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Estimating Cloth Simulation Parameters From Tag Information and Cusick Drape Test Supplementary Material

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1. Fabric Dataset

Category	Sub Category	Type Name	Quantity
Woven	Dobby	Dobby	236
	Double weave	Double weave	69
	Eyelet	Eyelet	58
	Jacquard	Clip jacquard	152
		Jacquard / Brocade	213
	Pile	Boucle	19
		Corduroy	135
		Velvet / Velveteen	27
	Plain	Canvas	26
		Challis	115
		Chambray / Oxford	66
		Chiffon	114
		Crepe / CDC	241
		Dewspo	102
		Flannel	167
		Gauze / Double gauze	75
		Georgette	45
		Memory	41
		Organza	42
		Ottoman	2
		Plaid	52
		Plain	178
		Poplin	58
		Taffeta	40
		Voile	45
	Ripstop	Ripstop	37
	Satin	Satin	103
	Seersucker	Seersucker	26
	TRS	TRS	53
	Twill	Denim	108
		Melton / Boiled	57
		Tweed	104
		Twill	137

Category	Sub Category	Type Name	Quantity
Cut & Sew knit	Double	Double knit / Interlock	211
		Neoprene / Scuba	29
		Pointelle	13
		Ponte	69
		Quilted knit	8
		Rib	131
		Waffle	24
	Jacquard	Dobby mesh	4
		Jacquard knit	264
	Pile	Fleece	54
		French terry	60
		Loop terry	46
		Polar fleece	30
		Sherpa	27
		Velour	33
	Single	ITY / Matte jersey	2
		Jersey	298
	Texture	Crepe knit	20
		Flatback rib	21
		Low gauge knit	11
		Pique	46
	Warp knit	Crochet	90
		Lace	155
		Mesh / Tulle	200
		Tricot	28
		Velvet	60
Animal alternatives	Vegan fur	Vegan fur	43
	Vegan leather	Vegan leather	111
	Vegan suede	Vegan suede	35
Non-fabric	PVC	PVC	63
	Tyvek	Tyvek	16
Total		5145	

Table 1: *Fabric types and the number of fabrics in each type in 5K–DATA*

Fiber	Quantity	Fiber	Quantity
Acetate	14	Nylon	699
Acrylic	299	Organic cotton	2
Alpaca	1	PE	31
Aluminium	3	PTT	1
Angora	11	PVC	23
Bamboo viscose	16	Pima cotton	5
Camel	1	Polyester	3069
Cashmere	5	Ramie	3
Cation	3	Recycled nylon	8
Cork	2	Recycled polyester	34
Cotton	1807	Silk	60
Cupro	7	Spandex / Elastane	1248
EVA	3	Supima cotton	7
Jute	2	TENCEL™	75
Linen	163	TPU	14
Lyocell	64	Triacetate	2
Metallic	129	Viscose rayon	714
Modal	32	Wool	320
Mohair	2		

Table 2: *Fiber types and the number of fabrics containing each fiber in 5K–DATA*

We acquired data for about 5000 real fabrics (5K–DATA), which are available for purchase by anyone, from [Swa22]. The data includes tag information for each fabric and simulation parameter data optimized by experts for each fabric. The fabrics are classified into 64 fabric types, and the total number of fiber types included in all fabrics is 37. Table 1 shows the number of fabrics in each type, classified into three levels of hierarchy according to the system commonly used in the fabric industry. Table 2 lists the types of fibers and the number of fabrics containing each fiber in 5K–DATA. It can be seen that the data includes a variety of fabrics with different characteristics.

2. Simulation

2.1. Stretching and Shearing Parameters

In Baraff-Witkin cloth simulation, we can construct a mapping between the weft and warp coordinates (u,v) of each point on the cloth and its 3D position $\mathbf{w}(u,v) : \mathbb{R}^2 \to \mathbb{R}^3$. The derivative of this mapping $F = [\mathbf{w}_u\ \mathbf{w}_v]$ is constant over each triangle primitive in the discretized cloth mesh, and is used to calculate various energies and well as its gradients / hessians.

