Proceedings of the 5th WSEAS International Conference on Applied Computer Science, Hangzhou, China, April 16-18, 2006 (pp635-640)

A Method of Drawing Cloth Patterns With Fabric Behavior

SHIH-WEN HSIAO, RONG-QI CHEN
Department of Industrial Design
National Cheng Kung University
Tainan 70101
TAIWAN

ABSTRACT: - Computer-aided cloth design is one of the quite popular research themes in recent years, and the authenticity of it's simulated result and the efficiency of simulation are two main research questions. The cloth behavior not only determines the authenticity of simulation, but also influences the efficiency of simulation. So 3D virtual clothing is simulated and rendered by the way of 2D patterning technique in this study. In this method, the outlines of 2D cloth patterns are first drawn with B-spline curve, and the cloth particles on the cloth pattern are then created. A logical method is used to construct the particles' interrelations and triangular meshes on the cloth pattern, such that the established 2D cloth patterns can be used in the 3D simulation. Finally the 3D virtual cloth is simulated by an approximate implicit method. Through the proposed method, not only the simulation result which accord with the fabric behavior of the cloth can be gotten, but also the feeling of different cloth and improvement the authenticity of the cloth can be presented.

Key-Words:- B-spline curve, Mass-spring model, Implicit method, Cloth design, Computer-aided design, Cloth pattern design

1 Introduction

The simulation of 3D virtual cloth has been one of the popular themes in computer graphics for more than ten years in the past. There are two main goals in research, one is to get the simulation result authentically [1, 4, 24], and another is the efficiency of the simulation [18, 33].

Among all kinds of models, mass-spring model is simple and complete to describe fabric behavior. Before 3D virtual cloth is simulated with this model, we can derive out the differential equation from the physics relation. Then the force that acts on the particle on the cloth can be calculated from the interrelation of particles in the model, and the position of every particle on the cloth can be calculated by iteration. Euler integral is the most direct method among them, but it has the unstable problem [29] and requires a small time-step for obtaining a convergent solution that makes the simulation process takes a long time. To solve the unstable problem, several related papers proposed a large time-step implicit integral method [7]. The method could reduce the CPU time for operation, so the implicit method is regarded as the best choice to simulate the relationship between cloth particles by mass-spring model. However, the implicit method has also some problems, such as the operation of a multi-step matrix is to be concerned during the calculation process. So the real-time simulation is unable to be reached. Therefore Desbrun etc. proposed a method of utilizing the calculation of anti-matrix [18] in the implicit method to improve the efficiency of real-time calculation. But the anti-matrix operation can't be omitted in this method. Young-Min Kang etc. proposed an approximate implicit method [32, 33] to solve these problems in the simulation of a 3D virtual cloth to improve the efficiency of simulation. They further proposed a bi-layer meshes method to improve the efficiency of operation to get the real-time result.

Most of the last researches related to 3D virtual cloth simulation are focused on the application of the simulated virtual cloth [13, 19, 25, 27, 31], but just the flattened 2D patterns have real contribution in the garment industry [3, 9, 14, 26]. So this study is focused on discussing how to draw the cloth patterns with fabric behavior. Through the proposed method, not only the simulation result in accord with the fabric behavior of the cloth can be obtained, but also the feeling of different cloths can be presented to improve the authenticity of the cloth.

2 The Mass-Spring Model

The mass-spring model is a simple and complete model to describe the fabric behavior of the cloth. It mainly expresses the structure of a cloth with the vertical and horizontal meshes, and the intersection points of meshes are regarded as particles. The particles maintain interrelations with the spring structure so each particle becomes a moving object influenced by various kinds of forces exist inside or outside of the model. There are three kinds of different spring types [25] as shown in Fig. 1:

(1) Structural Spring: The spring links particle [i, j] and particle [i+1, j] (particle [i-1, j], particle [i, j+1] or particle [i, j-1]), such as that shown in Fig. 1 (a). The main purpose of this spring is used to maintain the distances between the adjoining points, such that the adjoining points can be located in an appropriate region.

(2) Shear Spring : The spring links particle [i, j] and particle [i+1, j+1] (particle [i-1, j-1], particle [i-1, j+1] or particle [i+1, j-1]), such as that shown in Fig. 1 (b). The main function of this spring is to maintain the structure of the meshes, such that the cloth meshes can maintain the mesh form after it is subjected to forces.

