SHAPE ANALYSIS DRIVEN SURFACE CORRECTION

ON Animation Studios
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VINCENT LINDON
Le Petit Prince
D'après le chef-d'œuvre d'Antoine de Saint-Exupéry
Un film de
MARK OSBORNE

OMAR SY
IZIA HIGELIN
MICHAËL GREGORIO
MUNE
LE GARDIEN DE LA LUNE
ALEXANDRE HEBOYAN ET BENOÎT PHILIPPON
AU CINÉMA EN 2D ET 3D

Our production rig

- Fully procedural rig
  - Facial
  - Body
- Auto rig system
  - No blendshapes
  - No corrective blendshapes

Dynasculpt : *All in one* tool

- Pose space deformation
  - Facial
  - Body
- Artistic refinement
  - Post animation model polishing
  - Post corrections for physicaly simulated models

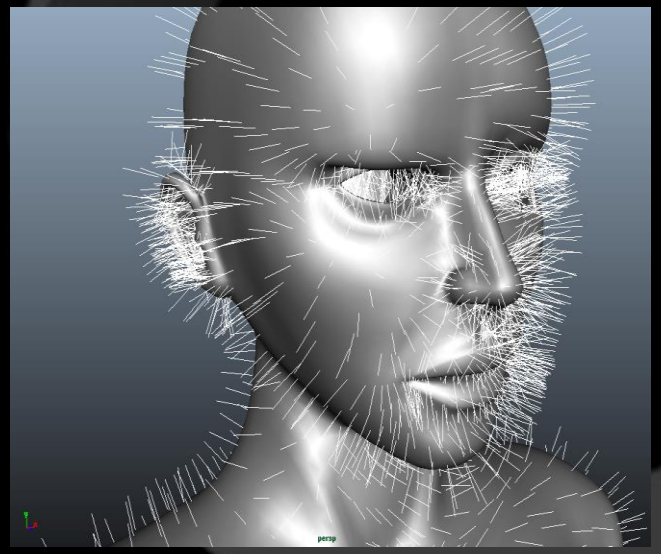
Dynasculpt main features

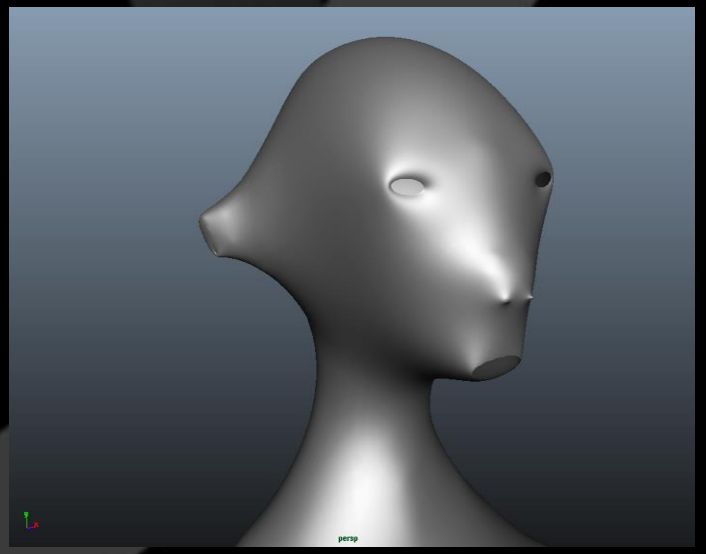
- Sculpt wrapping
  - Surface Local coordinate system
- Shape analysis to drive corrections
  - Direct drive
  - Across Radial Basis Function interpolators

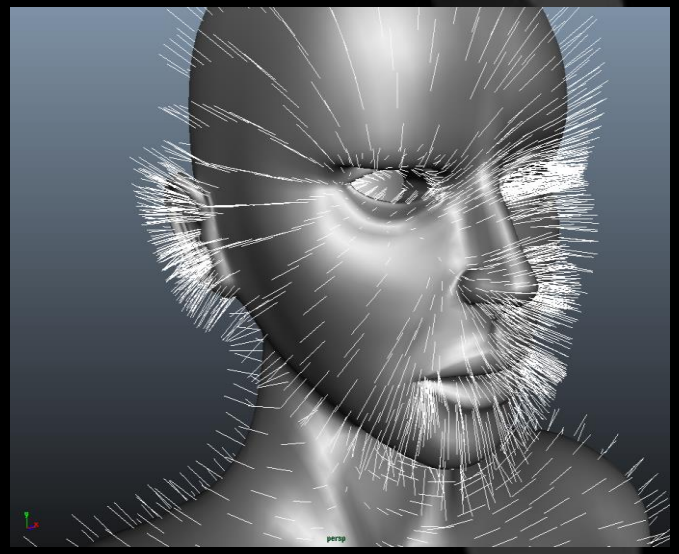
File Edit Modify Create Display Window Assets Select Mesh Edit Mesh Proxy Normals Color Create UVs Edit UVs Muscle Pipeline Cache Help
Polygons
General Curves Surfaces Polygons Subdivs Deformation Animation Dynamics Rendering PaintEffects Toon Muscle Fluids Fur Hair nCloth Custom Bullet MERY
Tool Settings
Move Tool
Reset Tool
Tool Help
Move Settings
Move Axis: Object Local World Normal Along rotation axis Normals average Along live object axis Custom axis orientation
0.0000 0.0000 0.0000
Set to Point
Set to Edge
Set to Face
Preserve Child Transform
Preserve UVs
Discrete move:
Relative:
Step size: 0.01
Tweak mode
Joint Orient Settings
Automatically Orient Joints
Orient Joint to World:
Primary Axis: X Y Z
Secondary Axis: X Y Z
Secondary Axis World Orientation: X Y Z
Move Snap Settings
Retain component spacing
Snap to live polygon: Face center Vertex
Common Selection Options
Selection Style: Marquee
Camera based selection
Drag
Camera based paint selection
Soft Selection
Soft Select:
Reset
Falloff mode: Volume
Display Show Panels
Group
Main
Geometry
model:geo
model:body_GRP
model:skinPink_L_finge
model:skinBrown_C_bc
model:hairBlack_C_hair
model:hairBlack_L_bro
model:hairBlack_R_bro
model:skinPink_R_finge
model:skinBrown_C_bc
model:skinBrown_C_bc
skinBrown_C_body_GE
skinBrown_C_body_GE
skinBrown_C_body_GE
model:teeth_GRP
model:R_eye_GRP
model:L_eye_GRP
model:glasses_GRP
model:clothing_GRP
FaceGroup
View Shading Lighting Show Renderer Panels
persp
0.4 fps
Attribute Editor
List Selected Focus Attributes Show Help
Make a selection to view attributes
Select
Load Attributes
Copy Tab
Channel Box / Layer Editor
DYNASCULPT 3.0
Attribute Editor

