3D VIRTUAL FITTING SYSTEM ON WOMAN'S GARMENT

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Professional paper
UDC: 687.2:004.94
doi: 10.5937/tekstind2104072J

Abstract: *Fit is one of the major concerns for the clothing industry, and pattern development process is significant during clothing manufacturing and the way clothing is constructed. Various pattern making methods have been introduced to the industry considering clothing fit satisfaction, but it is still impossible to provide the optimized clothing pattern for mass production. The aim of this paper is practical implications about 3D virtual fit simulation technology as a fit assessment tool in the fashion industry i.e. to predict the behavior of women's pants in relation to fitting and comfort in different poses of avatar. This was done by application CAD Clo 3D fashion design software.*

Keywords: fit, virtual garment, 3D garment simulation, apparel development.

3D VIRTUELNI SISTEM PRISTAJANJA ŽENSKE ODEĆE

Apstrakt: *Fit ili pristajanje je jedna od glavnih briga za industriju odeće, a proces razvoja šablona je značajan tokom proizvodnje odeće i načina na koji se odeća konstruiše. Različite metode izrade uzoraka su uvedene u industriju s obzirom na zadovoljstvo pristajanja odeće, ali je još uvek nemoguće obezbediti optimizovani uzorak odeće za masovnu proizvodnju. Cilj ovog rada su praktične implikacije o tehnologiji 3D virtuelne fit simulacije kao alata za procenu pristajanja u modnoj industriji, odnosno predviđanje ponašanje ženskih pantalona u odnosu na pristajanje i udobnost u različitim pozama avatara. Ovo je izrađeno primenom CAD softvera modnog dizajna Clo 3D.*

Ključne reči: fit ili pristajanje, virtuelna odeća, 3D simulacija odeće, razvoj odeće.

1. INTRODUCTION

Early garment CAD focused on 2D pattern drafting and modification. The pattern-making techniques in 2D CAD systems mainly consist of two parts: (1) individual pattern generation based on parametric design; (2) individual pattern altering based on grading rules. Since garment is more flexible than other industrial products, the constraint types used in both parametric design and the grading rules depend on pattern makers' experience which is case-sensitive [1].

As a potential technical solution, 3D virtual fit simulation technology has been introduced by the present apparel industry as a progressive means of rapid prototyping [2].

This technology is capable of converting 2D patterns into a finished sewn garment and placing it on a virtual fit model which has the identical body shape and measurements of the target consumer group, based on designers' input. This technology has the potential to assist both designers and manufacturers in evaluating fit and size issues quickly, using consistent virtual fit models [3].

Although final garment fitting is mainly conducted with live models, during product development patternmakers and designers usually use dress forms because they have consistent measurements and are convenient to use [4].

While researchers have found varying levels of accuracy in 3D apparel simulation software it is challenging to generalize from these studies because of the variations in garment types, virtual fabric used, and approach to measuring accuracy [5-7]. Otieno and Apeagyei [5] looked at measurements of cross sections of simulations to show similarities between the fit of real and virtual garments. Wu et al. [6] compared the fit of simulated garments with the fit of the same (actual) garments on a dress form, while Kim and Labat [7] compared real garments on live models with simulations on custom avatars. The important findings in these studies relate to the factors that impact accuracy of 3D garment simulation, rather than the accuracy itself.

Based on the feature-oriented parameterization of the human body, design-by-feature methodology [8,9] is applied to construct diverse feature-based profile templates of garments, each of which represents a different product styling of garment. The garment feature template is directly related to the feature graph of a parameterized human model by incorporating easing relationships [10]. When the body model is modified by inputting sizing dimensions, the easing relationship will automatically rescale and fit the garment product well on the individual body. Thus the difficult, experience-based 2D grading problem is avoided in 3D garment CAD systems.

Researchers have estimated ease allowance used for pattern making and comfort evaluation. Garment shape and distance ease between body and garment depends not only on garment construction and body measurements, but also on structural and mechanical characteristics of textile materials [11-14]. According to Xu and Zhang [14], the main factors affecting the values of distance ease are bending, shearing, tensile deformation and overhanging factor of material. Fan *et al*. [15] and Chen *et al*. [16] also claimed that ease is dependent on many factors including fabric characteristics, body movement, garment styling and comfort preferences.

3D simulation technology can reduce sample development time, and save the cost of multiple iterations of samples because the virtual fitting can help to fix the patterns through quick simulations of the fit and real-time pattern change, before making actual samples [2,17,18].

