7

Garment drape

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7.1 Introduction

The outstanding property of a textile fabric, which distinguishes it from other materials, such as paper or steel, is its ability to undergo large, recoverable draping deformation by buckling gracefully into rounded folds of single and double curvature.[1] According to the *Textile Terms and Definitions* of the Textile Institute,[2] drape is defined as 'The ability of a fabric to hang limply in graceful folds, e.g. the sinusoidal-type folds of a curtain or skirt'. It refers to the fabric shape as it hangs under its own weight. Cusick[3] defined the drape of a fabric as 'a deformation of the fabric produced by gravity when only part of the fabric is directly supported'.

Drape is an important component of the aesthetic appearance and appeal of garments, and also plays a crucial role in garment comfort and fit. Drape appearance depends not only on the way the fabric hangs in folds, etc., but also upon the visual effects of light, shade and fabric lustre at the rounded folds of the fabric as well as on the visual effects of folding on colour, design and surface decoration.[4] A fabric is said to have good draping qualities when it adjusts into folds or pleats under the action of gravity in a manner which is graceful and pleasing to the eye.[5] In practice, drape is usually assessed visually, or subjectively, and the actual assessment greatly depends upon such factors as fashion, personal preference, human perception, etc.

Drape is therefore a complex combination of fabric mechanical and optical properties and of subjectively and objectively assessed properties. Furthermore, there is frequently an element of movement, for example, the swirling movement of a skirt or dress, and therefore dynamic, as opposed to static, properties are also involved. In recent years, therefore, a distinction has been made between static and dynamic drape.

7.2 Reviews on drape

Jacob and Subramaniam[6] and Hu and Chan[7] have briefly reviewed published work on drape. Subramaniam[8,9] undertook thorough reviews of the published work on fabric bending and drape, and in 1983 Subramanian *et al.*[10] also reviewed published work on fabric shearing properties which play an important role in fabric drape.

7.3 The measurement of fabric drape

Although drape is usually assessed subjectively, considerable research has been carried out with a view to its objective measurement, and to relate the drape, so measured, to objectively measure fabric mechanical properties, notably bending and shear stiffness.

Initially, because of the large effect of bending stiffness on drape, instruments were designed to measure fabric bending length (the length of fabric which bends to a definite extent under its own weight), which provided a fairly good measure of the fabric draping properties, more particularly of the two-dimensional (2D) drape, as opposed to the three-dimensional (3D) drape which occurs in practice. Considerable work has been carried out in this field and a number of instruments have been developed and marketed for this purpose. 2D drape tests (cantilever method) cannot, however, accurately reflect fabric drape, since the latter involves three-dimensional double curvature deformations. Therefore, to better quantify the latter, various objective measurement techniques have been designed to simulate the subjective methods (e.g. laying the fabric over a pedestal or mannequin, allowing the fabric to fall naturally into folds and assessing the size and frequency of the folds). The most widely adopted method is to allow a circular disc of fabric to drape into folds around the edges of a smaller circular platform or template. Such instruments are commonly referred to as 'drapemeters'.

The more realistic and practical determination of drape took a great step forward with the development of an instrument, termed a drapemeter, for measuring three-dimensional drape. This was largely the consequence of the pioneering work of Chu *et al.*[11] who developed a method of measuring drape by means of the F.R.L. Drapemeter, quantifying drape as a dimensionless drape coefficient (DC%). Cusick[3,12] subsequently developed what has become known as Cusick's drapemeter (Fig. 7.1)[13] and which has become the standard method of measuring drape coefficient. It uses a parallel light source which causes the shape of the draped fabric to be projected onto a circular paper disc. The drape of a fabric is popularly defined as the area of the annular ring covered by the vertical projection of the draped fabric expressed as a percentage of the area of the flat annular ring of fabric, this being termed the drape coefficient.[3] In practice, the contour of the shadow is often traced onto the paper and cut out for weighing.[14] Cusick[14] defined the drape coefficient (DC%) as the weight of the paper of the drape shadow (W_2) expressed as a percentage of the paper weight (W_1) of the area of the full annular ring (Fig. 7.2).

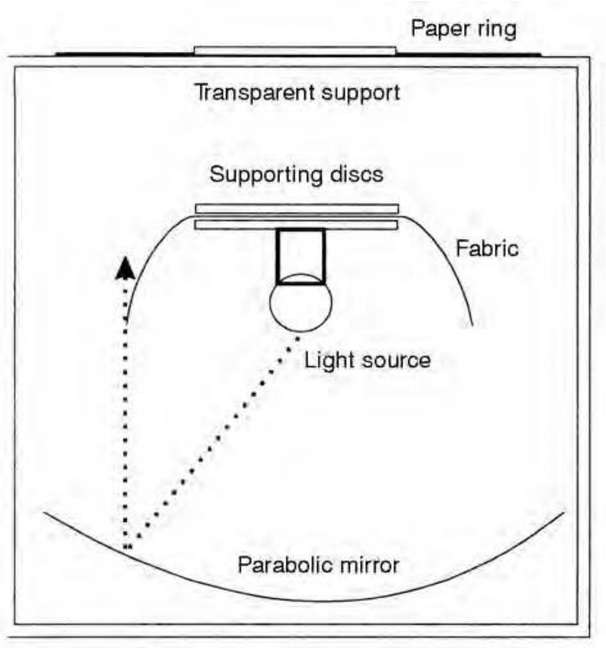

Figure 7.1 Cusick's Drapemeter. Source: Chung 1999.[13]