Sculpt wrapping

- Use smoothed normals of laplacian filtered mesh





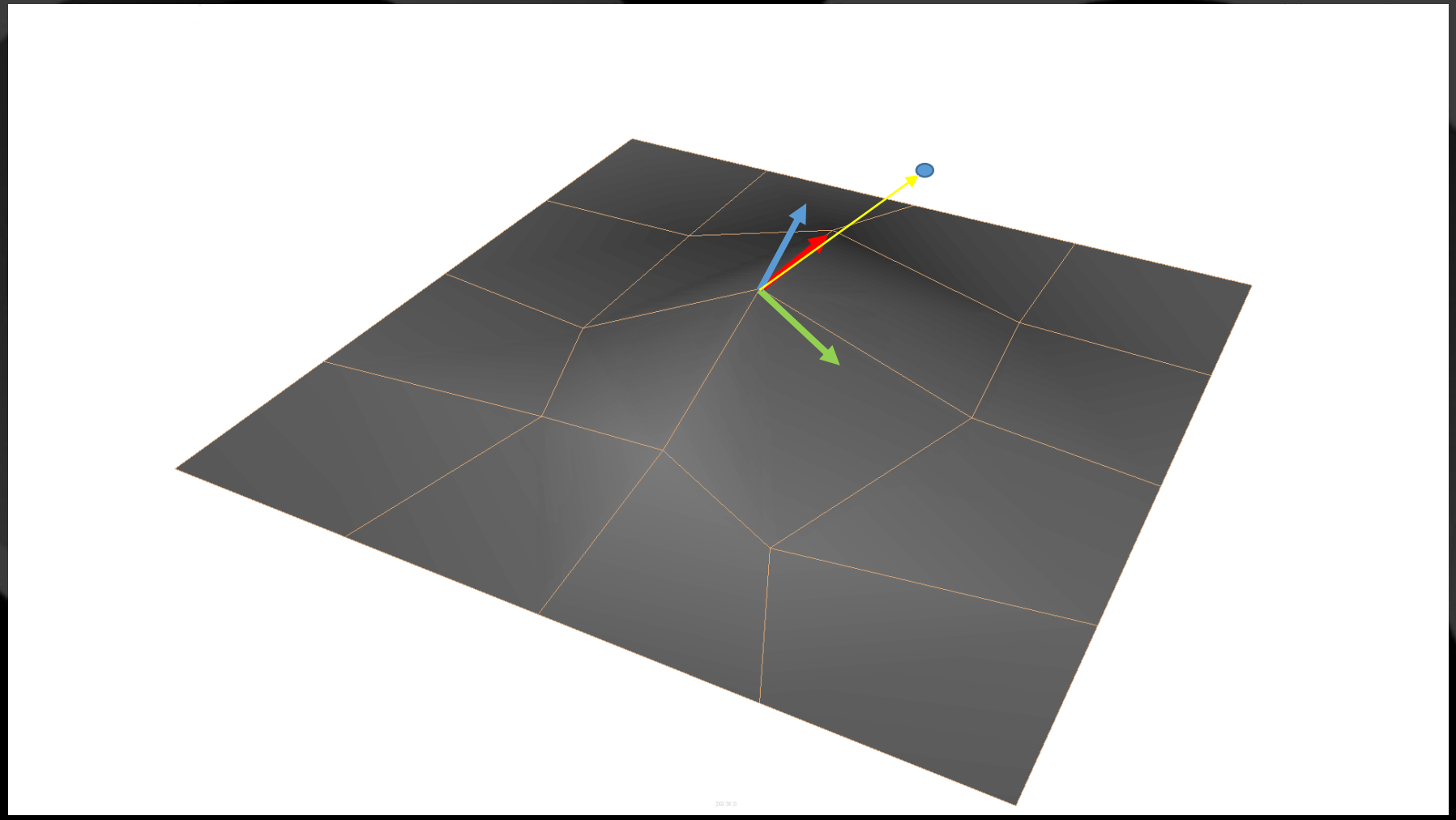


Computing sculpt deltas

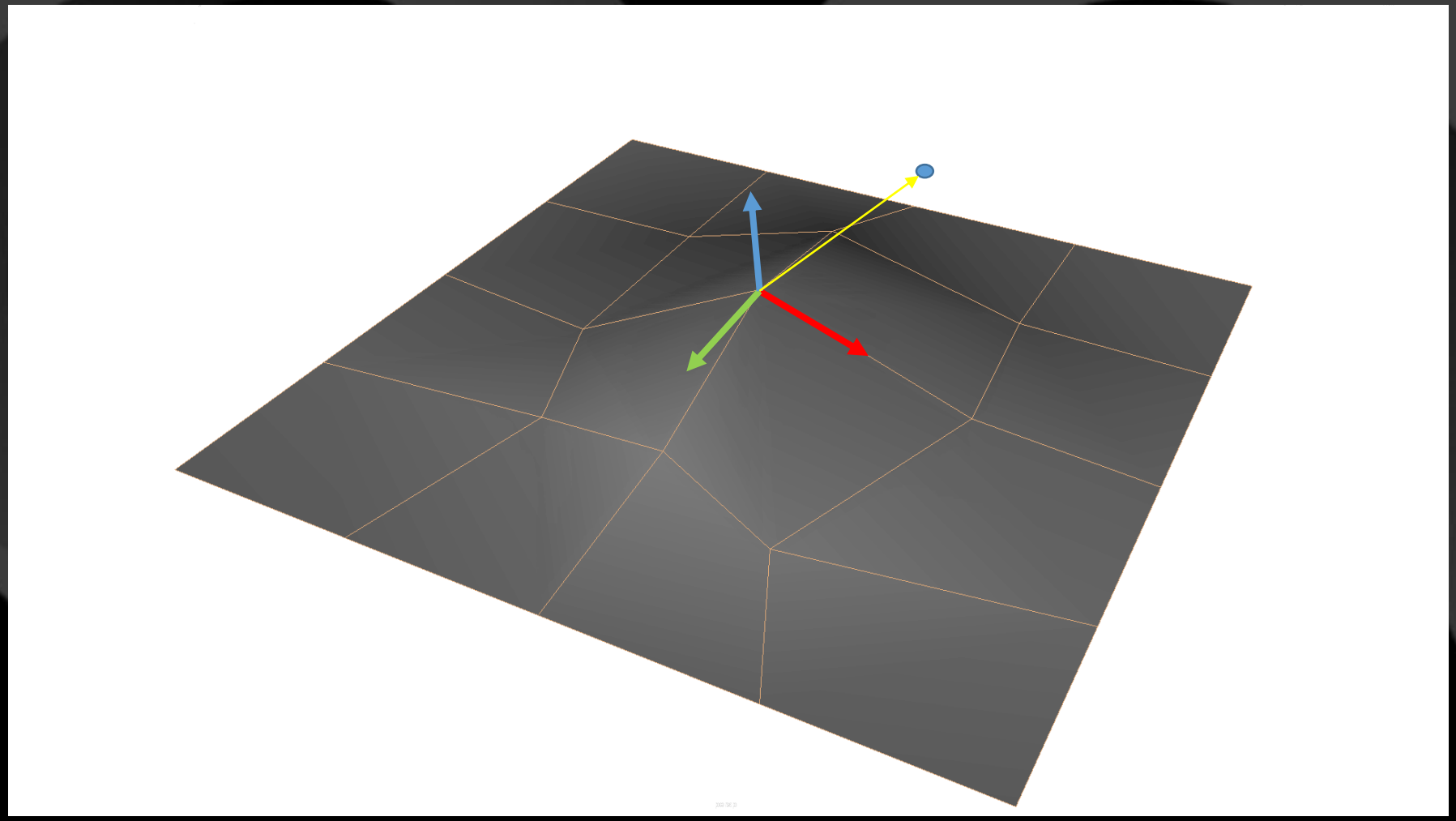
- Artist sculpts the corrected shape from a reference shape
- Compute smoothed normals of reference shape

```
For each moved vertex :
    Compute the delta in world space
    For each edge of vertex umbrella :
     Compute an edge matrix
     Compute a local delta  using edge
     matrix
```