To calculate the stiffness energy for each triangle, our simulation employs an energy term for each each weft and warp direction:

$$E_i = \frac{1}{2}k_i A(l_i - \bar{l}_i)^2 \tag{1}$$

where $i = \{u,v\}$, k_i is the weft and warp stiffness, respectively, A is the area of the triangle, $l_i = ||\mathbf{w}_i||$ denotes the stretch ratio in the weft/warp direction, and $\bar{l}_i$ is the rest length ratio. The distinction between warp and weft stiffness allows us to create various kinds of anisotropic cloth materials.

Since the cloth also needs to resist against shearing, we add an additional shearing stretch energy term as described in [CK03], which acts on the bias direction (the diagonal vector between warp and weft) and its orthogonal direction. We create a new set of coordinates $(\tilde{u},\tilde{v})$ which uses the diagonal directions as its basis, and calculate the shearing energy terms based on the newly constructed basis $\mathbf{w}_{RS} = (\mathbf{w}_u + \mathbf{w}_v)/\sqrt{2}$ and $\mathbf{w}_{LS} = (\mathbf{w}_u - \mathbf{w}_v)/\sqrt{2}$:

$$E_h = \frac{1}{2}k_h A(||\mathbf{w}_{RS}|| - \bar{l}_h)^2 + \frac{1}{2}k_h A(||\mathbf{w}_{LS}|| - \bar{l}_h)^2 \tag{2}$$

2.2. Bending Parameters

To express the buckling properties of cloth materials, we also define a bending energy term calculated for each bending wing (comprised of two adjacent triangles, show in Fig. 1 below). Denoting the angle between the two triangles as θ (and its rest angle θ_0, usually set to π). We can define a quadratic angle-based bending energy:

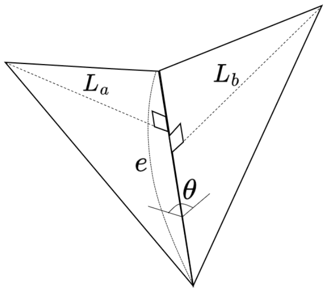


Figure 1: *Diagram of a bending wing used for our cloth model.*

$$E_b = k_b\left(\frac{e}{L_a} + \frac{e}{L_b}\right)(\theta - \theta_0)^2 \tag{3}$$

Since this energy term cannot describe any anisotropic bending behavior (where the cloth experiences a higher restoring force when folded in a different direction), we vary k_b depending on the direction of each bending wing. To achieve this, we define three stiffness parameters for the warp, weft, and bias direction (k_{bu}, k_{bv}, k_{bh}), and interpolate between the three values depending on the angle of bending direction in the (u,v) space ϕ:

$$I(\phi, a_u, a_v, a_h) = \begin{cases} (1 - \frac{4\phi}{\pi})a_u + \frac{4\phi}{\pi}a_h & (\phi < \frac{\pi}{4}) \\ (\frac{4\phi}{\pi} - 1)a_v + (2 - \frac{4\phi}{\pi})a_h & (\phi > \frac{\pi}{4}) \end{cases} \tag{4}$$

$$k_b = I(\phi, k_{bu}, k_{bv}, k_{bh}) \tag{5}$$

We observed the bending wing stiffness also needs to change depending on the angle θ in order to simulate a wider range of cloth. Therefore, we modelled the bending stiffness to be a piecewise constant function of θ: the value is scaled by s_b when the angle displacement is above a threshold T_b:

$$k_b'(\theta, \phi) = \begin{cases} k_b^0(\phi) & (|\sin(\frac{\theta}{2}) - \sin(\frac{\theta_0}{2})| < T_b(t_b)) \\ k_b^1(\phi)\left(= s_b k_b^0(\phi)\right) & (|\sin(\frac{\theta}{2}) - \sin(\frac{\theta_0}{2})| \geq T_b(t_b)) \end{cases} \tag{6}$$

