3D Mapping of Garment Patches Based on Human Body Section Loop Data

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Abstract. Virtual-try-on technology has been gaining popularity for its commercial potential. Many researches implement 3D garments mapping by sewing virtual garment patterns together around a mannequin. However, many systems need user interaction. In this paper, we propose a 3D mapping method of garment patches based on human body section loop data. The inputs include a virtual mannequin and the front and back patterns of a garment. The virtual-try-on process needs no user interference and can satisfy the real-time requirement after the pretreatment of human body section loop data.

Keywords: virtual-try-on, section loop data, garment locating loop, 3D mapping.

1 Introduction

The Internet becomes an attractive channel for the sale of garment products nowadays. With the development of virtual garment design and simulation techniques, virtual-try-on visualization has emerged as a compelling tool for online garment sales.

Many virtual-try-on system prototypes have been proposed and different simulation techniques have been applied so far. Meng et al.[1] and Wacker et al.[2] fulfilled 2D garment mapping to 3D surface by sewing virtual garment patterns together around a mannequin. Divivier et al.[3] proposed a set of methods for geometric pre-positioning, modeling and simulation. Ding et al.[4] put forward a co-evolutionary immune algorithm and use it to solve the large scale garment matching problem.

Generally, the typical virtual-try-on systems involve five processes including creation of human avatar (namely a 3D virtual counterpart of the user), 2D garment pattern design, pre-positioning of garment patterns, a virtual sewing process and physical simulations. Among the five processes, pre-positioning of garment patterns is a critical step. The result of pre-positioning decides the virtual-try-on effect to a great extent. However, there is no best method for automatic pre-positioning, and most systems complement pre-positioning by user interaction.

In this paper, we propose a 3D mapping method of garment patches based on human body section loop data. The inputs include a virtual mannequin and the front and back patterns of a garment. The virtual-try-on process needs no user interference and can satisfy the real-time requirement after the pretreatment of human body section loop data. Researches have been done for 3D body measurement and body scanning techniques concerning creation of avatar which is beyond the scope of this paper[5,6].

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2 Pretreatment of the Human Body Section Loop Data

A virtual 3D mannequin is generally expressed by triangle meshes, which seems redundant in the human body information expression and increases calculation workload of garment 3D mapping. In this paper, the mannequin data is organized based on the human body section loops. The loops are produced from the mannequin expressed by triangle meshes.

2.1 Generation of the Human Body Section Loop Data

We divide the mannequin into several parts including trunk, left arm, left forearm, right arm, right forearm, left thigh, left shank, right thigh and right shank. For each part, several cross sections are used to cut the mannequin and a slice is obtained when a cross section intersects with the mannequin part. Each slice is formed by connecting the intersection point set and these slices form the human body section loop data.

2.2 Demarcation of Vertical Marker Lines of the Mannequin

Four marker lines are demarcated on the mannequin. Two of them are on the front side and the other two are on the back side. The four lines all start from neck, and the front two pass through each side of breast while the back two pass through scapulae respectively, finally all of them extend downward to shanks. As marker lines of different people vary, they are irregular. Thus we demarcate them manually.

3 The Garment Locating Loops

In real life, there are gaps between a garment and a mannequin. For instance, as the chest circumference of a woman is greater than waistline, the waist part of a garment is always pending. To get pending effect, the human body section loop data is adjusted and the adjusted result is defined as garment locating loops.

3.1 The Adjusting Algorithm

The adjusting algorithm is described as follows, and the torso is a major part to be adjusted. Adjust the section loop data successively along the torso axis, starting from the first loop at neck. The Z axis is the torso axis in Fig. 1(a).

Definition 1(Current Loop, L_{cur}).
The current loop refers to the loop needed to be adjusted in this algorithm. In Fig. 1(a), the lower loop is the current loop.

Definition 2(Contour Loop, L_{con}).
Project the upper loop onto the plane of lower loop along the negative direction of Z axis, then contour loop is defined as the loop encircles the lower loop and the projection of the upper loop tightly. There are three circumstances as shown in Fig. 1(a). When one loop contains the other loop, the outer loop is taken as the contour loop. When the two loops intersect, the encircling loop is taken.

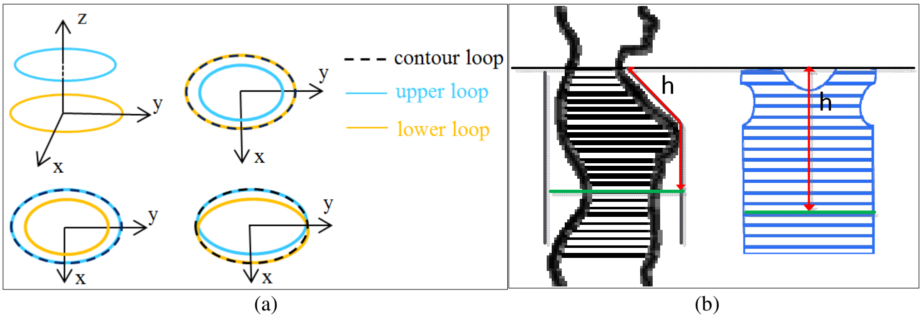


Fig. 1. (a) Contour loop (b) The measuring method of the distances

Definition 3(Corresponding Weft Length, CWL).
The corresponding weft length refers to the length of the garment weft whose distance from shoulder seam is the same as the distance between the current loop and the first loop at neck. The measurement of the distances is shown in Fig. 1(b). The distance between the current loop and the first loop at neck is measured along the vertical marker lines of the mannequin.

