Multiresolution Mesh Morphing

Aaron W.F. Lee, David Dobkin, Win Sweldens,
Peter Schroder

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Outline

- Introduction
- Previous Work
- Contribution
- Correspondence Map
- Metamesh
- Results
- Conclusions and Future Work

Introduction

- Metamorphosis(morphing) is the process of gradually changing a source object through intermediate objects into a target object.
- Advances in 3D scanning and acquisition technology have made dense triangle meshes popular as representations of complex objects.
- For boundary representations, the key problem is to find *vertex correspondence*.

Introduction - Vertex correspondence

- 1. Projection
- 2. Resample
- 3. Geometry Surface
- 4. Two dimensional correspondence

Previous Work

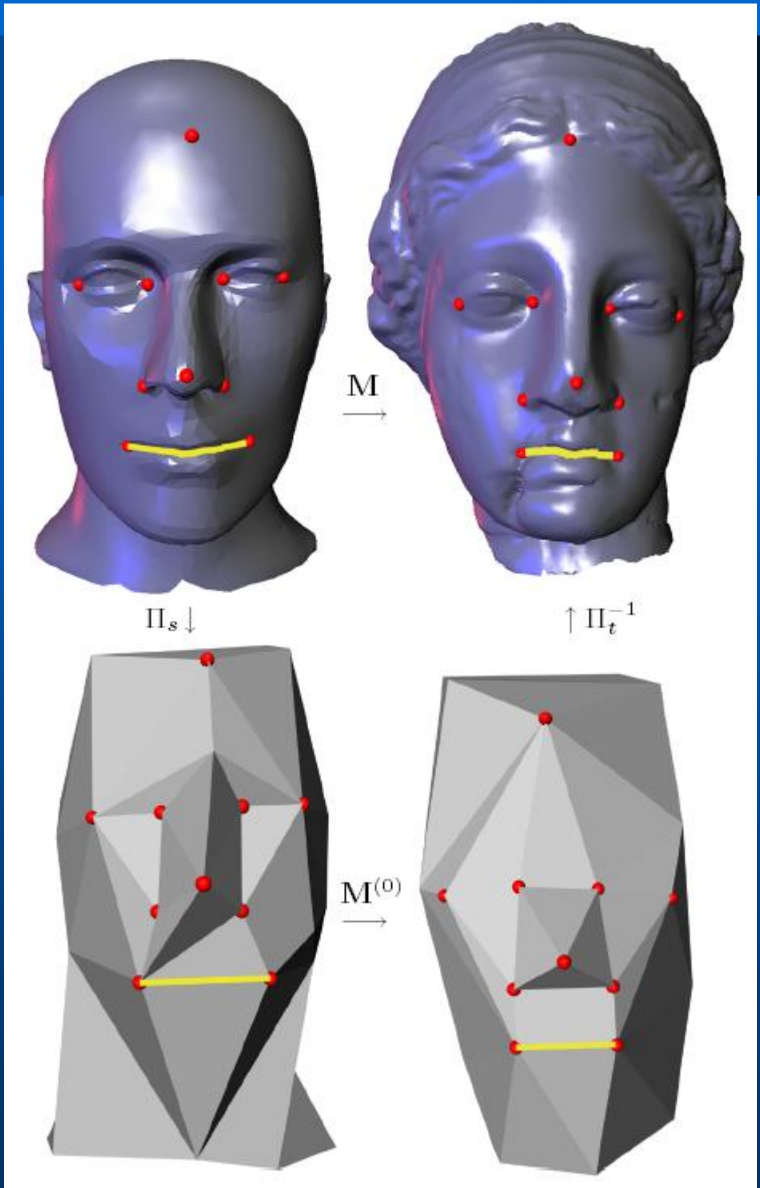
- Gregory, State, Lin, et al. 1998
  - Give a method that allows the user to specify pairs and then decompose the polyhedron into patches.
- Kanei et al. 1998, 2000
  - By overlapping source and target embedded meshes, they establish correspondence between vertices of two meshes.
- Drawback: The user has to outline all patches

Contribution

- Dense correspondences for arbitrary meshes.
  - The only requirement: two meshes should be topologically equivalent.
- Fine and coarse user control.
  - Fine control: one can simply mark feature points or lines on each mesh (original mesh) and pairing them up.
  - Coarse control: Modifying the mapping between the coarse source and target domains (moving corresponding vertex)

Correspondence Map

- Overview of the correspondence map computation.