Zhang *et al*. [19] present an intuitive method that seamlessly integrates the whole process of garment design including 3D modeling, pattern development, garment simulation, and grading. Shi *et al*. [20] present an automatic virtual fitting system for fitting the input garment model onto the human model constructed from the input full-body image. Modeling virtual clothing where 2D and 3D digital technology is a modern tool is becoming a platform for the design, preparation and production of clothing. 3D virtualized technology reduces the number of samples, creates efficient production, and makes quick decisions, increases competitiveness, communication and e-sales [21].

In the previous work, first a 2D pattern was made and then a 3D simulation of a men's shirt [22]. The aim of this paper is to predict the behavior of women's pants in relation to fitting and comfort in different positions of body movement and sitting. This was done application a 3D computer program. Size grading was also done.

2. EXPERIMENTAL

The construction of women's pants was made in a 2D system. 3D women avatar of standard size 38 was

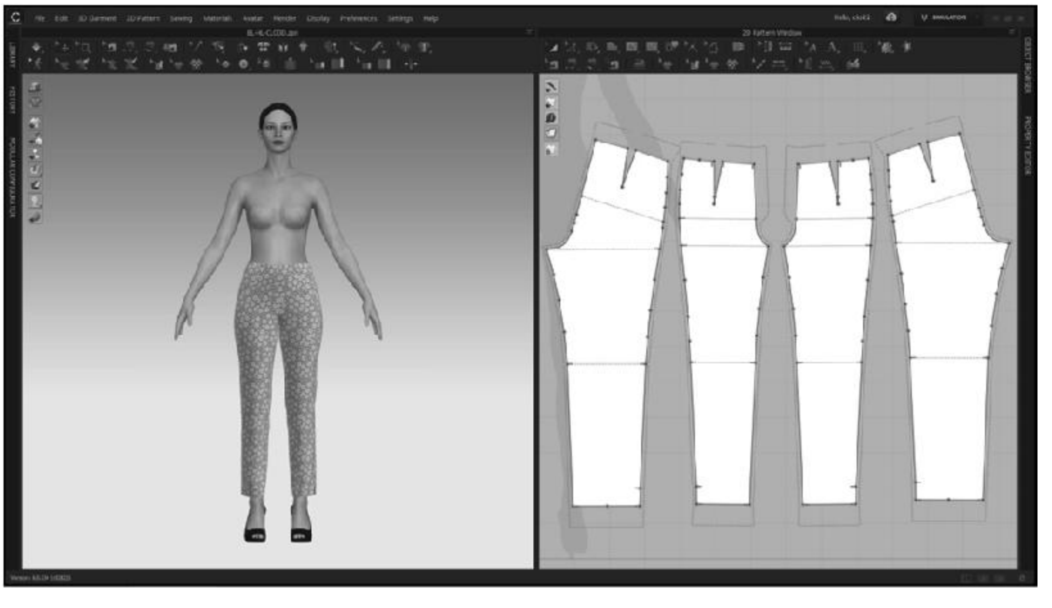


Figure 1: 2D-to-3D transformation of pant

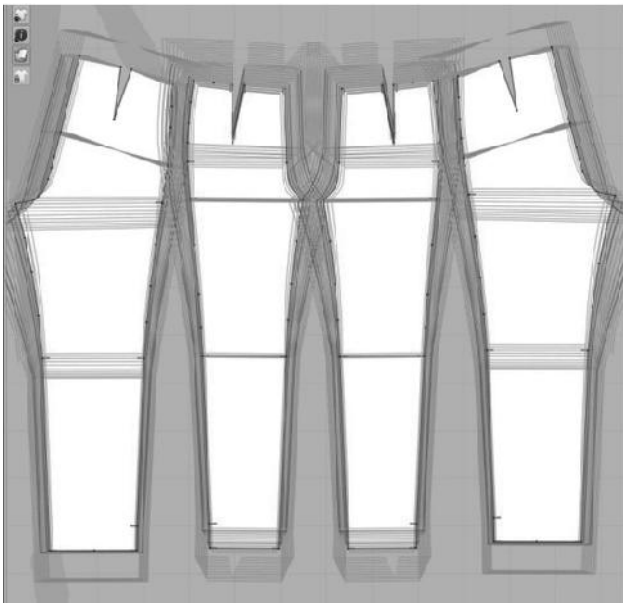


Figure 2: Grading 2D basic construction of woman's pants

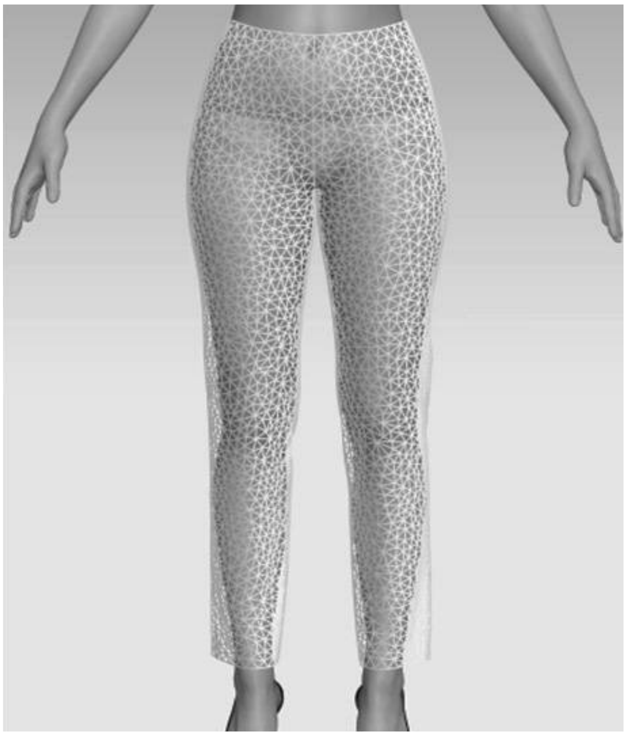


Figure 3: Mesh mapping - original pattern

covered with straight virtual pants stitched by Clo 3D software, (Figure 1). First of all, parametric basic pattern of straight pants with all the required construction ease allowances according to Müller pattern design method was drawn in Modaris software. Each line in basic construction was linked through formulas with the human body measurements and related ease allowance values. Later, without changing the measurements of the body, ten different basic constructions of the pants were grading, (Figure 2). The pants are made of designed material.

Also this construction were used for virtual fitting in order to determine the impact of different poses of avatar on impact strain map, stress map and pressure map.

