Skeleton Based As-Rigid-As-Possible Volume Modeling

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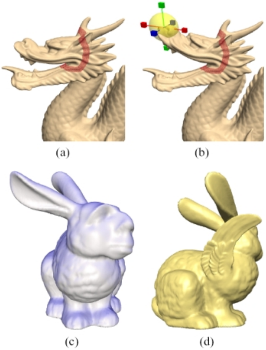
Introduction

- As-rigid-as-possible (ARAP) shape modeling is a popular technique to obtain natural deformations. There have been many excellent methods.



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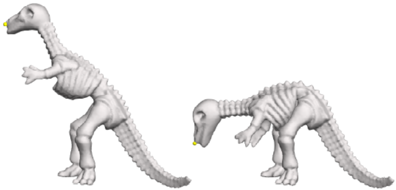

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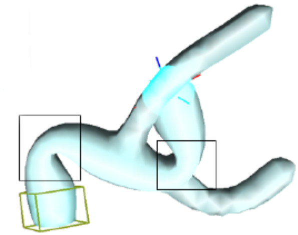

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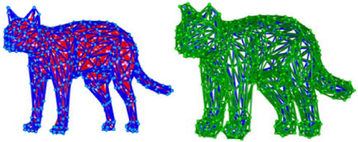
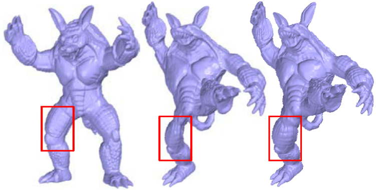
- VGL is a good approach. However, we do not want to break the manifoldness of ARAP surface modeling or sacrificing the speed.





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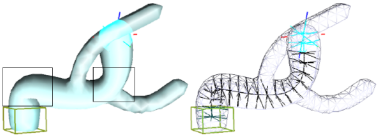
- We do it by leveraging the skeleton information.



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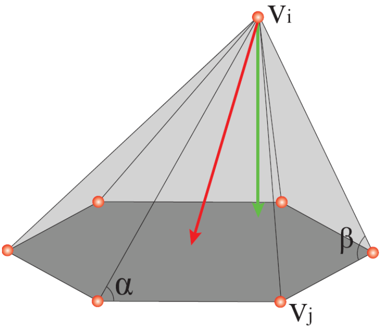
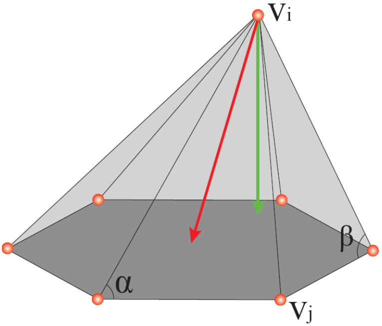
Linear LSE with C^0 continuity

- Laplacian coordinates represent each point as the weighted difference between such point and its neighborhoods.



Linear LSE with C^0 continuity

- Laplacian coordinates represent each point as the weighted difference between such point and its neighborhoods.
- Given original coordinates V, the connectivity, and m control points, the reconstructed object V' can be obtained by minimizing: $\|LV' - \delta\|_2^2 + \Sigma_{i=1}^{m}\|v'_{c_i} - v_{c_i}\|_2^2$



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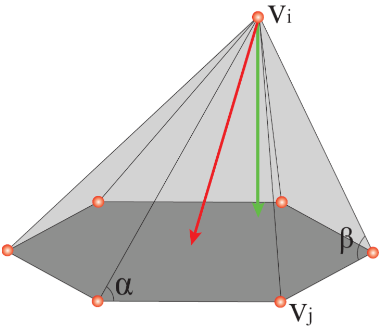

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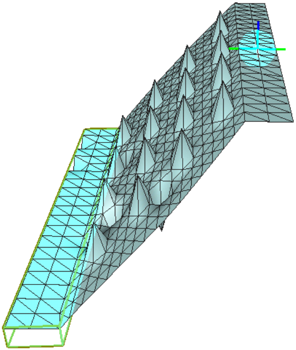

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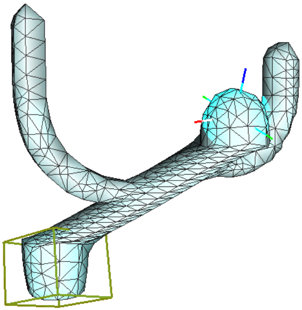

