Image-Based Cloth Capture And Cloth Simulation Used For Estimation Cloth Draping Parameters

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Abstract

This paper presents a technique for estimating cloth draping parameters of a sheet of round cloth for modeling. The sample is placed on a device used to measure the draping characteristics of cloth, the Drapemeter. The cloth is first acquired using a camera, producing a few colour images. Subsequently, a mass-spring based cloth simulator is used to drape an imaginary cloth over the solid surface, from which cloth parameters are inferred.

Key Words: cloth simulation, estimation draping parameters, parameters for simulation system, image-based cloth capture, Drapemeter

1. INTRODUCTION

Over the past several years, interest in computer simulated cloth algorithms has grown steadily. Recent advances in simulation algorithms allow complex and realistic looking cloth. Unfortunately, it remains quite difficult to adjust the parameters of these simulations to match a given real world cloth material.

In this paper, we present a method for measuring the draping characteristics of static cloth, captured from a photo images. Stretching, shearing and bending parameters could be estimated from the data we measure using a cloth simulator.

2. PROBLEM STATEMENTS

The goals of modelling cloth and cloth structures for needs of textile industry and for using in computer graphics are very different. If you come to your – real or virtual – tailor, choose a stuff and – before making any decision – would like to see how a ready suit or skirt would fit your body, you will not wait hours before the precisely modelled from a mechanical engineering point of view cloth will appear on the screen. For such kind of applications we are generally interested in creating the simplest model possible that will produce results that appear realistic or acceptable to the average observer.

Producing physically accurate and predictive model in this case play the latest (if any role); the main goal is to make computer-generated images and animation to “look right”. Nevertheless, your tailor should have a possibility not only measure your body and create your personal virtual mannequin, but also measure some parameters of real cloth needed for 3D visualisation.

Although the Kawabata Evaluation System (KES) can provide accurate measurements, your tailor will hardly possess it: it is expensive and special-purpose. The measurements made by the KES are also problematic for computer graphics cloth simulation problems because there might not be a direct and simple mapping between the parameters for a particular cloth model and the Kawabata parameters.

In many cases it would be more convenient to be able to determine parameters for simulation system using conventional equipment such as photo/video capture devices. In our case we will fit parameters of a particle-based cloth model to fit the geometry of real cloth in a static rest configuration, draped over a round table (Drapemeter), estimating parameters from photo images of the cloth.

3. APPLICATION AREA

Development of physics-based cloth models is very important for textile industry (3D CAD systems for clothing design), computer vision (tracking dressed humans) and virtual reality applications (model-based telepresence). In this paper we present a method for estimating parameters for modelling of cloth. The motivating application of our work is a Szilvi-CAT for textile modelling, grading and layout (Tamás et al, 2005) in which a particle-based cloth model is used for purposes of 3D presentation of designed garment on a virtual mannequin. However, the algorithm can be applied to any physics-based cloth model in a range of applications for cloth visualisation.

4. RESEARCH COURSE

1. Cloth Simulation
2. Cloth Capture and Image Processing
3. Simulation Parameter Recovery

5. METHOD USED

First, we wrote a user interface in OpenGL to allow the user control over creating meshes, placing constraints, setting timing and vertex properties, and animation. The user can view the simulation as it runs, can output the results to a data file, and can provide a texture file (in BMP format).

5.1 Cloth model

We used the mass and spring system described in a range of works (Provot, 1995, House, Breen, 2000) as the basis for our cloth simulator. The model is based on the observation that cloth is best described as a mechanism of interacting mechanical parts rather than a continuous substance, which derives its macro-scale dynamic properties from the micro-mechanical interaction of the threads.

The input of simulator is a 3D mesh of cloth points (mass particles) that are arranged in a rectilinear grid and connected with the three types of springs: structural, shear and flexion. Each spring includes a damping element. Springs are assumed to be linear, while damps are proportional to the velocity.

The physics engine running the simulator calculates vertex positions at a time *t* based on interaction forces with neighbouring vertices, including stretch, bend, and shear forces. The integration of the Newton's second law of motion is performed using the 4th order Runge-Kutta method of explicit integration. Initially, we tried to use a first-order implicit Euler time integration scheme and a second-order Mid-point method because of their faster speed of calculation, but both of them produced quite instable results.

In addition, the physics engine detects collisions with the floor and with collision objects (a sphere, a plane, and an array of spheres and planes). For purposes of our work we used only one collision object – a round frictionless surface representing the Drapemeter. Collision of the cloth model with the model of the underlying object is performed and handled in each time step. The time step can be adjusted by user. The system checks for collisions every time it evaluates the state derivatives.

