Surface-Based Deformation for Disconnected Mesh Models

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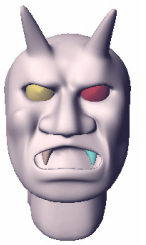
Interactive Deformation for Assembly Mesh Models

Motivations

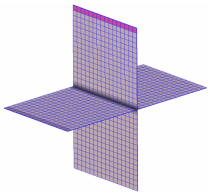
Surface-based deformation encodes geometric shapes using partial differential equations. Since this technique deforms mesh models in an interactive manner, it is useful for editing existing mesh models by trial-and-error.

However, most existing methods cannot be applied to mesh models that include **(1) multiple disconnected components**, **(2) T-vertices**, and **(3) non-manifold edges.** Unfortunately, these conditions commonly appear in mesh models. Our motivation is to develop an editing tool that can consistently deform such models.

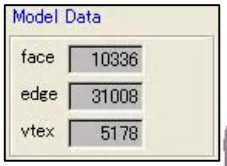


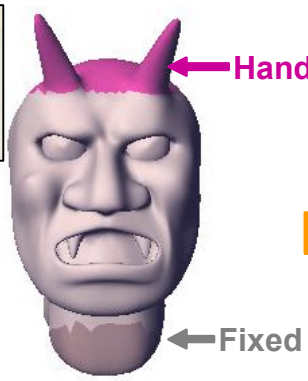
(1) Multiple disconnected components

(2) T-vertices

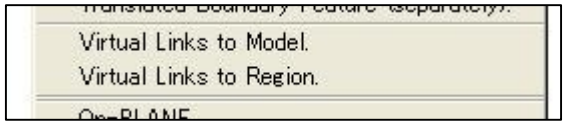


(3) Non-manifold edges





Original model
(5 disconnected parts)

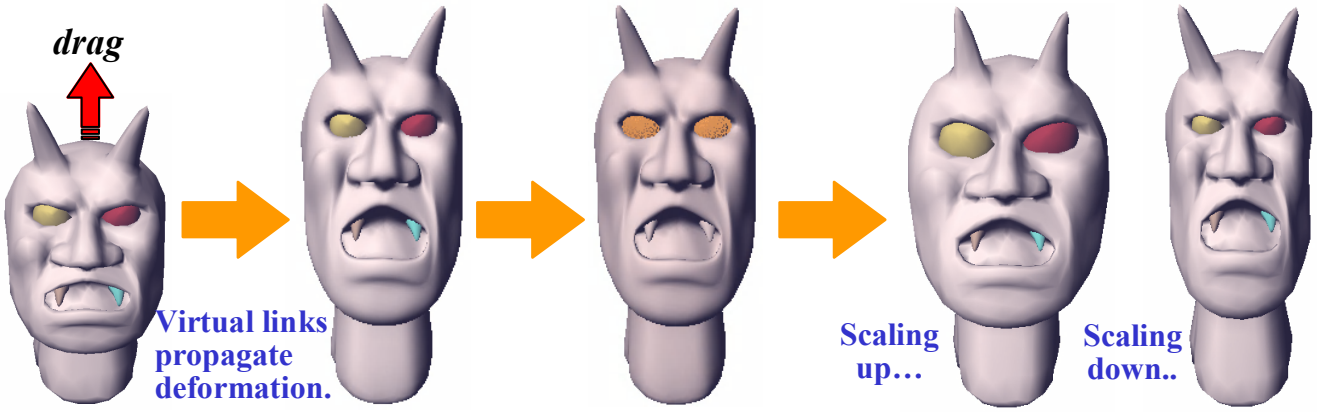


This is command to set virtual links.

"Virtual Links to Model" command
A virtual link is added between a pair of vertices in disconnected components when the distance to the nearest neighbor is less than a certain threshold.

"Virtual Links to Region" command
The user can select a region and locally specify virtual links.

Deformation of disconnected models

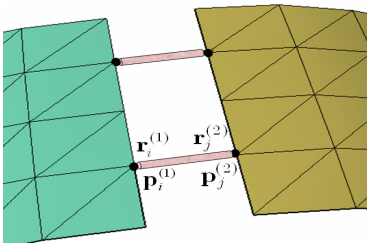


The handle is moved interactively.