The triangular mesh is used to represent the initial surface and base surface of a garment and it is also used to represent the fine garment surface. To create a fine garment which is suitable for cloth simulation, 2D patterns will be re-triangulated into regular meshes and after triangulation; a 2D mesh can be automatically mapped onto the 3D space [19]. However, if the boundary lines of a 2D pattern have been modified, the 2D pattern cannot be mapped directly. Otherwise, gaps and overlaps will probably occur in the meshes of the resulting fine garment. After mapping refined meshes of 2D patterns onto actual flattened 2D meshes, we can easily calculate the corresponding 3D positions of the refined meshes, and then a fine garment with regular meshes will be obtained automatically, as shown in Figure 3. The shape of the fine garment is the same as the base garment surface with un-flattened regions being hidden. The main difference is that the fine garment is consisted of regular meshes. Consequently, distortion and flipping will probably happen in cloth simulation.

3. RESULTS AND DISCUSSION

Findings of this study show that the current 3D virtual fit simulation technology is capable of converting 2D patterns into 3D forms on an avatar and making a close visualisation of the main shape. This implies that technical designers can use the technology mainly for preliminary fit analyses to check major fit issues of overall length, width, and shape of the garment at the beginning of the prototyping. In addition, the tightness or looseness, length, and seamline of the garment were visible with the 3D virtual simulation technology. The fit issues related to the paralleling and positioning of the seamlines and hem were easily recognised in the virtual garment. Also, our findings showed that 3D virtual simulation technology is capable of visualising the main shape information of the simulated garments.

In a 3D computer-aided garment design system, triangulated cloth patterns are used and mapped onto a mannequin model by minimizing a quadratic energy function [23]. Aono *et al.* [24] gave a further study on the fitting problem. In a versatile and efficient technique is proposed to simulate 3D dressing results from 2D pattern input [25]. Usually the 2D-to-