(3) Bending Spring : The spring links particle [i, j] and particle [i+2, j] (particle [i-2, j], particle [i, j+2] or particle [i, j-2]), such as that shown in Fig. 1 (c). The main purpose of this spring is to maintain the plane character of the cloth, such that the cloth keeps the continuity during simulation, and the simulated result will not come into being the overly sharp angle on the surface.

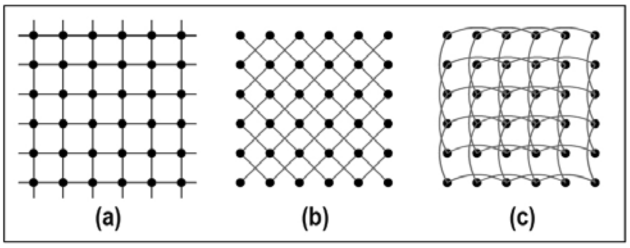

Fig. 1 Spring types in the mass-spring model (a) structural spring (b) shear spring (c) bending spring

Therefore, while carrying cloth simulation out with mass-spring model, the cloth would show

Proceedings of the 5th WSEAS International Conference on Applied Computer Science, Hangzhou, China, April 16-18, 2006 (pp635-640)

different appearance of different spring coefficient were taken, as Fig. 2 shows. In addition, there are two main border conditions to influence the change of particle position. One is the natural force that acts on the particle, for instance, the gravity, air resistance and so on. Another is the spring forces between the particles. So the new position of every particle would be correlative with the positions of all other particles on the cloth if the particles were connected with various types of springs in the model.

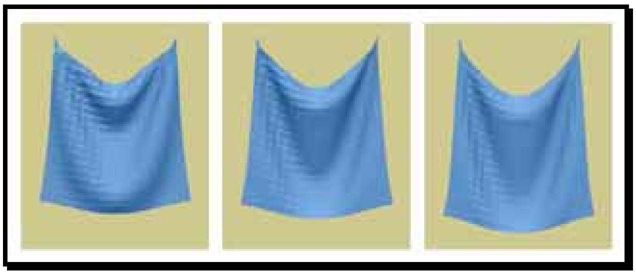

Fig. 2. Different cloth appearance simulated with different spring coefficients

3 Cloth Patterns with Fabric Behavior

2D patterns gotten by through the proposed method not only have the fabric behavior, but also can be used to simulate and render the 3D virtual cloth, such that the simulated results have authenticity. The proposed method is described as follows.

3.1 Draw a cloth pattern with B-spline curve

The outline of a cloth pattern is usually made up by various straight lines and curves. All kinds of straight lines and curves can be constructed by using B-spline curves with different orders. For example, second ordered B-spline curve is a straight line, and the third ordered one presents a curve with different cambers. So B-spline curve satisfies the requests for various kinds of 2D patterns' outlines. Especially, the B-spline curve can be used to present all kinds of curves by changing the positions of control points to get the 2D patterns we want. Therefore, B-spline curves with different orders are used in this study to draw the outline of cloth patterns and set up particles on the outlines. One of the results is shown in Fig. 3.

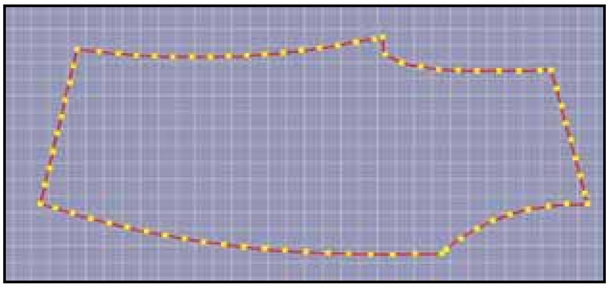

Fig. 3 Draw a cloth pattern with B-spline curve and set up particles on the pattern boundary

3.2 Get the particles in the pattern and Set up their relations with a mass-spring model

Because the virtual cloth is simulated by the relation of particles on the cloth to present the appearance of the cloth, the particles inside the cloth pattern should be constructed, and their relations are set up by mass-spring model. The 2D patterns that could be used to simulate 3D virtual cloth are obtained with the following steps.

(1) Get all particles inside the cloth pattern.
(2) Set up the outline of the particles inside the cloth pattern.
(3) Set up the relations of the particles inside the cloth pattern by mass-spring model, and set up the triangular meshes using the particles inside the cloth pattern.
(4) Set up the interrelations between the inside outline and outside outline, and set up the triangular mesh.

Finally, the cloth pattern meshes shown in Fig. 4 is obtained. It not only has the fabric behavior but also can be used to simulate the 3D virtual cloth.