- Π_s and Π_t^{-1} are computed using MAPS
- $M = \Pi_t^{-1} M^{(0)} \Pi_s$

Correspondence Map - Computing $M^{(0)}$

- Globally align the source and target base domains and project the source base domain to the target base domain.
- Apply an iterative relaxation procedure to improve the mapping.
- User adjustment of the coarse correspondence to produce the final mapping.

Correspondence Map - Global alignment

- Given the feature points, we can directly define their correspondence map as $M^{(0)}(s_i) = t_i$,where s_i / t_i is the feature point of source/target base domain,
- For other points, we use Chen and Medioni's method to globally align the two base domains and then compute a starting guess for $M^{(0)}(s_i)$ as the projection of s_i onto the closest triangle of $\varphi(K_t^{(0)})$
- The initial projection is improved through an iterative relaxation procedure.

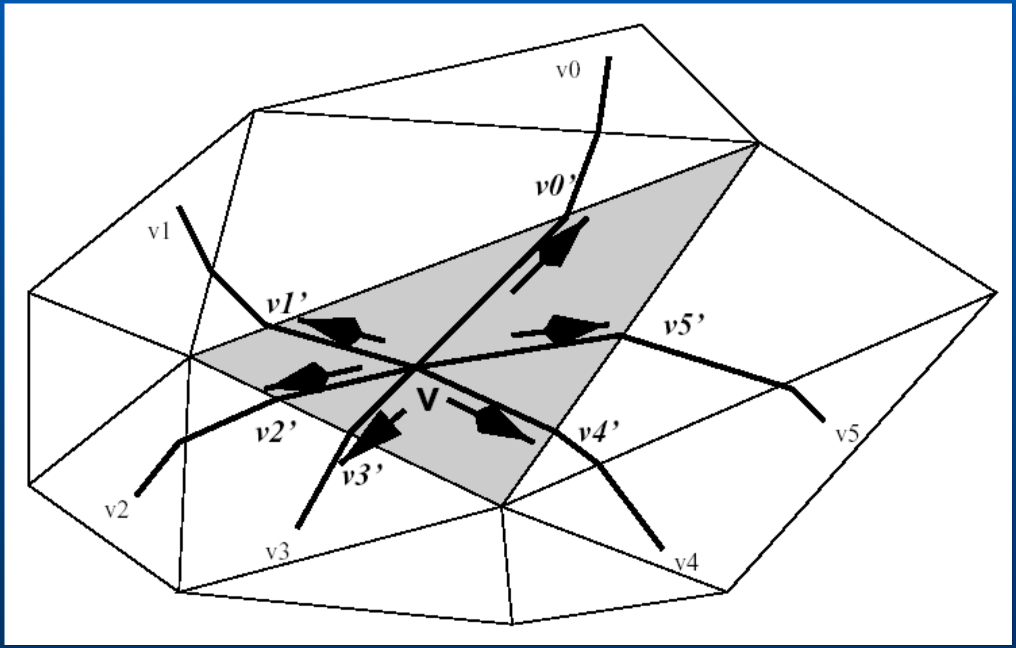
Correspondence Map - Relaxation

- Relaxation of source base domain vertices on the target base domain.

