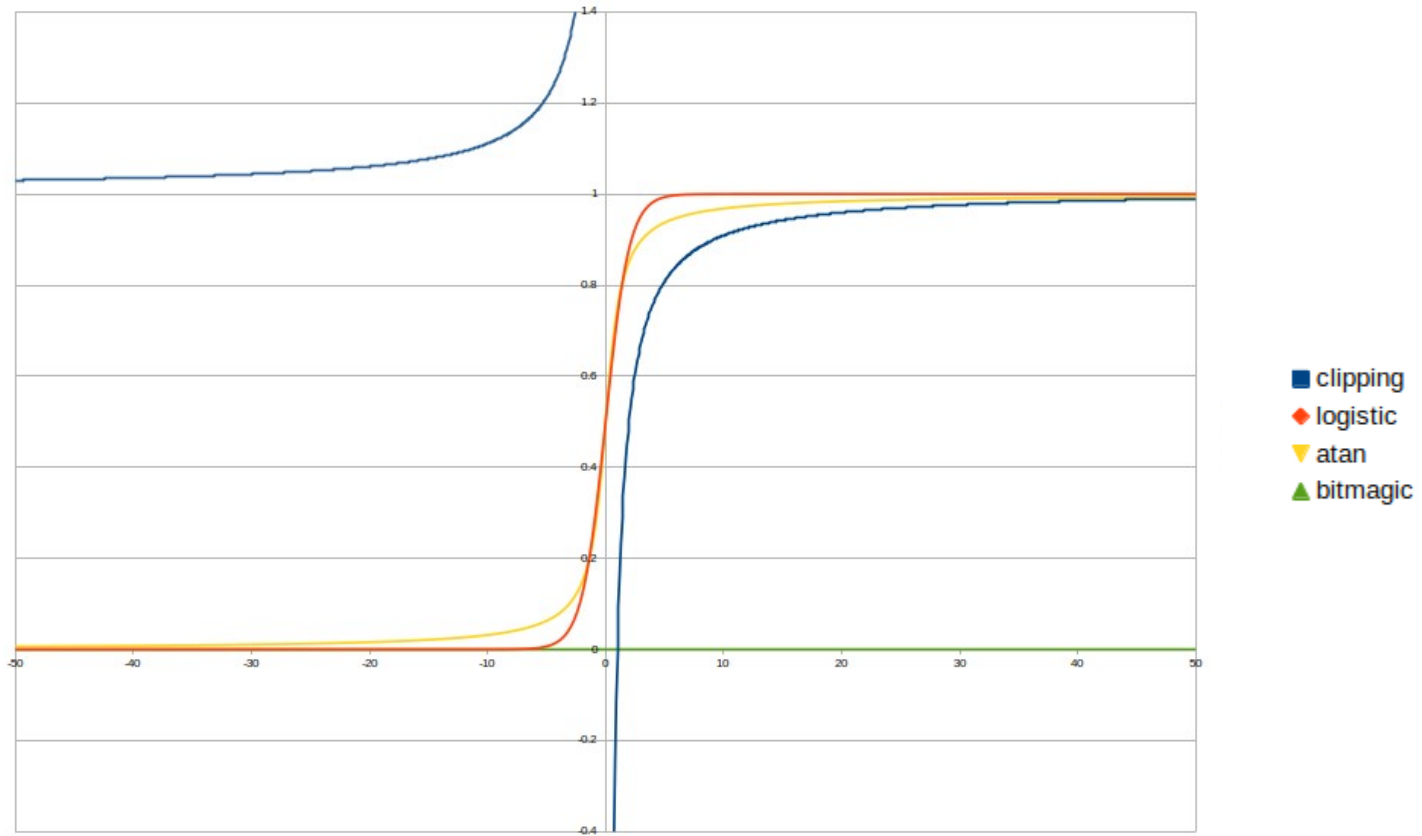
Signed Distance Field



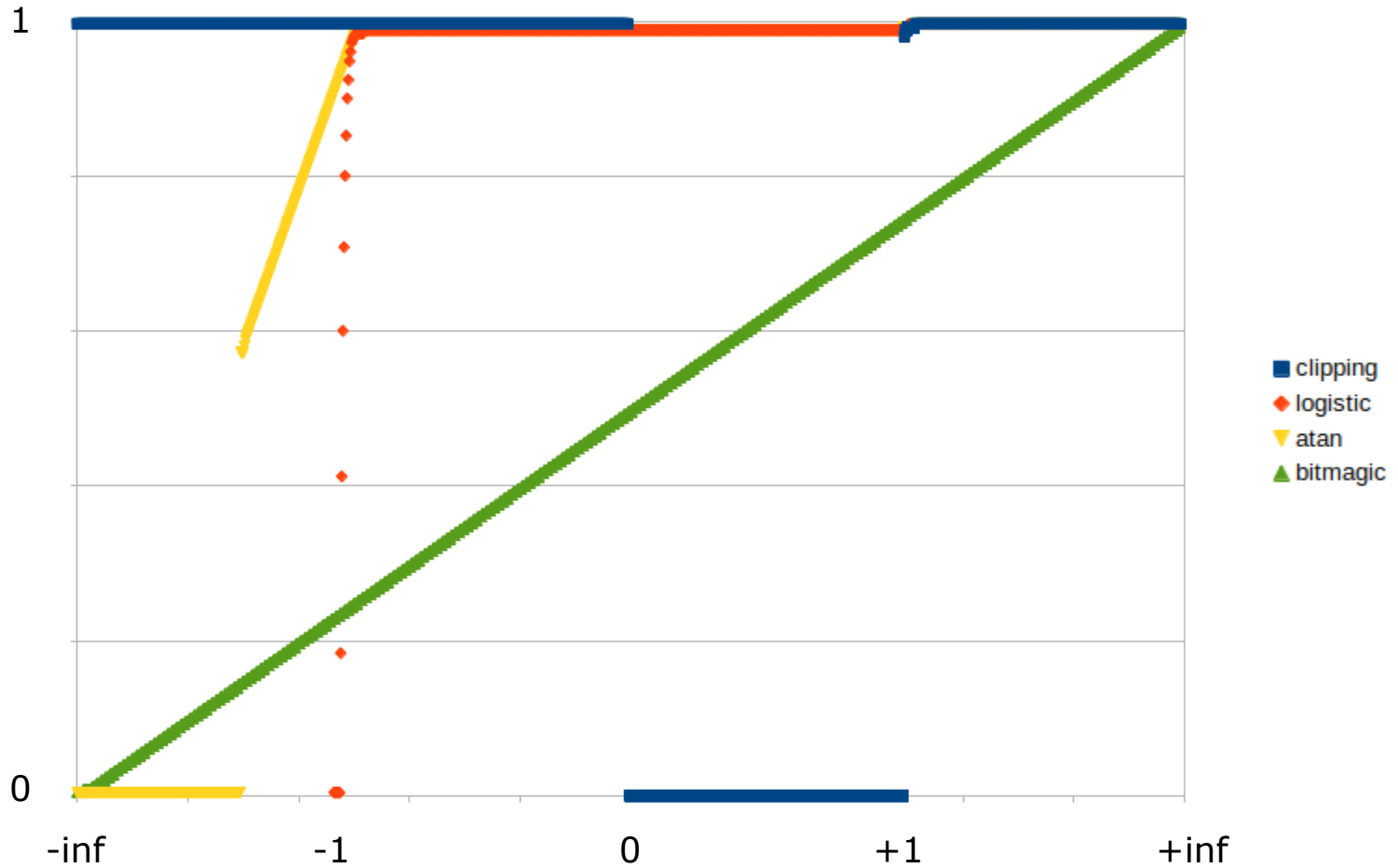
Depth Value Mapping

Quick Excursion into Floating Point Arithmetic

Depth Value Mapping



Depth Value Mapping

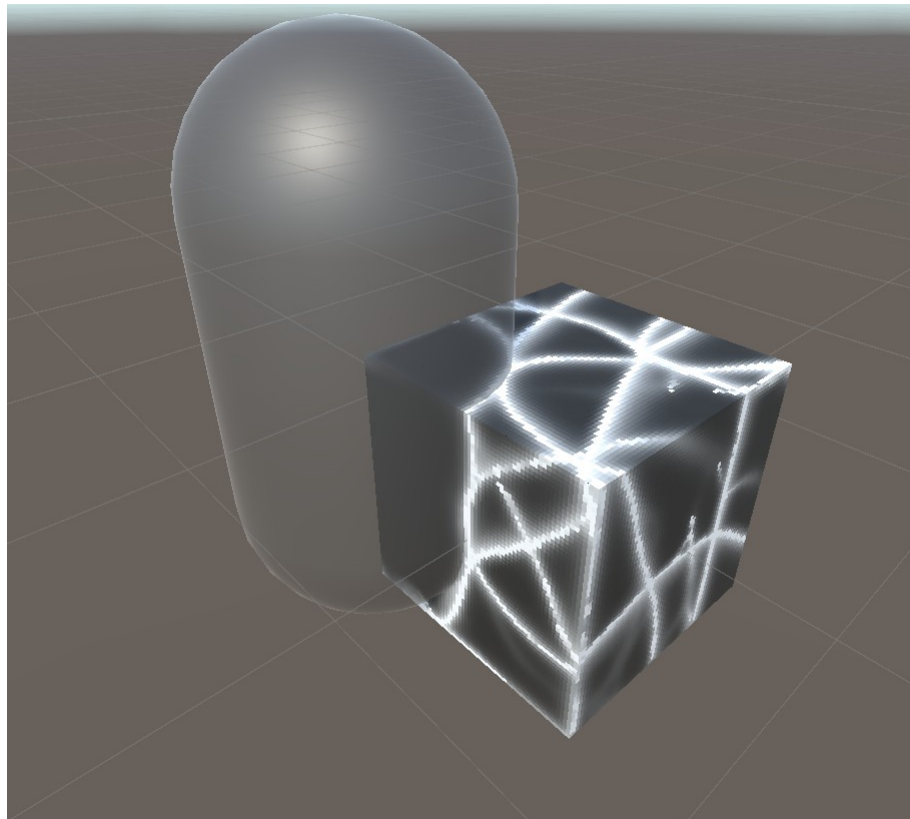


Depth Value Mapping

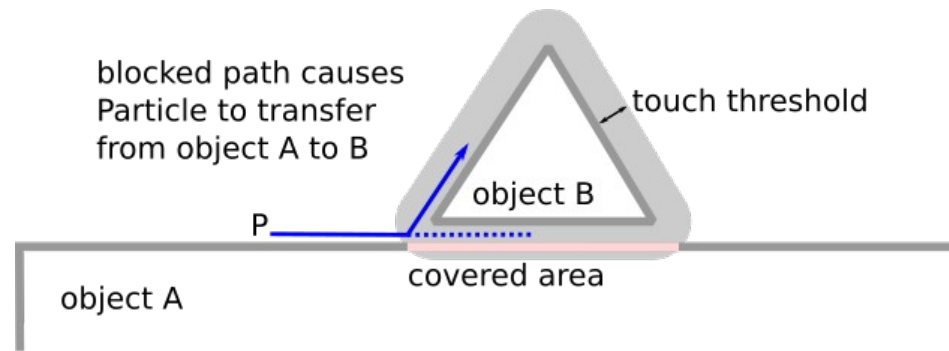
fp format	original fp value	bits	MSB = 1: flip all bits MSB = 0: flip first bit	bitshift >> 2	bits	mapped fp value
special	nan	1 11111111 111...1111			1 11111111 111...1111	nan
		1 11111111 000...0001			1 11111111 000...0001	
