Delta Mush: Smoothing Deformations While Preserving Detail

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Rhythm & Hues Studio

Delta Mush In Action:

_proximity binding to skeleton with delta mush smoothing

Voodoo: deltaMushDeform_screen2.vdu (work)
File Edit View Options Object Frames Window Tracking Help RigTools Light General Rig Handlers
Camera:camAux
Camera View Display Options Tools
camAux
seqSelected addCollision removeCollision copyCollisions showCollisions
rigShelf constraints model patches simulations
Char Vui
gemini-1
On Control Display Pds
Show Choose Only Filter
Controls
all
par
body
basePar
bFingers
bNeck
fingers
neck
arm
spine
Del Key
Tools...

rig1_bendyCage/mush1

Mush | Chan

Group: off (Browse...)
Pin Group: off (Browse...)
- [ ] Pin Perimeter
- [ ] Pin Convex
- [ ] Tangential
- [x] Weight By Distance
- [x] Use Threaded

Mode: delta
Mush Level: 14

rig1_bendyCage
undef 0
rig1_spCtrl * 1
mush * 1

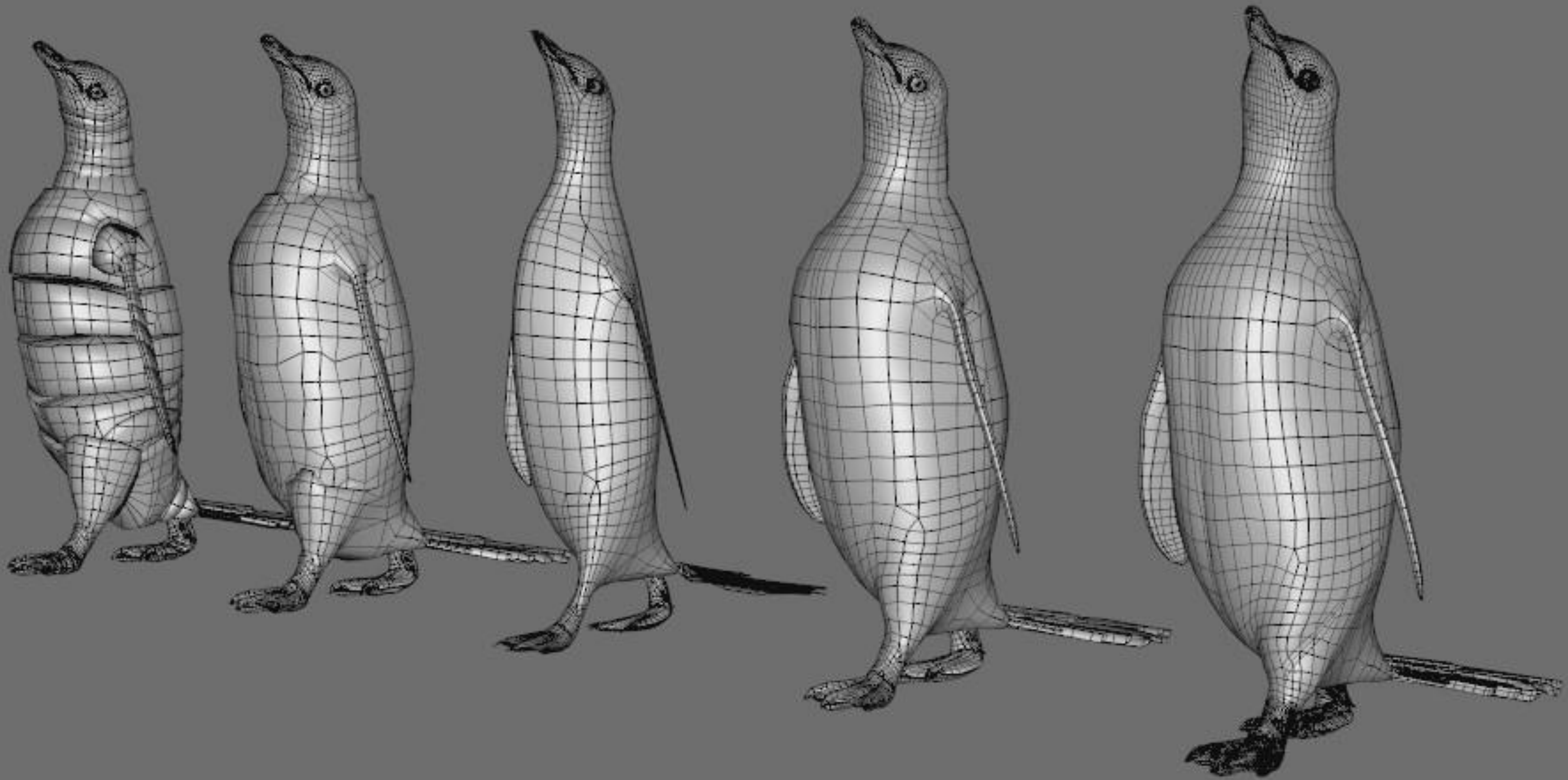
```
none
none
gem1_lClavicleIk
obj *bendyCage/mush -create
created 1 channel:
    rig1_bendyCage/[mush1]
c *bendyCage
```