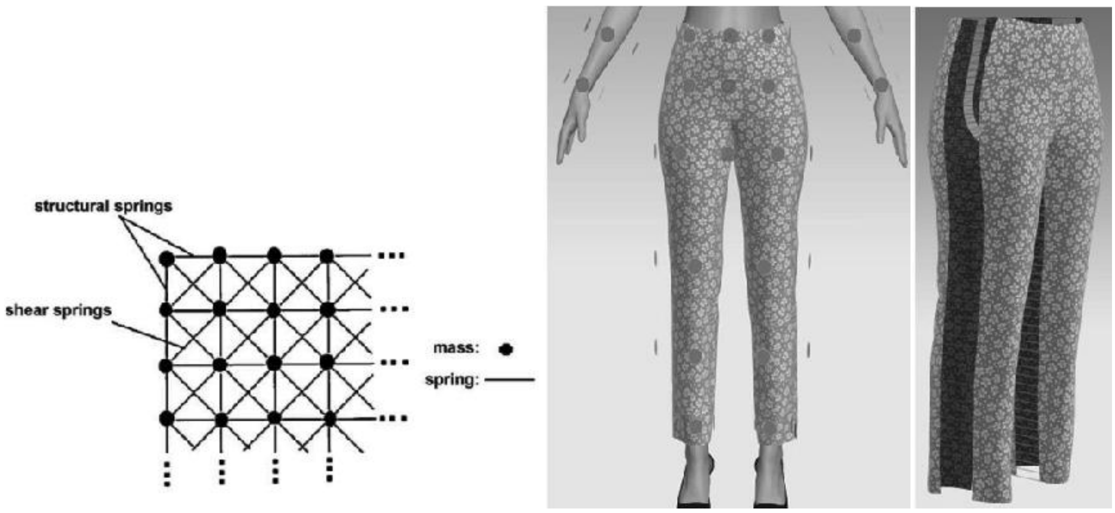


Figure 4: Virtual sewing and fitting with 2D pattern input to 3D transformation

3D transformation is treated as an elastic deformation process with large displacement but small stretch deformation. In a physical based deformable model is proposed for 2D-to-3D sewing and fitting [26]. In this model, the cloth patterns are modeled by a triangular mesh composed of mass nodes and massless edges: edges works as springs. Both structural and shear springs are defined as shown in Figure 4.

Garment's distortion rate due to external stress appears in percentage. Stain Map appears in total eight colors: Red indicates 120% of distortion rate while blue indicates 100% (no distortion). Numbers in between are expressed as gradation of two color. In addition to the strain map to determine the fit of the pants there is also a stress map showing the external stress causing garment distortion per area of the fabric appears in the range of color and numbers and fit map which shows the tightness of the 3D garment.

Figure 5 shows the virtual prototype on the front and back of the pants in standing pose of avatar behind the displayed strain map. It can be concluded that in this standing position red color of distortion (120%) occurs in the center front and on a very small area in the waist, which can be concluded that the construction of the pants is good and will not have problems when trained in real wear for given dimensions and target persons to wear. It can also be seen that there is a yellow color in the upper part of the pants, which indicates that the distortion is somewhat less present, which in percentage is somewhere around 114% on the scale. Where there is a blue color there is no distortion, and these are the length of the pants respectively.

In Figure 6, on the other hand, it can be seen that when the avatar is in the second standing position, the distortion increases to the hip side and in the seat

Figure 5: Virtual prototypes of pants on a standing pose 3D body model

Figure 6: Virtual prototypes of pants on 3D body model

Figure 7: Virtual prototypes of pants on a moving 3D body model

sewn (red color) and little yellow color where the distortion is somewhat less, where in addition to the upper part of the trousers it also occurs in the knees.

When the position of the avatar changes to the third pose or moving pose, it is seen that the distortion increases around the entire hips and back and thigh shown in Figure 7. That is, the situation is somewhat similar to Figure 6.

For developing pants for a sitting posture in a virtual environment, it is necessary to use a 3D body model in a sitting pose.