$$\vec{d}_j = \frac{v'_j - v}{\|v'_j - v\|},$$

$$v := (1-\xi)v + \xi \sum_j \frac{\vec{d}_j}{l_j},$$

$$\xi < 1$$



Correspondence Map - Relaxation

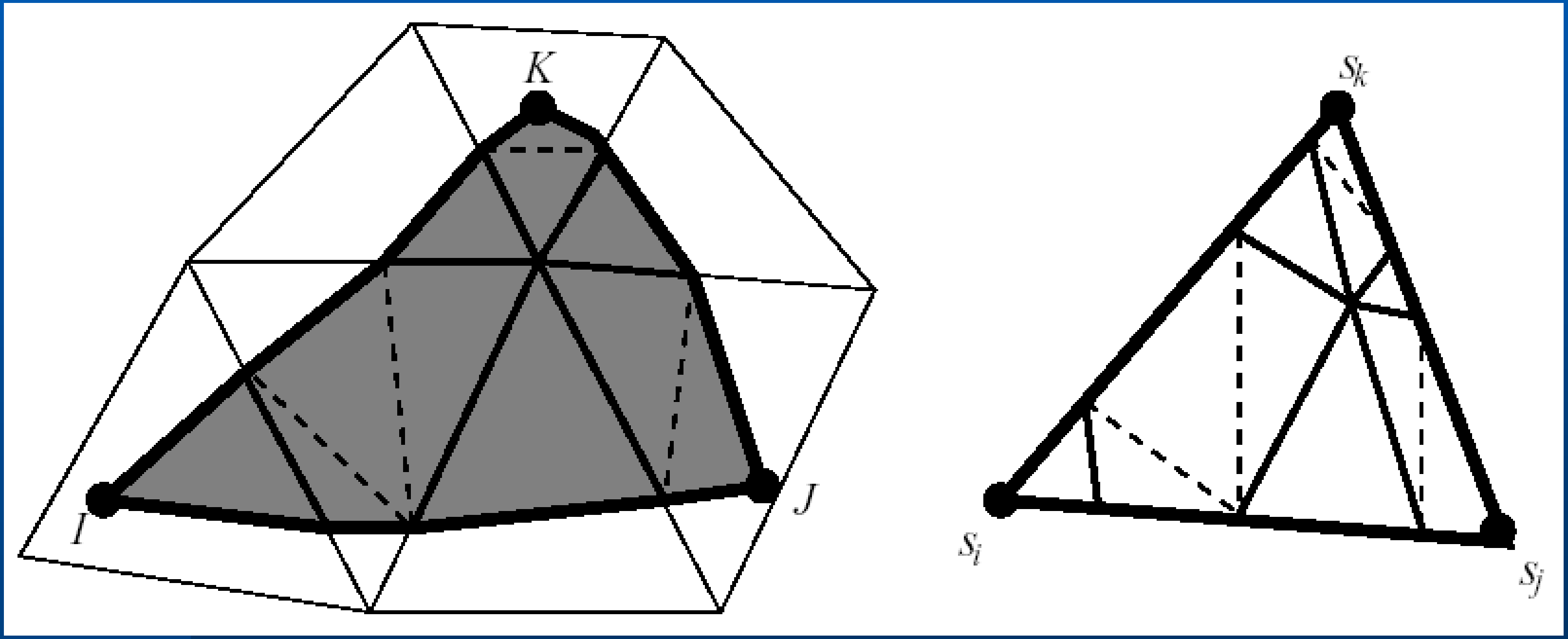
- Assume the guess for $M^{(0)}(s_i)$ lies in a triangle $\varphi(t)$ ($t \in T^{(0)}$) of the target base domain.
- Let $v = M^{(0)}(s_i)$ and v_j = neighbors of v
- Then
  - 1. compute the shortest paths between v and each of the v_j
  - 2. denote their lengths as measured on the mesh by l_j
  - 3. The intersection between the boundary of $\varphi(t)$ and each shortest path is given by v_j'
- The new, relaxed position is illustrated in previous slide.

Correspondence Map - User control

- After relaxation, we get an initial solution to the base domain correspondence.
- Sometimes, the initial solution may not be good enough so we allow user to map a vertex on the source base domain onto any point on the target base domain.

