

THE PREMIER CONFERENCE & EXHIBITION ON
COMPUTER GRAPHICS & INTERACTIVE TECHNIQUES



SIGGRAPH 2023
LOS ANGELES+ 6-10 AUG

OPENVDB IN PRODUCTION

JEFF BUDSBERG

VFX SUPERVISOR - DREAMWORKS ANIMATION



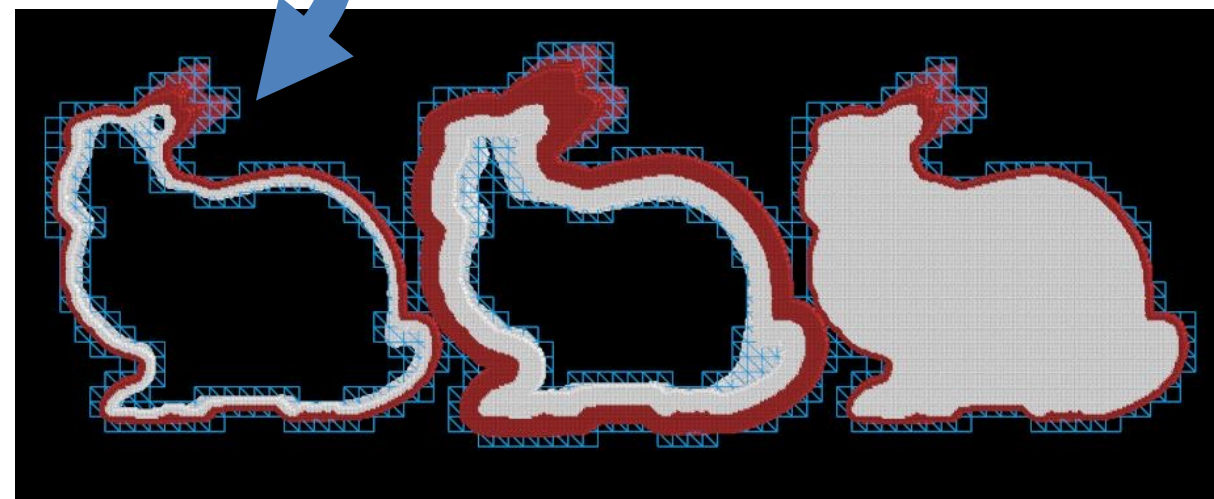
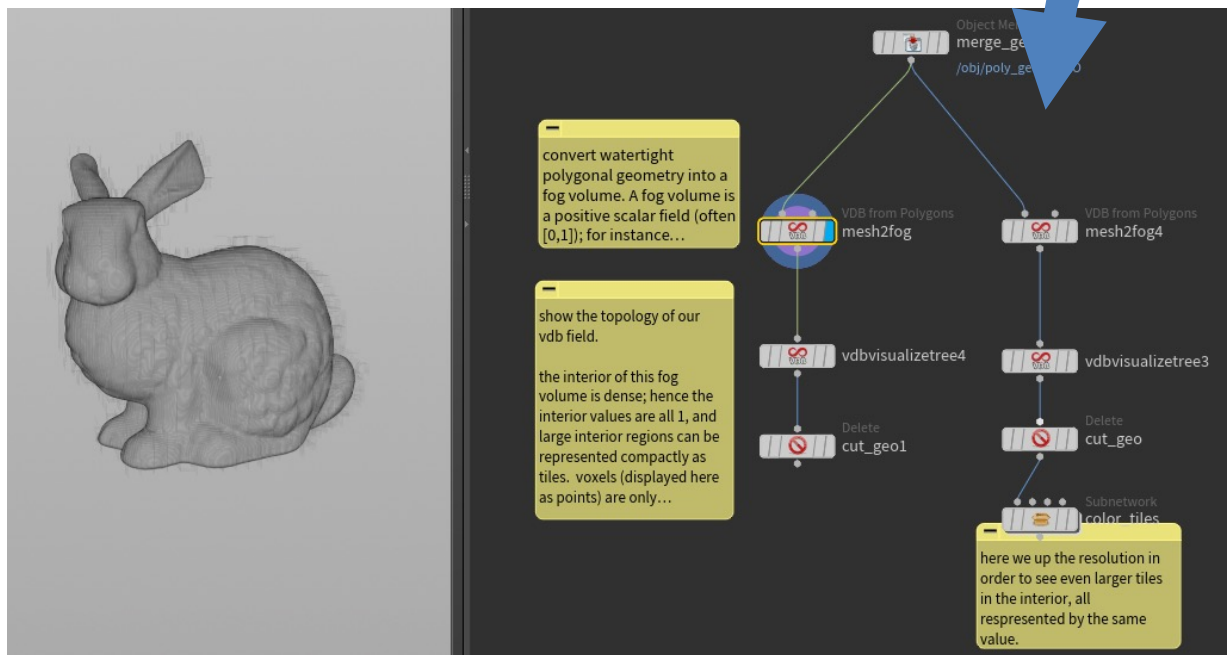
- Introduction to toolset via Applications
 - Clouds + Atmosphere
 - Liquids
 - Filtering + Morphological Operations
 - Grid analysis
 - Managing complexity
 - Advection + Simulation
 - Stylization + Retiming + Deformation
 - Extrapolation
 - Visualization + Rendering + Shading

→ TOOLS & WORKFLOW EXAMPLES



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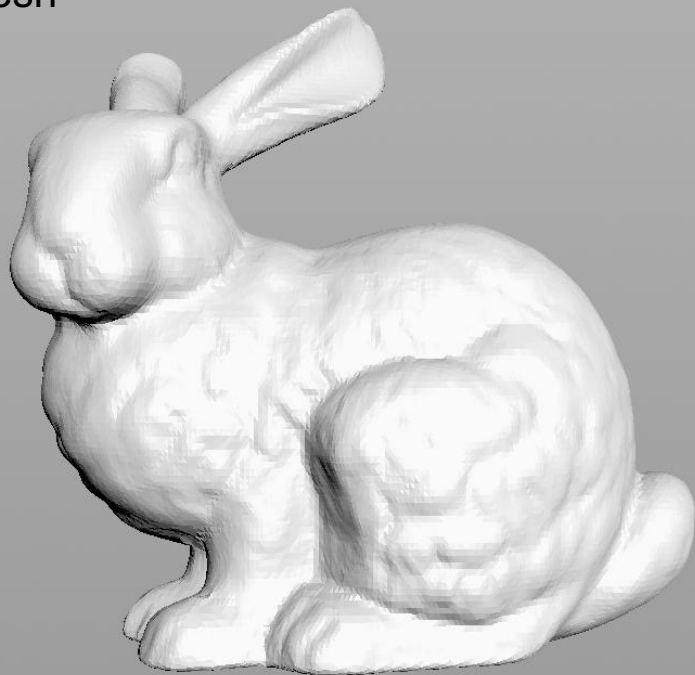




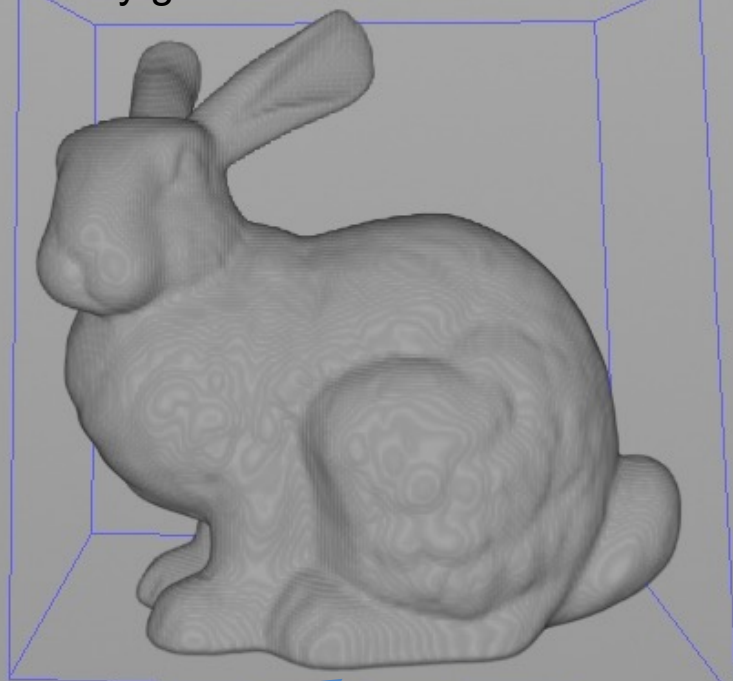
VOLUME CREATION



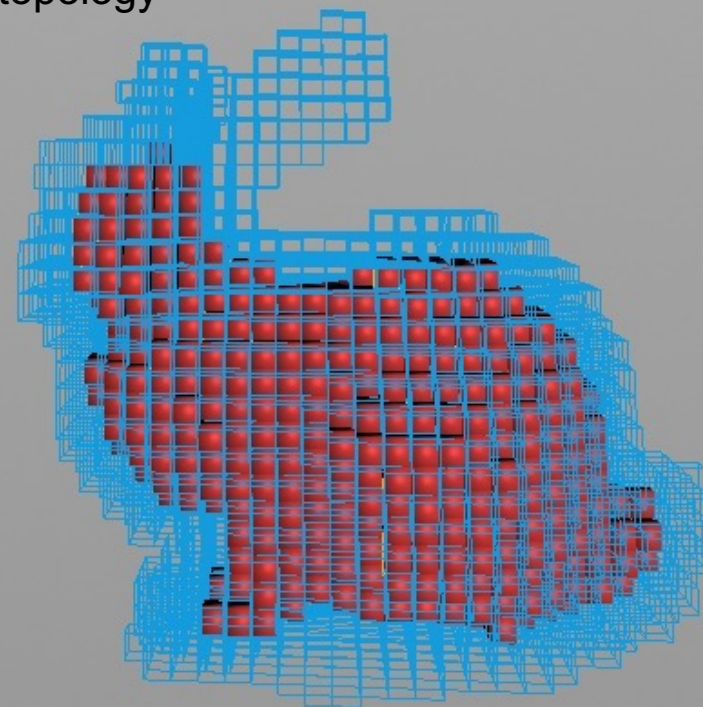
mesh



density grid

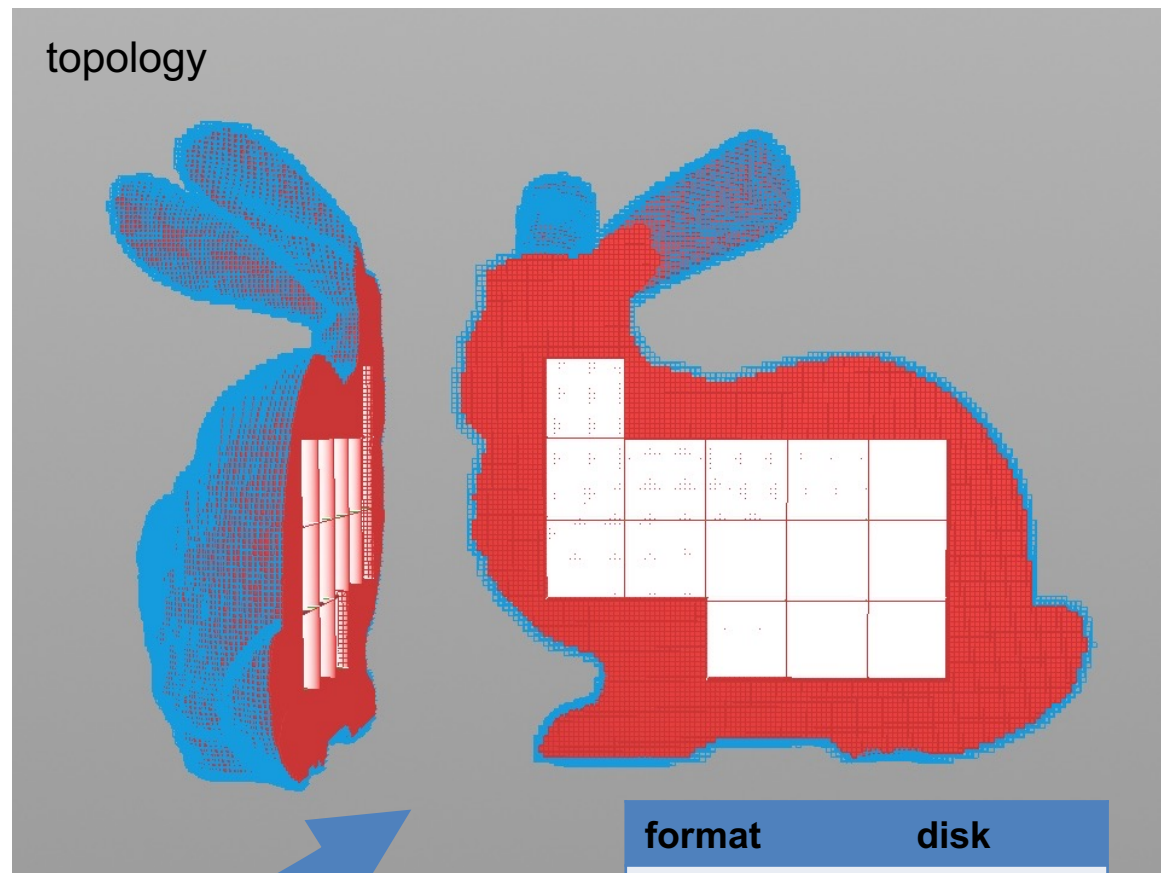
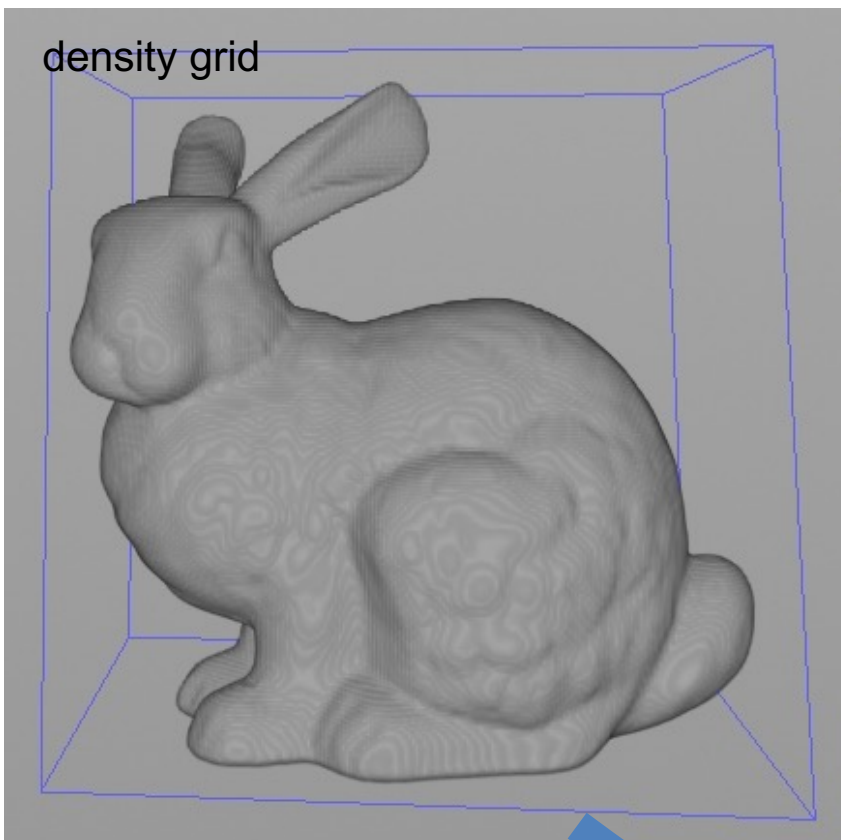


topology





VOLUME CREATION



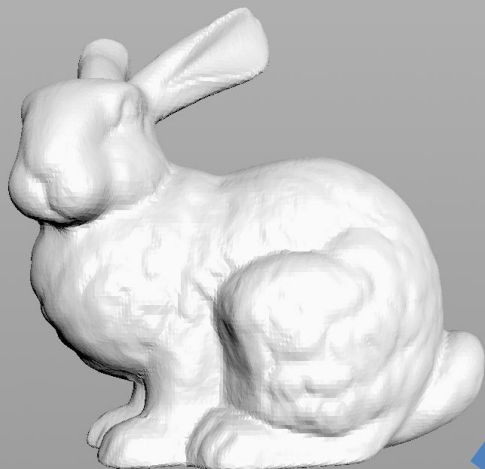
format	disk
32 bit	1.9 MB
16 bit	1.3 MB
16 bit blosc	970 KB



ARBITRARY GRIDS

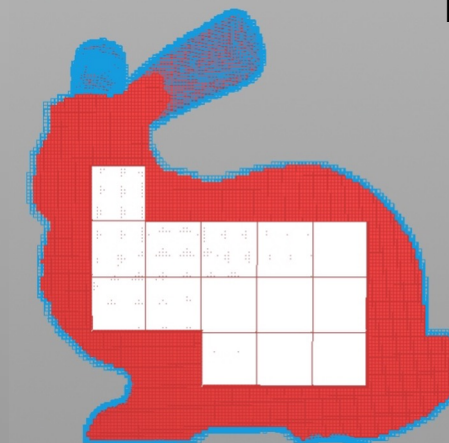


mesh

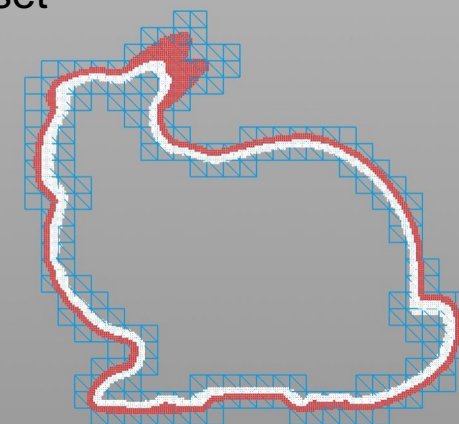


- grid metadata:
- background value
 - voxel size
 - index to world xform
 - class
 - bbox
 - name
 - value/vector type
 - ...