The angle threshold $T_b(t_b)$ can be controlled by a user-tweakable variable t_b, and its function is defined as:

$$T_b(t_b) = \text{clamp}(1 - \frac{L_{avg}}{2R_b(t_b)}, 0, 1) \tag{7}$$

$$L_{avg} = \frac{L_a + L_b}{2} \tag{8}$$

$$R_b(t_b) = \begin{cases} 0.01 & (t_b \leq 0) \\ 0.01 \cdot (1 - \frac{t_b}{0.1}) + 1 \cdot \frac{t_b}{0.1} & (0 < t_b \leq 0.1) \\ 1 \cdot (1 - \frac{t_b - 0.1}{0.8}) + 100 \cdot \frac{t_b - 0.1}{0.8} & (0.1 < t_b \leq 0.9) \\ 100 \cdot (1 - \frac{t_b - 0.9}{0.09}) + 10000 \cdot \frac{t_b - 0.9}{0.09} & (0.9 < t_b \leq 0.99) \\ 10000 & (0.99 < t_b \leq 1) \end{cases} \tag{9}$$

To model anisotropic behavior for the threshold and scaling values, t_b and s_b are interpolated from t_{bi} and s_{bi}'s depending on the angle of bending direction ϕ, similar to Eq. 11:

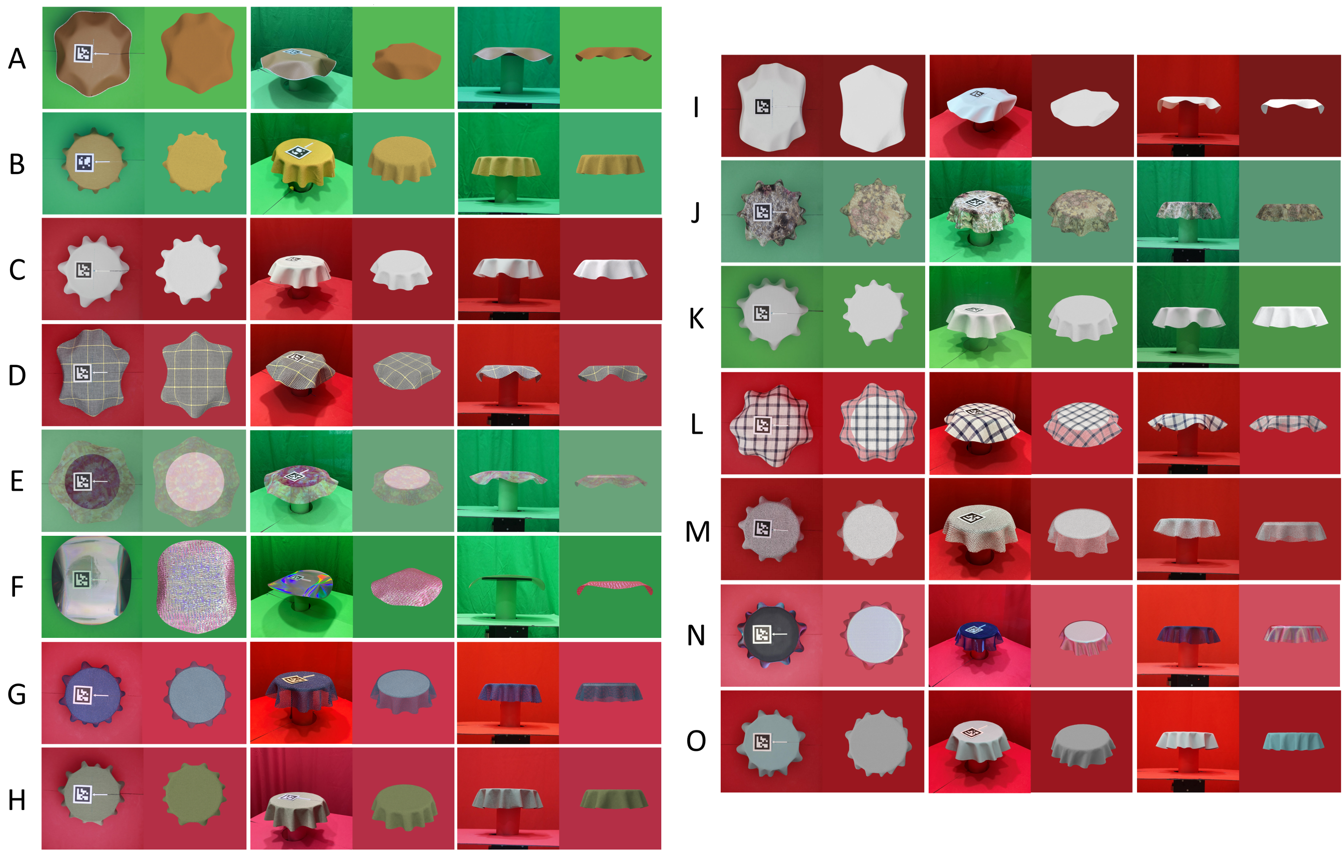
$$t_b = I(\phi, t_{bu}, t_{bv}, t_{bh}) \tag{10}$$