Correspondence Map - Extending $M^{(0)}$

- The source base domain triangle maps to a triangular shaped region (shaded) on the target base domain.



Correspondence Map - Extending $M^{(0)}$

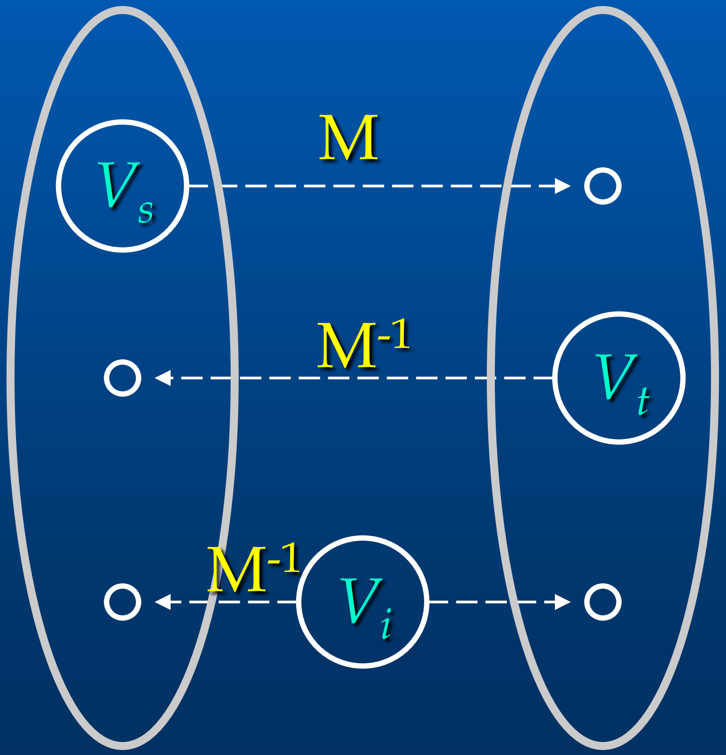
- At this point, we have computed $M^{(0)}$ only for the vertices of $S^{(0)}$.
- For computing the map for *any* point of source base domain, the piecewise linear harmonic map technique of Eck et al. is used.

Correspondence Map - Final map

- Now we can place any source mesh point onto the target using the composition $\Pi_t^{-1} M^{(0)} \Pi_s$
- However, we only get the source vertices placed on the target mesh with the source connectivity.
- So we introduce the the notion of a metamesh.