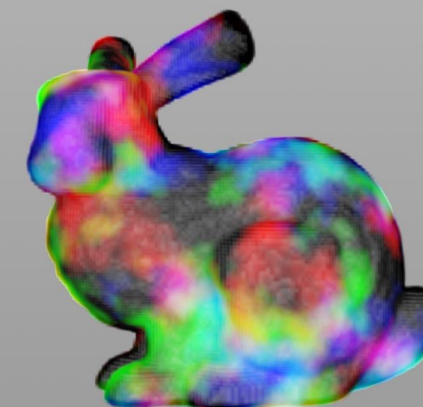
density



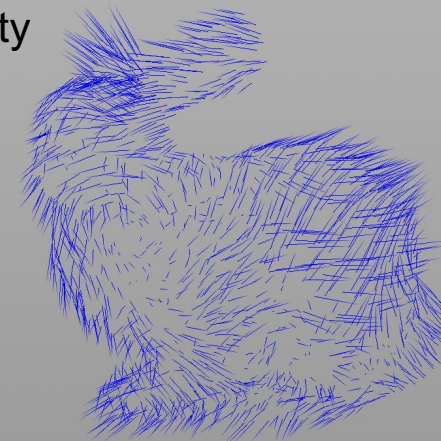
level set



color

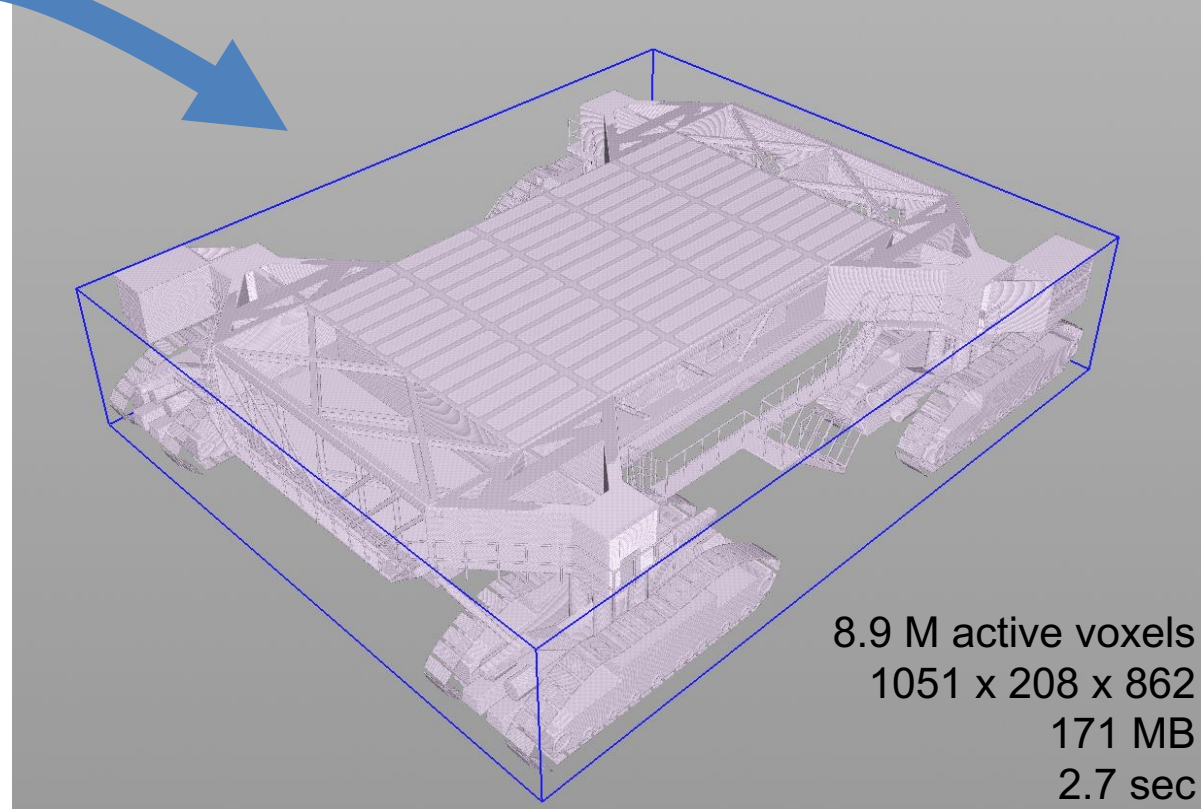
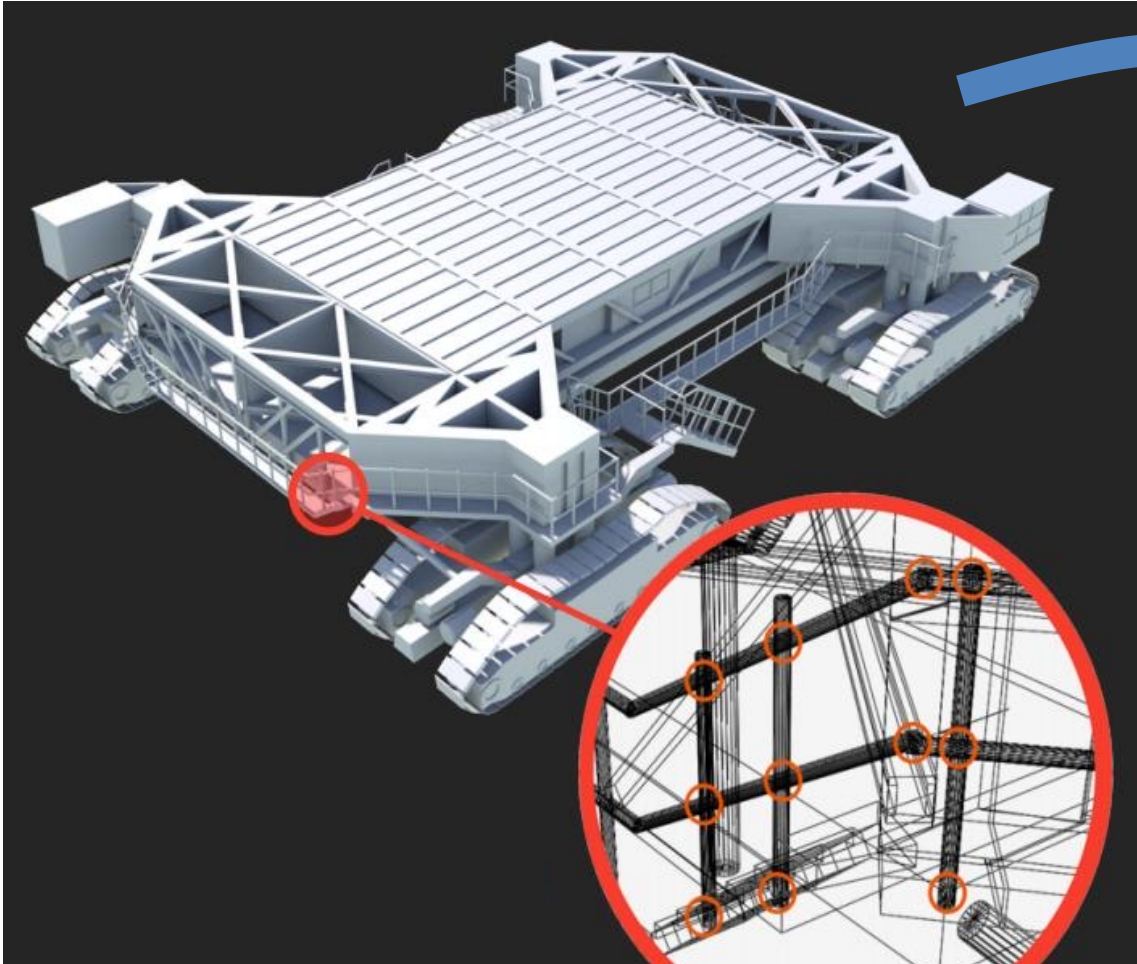


velocity



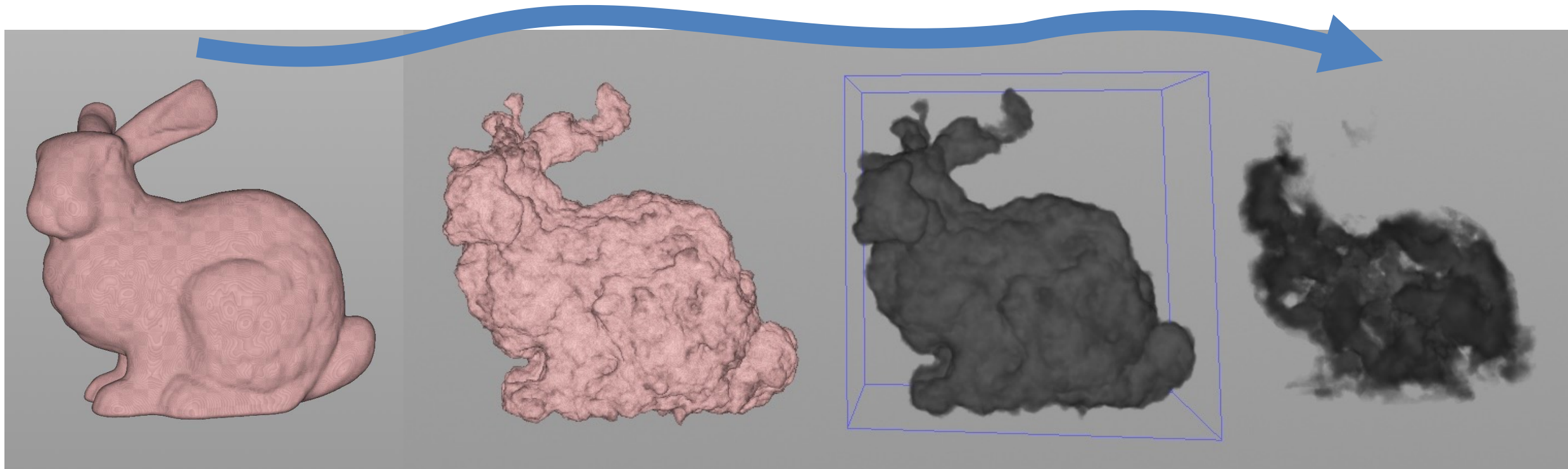


COMPLEXITY





VOLUME MANIPULATION

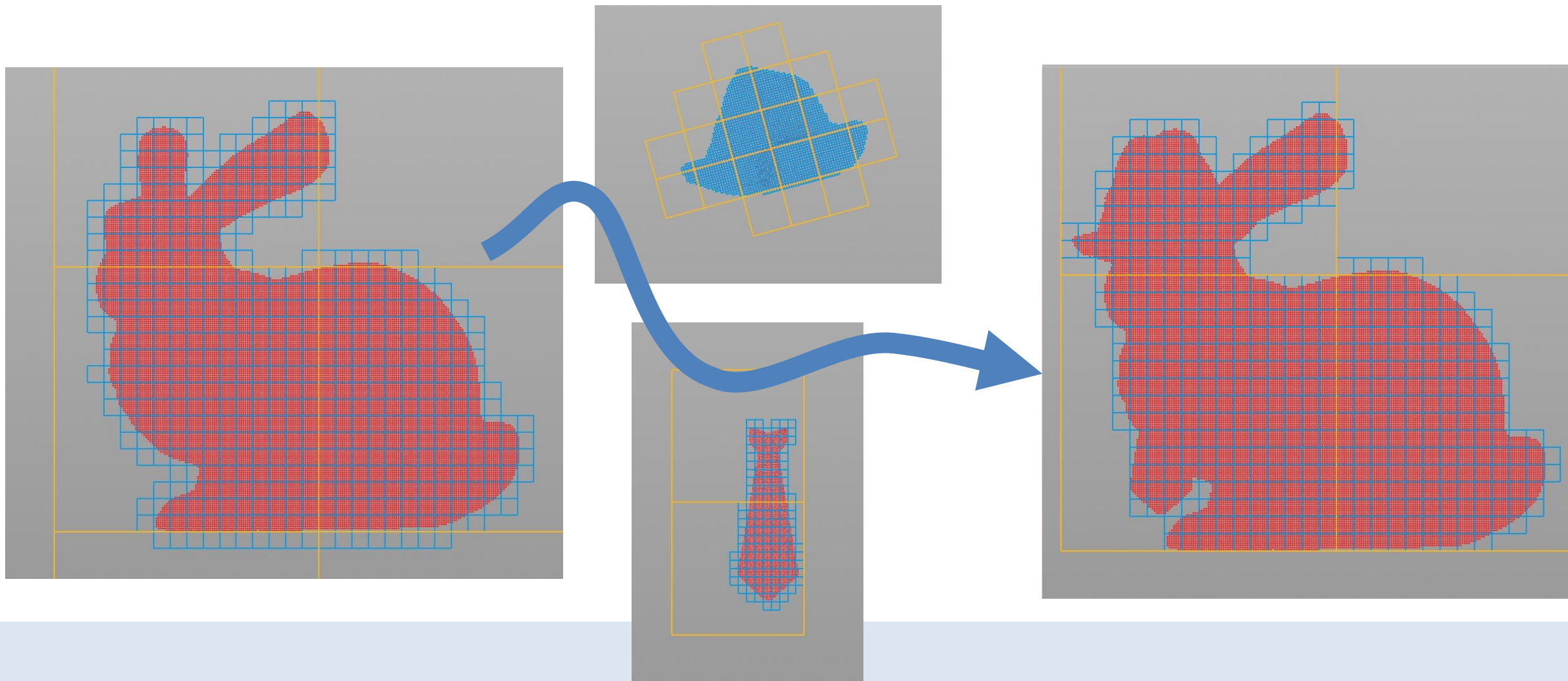


$\Phi += \text{noise}(\text{CPT})$

$\Phi \bullet = \text{noise}(\text{P})$

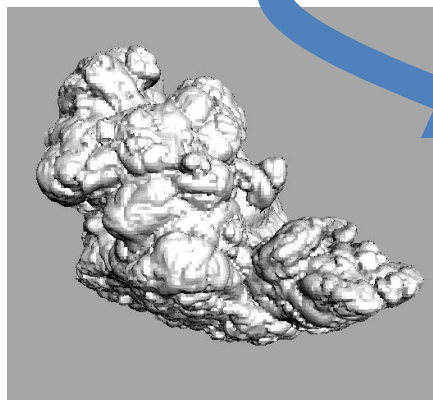
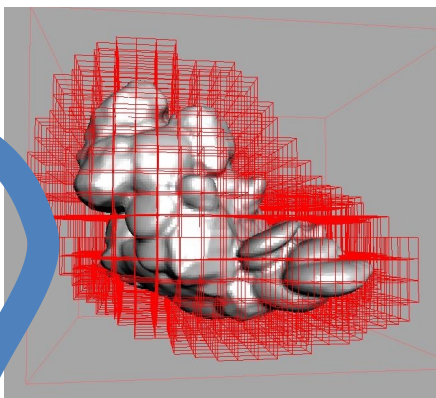
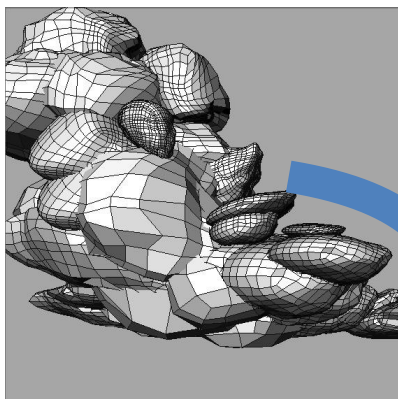


COMBINING GRIDS





CLOUD MODELING

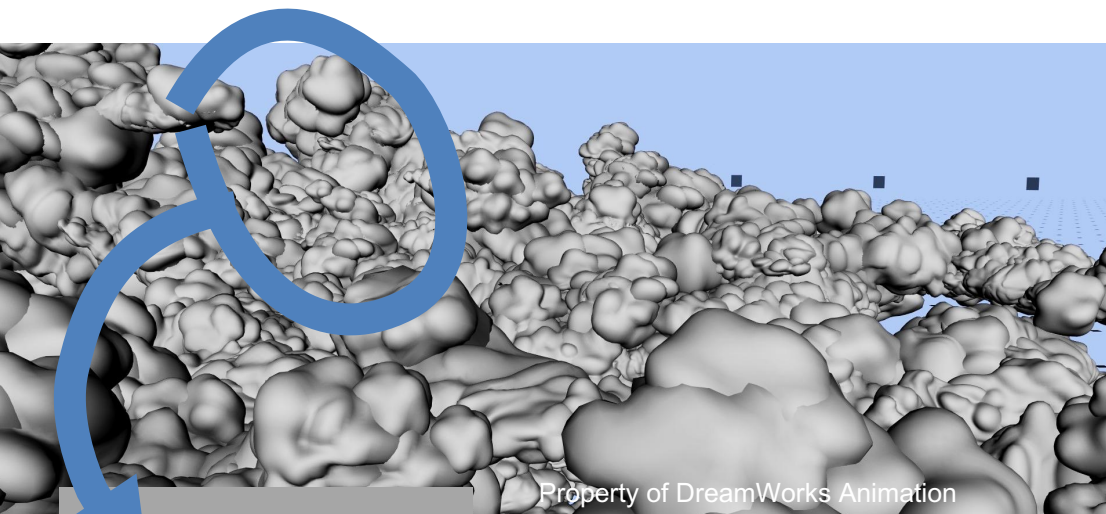


Lee, D. How to Train for Cloud. Siggraph Asia Course, 2020

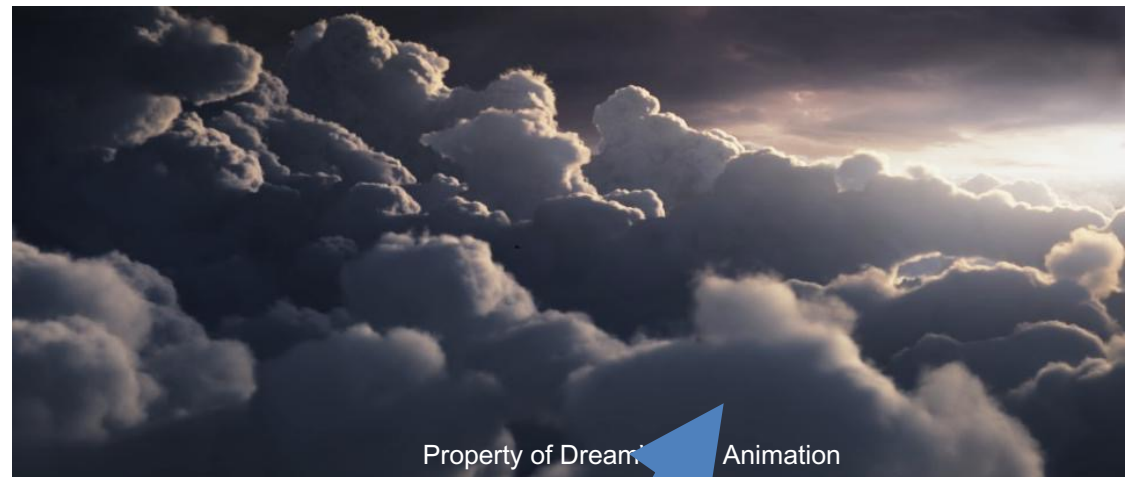
Miller, B., Museth, K., Penney, D. and Bin Zafar, N. Cloud modeling and rendering. Siggraph Talk, 2012

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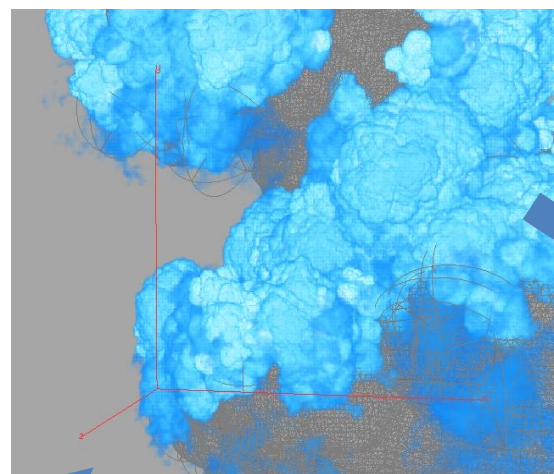
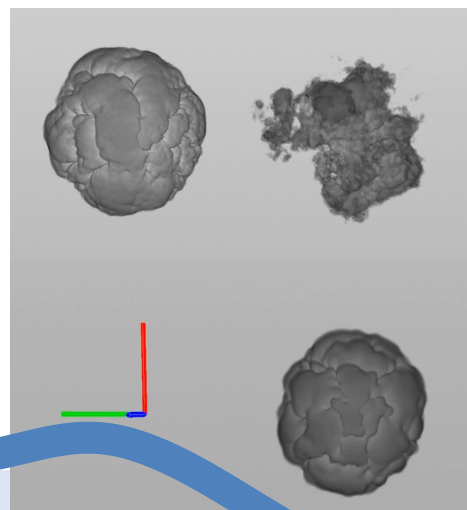
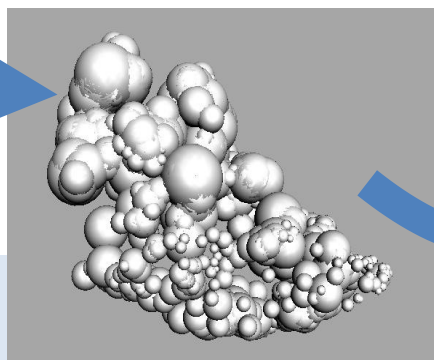
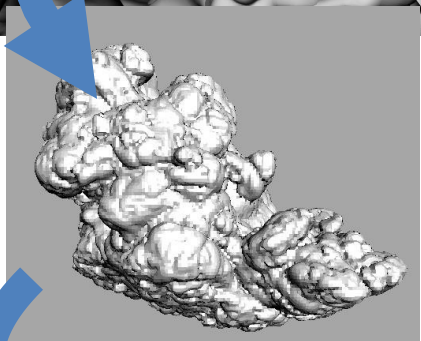
→ RASTER PRIMITIVES



Property of DreamWorks Animation

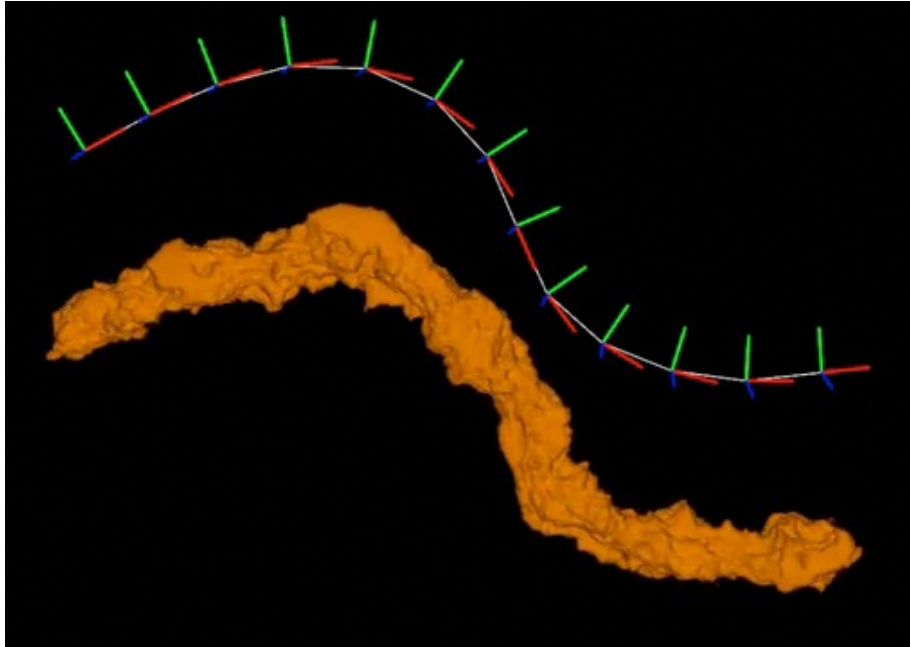


Property of DreamWorks Animation





RASTER PRIMITIVES



Property of DreamWorks Animation



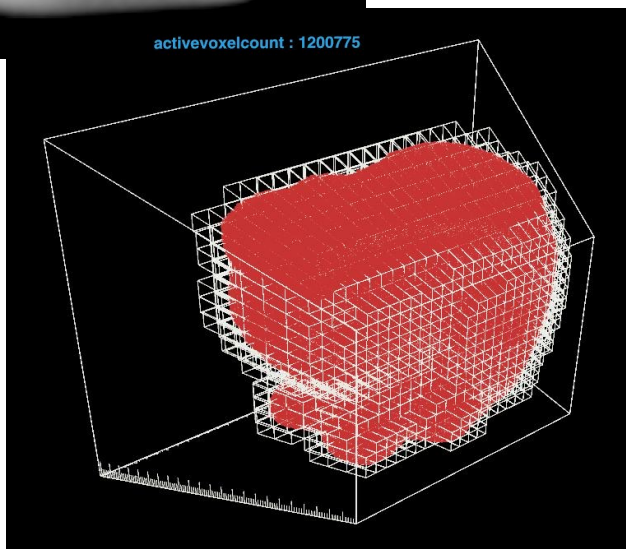
FRUSTUM GRIDS



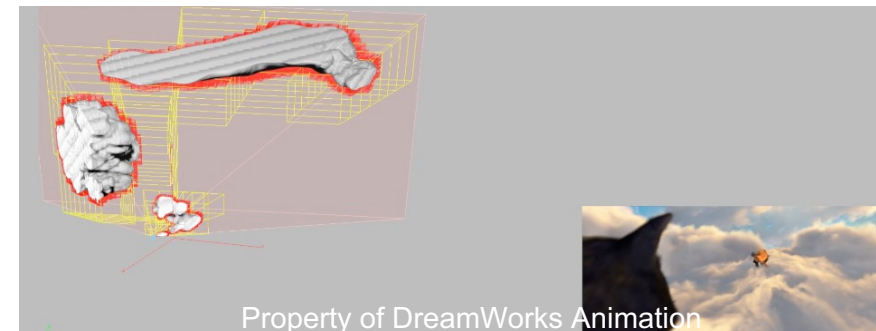
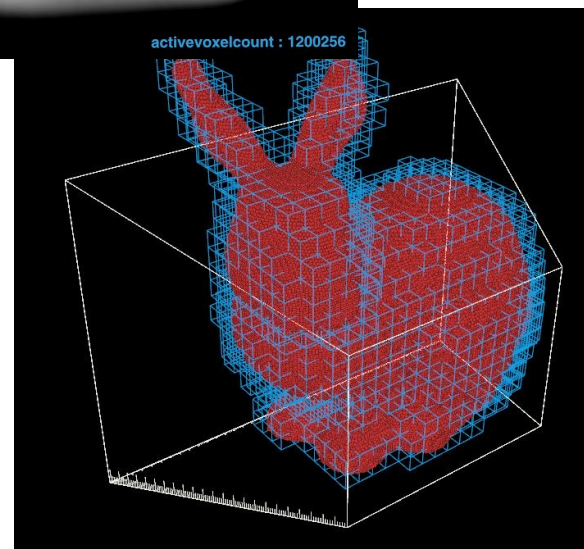
grid type comparison (same voxel count)