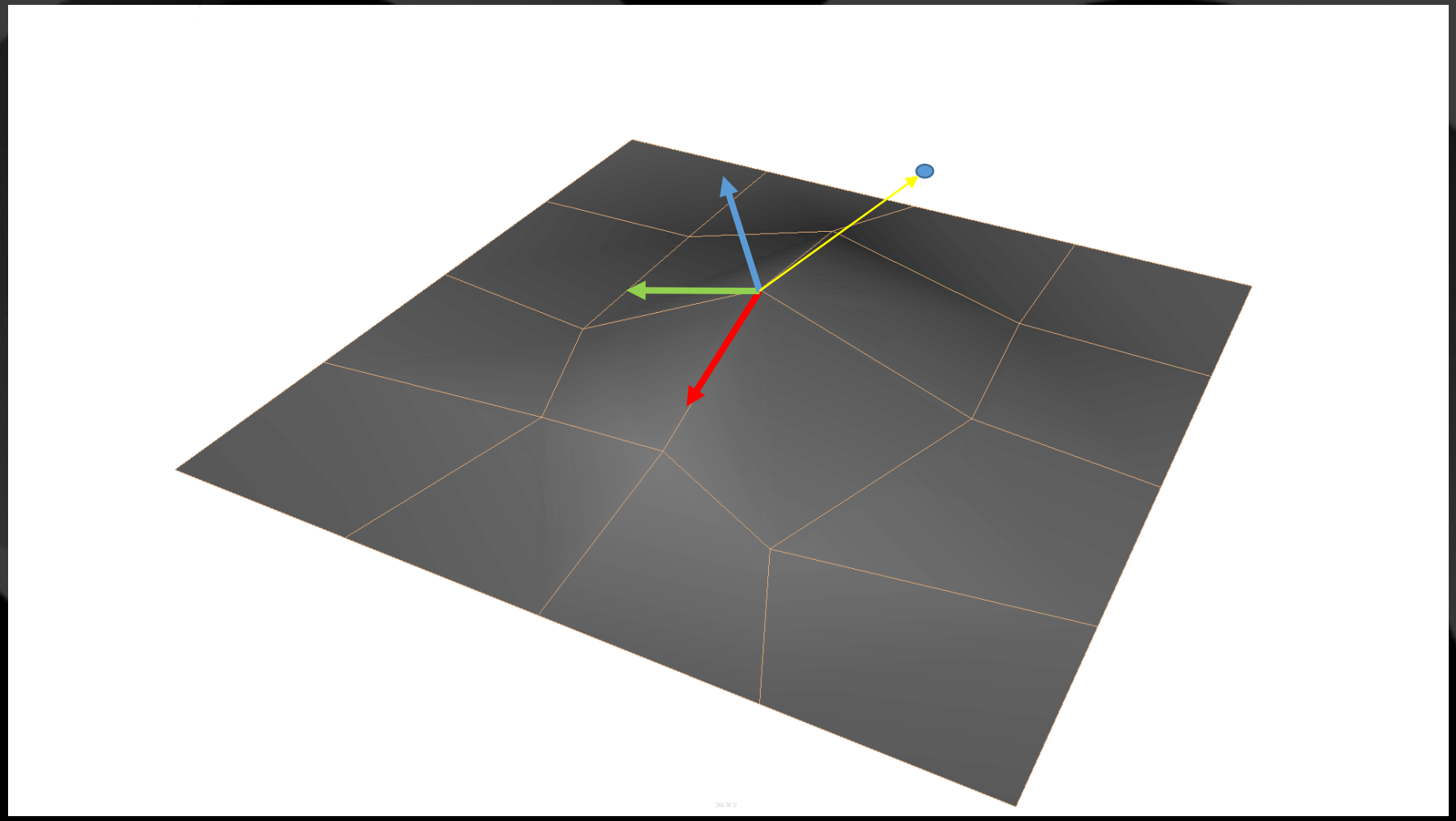
Local Delta for edge 1



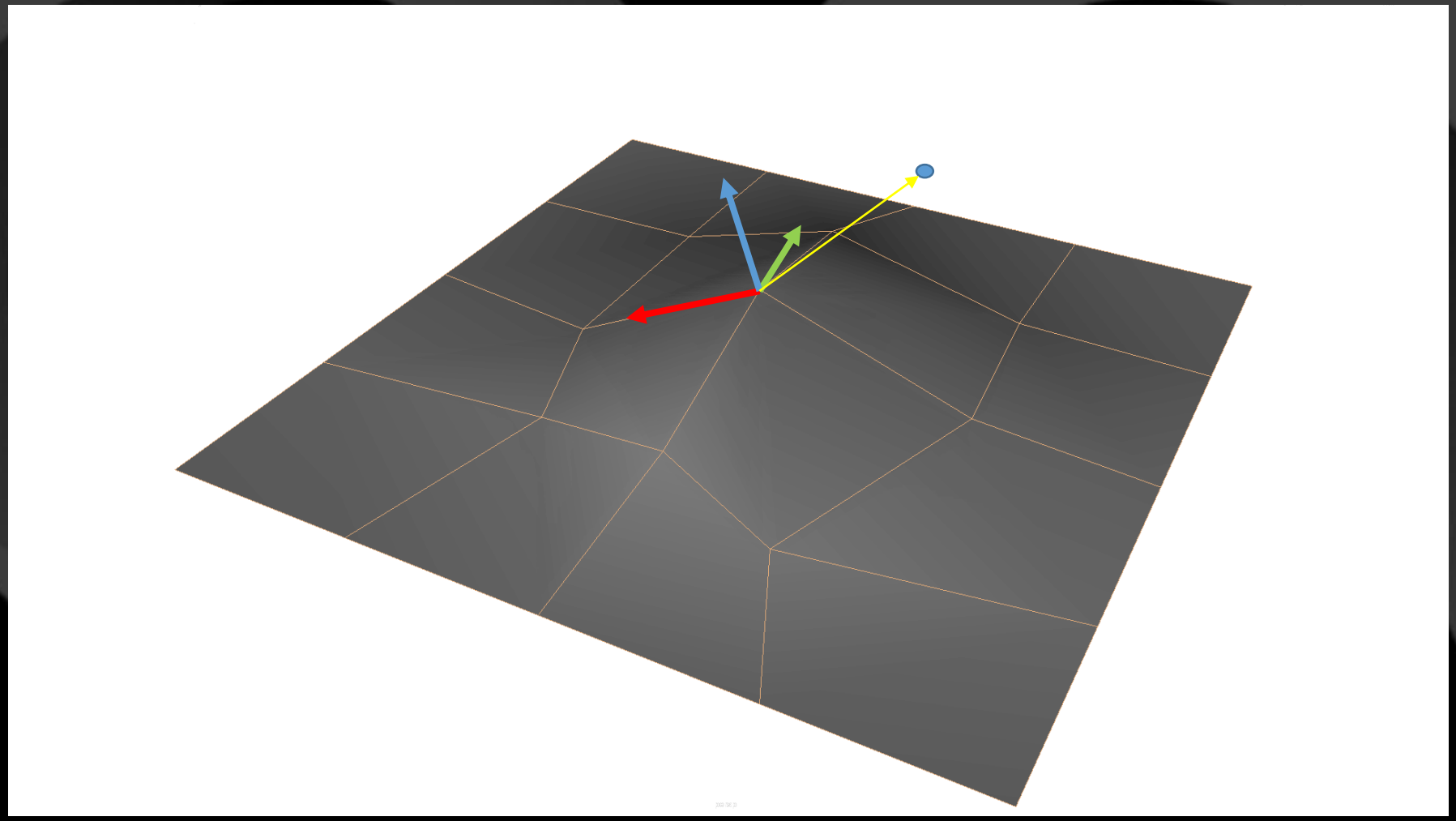
Local Delta for edge 2



Local Delta for edge 3



Local Delta for edge 4

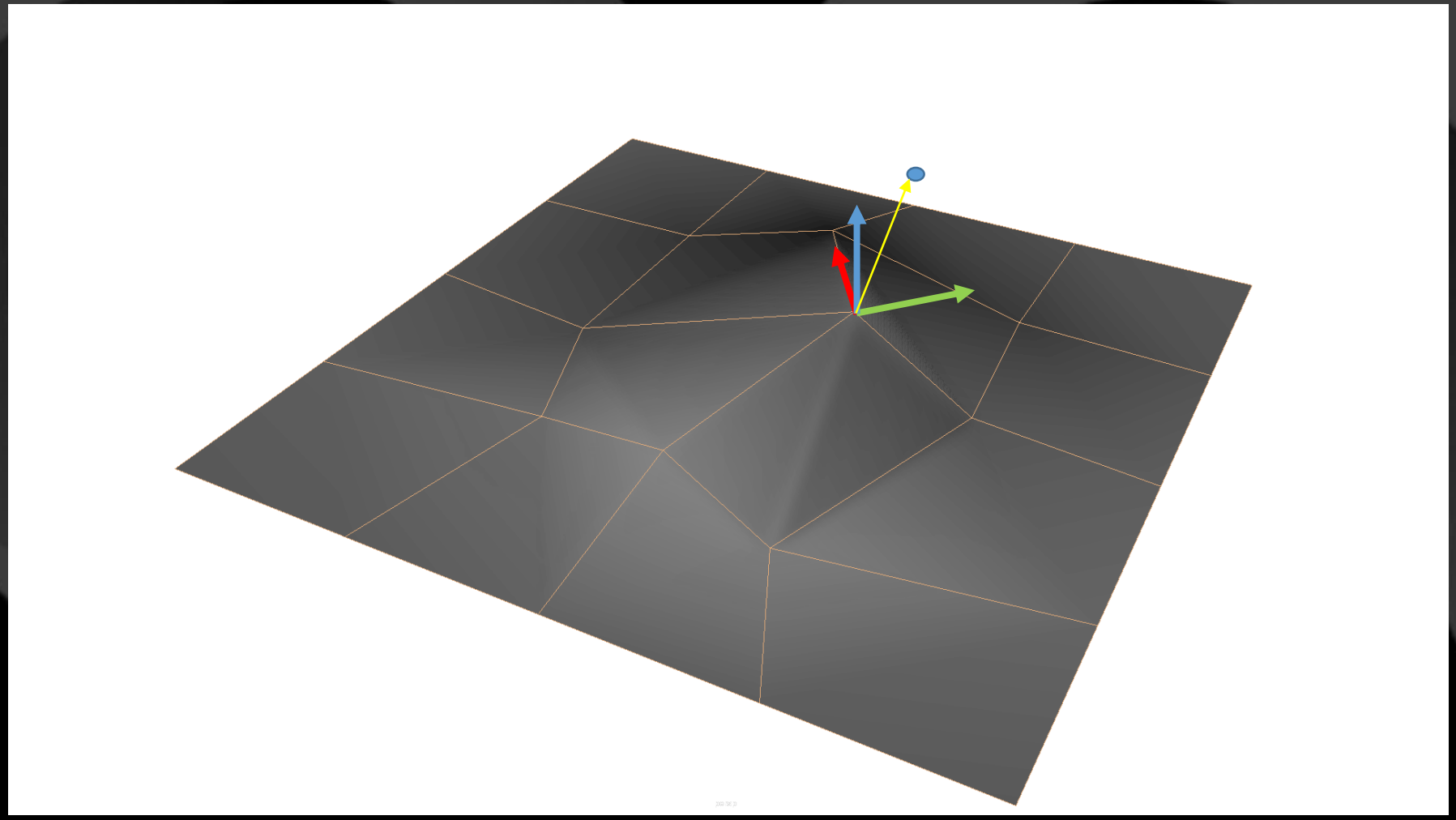


Restoring Sculpt deltas

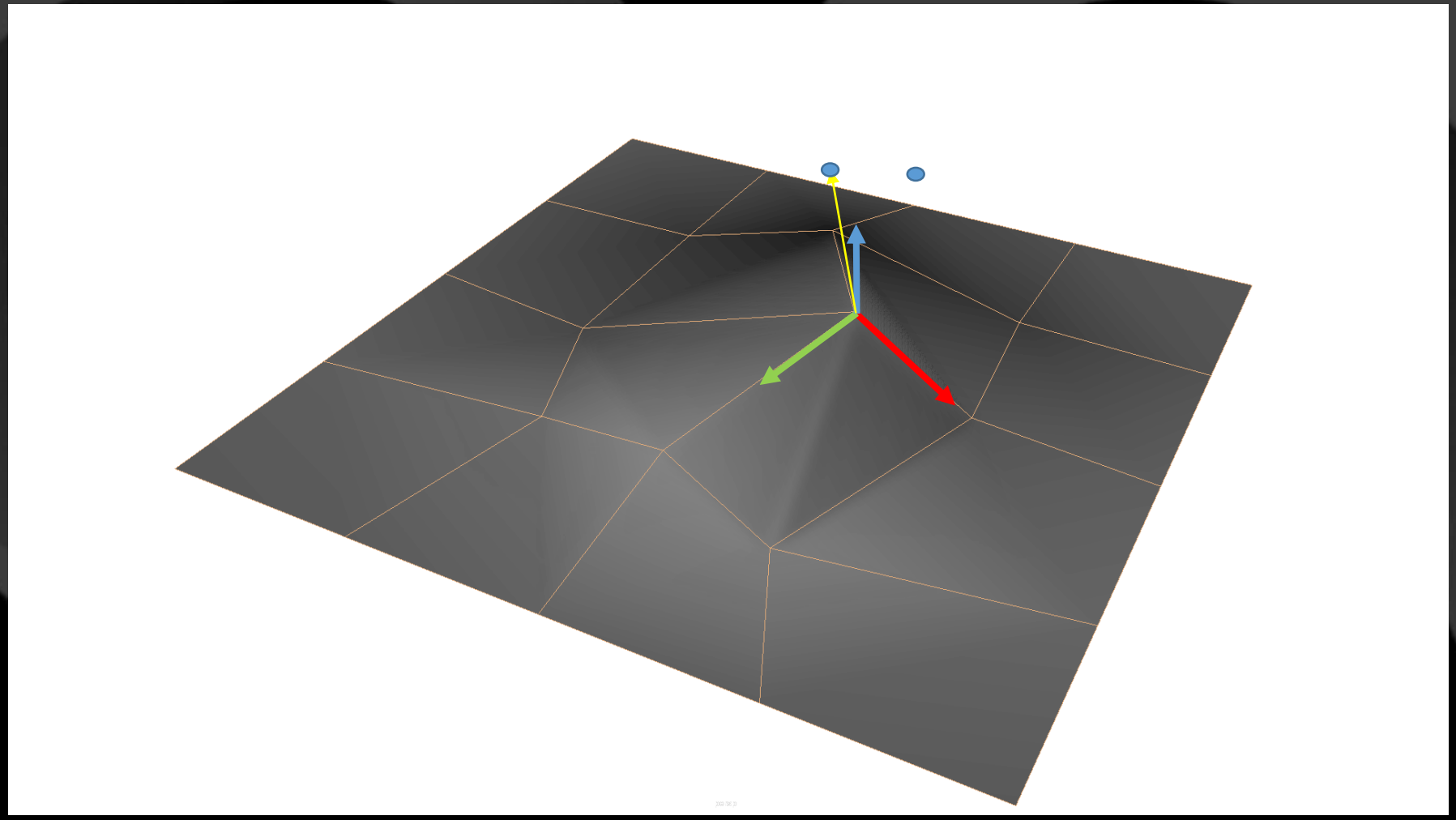
- Compute smoothed normals of current model

```
For each vertex :
  For each edge in vertex umbrella :
    Compute edge matrix
    Transform each local delta to get
    world delta
  Compute average delta
  Scale  average delta to the right length
```

