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Anisotropic hyper-elastic material model for the mechanical behaviour of cloth using polyconvex strain energy function

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ABSTRACT

The present study addresses the constitutive model of cloth using anisotropic hyperelastic materials and its implementation into a nonlinear finite shell element in order to simulate large deformation behavior of cloth. Present work focuses on a macroscopic continuum constitutive model able to capture the appropriate mechanical behavior of cloth, which is characterized by two families of yarns, i.e., warp and weft.

Hyperelasticity allows the formulation of large deformation including anisotropic effect by using a structural tensor which consists of fiber-directional unit vectors. The present work is based on an invariant formulation, in which pseudo-invariants are required in addition to 3 isotropic invariants. In order to avoid non-physical behavior, the related strain-energy function must be polyconvex[1]. There exists a number of literatures on polyconvexity[2][3], and they showed that the polyconvexity of a strain-energy function insures the existence of the global minimum for the total elastic energy, which implies that the material is said to be stable. In this work, a polyconvex orthotropic strain energy function using generalized structural tensor, which is developed by Itskov[4] etc., is utilized for the accurate and robust modeling of clothing behavior. This model considers the effects of interaction between two fiber families using weight values. The current research modifies this model in order to capture the response of cloth considering the interaction of yarn families in deformed configurations.

The present material model is implemented into a four-node shell element, and it is used to predict the outcome of uniaxial and biaxial tensile tests on knitted strips loaded in the warp, weft and bias directions. In all cases, the model accurately predicted the experimentally observed deformations and load-extension responses. With this constitutive model, the clothing pressure applied to human body is also investigated to design a form of cloth which fits the human body.

REFERENCES

[1] M. Itskov, A.E. Ehret and D. Mavrilas. “A polyconvex anisotropic strain-energy function for soft collagenous tissues”. *Biomech. Model Mechanbiol.*, Vol. **5**, 17–26, 2006.

[2] G.A. Holzapfel. *Nonlinear Solid Mechanics. A Continuum Approach for Engineering*, Wiley: Chichester, 2000.

[3] S. Reese, T. Raible and P. Wriggers. “Finite element modeling of orthotropic material behavior in pneumatic membranes”. *Int. J. Solids Struct.*, Vol. **38**, 9525–9544, 2001.

[4] M. Itskov and N. Aksel. “A class of orthotropic and transversely isotropic hyperelastic constitutive models based on a polyconvex strain energy function”. *Int. J. Solids Struct.*, Vol. **41**, 3833–3848, 2004.