frustum grid



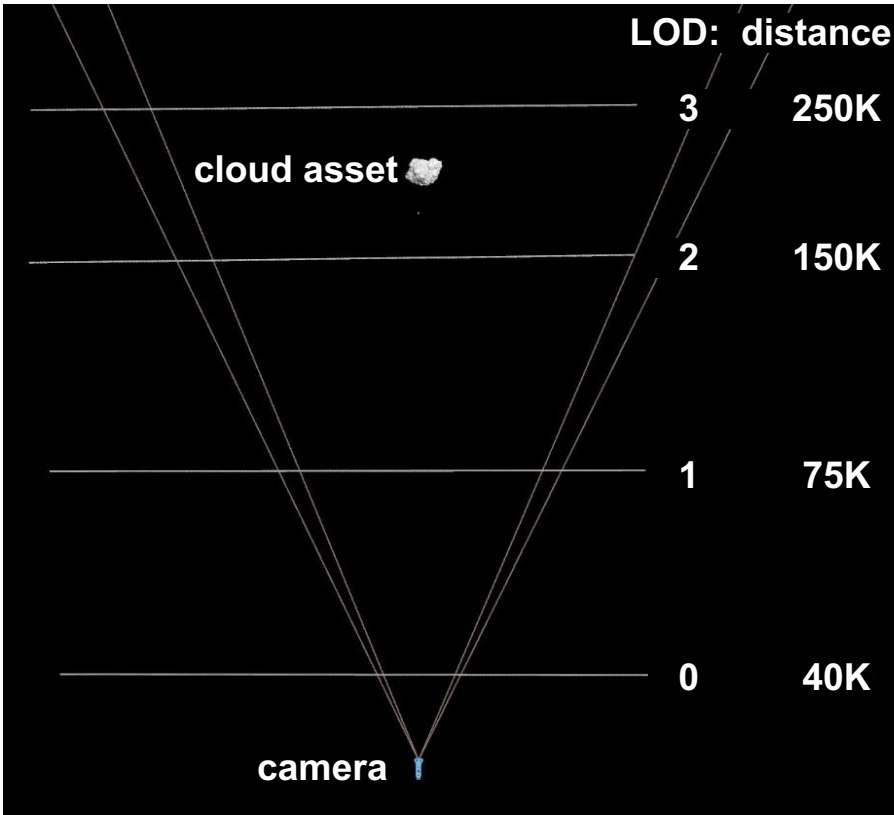
ortho grid



- resolution near camera:
0.28 (frustum) : 0.45 (ortho)
- 17% ortho voxels not visible



LEVEL OF DETAIL



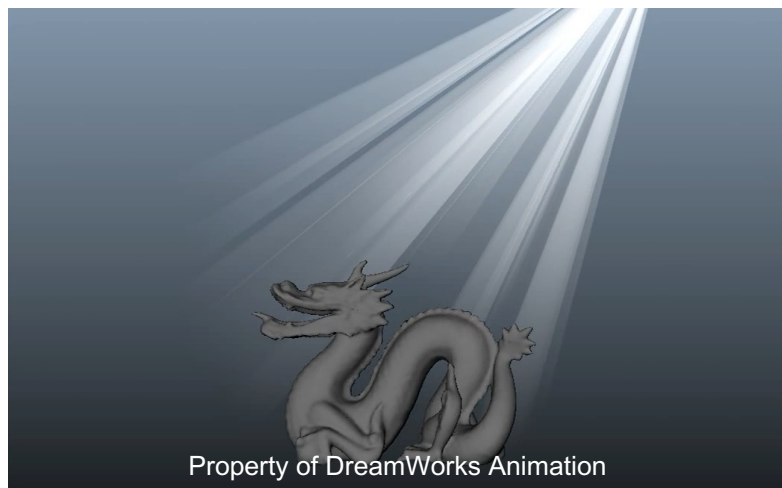
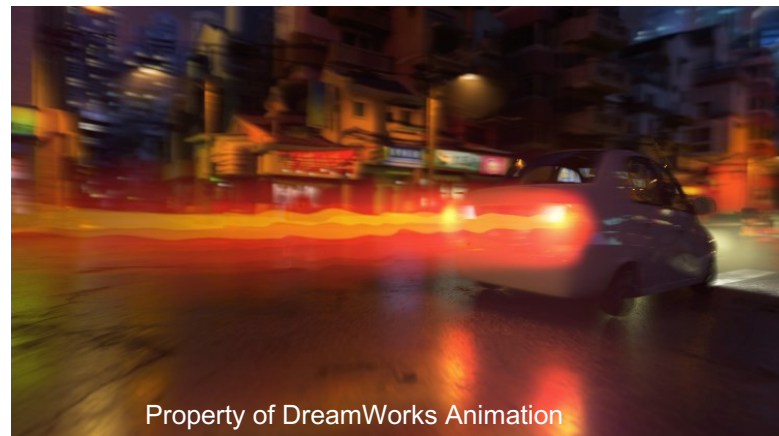
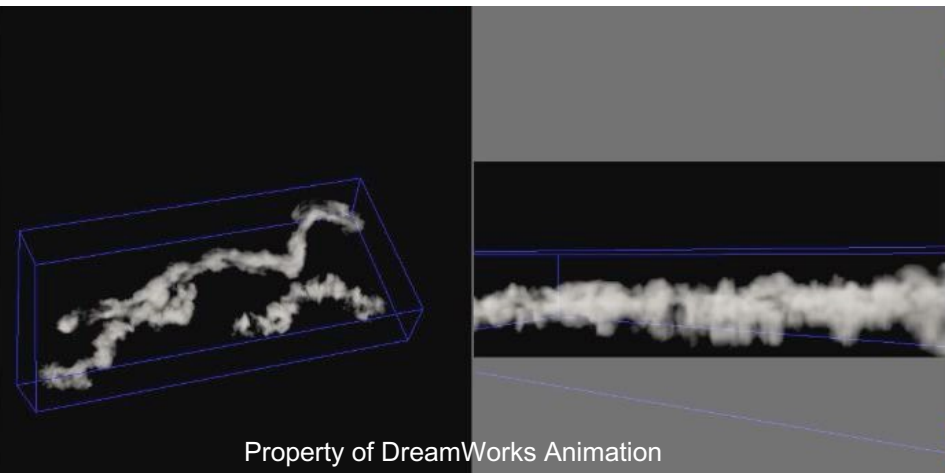
LOD	Voxels	Disk	Render memory	Render cost (relative to LOD0)
3	30 K	197 KB	0.6 KB	0.24
2	4 M	13 MB	0.8 MB	0.42
1	30 M	102 MB	1.0 MB	0.58
0	138 M	464 MB	2.5 MB	1.00



Property of DreamWorks Animation



ATMOSPHERE TOOLS

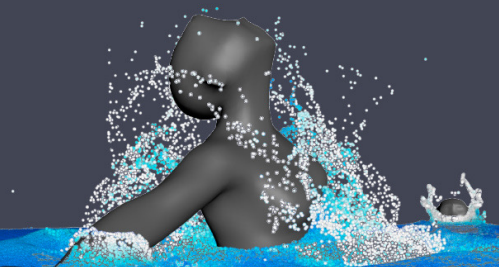




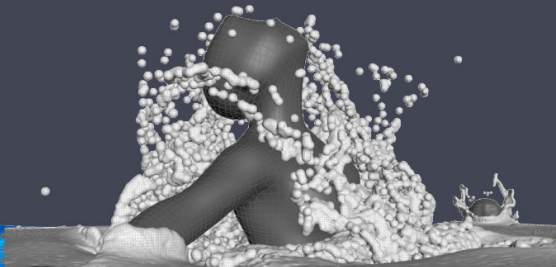
LEVEL SET FILTERING & MORPHOLOGICAL OPS



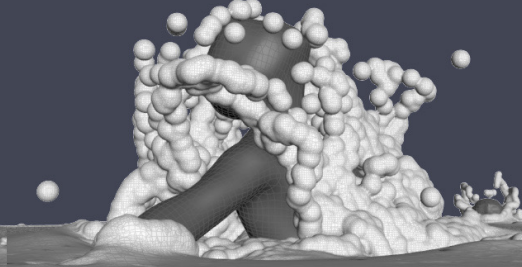
1 - Particles



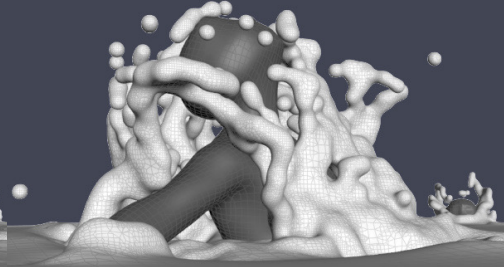
2 - VDB levelset



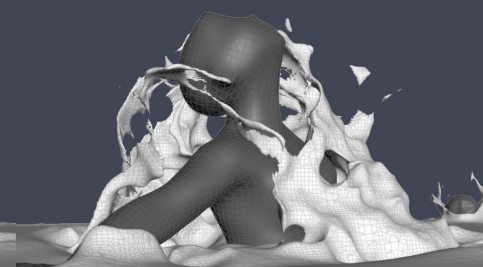
3 - dilation filter



4 - smooth filter



5 - erosion filter



Property of DreamWorks Animation

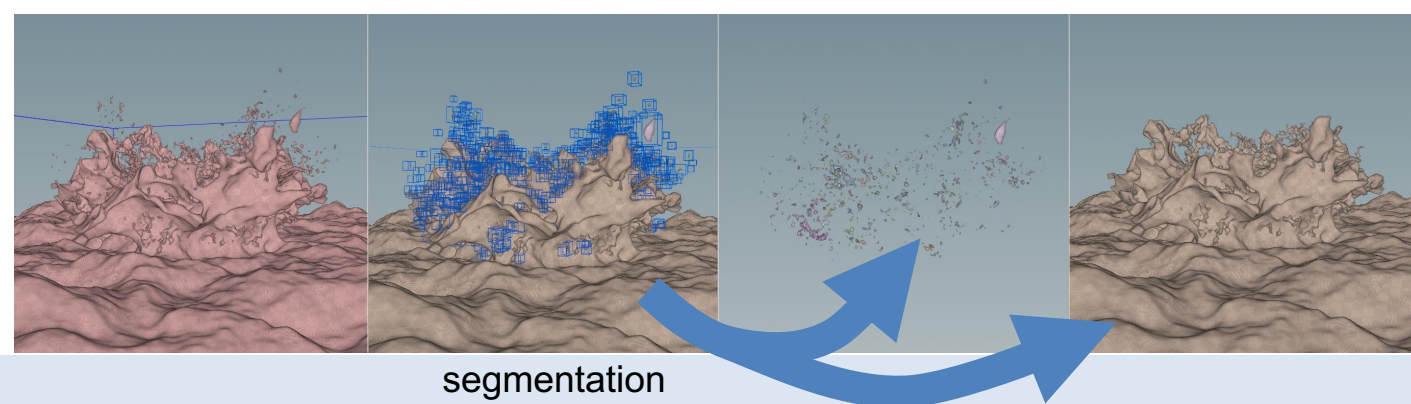
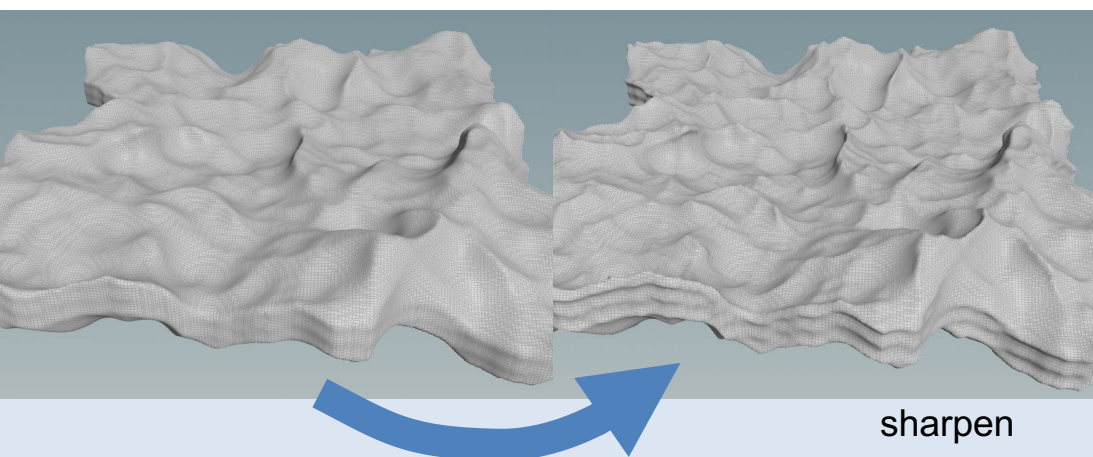
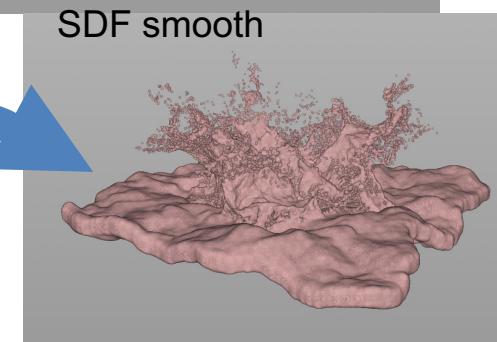
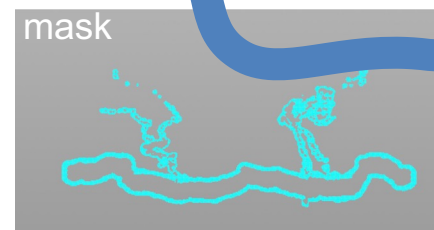
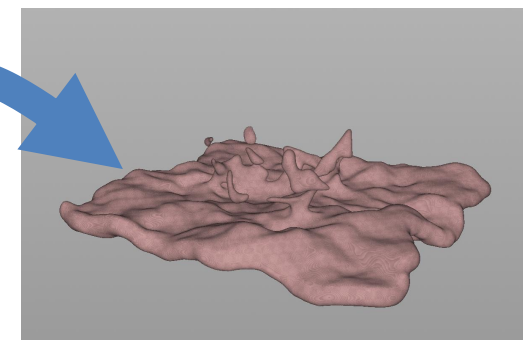
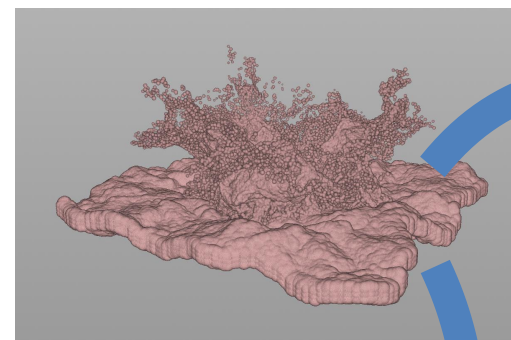
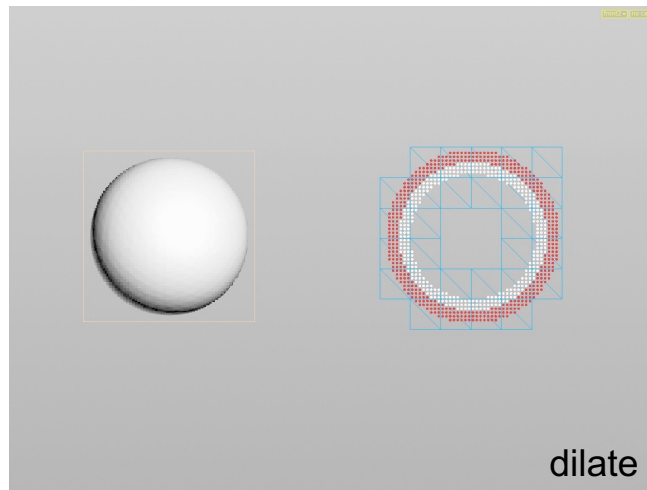
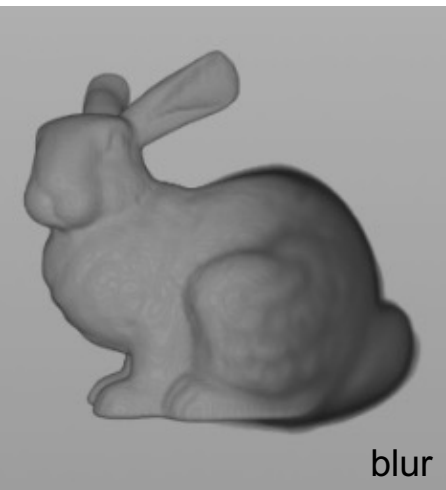
Budsberg, J., Losure, M., Museth, K., Baer, M. Liquids in The Croods. DigiPro, 2013

Van Opstal, B., Janin, L., Museth, K. Large Scale Simulation of Water and Ice in Dragon 2, Siggraph Talk, 2014

Losure, M. Surreal Night Swimming in Home. Siggraph Dailies, 2015

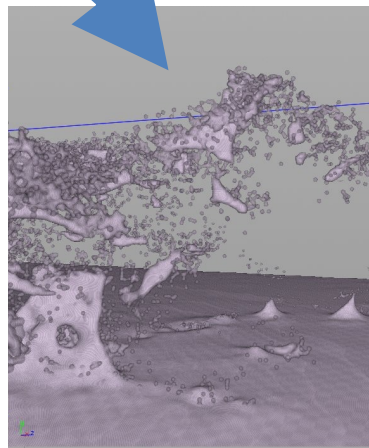
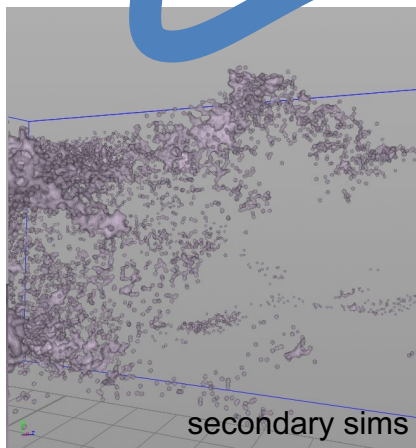
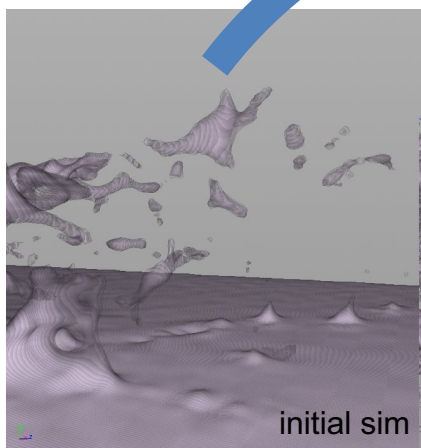
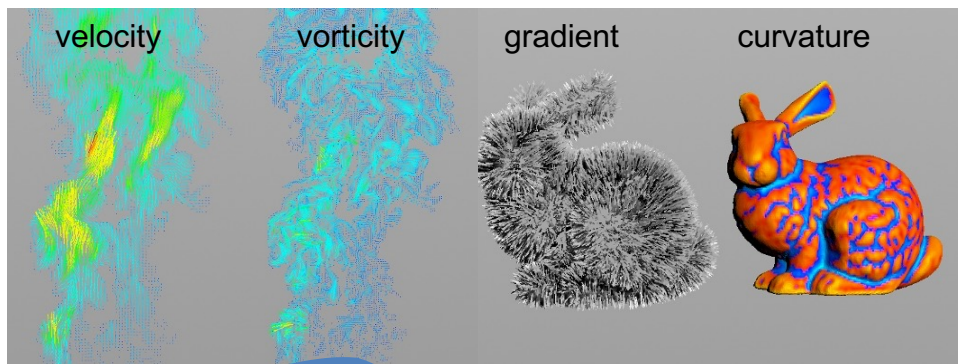
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→ FILTERING & MORPHOLOGICAL OPS