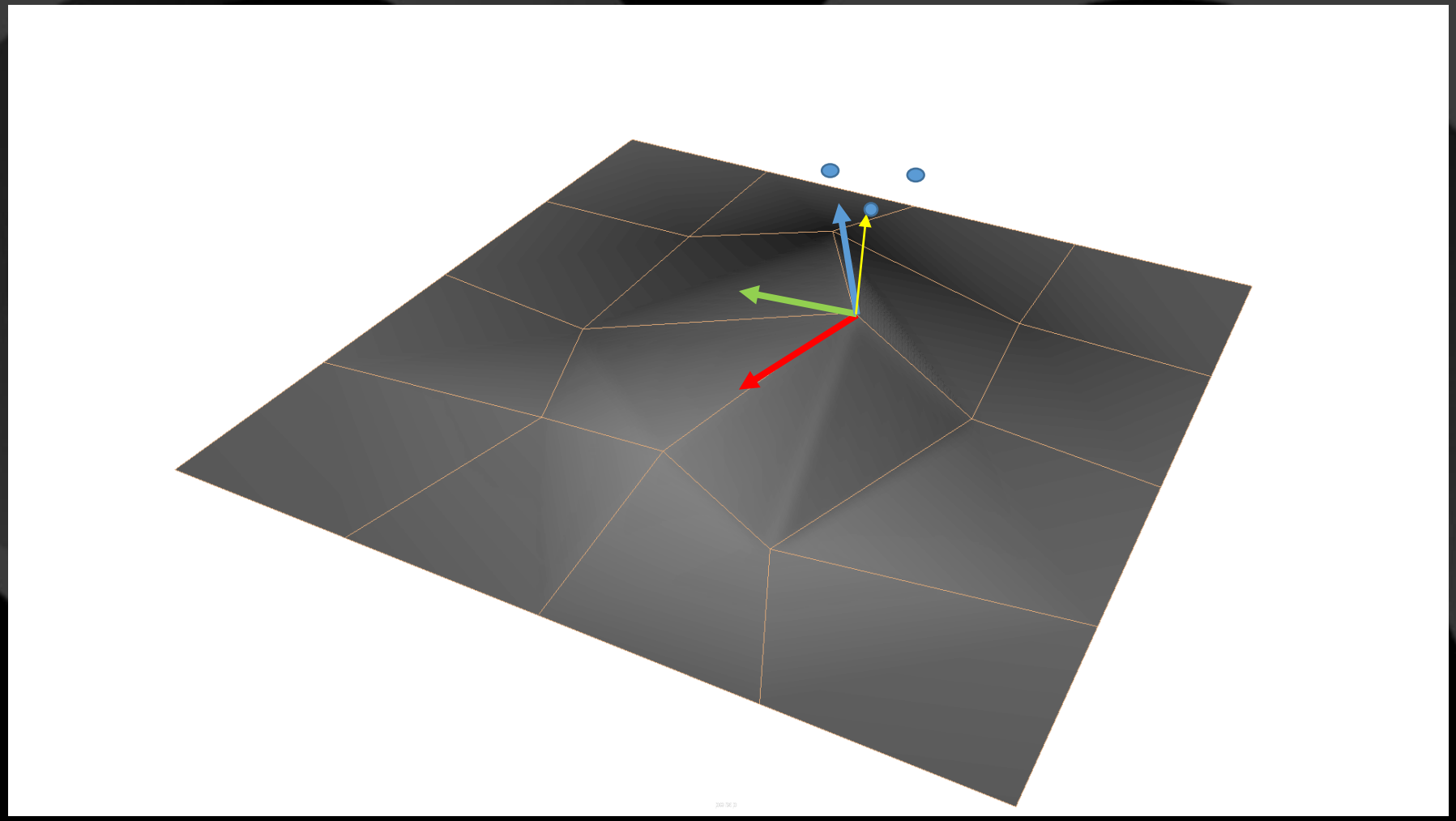
Restore local delta 1 in world space



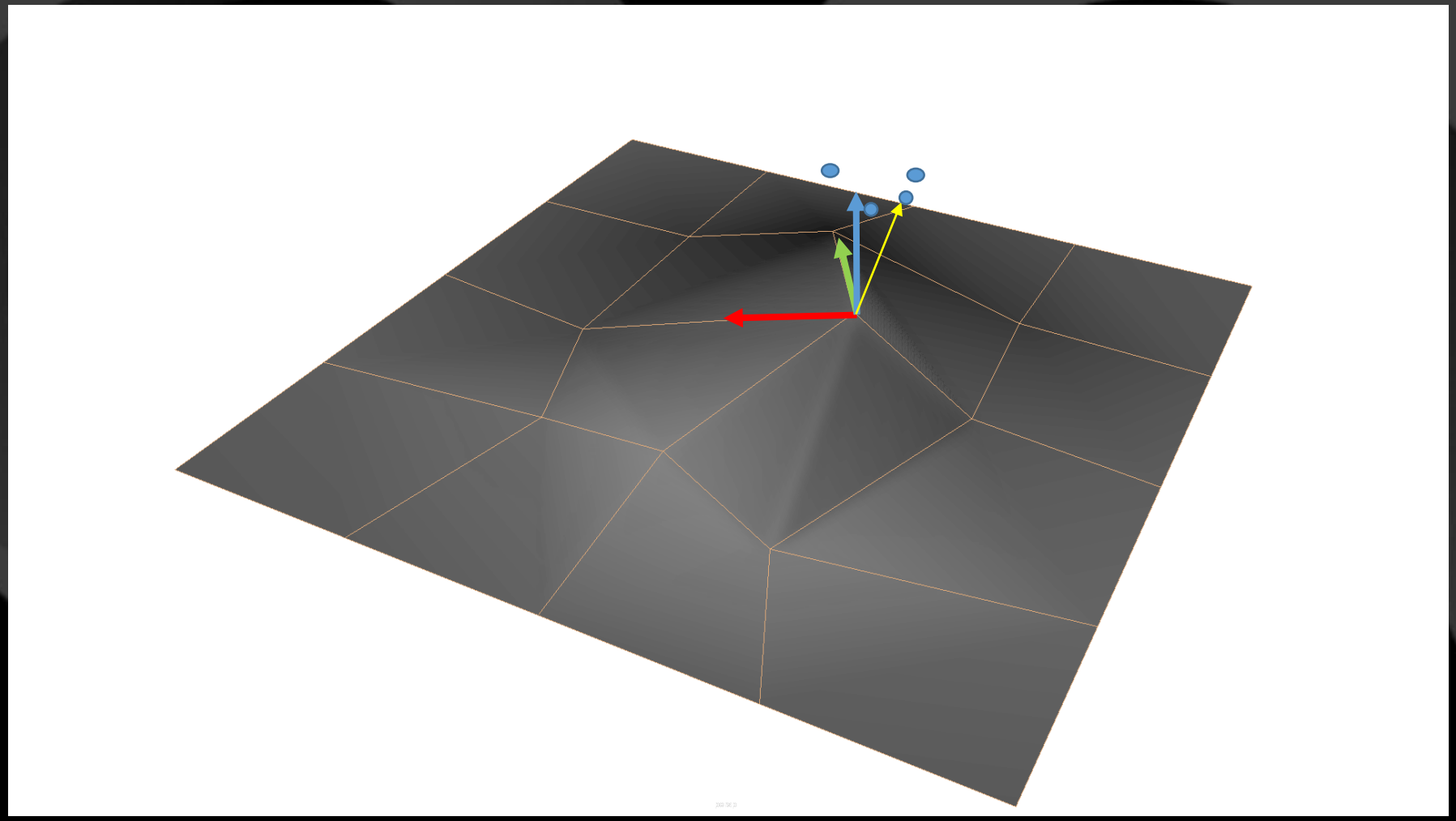
Restore local delta 2 in world space



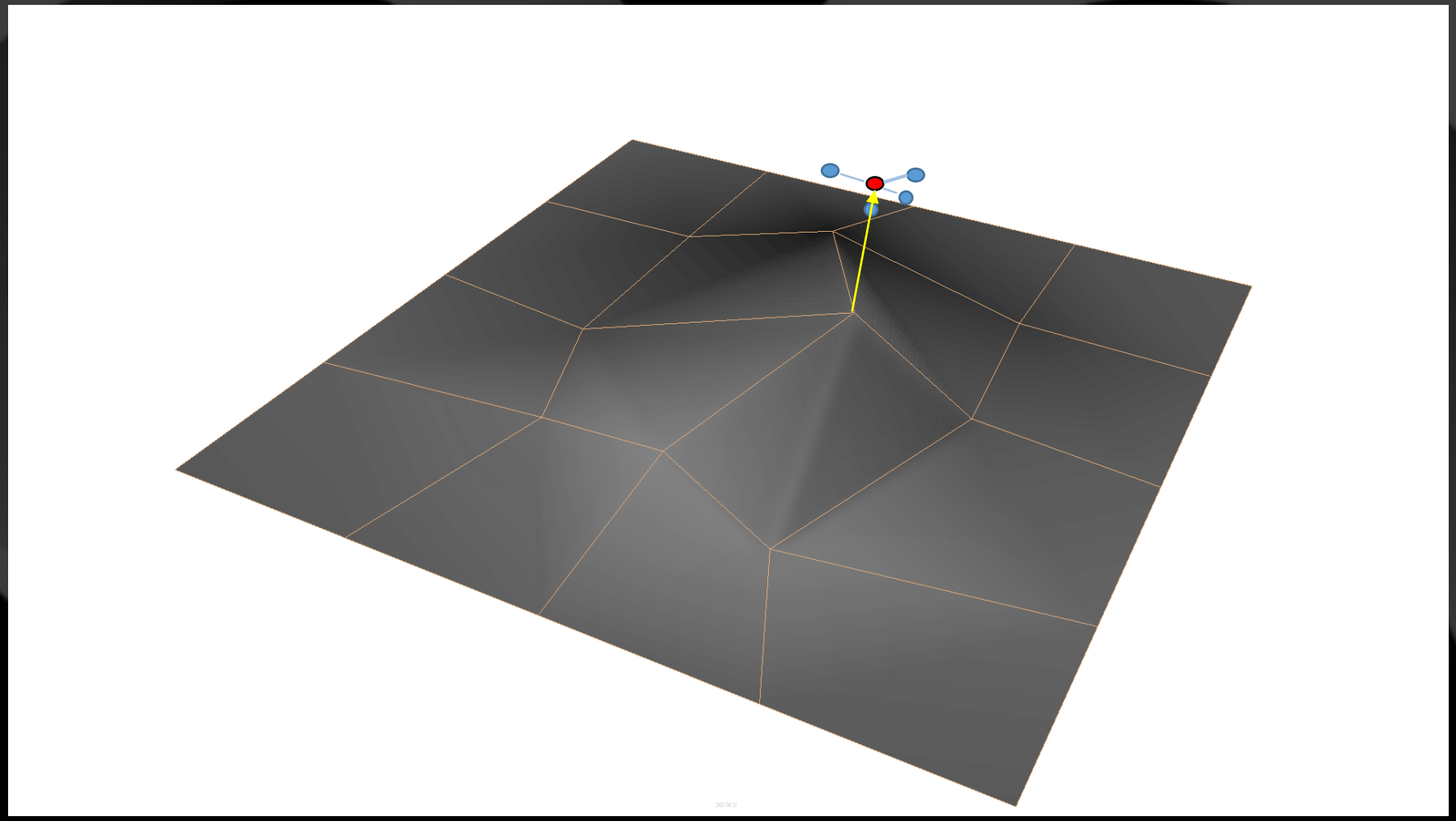
Restore local delta 3 in world space



Restore local delta 4 in world space



World delta is average of previous deltas



Multiple deltas VS classical simple delta

- More stability when restoring a sculpt
- Single delta technique failed with :
  - Huge tangential displacements (skin sliding)
  - Hard polygon deformation of target model

Sculpt wrapping efficiency

- Geometry post process
- Can be applied on current shape independently of previous deformations
- Sculpts are additive, orderless
- Good visual results when applied on animated model
- Good stability even with extreme deformation and polygon stretching

Shape Analysis

- Kind of point cloud comparaison
- Similarity factor between
  - Reference shape of correction
  - Current shape of animated model

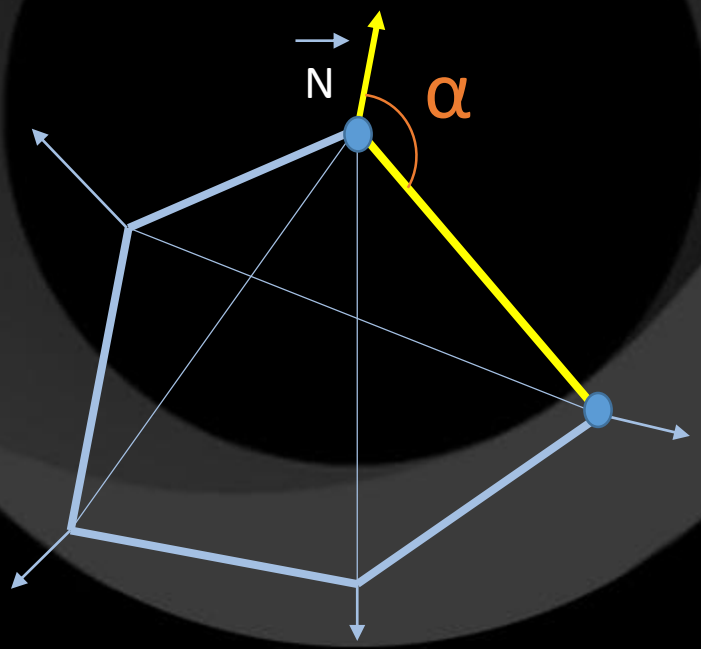
Shape analysis

Data needed :