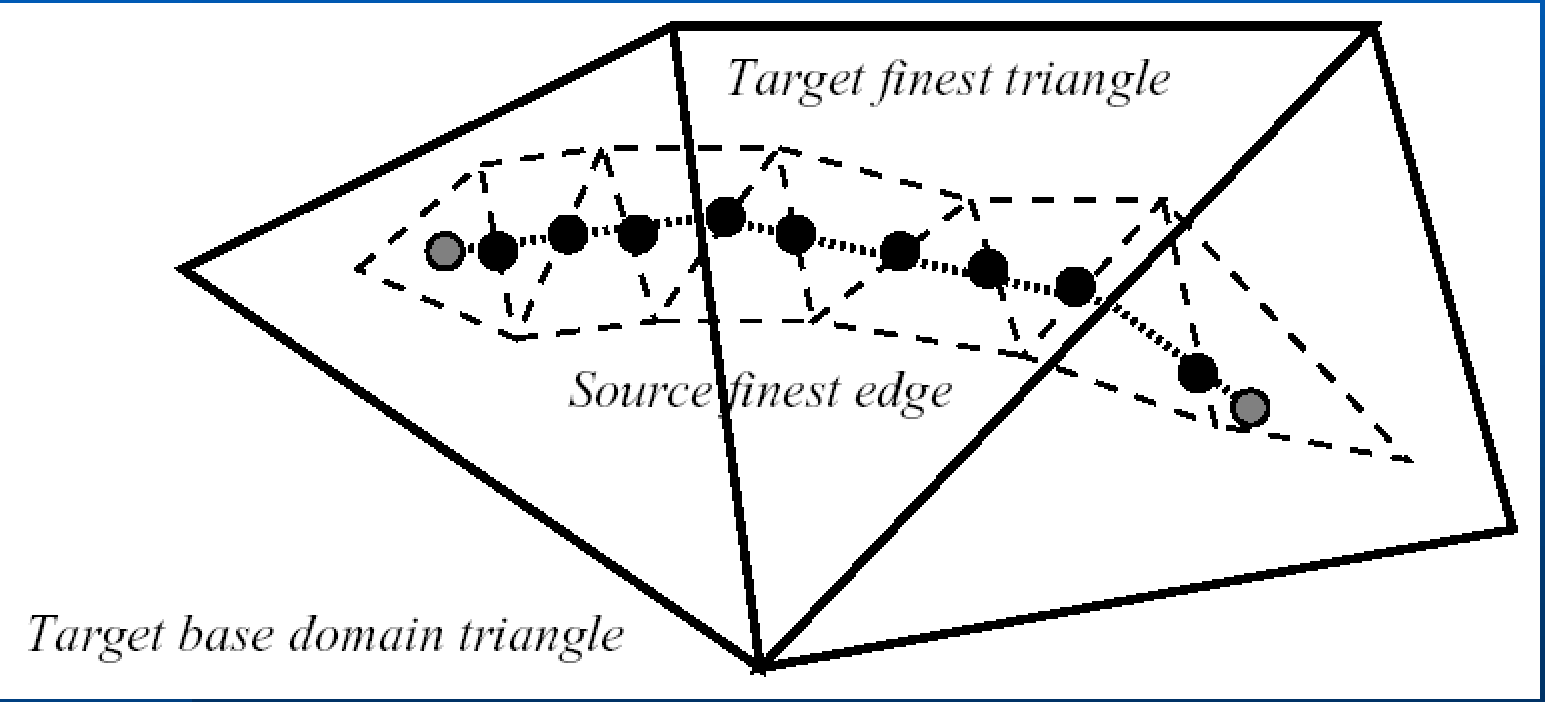
Metamesh

- The purpose of Metamesh (P,K_p) is to combine the source connectivity and target connectivity