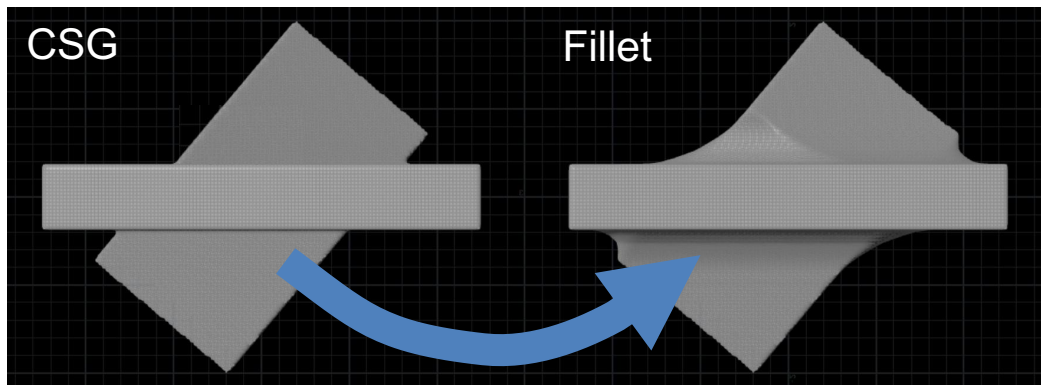


GRID ANALYSIS





LEVEL SET FILLET



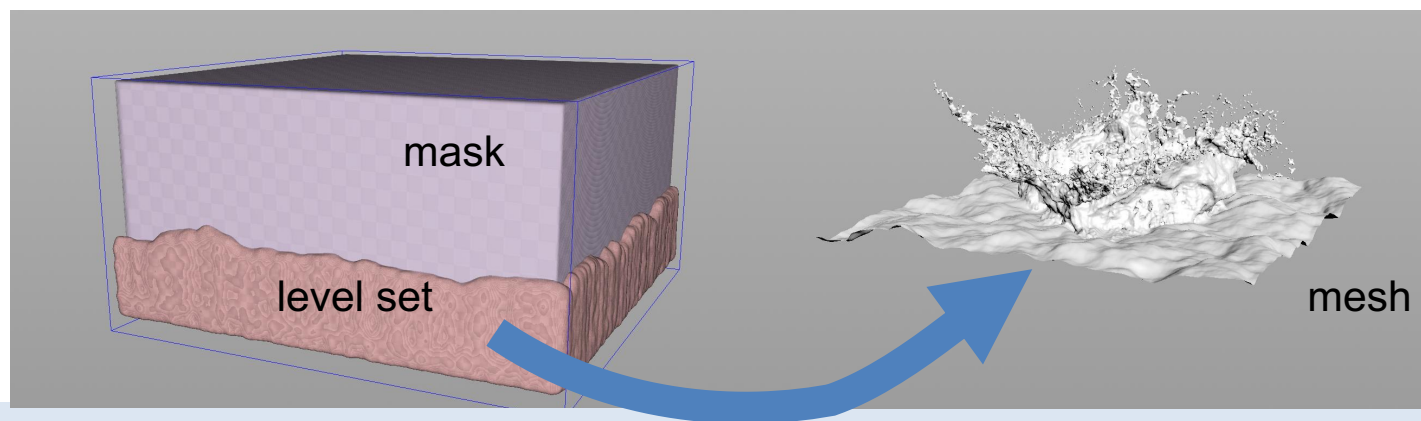
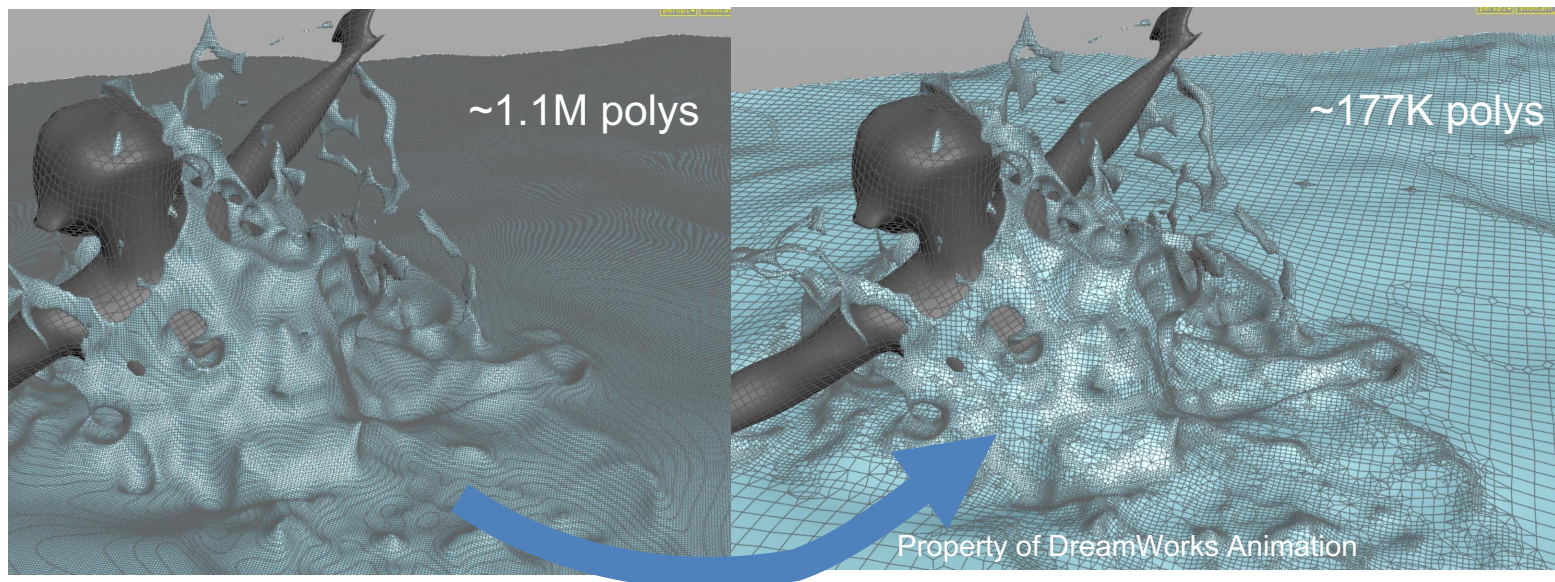
Property of DreamWorks Animation



Property of DreamWorks Animation

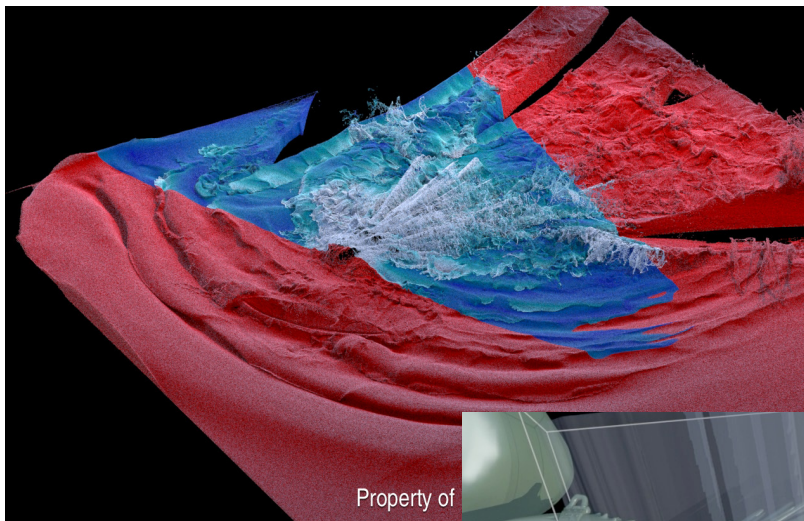


SIMPLIFICATION MASKS

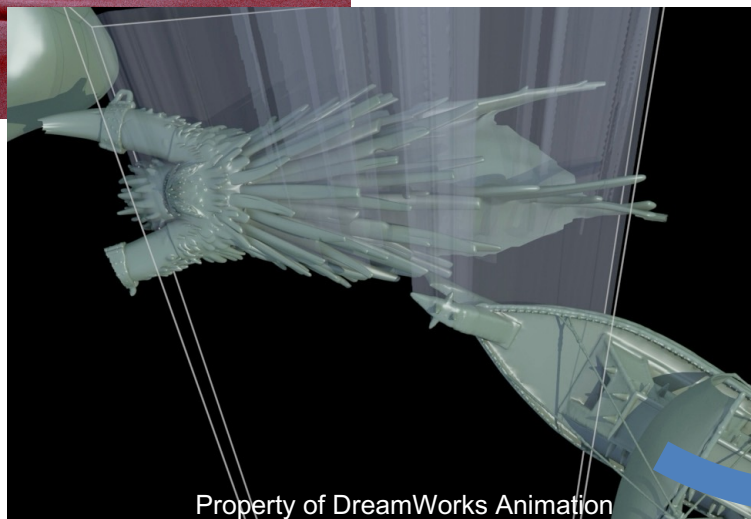




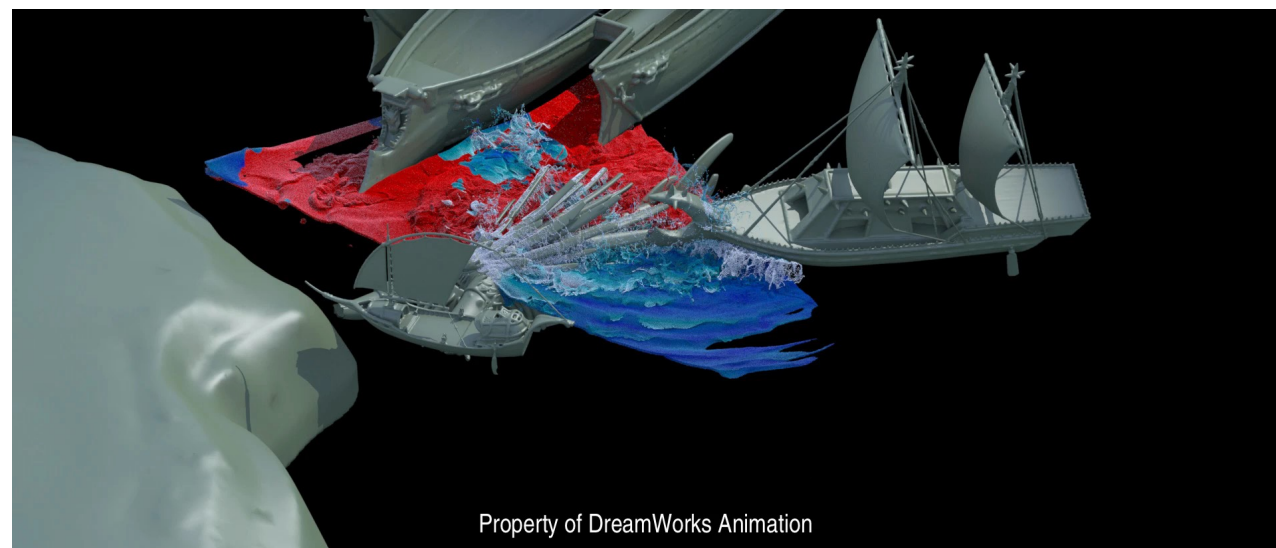
SIMPLIFICATION MASKS



Property of



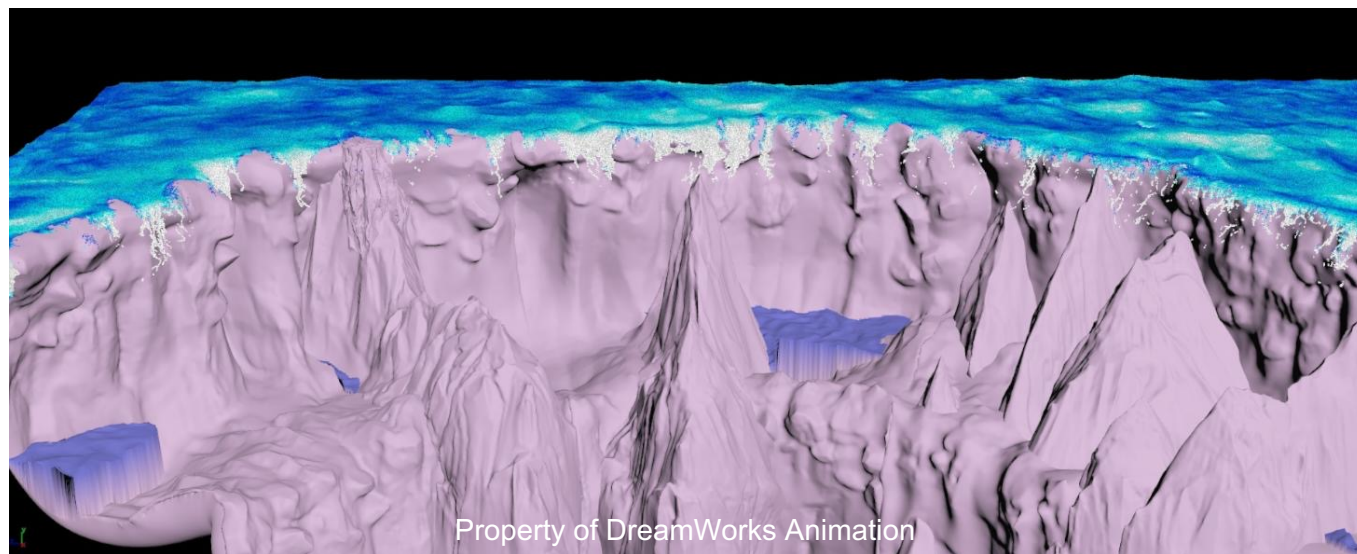
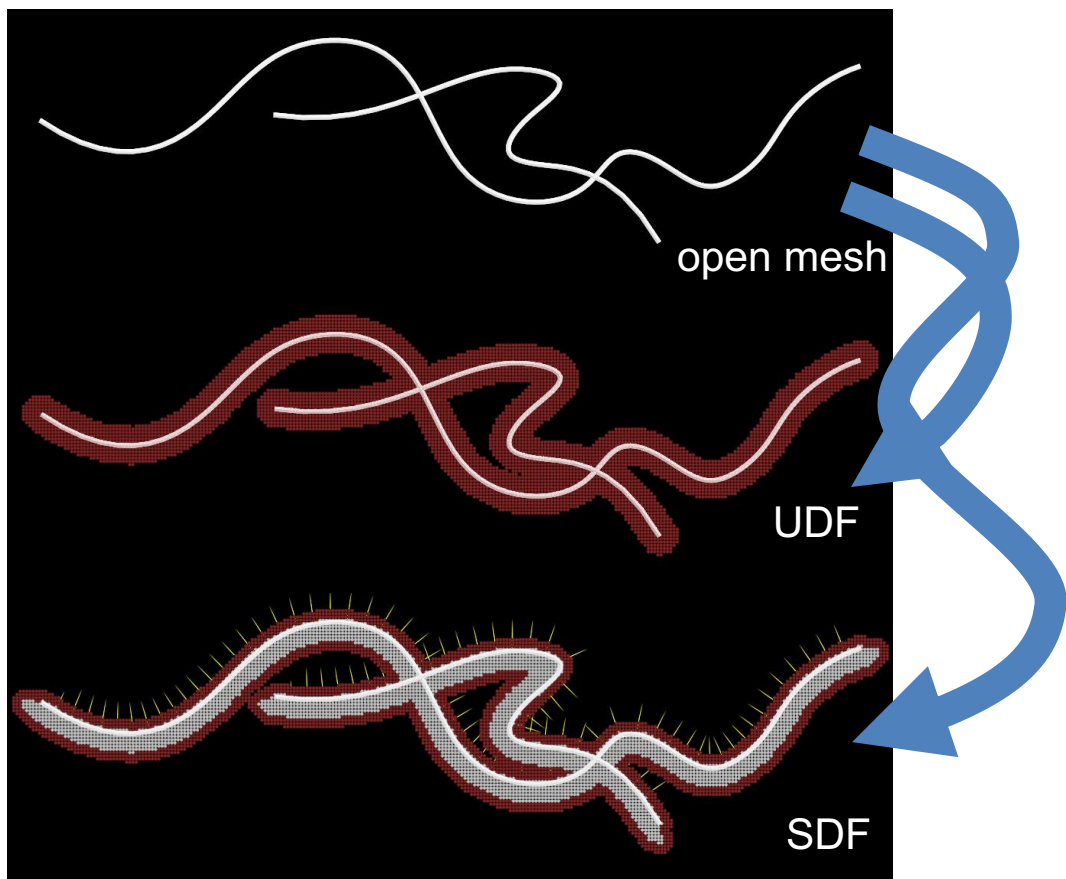
Property of DreamWorks Animation



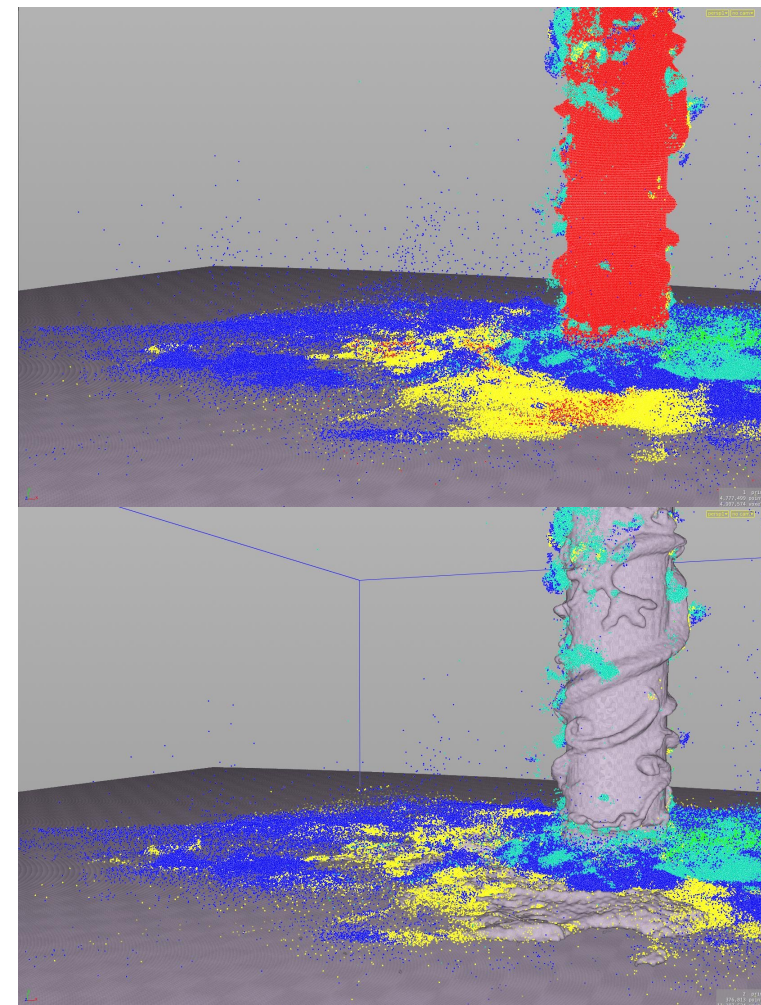
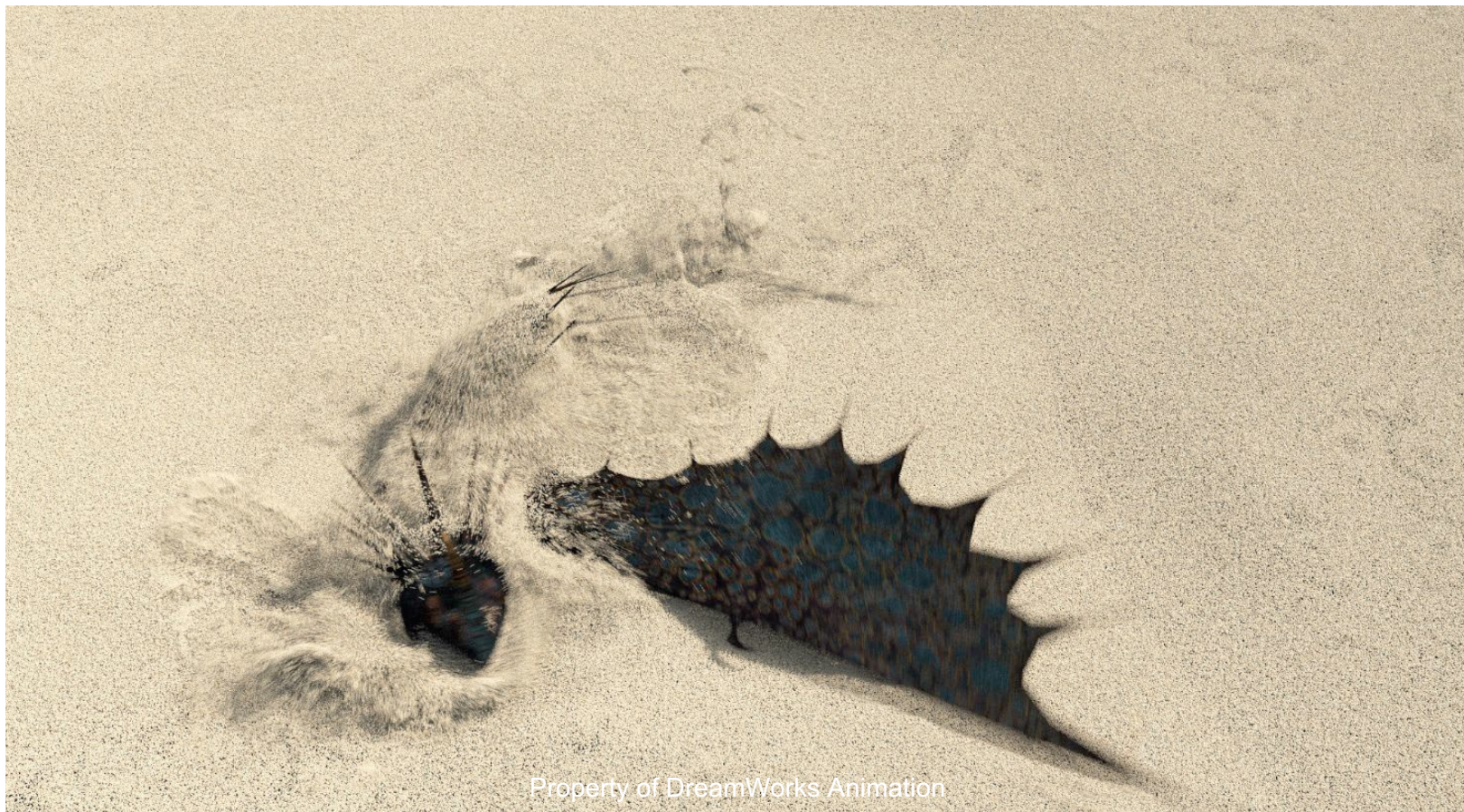
Property of DreamWorks Animation



