3D Polyhedral Morphing Using Feature-Based Surface Decomposition

(completed 1999)

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The Challenge

Morphing is a useful technique for computer animation, modeling, and shape recognition, that involves establishing and computing a realistic continuous transformation which changes one object into another. Our goal is to provide the animator with an intuitive interface to specify the desired correspondences between the important features of each polyhedron, and to specify the trajectories for each of these correspondences to travel during the morph. From the user's specification the system should generate a morph that results in a smooth and visually pleasing transition from one polyhedron to the other.

The Approach

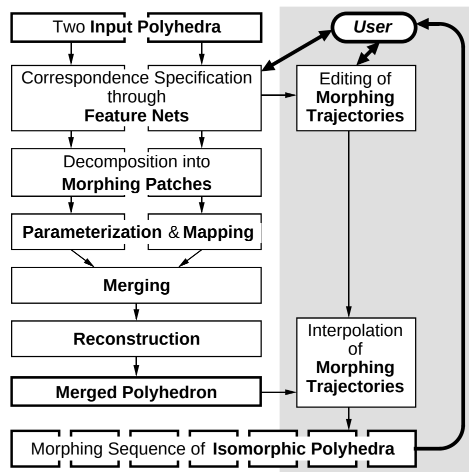
Our algorithm decomposes the problem of morphing two homeomorphic polyhedra into morphing corresponding pairs of surface patches. Given the user's specification, the algorithm automatically partitions each polyhedron into a series of morphing patches, each of which is homeomorphic to a closed disk. Based on this decomposition, our approach is applicable to non-simple polyhedra as well. The system computes a 2D parameterization one patch at a time. We use these mappings to merge the topologies of the polyhedra.

Correspondence

- **Feature Net Specification:** The user specifies a network of corresponding chains on the surfaces of the two input polyhedra by specifying their vertices. The interior edges of the chains are then computed as the shortest path between the specified endpoints. The feature net is a sub-graph of the vertex/edge connectivity graph of each polyhedron.
- **Decomposition into Morphing Patches:** Based on the feature nets, the algorithm decomposes the surface of each polyhedron into the same number of morphing patches, each being homeomorphic to a closed disk.
- **Mapping:** A pair of corresponding morphing patches are mapped to a 2D polygon.
- **Merging:** The algorithm merges the topological connectivity of morphing patches in the 2D polygon.

Highlights

- **User-specified morphing between arbitrary polyhedra**

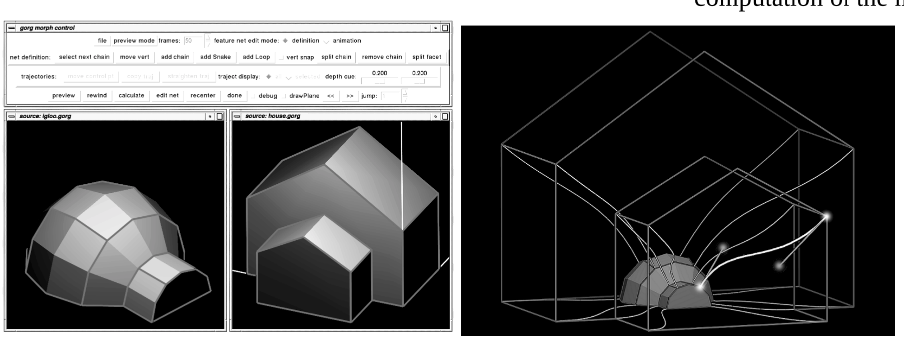


An overview of our approach. Given the user input, the algorithm consists of two phases: establishing a correspondence between the two polyhedra and interpolating between corresponding vertex locations.

- **Reconstruction:** Using the results from merging, the algorithm reconstructs the facets for the new morphing patch and generates a merged polyhedron with the combined topologies of the original two.
- **Local Refinement**: The user can make local changes to the feature net (such as splitting chains, moving extremal vertices, deleting chains or extremal vertices, or adding new ones) and can then re-compute the merged polyhedron.

Interpolation

- **Trajectory Specification:** The user specifies the trajectories for the vertices of the feature net to follow during the morph. The morphing trajectories for the remaining vertices of the merged polyhedron are computed from these.
- **Morph Generation:** The algorithm makes use of the trajectories and interpolates the surface attributes to generate a morph.
- **Local Control:** The user can modify the trajectories and generate a new morph. This step does not involve re-computation of the merged polyhedron.



Left: the user interface with the user-specified correspondence to morph an igloo into a house.
Right: the user-edited trajectories for these correspondences.

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Selected Publications

Gregory, A., A. State, M. Lin, D. Manocha, and M. Livingston. “Feature-Based Surface Decomposition for Correspondence and Morphing Between Polyhedra,” *Proc. Computer Animation*, 1998.

Gregory, A., A. State, M. Lin, D. Manocha and M. Livingston. “Interactive Surface Decomposition for Polyhedral Morphing,” *Visual Computer*, Vol. 15, 1999, 453–470.

Key Words

Morphing; animation; warping; mapping.