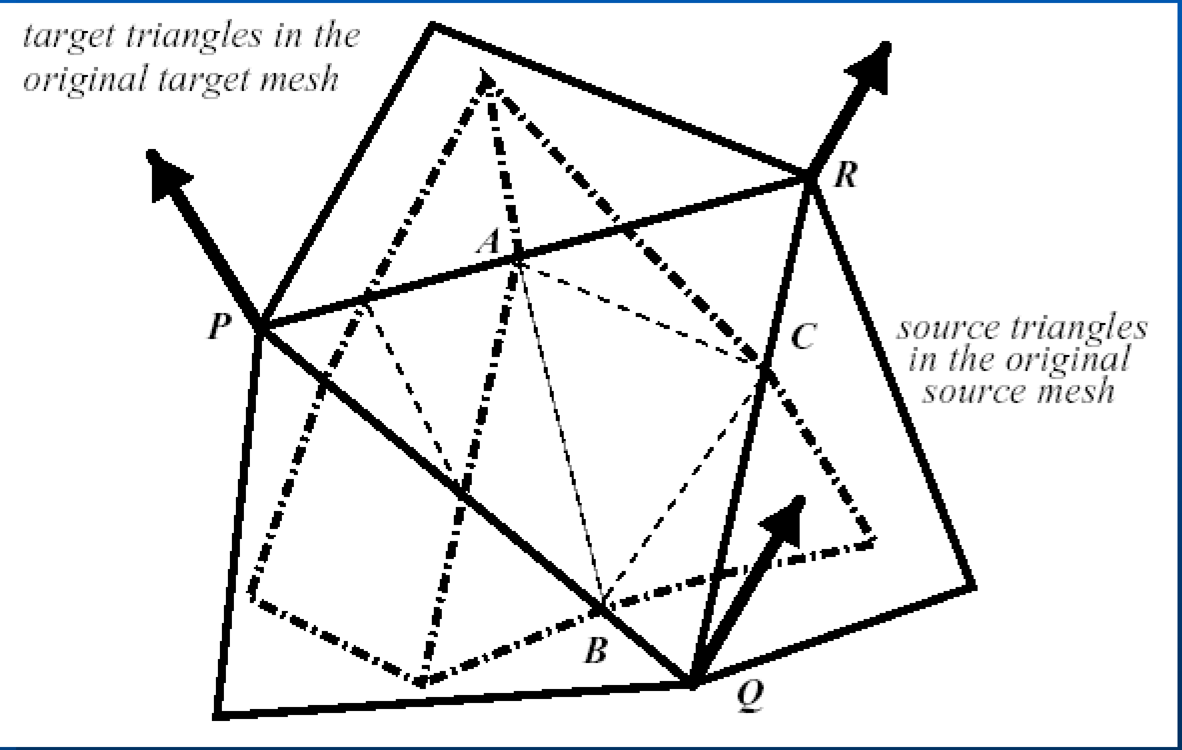
Metamesh

- The intersections define the new vertices of the metamesh



Metamesh

- New vertices in metamesh, A,B,C could get attributes derived from PQR using barycentric interpolation.



Metamesh

- The interpolation scheme
  - Simplest solution

    $$\theta(t) = t$$

  - Gentle fade-in and fad-out

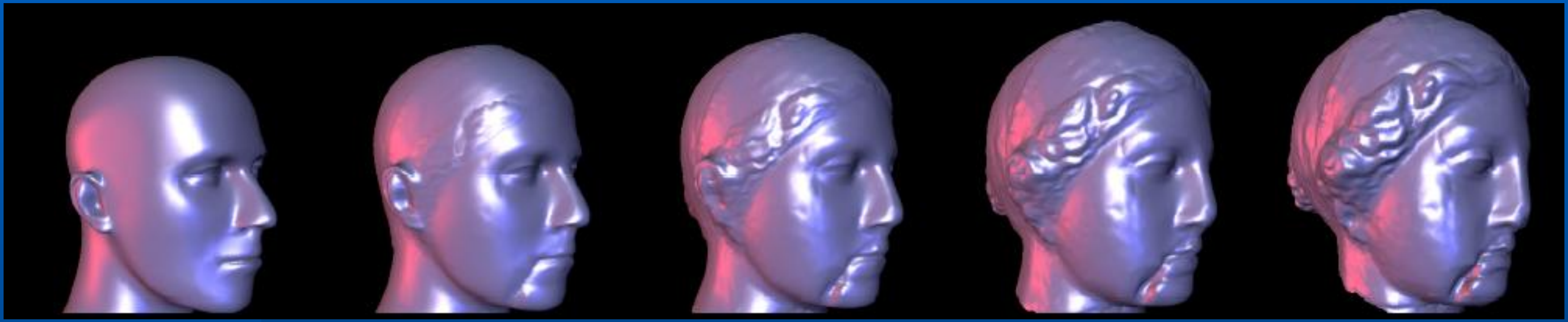
    $$\theta(t) = \tfrac{1}{2} - \tfrac{1}{2}\cos(\pi t)$$