normalized	- inf	1 11111111 000...0000			1 11111111 000...0000	- inf
		- 2 ¹²⁸ + 2 ¹⁰⁴			1 11111110 111...1111	- 2 ¹²⁸ + 2 ¹⁰⁴
denormalized	- 2 ⁻¹²⁶	1 00000001 000...0000			1 00000001 000...0000	- 2 ⁻¹²⁶
		- 2 ⁻¹²⁶ + 2 ⁻¹⁴⁹			1 00000000 111...1111	- 2 ⁻¹²⁶ + 2 ⁻¹⁴⁹
denormalized	- 2 ⁻¹⁴⁹	1 00000000 000...0001			1 00000000 000...0001	- 2 ⁻¹⁴⁹
		- 0			1 00000000 000...0000	- 0
spezial	nan	0 11111111 111...1111			0 11111111 111...1111	nan
		0 11111111 000...0001			0 11111111 000...0001	
normalized	+ inf	0 11111111 000...0000			0 11111111 000...0000	+ inf
		+ 2 ¹²⁸ - 2 ¹⁰⁴			0 11111110 111...1111	+ 2 ¹²⁸ - 2 ¹⁰⁴
denormalized	+ 2 - 2 ⁻²³	0 01111111 111...1111			0 01111111 111...1111	+ 2 - 2 ⁻²³
		+ 2 ⁻¹²⁶			0 00000001 000...0000	+ 2 ⁻¹²⁶
denormalized	+ 2 ⁻¹²⁶	0 00000001 000...0000			0 00000001 000...0000	+ 2 ⁻¹²⁶
		+ 2 ⁻¹²⁶ - 2 ⁻¹⁴⁹			0 00000000 111...1111	+ 2 ⁻¹²⁶ - 2 ⁻¹⁴⁹
denormalized	+ 2 ⁻¹⁴⁹	0 00000000 111...1111			0 00000000 111...1111	+ 2 ⁻¹⁴⁹
		+ 2 ⁻¹⁴⁹			0 00000000 000...0001	+ 2 ⁻¹⁴⁹
denormalized	+ 0	0 00000000 000...0001			0 00000000 000...0001	+ 2 ⁻¹⁴⁹
		+ 0			0 00000000 000...0000	+ 0