$$DC\% = \frac{W_2}{W_1} \times 100 \tag{7.1}$$

A measure of 100% on this instrument, which is widely used even today, indicates a completely rigid (stiff) fabric while a value of 0% represents a completely limp fabric, the values in practice ranging from about 30% for a loose, open weave rayon fabric to about 90% for a starched cotton gingham, and about 95% for stiff nonwovens.[7]

Since different template sizes can be used, which influence the drape coefficient, the diameter of the template must be given together with the drape result. Ideally, the template size should be such that the measured drape coefficient

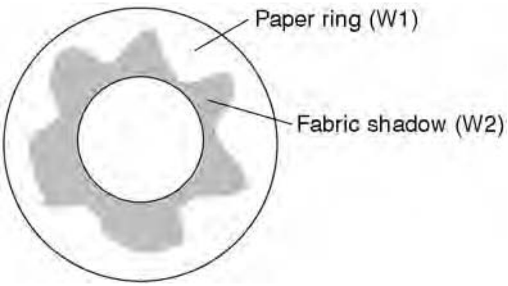

Figure 7.2 Drape image. Source: Chung 1999.[13]

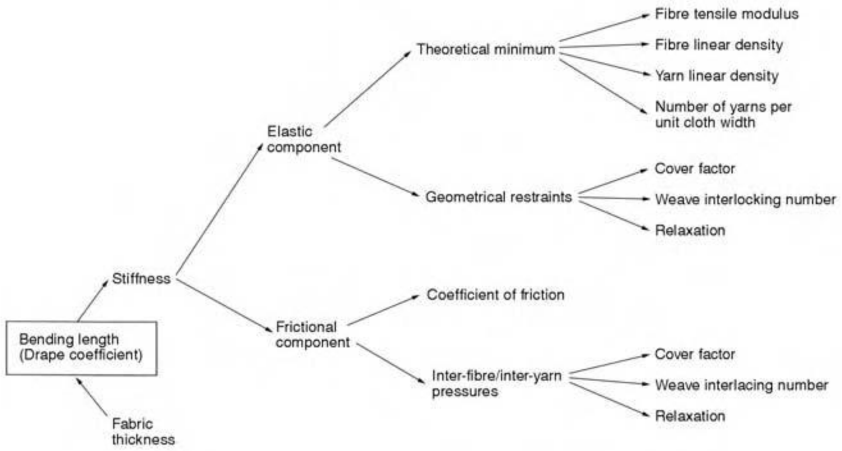

Figure 7.3 Some factors contributing to fabric drape behaviour. Direction of arrows indicates whether an increase or decrease in a given parameter will produce an increase in the drape coefficient of the fabric. Source: Anon, 1981.[15]

falls between 40 and 70%. Some of the factors contributing to fabric drape are shown in Fig. 7.3.[15]

Typical examples of 'drapemeters' include that of Cusick, F.R.L., I.T.F. and the M.I.T. Drape-O-Meter. Other principles of measuring drape include the force to pull a circular fabric sample at a constant speed through a ring, the force being termed the 'drape resistance' of the fabric. Collier[16] developed a digital drapemeter. Matsudaira *et al.*[17] used an image analysis system (Fig. 7.4) to measure static and dynamic drape. Vangheluwe and Kiekens[18] also used image analysis (video digital camera and computer-based image processing system) to measure the drape coefficient, while Stylios *et al.*[19] developed the next generation of drapemeters, enabling 3D static and dynamic drape to be measured by means of a CCD camera as a vision sensor. Image analysis enables many measurements to be made in a relatively short time.

7.4 Empirical prediction of static drape

Various empirical studies have attempted to identify those fabric properties which affect drape coefficient and to quantify the effects by means of regression equations and other analytical techniques.

One of the earliest studies on fabric drape is that of Peirce.[20] Initial studies demonstrated the dominant role of fabric stiffness on drape, with fabric weight also playing a role, though a lesser one. For example, Chu *et al.*[11] showed that drape depended upon three basic fabric properties, namely Young's Modulus (Y), cross-sectional moment of inertia (I) and fabric weight (W) (drape coeff. $= f(B/W)$, where $B = YI$). Later studies demonstrated the effect of fabric shear