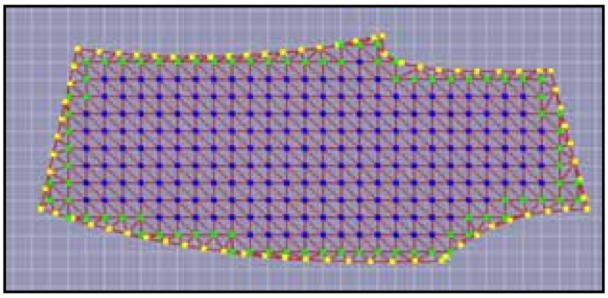

Fig. 4. 2D cloth pattern with fabric behavior

4 3D Virtual Cloth Simulation

After the 2D cloth patterns have been drawn with the proposed method, an approximate implicit method and collision detection technique are used to simulate the 3D virtual cloth in a three dimensional environment. One of the simulated results of a 3D virtual cloth is shown in Fig. 5. It looks like the 3D virtual cloth has the fabric behavior of the real cloth, and consequently the accuracy of the proposed method is proven.

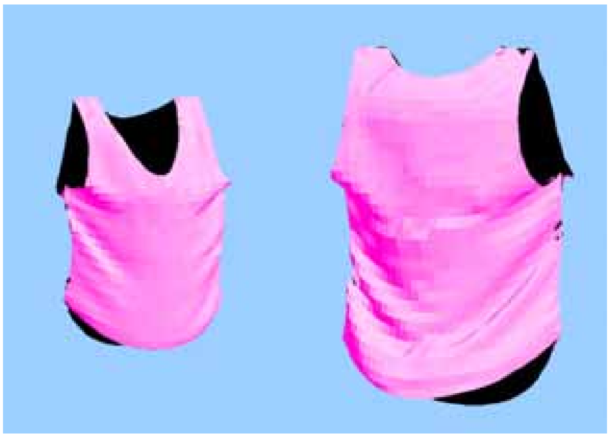

Fig. 5 A 3D virtual cloth simulated with the proposed method

5 Conclusion

Computer-aided cloth design is one of the various and challenging research themes in computer graphics. Though the most researches are focused on simulation and visualization of a 3D cloth, the creation of 2D patterns is the real contribution in the garment industry. A method of drawing 2D cloth patterns with fabric behavior that can also be used to simulate a 3D virtual cloth to get different cloth appearances by changing the spring coefficients in the mass-spring model is proposed in this study. In further research, if the multi-mesh algorithm could be used, then the efficiency of simulation could be improved and is used in order to a real-time result.

6 Acknowledgements

The authors gratefully acknowledge the support provided to this study by the National Science Council of the Republic of China under grant NSC 93-2213-E-006-018.

References:

[1] B. Eberhardt, A. Weber, and W. Strasser. A fast, flexible particle-system model for cloth draping. IEEE Computer Graphics & Applications, Vol. 16, pp. 52-59, 1996.

[2] B. Wang, Z. Wu, Q. Sun, M. Yuen. A deformation model of thin flexible surfaces. Proceedings of WSCG, pp. 440-446, 1998.

[3] C.C.L. Wang, Shana S-F. Smith, Mattew M.F. Yuen. Surface flattening based on energy model, Computer-Aided Design, Vol. 34, pp. 823-833, 2002.

[4] D.E. Breen, D.H. House, and M.J. Wozny. Predicting the drape of woven cloth using interacting particles. Proceedings of SIGGRAPH, pp. 365-372, 1994.

[5] D. Zhang, M.F. Yuen. Cloth simulation using multilevel meshes. Computer & Graphics, Vol. 25, pp.383-389, 2001.

[6] D. Zhang, M.F. Yuen. Collision detection for clothed human animation. Proceedings of Pacific Graphics, Hong Kong, 2000. pp.328-337.

