

Digital Human Modeling and Clothing Virtual Try-on

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Abstract

This study proposes a method to evaluate clothing fit on human body by dressing virtual clothes on 3D human model. The clothing patterns are designed and subsequently sewn up together around the human model. Due to the complex cloth shapes are difficult to fit well on the human body, this study proposes the 3D human model dressing with virtual clothes according to the body shape. Different clothing sizes are tested to fit on a human body for assuring a satisfactory fit. Several subjects were recruited to test in this study. In order to evaluate the clothing fit for virtual try-on, the representations of different-sized clothes are compared with virtual and human fit trials using visual analysis. For objective fit evaluation, the amount of clothing fit of specified size is assessed quantitatively by calculating the vacant space area between clothes and human body. Finally, the clothing fit information can be applied for the development of clothing products in apparel industry.

Keywords

Fit evaluation, Virtual try-on, Clothing fit, Visual analysis, Vacant space area

1. Introduction

The rise in technology has made it possible to create a system like a virtual dressing room for customers to try on clothes on the Internet (Volino and Magnenat-Thalmann 2005). The idea provides customers to see how well the clothes can actually fit before making a purchase decision. The virtual try-on scenario can help customers to speed up the process for trying on various clothing styles. Generally, customers choose clothes based on their personal sizes and preferences. Many factors including culture, fashion, style, body figure, and experience would influence the preference of clothing selections (Huang 2011). People who preferred tight fit clothing were usually satisfied with their weight, while people who were dissatisfied with their body shapes preferred baggy clothing (Alexander et al. 2005).

Actually, improper cloth sizes distort the clothing fit because bigger clothing size tends to cause extra space between clothes and human body. The problem caused by poorly fitted clothing shows the wrinkles and unattractive clothing folds on the human body. Traditional method used the image-based analysis to evaluate the contour shape of clothes (Huang 2011). Research staff trained with experiences collected customers' opinions by questionnaire survey to provide assessment for clothing fit observations (Lee et al. 2007). However, it is observed that most of the clothes do not fit well for individuals, especially the human back shape along the spine area with varied shape curves (Yu et al. 2011).

Since the virtual dressed model can be used to evaluate the quality of fit (Liu et al. 2010), the 3D model is used to set the body proportion similar to the customer's body shape (Xu and Zhong 2003; Chen et al. 2008). Based on the 3D model, the user built a virtual self to experiment with various clothes. Recent survey discussed the fitting satisfaction to make the customer have sufficient ease to easily move (Huang et al. 2012). In addition, some research applied the pressure evaluation to test wear comfort of clothes (Au and Ma 2010). Phoebe and Rose (2007) proposed methods to evaluate the fit of virtual clothes by using the key dimensions selected from the chest and waist areas. Lee et al. (2007) and Loker et al. (2005) analyzed the differences in the slice areas between body and clothes for ease allowance. The ease allowance was evaluated to fulfill the functional requirements among different clothes and to provide acceptable fitting criteria (Huang et al. 2012).

The realistic representation of virtual try-on requires suitable clothes to fit to human body. Due to the variety of body shapes involved in individuals, it costs a lot for manufacturers to make the sufficient clothing sizes to meet

every individual's preference with desired fit. Thus, it is important to evaluate how different-sized clothes can actually fit on the human body. The objective of this study aims to evaluate the clothing fit on human body by dressing virtual clothes on 3D human model. The method starts in designing clothing patterns and the sewing patterns are subsequently fitted to human body according to different body shape. Based on the clothing simulation, the human body dressed in different clothing sizes are tested for assuring a satisfactory fit. Finally, the clothing fit evaluation can provide useful information for clothing products in apparel industry.

2. Clothing Virtual Try-on

2.1 3D Human Model

This study starts with constructing 3D human model for clothing simulation. In order to dress clothing patterns on the 3D human model, the Vitus 3D 1600 whole body scanning system was used to construct the 3D human model. Prior to scanning, the scanner had to be calibrated. In 3D scanning, each subject was asked to wear a set of scanning attire and cap, and to adopt a standard posture. The subject with minimum clothes was scanned to obtain the 3D body scanning data. The 3D human model was constructed by using the Geomagic software. Then, the constructed 3D human model was imported into the commercial software 3D MAX™ for further clothing simulation.