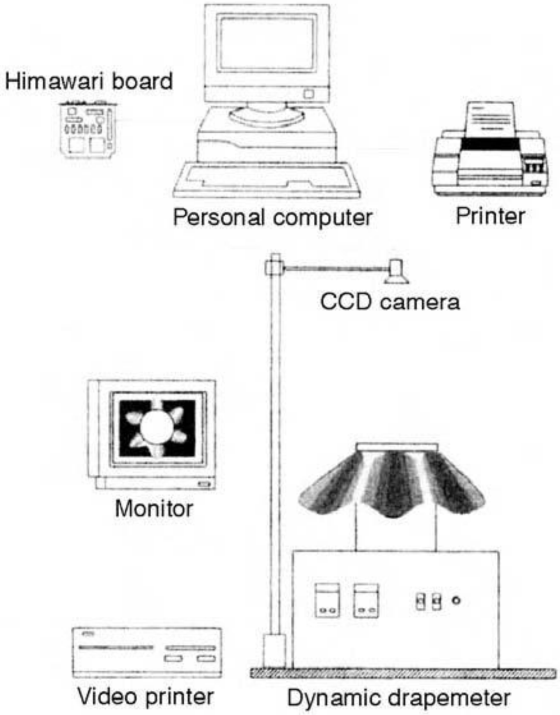

Figure 7.4 An image analysis system for measuring static and dynamic drape behaviour of fabrics. Source: Matsudaira *et al.*, 2002.[17]

on drape. For example, Cusick[3,14] demonstrated, both theoretically and experimentally, the effect of shear stiffness on drape, deriving the following empirical equation relating drape coefficient to bending length and shear angle, 'shearing' being the deformation which results in a flat fabric when opposing forces act parallel to each other (shear stiffness being the shear angle at which a fabric begins to buckle):

$$DC = 35.6C - 3.61C^2 - 2.59A + 0.0461A^2 + 17.0 \tag{7.2}$$

where $DC =$ the drape coefficient, $C =$ the bending length measured with the Shirley Stiffness Tester and obtained from $C = \frac{1}{4}(C_1 + C_2 + 2C_b)$, where $C_1 =$ is bending length in the weft direction; $C_2 =$ bending length in the warp direction; $C_b =$ bending length in the bias (45%) direction; and $A =$ the shearing angle at a shearing stiffness value of 2g wt. cm/cm^2.

Table 7.1 gives drape coefficients given by Sudnik,[21] using an improved version of Cusick's drapemeter. Sudnik also concluded that the optimum drape coefficient depends upon fashion and end-use.

Table 7.1 Drape coefficients (%)

End use	Template A (24)	Template B (30)	Template C (36)
Lingerie	<80	<40	<20
Underwear	65–90	30–60	15–30
Dresswear	80–95	40–75	20–50
Suitings	90–95	65–80	35–60
Workwear, rainwear	>95	75–95	50–85
Industrial	>95	>95	>85

Source: Sudnik[21]

Kim and Vaughn[22] showed that drape was not so much affected by the fabric weight, but had a closer relationship with the fabric bending, shearing and tensile parameters.

Tanabe *et al.*[23] used multiple-variance regression analysis to show that drape coefficient is affected by fabric bending modulus (B), bending hysteresis (HB) and weight (W), the correlation being increased by introducing the anisotropy of the bending properties into the regression equation. Using photographs of draped fabrics varying greatly in drape coefficient, Suda and Ohira[24] concluded that the drapeability of fabrics of equal drape coefficient can be determined visually and that it was easiest to do so with fabrics having a drape coefficient of around 30%.

Using the F.R.L. Drapemeter, Morooka and Niwa[25] derived the following empirical equation relating fabric drape to KES parameters, finding that fabric weight and bending modulus were the most important parameters.

$$DC = 5.1 + 115.0\sqrt[3]{\frac{B_{90}}{W}} + 131.1\sqrt[3]{\frac{B_o}{W}} + 1.2\sqrt[3]{\frac{B_{45}}{W}} \tag{7.3}$$

where: W = fabric weight per unit area (mg/cm^2)
B_{90} = bending rigidity (gf. cm^2/cm) in the warp direction
B_o = bending rigidity (gf. cm^2/cm) in the weft direction
B_{45} = bending rigidity (gf. cm^2/cm) in the bias direction
DC = drape coefficient.

According to Sudnik,[26] drape is affected by the fabric flexural rigidity (or stiffness), i.e. the elastic component, as well as by the frictional couple (i.e. nonelastic component), the latter being partly dependent upon the amount of shear.

Gaucher[27] found that, for the weft and warp knitted fabrics they investigated, bending length, thickness and secondary shear modulus played the main role in determining drape. Using a theoretical approach, Hearle and Amirbayat[28] showed that a more complicated relationship existed between fabric drape coefficient and mechanical properties, possibly involving anisotropic in-plane and out-of-plane bending, cross-term elastic constants and nonlinearity of response. They related the fabric geometric form to two dimensionless energy groups J_1 and J_2, where, in terms of material properties:

$$J_2 = Y\ell^2/B \text{ and } J_2 = W\ell^3/B \tag{7.4}$$

where: B = bending stiffness
W = fabric weight
Y = fabric membrane modulus and
ℓ = the characteristic length defining the size of the material.

The more generalised expression is:

$$DC = f(J_1, J_2, \pi_3 \pi_4 \pi_5) \tag{7.5}$$

where: DC = drape coefficient
$\pi_3 = G/Y$
$\pi_4 = T/B$
$\pi_5 = \mu$, where G, T and μ, respectively, are the overall shear modulus, overall torsional rigidity and overall Poisson's ratio from all directions.