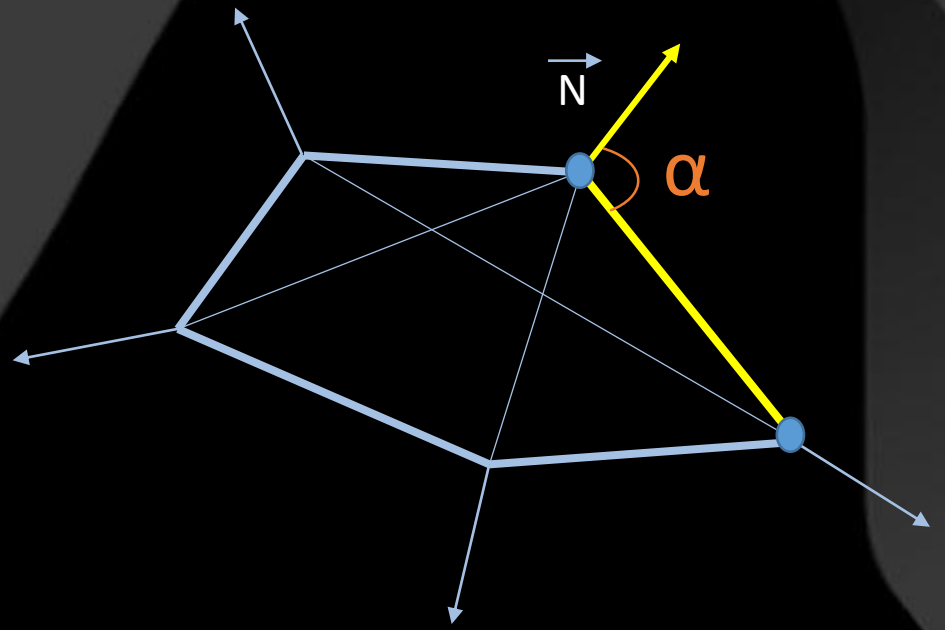
- A reference shape (the *wrong* shape to recognize)
- Current animated shape
- A set of vertices to analyse
  - Vertices moved by correction
  - User defined recognition zone