Rotation and edge length constraints

- Iterate two steps to recover rotations:

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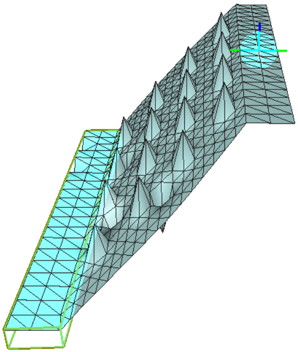

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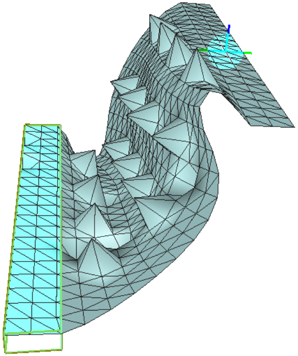

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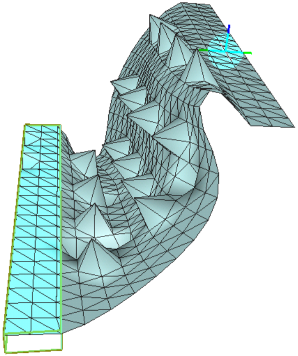
- Robustness, simplicity, efficiency.



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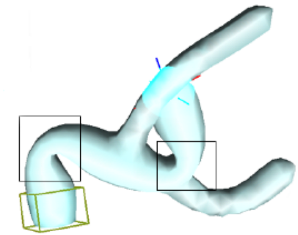
- Robustness, simplicity, efficiency.
- However, there is no volume preserving constraint.



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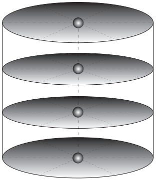

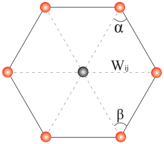

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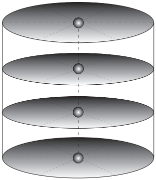

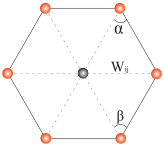

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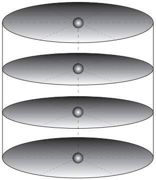
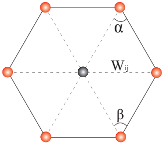
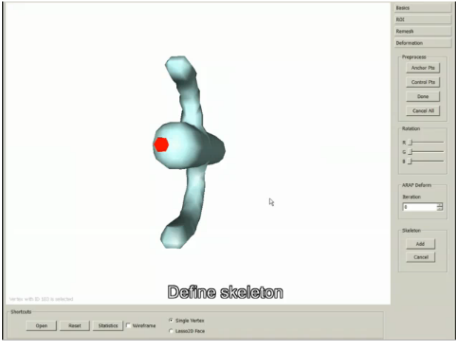
- One-way coupling property.





Mesh editing framework

- Manually define the skeleton.



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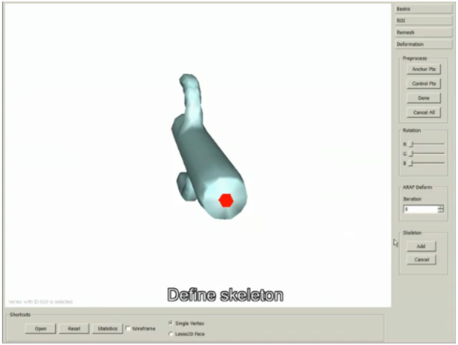
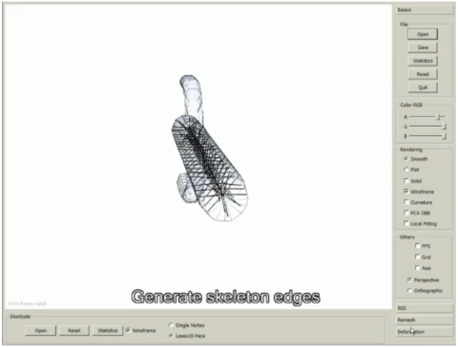


Mesh editing framework

- Manually define the skeleton.
- Evenly generate skeleton points, and connect them with surface vertices automatically.