2.2 Clothing Pattern

For clothing design, the clothing patterns are represented as a set of 2D polygons using CAD software for a shirt (Lin 1985). The patterns are digitized and triangulated to enable the construction of the clothes. For virtual try-on, the patterns are designed by measuring the real shirts to make different-sized clothes. Then, the clothing patterns are placed in the corresponding position around body surface for clothing sewing.

2.3 Clothing Simulation

In order to simulate the clothing behavior on the 3D human model, different clothing patterns are assembled and linked by seaming lines. By applying forces between the seams in clothing pieces, the two clothing patterns can attach each other during the sewing process. Subsequently, the sewing clothing patterns can be tightly connected to fit to the 3D human model.

Then, the clothing materials are specified with given parameters. The clothes with textile materials are generated to reflect the characteristics of the fabric. A simulation procedure is executed by modifying different parameters to adjust the fabric property on the sewed clothes. After completing the simulation procedure, the texture of the clothes can be represented on the 3D model. Afterwards, the simulation of virtual try-on with the specified textile material can be visualized. And, the clothing simulation results can be further used for evaluating the clothing fit.

2.4 Clothing Fit

Initially, clothing fit is conducted on a 3D human model with appropriate shape for virtual try-on. Since the 3D character of the individual body shape can be constructed by a 3D body scanner, it is observed that a proper size of clothes can represent a suitable fit on the individual body. The designer chooses the size of clothes close to the body shape of the human model, and then performs the seaming process to sew up the clothing patterns together to fit to the human body shape.

Since a well-fitted clothing usually hangs evenly on the human body with sufficient ease, the amount of ease space is assessed by analyzing the ease index between clothes and human body. In order to define the fitness of the clothes in different sizes on the body, the wearing trials were conducted using 3D scanning for clothing fit evaluation. It allows the individual to try on clothes with several sizes on the human body. The vacant space area is the ease space between the cross section of the human body and the clothes. The vacant space area at the key positions of human body can be analyzed to evaluate clothing fit. After that, the specified ease area between cloth and body can be identified to make the well-fitted cloth patterns. Then the desired wearing ease can be used in creating the well-fitted clothes. Thus, a proper evaluation of clothing fit is necessary to identify the right size of the clothes.

3. Clothing Fit Evaluation for Virtual Try-on

3.1 Visual Analysis

In order to evaluate the clothing fit for virtual try-on, six subjects with different body shapes were recruited to the fitting evaluation. For fit evaluation, every subject was scanned by putting on the fitted size of shirt at the beginning, and then changed the shirt sizes to a bigger one and a smaller one. In order to have a comparison with virtual and human fit trials, the virtual clothes made by the proposed method are dressed on the individual body of every subject. The virtual try-on clothes are considered to be simulated with the same textile material property as the real shirt. For fit evaluation, subjects tried different cloth sizes in making contrast to meet the fit requirement. Each subject chose one of the cloth sizes better fit than the others and considered as the well fitted clothes, and changed the cloth sizes into a bigger one and a smaller one.

3.2 Vacant Space Analysis

This study can not only visualize the appearance of wearing fit, but also compute the degree of clothing fit. Fitting appearance can be visually represented before the clothing fit is calculated and evaluated. To analyze clothing fit objectively, a statistical approach is used to examine the shape variation between clothes and human body. The ease measurements between the body cross section and the clothing cross section are calculated to determine the shape variation. The desired ease area integrating body feature in anthropometric studies indicated that the cross sectional ease area in the key locations of the human body such as chest and waist parts can be analyzed to fulfill the desirable fit (Phoebe and Rose 2007). The cross sectional ease area at the chest and waist parts can be analyzed to examine the fit performance using the fitting index.

The shape variation at the key cross sections of the chest and waist areas are analyzed for evaluating the clothing fit. The key cross sections at the positions of chest line and waist line were identified by using the proportions of the human body. The amount of ease area at different positions of chest line and waist line can be measured by using the ScanWorX software. The ease area among different-sized trial shirts can be obtained and further analyzed for examining the correlation with clothing fit. For objective fit evaluation, it is conducted by quantifying the ease values between clothes and human body. The ease quantity can be found to be related with the wearing feeling representing the clothing fit. The clothing fit is assessed quantitatively by the fitting index method (Huang 2011; Xu and Zhong 2003).