OPEN MESH COLLISIONS

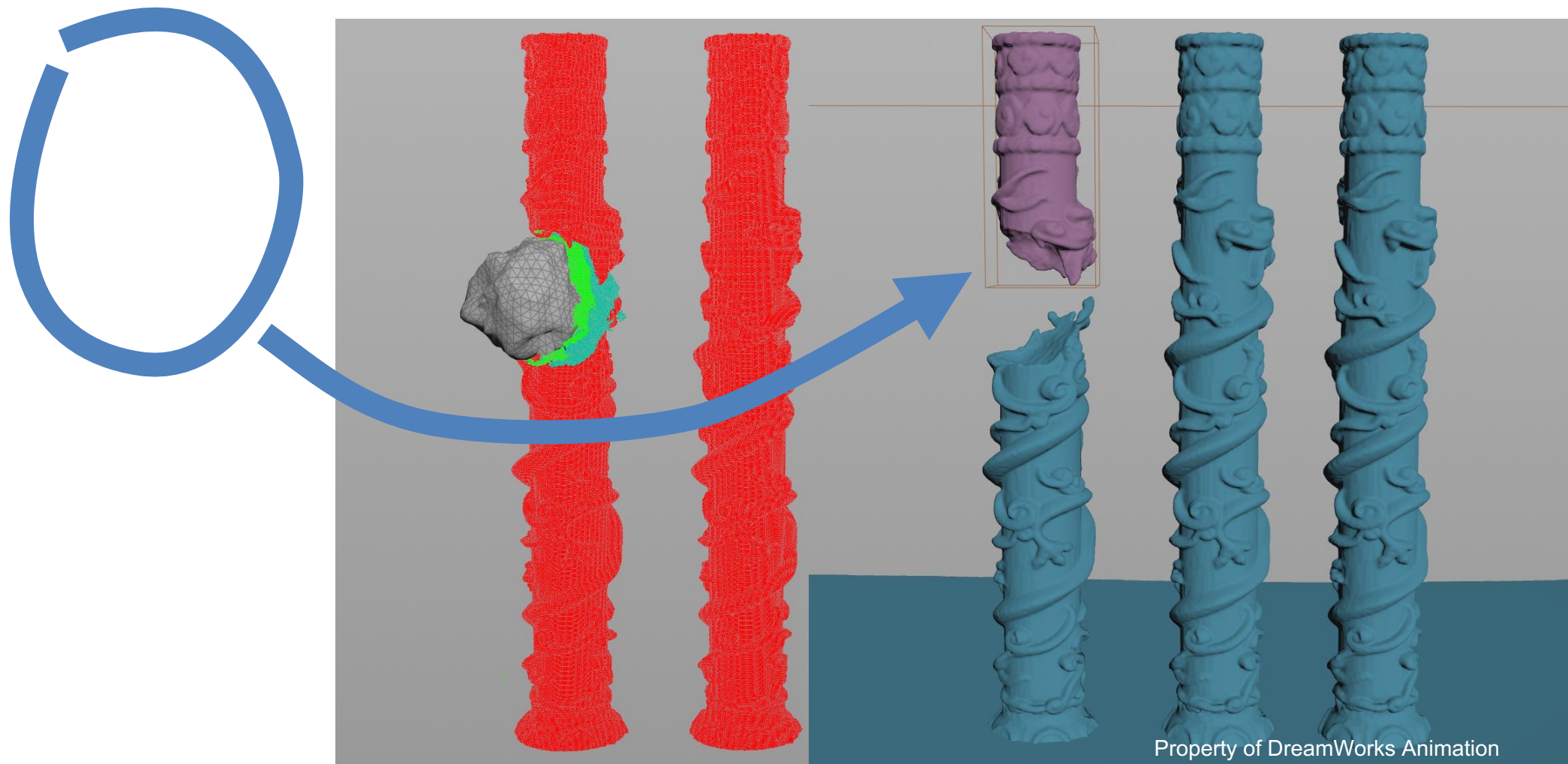


→ COMPLEXITY



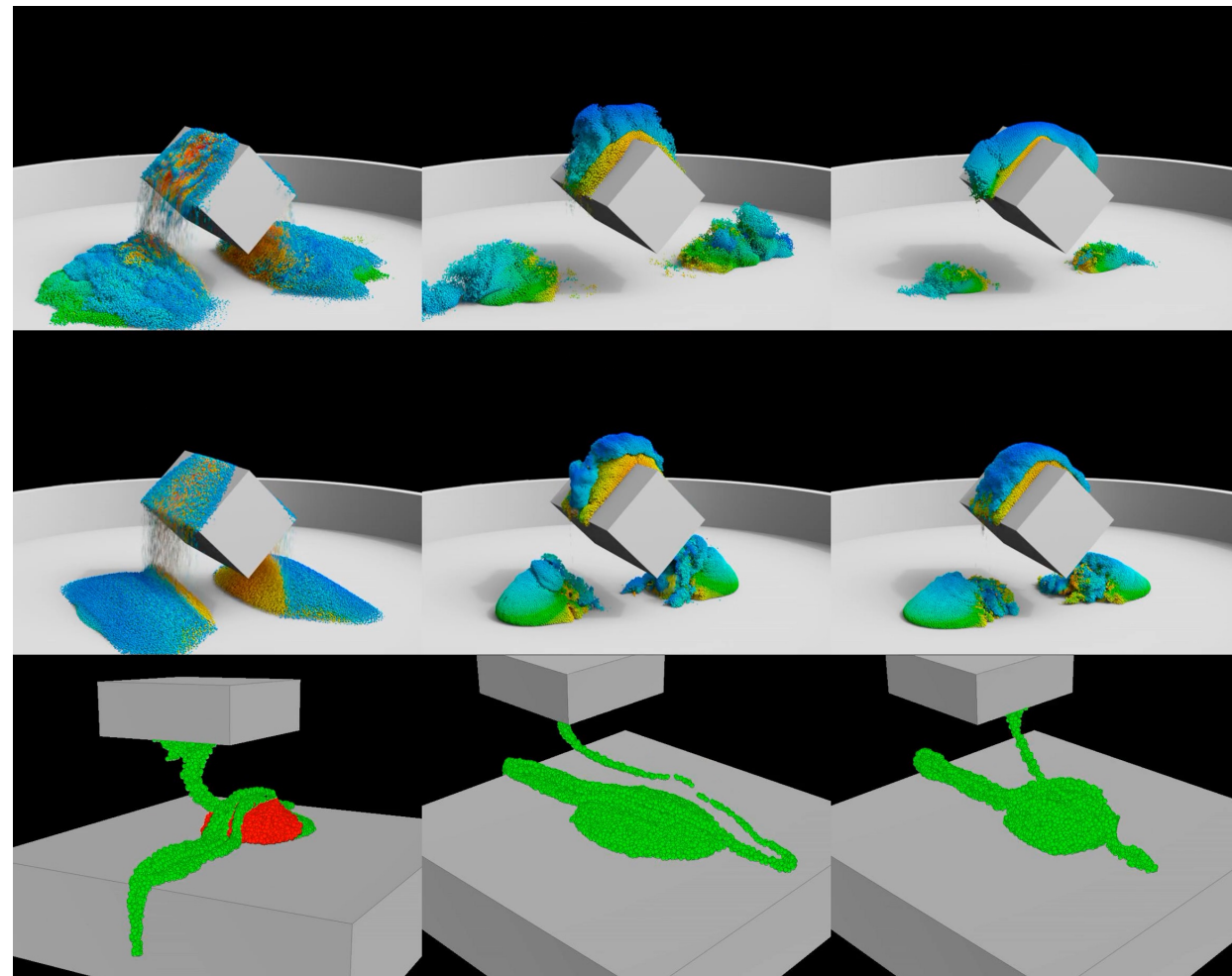


GRID ANALYSIS



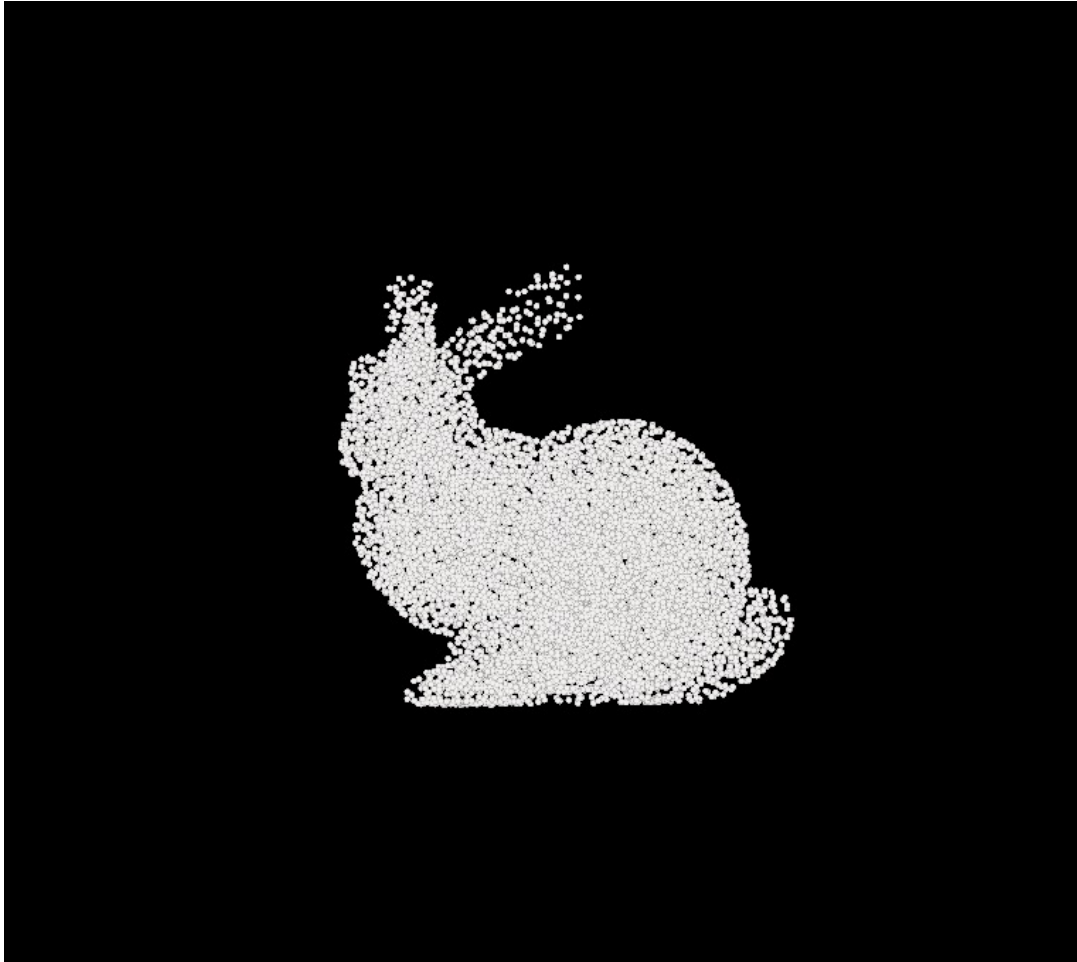


MATERIAL POINT METHOD



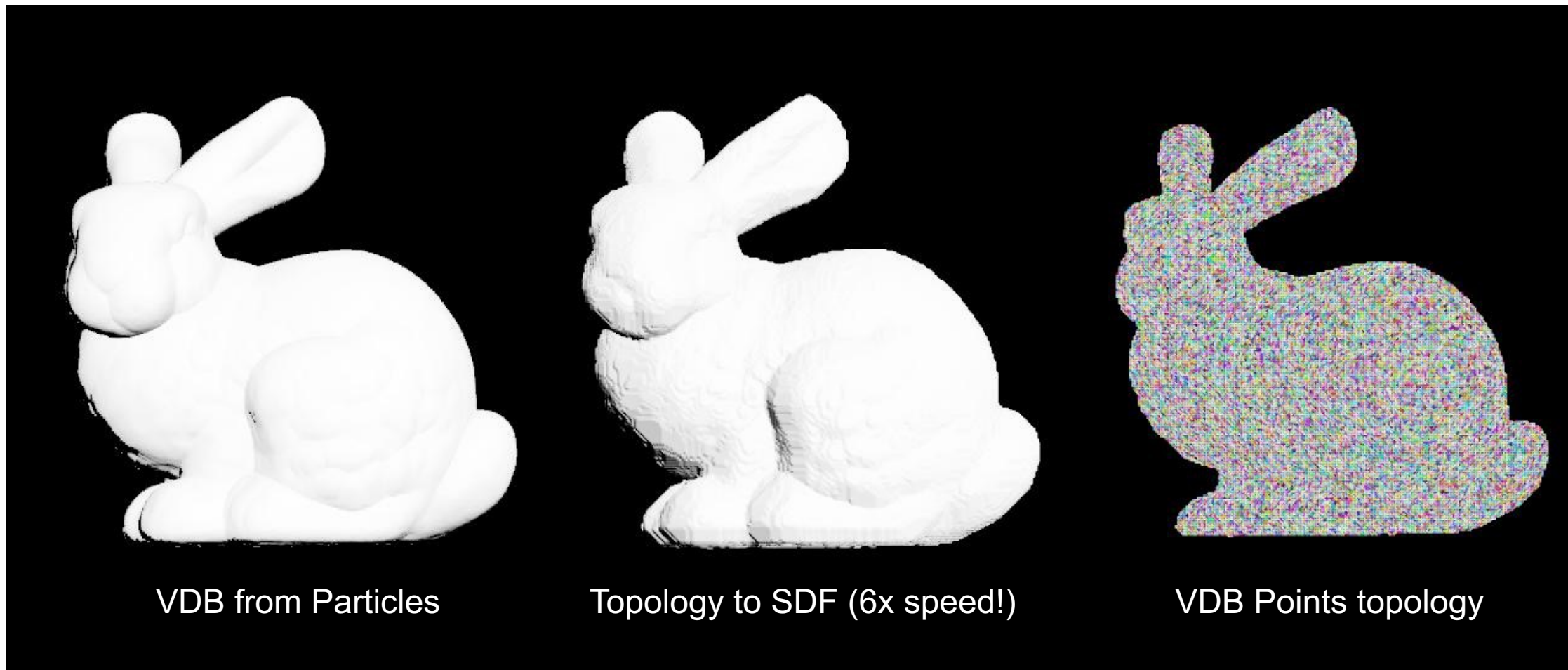


VDB POINTS



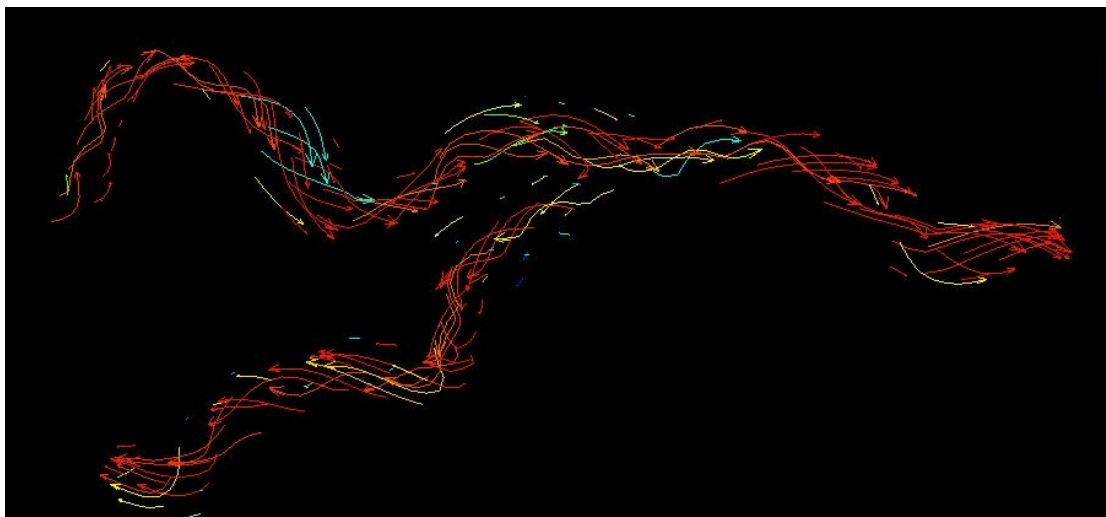
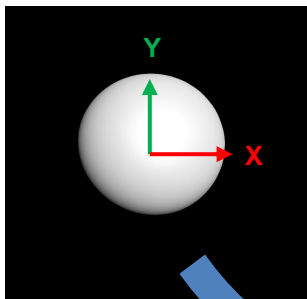
example: 1 M points

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bgeo.sc	23 MB	P, v, N (16 bit) Cd (8 bit)
abc	45 MB	
usdc	46 MB	
vdb	25 MB	
vdb	16 MB	P (8 bit fix) v (16 bit trunc) Cd (8 bit unit) N (unit)





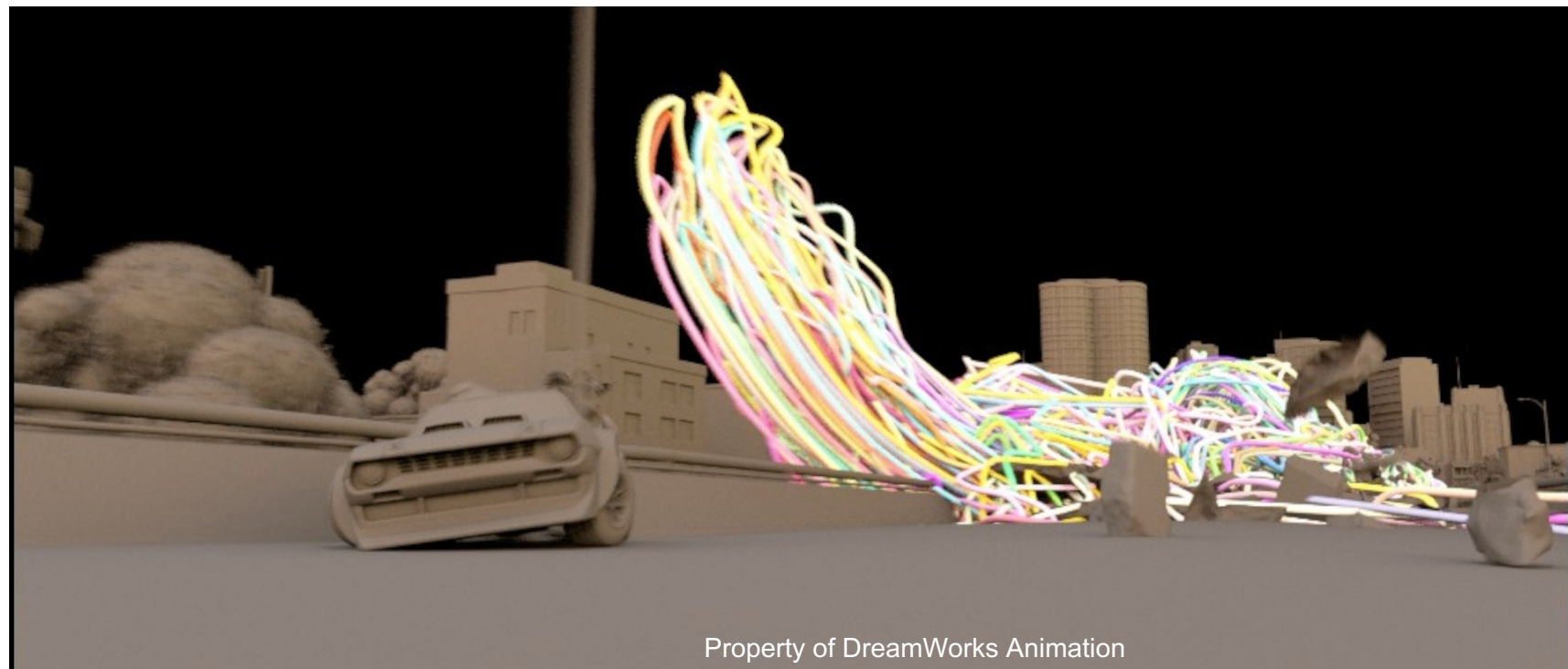
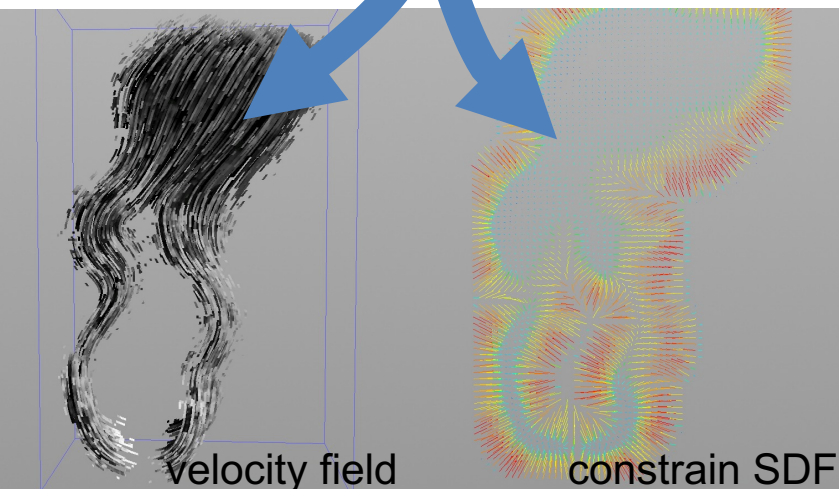
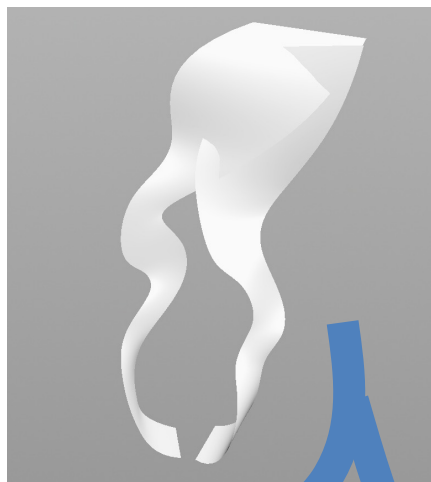
RASTER PRIMITIVES (VECTOR FIELDS)