Niwa and Seto[29] introduced bending and shear hysteresis into the relationship, relating drape coefficent to mechanical properties as follows:

$$DC = b_o + b_1\sqrt[3]{\frac{B}{W}} + b_2\sqrt[3]{\frac{2HB}{W}} + b_3\sqrt[3]{\frac{G}{W}} + b_4\sqrt[3]{\frac{2HG}{W}} \tag{7.6}$$

where: DC = drape coefficient
b_1 to b_3 are constants
B = bending rigidity
$2HB$ = bending hysteresis
W = fabric weight per unit area
G = shear stiffness
$2HG$ = shear hysteresis.

Collier and Collier[16,30] also demonstrated the importance of shear hysteresis in determining the drape coefficient.

Hu and Chan[7] related the Cusick drapemeter drape coeffient to the KES-F mechanical properties, finding logarithmic regression equations, of the form:

$$DC = b_o + \sum_{i=1}^{n} b_i \ln x_i \tag{7.7}$$

or

$$\ln DC = b_o + \sum_{i=1}^{n} b_i \ln x_i \tag{7.8}$$

better than simple linear regression equations, their results for bending and shearing were similar to other results, but two additional parameters, LT (tensile) and MMD (surface roughness) were also significant. They compared the various models, and found that all bending and shear properties can be related to drape, but that three or four parameters were probably enough for an accurate prediction.

Matsudaira and Yang[31] found that there existed an inherent node number for any fabric, and the conventional static drape coefficient (DC_s) could be measured accurately by an imaging system. Yang and Matsudaira[32] also derived regression equations from the static drape shape of isotropic and anisotropic fabrics, using cosine functions, and showed that static drape coefficient (DC_s) and the number of nodes (n), can be calculated from the following equations:

$$DC_s = \frac{4a^2 + 2b^2 + 2a_m^2 + b_m^2 - 4R_0^2}{12R_0^2} \tag{7.9}$$

$$n = 12.797 - 269.9\sqrt[3]{\frac{B}{W}} + 38060\frac{B}{W} - 2.67\frac{G}{W} + 13.03\sqrt{\frac{2HG}{W}} \tag{7.10}$$

where Ro = the radius of the circular supporting stand of the drapemeter (e.g. 63.5 mm)
a = a constant showing the total size of a two-dimensionally projected area (mm),
b = a constant showing the height of a sine wave of the two-dimensionally projected shape (mm), and
a_m and b_m = constants showing fabric anisotropy, derived as follows:

$$a = 35.981 + 1519\sqrt[3]{\frac{B}{W}} - 204300\frac{B}{W} + 23.27\sqrt[3]{\frac{G}{W}} + 0.0178G$$

$$b = 29.834 - 1.945n - 0.0188G - 91.84\frac{2HG}{W}$$

$$a_m = 9063\left(\frac{B_1 - B_2}{W}\right)^{2/3} \qquad b_m = 6224\left(\frac{B_1 - B_2}{W}\right)^{2/3}$$

where: B = bending rigidity (mN. m^2/m)
G = shear rigidity (N/m/rad)
$2HG$ = shear hysteresis at 0.0087 radian (N/m)
W = fabric weight (g/m^2)
B_1 = bending rigidity in warp direction
B_2 = bending rigidity in weft direction

Yang and Matsudaira[33] also quantitatively related the basic fabric mechanical parameters to static drape shape, using computer simulation.

Okur and Cihan[34] related drape to FAST properties, finding shear coefficient to have the greatest effect on drape, followed by the bending properties and the extension at 45° bias angle (used to calculate shear stiffness), 86% of the variation in drape coefficient could be explained by C2, C1, EB5 and E20-2, only the first three being useful for the prediction of the drape coefficient.

7.5 Dynamic fabric drape

Because an element of movement is frequently involved in garment drape, various workers have investigated dynamic, as opposed to static, drape. Yang and Matsudaira[35] derived the following dynamic drape coefficient (D_d), with swinging motion, which is more closely related to human motion in walking:

$$Dd = 90.217 + 0.1183W - 720.7\sqrt[3]{\frac{B}{W}} - 41.1\sqrt[3]{\frac{G}{W}} \tag{7.11}$$

Yang and Matsudaira[35–37] defined drape coefficients in the revolving state and also with a swinging motion and proposed a relationship between these coefficients and the basic Kawabata KES-F mechanical parameters. Subjective evaluation of dynamic drape is highly correlated with dynamic bending and shear properties as well as the KES-F hand values. Lai[38] applied the regression method and artificial neural network to predict the dynamic visual appearance of a swirling skirt from the fabric mechanical properties, with a view to replacing the subjective assessment with a more objective assessment. It was found that the neural network method provided a more accurate prediction than the regression method.[36] Two fabric mechanical properties were key in the prediction of skirt swirl, namely:

$B =$ bending rigidity: gf. cm^2/cm

$2HG =$ hysteresis at 0.5°; gf. cm

Matsudaira *et al.*[17,39] showed that both the static and revolving dynamic degree of spreading of the (revolving fabric) drape coefficients decreased through the various finishing stages, especially with relaxation, defining the revolving drape increase coefficient.

