The Shape Matching Element Method: Direct Animation of Curved Surface Models
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Abstract
We introduce a method for direct physics-based animation of volumetric curved surface models, represented by NURBS surfaces, that is completely meshless, robust to gaps and overlaps in geometry, and compatible with standard material models.

Method
We use shape matching on the boundary NURBS to produce a polynomial describing the deformation of each NURBS. The deformation map for interior points is constructed by blending the polynomials on the boundary.

Meshless Quadrature
Use meshless raycasting method based on method from [Khosravifard & Hematiyan 2010]

Blending Weights
Meshless construction by raycasting

Deformation Map
\[ x(X) = \sum_{i} w_i(X) P_i(X) c_i \]

Surface Only Discretization
Degrees of freedom are the control points of the NURBS surfaces.

Comparison with FEM
Adding more NURBS parts to the beam model shows that SEM qualitatively converges to the FEM solution.

Handles Large Deformation
With relatively few NURBS parts, we can simulate this beam twisting with no instabilities.

Heterogenous Materials
Supports simulation of multi-material models

Robust to Gaps and Self-Intersections
Supports simulation of models consisting of NURBS parts without explicit connectivity.

Future Work
- Engineering-level accuracy guarantees
- Explore more robust shape matching
- Simulation of models with multiple boundary representations.