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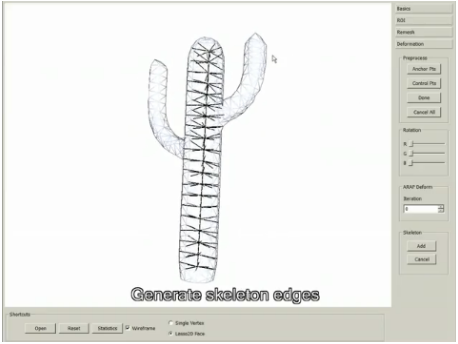

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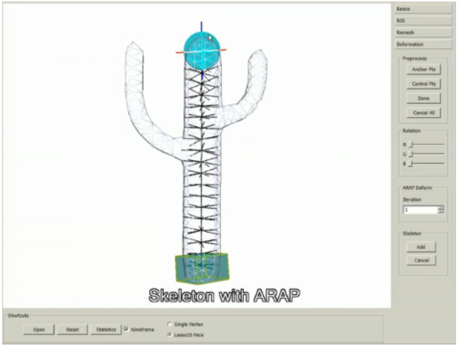
- Manually select anchor points (bottom) and control points (top).



Mesh editing framework

- Manually define the skeleton.
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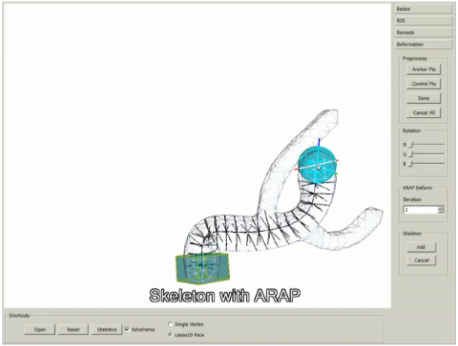
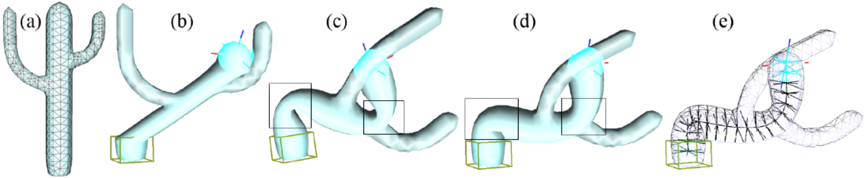
- Manually select anchor points (bottom) and control points (top).
- Interactively deform the shape.



Experimental settings

- The C++ implementation was run on a Intel Core2 Quad 2.40GHz CPU with 8G RAM.
- We compare the linear LSE, ARAP surface modeling and our method.
- We tested on the cactus model (620 vertices, $1,236$ polygons) and the horse model ($2,482$ vertices, $4,960$ polygons).
- The relative root mean square errors of edge lengths and volume magnitudes are reported.

Results



Model	RRMS-E	RE-V	Times
(b)	0.126	0.453	0.017
(c)	0.074	0.131	0.024
(d)	**0.075**	**0.056**	**0.025**

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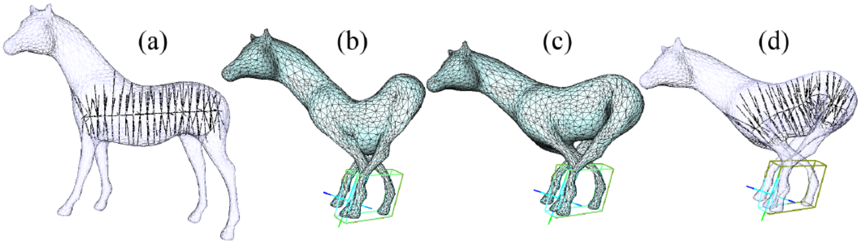

Model	RRMS-E	RE-V	Times
(b)	0.068	0.356	0.117
(c)	**0.040**	**0.125**	**0.121**

Conclusions

- We proposed an approach to approximately preserve the volume without breaking the manifoldness of traditional ARAP or increasing the computational complexity.
- Our method is easy-to-implement and may be useful to systems relying on ARAP techniques.
- Limitations: Skeleton generation; complex skeletons; self intersection.

Thanks for listening.