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7.6 Seamed fabric drape

The drapeability of a seamed fabric or garment is affected by both the flexibility of the materials and by the construction of the seam. Although much research has been done on fabric drape, in practice the fabric almost always has a seam which influences its drape behaviour. Comparatively little work has been done on the drape of seamed fabrics.

Chung[13] presented a detailed review of studies on drape, both static and dynamic, on both unseamed and seamed fabrics and investigated the effect of seam allowance, type and position on woven fabric drape. She found that bending length increased with the insertion of a vertical seam, while drape coefficient increased with the addition of radial seams, increasing the seam allowance having little effect. The highest drape coefficient occurred with the circular seam located just out of the pedestal.

7.7 Modelling fabric and garment drape

Hardaker and Fozzard[40] stated that one of the main obstacles in developing 3D garment CAD systems is the difficulty in modelling garment drape. Various researchers have attempted to model the draping behaviour of fabrics and garments, testing their models against experimental results. Generally two approaches are followed in modelling garment drape, namely geometric and physical.[41]

The geometrical approach treats the fabric as a deformable object, represented by a grid or two-dimensional array in three-dimensional coordinates, and drape is simulated by approximating the shape of the fabric surface to constraint points.[42–44] Since fabric properties are not incorporated in the existing geometrical models, these have limited use in 3D CAD.

The physical approach employs a conventional theory of mechanics, elasticity, and/or deformation energy to model complex fabric deformation during draping. Conventional continuum mechanics and the finite element method[45–47] were used to simulate complex fabric draping with only limited success compared to the simple geometric approach because the fabric undergoes complex and large deformation.

For example, Collier *et al.*[48] used a geometric non-linear finite element method to predict drape. They assumed the fabric to be a shell membrane with orthotropic rather than isotropic properties, finding that three independent parameters, tensile moduli in the two principal planar directions and Poisson's ratio, were required to predict drape. Gan *et al.*[49] applied geometric nonlinear finite elements, associated with a shell element, to model large fabric deformation, such as drape, the fabrics being considered as orthotropic and linearly elastic.

Chen and Govindaraj[50] used a shear flexible shell theory to predict fabric drape, taking the fabric to be a continuous, orthotropic medium, and using finite element formulations to numerically solve the governing equations under specific boundary conditions. The fabric characteristics used in the model were Young's modulus in the warp and weft directions, shear modulus and Poisson's ratio. Their physically-based modelling tied in closely with the processes of mathematical modelling and moved towards using drape modelling in apparel

CAD and made-to-measure garment-making applications, also being applicable to the study of fabric deformation during the apparel assembly process.

Postle and Postle[51] developed a commercially applicable mathematical model for fabric buckling, folding and drape, fabric bending and interfibre friction within the fabric being considered in their mathematical model, which involved solving nonlinear differential equations which had analytical (as opposed to numerical) solutions (called solitary wave or soliton solutions).

Kang and Yu,[52] developed a nonlinear finite element code to simulate the three-dimensional drape shapes of woven fabrics, assuming the fabric was an elastic material with orthotropic anisotropy, also considering fabric drape to be a geometric nonlinear phenomenon.

Stump and Fraser[1] applied a simplified model of fabric drape, based upon a two-dimensional elastic ring theory, to the circular geometry of the drapemeter, using a parameter incorporating fabric properties and drape geometry, to characterise the drape response of the energy contained in a series of deformed rings. They could also explain the fact that a particular fabric does not always drape with the same number of nodes. They focused attention on the large deflection and nonlinear kinematics associated with deep drape.

Bao *et al.*[53] conducted experimental and simulation studies on the MIT drape behaviour of fabrics, finding that the nonlinear finite element method, combined with the incremental method in which an elastic shell models the fabrics, simulated the large deformation of a fabric, such as in drape. They found that the fabric drape depended upon bending and torsional rigidity, but not on extensional or shearing rigidity.

Lo *et al.*[54] found that their model, using polar co-ordinates, for predicting fabric drape profile (i.e. characterised in terms of drape coefficient and node locations and numbers) could accurately predict the drape coefficient, node locations, node numbers and node shape in the fabric drape profile. Constants in the drape profile model could be obtained by regression analysis involving bending and shear hysteresis. They concluded that drape profile may be better predicted directly from bending and shear hysteresis.

Termonia[55] used a discrete model of fibres on a lattice to determine the importance of bonding pattern, laydown non-uniformities, fibre length and orientation distribution on the bending stiffness and drape of nonwovens.

Another physical approach involves the use of deformation energies with certain dynamic constants[17,56–58] which is particularly suitable for modelling dynamic garment drape in a virtual fashion, provided effective collision direction and response algorithms are developed.