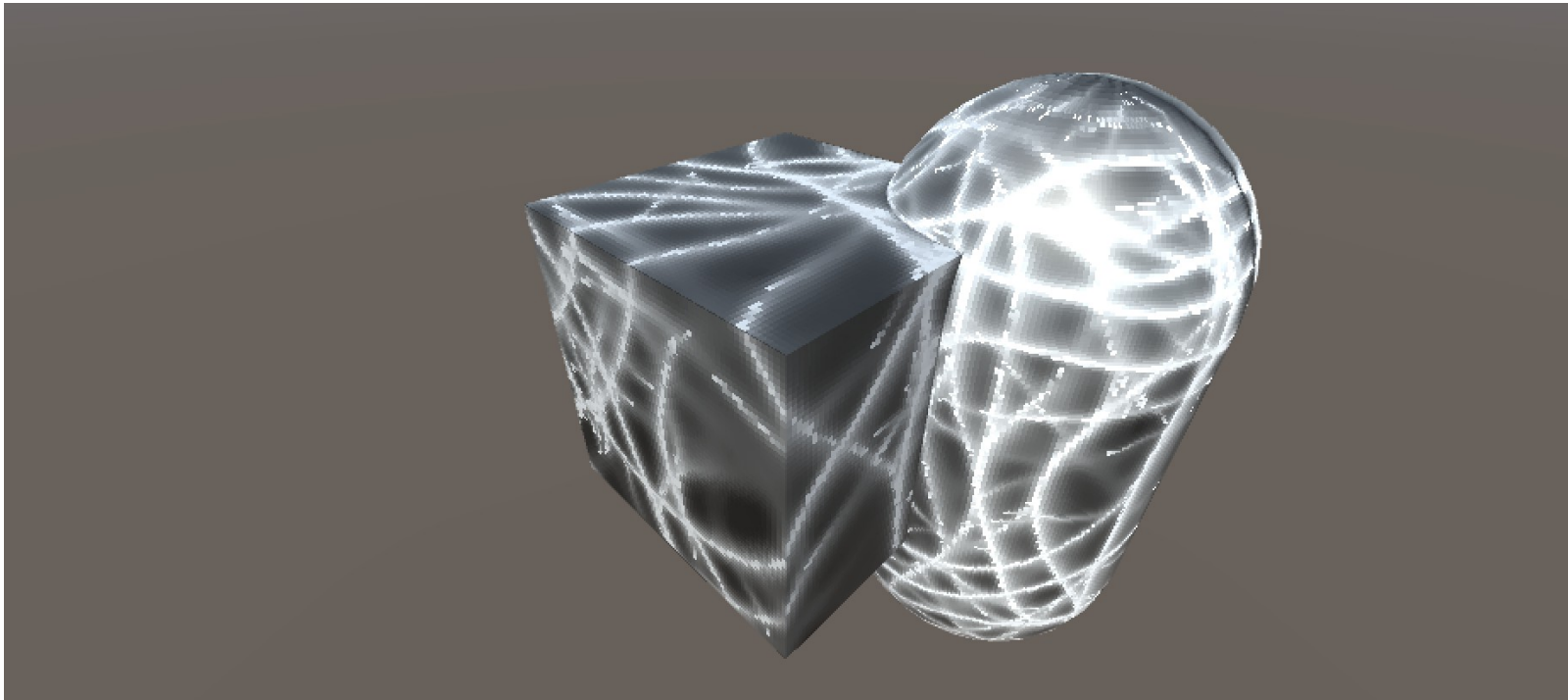
Obstacle Avoidance



Particle Transfer between multiple Objects



Particle Transfer between multiple Objects



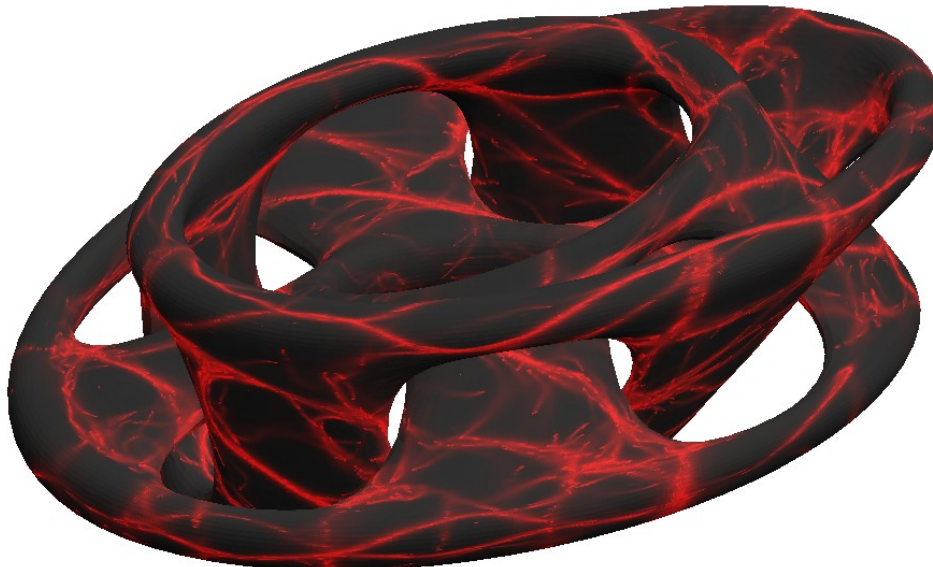
Another Live Demo!

Loading

Another Live Demo!







Loading...

WebGL UI





FPS: 13.3

Particles:

10000		Particle Count*
0.003		Particle Speed [units/tick]
3		Rotation Speed [°/tick]