Adjusting Algorithm:
Define: C(L) is the circumference of loop L.
If CWL < C(L_{cur})
  Then L_{cur} needs no adjustment
Else if CWL > C(L_{cur}) && CWL < C(L_{con})
  Then extend L_{cur} until its circumference reaches CWL
Else if CWL > C(L_{con})
  Then extend L_{cur} until its circumference reaches C(L_{con})

3.2 Optimization of the Garment Locating Loops

The correctness of the garment locating loop data will directly affect the effect of the 3D garment simulation. Therefore, the garment locating loops should be optimized before 2D-3D patch mapping.

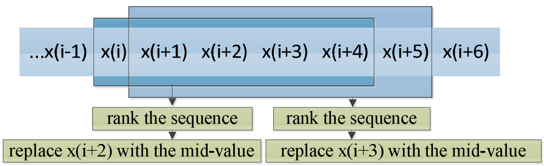


Fig. 2. One-dimensional median filter method

The garment locating loops optimization can be seen as a process of re-sampling and smoothing of curve in the plane. In this paper, one-dimensional median filter method is adopted to smooth the curve, and the basic principle of the method is to replace the value at the central point in digital sequence with mid-value in the point domain as shown in Fig. 2. The specific steps are described as follows:

(1) Each garment locating loop can be seen as a point set on the plane, or a digital sequence. A median filter window with a length of 2n+1 is set up for these point sets and moved along the digital sequence with a step length of 1 each time. In our experiment, n is taken as 2;
(2) After moving the window, sequences in the window should be ranked;
(3) Calculate the mid-value of the sequence in the window and replace the value at the central point with mid-value;
(4) Repeat until the end of the point sequence.

4 2D-3D Mapping of Garment Patch

4.1 The Garment Locating Loops Unfolding

Unfolding of the garment locating loops is designed to facilitate 2D-3D mapping. The principle of the garment locating loops unfolding algorithm is that the loop data are considered as a 3D point set, and one point has relative positional relation with the other point, as long as the loop data after unfolding can keep this relation to the maximum extent, the unfolding algorithm is regarded as rational.

Constraint conditions to be considered during the unfolding process include spatial distance and curvature constraint. Azariadis[7] et al. put forward a curvature unfolding algorithm, in which, distance constraint equals to constraint of the sum of the distances between one point and other vertices of triangle with the point as the vertex, while the curvature constraint equals to the constraint of the included angle formed by edges of triangle.

In the algorithm proposed by Azariadis, when the distances constraint is considered, the way of curved surface triangularization influences the number of affected vertices. If the triangular mesh is irregular, the number of vertices to be taken into consideration will be less, thus losing some curved surface information and leading to inaccurate curved surface unfolding. Fig. 3 shows the relationship between the way of curved surface triangularization and the number of affected vertices. In this paper, the original algorithm is improved, distance constraint is no more considered based on the adjacent triangle after the curved surface triangularization. No matter how the curved surface is triangularized, the spatial distance constraint should ensure that eight points near each point (boundary excluded) are taken into consideration. In our experiment, conjugate gradient method is adopted to calculate the minimum value.

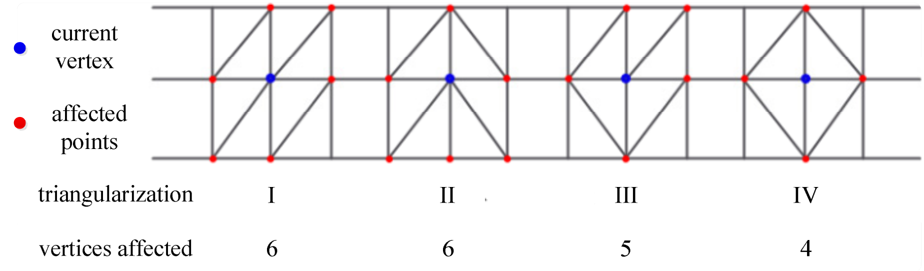


Fig. 3. Relation between triangularization method and number of affected vertices

4.2 2D-3D Garment Patch Mapping

The unfolded garment locating loops and the 2D garment patch are on the same plane and the unfolded garment locating loops contain both planar and 3D coordinates. Therefore, we can implement the 2D to 3D garment patch mapping as follows:

(1)The garment patch is subdivided into mesh grids using regular grid method as shown in Fig. 4.