Particle-based physical models[59–61] have been proposed and show some potential. Based on the microstructure of woven fabric, Breen *et al.*[59] assumed that the fabric consists of a set of particles interacting according to certain physical laws (Fig. 7.5). Stylios *et al.*[19] assumed the fabric is formed of rigid bar-deformable nodes and the governing differential equations of motion and

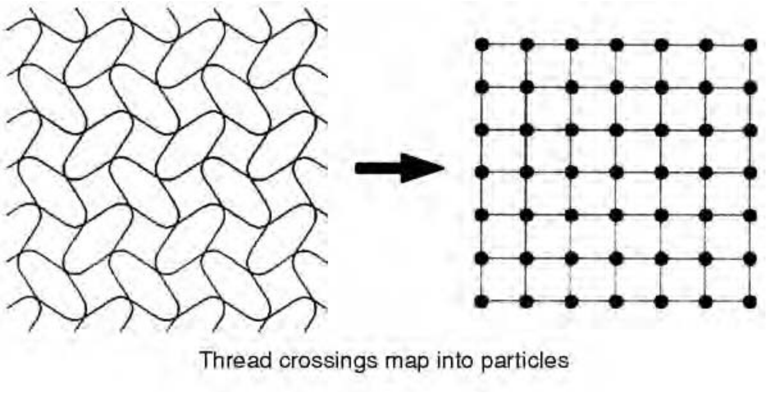

Figure 7.5 Particle-based model. Source: Breen *et al.*, 1994.[59]

deformation incorporating fabric mechanical properties were used to produce draping simulation.

Fan *et al.*[41] stated that such conventional methods, based upon fabric mechanics, have the advantage of understanding the fundamentals but have difficulty in accounting for the effects of accessories, seams and styles, their application to more complex garments being questionable. Using a database of stored drape images of garments made of typical fabrics, Fan *et al.*[41] demonstrated the feasibility of using a fuzzy-neural network system to predict and display drape images of garments comprising different fabrics and styles. A prototype drape prediction system was developed to predict the drape of a ladies' dress style made from different fabrics. The advantage of the fuzzy-neural network approach is that they allow very fast computation, provided the database contains an adequate number of drape images, and used to train the fuzzy-neural model, the predicted drape image will be very close to the actual one. The disadvantage is that only a limited number of styles and changeable feature dimensions can be accommodated.

Fan *et al.*[41] concluded that drape simulation was a complex and challenging task, and that their approach tested satisfactorily against lady's dresses and of a wide range of fabrics.

7.8 Drape models in commercial CAD and Internet systems

Drape modelling, in particular 3D visualisation of designed garments in draped form, is one of the key technologies in computer-aided garment design (CAD) and Internet apparel systems. It is essential for designers to assess the design, fabric suitability and the accuracy of garment patterns in a computer environment. It is also essential for the popular Internet systems to work effectively for trading and retailing as, without it, buyers and consumers will not be able to assess garment style, appearance, fit and suitability through the Internet. In this section, various draping models in commercial apparel CAD and Internet systems are reviewed.

7.8.1 Gerber system

Gerber Technology's apparel CAD system,[62,63] AccuMark APDS-3D, is a product acquired from Asahi Chemical Industry Co. Ltd. The system allows pattern makers to select patterns from AccuMark™ Pattern Design and instantly view them assembled on a 3D dress form. The garment can be modified to change the fit or even the design on the 3D form. Garments can be viewed with fabric designs/textures and drape characteristics for a realistic representation, essentially creating a virtual sample.[62]

The APDS-3D program enables pattern makers to select patterns from a file library, it modifies them in two or three dimensions using exact body measurements, and instantly re-drapes the revised patterns in three dimensions. The pattern is designed, manipulated or simply recalled from a pattern library on screen and can then be virtually 'sewn together' and placed onto a virtual stand. The virtual stand can be rotated to allow the garment to be viewed from any angle. It can also be adjusted to any specific body measurements, whether standard sizes or individual customer measurements, to allow the operator to visualise a garment in any size.

Modifications can be made in two or three dimensions. Any changes made to the pattern on the stand are automatically translated into a two-dimensional pattern and vice versa. The scanned or digitally photographed images of the fabric can be rendered on the garment surface to give a realistic look in terms of colour, texture and surface design. Since fabric mechanical properties are important to drape, for example, a garment in the same pattern made of soft-flowing silk will give a completely different look from that made of a stiffer cotton material, a number of fabric coefficients in the KES-F measurements or fuzzy values can be entered, to simulate the drape properties of different fabric types, giving a relatively accurate visualisation of the finished sample. Full-colour 3D styles can be printed on any Windows-compatible colour printer.

AccuMark APDS-3D is claimed to be one of the most technologically advanced 3D systems available for the pattern design process. It can significantly reduce the time needed to create the most accurate, realistic draping effects and communicates these results seamlessly to the AccuMark Pattern Design for actual pattern design.