5.2 Image Capture

Capture was performed using a Creative PC-CAM 880 camera, providing three images of static draped cloth (top, side and isometric view), each at resolution 1152x872. The 4th image needed for purposes of texturing was derived for all samples from top-view image in BMP format. We have used round samples of fabric that had dimension ∅30 cm. The dimension of the circular table of Drapemeter was ∅15 cm.

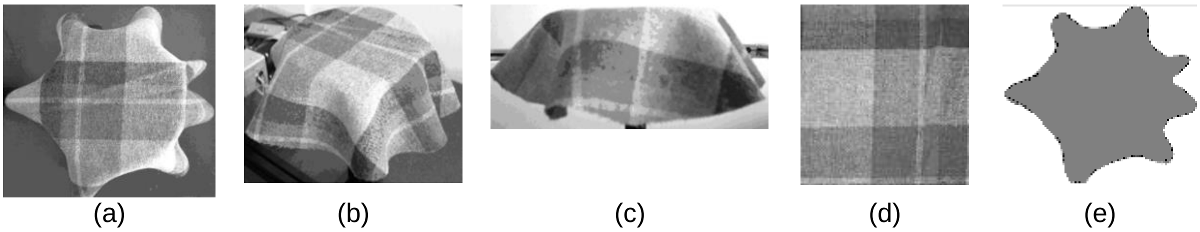
(a) (b) (c) (d) (e)

Figure 1. Captured Images (a, b, c), texture image (d) and contour-traced image after “shadowing” (e)

After contour tracing of top-view image two measurements may be taken. The first is the number of nodes or folds buckling out of the fabric. The second is the Drape Coefficient D defined as

$$D = \frac{A - \pi R_2^2}{\pi R_1^2 - \pi R_2^2} \times 100\%$$

where R_1 is radius of the cloth, R_2 is radius of the disc holding the cloth, and A is the area of the projected shadow.

It was found that the Kawabata parameters significantly influence the fabric drape property. Among 18 parameters, that could be measured by the Kawabata System, bending hysteresis (2HB), mean frictional coefficient (MIU), shearing stiffness (G), tensile resilience (RT), compressional energy (WC), compressional resilience (RC), fabric thickness (t0), compression rate (EMC), and weight (W) are significantly correlated with drape coefficient (Gider, 2004). The equation to predict drape coefficient (DC) can be estimated as

$$DC=69.17+25.51(2HB)-35.69MIU+3.50G+0.00049RT+21.13WC-0.492RC-13.04t0+0.303EMC+0.51W$$

5.3 Contour capture

The contour of cloth samples in a static configuration was captured at different levels by laser beam. Picture processing of cross-section contours was used for 3D modeling of the sample.

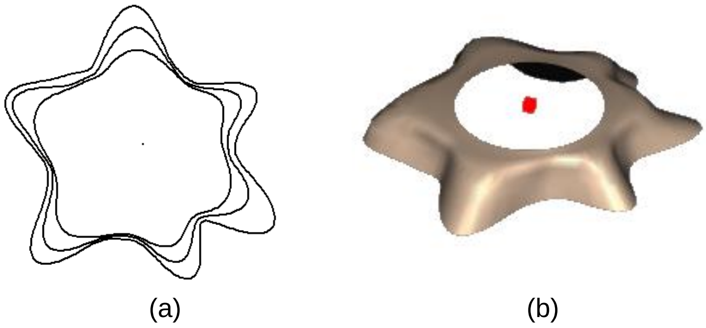
(a) (b)

Figure 2. Captured contour after Fourier transformation (a) and recovered 3D model (b)

5.4 Parameter Estimation

The setup involved the draping of a cloth over a circular table. The cloth was modelled as a round sheet of square patches. The circular table (Drapemeter) was simulated as a round surface with it’s position (vx1*x + vy1*y + vz1*z + d1 = 0; 0.0, 0.5, 0.0, 1.0) and size (radius; 7.5).

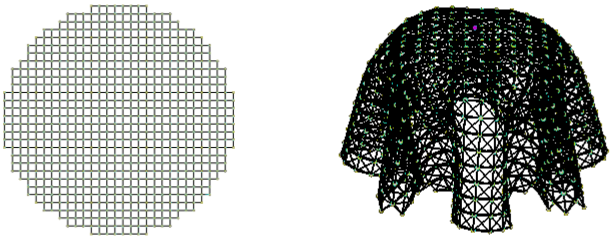
(a) (b)

Figure 3. Grid for simulated cloth (a) and one of the final configurations (b)

For each type of simulated cloth in our cloth model there are 19 synthetic parameters describing it's size (w, h), position (x0, y0, z0), size of the grid (u, v), 1/mass of each particle (ClothOverMass), and spring and damping coefficients of each type of spring (SstKu, SstDu, SstKv, SstDv, SshK, SshD, SflKu, SflDu, SflKv, SflDv). The cloth is modelled with different parameters for warp and weft directions. It is assumed that the cloth sample is round and its size is known. We set w, h and u, v in advance, so only the rest parameters can be changed.