Voodoo (debug): hulk1.vdu (Win+V)
File Edit View Options Object Frames Window Tracking Help Create XFORM Handlers
Camera:camAux
Camera View Display Options Tools
camAux
Reset Key Del Key
boneDrag bone color converge guide home icon instanceDrag layoutFour layoutPerspCE
verts handlers
Channels Remove Options
Char Vui
hulk
On Control Display Pds
all
Show Choose Only Filter
Controls
all
par
body
minors
path
settings
L C R Tools...

```
                 hul_bendyCans   0.0633     0.284     frames     84.54    fps   22.29%
                     ------item   delta-time  accum-time          --fps--
write
Finished writing /home/joe/muse/devel/partition/voodoo/./hulk1.vdu
```

hul_lClavicle
zr 0
yr 0
hul_lShoulderSwingFk
xr 0
hul_lShoulderFk
xr 0
yr 0
zr 0
limpArmON=1 0
limp-baseRelative 0
hul_lElbowFk
zr 0
hul_lWristTwistFk
xr 0
hul_lWristFk
zr 0
yr 0
xr 0
hul_lArmDRigHome
S xr 1.49208
S yr -32.4554
S zr -24.818
S xt 108.294
S yt 195.555
S zt 2.60057
S homeMax 11.3683
S homeMin -13.3631
hul_bendyLoCopy
xt 0
yt * 0
zt 0