$$s_b = I(\phi, s_{bu}, s_{bv}, s_{bh}) \tag{11}$$

In our experiments, t_b is fixed to 0.3.

3. Comparison between Actual and Simulated Garments

3.1. Cusick's Drape Test



	Category	Sub Category	Type	Composition	Density (gsm)
A	Animal alternatives	Vegan leather	Vegan leather	Spandex / Elastane (100%)	340
B	Cut & Sew knit	Double	Ponte	Polyester (68%), Spandex / Elastane (2%), Viscose rayon (30%)	276
C	Woven	Plain	Crepe / CDC	Polyester (100%)	84
D	Woven	Twill	Twill	Linen (29%), Polyester (68%), Spandex / Elastane (3%)	168
E	Woven	Plain	Organza	Polyester (100%)	24
F	Animal alternatives	Vegan leather	Vegan leather	Viscose rayon (100%)	604
G	Cut & Sew knit	Warp knit	Mesh / Tulle	Metallic (10%), Viscose rayon (90%)	120
H	Cut & Sew knit	Single	Jersey	Polyester (88%), Spandex / Elastane (12%)	197
I	Woven	Plain	Plain	Cotton (63%), Nylon (31%), Spandex / Elastane (6%)	197
J	Cut & Sew knit	Warp knit	Lace	Metallic (5%), Polyester (90%), Spandex / Elastane (5%)	87
K	Woven	Plain	Challis	Modal (20%), Polyester (80%)	124
L	Woven	Plain	Plaid	Linen (100%)	140
M	Cut & Sew knit	Double	Double knit / Interlock	Metallic (20%), Viscose rayon (80%)	180
N	Cut & Sew knit	Single	Jersey	Nylon (50%), Polyester (50%)	64
O	Woven	Plain	Plain	Polyester (85%), Spandex / Elastane (15%)	123

Figure 2: *Cusick's drape test examples. (Left) Actual garments. (Right) Simulated results by estimated parameters. (Table) The tag information of each fabric.*

3.2. Dress

	Category	Sub Category	Type	Composition	Density (gsm)
A	Woven	Plain	Chiffon	Silk (88%), Spandex / Elastane (11%)	55
B	Woven	Plain	Organza	Polyester (99%)	56
C	Cut & Sew knit	Double	Neoprene / Scuba	Polyester (91%), Spandex / Elastane (8%)	468
D	Cut & Sew knit	Single	Jersey	Cotton (59%), Modal (40%)	104
E	Woven	Plain	Dewspo	Recycled polyester (99%)	52

Figure 3: *Dress examples. (Left) Actual garments. (Right) Simulated results by estimated parameters. (Table) The tag information of each fabric.*

3.3. Flared Skirt

Figure 4: *Flared skirt examples. (Left) Actual garments. (Right) Simulated results by estimated parameters. The tag information of each fabric is the same as in Fig. 9 in the main paper.*

References

[CK03] CHOI, KWANG-JIN and KO, HYEONG-SEOK. "Extending the Immediate Buckling Model to Triangular Meshes for Simulating Complex Clothes". *Eurographics 2003 - Short Presentations*. Eurographics Association, 2003. DOI: 10.2312/egs.20031062 2.

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