0.1		Sensor Offset
10		Sensor Angle [°]
0		Sensor Noise (standart deviation)

Particle Opacity

Texture:

8		Size of Triangles*
<input checked="" type="checkbox"/> Interpolate Texture*		
10		Edge Crossing Attempts
<input type="range"/>		Trace Diffusion
<input type="range"/>		Trace Decay

Model:

torus.obj

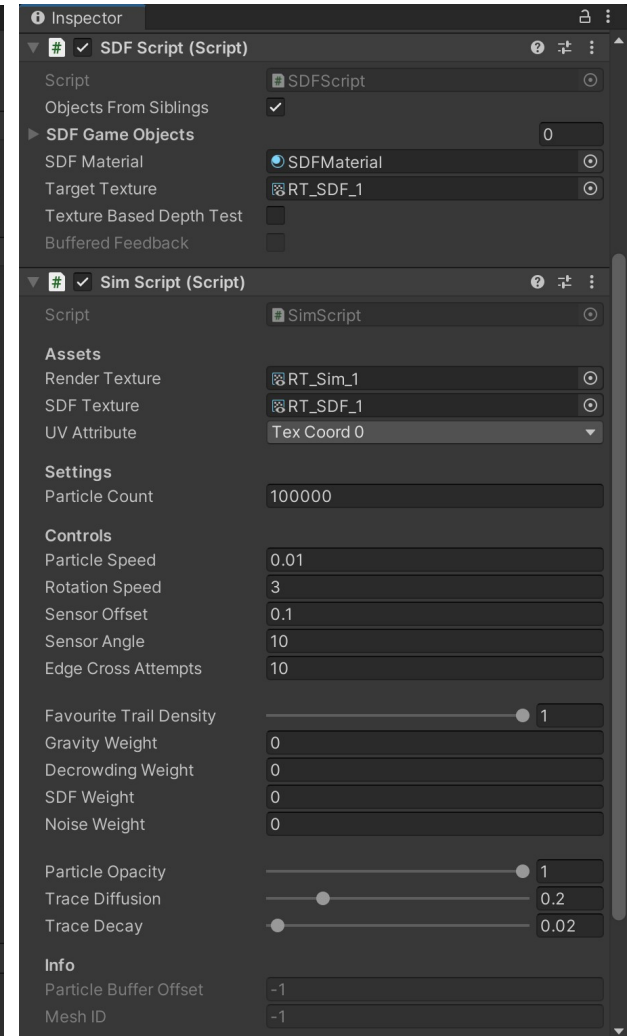
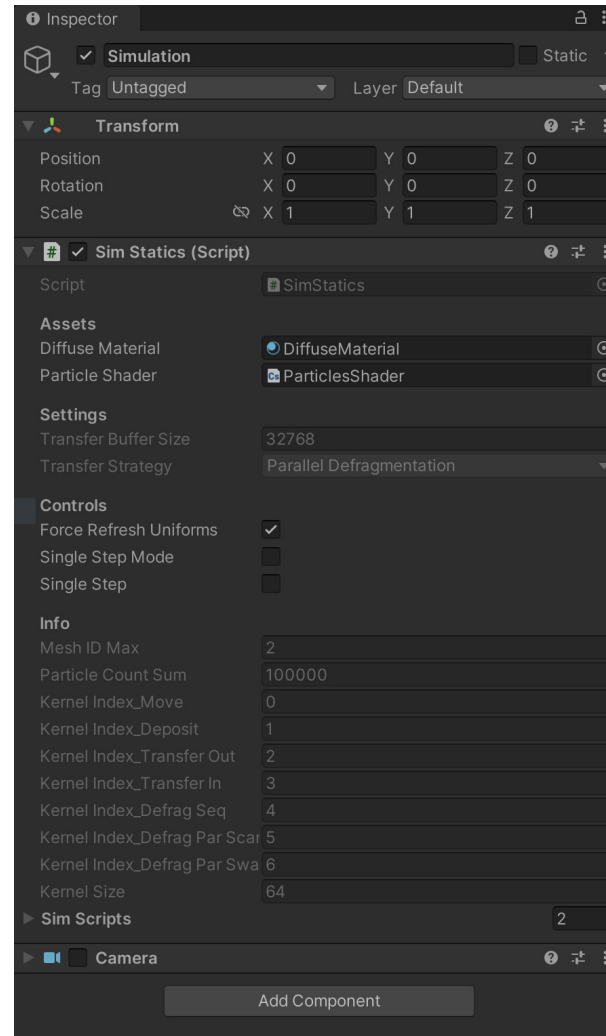
Render Mode:

