Physically Based Fabric Drape Models for Computer-Aided Design

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Goal

A flexible shell based model, with a unique way of modeling fabric taking into consideration the initial, dual curvature formation, has been developed and successfully demonstrated by the principal investigator of this project. The model has a low CPU time and lends itself to be used in complex fabric drape situations. In this work it is our goal to enhance this model so that drape over complex arbitrary surfaces, of fabrics with seams, stitches and multiple layers can be simulated.

Abstract

Characterization of fabric plies was carried out using three well established fabric characterization methods, namely, the cantilever test, Kawabata fabric evaluation tests and Cusick drapemeter. All four types of seams and several types of stitches were evaluated. With the established mechanical characteristics, simulation of fabrics with seams were carried out using our finite element modeling method. Merits of representing seams in different ways have been evaluated. Simulations of fabrics with seams have been compared to actual fabrics with seams. Further, simulations of a table cloth with seams along the edges and a skirt with two side seams and a seam at the hem have also been carried out.

Technical approach

Fabrics are discontinuous structures possessing anisotropic, nonlinear, hysteric, and time dependent characteristics. Fabrics undergo large deformations for small applied forces. Fabric drape is a complex buckling of planar sheet problem which requires post-buckling response. A method to model fabric drape using flexible thin shell theory and finite element method has already been developed by the principal investigator of this proposal. A two step method of using dynamic and static analysis with a nine node flexible shell element produces drape simulations very close to actual fabric. The method uses mechanical parameters of fabrics namely, Young’s modulus, shear modulus, Poisson’s ratio, weight and thickness, to model fabric drape to a high degree of accuracy. Various Young’s modulus, shear modulus, Poisson’s ratio, and thickness values were used to study their effect on drape behavior.
During the current phase of this work, we have concentrated on evaluating fiber plies with seams, stitches and fusings and finding the right

parameter for input to our FEM model. Detailed description of the modeling method is given in published papers[1,2].

We have three different ways in which to model fabrics with seams. These are:

1. Plies of a seam are assumed to be a single fabric with the thickness value a multiple of single fabric thickness.
2. Plies represented as multiple layers of fabric bonded to each other with no relative movement between them.
3. Plies represented as separate fabrics with provision for relative movement between the plies and the stitches represented by node joints.

The third approach mentioned above is obviously the most accurate representation for modeling fabric plies with seams. Accordingly, we have devised procedures for model geometry input to our system.

When modeling multiple plies (layers) we need to consider the surface interaction and contact. In our model representing two plies of fabric, we have used “master” and “slave” surfaces. The nodes of the slave surface are constrained to not penetrate into the master surface. This procedure is required only in cases where there are chances of one surface (a layer) penetrating into another surface. In other cases, a simple separation of the fabric by a very small distance would suffice.

There are two types of contact formulations possible. One is a small-sliding formulation and the other is a finite sliding formulation. As the sliding of the two layers of fabrics are constrained by the sewing thread, we have adopted the use of finite sliding between the plies with a maximum sliding limit.

When two layers of fabrics are modeled as plies, we need to also consider the frictional contact between the surfaces. A friction coefficient of 0.3 has been used in our model. And finally, the stitches are represented by pin joints at nodes which allow relative movement between the plies.

Types of stitches

Federal Standard 751a classifies four types of seams and two stitch classes . These are the superimposed seam (SS), lapped seam (LS), bound seam (BS) flat seam (FS) ornamental stitch (OS) and edge finish (EF). Figure 1 shows the simple cases of the four types of seams. All these four types of seams could be represented in our drape model.