0028
#966693 : gsteele RDENVGS_LightAbomEnv_v0005 20:51 Feb 28



0001

#3594461 : library.gentoo:AnimDump.BindRD - 23:34 Dec 20

Definitions

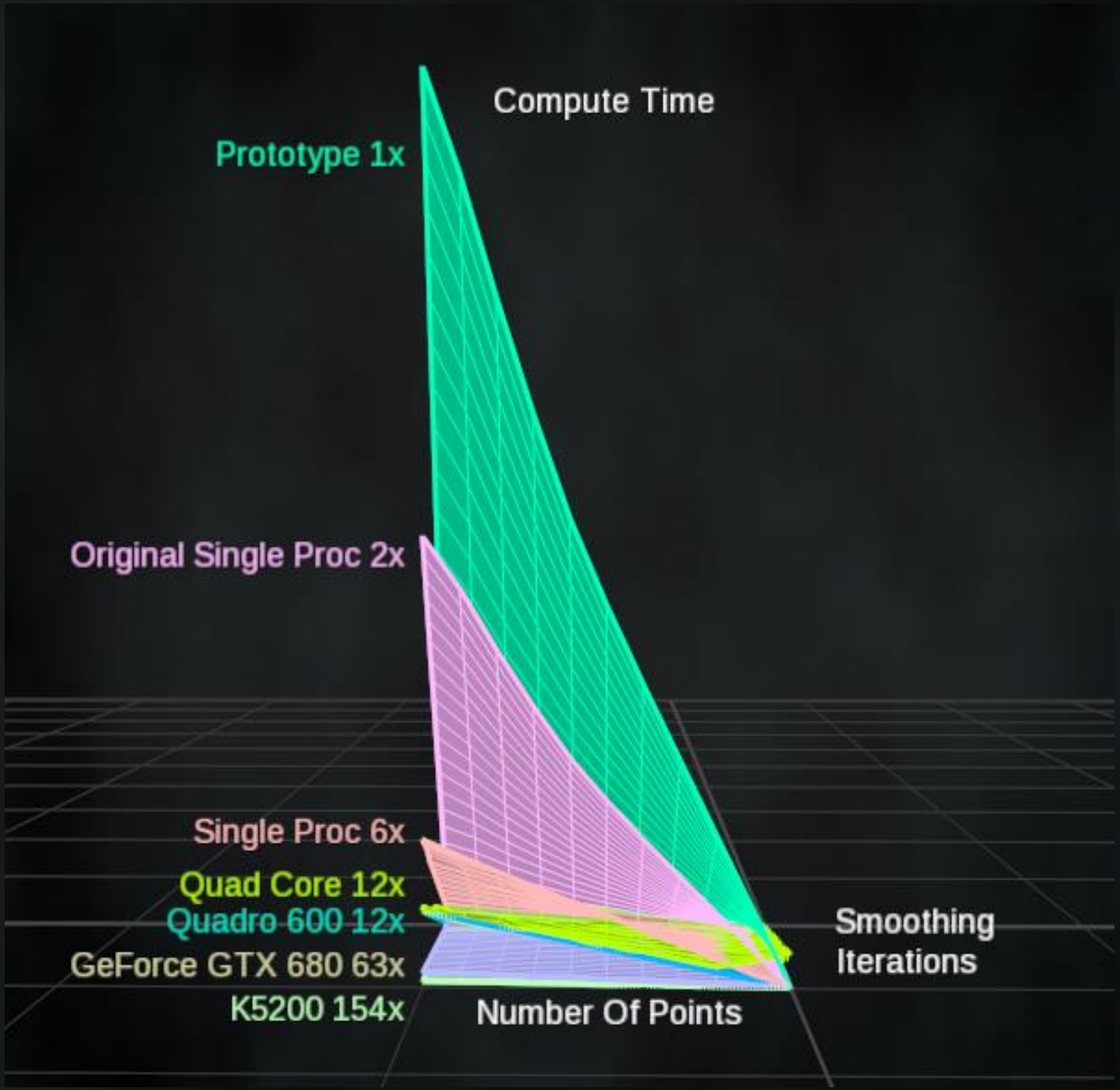
- Delta => tangent space displacement vector
- Mush => smoothing
- Pin Perimeter => boundary conditions
- Weight By Distance => apply Lapacian coefficients
- Prox => proximity binding (wrap deformer)