Table 1. Parameter values for the start run of simulator

Parameter	**Symbol**	**Value**
Size of cloth	w, h	30
Size of the grid	u, v	30
Position of cloth	x0, y0, z0	-15.0, 15.0, 0.0
1/mass of particle	ClothOverMass	0.5
Stretch resistance	SstKu, SstKv	150.0, 150.0
Shear resistance	SshK	40.0
Bend resistance	SflKu, SflKv	24.0, 24.0
Stretch damping	SstDu, SstDv	7.0, 7.0
Shear damping	SshD	6.0
Bend damping	SflDu, SflDv	8.0, 8.0

To evaluate the influence of the individual parameters, a series of simulations was performed. In each experiment, only a single parameter was varied, and the appearance of the cloth was recorded. Consequently, we could draw few substantial conclusions about the general behaviour of our cloth model, for example, that number of folds (and asymmetry of wrinkles) is influenced not only by stiffness of the cloth, but also by it's position.

For the real cloth samples, a range of cross-section curves is captured, digitalized and interpolated by Fourier series (left side of Figure 2). The same Fourier coefficients are determined for the cloth model as a function of simulation parameters. The contour-tracing for the model is performed by recording the geometry of cloth in a static rest configuration as a massive of intersection points of the springs and a number of cross-section cutting surfaces. The actual simulation parameters are defined by the minimum of the difference between the modeled and the measured geometry.

6. RESULTS

Experiments were performed for samples ∅30 cm of 21 different fabrics. In Figure 4 a drape of two simulated cloth samples over round table is given.

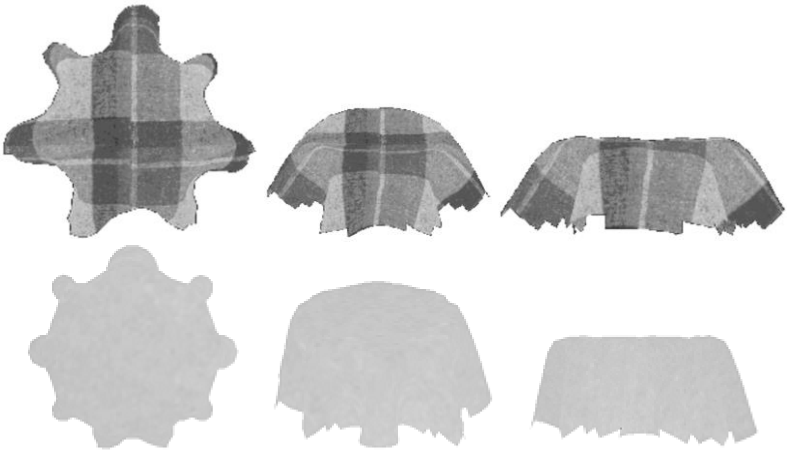

Figure 4. Images of simulated cloth

7. DISCUSSION

Our approach has several limitations. First, we treat only static simulation parameters and do not consider dynamic movement of cloth. Second, we only make use of the cloth's geometry, and do not incorporate surface parameterisation data. Third, we use a known underlying geometry.

The usability of our method is restricted to cloth visualisation applications were the speed of computation and the “right looking” of the simulated cloth is of the greatest value.

Kinematic model used in our simulator seems to be plausible. Future research it is needed to examine evaluation of stress, and to explore the possibilities and limits of our method.

8. CONCLUSION

Our method offers an alternative to using the expensive Kawabata Evaluation System for estimating cloth model parameters in the case where only the final static configuration of draped cloth does matter, although our approach can be extended to include dynamic behaviour. Given the synthetic data from a simulation and a suitable experimental setup it may be possible to infer the most likely parameters for a given cloth.

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ACKNOWLEDGEMENT

The present publication was made in the framework of the Hungarian-Slovenian intergovernmental S & T cooperation programme supported by the Hungarian Research and Technology Innovation Fund and the Slovenian Research Agency (SLO-7/03).

This work has been supported as well as by the OTKA T-42775.

The background of the present publication is R&D programme within the framework of Economic Competitiveness Operational Programmes of the National Development Plan funded partly by the European Union's Structural Funds (GVOP 2004/182).

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