Property of DreamWorks Animation



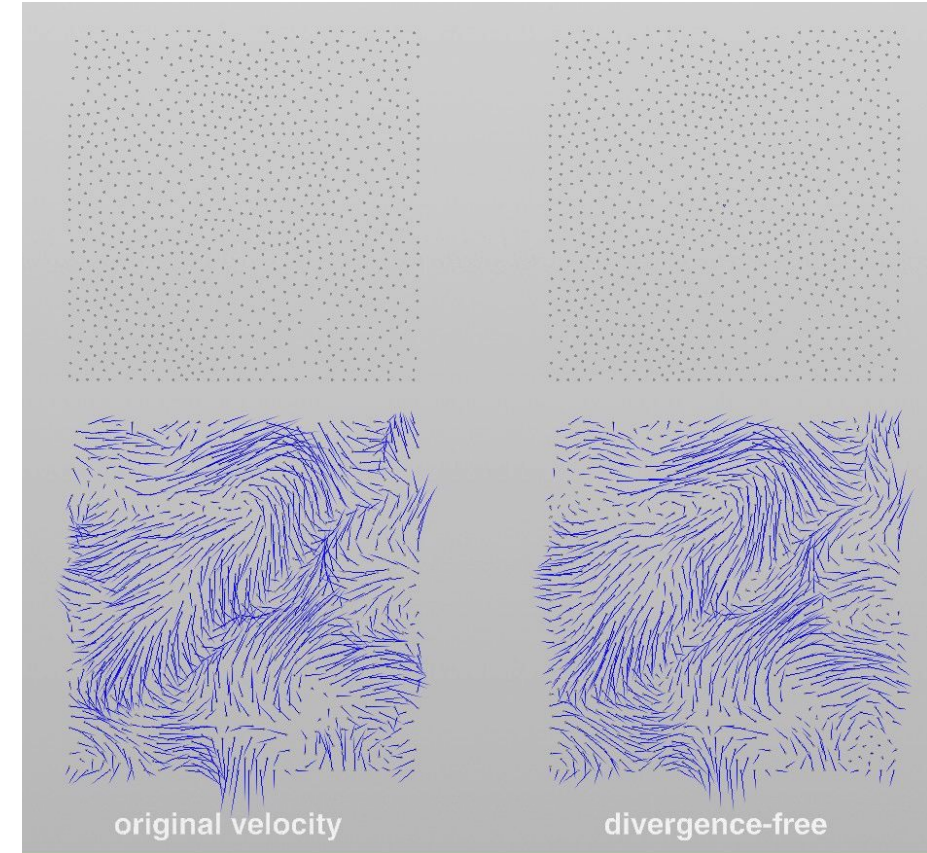
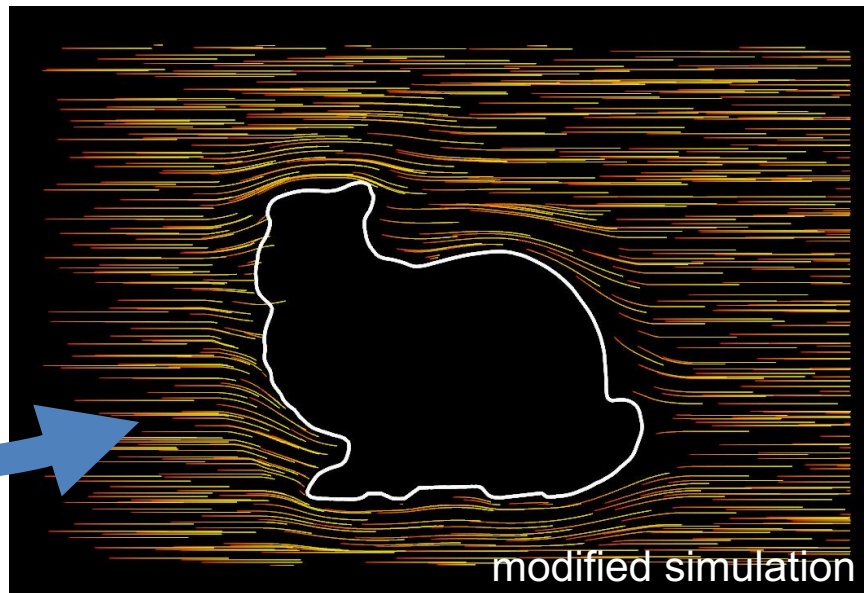
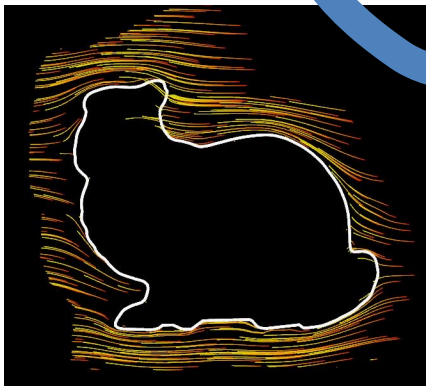
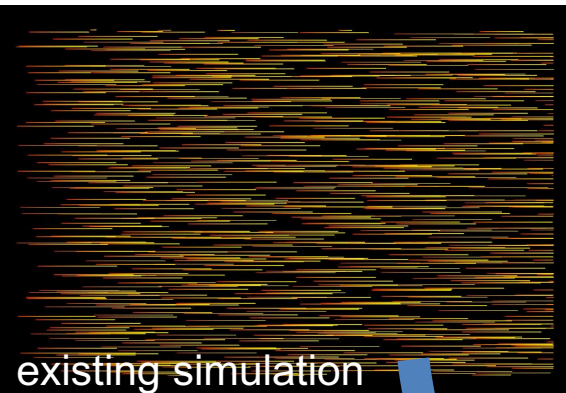
CONSTRAINED ADVECTION



Property of DreamWorks Animation



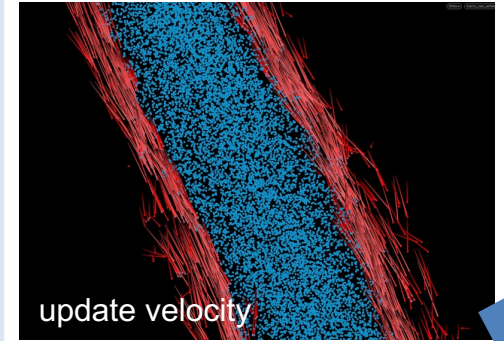
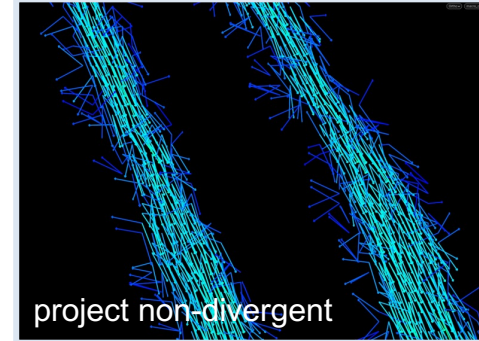
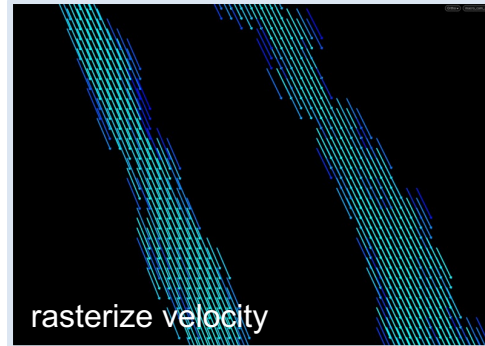
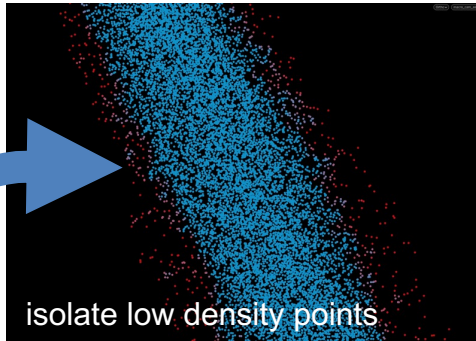
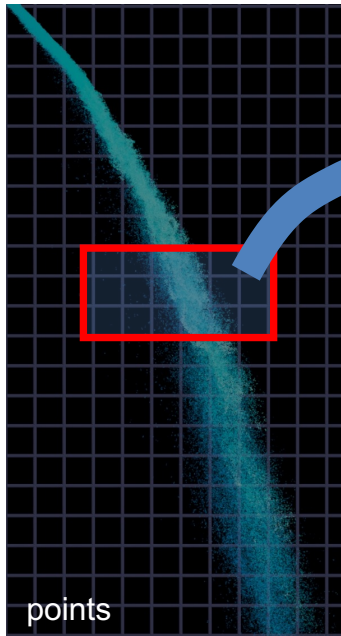
FLOW FIELDS



project non-divergent

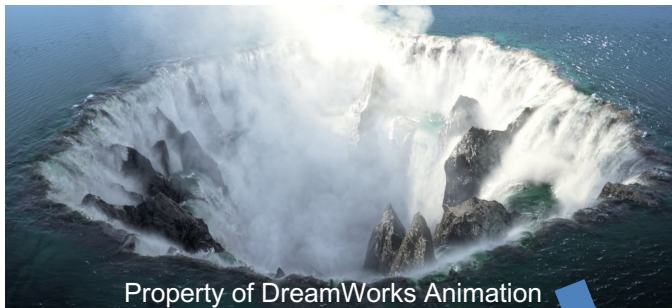


FLOW FIELDS





DISTRIBUTED DATA PROCESSING



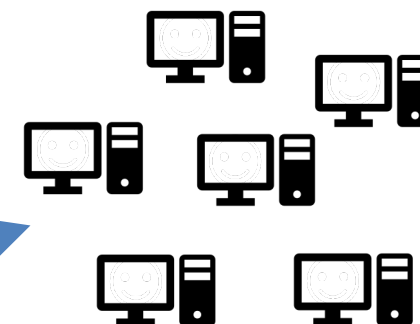
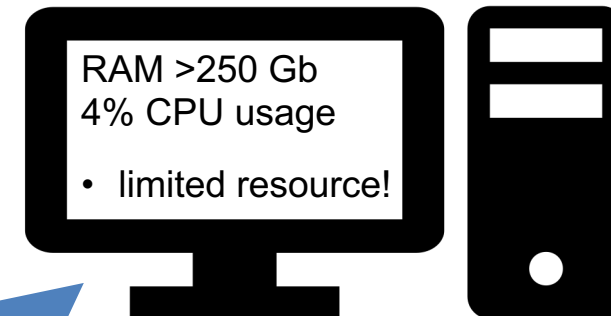
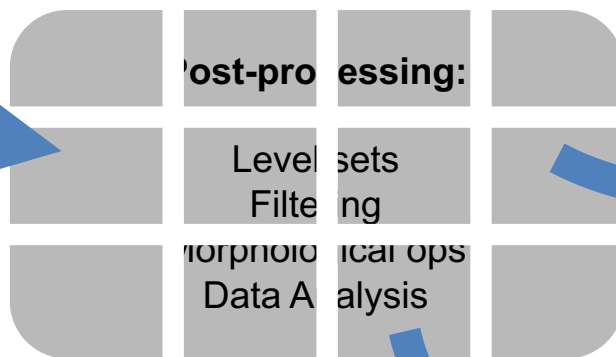
Property of DreamWorks Animation