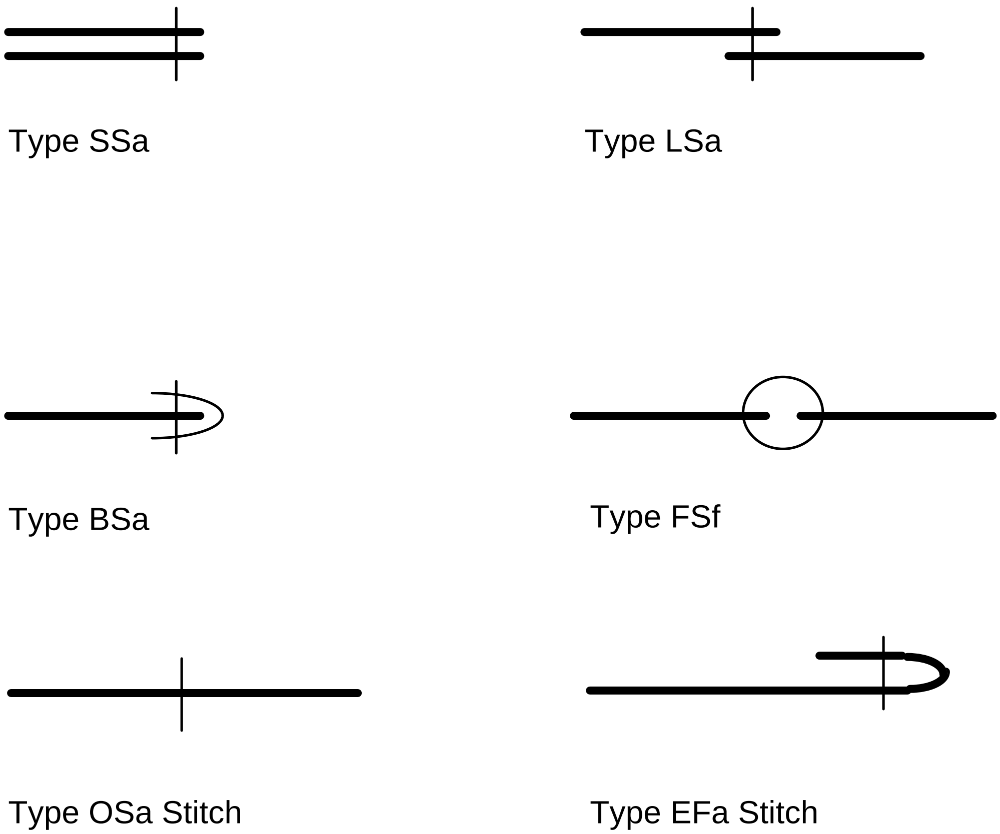

Figure 1

Drape simulations of fabrics with seams

Figures 2a-d show simulations of two ply strips of fabrics, with SS, LS, and FS type seams and an EF type stitch. The simulations show deformation of the stitched fabric plies in a cantilever form.

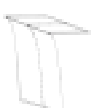

Fig 2a: Simulation of Type SS seam

Fig 2b: Simulation of type LS seam

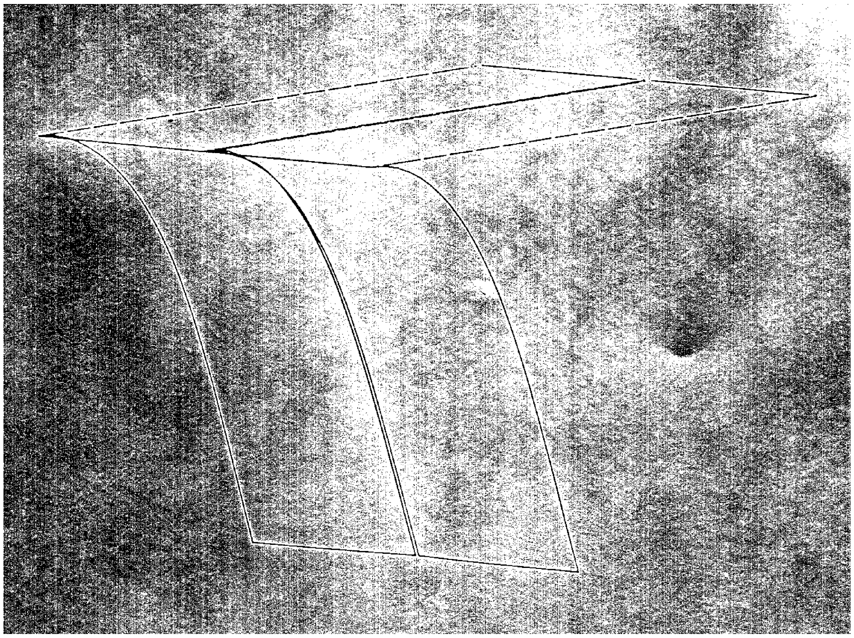

Fig. 2c: Simulation of type FS seam

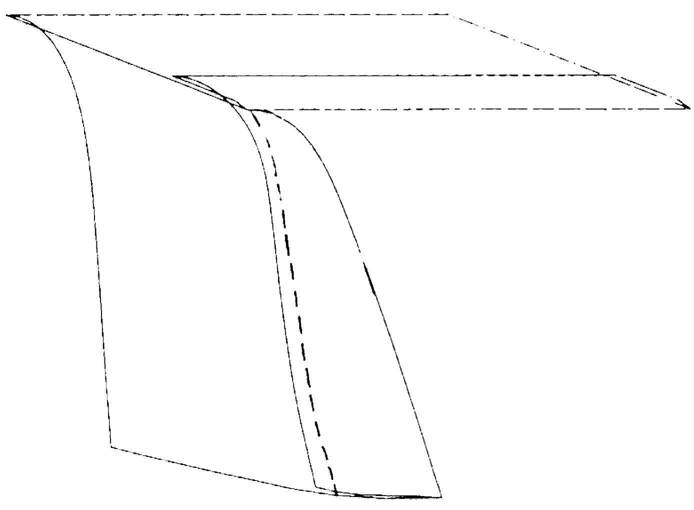

Fig. 2d: Simulation of Type EF stitch

The above simulations indicate the possibility of modeling fabric plies with seams. Drape simulations of assembled garments with seams is the ultimate aim of this work. To this end we have simulated some simple fabric assemblies, an example of which is the tablecloth in Figure. Figure 3a shows the drape simulation of a tablecloth without any seam. Figure 3b shows the simulation of the same size tablecloth with a stitched, folded edge, approximating an EF stitch.