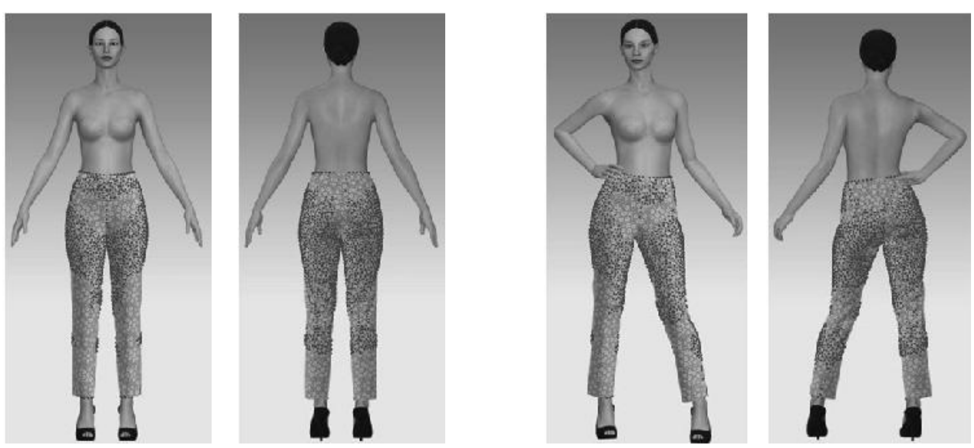
It is a fact that garments for a sitting posture cannot be developed on a standing 3D body model, as there are differences in the position of the construction line of the knee, the length of the pants and the circumference of the pants around the hips and thighs, as can be seen in Figure 8. Based on that, as can be seen in Figure 8 in relation to strain maps where the greatest distortion of the pants is in the sitting position, with the appearance of red in the area of the hips and thighs, i.e. in these places there is 120% of distortion. It can be assumed that, when using pants in real wear, distortion and discomfort could occur, another indicator that indicates how the pants would behave and whether something needs to be done in those parts, or add a little allowance to reduce this distortion or correction in pattern making. In places where the yellow color occurs, there is a distortion of about 114%, which means that it is somewhat smaller, but it is still present, and where there is a color from green to blue, there is 100% distortion or no distortion.

From all four avatar poses made, it can be concluded that the distortion on this model of pants and the given dimensions occurs in fairly the same places on the avatar's body, only the intensity is different. So, when it is in a standing position, then the appearance of greater distortion, i.e. in red, there is little in certain places such as hips, seat sewn, thighs, and when the avatar is in a sitting position, and then the area of increased distortion is larger.

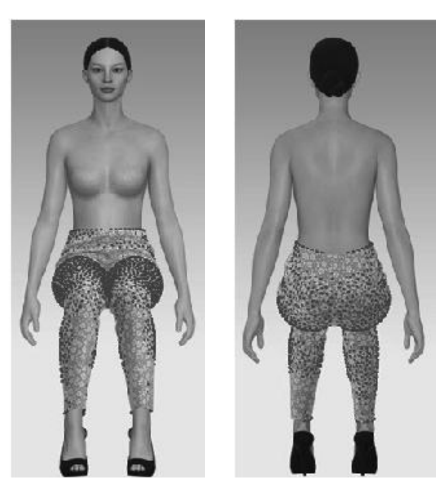
Show pressure points are show or hide contact points between 3D garment and avatar, Figure 9.

From Figure 9 (a, b, c) where the avatar is placed in multiple poses from standing, moving and sitting position it can be seen that the contact points of 3D garment and avatar are greatest in thighs and pants lengths on legs and back and less pronounced around waist. These pressure points show us how the pants

Figure 8: Virtual prototypes of pants on a sitting 3D body model



a) standing poses of 3D avatar



b) moving pose of 3D avatar c) sitting pose of 3D avatar

Figure 9: Pressure points - contact points between 3D garment and avatar

would fit the body depending on the chosen model and type of material, or whether the pants would be close to the body or not. Thus, before the start of tailoring, it will be known how the pants will behave in reality, i.e. whether what was needed according to the given model was obtained.

4. CONCLUSION

The research on 3D clothing simulation is booming. 3D cloth simulations are either geometrical based or physical based. Because of the contributions from the computer graphics community, the simulation accuracy and speed have been much improved in recent years. In the field of clothing and textiles, 3D simulation is considered to be of great potential for fit analysis, and a number of commercial clothing CAD systems have deployed 3D simulation modules.

From the presented results it can be concluded that 3D clothing simulation with some different poses of avatar can show what the final model of women's pants would look like for a certain target group for which they are intended, their fitting as well as material distortion and pressure, i.e. how much material will touch the body in real wear. Typically, a 3D virtual fit model is firstly created and then the clothing patterns are virtually sewn around the 3D model as if the garment were worn by the customer. The fit model can be customised based on customers' body dimensions. It can be an excellent tool for clothing product development, because costly sample making and fitting process can be reduced or completely eliminated, suggested by the software suppliers. However, with the range of validity identified, guidelines can be provided to the fashion industry for the use of 3D simulation system in design and fit evaluation. There by 3D simulation can benefit the industry by reducing cost and shortening development process.

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Primljeno/Received on: 2.11.2021.

Revidirano/ Revised on: 17.11.2021.

Prihvaćeno/Accepted on: 21.11.2021.