Billions of simulated points



Property of DreamWorks Animation

Hundreds of waterfalls



Less RAM/CPU
100% CPU usage

- fits on average farm blade
- lots of resources
- faster turnaround



DISTRIBUTED DATA PROCESSING



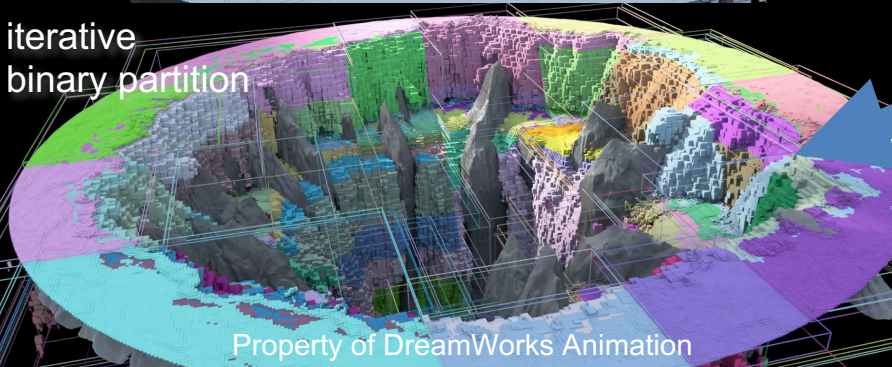
points



uniform partition

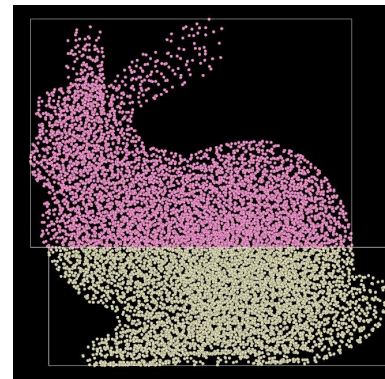


iterative
binary partition



Property of DreamWorks Animation

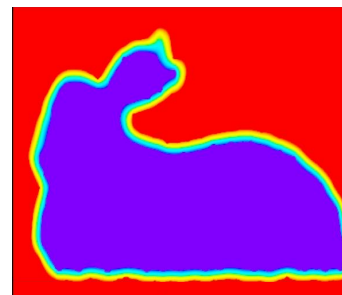
partitioned points



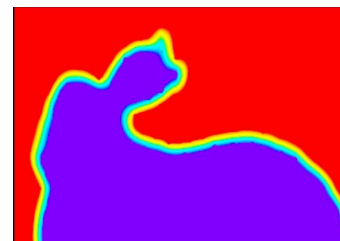
padded read



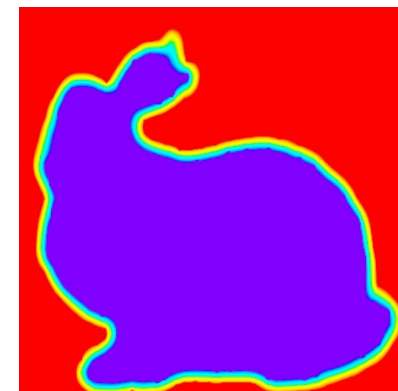
level set + filtering



VDB clip

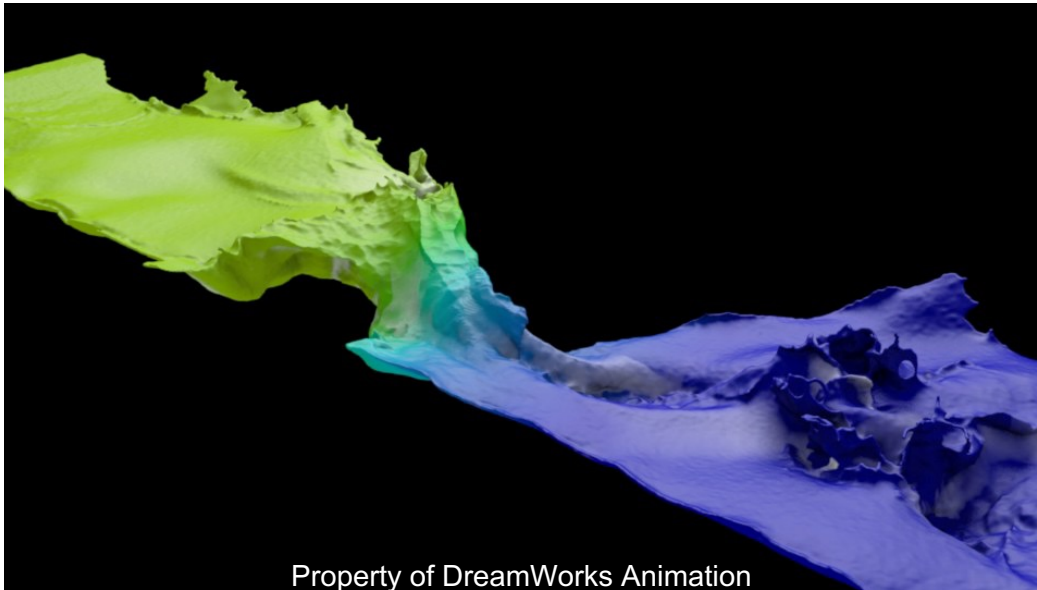


seamless distributed level set



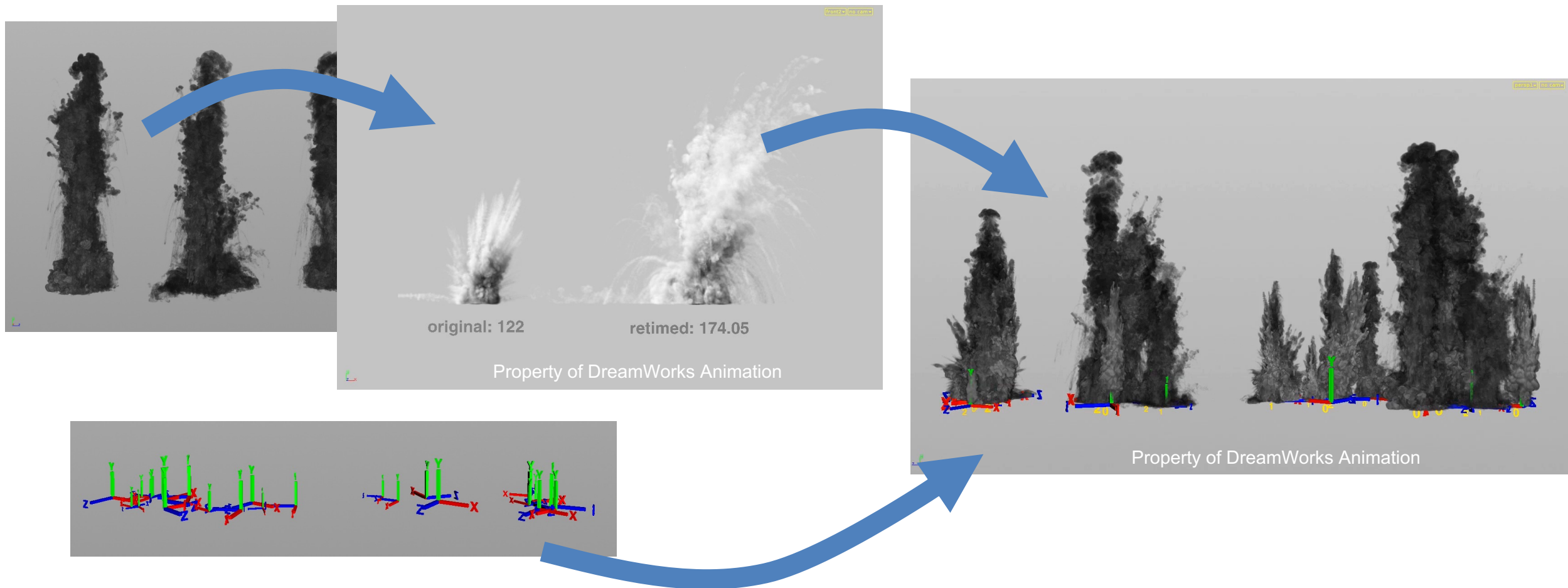


MORPHING



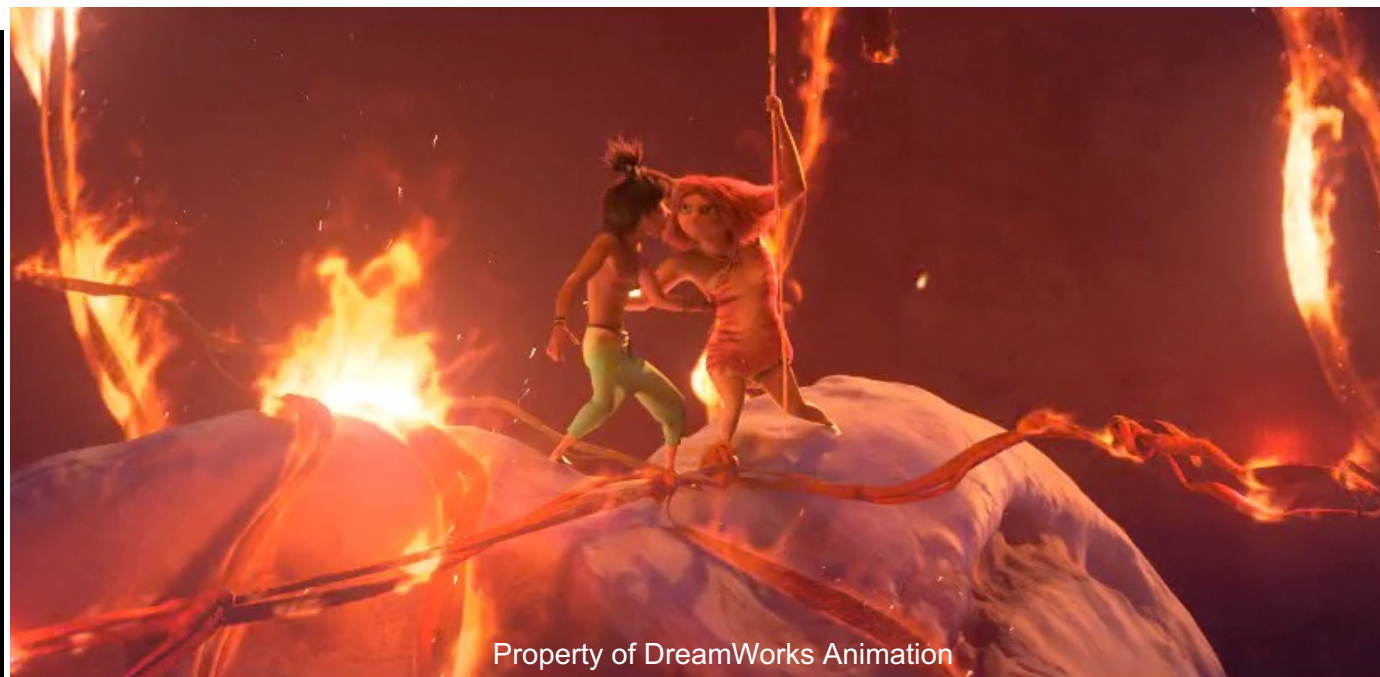
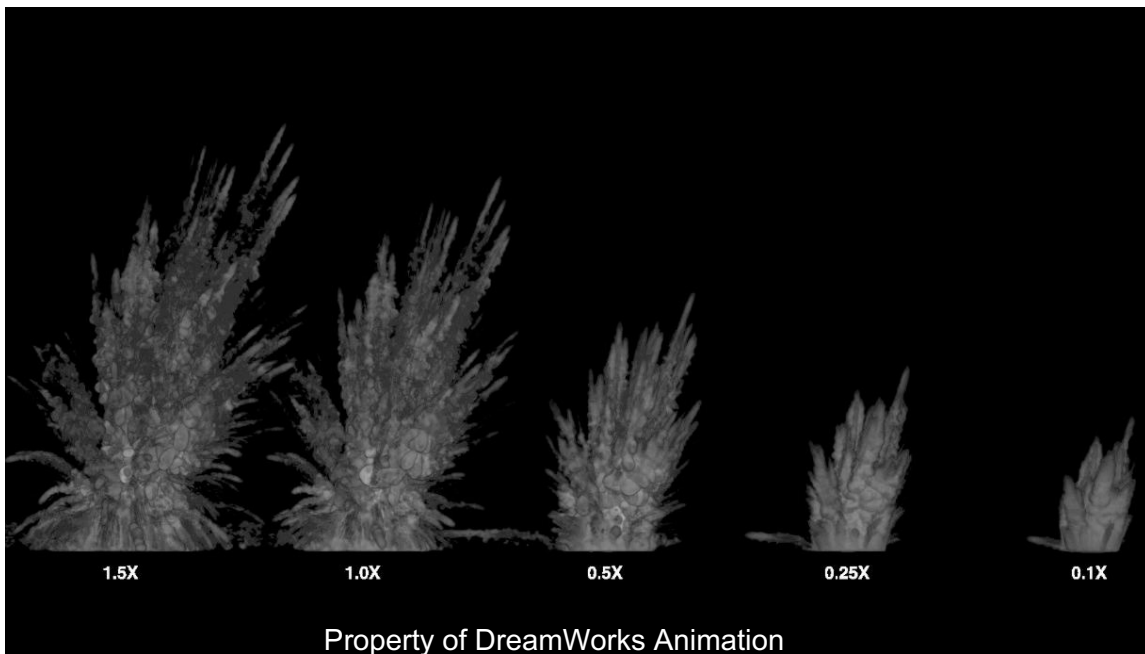
- 5 minute-long river simulation
- art-direct sections independently
- multiple artists iterate simultaneously