Angular variation of each possible vertex pair

- Reference shape

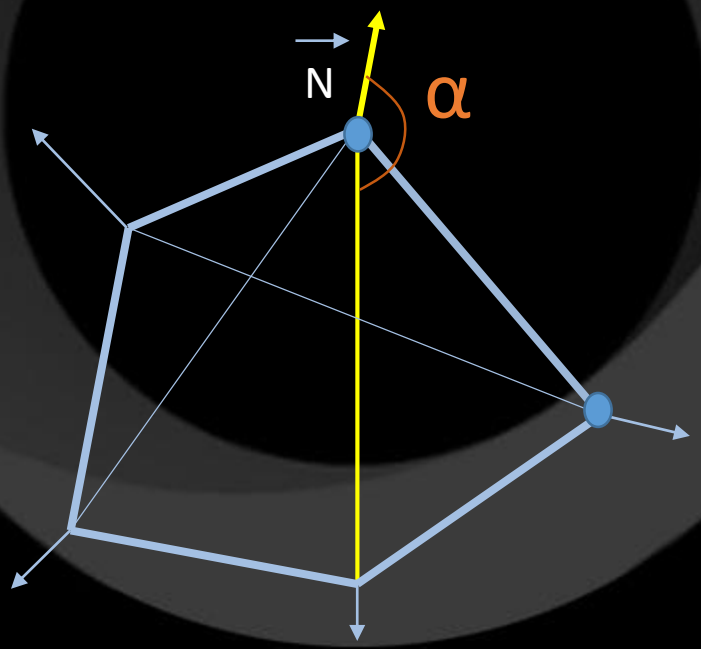


- Current shape

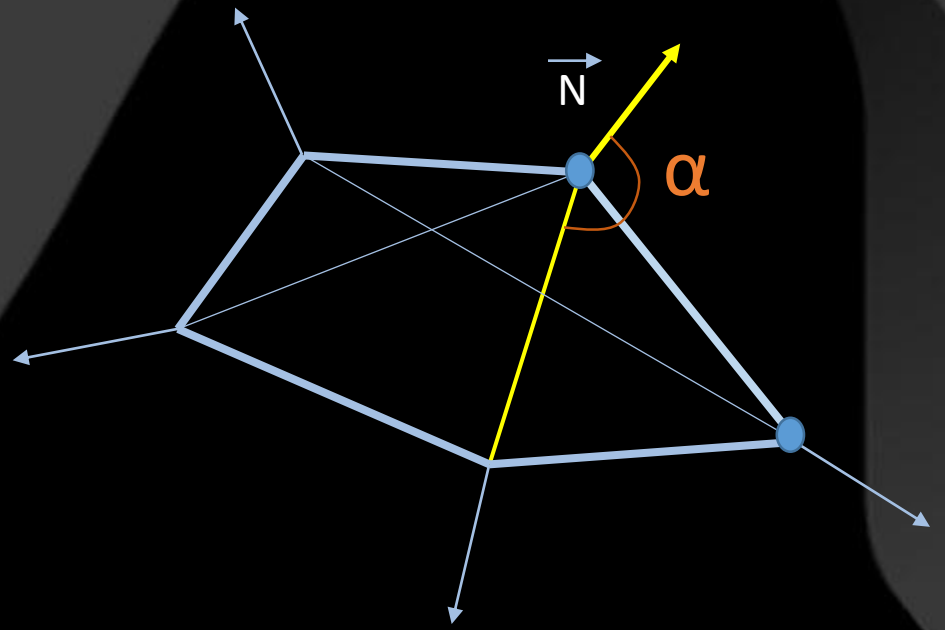


Angular variation of each possible vertex pair

- Reference shape

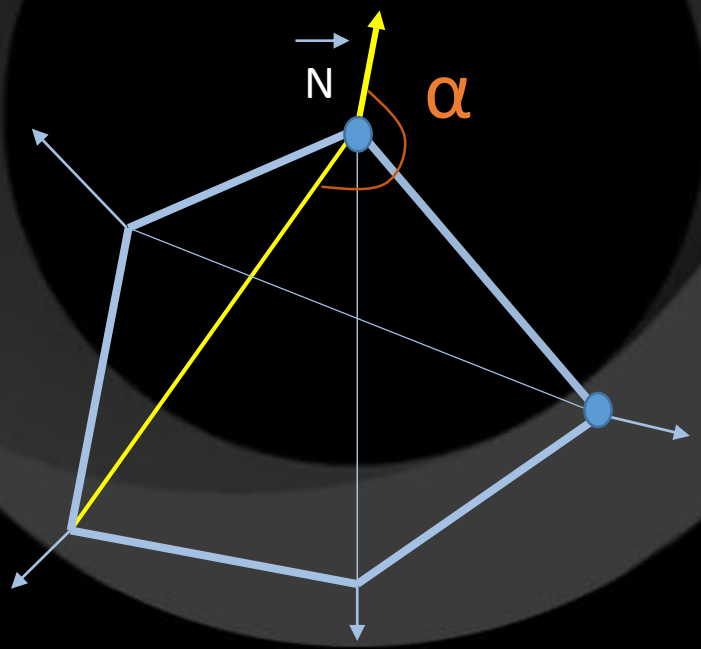


- Current shape

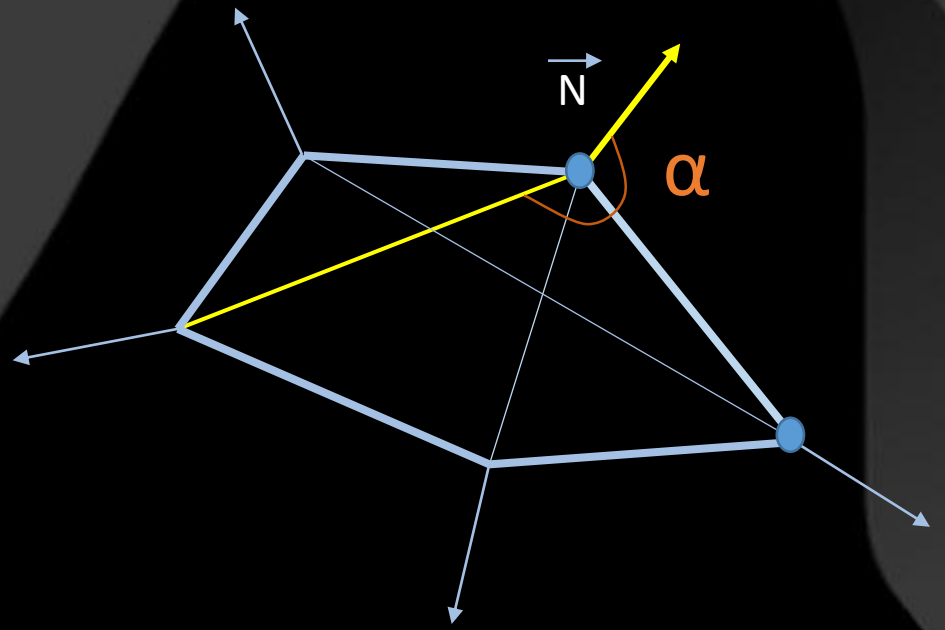


Angular variation of each possible vertex pair

- Reference shape

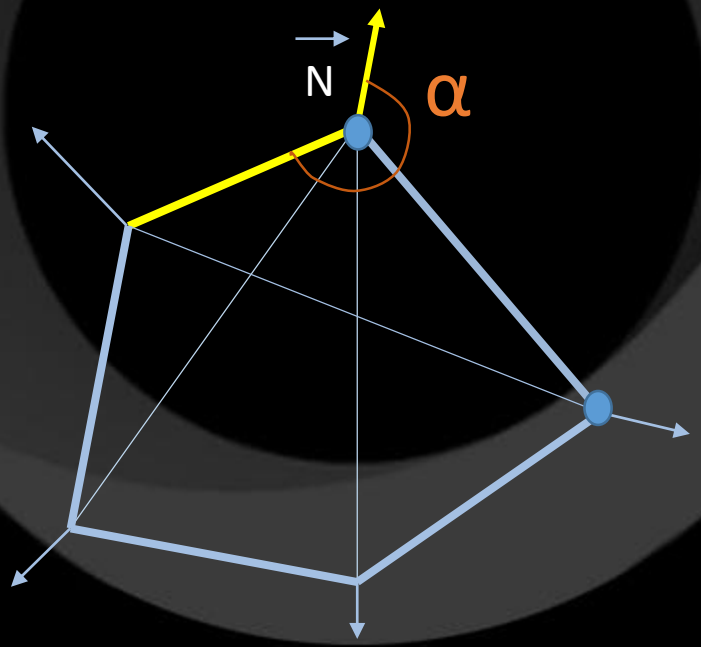


- Current shape

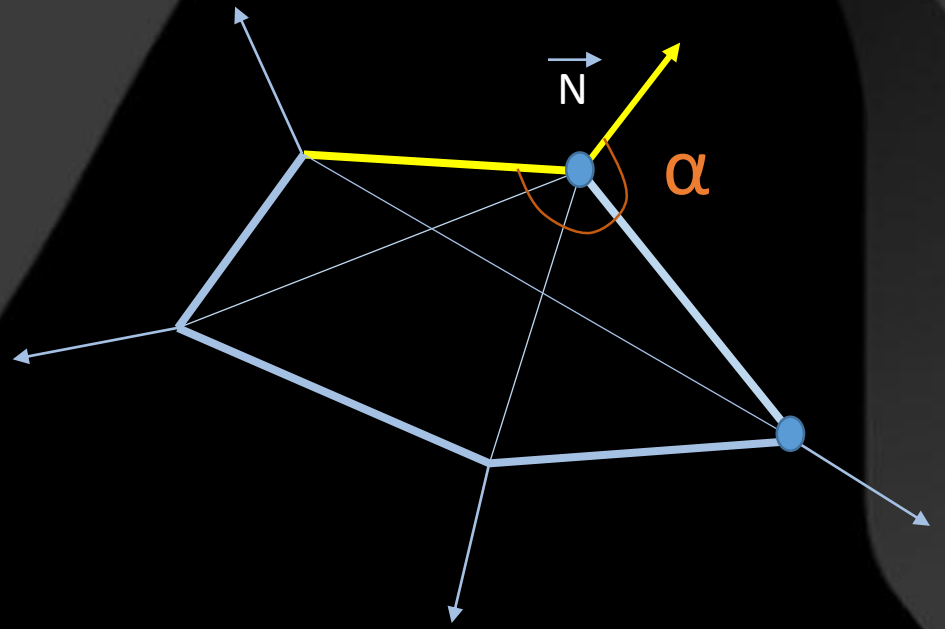


Angular variation of each possible vertex pair

- Reference shape



- Current shape

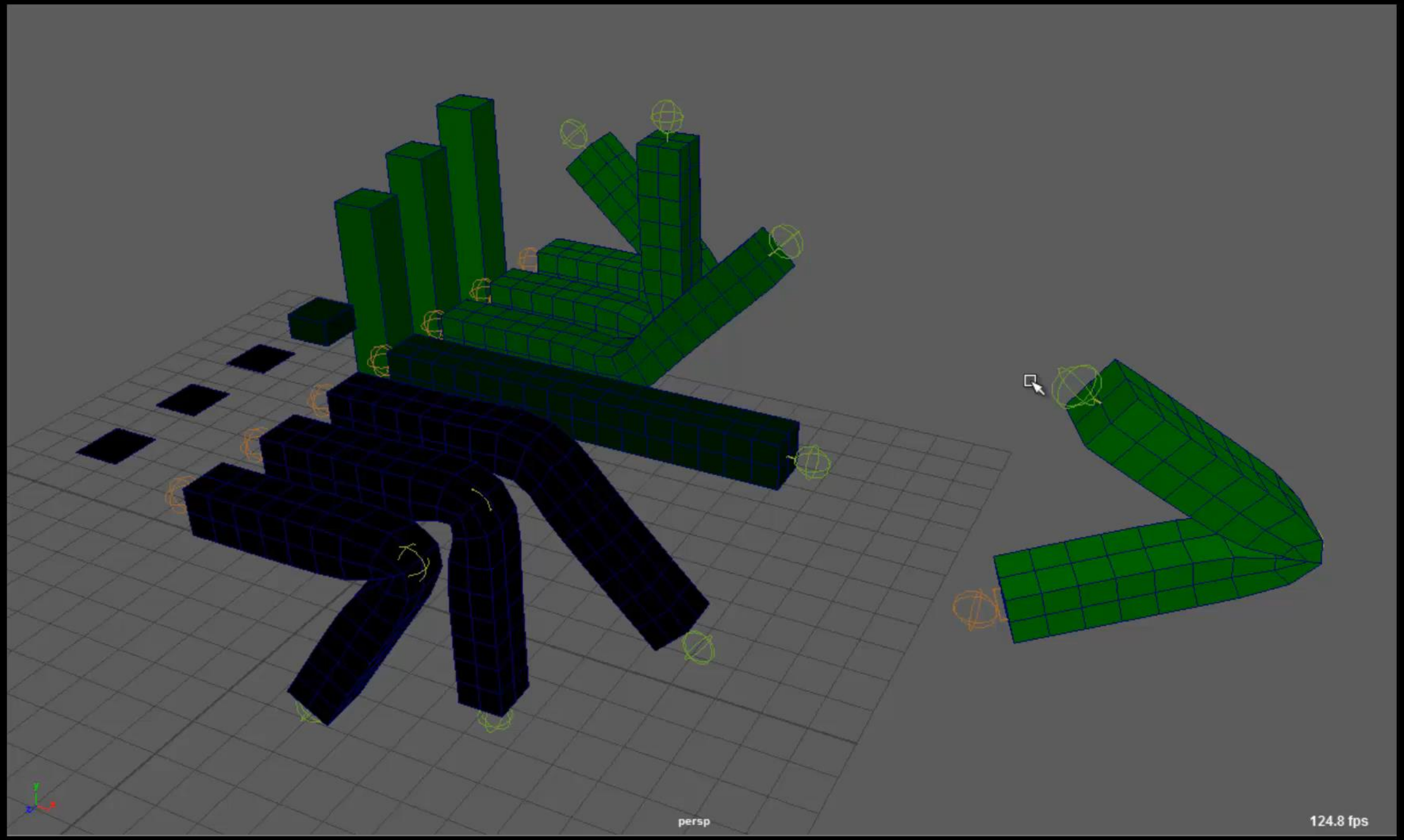


$$D_{ij} = 0.5 * \left| \left(\widehat{Vc_i - Vc_j} \right) \cdot \vec{Nc_i} - \left(\widehat{Vr_i - Vr_j} \right) \cdot \vec{Nr_i} \right|$$

$$Similarity = 1.0 - s * \left(\frac{\sum_{i=0}^{n-1} \sum_{j=i+1}^{n} {D_{ij}}^{p}}{\frac{n*(n-1)}{2}} \right)^{\frac{1}{p}}$$