  - Spatial control

    $$\theta(t,i) = x, \text{ with } \{i\} \in K_p$$

Results

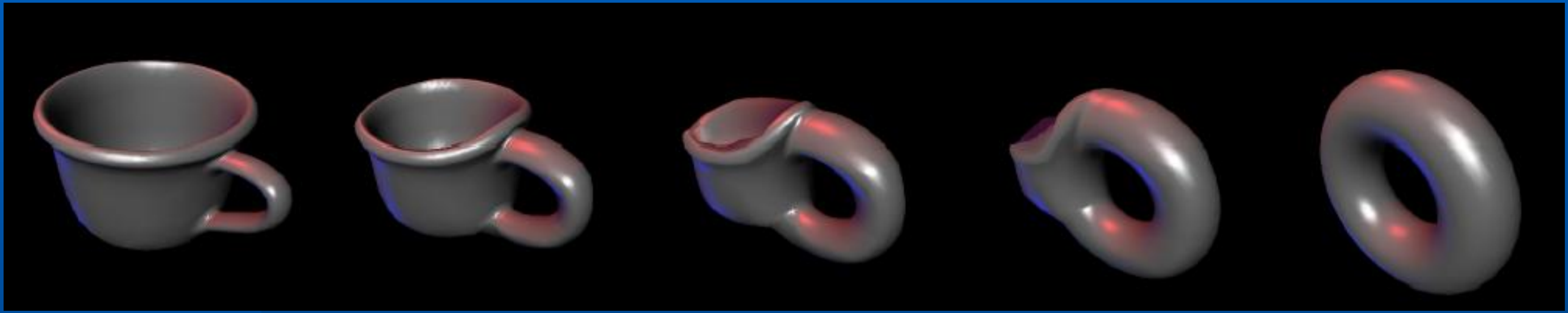
- Mannequin to Venus



Source-Target	Source size (triangles)	Target size (triangles)	Metamesh size (triangles)	Feature pairs	Corresp. map time	Metamesh time	User time
mann-venus	5422	90709	225502	24	3'	19'	5'
cup-donut	8452	2048	43188	30	1'20"	4'	30'
mann-spock	5422	14100	75427	24	1'	7'	5'
horse-rabbit	21130	21582	220201	60	22'	27'	60'

Results

- Cup to Donuts (Genus-1)



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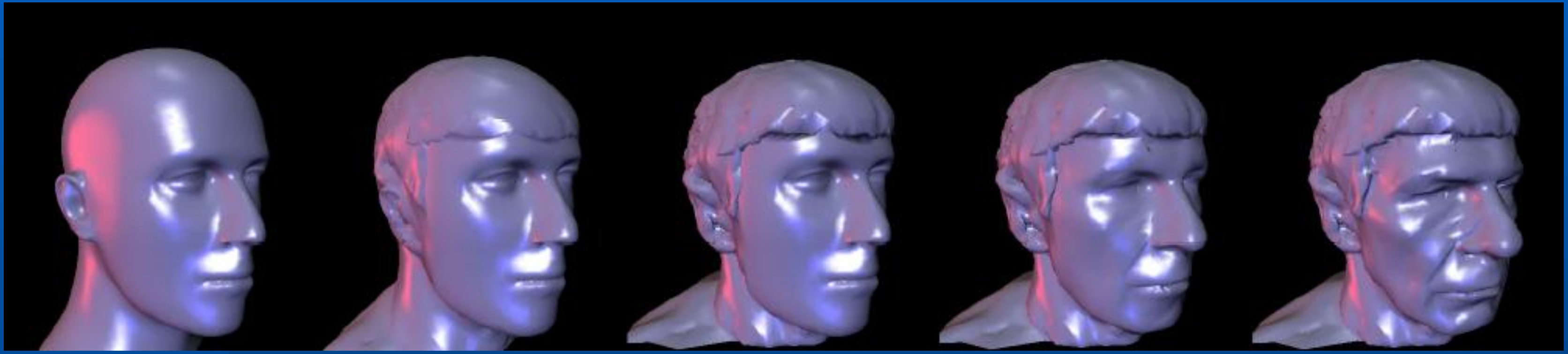
Results

- Mannequin to Spock (Spatial control)