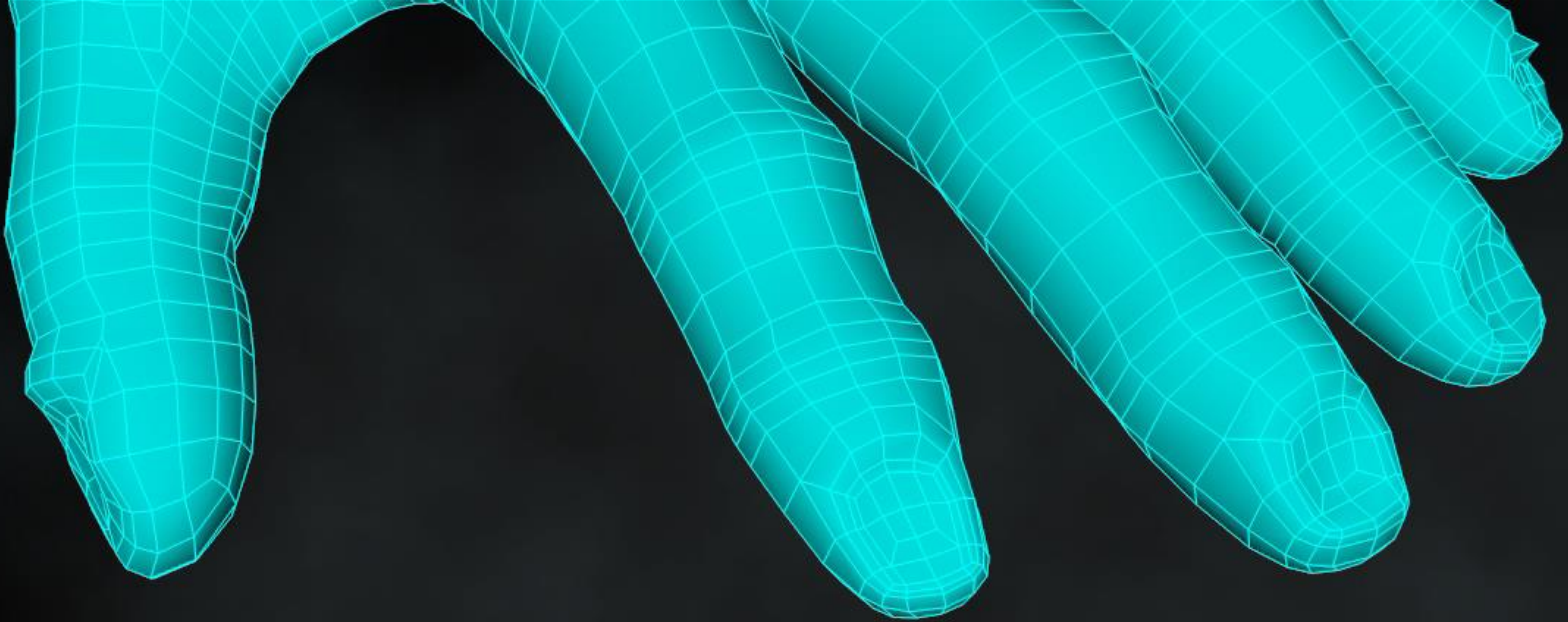
Motivation

- Rigging efficiency
    - More characters
    - Fewer riggers
    - Quicker rigs
        - Fast to setup and evaluate
        - Eliminate fix shapes and PSD

What it has become

- Added the Delta option to the Mush deformer.
- Recent refactor improved performance ~2x.
- GPU improved performance 75x.





Weighted Laplacian

- Standard mesh Laplacian treats all neighbors the same.
- Weighting by distance limits redistribution of points