7.8.2 PAD System

The PAD System offers the following two 3D CAD software systems:[64–66]

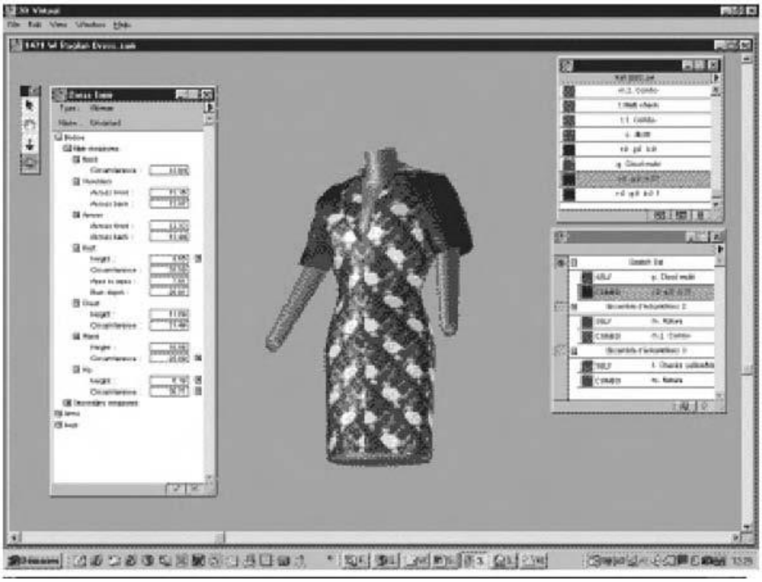

Figure 7.6 Visualisation of garment in 3D. Source: URL.[64]

3D virtual design sofware

3D virtual design software gives users the possibility to visualise all modifications to pattern pieces in real time. Figure 7.6 shows a virtual garment generated by the system. The software has the following features:

- texture and colour library
- simple garment and sewing line settings
- automatic link to master pattern module
- fast transformation between 3D image and 2D patterns
- 2D technical sketch window generated from 3D simulation to be used with the pattern file as a visual reference
- tool box for 3D setting, fold parts and texture positioning
- instant display of style with fabric swatch and colour
- new swatch library to show all colour combinations available for the style
- modifiable dress form measurements.

Hauté Couture 3D software

The Hauté Couture 3D software is an application which addresses the growing needs of the 3D animation industry with regard to the production of high quality, photo-realistic, 3D garments. This software includes a graded, framed and sewn pattern library. It has the following features:

- interface between the PAD System and Maya
- 2D environment and specialised tools for fast and easy sewing of pattern pieces

- darts automatically receive sewing information which can be exported to Maya
- possibility to import any 3D model or character
- intelligent placement of pattern panels around the character in a user friendly interface
- ease of use with practical working methods
- link between Hauté Couture 3D files and master pattern files
- sewing and placement information is retained even when patterns are modified
- pattern pieces are an excellent reference for placing seams or other garment details in the texture viewer
- export option to Maya ASCII format for patterns and sewing information
- possibility of exporting up to 200 graded patterns at once
- PAD tools for Maya allow application of the sewing information with a single click
- PAD tools for Maya enable the pattern pieces in the 3D scene to be replaced automatically to avoid repetitive placing of pieces
- graded, framed and sewn patterns for men and women.

7.8.3 Maya Cloth™

Maya Cloth™ (Fig. 7.7) is a software designed for the animation industry. Garments are created with Maya Cloth in much the same way as they are in real life. Patterns are designed and then sewn together virtually. The 3D drape of garments can be easily modified by altering the pattern and the types of material used. Fabric properties, such as thickness, weight, extensibility and stiffness, can

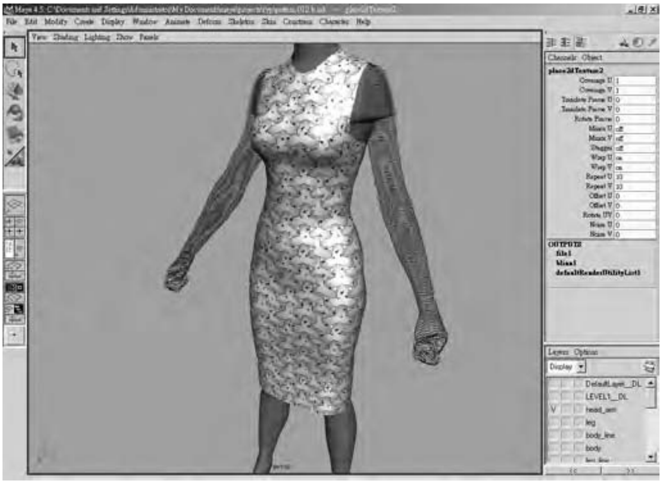

Figure 7.7 Computer screen of Maya Cloth™.

be changed in a relative scale (not in terms of strict mechanical properties) to change the drape effect.[67] When the virtual person is animated, the dynamic draping effect is simulated. Figure 7.7 shows a clothed person created using the Maya Cloth™ software.