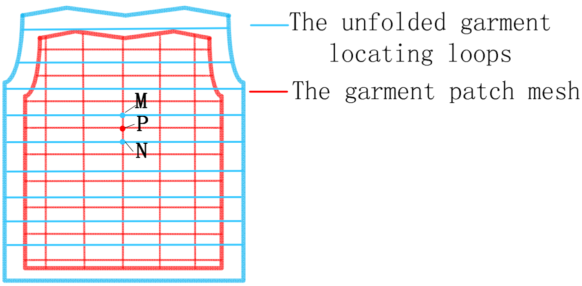


Fig. 4. 2D-3D garment patch mapping

(2)We let the unfolded garment locating loops overlap the 2D garment patch mesh by putting them in the same coordinates.

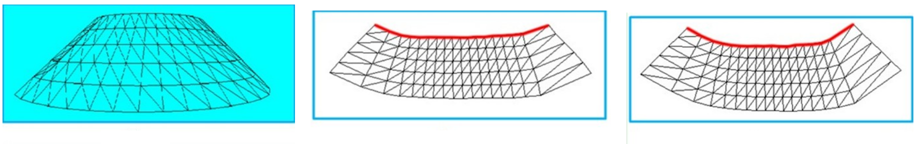
(3) By matching the 2D coordinates of the unfolded garment locating loops with that of 2D garment patch mesh, 3D coordinates of the garment patch mesh vertices can be calculated by the 3D coordinates of the unfolded garment locating loops. As shown in Fig , the 3D coordinate of vertex P on the garment patch mesh can be interpolated by the 3D coordinates of vertices M and N on the unfolded garment locating loops.

Using the method described above, 2D-3D garment patch mapping is completed and a 3D garment wore on a mannequin is acquired.

5 Experiment Results

5.1 Experiment I: Comparison between the Unfolding of Curved Surface Adopting the Azariadis's Algorithm and the Improved Algorithm

Fig. 5 shows the comparison result. The spatial curved surface to be unfolded in this experiment contains 108 vertices and 170 triangles; curvature weight in the unfolding algorithm is 0.9, and distance weight is 0.1. According to the figures, after improving



(a) (b) (c)

Fig. 5. (a) Spatial curved surface to be unfolded; (b) Effect of curved surface unfolded adopting the Azariadis's algorithm; (c) Effect of curved surface unfolded using the improved algorithm

the unfolding algorithm, boundary lines of the unfolded curved surface are more curved, with less information lost and accurate data obtained.

5.2 Experiment II: 3D Garment Simulation Result

Our method has good simulation effect. The overall simulation effects of a shirt and a trouser are shown in Fig. 6, and both of the simulation processes take less than 5 seconds.

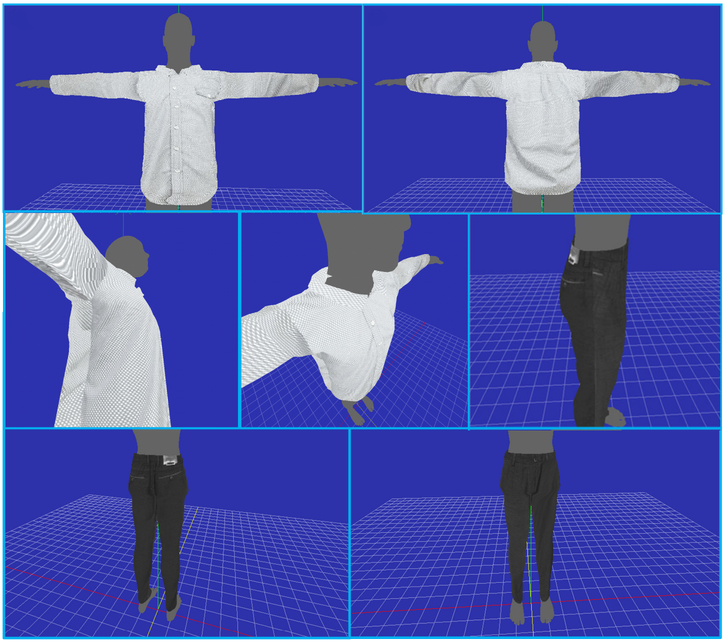


Fig. 6. Coat/trouser simulation effect

6 Summary

A garment patch 3D mapping method based on the human body section loop data is presented in the paper. The human body model is expressed by the section loop data. First, a virtual mannequin expressed by triangle meshes is cut into section loops, and vertical marker lines of the mannequin are demarcated on the resulted section loop data. Then, garment locating loops are generated from section loops. Finally, 2D-3D garment patch mapping is completed by calculating 3D coordinates of the garment patch mesh vertices from the information on unfolded garment locating loops. Experiments show that the section loop data have obvious advantages in extracting human body characteristic information. The method proposed is totally geometry-based. To improve visual effects, physical details would be added in our future work.

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