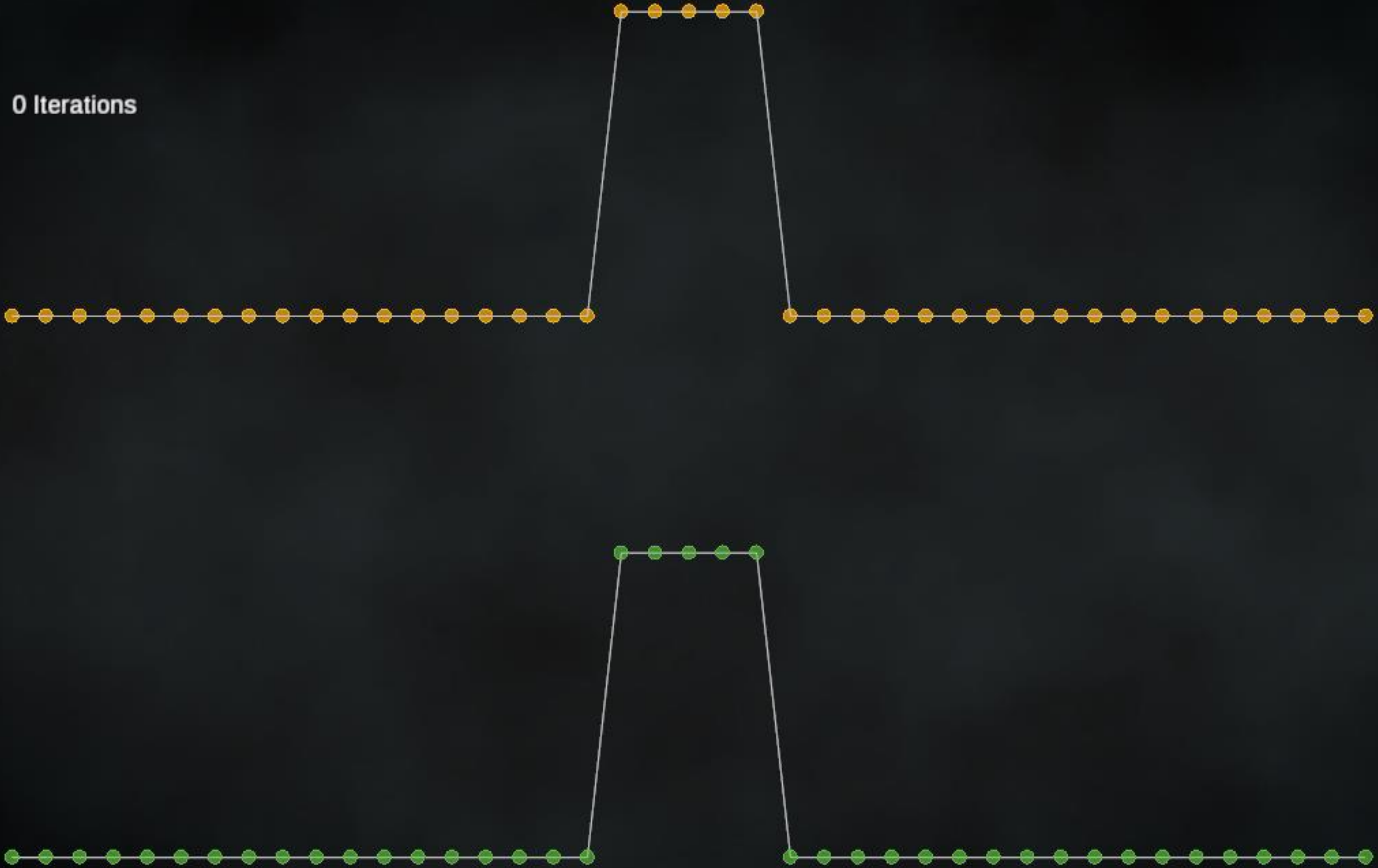
$$\vec{x'}_i = \frac{1}{N} \sum_{j=1}^{N} \vec{x'}_j$$

$$\vec{x'}_i = \frac{1}{N+1} \left\{ \vec{x}_i + \sum_{j=1}^{N} \vec{x'}_j \right\}$$

$$\vec{x'}_i = \frac{1}{1 + \sum_{j=1}^{N} \alpha_{ij}} \left\{ \sum_{j=1}^{N} \alpha_{ij} \vec{x'}_j \right\}$$

$$where \quad \alpha_{ij} = \frac{1}{\| \vec{x'}_i - \vec{x'}_j \|}$$

0 Iterations



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$$where \ \ \alpha_{ij} = \frac{1}{\| \vec{x'}_i - \vec{x'}_j \|}$$