The fitting index, $F(\%)$, which provides an assessment of the clothing fit on a human body, is used to indicate the level of fitting between the clothes and the human body (Huang 2011; Xu and Zhong 2003; Phoebe and Rose 2007). A smaller $F(\%)$, i.e., a smaller vacant space area, indicates a tighter fit. The fitting index, $F(\%)$, can be obtained by the following equation:

$$F(\%) = \frac{A_{Clothing} - A_{Body}}{A_{Body}}, \quad (1)$$

where $A_{Clothing}$ represents the value of the clothing area, and A_{Body} represents the value of the human body area.

The calculated $F(\%)$ between virtual and human fit trials are listed in Table 1. Six subjects with age ranging from 25-30 years were tested for fit evaluation. The differences between the clothing fit trials were compared to obtain a correlation of how well they fit to each other.

Table 1: The results of the fitting index analysis.

F (%)			Mean
Subject 1	M size	Human fit trial	16.3 %

	(Fit size)	Virtual fit trial	23.6 %
Subject 2	S size (Fit size)	Human fit trial	20.0 %
		Virtual fit trial	23.9 %
Subject 3	S size (Fit size)	Human fit trial	16.2 %
		Virtual fit trial	18.1 %
Subject 4	XL size (Fit size)	Human fit trial	14.3 %
		Virtual fit trial	18.4 %
Subject 5	M size (Fit size)	Human fit trial	27.6 %
		Virtual fit trial	33.9 %
Subject 6	L size (Fit size)	Human fit trial	19.7 %
		Virtual fit trial	25.2 %

As it can be seen, the fitting results with virtual fit trials are bigger than the fitting with human fit trials because of the bigger vacant space area. The vacant space area among different-sized clothes increases according to the bigger size of clothes. From the fitting experiment, the cloth sizes that subjects choose as their better fit sizes are the cloth sizes they typically wore. It is found that the relationship between the ease area of different-sized clothes and the clothing fit are different from different subjects. Besides, the amount of fitting index may change based on the design of various kinds of clothes, complex properties of the fabric, different types of body shapes, and even personal preference.

Although it is hard to obtain the optimal fit for subjects with different body shapes, the relation between the fitting quantity and wearing comfort indicates that cloth fitting was more related to the extreme circumference across body parts such as chest and waist. For this shirt, the ease amount at the key cross sections of the chest and waist parts are different for varied body shapes of subjects. The vacant space area at the chest part represents tighter cloth fitting while the higher fitting index means there are more ease area at the waist part.

The ease value adopted in the other methods preferred more ease on both chest and waist areas to achieve acceptable fit. Comparing with the previous studies, the proposed method develops a systematic process from virtual try-on to clothing fit evaluation. It not only presents a complete procedure for virtual try-on experiment, but also evaluates fit of different-sized clothes with virtual and human fit trials using the 3D graphic technology. Thus, the approach can achieve the acceptable clothing fit by providing sufficient ease for every subject with different body shapes. The resulting fit estimation can be further adapted to create suitable vacant space area needed by the 3D virtual clothes. This findings support the effectiveness of the virtual try-on system with a satisfactory fit.

4. Conclusion

This study presents an approach for evaluating clothing fit on 3D human model. The clothing fit was evaluated by wearing different-sized clothing patterns of shirts. The clothing patterns were simulated on the human body of six individuals. The appearances of the virtual clothes were visualized and subsequently compared to the human fit trials. For clothing fit evaluation, the relative fitting index was calculated. The amount of ease area on the human fit trials showed smaller variation than that of the virtual fit trials. In addition, this study analyzed the fitting requirements by evaluating the ease amount at chest and waist areas. Both the subjective fit evaluation of the cloth appearance and the objective quantitative analysis of the fitting index were conducted. With the results of the fit tests, the findings can be useful to enhance better fitting on the dressed human body.

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Biography

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