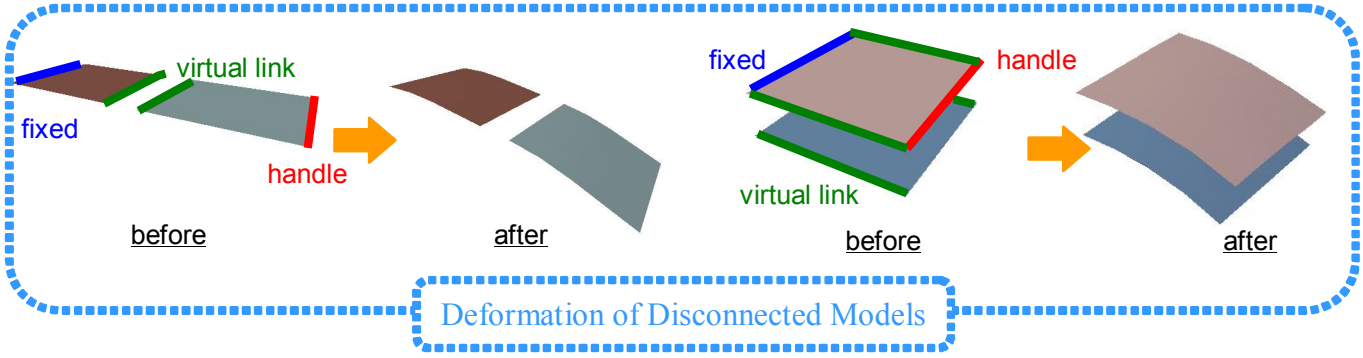
Eyes are scaled interactively.

Constraint propagation

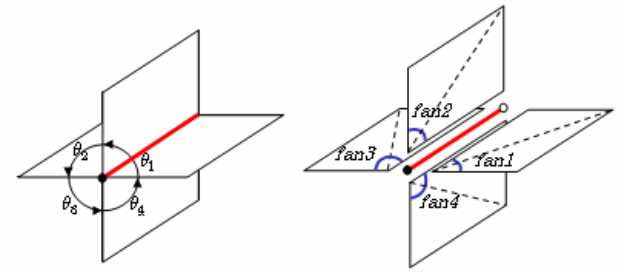
【Virtual Link】

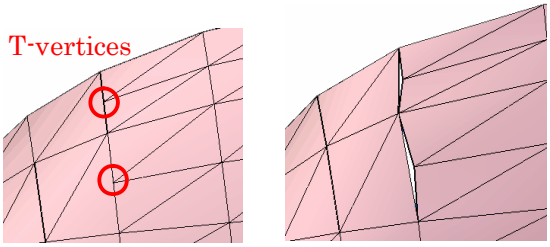


A virtual link is defined between a pair of vertices for propagating constraints between disconnected components. A virtual link preserves the relative positions and directions between the two vertices. These constraints are represented as linear equations and added to a linear system for interactive surface-based deformation.

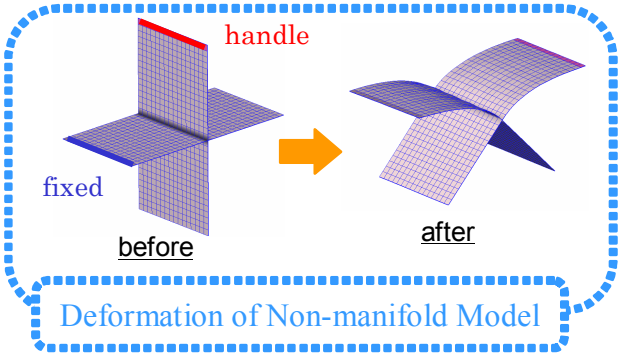


【Non-manifold edges and T-vertices】





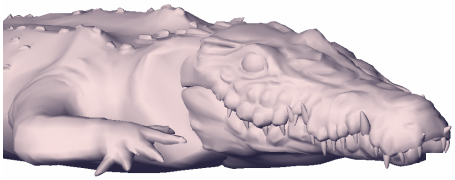
Non-manifold edges: Faces around a non-manifold edge are divided into a set of fans. Each fan is separately encoded so that the angles between adjacent fans are preserved during deformation.
T-vertices: A virtual link is specified at each T-vertex so that the distance between the vertex and the edge becomes 0.