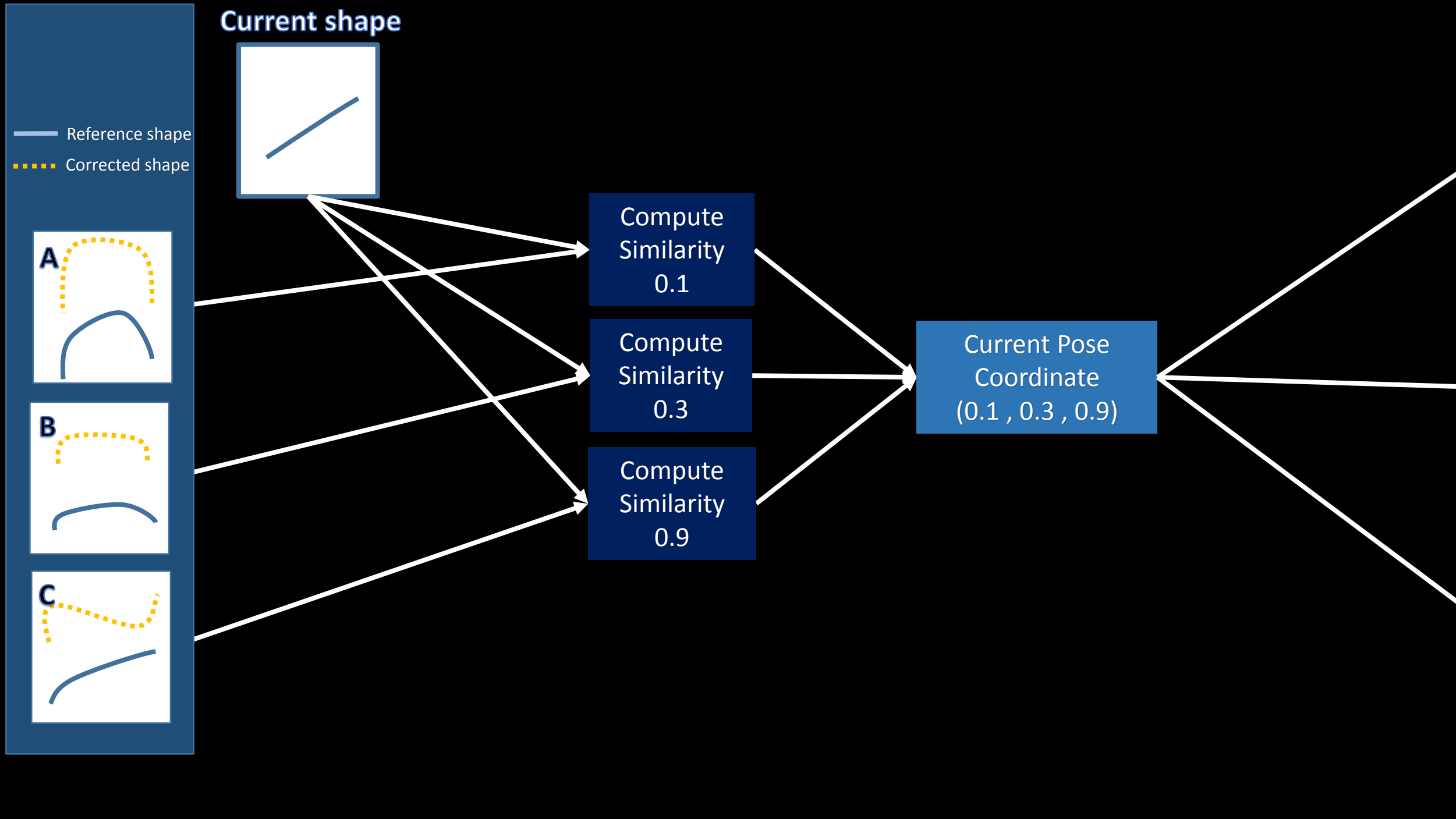
N = vertices count
Vc = current vertex position
Vr = reference vertex position
s = scale factor (user tuning)

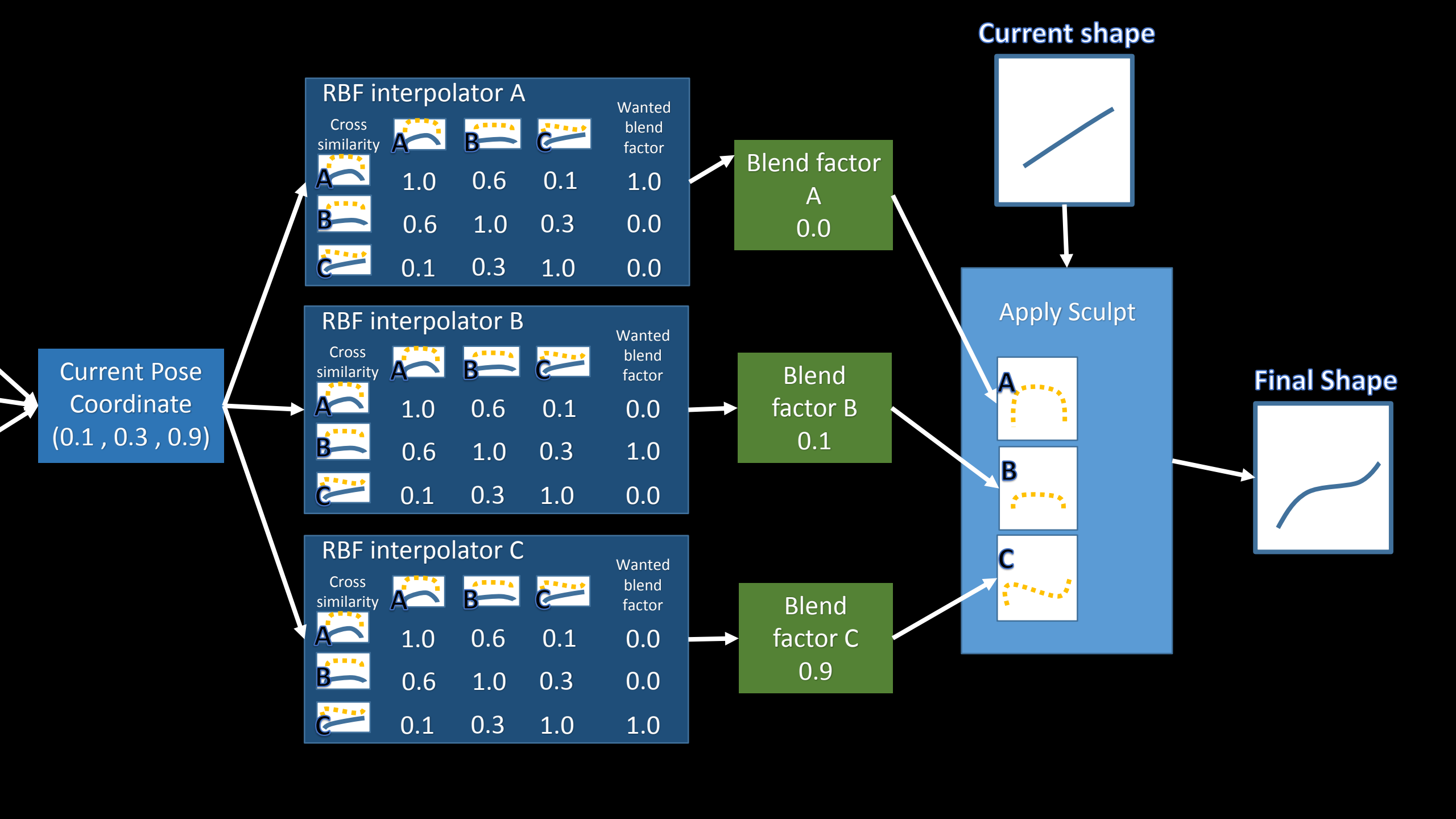
Nc = current vertex normal
Nr = reference vertex normal
P = power mean factor (for user tuning)


persp
124.8 fps

Combine Shape Analysis with PSD ?

We need a
POSE SPACE
for
‘Pose Space Deformation’


Current shape
Reference shape
Corrected shape
A
B
C
Compute Similarity 0.1
Compute Similarity 0.3
Compute Similarity 0.9
Current Pose Coordinate (0.1 , 0.3 , 0.9)

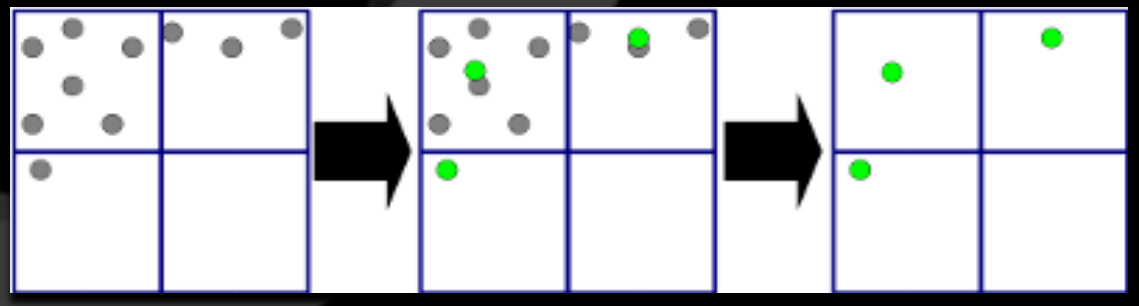

Current shape
RBF interpolator A
Cross similarity
A
B
C
Wanted blend factor
A 1.0 0.6 0.1 1.0
B 0.6 1.0 0.3 0.0
C 0.1 0.3 1.0 0.0
RBF interpolator B
Cross similarity
A
B
C
Wanted blend factor
A 1.0 0.6 0.1 0.0
B 0.6 1.0 0.3 1.0
C 0.1 0.3 1.0 0.0
RBF interpolator C
Cross similarity
A
B
C
Wanted blend factor
A 1.0 0.6 0.1 0.0
B 0.6 1.0 0.3 0.0
C 0.1 0.3 1.0 1.0
Current Pose Coordinate (0.1 , 0.3 , 0.9)
Blend factor A 0.0
Blend factor B 0.1
Blend factor C 0.9
Apply Sculpt
A
B
C
Final Shape

Realtime performance

- Use OpenCL on workstation
- Use Intel OpenCL driver on farm
- Working Buffers are mostly stored on GPU
  - Corrections deltas
  - Vertex connectivity
  - Vertex normals
  - tangent matrices, etc…

Shape analysis with GPU

- Two stages parallel reduction algorithm
- Preprocess a reduced set of vertices to analyse
  - Precompute vertices decimation with a 3D grid



Conclusion

- Sculpt wrapping vs blendshapes or corrective blendshapes.
  - Less intermediate sculpting
  - Good visual results and stability
- Shape regognition
  - Fast shape fixes and refinement without any driver
  - Requires minimal user skills
- PSD for facial and body rig correction require more advanced user skills

Many thanks for coming

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www.onanimationstudios.com/technology