[7] David Baraff, Andrew Witkin. Large steps in cloth simulation. Computer Graphics, Vol. 32,

pp. 43-52, 1998.
[8] G. Celniker, D. Gossard. Deformable curve and surface finite-elements for free-form shape design. Computer Graphics, Vol. 25, pp. 257-266, 1991.
[9] J. McCartney, B.K. Hinds and K. W. Chong. Pattern flattening for orthotropic materials. Computer-Aided Design, Vol. 37, pp. 631-644, 2005.
[10] J. Meseth, G. Müller, R. Klein. Reflectance field based real-time, high-quality rendering of bidirectional texture functions. Computers&Graphics, Vol. 28 , pp. 105-112, 2003.
[11] K-J Choi and H-S Ko. Research problems in clothing simulation. Computer-Aided Design, Vol. 37, pp. 585-592, 2005.
[12] L. Balmelli, T. Liebling, M. Vetterli. Computational analysis of mesh simplification using global error. Computational Geometry, Vol. 25, pp. 171-196, 2003.
[13] L. Chittaro, D. Corvaglia. 3D virtual clothing: from garment design to web3D visualization and simulation. Proceeding of the eighth international conference on 3D Web technology, Session 3, pp.77-ff, 2003.
[14] L. Parida, S.P. Mudur. Constraint-satisfying planar development of complex surfaces, Computer-Aided Design, Vol. 25, pp. 225-257, 1993.
[15] Leslie A. Piegl and Arnaud M. Richard, Tessellating trimmed NURBS surfaces, Computer-Aided Design, Vol. 27, pp. 16-26, 1995.
[16] Luiz Velho and Denis Zorin. 4-8 Subdivision, Computer Aided Geometric Design, Vol. 18, pp.397-427, 2001.
[17] M. Carignan, Y. Yang, N. Thalmann, D. Thalmann. Dressing animated synthetic actors with complex deformable clothes. Computer Graphics Vol. 26, pp. 99-104, 1992.
[18] M. Desbrun, P. Schroder, A. Barr. Interactive animation of structured deformable objects. Proceedings of Graphics Interface, pp. 1-8, 1999.
[19] M. Fontana, C. Rizzi and U. Cugini. 3D virtual apparel design for industrial applications. Computer-Aided Design, Vol. 37, pp. 609-622, 2005.
[20] M. Meyer, G. Debunne, M. Desbrun, and A. H. Barr. Interactive animation of cloth-like objects in virtual reality. ASC-89-20219.
[21] P. Volino and N. M. Thalmann. Efficient self-collision detection on smoothly discretized surface animations using geometrical shape regularity. Computer Graphics Forum, Vol.13, pp. 155-166, 1994.
[22] P. Volino and N. M. Thalmann. Implementing fast cloth simulation with collision response. Computer Graphics international 2000, pp. 257-266, 2000.
[23] P. Volino, F. Cordier and N.M. Thalmann. From early virtual garment simulation to interactive fashion design. Computer-Aided Design, Vol. 37, pp. 593-608, 2005.
[24] P. Volino, M. Courchesne, N. Thalmann. Versatile and efficient techniques for simulating cloth and other deformable objects. Computer Graphics. Vol. 29, pp. 137-144, 1995.
[25] P. Volino, N. Magnenat-Thalmann. Avenues of research in dynamic clothing. Proceedings of the Computer Animation, pp.193-202, 2002.
[26] P.N. Azariadis, N.A. Aspragathos. Geodesic curvature preservation in surface flattening through constrained global optimization. Computer-Aided Design, Vol. 33, pp. 581-591, 2001.
[27] T. Igarashi, J. F. Hughes. Clothing Manipulation. Proceedings of the 15th annual ACM symposium on User interface software and technology, Vol. 4, pp.91-100, 2002.
[28] X. Provot. Collision and self-collision handling in cloth model dedicated to design. Computer Animation and Simulation 97, pp. 177-190, 1997.
[29] X.Provot. Deformation constraints in a mass-spring model to describe rigid cloth behavior, Proceedings of Graphics Interface, pp.147-154, 1995.
[30] Y.-M. Kang, H.-G. Cho. Bilayered approximate integration for rapid and plausible animation of virtual cloth with realistic wrinkles. Proceedings of the Computer Animation, pp.203-211, 2002.
[31] Y.-M. Kang, H.-G. Cho. Complex deformable objects in virtual reality. Proceedings of the ACM symposium on Virtual reality software and technology, pp.49-56, 2002.
[32] Y.-M. Kang, J.-H. Choi, and H.-G. Cho. Fast and stable Animation of Cloth with an approximated implicit method. Proceedings of Computer Graphics International, pp.247-255, 2000.
[33] Y.-M. Kang, J.-H. Choi, H.-G. Cho, and C.-J. Park. An efficient animation of wrinkled cloth with approximate implicit integration.

The Visual Computer, Vol. 17, pp. 147-157, 2001.

[34] Z-G Luo and M.M.F. Yuen. Reactive 2D/3D garment pattern design modification. Computer-Aided Design, Vol. 37, pp. 623-630, 2005.