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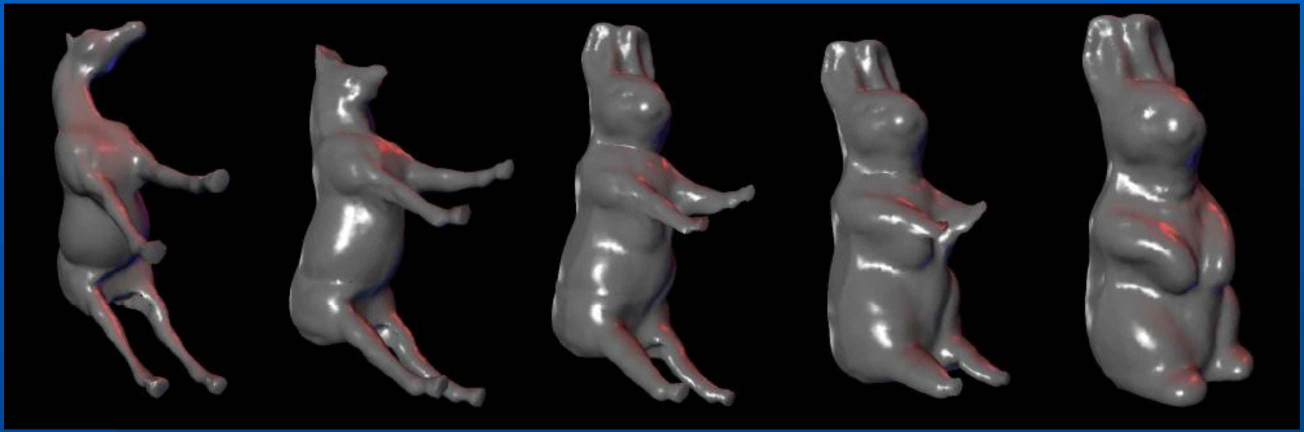
Results

- Horse to Rabbit



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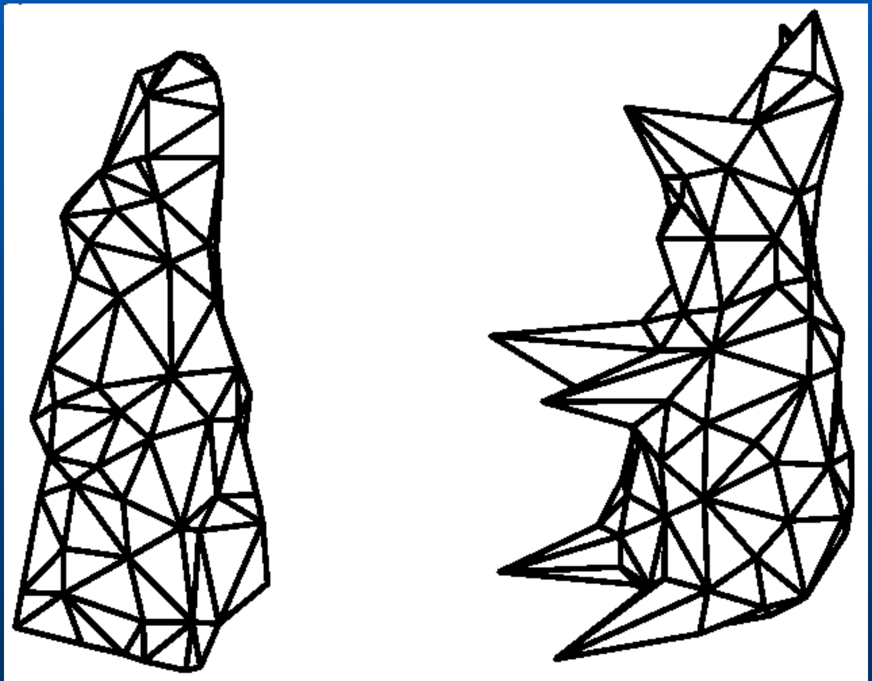
Results

- Modification of the rabbit base domain to more closely match the horse base domain



Conclusions and Future work

- Extending MAPS to deal with genus changes.
- More sophisticated interpolation controls.
- We can compute a wavelet transform on the metamesh.
- Editing the metamesh in certain keyframes.
- More tools to help users guide the correspondence map.