☒ 3D Model
☐ Unwrapped Texture

30  Animation Speed

*) for changes to this setting to take effect.

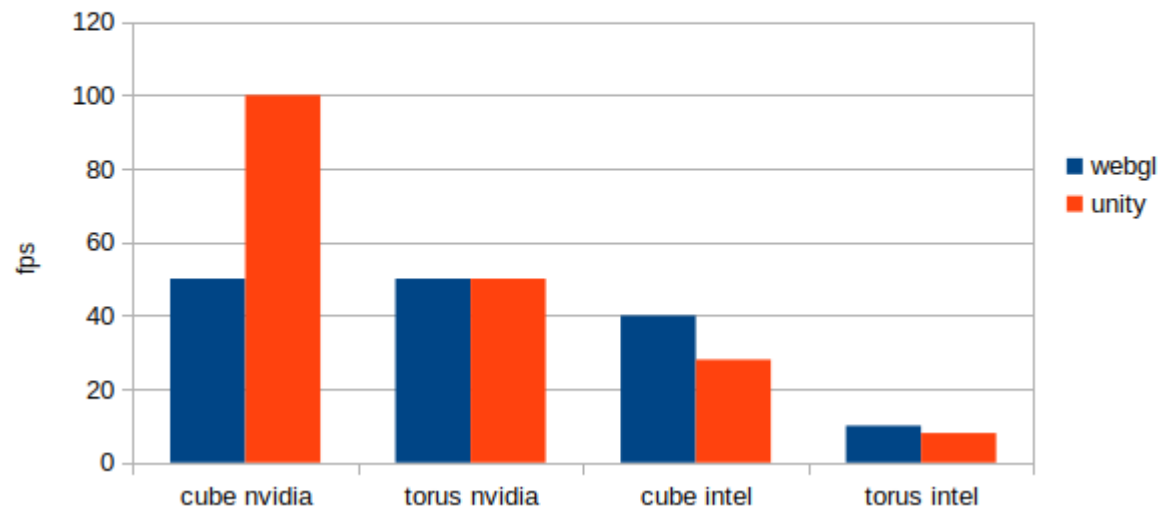
Unity UI



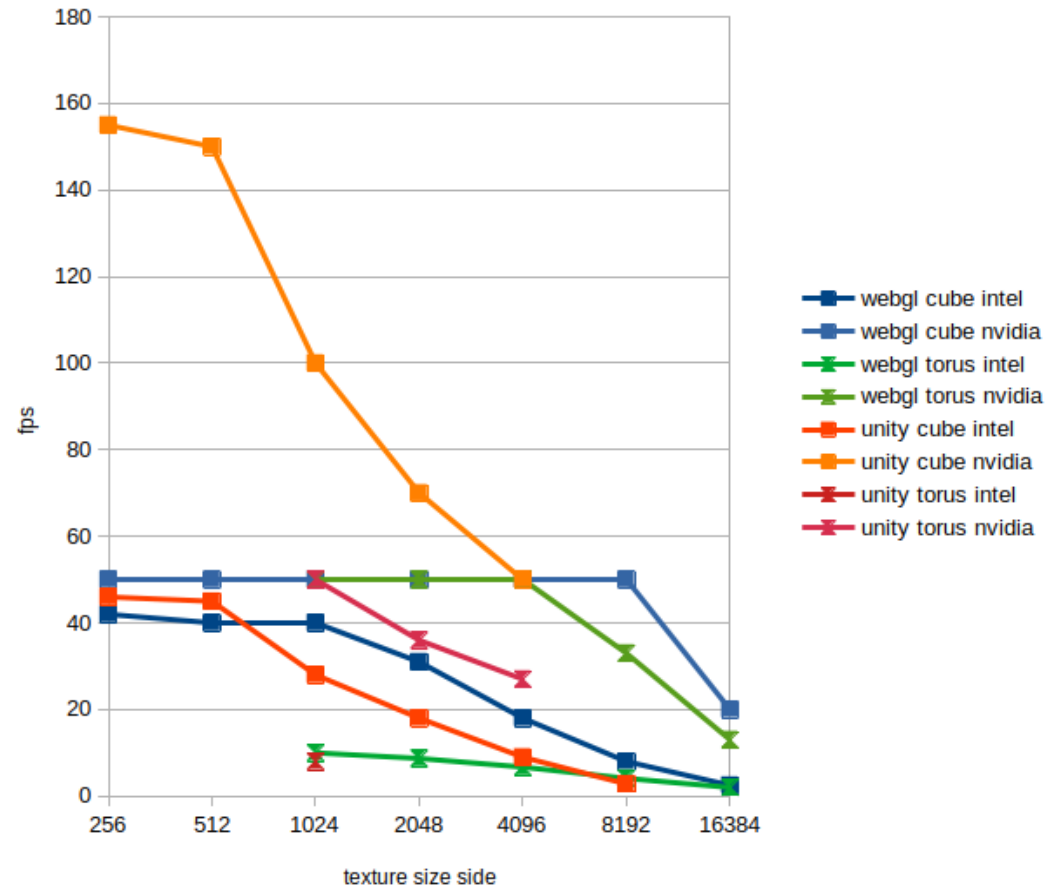
Performance