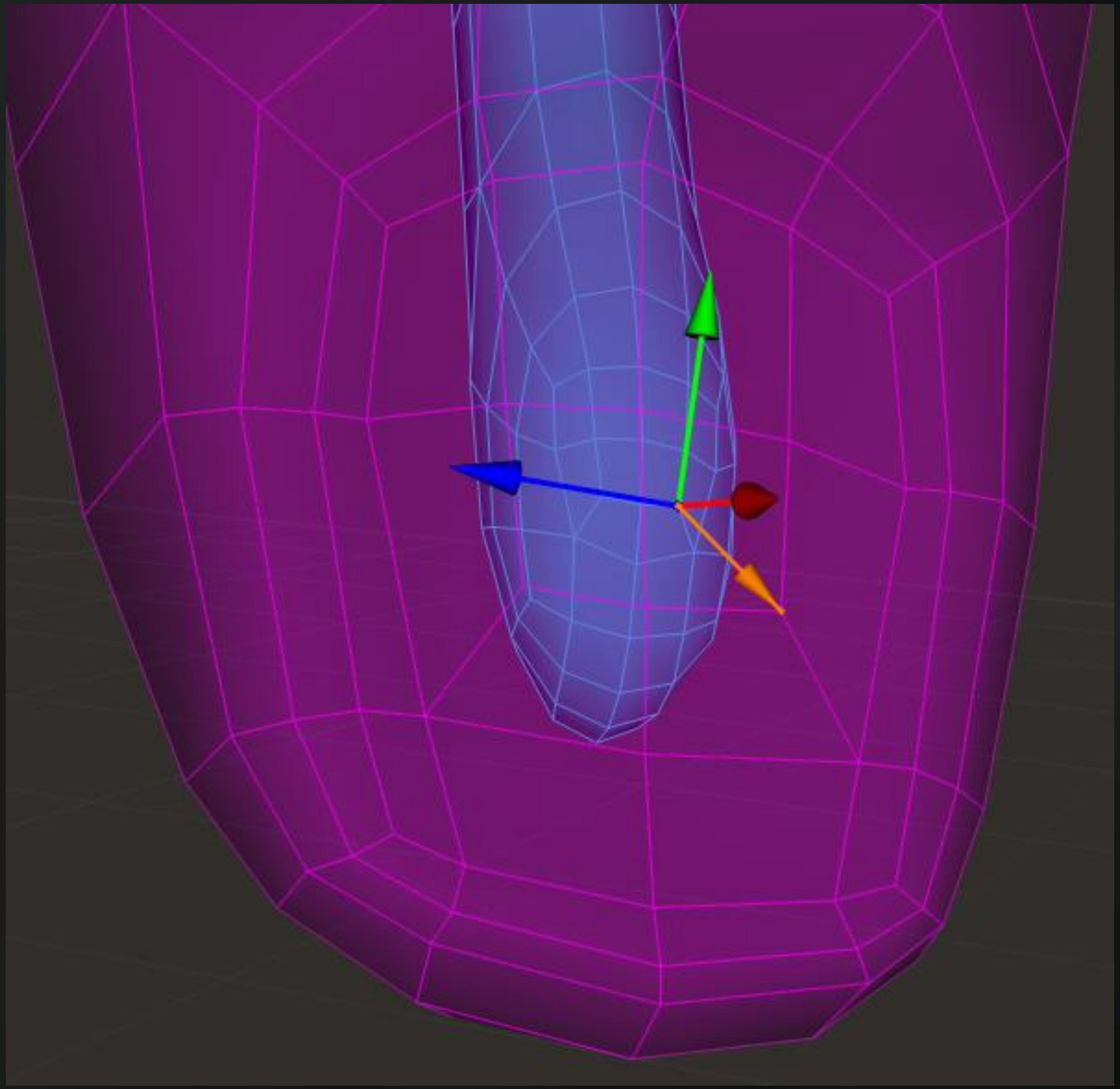
Vector displacement

$$\overrightarrow{x'_i} = \overrightarrow{r_i}\, S_i^{-1} S'_i$$

or

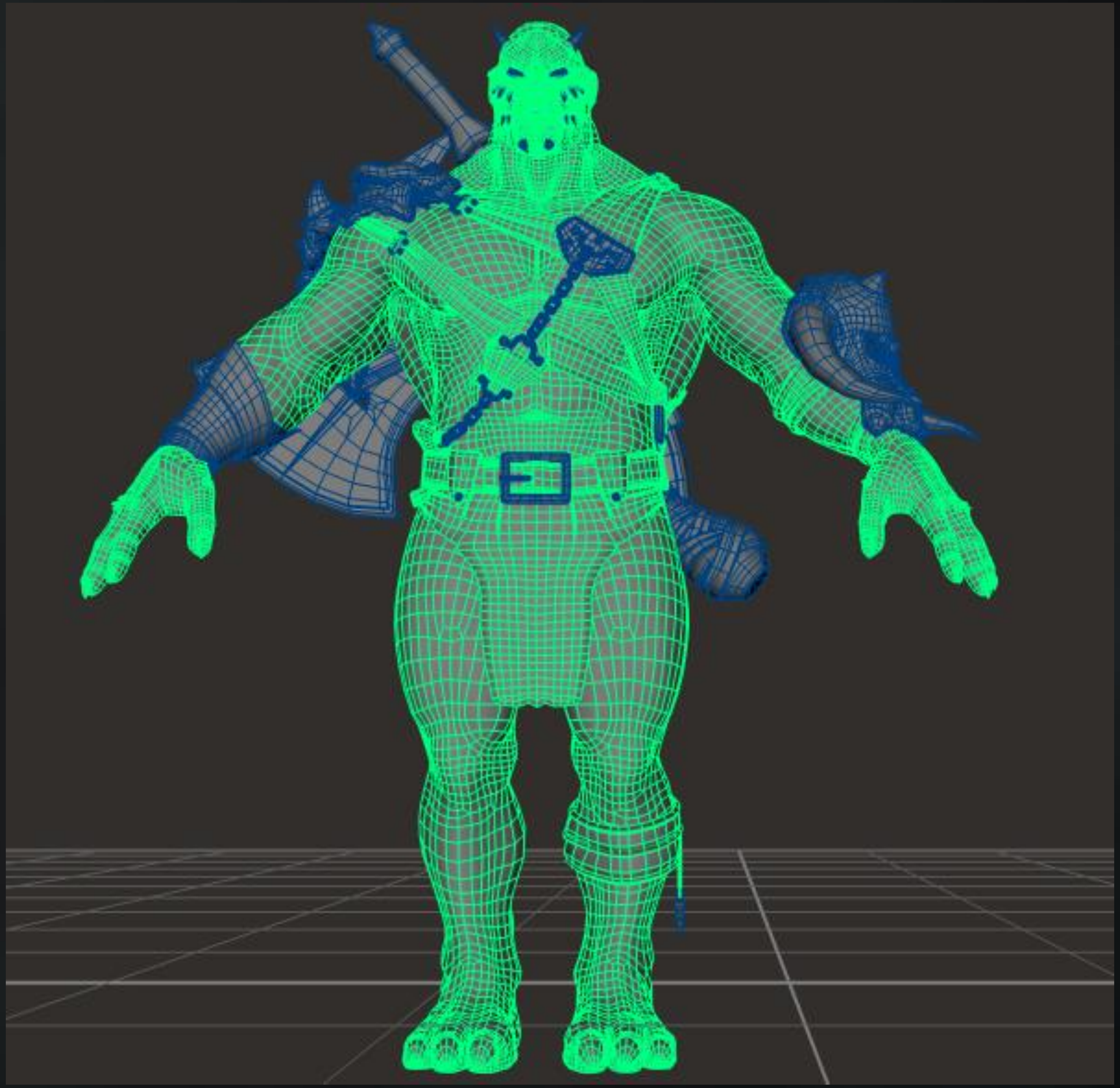
$$\overrightarrow{d_i} = \overrightarrow{r_i}\, S_i^{-1}$$

$$\overrightarrow{x'_i} = \overrightarrow{d_i}\, S'_i$$



In practice

- On a 40,000 point mesh
- 15 iterations
- 4% of a frame at 24 fps (K5200)



What this lead to

- Interactive Rides
- Video Games
- Augmented Reality / Virtual Reality

Current and Future Work

- Ported our simple bone bind, proximity bind, and blend shapes to cuda
- Have characters authored in voodoo, running through our cuda deformation library, in UnrealEngine4
- Looking to port a few more key deformers
- Looking to reduce CPU<=>GPU memcpys

StarterMap*
theHuntVignette
File
Edit
Window
Help
Search For Help
Modes
Save
Content
Settings
Blueprints
Matinee
Build
Pause
Stop
Eject
Search Classes
Recently Placed
Basic
Lights
Visual
BSP
Volumes
Content Browser
New
Imp
Gar
Filters
Level
landscapeBG
Minimal_Default
Minimal_Default
StarterMap
StarterMap
View Op
Search
Actor
80 actors
Details
Select an o
Level: StarterMap (Persistent)

Go forth and implement

- Easy to implement and easy to use
- Perfect for the GPU
- Game Engines

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