中国科学院软件研究所学术年会’2019
暨计算机科学国家重点实验室开放周

学术论文

Reformulating Hyperelastic Materials with Peridynamic Modeling

作者：徐力有, 何小伟*, 陈伟, 李胜，汪国平

文献信息：Computer Graphics Forum 37(7):121-130 · October 2018 联系方式：xiaowei@iscas.ac.cn

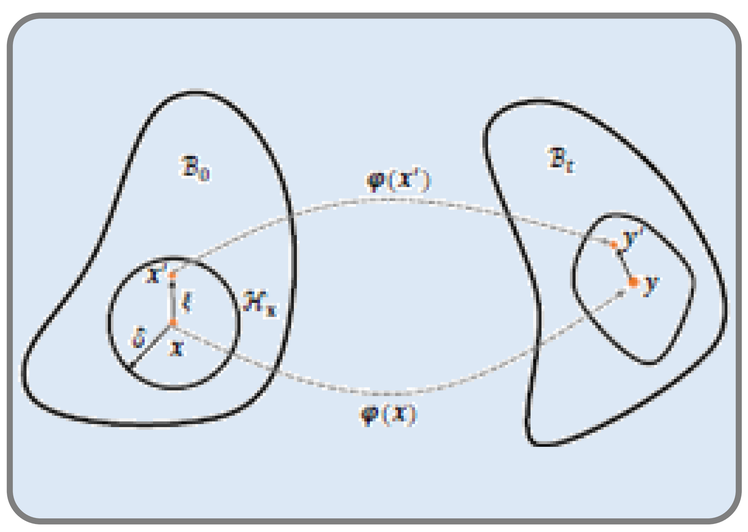
Background

Peridynamics is a formulation of the classical elastic theory that is targeted at simulating deformable objects with discontinuities,especially fractures. Till now, there are few studies that have been focused on how to model general hyperelastic materials with peridynamics.

Contributions

- A reformulated strain energy density function of hyperelastic materials
- A set of one-dimensional basis functions
- A simple technique to control the material anisotropy

Method



Schematic representation of a peridynamic body

strain energy

$$W(\theta,\tau\langle\xi\rangle)=\lambda g(\theta)+\mu\int_{\mathcal{H}_{\mathbf{x}}} w\langle\xi\rangle\,\mathcal{G}\langle\xi\rangle\,h(\tau\langle\xi\rangle)\,dV_{\xi}$$

Basis functions

$$\mathcal{A}_n=\frac{1}{n}\left(\frac{s^{n+1}-1}{n+1}+\frac{s^{-n+1}-1}{n-1}\right)$$

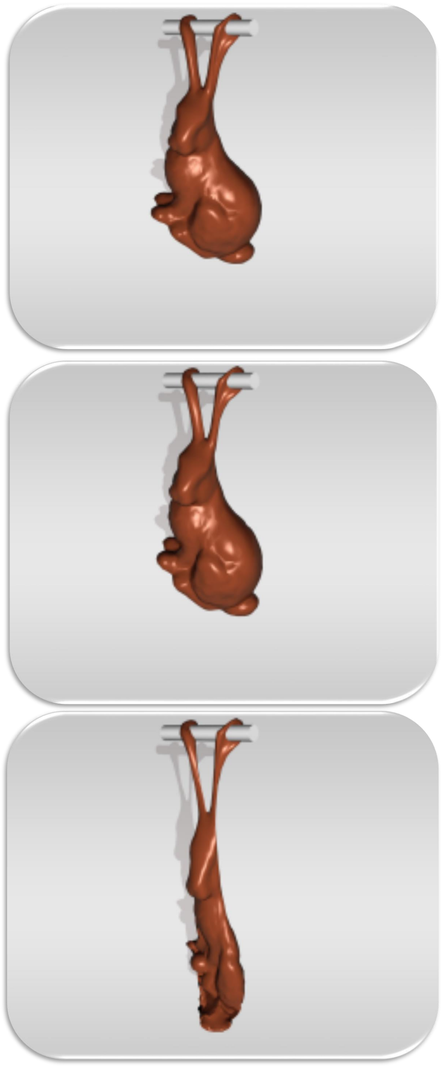
$$\mathcal{B}_n=\frac{2}{n}\left(\frac{s^{n+1}-1}{n+1}-s+1\right)$$

Quasi-Newton

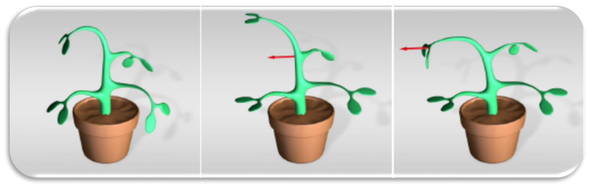
$$\left(\mathbf{K}+\frac{\mathbf{M}}{\Delta t^2}\right)\left(\mathbf{q}^{k+1}-\mathbf{q}^{k}\right)=\frac{\mathbf{M}}{\Delta t^2}\left(\mathbf{q}^{*}-\mathbf{q}^{k}\right)+\nabla_{\mathbf{q}^k}\sum_i W(\theta_i,\tau_{ij})V_i$$

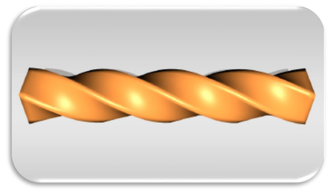
Evaluation

Our method (middle and bottom) is robust at simulating the StVK material while FEM (Top) breaks down at large deformations, both of which are simulated with the same Young's modulus and Poisson's ratio.



Results





Conclusion

we present a general strain energy model for peridynamics to simulate various hyperelastic materials involving nonlinearity and anisotropy. The new model is intuitive, flexible and easy to implement.