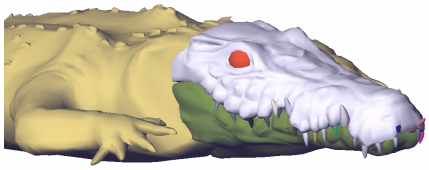


Conclusions

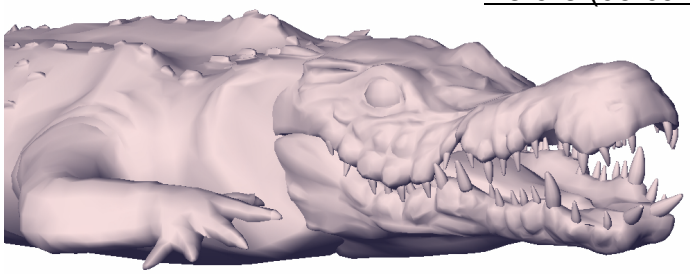
Our framework provides reasonable and various deformed results. Our method is very simple and easy to implement. This method propagates the deformation of one mesh to other disconnected meshes by introducing linear constraints between two vertices on disconnected components. All additional constraints are represented in linear forms and are solved very efficiently using sparse linear system solvers. In future work, we would like to improve the performance by incorporating GPU.

Examples



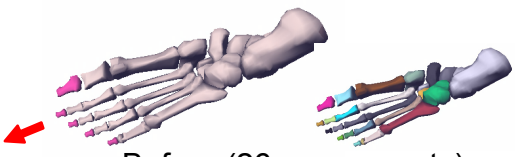


Before (65 components)

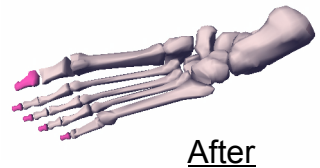


After

Crocodile Model



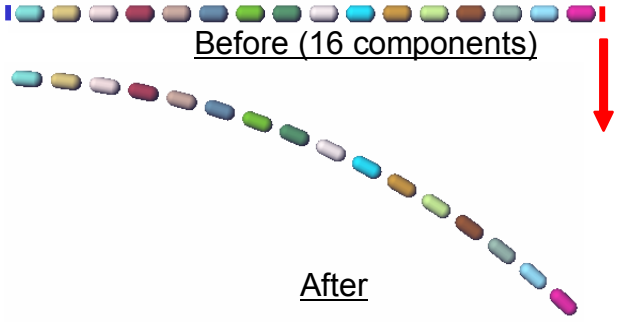
Before (26 components)



After

Foot bones Model

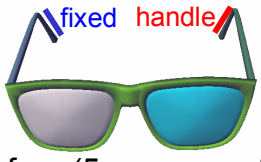
fixed handle



Before (16 components)

After

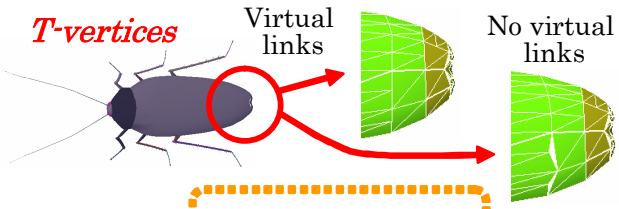
16-Chain Model



fixed handle

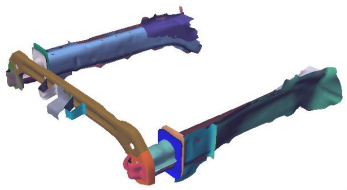
Before (5 components) After

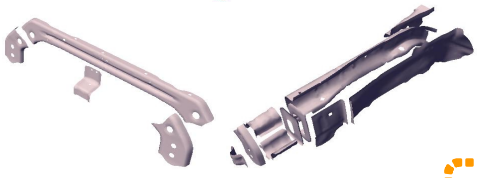
Glasses Model

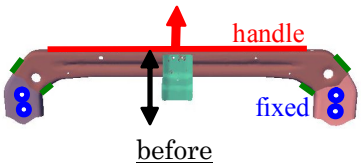


T-vertices Virtual links No virtual links

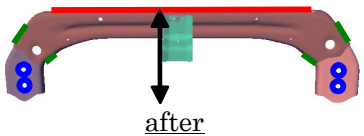
Cockroach Model



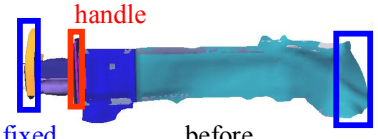




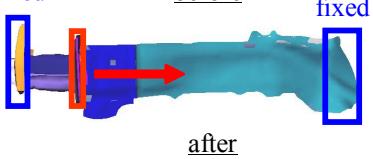
handle fixed before



after



handle fixed before



fixed after

FEM Models for Structure Analysis