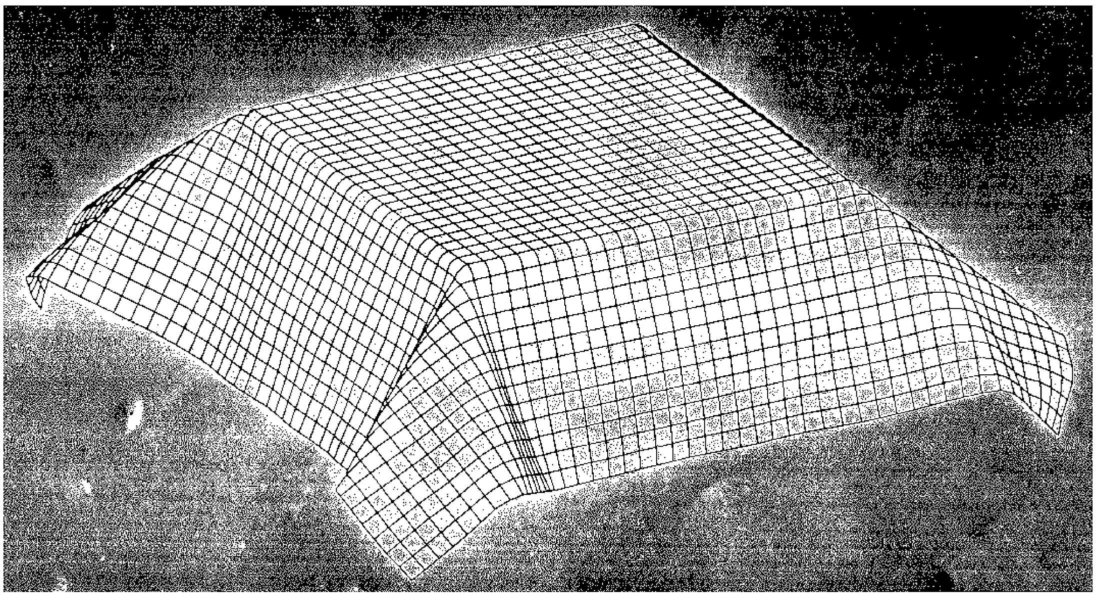

Figure 3a: Drape simulation of tablecloth without seam

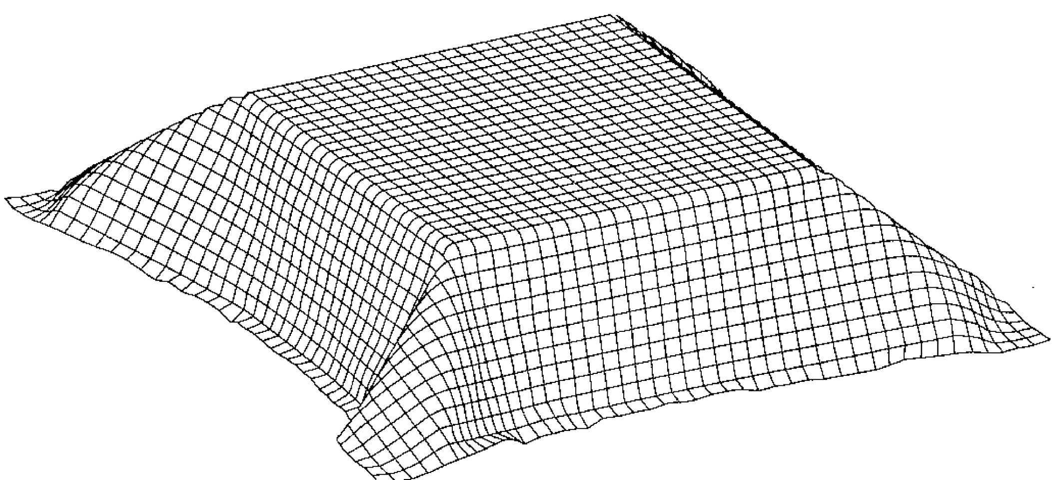

Figure 3b: Drape simulation of tablecloth with a folded, stitched edge (Type EF stitch)

Industry and outside contacts

We have been contacted or made contact with the following companies: Levi Strauss, Hunter Douglas, QVC, Primavision and University of Pennsylvania, Universitet Norges Teknik-naturvitenskapelige.

References

1. Chen, B., and Govindaraj, M., A Physically-based Model of fabric Drape Using Flexible Shell Elements. Text. Res. J. 65(6),324-330, 1995.

2. Chen, B., and Govindaraj, M., A Parametric Study of Fabric Drape. Text. Res. J. 66(1),17-24, 1996.