Model reduction for dynamics on deformable complex surfaces.

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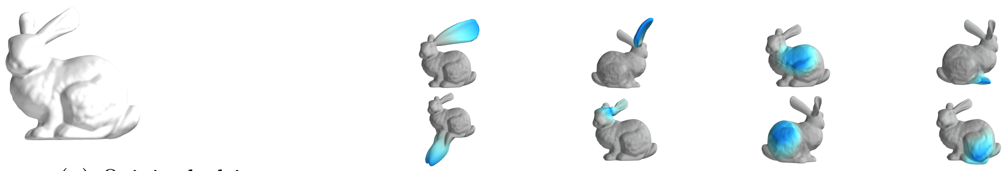
Dynamics of deforming surfaces, 2-dimensional objects embedded in 3D spaces, are governed by Newton's law of motion for mechanical systems under internal and external forces, $\mathbf{M}\ddot{q}(t) = f_{int}(q(t)) + f_{ext}$. Simulating such structures is very expensive, especially under real time changing internal forces acting on vertices and/or their connected faces, particularly when the meshes under consideration include hundreds of thousands of vertices.

Exploiting the variational formulation of the system, positions $q(t) \in \mathbb{R}^{N\times 3}$ of vertices at different time steps, can be written as a minimizer that compromises between both associated momentum and potential energies. The computations then divided into many parallel local nonlinear solves and one linear global solve; this is known as the projective dynamics scheme [2].

The nonlinear internal forces, such as bending and strain, express and control the material behavior of the surface as a geometrical object and they require re-computation at every time step. External forces typically remain constant during computations. We explore different model reduction techniques to tackle the computational complexity of simulating deformable surfaces. To find a low dimensional subspace, we consider different candidate methods, namely localized sparse-PCA [4] and localized quaternion-PCA [1]. We also compare to skinning subspaces which have been earlier used [3]. Figure 1 bellow shows the first 8 sparse localized PCA components extracted using a simple simulation for the bunny mesh falling under gravitational forces.



(a) Original object

Figure 1: First 8 sparse-PCA components under gravitational force simulation for a bunny object. Each component is localized around the vertex that shows the largest change. Normalized weights associated to different components are shown in blue.

References

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