A Study on Area Ease Distribution between Body and Garment

Ji-Hong Xu[1,2,*], Xiu-Feng Chen[1], Wen-Bin Zhang[2]

[1]*Yangzhou Polytechnic College, Yangzhou 225009*
[2]*Institute of Fashion Design, Donghua University, Shanghai 200051*

Abstract: Using 3D scan data, the ease-space area relations between a standard body and a specific style of garment with various sizes are studied. The least square method, cubic polynomial approximation and even arc-length with the idea of reverse engineering are employed in analyzing the curves of different cross sections of the body and the garment. Moreover, the area between the body surface and the garment section curves is used in calculating the ease-space distribution along with the changes of the body angles. 30% of the total ease space is distributed in the front and back and 70% around the sides and waist if the garment is to possess a good appearance, which is provided in an evaluation indicator used for the 3D garment simulation. This study is useful in further investigation of the fitness of garments on the human body, and it provides an evaluating indicator in the 3D garment simulation. It can also be used in firefighting industry for the air gap calculation and fireproof clothing.

Keywords: 3D scanning, curve fitting, area ease, distribution relation.

1. Introduction

The ease relation between body and garment is a main concern of the apparel fit. It also serves as the starting point in 3D virtual garment technology and fireproof clothing industry, *etc*. The ease of garment generally means the gap, or vacant space, between the body and the garment which includes distance, area and volume [1]. As it is well known, apparel fit is the first concern when people purchase clothes. It is reported that 50 percent of women cannot find apparel that fit perfectly, and in the United States, 50 percent of the catalog returns is due to the fit problem [2].

A research in analyzing the garment appearance, fit and pattern making from the point of space relationship between the body and garment is very necessary. Yu *et al*. measured the jacket shape by using Moiré topographic system. The fringe pattern was digitized and the co-ordinates of the sectional profiles were quantified using fourth-order polynomial functions, and root-mean-square measures of the shape characteristics were derived [3]. Taya *et al*. digitized the 3D coordinates of measuring grids marked on the dummy, using a Vectron measuring apparatus and discussed the space between the body and dress [4]. Wang *et al*. measured the coordinates of reference points marked on the bust line, and waist line of mannequin using manual method. The cubic spline was used to fit the cross section curve of bust line, waist line of body and garment, and the fitted functions of ease distribution were obtained using the polynomial functions and trigonometry functions [5].

The manikin modeling and the 3D garment modeling now is one of the most interesting topics in textile engineering, computer graphics and 3D garment CAD. The digital technology in geometrical modeling, physical modeling and the mixtures is thus developed. However, these technologies in garment simulation is far away from perfectly simulating the real garments because the technology is based on the ideal model and the space relation between virtual body and virtual garment is not very clear.

Moreover, the air gap between body and garment is a key index in studying firefighter's fireproof clothing. The air gap between the fabric inner surface and the surface of the skin is usually present and it plays an important role in insulating the skin from the intensive thermal exposure. And, both the distribution of the air gap thickness and the amount of free water affect the maximum duration of the flash fire exposure before getting second and third degree burns [6]. Song used a three dimensional body scanning technique to measure the air gap layer distribution between different-size protective garments, and the body of a manikin to evaluate garment thermal protective performance[7]. Therefore, it is important to investigate the real ease distribution relation between body and garment.

In this paper, we define the area ease of garment more mathematically as area from the body surface to the inner surface of the clothes on the horizontal cross section. By using the 3D scan data from a standard body and a specific style of garment of different sizes, we calculate the value of the ease with the changes of the body angles. Since the garment style is determined by the body shape and vacant space between the body and the garment, in which the body shape is the base of garment pattern, and garment style is ultimately implemented through

*Corresponding author's email: xujihong@sohu.com

the vacant space between the body and garment, the ease distribution is crucial when a 3D garment style is projected to a 2D garment pattern. Because the distribution of ease is not even, a thorough mathematical study of the ease relation between the body and garment in the cross sections of bust, waist, etc. is very necessary. In our approach, the least square method, cubic polynomial approximation and even arc-length in reverse engineering are used also in analyzing the cross section curves of the body and the garment in many different locations. We find that the area ease varies in a rule rather than being equally distributed, and derives some equations for the cross-section curves of the ease distribution at specific body angles. Finally, a program in the VB language is provided in order to calculate the ease gap between the body and garment. The results obtained in this paper certainly have future applications in the garment industry.

2. Experimental

2.1 Modified Mannequin

The mannequin is an important tool in garment industry with wide applications in drape designs, production, demonstration and testing of garments. In order to avoid the influences caused by respiration and size difference, it is better to use the standard mannequin in the study of the garment ease. The mannequin has two states: naked and dressed. The one we used is the one with the standard GB/T1335.2—1997 whose bust size, waist size and hip size are 84, 64 and 89 cm, respectively, together with a $[TC]^2$ 3D body scanner, which is unique for human body. We add two arms and legs to the standard mannequin for better results in the experiments (Figure 1)

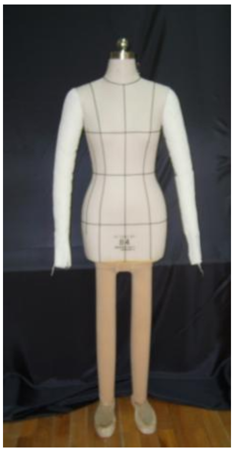

Figure 1 The modified mannequin

2.2 Sample clothes

Ten jackets, X1 to X10 of sizes in Table 1, with typical X-line are used as the initial outline of fashion style. In order to obtain a style with better aesthetic appearance, the draping method is used in making the garment. The relationship between bust(B), waist(W) and hip(H) of X1 to X4 is: W=B-16, H=B+6 and the relationship between bust(B), waist(W) and hip(H) of X5 to X10 is: W=B-14, H=B.

Table 1 The size of the 10 clothes

size / style	body	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
B	84	90	92	94	96	98	100	102	104	106	108
W	64	74	76	78	80	82	84	86	88	90	92
H	89	96	98	100	102	104	106	108	110	112	114

2.3 The data coordinates

The mended mannequin is scanned using $[TC]^2$ scanner in both naked and dressed states, respectively. The 3D data are stored in *.wrl forms in order to convert the scanned mannequin into two parts of limbs and torso by taking advantage of the scanner software. And then acquire the multi-face meshes data of manikin torso so that further study is possible (Fig. 2).

The 3D data of the manikin in both naked and dressed states are converted into *.dwg through 3DMAX program in order to be analyzed using AutoCAD program. In AutoCAD2007, the 3D data of limbs are deleted and 3D data of torso are restored (Fig.3). There are about $4*10^3$ 3D data points in scanned torso multi-face mesh. In each horizontal section layer there are about 60 data in each layer, and 1.5 cm apart from layer to layer. Using the coordinates of these points, the data of the cross sections like the bust circumference, waist circumference and hip circumference are obtained.