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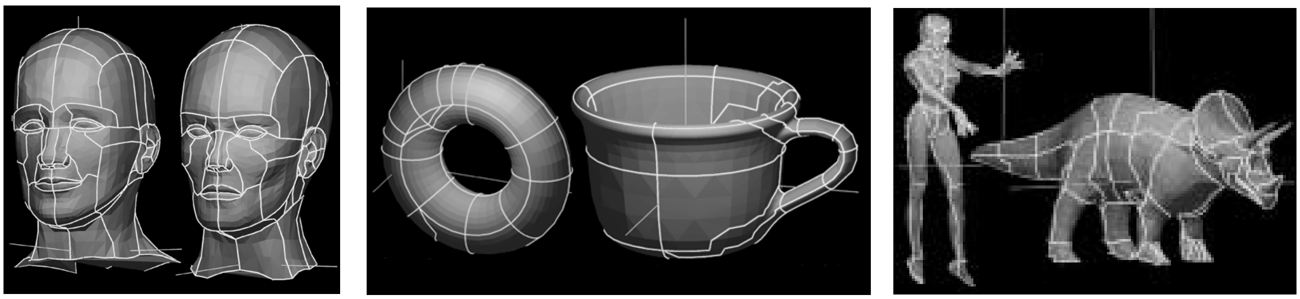
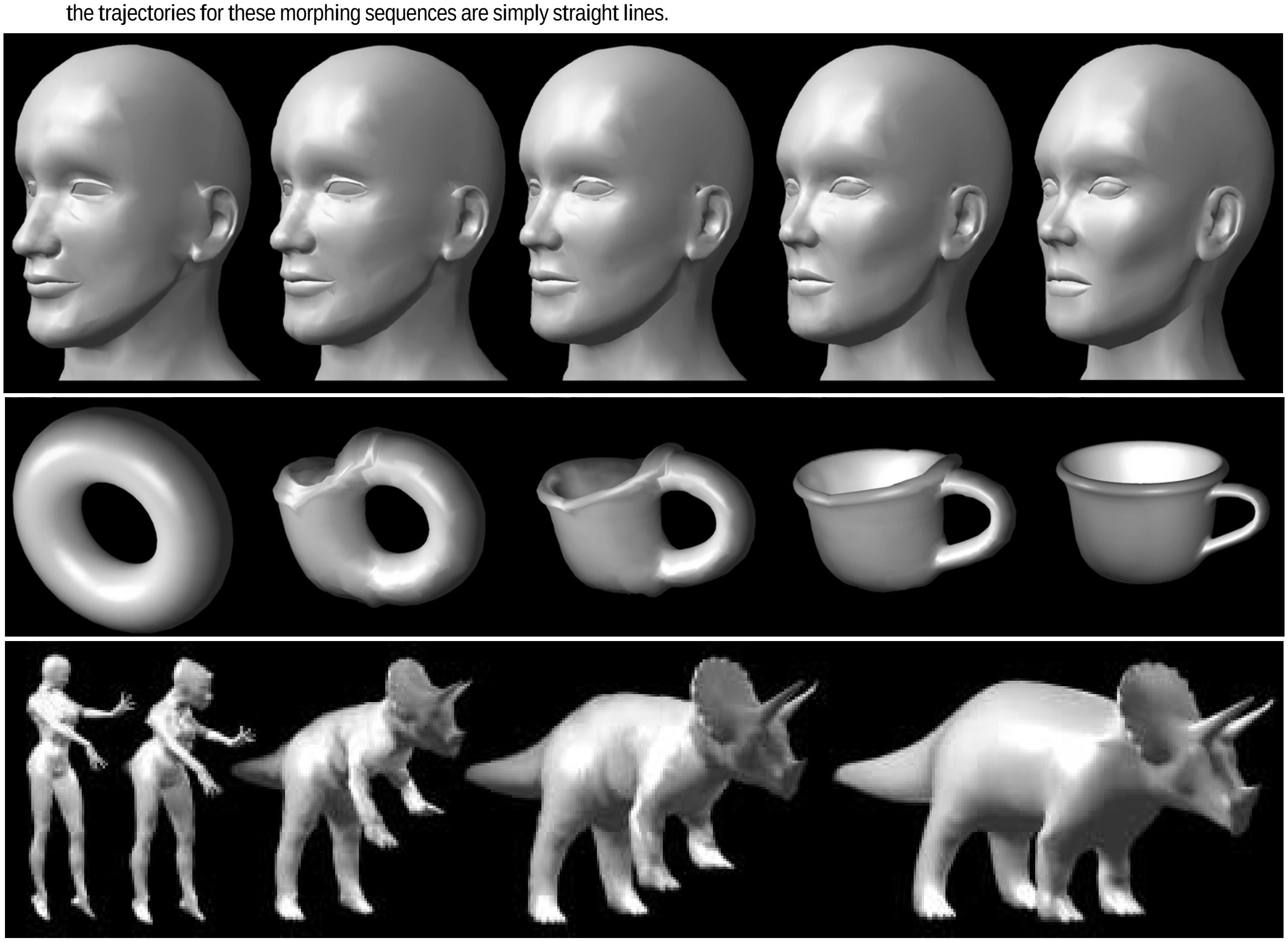


Three examples of our morphing technique. Above is what the user specified to obtain the morphing sequences shown below. The male head contains 3,426 triangles and the female head contains 4,030 triangles; however, the user only specified 134 corresponding vertices. The donut is 4,096 triangles; the cup is 8,452 triangles; but the user only required 63 corresponding vertices to specify this morph. Finally, the triceratops contains 5,660 triangles; the woman 17,528; still the user only specified 185 correspondences. Most of the trajectories for these morphing sequences are simply straight lines.



www.cs.unc.edu/~geom/3Dmorphing