Comparing Performance of Unity and WebGL Implementations

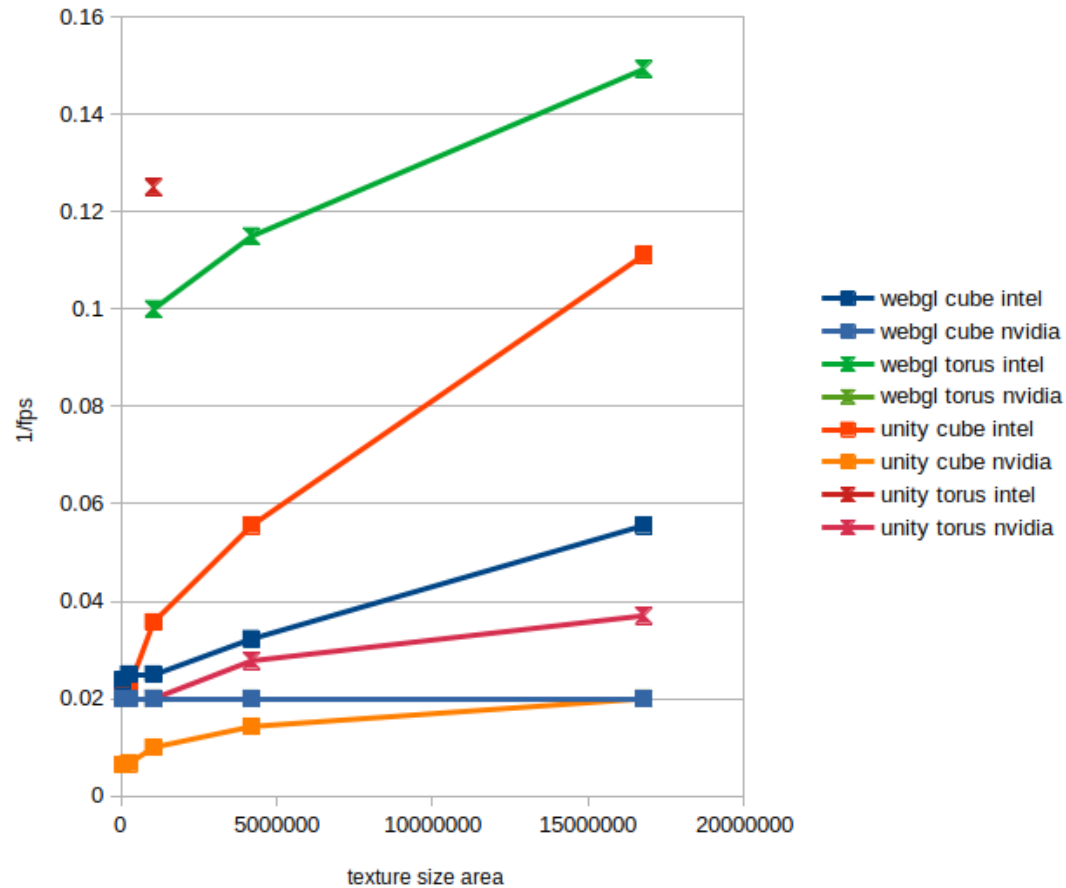
500000 particles, 1024x1024 texture



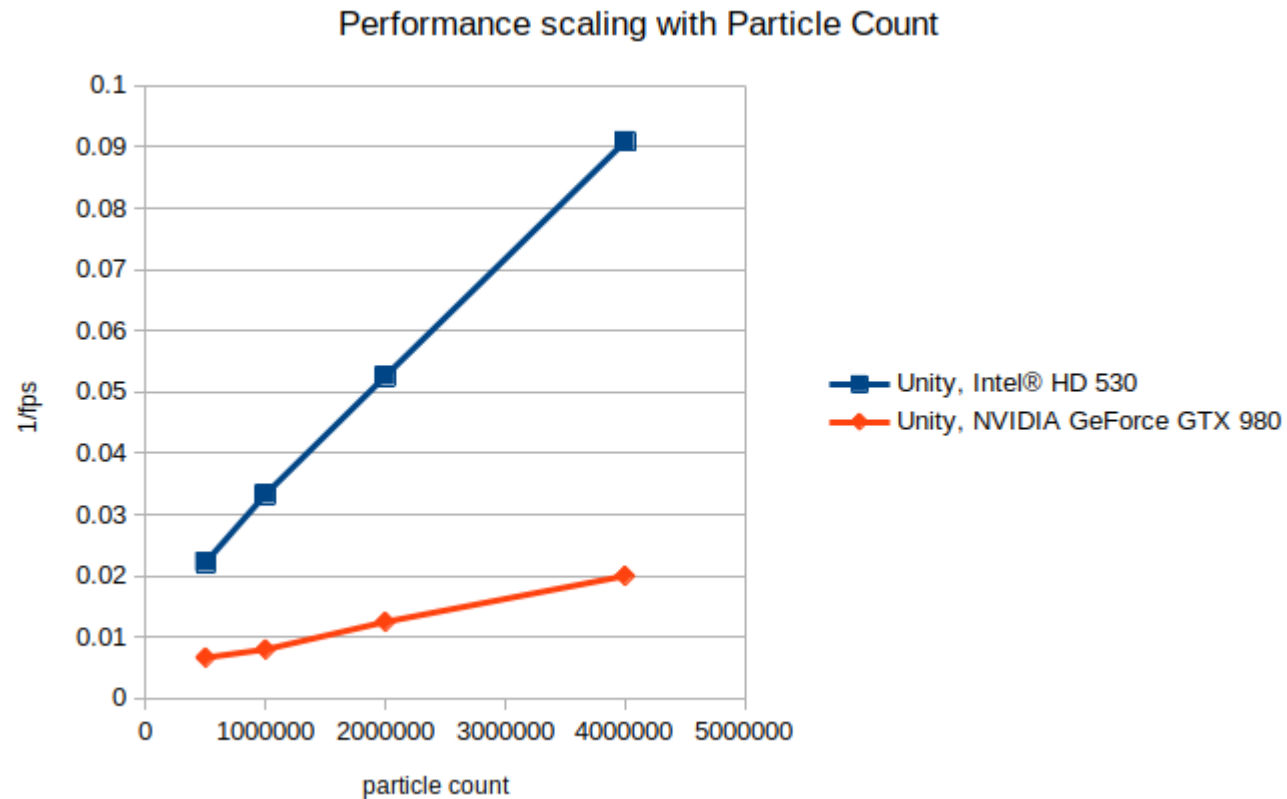
Performance



Performance



Performance



Future Work

- VR/AR with scanned room model
- Interaction using motion controllers
→ grab objects, paint on texture, ...
- Multi user environment
- Food inspired reward system to incentivise particles to visit certain spots
- Light / Shadow maps
- ...

Thanks