→ VOLUME STAMPING



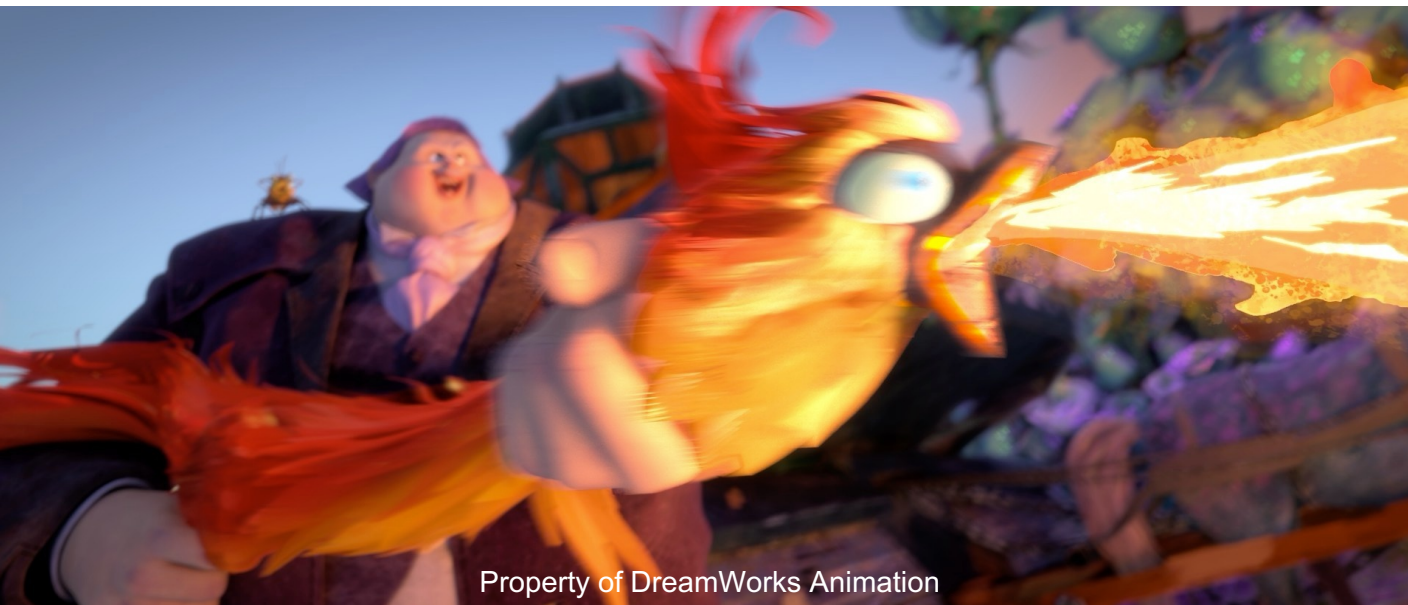


VOLUME RETIMING

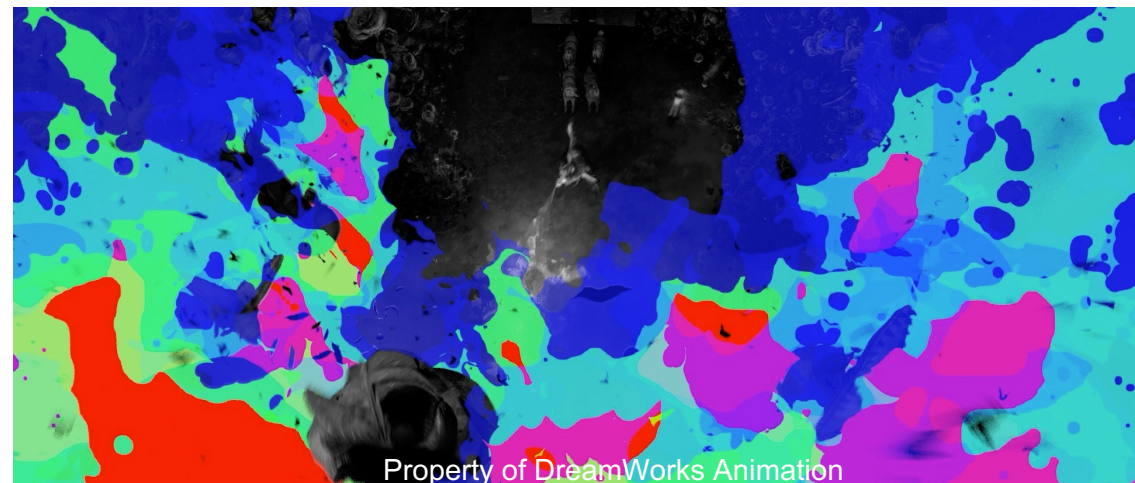




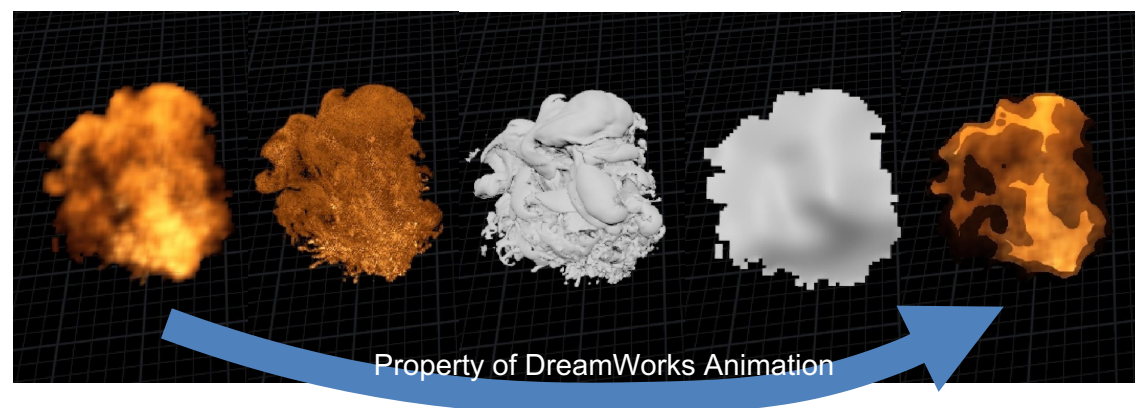
VOLUME STYLIZATION



Property of DreamWorks Animation



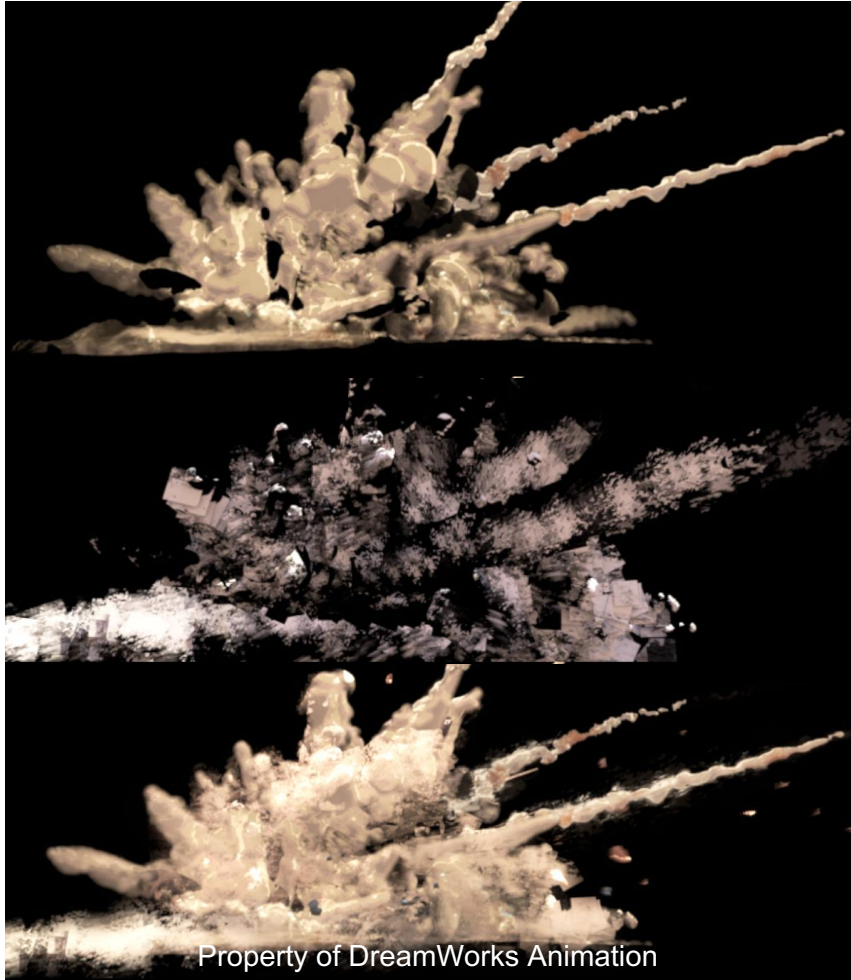
Property of DreamWorks Animation



Property of DreamWorks Animation



VOLUME STYLIZATION



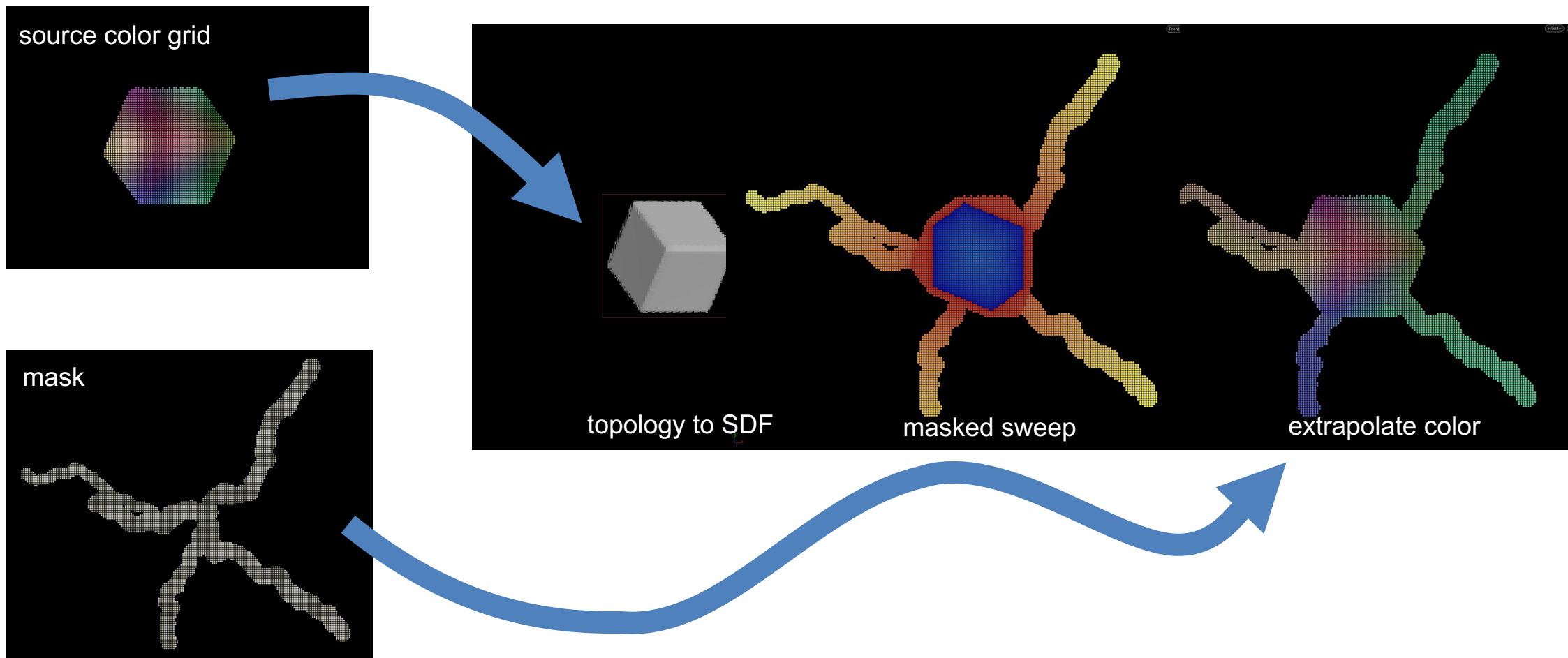
Property of DreamWorks Animation



Property of DreamWorks Animation

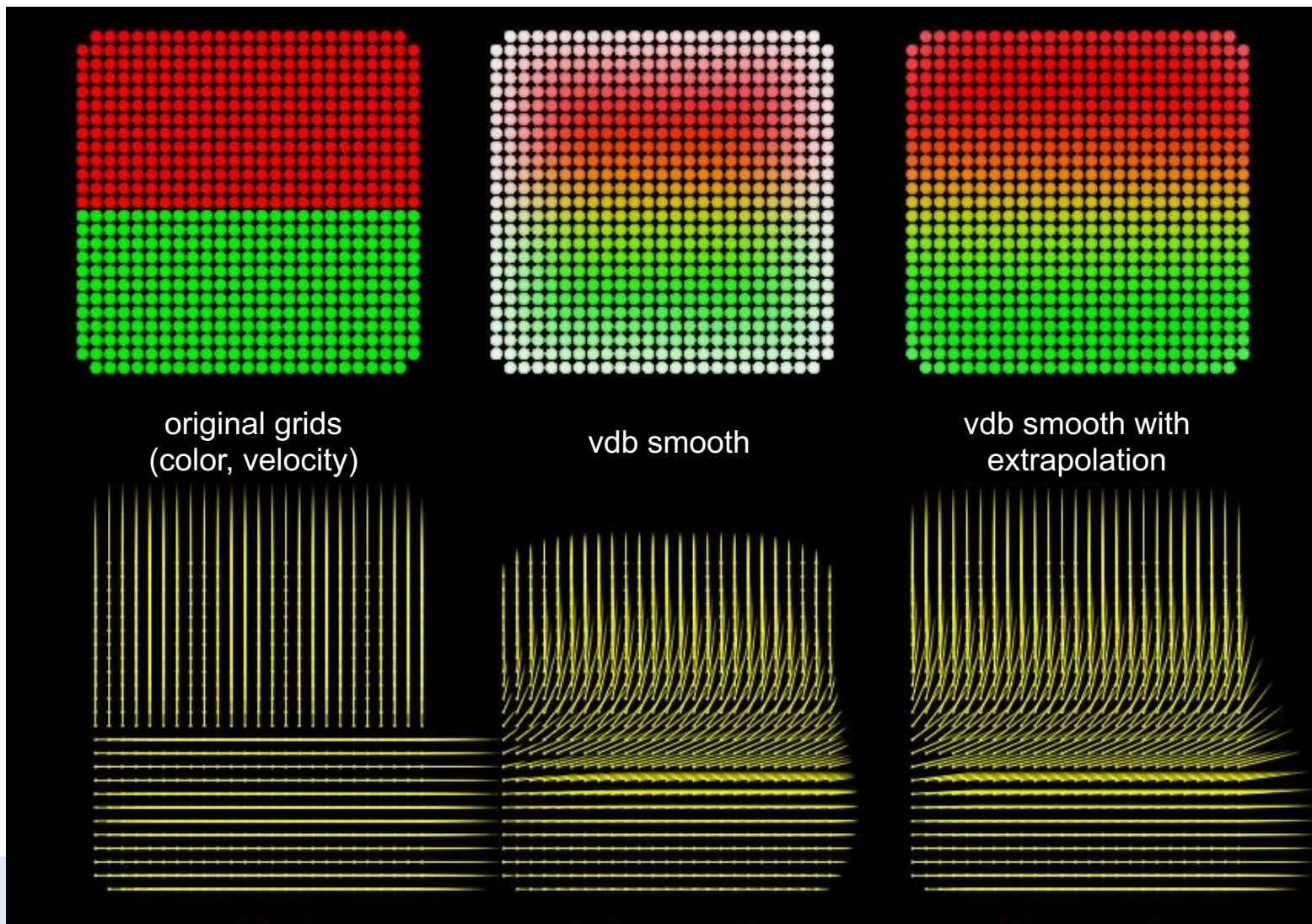


MASKED EXTRAPOLATION



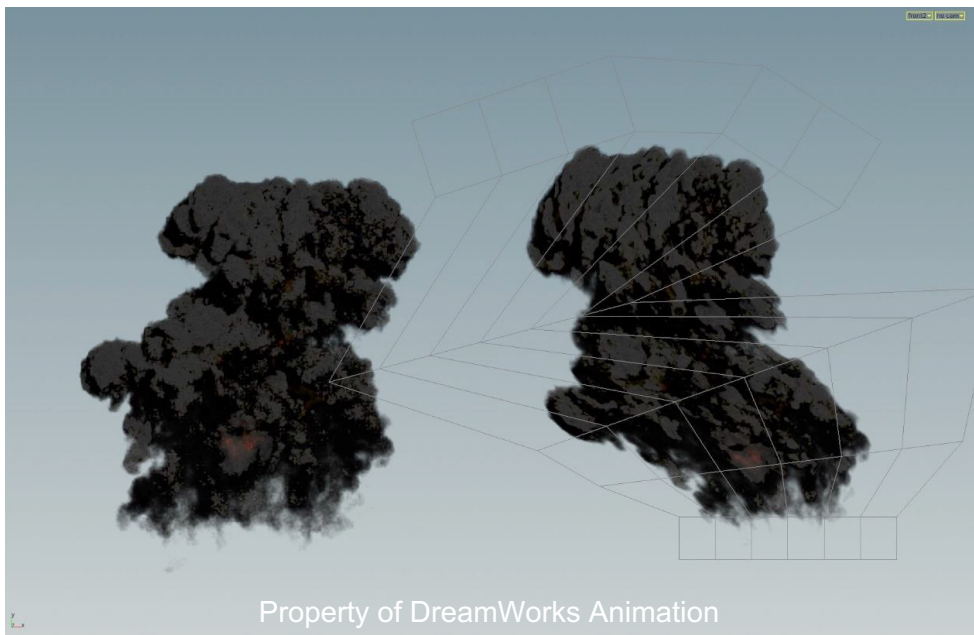


FILTER EXTRAPOLATION





VOLUME DEFORMATION



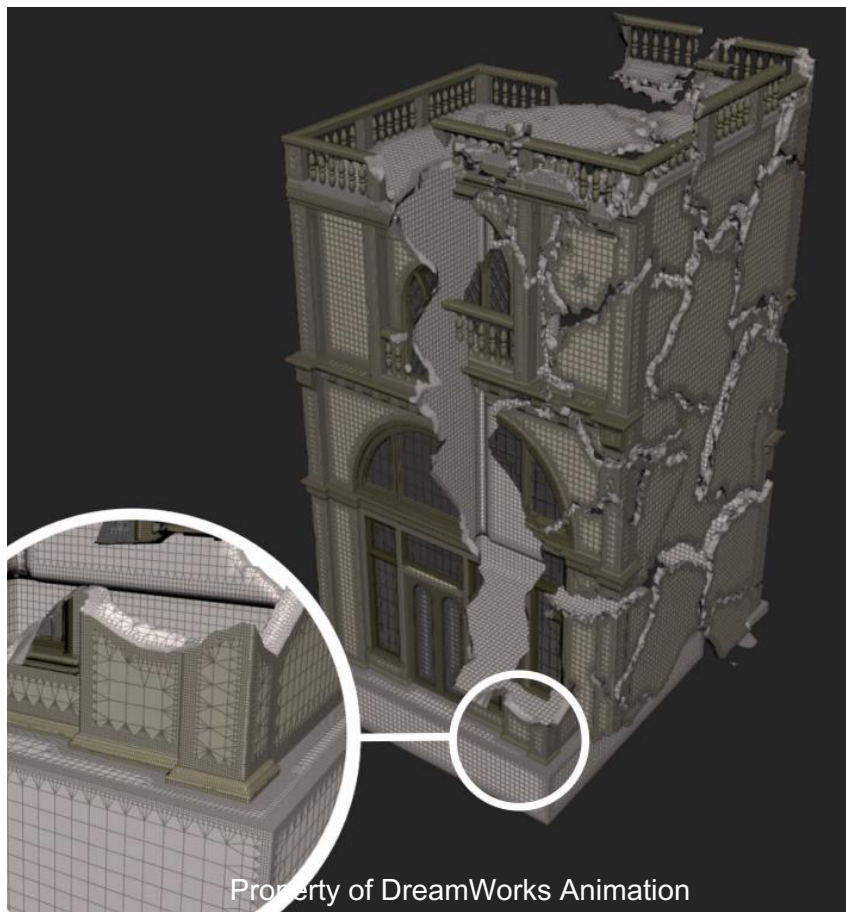
Property of DreamWorks Animation



Property of DreamWorks Animation

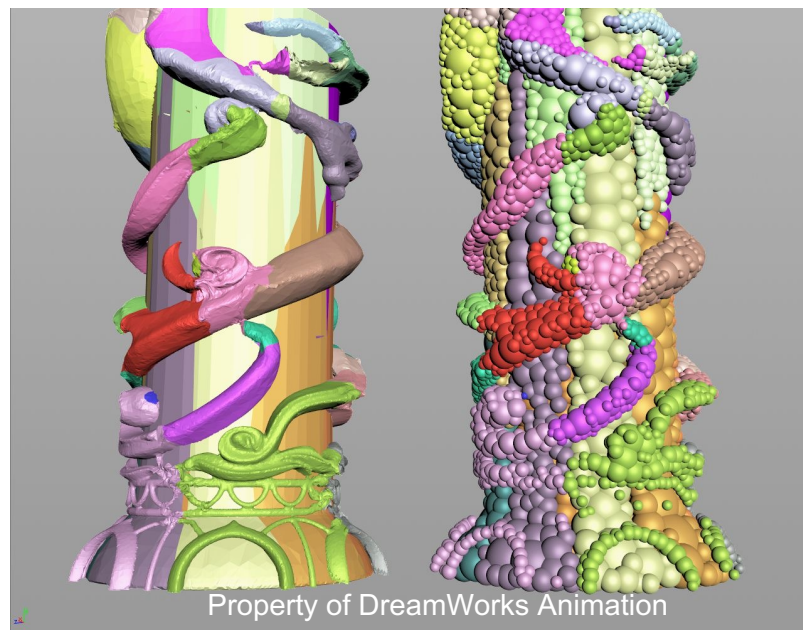
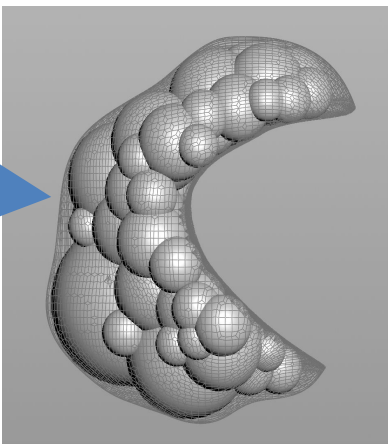
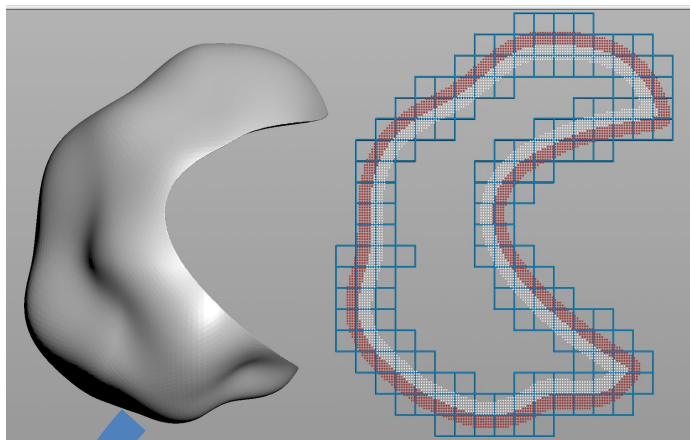


VOLUME FRACTURE



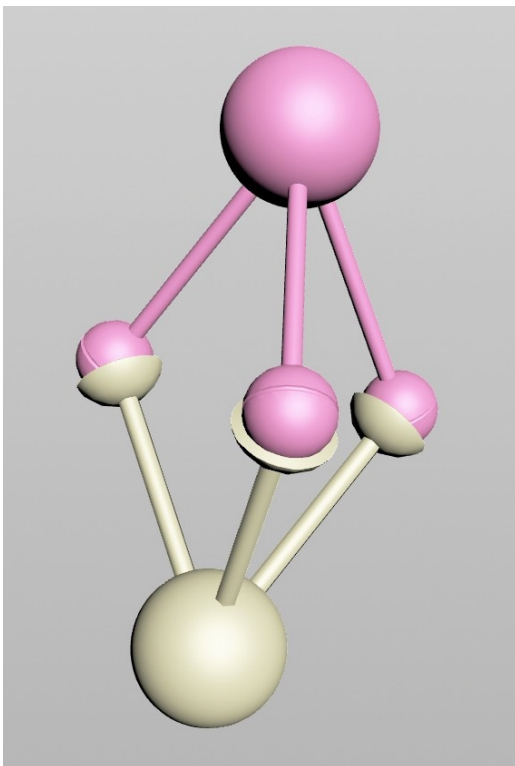


PROXY GENERATION



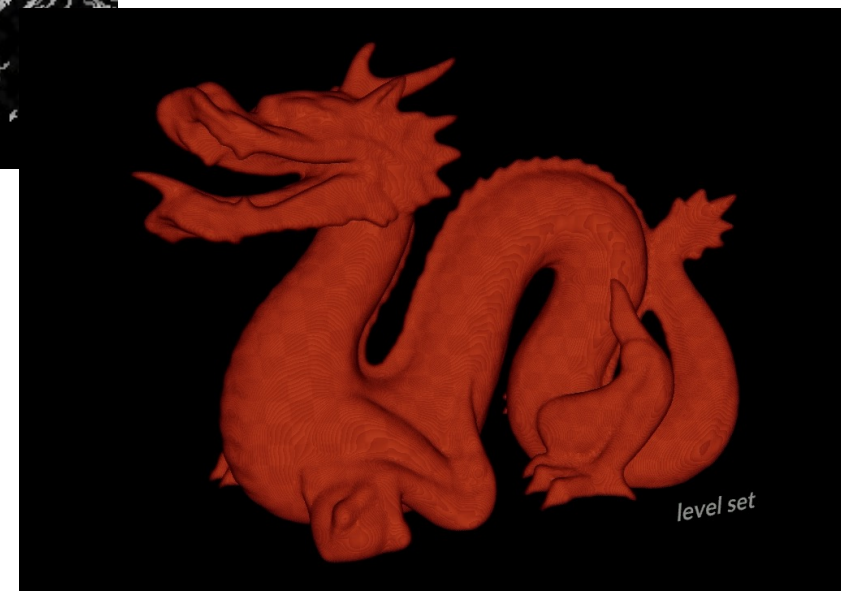
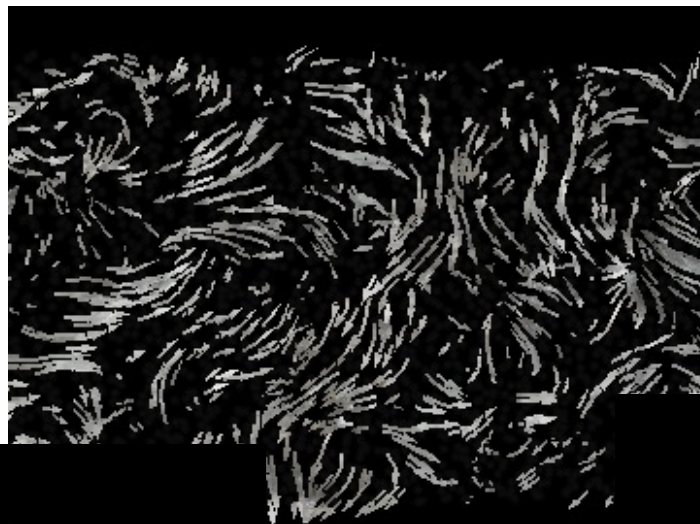
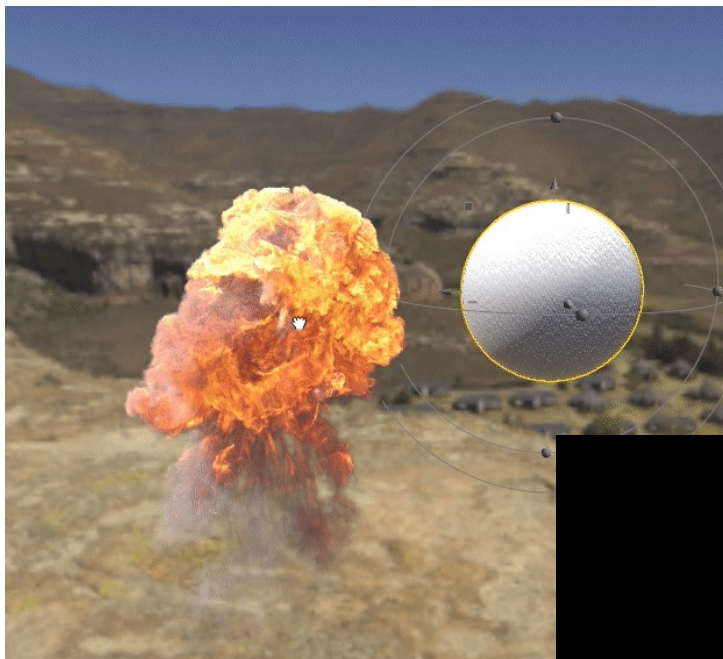


ELASTIC DEFORMATION





VISUALIZATION





RENDERING



3D viewer



parity across renderers



```
×openvdb_print fire.vdb -m
```

```
density float (8,6,8)->(183,142,153)
```

```
...
```

```
temperature float (8,6,8)->(183,142,153)
```

```
background: 0
```

```
voxel size: 0.5
```

```
index to world:
```

```
[0.5, 0, 0, 0]
```

```
[0, 0.5, 0, 0]
```

```
[0, 0, 0.5, 0]
```

```
[-47.5, -4, -40, 1]
```

```
amorphous: {"_format":100, "default": {"enabled":f
```

```
 {"enabled":true, "field":"temperature", "gain":1.0, "
```

```
 "ramp":[[[0.0,[0.0,0.0,0.0,1.0],0.50,0], [0.200, [0.03
```

```
class: fog volume
```

```
file_bbox_max: [183, 142, 153]
```

```
file_bbox_min: [8, 6, 8]
```

```
...
```

```
...
```




EMISSIVE LIGHTING



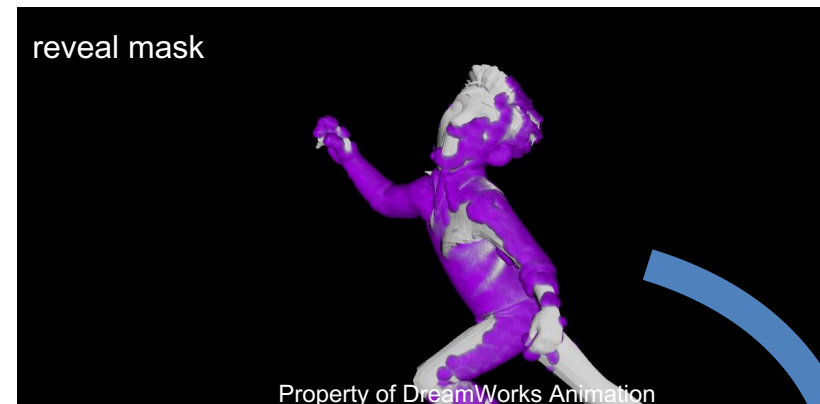
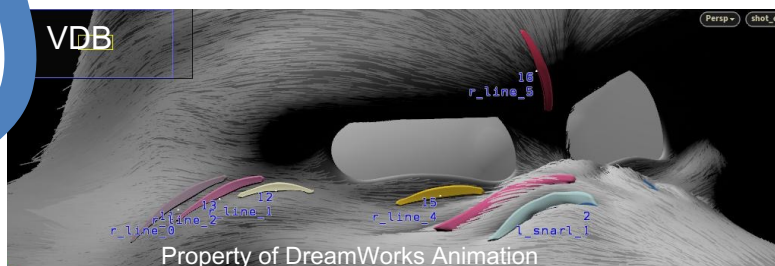
Property of DreamWorks Animation



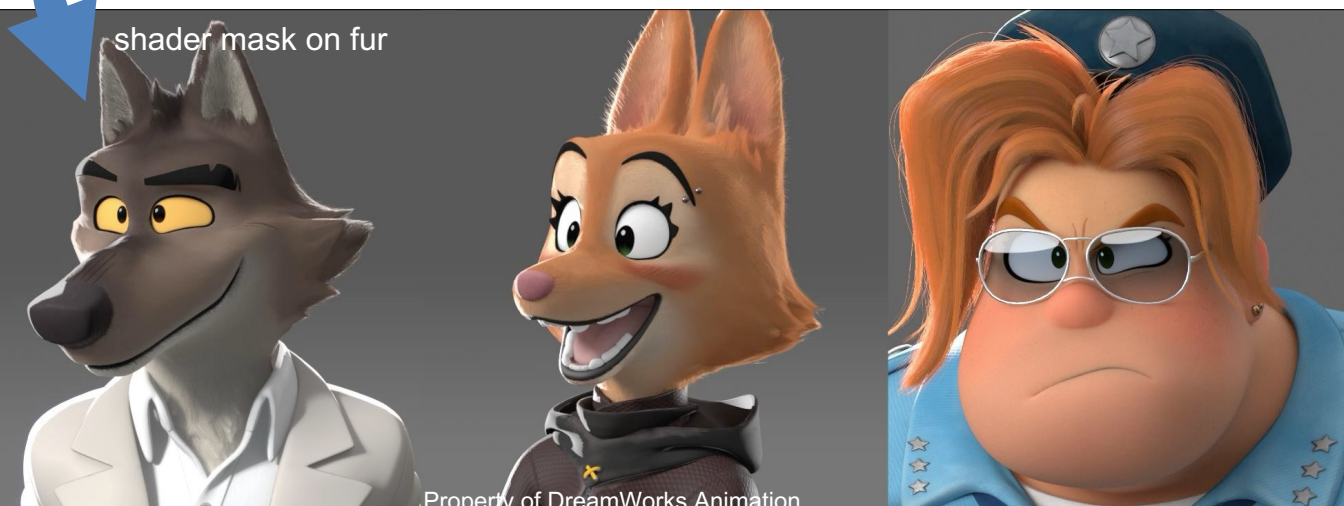
Property of DreamWorks Animation



SPATIAL MAP

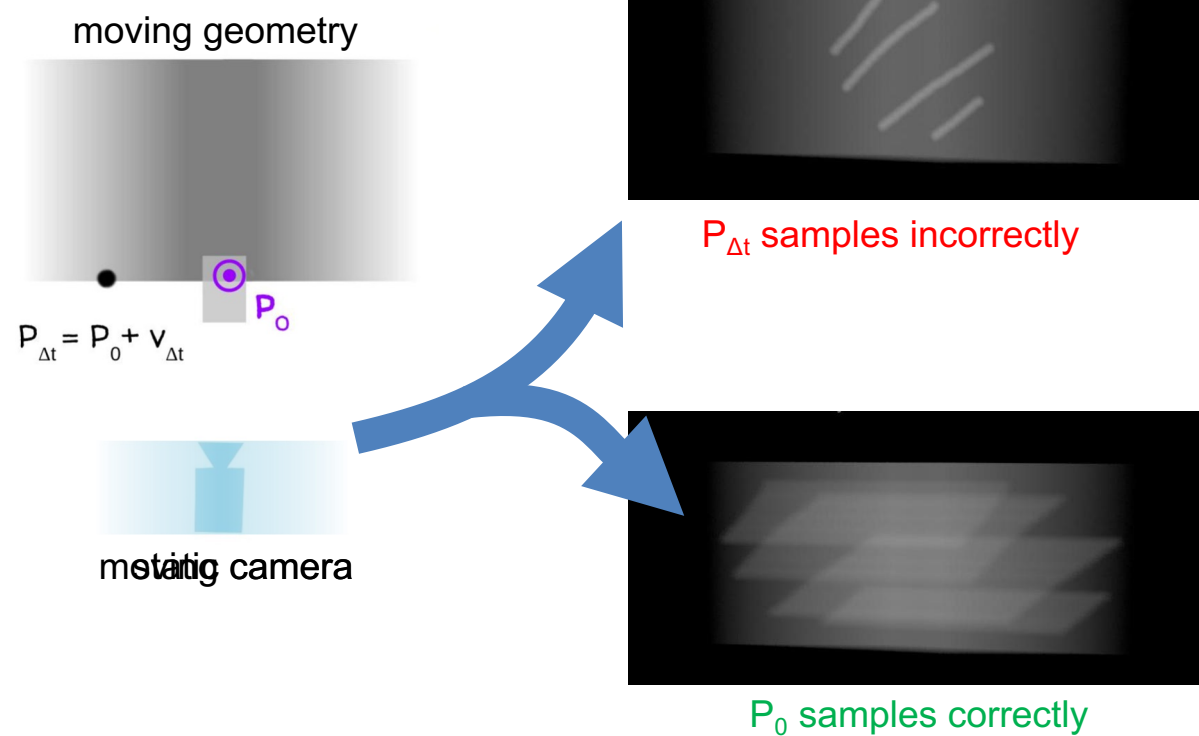
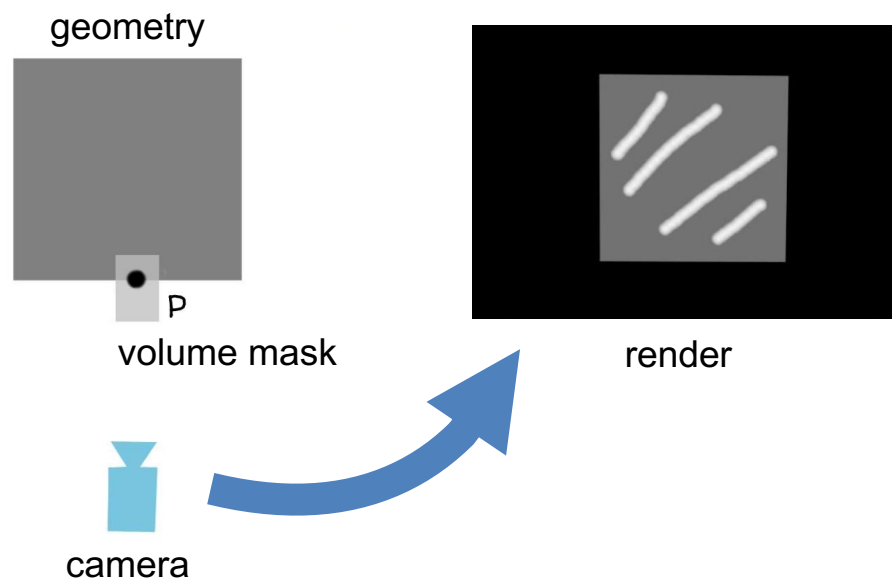


1 VDB > lots of animated UDIMs per frame
(across multiple shaders & geometry types)





SPATIAL MAP





QUESTIONS?



THE PREMIER CONFERENCE & EXHIBITION ON
COMPUTER GRAPHICS & INTERACTIVE TECHNIQUES



SIGGRAPH 2023
LOS ANGELES+ 6-10 AUG

OPENVDB

IN PRODUCTION