7.8.4 Syflex system

The Syflex LLC system[68] was developed by Syflex LLC and PAD System Inc for the 3D animation market. It is claimed to be superior in terms of speed, stability, simulation and ease of use. Any vertex of the cloth can be nailed. These nails may be animated as any other object. Any vertex can be pinned to another static or moving object. The properties of a cloth, such as its mass or stiffness,

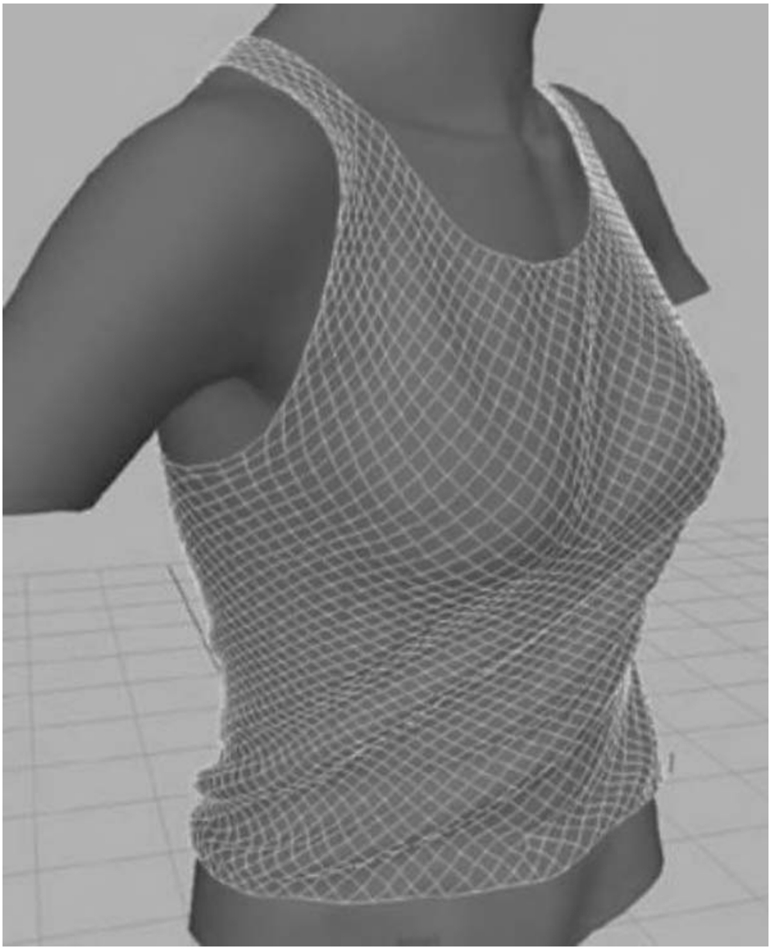

Figure 7.8 Cloth simulation in Syflex. Source: URL.[68]

Welcome to My Virtual Model™

My Virtual Model for Men and Women. To start creating your model, or to access one you have previously built, just click on the "My Model" button here.

Because of the rapidly growing popularity of My Virtual Model™, you may find that this portion of the site moves slowly today. We're working on a remedy, and thank you for your patience. You may wish to try again later.

Licensed under Rosengard U.S. Patent 5,930,769

Outfit Collections
Select a collection from the menu below

Casual

Figure 7.9 Virtual draping of clothing in My Virtual Model^{TM}. Source: URL.[69]

can be modified on a per vertex basis, using artisan maps. This allows a precise control over the surface. Collisions of the cloth with any static or moving object are computed accurately. To optimise collisions, the user can specify which faces may collide. Self-collisions are also available. The simulator adapts to any movement which the characters perform, for example, running or dancing. It allows artists to animate any kind of clothing, such as t-shirts, trousers, aprons, skirts and jackets. It also provides all the flexibility necessary to model any kind of material, such as cotton, silk and leather. Figure 7.8 shows an animation from the Syflex system.

7.8.5 Draping models used on the Internet

Drape models have been incorporated in Internet websites for virtual shopping. For example, in landsend.com,[69] customers can log onto the Web[70] using My Virtual Model^{TM} (Fig. 7.9) to create their own model (3D mannequin) by submitting their body measurements and appearance details, such as height, weight, shoulder width and hair colour. After creating their own model, customers can select the outfit from the web store to drape onto the model. Users can also rotate the model to view the outfit from different sides.

7.9 Concluding remarks

Initially, work on drape concentrated on its accurate measurement and on the empirical prediction of drape from the fabric mechanical properties, notably, bending and shear rigidity and hysteresis. More recently, however, attention has increasingly focussed on modelling garment drape, this being important for developing 3D garment CAD systems. Ideal drape models should not only be able to display the static drape of the garment realistically with 3D renderings of design features, colours and surface textures, but simulate the animated dynamic drape. It should have the capability to convert 3D shapes into 2D patterns or vice versa. Although most apparel CAD systems or drape models on the Internet are claimed to present realistic draping effects, the real performance needs to be evaluated by the end user.

Although significant improvements in the drape models have occurred over the past two decades, further development in this area is still needed. As Wentzel[70] pointed out, ‘the imagery of the virtual 3D sample is still flat; the stand and garment look somewhat sterile. Although fabric coefficients can be entered, the representation of the fabric drape still leaves some room for improvement’. When 3D animation is to be achieved, the challenge is greater. The resolution of the 3D virtual garment is still low in real-time presentation. Owing to the complexity and high polygon calculation, it takes a long time to achieve accurate performance of 3D animation. When the virtual garment is presented in a dynamic way or 360° rotation, the figure tends to show a lot of shading and poor texture effects.

7.10 References

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